Proceedings on the 4th SEASTAR2000 Workshop

December 11-13, 2003
Bangkok, Thailand

SEASTAR2000

Edited by Nobuaki Arai

Organized by
Graduate School of Informatics, Kyoto University
Fisheries Laboratory of Kinki University
JSPS Bangkok Liaison Office
Informatics Research Center for Development of Knowledge Society Infrastructure

FORWARD

On behalf of the SEASTAR2000 4th Workshop, I would like to introduce the background of the development of research and conservation of sea turtles in ASEAN which has started since 2000. In 2000, we had the first international workshop in Kyoto, Japan to discuss the marine animal biology and conservation. The main scientific object focused on how to avoid the incidental catch of sea turtles and the other endangered marine animals from fishing gears such as shrimp trawls, gill nets and longlines. As the collaborative research has been carried out between Thai and Japanese scientists, we have discussed the migration routes of adult female nesting behavior, and genetic difference of sea turtles in Thailand, which have been extended to green, olive ridley and hawksbill. In addition, the biology of dugong has been discussed. We compared seasonal spatial shift of fishing grounds and migration routes of adult female turtles. Then, we found out that the incidental catch of sea turtles due to fishing gears was very few in the Gulf of Thailand. After the workshop, we realized that it was necessary to expand the collaborative research areas among several countries along the migration routes based on the results which indicated that the post nesting turtles in the Gulf of Thailand returned to the Sulu Sea, Java Sea and South China Sea beyond the Thai waters. In the Andaman Sea, they return from the Similan Islands to the Andaman Islands. There are many countries along the migration routes of turtles.

From 2001, the collaborative research has been carried out among Japan, Malaysia and Thailand to find similarity of migration behavior along the Malay Peninsula. We have found out the similar migration pattern between Malaysia and Thailand population from the nesting beach through the feeding ground. Scientists of the other Asian countries have started to show their interest in this information. In 2002, the number of SEASTAR participants increased, they came from many Asian countries such as India, Myanmar, Thailand, Cambodia, Vietnam, Malaysia, Negara Brunei Darussalam, the Philippines and Japan. The main objectives are 1) to carry out the research of migration routes of young turtles, new hatchlings, and adult males, 2) to investigate and find out the correlation between migration routes and environmental factors in feeding areas, such as seagrass bed density, 3) to examine genetic difference of local population in different feeding grounds, 4) to develop conservation plans of endangered aquatic animals. Recently, it seems to be necessary to discuss aquatic endangered species other than sea turtles. The species include dugongs, Mekong giant catfish and other useful fish resources.

It is deeply meaningful to publish the Proceedings on the 4th SEASTAR2000 Workshop.

I hope the newest knowledge will make a great contribution to conservation of endangered marine animals.

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CONTENT

Sea turtle conservation in India: existing laws and problems - A case study from Gulf of Mannar, Southeast coast of India

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ABSTRACT

Olive ridley, green, hawksbill, leatherback and loggerhead turtles have been found to occur along the Indian coast. The Gulf of Mannar, located along the Southeast coast of India is a marine biosphere reserve and is unique for coral, seaweed and sea grass ecosystems. Gulf of Mannar is also an important place wherein all the five species of sea turtles have been reported. The survey indicated that the turtles were abundant along Gulf of Mannar coast in 1960s and 1970s. This could be evidenced from the live turtle trade existed in this coast in 1960s with Sri Lanka with an annual landing of about 3000 to 4000 turtles between Rameswaram and Mimisal. Also, turtle poisoning have been reported along this coast. After the enactment of the Indian Wildlife (Protection) Act 1972, the exploitation has got much reduced. Though all the five species are legally protected under Schedule I of the Indian Wildlife (Protection) Act 1972, the exploitation still continues along the Tuticorin coast of the Gulf of Mannar. The turtle number has got reduced along this coast in recent years due to habitat disturbance and exploitation. Green turtle is the much exploited species for the meat and the fisher folk are offered lucrative price by the turtle meat traders. Four green turtles have been recently rescued from the traders and released back into the sea. Though the present law is enough to contain the exploitation, shortage of manpower and facilities for its effective implementation are considered as the major lacuna for the continuing turtle exploitation apart from the lack of awareness among the coastal people.

KEYWORDS: sea turtle, Gulf of Mannar, Tamil Nadu, exploitation, conservation

INTRODUCTION

India is one of the twelve mega-diversity countries which together constitute about 60 to 70 % of the world's biological diversity. India has an exclusive economic zone of 2.1 million sq. km. Five species of sea turtles, olive ridley (*Lepidochelys olivacea*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) are distributed along the Indian coast. Except the loggerhead, all other species have been reported to nest along the Indian coast. Among the five sea turtles, olive ridley is the most common and abundant in India and is unique for its mass nesting along the Orissa coast (Karthik, 2000; Kar, 2001). Three olive ridley mass nesting beaches-Gahirmatha, Devi river mouth and Rushikulya-are located in the Orissa state. The olive ridleys are said to be migrating along the coasts of Tamil Nadu and Andhra Pradesh states towards the mass nesting beaches in Orissa.

The turtles migrating to Indian waters are on the decline in recent years owing to many threatening factors. The main detrimental factor is the incidental catch which is more on the east coast. Next to Gahirmatha coast in Orissa, the incidental catch is high along Tamil Nadu and the gill nets are accounted for the major killings (Rajagopalan *et al.*, 2002). They observed higher incidental catch during January to February in the year 1997 and 1998 and during that period, the mortality due to incidental catch was observed all through the year along Tamil Nadu (Rajagopalan *et al.*, 2002). Exploitation by humans, developmental activities on the beach including artificial illumination, predation by wild animals and beach erosion are the other factors affecting the sea turtles. All the five species of sea turtles are listed under Schedule I of the Indian Wildlife (Protection) Act 1972 and India is a signatory to the Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Tamil Nadu state which is located along Southeast coast of India has a coast line of about 950 km. All 5 species of the sea turtles have been reported along Tamil Nadu coast and is considered the next dense nesting area for olive ridleys after Orissa. Sporadic nesting of olive ridley occurs along the northern coast of Tamil Nadu especially between Nagapattinam and Chennai coast. The coastal stretch between Tranquebar and Pazhayaru, Mamallapuram and Chennai, Point Calimere and Nagapattinam and Kanyakumari and Trichendur are the other turtle nesting areas in Tamil Nadu. In Gulf of Mannar and Palk Bay on the south, except the leatherback, the other four species were reported (Kar and Satish B., 1982). In the Kanyakumari to Trichendur stretch, the core nesting area has been identified as between Manapad and Periathalai (Bastian Fernando, 1983). Turtle nesting has been reported during December to February and also during April to June (Murugan, 2003). The rich coral reef and sea grass areas in Gulf of Mannar form a good foraging ground for sea turtles.

The sea turtle study in India is mainly focused on olive ridleys, especially the mass nesting beaches in Orissa. But, there are other places wherein nesting of other sea turtle species has been reported and are also under threat. So, the objective of this paper is to address the sea turtle conservation issues in India through a case study in Gulf of Mannar. A survey was conducted during mid 2003 in the coastal villages and islands and the previous reports were also taken into account for comparison and assessment.

GULF OF MANNAR

The Gulf of Mannar Marine Biosphere Reserve, established in 1989, is located along Tamil Nadu State, Southeast coast of India between 8°46' and 9°14' N lat. and 78°9' and 79° 14' E long. and covers an area of about 10,500 sq. km. The biosphere consists of 21 islands categorized under four groups - Tuticorin, Vembar, Kilakarai and Mandapam groups. Tuticorin group comprises Van, Kariachalli, Kasuwar and Velanguchalli Islands; that of Vembar group Upputanni, Puzhuvunnichalli and Nallatanni Islands; the Kilakarai group Anaipar, Valliamunai, Poovarasanpatti, Appa, Talairi, Valai and Mulli Island and that of Mandapam group Musal, Manoli, Manoliputti, Poomarichan, Pullivasal, Krusadai and Shingle Islands (Fig.1).

The biosphere harbours marine biodiversity of global significance and is considered as the richest coastal regions of India with about 3600 species of fauna and flora. Two coastal districts - Ramanathapuram and Tuticorin are located along the Gulf of Mannar. One of the islands, Krusadai is considered as biologist's paradise which is unique for the endemic living fossil Balanoglosus (*Ptychodera fluva*). 11 species of sea grass belonging to 6 genera are reported to occur in Gulf of Mannar. The biosphere is characteristic for the occurrence of sea turtles and dugongs.

STATUS OF SEA TURTLES IN TUTICORIN AREA OF GULF OF MANNAR

The habit of sea turtle meat consumption exists in Tuticorin area for many decades. In 1960s, exclusive sea turtle fishing was carried out in Gulf of Mannar and Palk Bay region and live turtle trade existed with Sri Lanka. An estimated 3000 to 4000 turtles were landed annually between Rameswaram and Mimisal during that period and green turtle represented three fourth of the catch (Rajagobalan, 1984). Rameswaram, Kilakarai, Tuticorin, Tondi and Pamban were the assembling centers for the captured turtles. Special pens were erected in the sea to keep the live turtles. Special types of nets, 'Pachuvalai' and 'Kattuvalai' were used for turtle fishing. Pachuvalai' was a cast net and that of 'Kattuvalai' was a type of haul net. During 1971-76, the green turtle constituted the major share of around 89% along Gulf of Mannar and Palk Bay (Agatheesapillai and Thiyagarajan, 1979). Turtles are also got trapped in the bottom net for skates and rays,

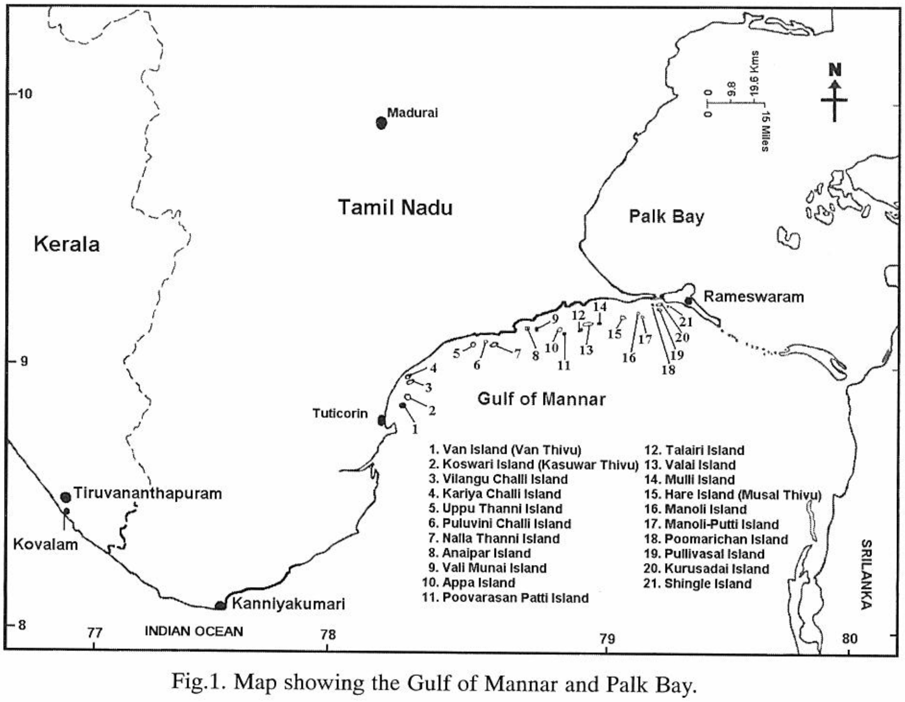

Fig.1. Map showing the Gulf of Mannar and Palk Bay.

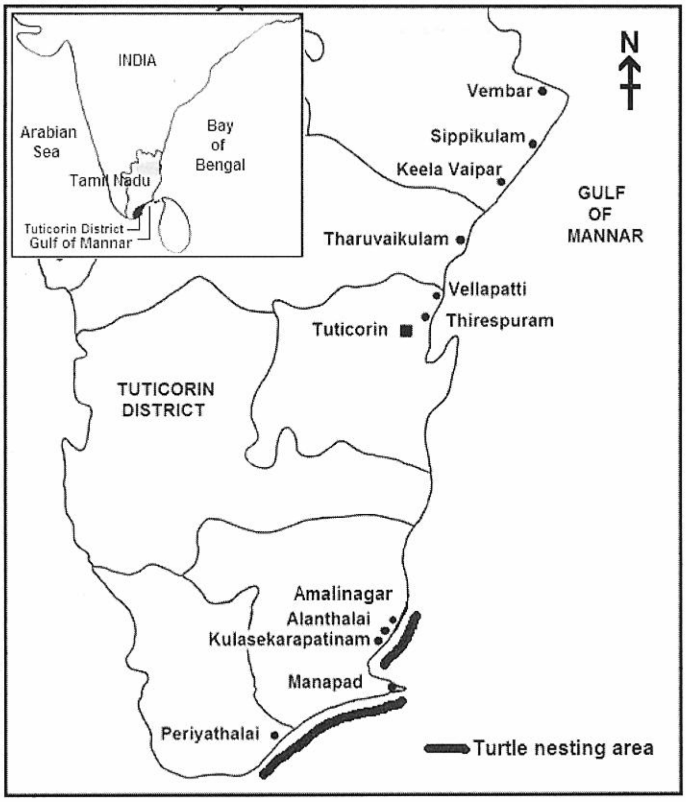

Fig.2. Map showing Tuticorin district

'Thirukkai valai' in Gulf of Mannar area. Turtle poisoning related death or injury has been reported along Tuticorin coast (Silas and Bastian Fernando, 1984). The local names for the sea turtles in this area are 'Peramai' for green turtle, 'Sithamai' for olive ridley, 'Azhungamai' for hawksbill, 'Yezhuvarai or Thoniamai' for leatherback and 'Perunthalaiamai' for loggerhead.

A survey in 1977 mentioned the turtle nesting in Puluvinichalli, Nallathani, Anaipar, Valiamunai, Appa, Valai, Mulli, Hare, Manoli, Manoli-Putti and Pullivasal Islands (CMFRI, 1977). The report indicated large scale nesting in Nallathanni Island during that period. But the recent survey in the Nallathani Island by the author indicated the lapse of prominent turtle nesting. Also, the survey among the fishermen indicated the drastic reduction or absence of turtle nesting activity in the islands.

A survey was conducted in the coastal villages of Tuticorin during mid 2003 to assess why these people like the turtle meat in spite of the reported poisoning. The common answer is that they like the taste. It is also said to cure many body ailments and is considered as an effective medicine for piles and diarrhea. An interesting factor was revealed during the survey. Some people believe that since the sea turtles travel a long distance, they possess special adaptive characters to keep their body joints in good condition. So, a soup made out of the joints of the sea turtles is believed to help them too. The turtle blood which is considered as an elixir (Rajagopalan, 1984) is consumed raw. The person who consumes the raw blood runs for a certain distance for effective digestion and absorption. Turtle eggs are also consumed as raw and in cooked state.

Turtle nesting (green, olive ridley and hawksbill) has been observed in between Manapad and Periathalai villages in Tuticorin district. Based on the interview with the fishermen, it has been noted that the turtles nests in this area during October to January and also from June to July. Abundant turtle nesting was observed a decade ago near Alanthalai, Kulasekarapattinam and Amalinagar (Fig.2). But, the continuous poaching for eggs and meat trade have reduced the nesting intensity and only sporadic nesting is observed (Bhupathy and Saravanan, 2002).

In northern Tamil Nadu coast especially in Nagapattinam coast, gill nets are widely used. In contrast to the southern coast, the people in this area have no habit of eating the turtle meat and hence, the fishermen chop off the head or flippers of the entangled turtles in order to save their nets from damage. But, egg poaching is quite high in this area like southern part. A recent study by Bhupathy and Saravanan (2003) indicated the poaching of 69 out of 72 nests by humans.

Four green turtles were rescued from the traders on 23 July 2003 by the Gulf of Mannar Marine National Park officers at Tuticorin with the help of police and were released back safely with the help of Suganthi Devadason Marine Research Institute on 24 July 2003. Before the release, the measurements were recorded for each turtle (Table 1). Obviously, after 1979, this record gives some sort of information on the green turtles distributed in Gulf of Mannar.

Table 1. Data of rescued green turtles

St. No.	Sex	CCL (cm)	CCW (cm)	Wt. (kg)
1	F	61	59	26
2	F	76	71	51.5
3	F	92.5	78	70
4	M	98	79	83.5

THE MANAGEMENT OF GULF OF MANNAR

The Gulf of Mannar Marine Biosphere Reserve is managed by a separate authority. The Gulf of Mannar Marine National Park, which is the core sector of the biosphere, is under the supervision of a Wildlife Warden. The park has four ranges, each headed by a Forest Ranger. Apart from this, the authority has seven Foresters, twelve guards and five administrative staff. The Tuticorin area is managed by a Forest Ranger, two Foresters and three Guards.

The Wildlife office has only two petrol boats at their disposal. The lower budget allocation for fuel restricts their movement. Only recently, a vehicle has been provided for the Tuticorin unit from the neighbouring forest division. But the ceiling on the fuel utilization is again a hurdle in effective monitoring process. The UNDP-GEF project under implementation is expected to provide the required facilities. Effective coordination between district administration and wildlife office is also the need of the hour. The lack of proper awareness on the endangered marine species among the various agencies like Coast Guard, Customs, Police and district administration aggravates the problem of management. After the rescue of the green turtles on 23 July 2003, additional check posts have been established along Tuticorin coast.

The infrastructure for the effective management of the Gulf of Mannar Marine Biosphere Reserve is to be strengthened under the UNDP-GEF project. Considering the vast area of the biosphere reserve, the man-power and the number of petrol boats have to be suitably increased. Though the legal protection for the management of the biosphere reserve is adequate, its effective enforcement is the need of the hour. Also, the legal proceeding against defaulters is a protracted process which has to be speeded up or a fast-track court may be established to deal with such cases. The creation of awareness among the people and involving them in conservation issues are very important for successful management of the sea turtle resources along Gulf of Mannar.

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Reconstruction of three-dimensional moving paths of green turtles by means of magneto resistive data loggers

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ABSTRACT

We reconstructed the spatial and temporal diving behavior of a green turtle using cutting edge data loggers. The reconstruction of three-dimensional moving paths of the green turtle has been one of important themes in SEASTAR2000 project. To reconstruct the three-dimensional moving paths of green turtles, we developed the magneto-resistive acceleration data logger (MR logger) to record magnetic field and acceleration. Field experiments were conducted in Huyong Island, Thailand. The MR logger and Speed/Depth/Temperature data logger (PDT logger) were attached on a carapace of a female green turtle nested on the beach. Sampling frequencies of the data loggers were 10 Hz for the MR logger and 1 Hz for the PDT logger. The 3-D moving paths of the green turtle were reconstructed by her horizontal body directions, vertical tilt angles and swimming speeds. The horizontal body directions of the green turtle were calculated from the surging and swaying magnetic field. The vertical tilt angles of the green turtle were calculated from the surging acceleration.

KEYWORDS: green turtle, diving behavior, three-dimension, data logger

INTRODUCTION

The green turtle (*Chelonia mydas*), is listed as an endangered species on the IUCN red list, and has been recognized as species for conservation in many countries. Traditionally, to conserve the turtles, many studies have focused on the investigation on the beach. The biotelemetry contributed to these studies undoubtedly. For example, long or short distance migrations between reproductive sites and feeding sites were found using satellite telemetry in their habitats (Hays *et al.*, 2001; Hatase *et al.*, 2002). In the studies using data loggers, Eckert *et al.* (1989) reported that leather back turtle (*Dermochelys coreacea*) has dived to more than 1,000 m. Recently, Minamikawa *et al.* (2000) reported that the lung air was used to achieve neutral buoyancy in loggerhead turtles (*Caretta caretta*). Although spatial-temporal analysis of the behavior of the sea turtles is very important for better understanding of the species, a three-dimensional diving path for the sea turtles is still unknown. Major reason is that the measurement technique, which can record spatiotemporal data, has not been developed. Sea turtle researchers who used data loggers depended on time-depth series data logger (Eckert *et al.*, 1989; Minamikawa *et al.*, 2000). But, time-depth-series data alone cannot give a real moving track of aquatic animal. In this paper, we introduce the new data logger to record the magnetic field and acceleration. We tried to calculate body direction and tilt angle of the green turtles through this data logger and to illustrate a three-dimensional diving path of the turtle.

MATERIALS AND METHODS

Data loggers

To measure a three-dimensional diving path of green turtles, we developed two types of data loggers (Fig. 1). Magneto-Resistive (MR) logger has two types of sensors, MR sensor and acceleration sensor. The MR sensor is to record a surging and a swaying magnetic field, whereas an acceleration sensor records a surging acceleration and a swaying acceleration (Fig. 2). The MR logger has a memory of 64 MB (5,760,000 data) and is programmed to record the data at an interval ranging from 5 ms to 1 min. The range of measurement and resolution were ±2 Gauss and ±1 % FS (magnetic field) and ± 98 m/s^{-2} and ± 0.2 % FS (acceleration), respectively. The instrument was 40.8 mm in diameter, 300 mm in length, and weighed 320 g in water.

CCD logger has a color CMOS sensor to record 28,000 pixels photograph. The sampling interval is four photographs per 1 hour. The logger has a memory of 1 MB (80 photographs). A light sensor equipped with the

CCD logger helped in taking photos in the daytime because the logger does not have a flash unit. The instrument was 92 mm in length, 40 mm in width, less than 28 mm in height, and weighed 155 g in water. Swimming speed and depth were monitored using speed-depth-temperature (PDT) logger (UWE-200PDT; 13 g in water, 20 mm in diameter, 90 mm in length, Little Leonardo Co., Ltd), simultaneously.

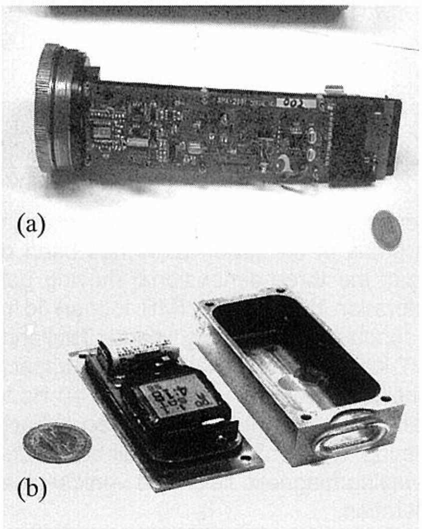

Fig.1. Photos of a MR logger and a CCD logger. The photo (a) is MR logger and the photo (b) is CCD logger.

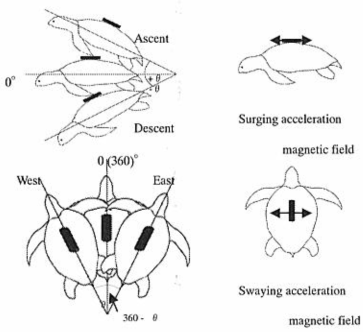

Fig.2. Schematic diagram showing the direction of surging and swaying geomagnetic and acceleration recorded by a data logger on the carapace of a green turtle (black bar). Data for surging acceleration were converted to tilt angles. Data for surging and swaying geomagnetic were converted to body directions.

Field experiments

Experiments were conducted on the nesting beach at the Huyong Island of Similan Islands (8.28°N, 97.38 °E) in the Andaman Sea from May 15 to May 31, 2003. The Huyong Island is a desert island. But it has a primal nesting beach of green turtles on the Similan Islands. The length of the nesting beach is approximately 800 m and the beach is protected by the Royal Thai Navy. All nesting turtles landed on the beach are identified by microchips inserted into their roots of both flippers and inconel tags. Generally, green turtles lay eggs several times on the same beach at approximately 2-week intervals during one breeding season. Therefore, if we attach the data loggers to a turtle at the first or second nesting, we can recover the data loggers from the turtle at next nesting.

Night patrol was conducted from 8:00 PM to 4:00 AM to find female green turtles landed on the beach for nesting. The data loggers were attached on the carapace of the nesting female green turtle (Curved carapace length 100.0 cm) after the turtle laid eggs. First we attached two wooden pedestals on the carapace of the turtle using epoxy resin. We used the pedestals to attach the MR logger parallel to body axis of the turtle, and the pedestals played a role as float. Second, the MR logger (sampling frequency 10 Hz) was attached on the pedestals using cable ties. The PDT logger (sampling frequency 1 Hz) was attached beside the MR logger using epoxy resin. The CCD logger was attached on the front of carapace of the turtle using epoxy resin. We retrieved the data loggers from the turtle when the turtle subsequently returned to the beach.

Body direction

Figure 3 shows normalized outputs of the MR sensor. The normalized outputs were ranging from -100 to 100. When the sensor was held horizontally and was rotated clockwise from the north direction, responses of the surging and swaying magnetic field recorded by the MR sensor showed the cosine (surging) and sine (swaying) functions. We calculated the horizontal body direction (θ_1) using this relationship between surging magnetic field (x) and swaying magnetic field (y) by following Equation 1.

$$\theta_1 = \begin{cases} 90 & (x = 0, y > 0) \\ 270 & (x = 0, y < 0) \\ 180 + \mathrm{atan}(y / x) * 180 / \pi & (x < 0) \\ \mathrm{atan}(y / x) * 180 / \pi & (x > 0, y > 0) \\ 360 + \mathrm{atan}(y / x) * 180 / \pi & (x > 0, y < 0) \end{cases} \quad (1)$$

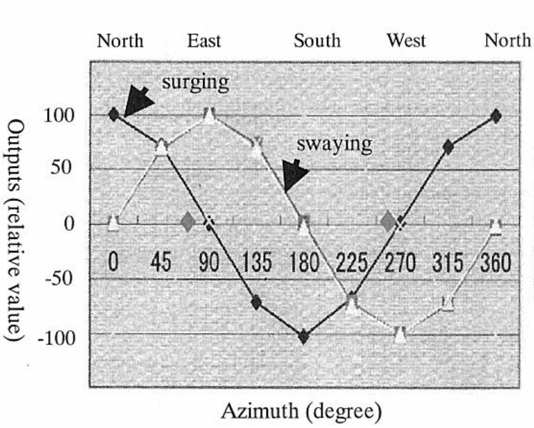

Fig.3. Normalized outputs of MR logger when the logger was held horizontally and rotated clockwise from the north.

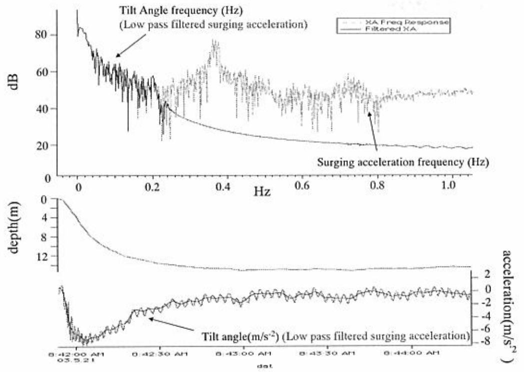

Fig.4. Frequency response and expanded time-series of surging accelerations of the turtle for a typical diving. The Upper graph shows frequency response of surging acceleration and lowpass filtered surging acceleration. The lower graph shows expanded time-series of depth, surging acceleration and lowpass filtered surging acceleration, which showed tilt angle of the turtle.

Tilt angle

The acceleration sensor along the body axis of an animal is affected by both forward movement s of an animal and gravity (Yoda *et al.*, 2001; Tanaka *et al.*, 2001). We found the peak at 0.36 Hz. This peak may indicate a flipper movement frequency of the turtle. Moreover, high frequency variations ranging from 0.2 Hz to 0.4 Hz recorded in the surging acceleration may indicate to be caused by the flipper movement for the turtle. These frequencies were filtered out using a 0.2 Hz low-pass filter (IFDL Version 3.1; WaveMatrics, Inc., USA; Tanaka *et al.*, 2001) to get the tilt angle (Fig. 4). When the animal is still or moving at constant speed, the gravity vector (g = 9.8 m/s2) will change in response to the tilt angle (Tanaka *et al.*, 2001). Therefore, we have calculated tilt angle (θ_2) of the turtle using low-pass filtered surging acceleration (A) as the following Equation 2

$$\theta_2 = \text{asin}(A/g) \qquad (2)$$

We tried to attach the MR logger parallel to body axis of the turtle using the two wooden pedestals. However, it was difficult to put the MR logger exactly parallel to the body axis of the turtle. Therefore, it was necessary to correct an initial error of the tilt angle calculated from the surging accelerations. As described by Sato *et al.* (2003), initial error of the tilt angle can be corrected by the comparison between a dive profile measured by depth sensor and calculated dive profile by several adjustment tilt angle. Therefore, we corrected the initial error of the tilt angle by this method.

Horizontal moving paths

Horizontal moving paths of the turtle, which are longitudinal moving distance (d_1) and latitudinal moving distance (d_2), was calculated from the body direction (θ_1), tilt angle (θ_2) and swimming speed (v) by Equation 3 (longitudinal movement) and Equation 4 (latitudinal movement).

$$d_1 = v * \cos(\theta_2) * \cos(\theta_1) \qquad (3)$$
$$d_2 = v * \cos(\theta_2) * \sin(\theta_1) \qquad (4)$$

RESULTS AND DISCUSSION

We analyzed the data from May 21 to May 23, 2003. The turtle carried on with a continuous dive. The mean maximum depth of dives was 13.88 m. The mean duration of dives was 18.17 min. The mean rate of bottom time (bottom time per dive duration) was 0.35 % (n = 95).

The data presented in Figure 5 describe a typical dive of the turtle. Dive duration was 710 seconds. Maximum dive depth was 15.20 m. Mean swimming speed was 0.81 m per second. Figure 6 shows horizontal moving path and relationship between swimming direction and diving depth. The turtle descended northwestward and ascended southwestward during this dive. The turtle has maintained its direction relatively constant during this dive. Therefore, we illustrated the three-dimensional diving path of the turtle by direction and swimming speed data (Fig. 7). However, the illustrated moving path of the turtle may be affected by ocean current because the PDT logger measured a swimming speed using a propeller. Therefore, an estimated error that could affect the accuracy of the calculation of the turtle was accumulated in the moving path. Davis *et al.* (2001) and Mitani *et al.* (2003) adjusted the accumulation of the errors of the three-dimensional diving path of seals using "dead reckoning" methods. However, we cannot apply this method to adjust the accumulation of errors because a start position of dive of sea turtles differs from a goal position of the dive. To adjust the accumulation of errors of the diving track, it is very important to get positional information of diving turtle. Now we are developing the Argos transmitter equipped with GPS sensor for sea turtle study. So we will adjust the accumulation error of diving path of the turtle using GPS position in the near future.

Three-dimensional analysis by the MR logger will gratefully contribute to the studies on behavior of sea turtles. For example, we know that a sea turtle lay eggs on the beach and migrate between the fixed feeding area and fixed nesting area. However, the ability to find the nesting beach and feeding area is still unknown. A body direction of the turtle measured by the MR logger will contribute to elucidate this ability.

Traditionally, migration paths of sea turtles were studied using satellite telemetry (Hays *et al.*, 2001; Hays *et al.*, 2002; Hatase *et al.*, 2002). However, when detailed aspects of satellite tracking data are considered, such as speed of travel and small-scale movements of sea turtles, then location accuracy is likely to become an important issue (Hays *et al.*, 2001). In sea turtle study, a high proportion of locations may be of low quality because a signal from a transmitter uplinks to the satellite only when a turtle swim at sea surface. The MR logger tracking will become a solution for this problem. MR logger can track a migration path of the turtle continuously. The recording time of the MR loggers, however, are limited due to their battery. Therefore, our future plan is to track more detailed migration paths of turtles all through the inter-nesting intervals.

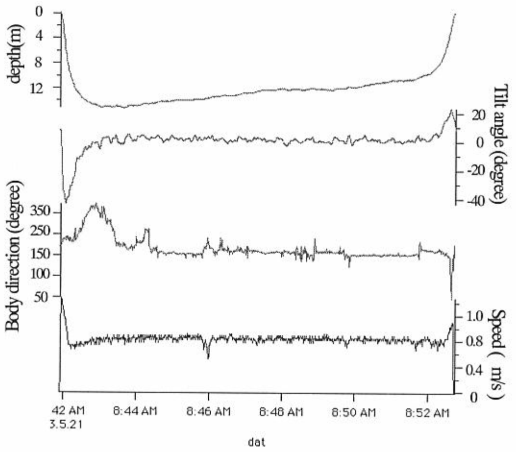

Fig.5. Expanded time-series of depth, tilt angle, body direction and swimming speed for typical 1 dive of the turtle.

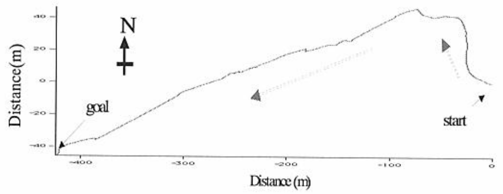

Fig.6. Horizontal moving path for typical 1 dive of the turtle.

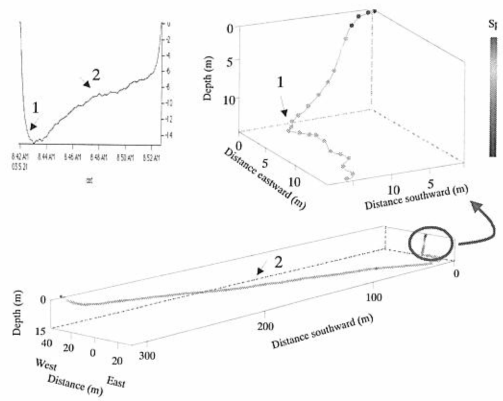

Fig .7. Three dimensional moving paths for typical transit dive of the turtle during inter-nesting interval.

ACKNOWLEDGEMENTS

We gratefully thank all members of Phuket Marine Biological Center and Royal Thai Navy who have supported the field experiments. We thank the National Reserch Council in Thailand. This study was partly supported by a Grant-in-Aid for Scientific Research (13375005, 12556032 and 14560149) and Information Research Center for Development of Knowledge Society Infrastructure, the Ministry of Education, Culture, Sports, Science and Technology. We thank three anonymous reviewers for their comments.

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The research, conservation and management of sea turtles in Viet Nam

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ABSTRACT
It is recognized that there are five species of sea turtle to reside in Viet Nam. However, there are only three species often nest on beaches. Major nesting beaches are concentrated on offshore-islands in the Tonkin Gulf, Central Coasts and Islands in the Southern part of Viet Nam. Our results showed that locals have harvested nesting turtles and approximately amount of 50% of eggs for each species during nesting season, with the exception of Tho Chu Island, Con Dao National Park and Nui Chua Natural Reserve Area. Continuation of those threats will lead to the extinction of sea turtles in Viet Nam in the forthcoming decades. The current threats for marine turtles are including: (i) the incidental and opportunistic capture by fishermen and locals; (ii) the direct take of nesting females and their eggs at beaches; (iii) the urbanization, illegal trade issues, sand mining, tourism development and marine debris... The largest risk for marine turtles are bottom trawlers, especially in "Cao bay" trawling with big mesh-size net, gillnet operation, long-line net with several hook operators and diving activities. In general, most green, hawksbill and olive ridley turtles are captured by those methods. The immediately taken action to preserve sea turtles and other wildlife, based upon the collaboration between Local, National Sectors and Regional Organizations are the best choice.

KEYWORDS: **loggerhead, olive ridley, leatherback, green and hawksbill turtle, Tonkin Gulf, national park, reserve area.**

INTRODUCTION

The seawaters and remote islands of Viet Nam are recognized as a critical habitat for sea turtles of the world. Research, conservation and management activities on sea turtles have been conducted in coastal provinces of country as well as in other countries of ASEAN/SEAFDEC members. There are 5 species, which had been found in Vietnam Seawater and they have been threatening species (Hamann Mark, 2002).

Since early 1998, the Ministry of Fisheries has appointed the Research Institute for Marine Fisheries (RIMF) as National Institution taking responsibility for research activities and proposing the general framework in managing and protecting sea turtles in Viet Nam.

OBJECTIVES

Our program objectives on the sea turtle conservation are:

- To facilitate in regarding to the research, conservation and management for sea turtles between ASEAN/ SEAFDEC Countries and Viet Nam,
- To enhance the common awareness in term of protecting the sea turtles and their habitats,
- To introduce some advanced technologies in monitoring, controlling and surveying for sea turtle resource with integrated coastal zone management approaches,
- To primarily set-up the National Database as well as National Action Plan for Sea Turtle Conservation and Management beyond 2010.

RESULTS AND DISCUSSION

The distribution of sea turtles

Nesting season and hatch rate

Annually, hundred of sea turtles went to shoreline for nesting on sand beaches. Nesting season for sea turtles differs among different species. In general, nesting season lasts from March to November. Con Dao (Ba Ria-Vung Tau), Tho Chu (Kien Giang) and Nui Chua (Ninh Thuan) Reserve Park are the main nesting sites and so on.

Nesting behaviour of sea turtles showed that turtles nest at nighttimes. Hatch rate of sea turtles depends on the interaction of numbers of factors, such as salinity, humidity, temperature, gas flow, rainfall, tidal inundation, erosion, and predation. The hatch rate ranged with average of 67,93% during the period of 1994 till 2003 (Table 2; Figure 2).

Table 1: Nursing grounds of sea turtles found in Vietnam

No	Nursing ground	Sea turtle species
1	Con Dao Archipelago (including 14 places)	*Chelonia mydas, Eretmochelys imbricata, Caretta caretta*
2	Nui Chua Natural Reserve Area (Ninh Thuan)	*Chelonia mydas, Eretmochelys imbricata, Lepidochelys olivacea*
3	Quang Ninh (including Vinh Thuc Island and Minh Chau beach)	*Chelonia mydas*
4	Bach Long Vi Island (Hai Phong)	*Chelonia mydas*
5	Spratly Archipelago	*Chelonia mydas, Eretmochelys imbricata*
6	Phu Quy Island	*Chelonia mydas, Eretmochelys imbricata*
7	Phu Quoc Island	*Chelonia mydas, Eretmochelys imbricata*
8	Tho Chu Archipelago	*Chelonia mydas, Eretmochelys imbricata*

Table 2: The hatch rate of Sea turtles in 1994 -2003.

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Hatch rate (%)	19.92	35.32	74.37	75.29	78.32	80.31	81.15	84.38	73.23	76. 99

Source: (RIMF_MoFI, WWF and IUCN, 2003).

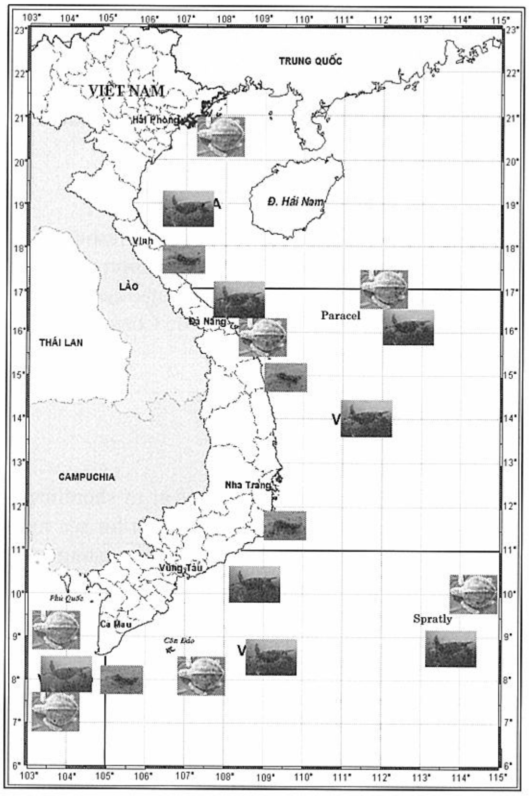

Fig. 1. The Map of distribution for Sea Turtles in Viet Nam Seawater

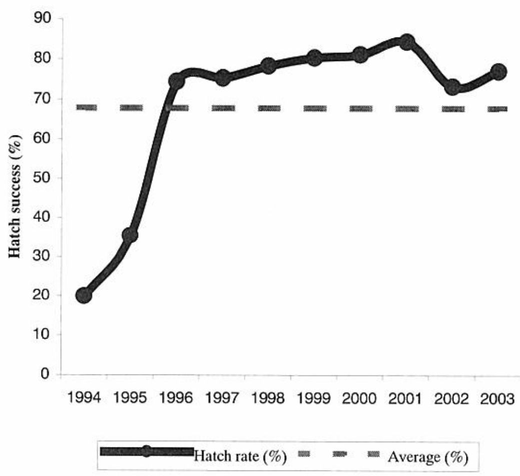

Fig. 2. Hatch rate of the Sea Turtle in Viet Nam

Threats to marine turtles in Viet Nam:

At all stages of their life cycle marine turtles are subject to various impacts that may combine their survival and capacity to breed successfully. These impacts have the potential to decrease population sizes and threaten the species with endangerment. Listed below are summarised threats that have been identified by the previous and recent researches and surveys, which of these threats is presented below (Table 3).

Table 3. Potential human-related impacts/threats associated with species marine turtle in Viet Nam. Although they do not nest in Viet Nam, reside in Viet Nam's waters these are threats to a distant nesting population(s).

Human-related impacts	Green (southern)	Green (northern)	Green (Gulf of Thailand)	Green (Spratly)	Hawksbill	Hawksbill (Spratly)	Olive ridley	Leatherback	Loggerhead
Defence activities	×	×	?	✓	×	×	×	×	×
Diseases	×	×	×	×	×	×	×	×	×
Sand mining	×	✓	×	×	×	×	✓	×	×
Tourism Developement	✓	✓	?	×	?	?	✓	×	×
Illegal egg collecting	✓	✓	✓	?	✓	?	✓	✓	×
Incidental catch - lines	✓	✓	✓	?	✓	?	×	×	✓
Incidental catch - gill nets	✓	✓	✓	?	✓	?	✓	✓	✓
Incidental catch - Longlines	✓	?	?	?	✓	?	×		✓
Incidental catch - trawl nets	✓	✓	✓	?	✓	?	✓	✓	✓
Ingestion of, or Entanglement in, marine debris	?	?	?	?	?	?	?	?	?
Illegal direct take - in Viet Nam	✓	✓	✓	?	✓	?	×	×	×
Direct take - overseas	?	?	?	?	?	?	?	?	×

Table 4: The number of released hatchlings during the period of 1994-2003.

Year	1994	1995	1997	2001	2002	2003	Total	Average per year
Hatchling (individual)	6,000	28,500	70,000	90,000	140,450	161,210	496,160	82,693

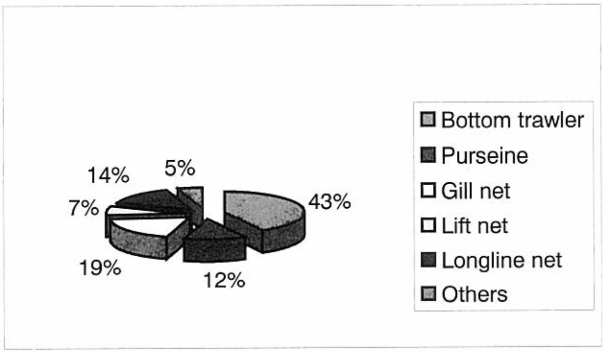

Fig. 3. Percentage of fishing gear in fisheries sector of Viet Nam

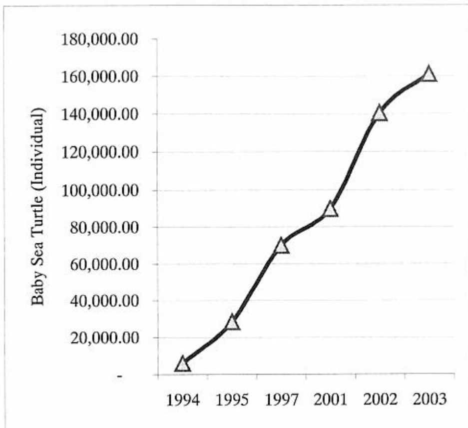

Fig. 4. Amount of baby sea turtle released into Seawater

Direct and indirect take of nesting and foraging turtles and eggs

Interview-based studies were carried out in 1998-2002 by RIMF and 2002 by IUCN_VN, in Thanh Hoa (Tonkin Gulf), Quang Nam, Da Nang and Khanh Hoa provinces (Central of Vietnam), Phu Quy, Con Dao, Tho Chu and Phu Quoc Islands (Southern part and Gulf of Thailand). The results showed that almost marine turtles were incidentally caught by various types of fishing gears especially by bottom trawls, gillnets, long-line and sometime by purse seine. However, number of marine turtles incidentally caught by fishing gears as by-catch in Viet Nam was estimated to be less or more than 30 individuals per year (Mark Hamann *et al.*, 2002).

Direct harvest

The direct take of turtles and eggs from the nesting beaches is a principal factor underlying the decline in nesting numbers of all marine turtle species in Viet Nam. However, data from a joint (IUCN, RIMF and MoFI, 2002) survey indicates that most of the eggs harvested in the non-protected locations. It is clear that Vietnamese nesting populations cannot sustain this practice. In addition, fishing techniques such as longline fishing and gill nets, have been adapted or used to. Hence most of the foraging turtles are caught accidentally in fishing gear. However, the opportunistic capture of both green and hawksbill turtles by fishermen want diving for other economically important marine products such as molluscs and crustaceans poses a significant threat to these species. This take could involve hundreds of turtles from each species, and needs to be eliminated in the near future if Viet Nam's foraging populations of these species are to survive. The fishing sector in Vietnam has grown considerably over the last 10 years. By 2002, while the number of artisan vessels has remained similar, the number of registered vessels had increased to 79,000. Most of these (69,000) work in the coastal zone. Of these registered vessels (Source: Research Institute for Marine Fisheries-RIMF):

- 42.3% are registered as bottom trawlers
- 12.3% are registered as purse-seining vessels
- 19.2% are registered as gill net vessels
- 7.0% are registered as lift netting
- 14.2% are registered as long lining vessels
- 5.0% are registered as other.

Fishers using SCUBA, Hookah or free divers, dive around the coral/rocky reef areas, usually around islands. In some locations these divers attempt to catch fish using cyanide, however, most are diving to collect commercially valuable species of finfish, mollusc and crustacean such as lobster and abalone.

Incidental take

The incidental capture of marine turtles is a large and widespread problem, with a large percentage of these either drowning in fishing gear or being killed for food when accidentally caught in nets and brought on boat alive. The fishing methods of most concern are, (1) bottom trawling, (2) drift and gill nets, and (3) longlines.

RIMF (2002) reported that between 1993 and 2001 there were the average of 69,000 registered vessels operating within the waters of total 23 coastal provinces in Viet Nam. Of the registered vessels operating, nearly 42.3% are bottom trawlers and 19.2% are gillnetting vessels. Survey data compiled by MOFI, RIMF and IUCN indicates that turtles are caught as bottom trawl or gill net bycatch in 15 of targeted provinces, with catch rates varying from one turtle per province per year up to 10 of turtles per year (Pham Thuoc *et al.*, 2002).

Trade issues

Several green turtles and hawksbill turtles are illegally sold for the production of stuffed turtles or shell products (Thomson, 2002). This trade has been reported on by several authors (Baird, 1993; Duc and Broad 1995), and although it is difficult to ascertain actual numbers of turtles that are killed each year, or the rate in which products turn over in stores, the number of products for sale with significant numbers of turtle shell products being sold to international and domestic tourists. While most olive ridley, leatherback and loggerhead turtles that are killed, indirectly or directly, are eaten by fishers or sold for food (Baird, 1993).

Impacts on foraging habitat and food sources

The number of fishing and tourist boats along the Viet Nam coastline has increased significantly in the last two decades. Associated with this has been an increase in marine noise and pollution levels e.g. oil/fuel residue, rubbish (including plastics, discarded net and other foreign material). These factors have negatively affected marine turtle populations in other areas of the world through ingestion, entanglement, injury, and obstruction or by degrading the foraging or nesting habitats, and it is likely that they have contributed in some way to the demise of marine turtles in Viet Nam. In fact, these factors are to constitute the largest non-by-catch or consumptive threat for marine turtles in Viet Nam. Marine debris does not only impact marine turtles but also threatens the health of the marine ecosystem and dependent industries such as tourism and fishing. Unless this problem is addressed in the short term, Viet Nam's valuable coastal and marine ecosystems will be under serious threat of becoming irreparably damaged.

Coral reefs in Viet Nam have long suffered from explosive and cyanide fishing, and sea grass and mangrove habitats have experienced decades of clearing, harvesting, sedimentation and other anthropogenic impacts. Considerable efforts have been made in recent years by various Government and Non-Government Organisations to stop these destructive fishing operations, to promote the suitable use of marine resources and coastal habitat protection (RIMF).

Impacts to nesting turtle habitat

Sand mining

It is unknown whether current sand-mine operations have impacted upon nesting distributions in Minh Chau and Quan Lan Island, however, if the mining area is extended to the beaches where nesting currently occurs (Son Hoa) threats to the stability of the nesting beaches are inevitable. Along the mainland coast sand mining exists in numerous areas, however it is unknown whether any conflicts with marine turtle nesting beaches exist. Continued marine turtle surveys in Phu Yen and Khanh Hoa provinces will be required to determine if any negative impacts are likely along those beaches.

Urbanization and Tourism

The beaches on which turtles are still occasionally seen nesting are mostly undeveloped and mainly located on offshore islands, or away from tourist developments. However, the beaches on Son Tra peninsula (Da Nang City) and several beaches in Quan Lan and Minh Chau are earmarked for tourist development. If these beaches are developed, marine turtle nesting rookeries may be threatened by a variety of factors such as beach removal or alteration, physical obstruction to the dunes, lighting, noise, and increased beach use by people.

Marine debris

Once thrown in the water, whether the original receptacle is a gutter, drain, creek, river or ocean, rubbish has to end up somewhere. Many mainland beaches in Viet Nam have extremely high levels of marine debris. Much of this debris consists of glass, plastics and polystyrenes, and other items associated specifically with fishing such as floats, nets, and light bulbs. This is a problem for marine turtle nesting because it may impede movement and nest digging, lead to injury and infections, and in some cases may cause turtles to be trapped.

Management activities

National and NGO programs

In 1995, the Programme " Salvation of Sea Turtles in Vietnam " has been launched and supported by WWF Indochina. Observations on nesting behaviour of marine turtles have been conducted during reproduction period in Con Dao Island. Nesting on nesting sites in Con Dao are recorded and marked, and those being threatened be washed away by wave should be removed to safe sites. Nearly, emerged hatchlings are rearing in tanks for period of time then is released to sea. However the baby turtle in 1996, 1998, 1999 and 2000 are not yet statistically completed and missed. Present research has being conducted in relation to sea turtles in Viet Nam. The topic titled "Study on marine turtles resources", to determine measures to protect and develop their resources in seawaters of Viet Nam since 1998 only and with very limited budget granted by Ministry of Fisheries of Viet Nam. The main objectives of the study are as follows:

- To estimate the abundance and distribution of sea turtles.
- To study on tagging, nesting behaviour and biology.
- To study on affect of fishing gears on sea turtles.
- To establish sanctuaries.

On the other hand, activities on conservation of sea turtles in Con Dao have been carried out since 1995 with assistance of IUCN VN and WWF Indochina in both technical and financial terms.

Turtles, dugong, sharks and fish rays are not wanted in prawn trawl nets. Turtle Excluder Devices (TEDs), which reduce those target in terms of 'bycatch', but improve the value of the prawn catch. TEDs are metal grids placed inside the trawl net, which block the entry of larger sea-life and allow prawns to pass through. However, TED implementation has not been applied yet in Viet Nam.

With the help of governmental agencies, RIMF coordinated with SEAFDEC/TD developed the Juvenile Trash Excluder Device (JTED). It now requires that JTED be encouraged for using on Swallowed Fishery Operating in order to minimize juvenile mortality. During the period of 9-15th May 2001, JTEDs introduced into Viet Nam in collaboration between SEAFDEC/TD and RIMF. The experiment and demonstration were carried out at Cat Ba bay at Hai Phong City. The result had been less or more successful. Fishing boats, which installed with a JTED with 3 distances of bars, included of 20, 30 and 40 cm interval (see more detailed in SEAFDEC/RIMF report concerned). Those results also showed that 28 trial hauls with 3 different bar distances has not been found the best distance of bar. It may have been caused by too small targets as well as is not enough haul of trial. However, those rigid sorting grids JTEDs have higher separating performance than rectangular and semi-curve ones for release juvenile and trash fishes. The highlight issues are still thinking about how much the survived rate of Juveniles after escaping of JTEDs that is not known (Nguyen Phi Toan *et al.*, 2001).

Based upon the previous results, RIMP staffs had carried out another JTED trial operations in the South of Viet Nam. This trial lasted 2 months from September till October, 2003 in the outermost of buffering Zone at Con Dao National Park to reassess the survived rate of Juveniles. Generally, the result showed that the percentage of the rate of Juveniles escaped is 20% higher than it was in 2001 (Nguyen Phi Toan personal information unpublished).

Tagging activities have been also initially conducted since 1998 especially on Green Turtle, Hawksbill in some coastal areas at Viet Nam, especially at Con Dao National Park in the collaborative program among SEAFDEC member countries as well as WWF Indochina project for the sea turtle conservation (Nguyen Duy Thuong, 1999).

Satellite telemetry of marine turtles has been proven to be a valuable tool for initiating conservation awareness programs in local communities and communicating that management of marine turtles is the responsibility of numerous user groups from a variety of agencies and locations. A project using modern satellite telemetry is initiated by WWF Indochina, NOAA at Con Dao National Park to increase the awareness and understanding about marine turtle migration. This primary allowed Con Dao NP staffs to access information and follow the track of the turtle as she migrates back to her foraging area.

However, the difficult problems being faced in research and conservation of marine turtles in Viet Nam are shortage of financial support, lack of training opportunities, insufficient knowledge to technology and it's applications, etc.

Some Conservation Activities at Con Dao National Park:

- 1994-2003: It is recognized that On 5 Island (rookeries), there are 2082 Sea Turtles for nesting, which included 4 Hawksbill.
- 8/1998 till 2003: there are 1230 turtles had been tagged by SEAFDEC tags as well as several tags had been made by Con Dao National Park.
- 1995-2003, 376.680 hatchling of 6252 egg clutched had been released into sea.
- Two green turtles had been used in terms of Satellite tracking studies to determine their pathway and foraging ground at southern part of VN Seawater. Unfortunately, a green turtle lost PTT with its ID: TE 19590 (USA) at Hon Cai Lon Island. Another one attached PTT on 3rd July 2001. It surfaced during 8 day and moved to nearby Vung Tau. It travelled total period of 30 day and nesting on Phu Quy Island, which is far from the started point of 342 km (Con Dao report, 2003).

RECOMMENDATION

There is a strong urge to provide the resources necessary to enforce the prevention of trade in sea turtle products. It may be building on experience and knowledge gained by other ASEAN/SEAFDEC nations and continuing research and evaluation in terms of useful TED's and JTED's in the Vietnamese trawl fisheries.

It is strongly urged to collect baseline biological data on foraging area populations. If implemented, this would be the first systematic foraging ground study as well as to conduct baseline surveys of sea turtle distribution, abundance, status and threats in our region.

It is strongly urged to continue supporting the extremely valuable nesting beach tagging studies and uses modern satellite telemetry techniques to increase the awareness and understanding of local Vietnamese community about sea turtle migration at Con Dao National Park, Nui Chua (Ninh Thuan) Reserve Area and Tho Chu Island (Kien Giang). There is a need of enhancing awareness and developing the suitable Eco-Tourism Activities as well as banning the illegal market of Sea Turtle businesses. In addition, the coordination with the Regional and International Organization in order to protect the Sea Turtles and other wildlife is very necessary.

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No genetic divergence of green turtle Chelonia mydas nesting populations between the Andaman Sea and the Gulf of Thailand

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ABSTRACT

Nucleotide sequences from the control region of the mitochondrial (mt) DNA were analyzed for Thai green turtles (*Chelonia mydas*) to reveal population genetic structure. Four primers were employed *i.e.* Green15552F (GTGTC CACAC AAACT AACTA CCT), Green16300R (GTCTC GGATT TAGGG GTTTG GCG), Green15579F (CTGCC GTGCC CAACA GAACA), and Green16087R (CCAGT TTCAC TGAAT CGGCA). The aligned sequences contained 438 base pairs (bp) with 254 polymorphic sites. There were 8 haplotypes assigned from the 49 green turtles sampled from the Andaman Sea (19 individuals) and the Gulf of Thailand (30 individuals). Low genetic divergence between the nesting green turtle populations of the Gulf of Thailand and the Andaman Sea was detected in both haplotypic (Gst=0.00311) and nucleotide levels (Nst=0.02838) as well as genetic distance (DTN=0.016±0.003). Haplotype frequencies were not significantly different between the two nesting sites. The result was in contrast with a finding using satellite telemetry that discovered separated home ranges. Recent population separation and/or highly conservation of the studied mtDNA region might be an explanation.

INTRODUCTION

Thailand faces two seas *i.e.* the Gulf of Thailand and the Andaman Sea. The two seas are separated by the southern part of Thailand through Malaysian peninsular and further semi-separated by Indonesia (Fig. 1). These geological barriers act effectively to limit geneflow among conspecific populations from the two seas as revealed in several marine organisms *e.g.* banana prawn *Peneaus monodon* (Supungul *et al.*, 2000; Klinbunga *et al.*, 2001), giant clams *Tridacna squamosa, Tridacna maxima* (Kittiwattanawong, 1999; Kittiwattanawong *et al.,* 2001), starfish (Benzie, 1999), rock oysters *Crassostria spp.* (Bussarawit, 2003). Additionally, separation at community level was detected (coral reef fish communities, Satapoomin, 2002). At the larger scale, this geological barrier may serve as a wall to separate marine organisms between Indian and Pacific oceans.

A green turtle *Chelonia mydas* is another organism distributes in both the Gulf of Thailand and the Andaman Sea (Phasuk, 1992). This allows a possibility to test the effectiveness of this geological barrier. In our previous study (Kittiwattanawong *et al.,* In press), satellite transmitted tracking of the nesting green turtle populations from the Andaman Sea and the Gulf of Thailand suggested contemporary allopathic life cycles (Fig. 1). However, such a finding only reflects the present scenario. An improved understanding of life history may be obtained by research on population

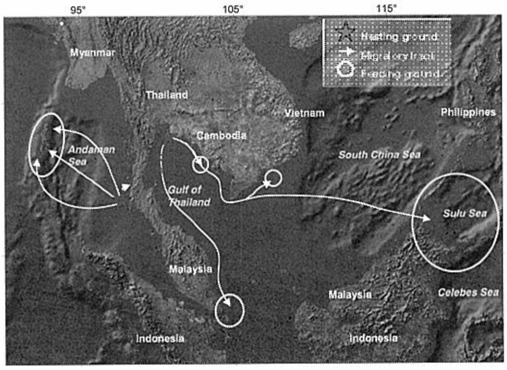

Fig. 1. The two major nesting grounds of green turtles Chelonia mydas in Thailand (Khram Island in the Gulf of Thailand and Huyong Island in the Andaman Sea) with the satellite transmitted results showing the simplified migratory routes and their feeding grounds.

genetic structure. Several kinds of genetic materials vary from proteins to nucleic acids can be employed to reveal population genetic structure (Avise, 1994). Since, genetic materials are inherited from one generation to another, information obtained from genetic materials reflect the summary of natural history from the past till present (Futuyma, 1986; Page and Holmes, 1998).

This study is an analysis of nucleotide sequence from mitochondrial DNA (mtDNA) at control region or D-loop which is recognized as highly polymorphic site (Norman *et al.,* 1994). Within the d-loop, the mutation rate is approximately five to ten times that of the rest of the mitochondrial genome, (Aquedro and Greenberg, 1983). The paper describes the genetic diversities and divergence of the two green turtle nesting sites i.e. Khram Island in the Gulf of Thailand and Huyong Island in the Andaman Sea (Fig. 1).

MATERIALS AND METHODS

The tissues

The samples of turtles tissues were collected with supports from the Royal Thai Navy during 2001-2002. Usually, the staffs patrolled the beaches at night during high tide. After a turtle had laid eggs, the staffs scanned for a microchip tag at both flippers, and a new one would be inserted,subcutaneously to the left flipper when it was not found. Thereafter, a small piece of skin tissue (approximately 0.3x0.3 cm^2) at the inner flipper was cut with a sterile surgery knife and put into a 2-ml microcentrifuge tube filled with sodium chloride saturated DMSO or TNES (a mixture of 150 mM NaCl, 10 mM Tris-HCl pH 7.5-8.0, 25 mM EDTA, and 0.5% SDS) solutions and stored at room temperature. The wounds were treated with medicine such as Gentian Violet, Povidoiodine, or tetracycline ailment before the turtles were released. Twenty-seven samples were collected from Khram Island in the Gulf of Thailand and nineteen samples were from Huyong Island in the Andaman Sea. All samples were analyzed at Graduate School of Agriculture, Kyoto University, Japan under the permission of the CITES.

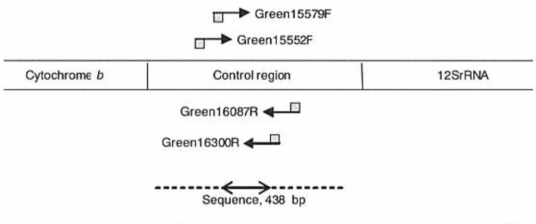

Fig. 2. Location of the primers employed in the study overlaid to a none-scale mtDNA of Chelonia mydas. Arrows indicate the nucleotide synthesis directions. The line with both ends arrows indicates proximal length of nucleotide sequence (438 bp).

DNA analysis protocol

The tissues were digested with Proteinase K. The DNA solutions were obtained by a standard phenol/chloroform extraction (Sambrook *et al.,* 2001) and precipitation. The forward primers *i.e.* Green15552F (FGTGT C CACA CAAAC TAACT ACCT), Green15579F (CTGCC GTGCC CAACA GAACA) and reward primers i.e. Green16300R (GTCTC GGATT TAGGG GTTTG GCG), Green16087R (CCAGT TTCAC TGAAT CGGCA) were used to obtain the specific nucleotide sequences in the control region mtDNA (Fig. 2). Afterward, the selected sequences were amplified with a PCR machine. The PCR products then were run on the Argarose gels to identify the successful of PCR amplification. Finally, the PCR products were sequenced with an automated sequencer to obtain direct reading of the nucleotide sequences.

Data analysis

The nucleotide sequences were aligned and cut using the computer program CLUSTAL W 1.7 multiple sequence alignment (Thompson *et al.,* 1994). Haplotypes were determined by examining the aligned sequences. Haplotypes were assigned when one or more base changes differed from the consensus or conserved sequence. Haplotype (h) and nucleotide (π) diversities were calculated according to the method described by Nei 1987. Divergences between the two populations were calculated as Gst (based on haplotype frequencies, Hudson *et al.,* 1992), Nst (based on nucleotide sequences, Lynch and Crease, 1990), and Tamura-Nei's genetic distance (DTN, Tamura and Nei, 1993). Nst is similar to Fixation indices (Fst) described in Weir and Cockerham (1984), but uses the Jukes and Cantor (1969) correction. Additionally, the differences in haplotype frequency among populations and the nucleotide divergence among haplotypes are also taken into account in the calculation of Nst (Ramey II, 1995). Gst and Nst values range from 0 to 1, which indicate from non existence of population subdivision to well defined sub population. A chi-square test (Hudson *et al.,* 1992) based on pair-wise comparisons of haplotype frequency data was also conducted to detect genetic differentiation between populations. Geneflow (Nm) between the two populations was estimated from Nst and Gst values by the formula Nm=0.5(1/Nst or Gst-1) (Wright, 1951). Nm can be interpreted as the absolute number of individuals exchanged between populations per generation (Avise, 1994). All calculations were performed by the program DnaSP version 3.99.5 (Rozas and Rozas, 1999) and MEGA version 2.1 (Phylogenetic and molecular evolutionary analyses, Kumar *et al.,* 2001). The nucleotide sites with gaps or missing data were completely excluded from the analysis. All sampling errors were reported as standard error (SE) calculated by the mentioned programs with 1,000 bootstrap replicates (Nei and Kumar, 2000). A chi-square test was conducted to test for a significant genetic divergence between the two populations (Nei, 1987; Hudson *et al.,* 1992).

RESULTS

Diversity

The aligned sequences contained 438 base pairs (bp) with 254 polymorphic sites. There were 8 haplotypes assigned from the 49 green turtles sampled from the Andaman Sea and the Gulf of Thailand (Table 1). The two most dominant haplotypes (B1 and A1) were observed in common in the both waters. The number of haplotypes was higher in the samples from the Gulf of Thailand (7 haplotypes *i.e.*

A1, A2, A3, B1, B3, B4, B5, and B6) than the Andaman Sea (3 haplotypes *i.e.* A1, B1, and B3). The haplotype A2, A3, B4, B5, and B6 were detected only from the Gulf of Thailand, while B3 was edemic to the Andaman Sea.

Overall haplotype diversity (Andaman Sea and Gulf of Thailand combined) for the green turtle nesting populations of Thailand was high (h=0.640; Table 2). However, haplotype and nucleotide diversities in all cases might be slightly less than the actual value since the calculations excluded gaps in the aligned sequences. The Gulf of Thailand had a slightly higher degree of haplotype diversity than the Andaman Sea. On the contrary, nucleotide diversity was higher in the population from the Andaman Sea than the Gulf of Thailand.

Table 1. Distribution of the mtDNA control region haplotypes between the nesting populations of the Andaman Sea and the Gulf of Thailand.

Haplotype	*Andaman*	*Gulf*	*Total*
A1	*8*	*8*	*16*
A2	-	*1*	*1*
A3	-	*1*	*1*
B1	*10*	*15*	*25*
B3	*1*	-	*1*
B4	-	*1*	*1*
B5	-	*1*	*1*
B6	-	*3*	*3*
Total	*19*	*30*	*49*

Divergence and geneflow

Low genetic divergence between the nesting green turtle populations of the Gulf of Thailand and the Andaman Sea was detected in both haplotypic (Gst=0.00311) and nucleotide levels (Nst=0.02838) as well as genetic distance (DTN=0.016±0.003). The estimated female mediated gene flows (Nm) from haplotype and nucleotide data were 161 and 17. This finding implies a lack of population subdivision between the nesting populations of the Andaman Sea and the Gulf of Thailand, and a sufficient degree of gene flow to prevent genetic differentiation between the two populations. The chi-square tests of genetic divergence of both Gst and Nst, revealed no significant differentiation (P>0.05) between the nesting populations of the Gulf of Thailand and the Andaman Sea.

DISCUSSION

Our results indicate that the two nesting green turtle populations from the Gulf of Thailand and the Andaman Sea were well mixed. The present geological boundary (the part of the Southern continent from Thailand to Malaysia peninsula down to Indonesia) seems not to effectively prevent the geneflow between the two populations as observed in invertebrate species (Kittiwattanawong, 1999; Supungul *et al.,* 2000; Kittiwattanawong *et al.,* 2001; Klinbunga *et al.,* 2001 Benzie, 1999; Bussarawit, 2003). However, this finding is not accord with the previous results of satellite tracking that the two nesting populations possessed separated feeding grounds and hence, they may be separated populations (Kittiwattanawong *et al.,* 2003). This contradiction leads us to discuss which of the two findings is the better understanding of the population structure.

First, genetic information may not echo the real time structure due to the high genome conservation, while tracking results reveal a present distribution of green turtle nesting populations. Extremely low genetic divergence rate in sea turtles has been reported in various genetic material levels such as protein (hybridization test, Karl *et al.,* 1995), chromosome (banding pattern, Bickham, 1981), Single-copy nuclear DNAs (Karl *et al.,* 1992), and microsatellite loci (Fitzsimmons et al., 1995). In addition, mtDNA evolution in turtles proceeds at a several-fold lower rate than "conventional" vertebrate pace (Avise et al., 1992; Bowen *et al.,* 1996). Such evidences suggest that a large part of genetic information has been remaining the same since the founding of the two populations from a common ancestor.

A limitation of our study is, however, the small sample size of the tracking. Only 11(Khram Island) and 9 (Huyong Island) turtles were tracked although we believe the sample size was appropriate considering the nesting population size at Khram Island (<100 nesters per year, Monanunsap and Charuchinda, 1994) and Huyong Island (12 individuals per year). In addition, the period of tracking period may be too short (9-126 days, Kittiwattanawong *et al.,* 2003) compared to the life span of the sea turtles (60 years, Seminoff, 2002). This suggests that the tracked turtles might do not stay at the same feeding ground, but wander to the wider range than we expect. Incorporate of this factor with a long range migratory ability may break down the barrier and hence leading to a mixing of the populations. Lastly, the sea level fluctuation may support the genetic-based finding. Geneflow between the two populations can occur by migration across seaways (via stepping stone mechanisms along nesting and feeding grounds or directly via long migratory pattern) in-betweens Malaysia peninsula-Sumatra, Sumatra-Java. These seaways have been closed and widen up over the time scale due to sea level fluctuation (Geyh *et al.,* 1979). Figure 3a shows that there were two periods that sea level were higher than the present during the past 140,000 years (Potts, 1983). High sea level would widen the Strait of Malacca, seaways in between Sumatra-Java, and consequently allowed higher geneflow of these two populations (Fig. 3c). In contrast, lower sea level would narrow the seaways or even closed them (Fig. 3b).

The present high sea level which started about 4,000 years ago may maximize the geneflow and cause a low genetic divergence (Fig. 2b, c, and d). This rise and fall of sea level may make two populations one non-differentiated population.

Table 2. Haplotype diversity (*h*), Nucleotide diversity (π), number of polymorphic nucleotide, and average number of nucleotide difference for the green turtle nesting populations from the Andaman Sea and the Gulf of Thailand. Diversity indices were calculated by DnaSp ver.3.99.5 (Rozas and Rozas 1999) and MEGA ver 2.1 (Kumar et al. 2001).

	Andaman	Gulf	Overall
Haplotypes diversity (*h*)	0.573 ±0.014	0.678±0.016	0.640±0.011
Nucleotide diversity (π)	0.294±0.068	0.264±0.008	0.272±0.005
No of polymorphic nucleotide	251	254	254
Average No of nucleotide difference	129	116	119

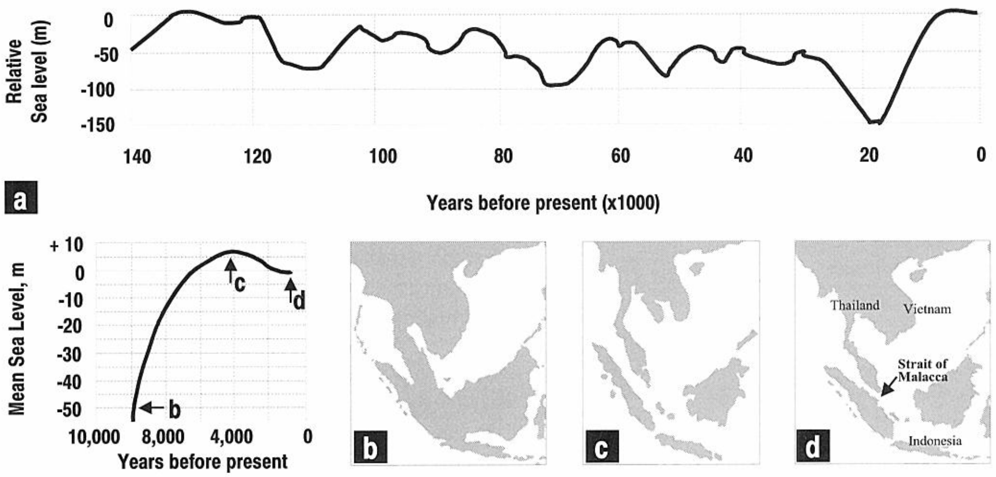

Fig. 3. a) Sea level fluctuation over the past 140,000 years ago (Potts 1983). b), c) and d) Sea levels and topographies of SPouth East Asia during 8000, 4000 years ago and at present, respectively (modified from Lekagul and McNeely 1977; Geyh et al. 1979).

ACKNOWLEDGEMENTS

Without the direct and indirect supports from the following people, this paper would never been accomplished. I thank to Professor Wataru Sakamoto, Dr. Nobuaki Arai, Caption Winai Klom-In, the staffs of Royal Thai Navy, the staffs of Marine Endangered Species Unit, Phuket Marine Biological Center.

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Satellite tracking of female green turtles *Chelonia mydas* at Ma'Daerah Turtle Sanctuary, Malaysia

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ABSTRACT
Two KiwiSAT 101 satellite transmitters were deployed in July 2003 on female green turtle (*Chelonia mydas*) for the purpose of understanding their inter-nesting migration. The study was conducted at Ma' Daerah Turtle sanctuary in Kertih, Terengganu, Malaysia. The data received were analysed and plotted on to a digital map to estimate the travel points and distance travelled. The turtles roamed the water in the vicinity of nesting site and rarely travelled far during the nesting season. The furthest distant travelled to the sea (East) is approximately 42.4 km, to the South 44.4 km and to the north 7.8 km. Percentage of GPS location near (5-12 nm) nesting shore was 83.3% and far (>12 nm) was 16.7%. From this study, it is suggested that the strict/compulsory conservation boundary within the selected nesting site should be between 0-12 nm and additional 45 km for the outer boundary.

KEYWORDS: KiwiSAT, female green turtle, Terengganu

INTRODUCTION

The decline of sea turtles population is still a result achieved from a long term struggle to conserve it (Mortimer, 1990). Breeding adults were killed in incidental catch by fisherman or hit by speeding boats Mortimer (1990). Tisen and Bali (2000) found out that the inter-nesting resting areas lies within a kilometre from mainland where illegal trawling took place resulting in multiple incidental catch of turtles.

Studies on turtle migration has been done by numerous researchers for example Shiba et al. (2002) and Ibrahim *et al.* (2002). PTT transmitter was used as the main turtle locator and deployed on several female and male turtles to get the location of each and every turtles released. Arai and Ono (2000) stated the positive and negative side of using these platform terminal transmitters (PTT) as the data produced relied on several uplinks from the PTT before a good positioning of the turtle can be achieved. Previous studies showed that from all the data received from ARGOS, the satellite operators more than 50% were with minimum uplink i.e. one uplink giving no location of the turtle. However for the time being, this is the best method for collecting location data from released sea turtles.

A study was carried out by TUMEC (Turtle and Marine Ecosystem Centre, Malaysia) using PTT transmitter to determined the pre and post nesting of green turtle at Ma' Daerah turtle Sanctuary, Terengganu Malaysia. This study was in conjuction with an education program run by TUMEC for an A level Matriculation students of Yayasan Satu Matriculation College. As a show of support to the turtle conservation activity the college students help raised some fund to purchase a PTT and satellite transmission services. The sum of money raised was RM 15,000.00. The PTT was then attached to a female green turtle and released by the deputy minister of education who officiate the opening of the program.

Recent study by Ibrahim *et al.* (2000) showed that the maximum radial distance from the nesting site travelled by a turtle during interesting period was 14.3 km. The speed of swimming was between 0.05 km/hour to 11.70 km/hour. The turtle were observed to stay offshore of her nesting site before completing her nesting activities. Bali *et al.* (2000) reported that it took 45 days post-nesting for a female turtle to swim a distance of 1506 km with average speed of 35 km/day.

Determination of nesting and inter-nesting area was also carried out using normal tagging fin data to see the degree of site fidelity. Tagging data of different nesting site along the coast of Terengganu were collected and compared. Proper fin tagging will last to as long as more than ten years and improper tagging and data recording will expedite the tag loss. Now, in Malaysia, the main and most reliable tagging is using fin clip tag. Tagging activities in Terengganu were done by the Department of fisheries staff. Turtles observed during nesting activities were tag and recorded.

Observation on leatherback turtles showed that nesting site changes from one to different site following tidal current. In 2003 during leatherback nesting season a turtle was observed to nest at three different sites which were separated by at least 20 km (Pers. comm., fisheries assistant). The distance between nesting sites and the degree of site fidelity of a female green turtle has to be determined as this may affect the nesting protection zone and protection activities. For the purpose of understanding the behaviour of sea turtle during nesting and inter-nesting, a study was carried out using PTT satellite tracking and analysis of fin tags. The result can then be converted into actions for example proper monitoring, surveillance and protection.

Objective of this study

1. determine pre, post nesting position, the site fidelity and other possible nesting site using tag record and PTT data.of green turtle from Ma' Daerah.
2. determine problems from using PTT and fin tagging for sea turtle study.

MATERIALS AND METHODS

Platform transmitter terminal (PTT)

Two PTT with serial number 38619 and 38620 were used to tag two female green turtles at Ma' Daerah, Terengganu. The PTT 38619 was tag to a female with fin tag number MY1615/MY1660 on the 6th of July 2003 and laid her eggs for the last time on the 20th July 2003. The second PTT tag (38620) was attached to a female green turtle with fin tag number MY 1005/1016.

The data from ARGOS were relayed from Dr Nobuaki ARAI from the Kyoto University, Japan through e-mail transmission. Data from 38619 were received starting 29th June 2003 until the 12th September 2003. The data transmission for 38620 were received between 7th August and 8th August 2003 for only two days.

The data received then got transferred to Excel program for analysis and sorting. This then got transferred to SURFER 6 program for plotting. The data were separated into three categories; a) all seaward data, b) LC's 1, 2 and 3 and c) all LC's 3 data. For plotting purposes also, all close up data and overlapping data were erased from the map.

A base map was created by scanning a section from British Admiralty chart 3543. The map was than overlaid with the position map using SURFER 6 program.

Tag data

Tag data from two different sites were compared to see the nesting site fidelity of the green turtle. The tag data was collected from Ma'Daerah and Cherating.

RESULTS

PTT Tagging

Data from PTT tagging were received from ARGOS via Kyoto University (Dr Nobuaki Arai) since 29 June 2003. After processing the data and using only the data with Location Class of 1, 2 and 3 a total of 34 data were used for 38619 turtle and 10 for 38620 turtle. All the data used were from August PTT transmission.

Positions which were on the mainland during the testing of the PTT were erased and selected positions plotted (Fig. 1).

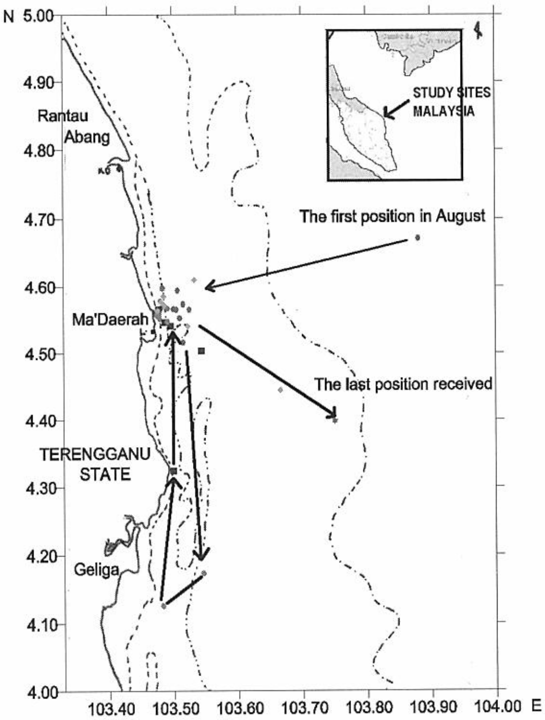

Fig. 1 Travel positions of the PTT38619 green turtle tag at Ma'Daerah Turtle Sanctuary

The LC3 data for PTT 38619 plotted showing the movement of the turtles (Fig. 2).

Data plotted for PTT 38620 showing the movement of the second female turtles (Fig. 3). Movement from the lowest position to the second position took 3 hours, 2 to 3 took 12 hours, 3 to 4 took 2 hours and 4-5 took 20 minutes

Location class percentages for PTT 38619 from 155 data were as Table 1.

Table 1: a) Percentages of Location class for PTT 38619, 38620

38619		
LC categories	No	%
LC3	57	36.8
LC2	16	10.3
LC1	15	9.7
Not good	67	43.2
Total	155	100
38620		
LC categories	No	%
LC2	1	8.33
LC1	2	16.67
LC0	2	16.67
LCA	4	33.33
LCB	3	25.00
Total	12	100

Fin Tag

Fin tag data for the year 2003 were collected from 2 sites, Ma' Daerah and Cherating Pahang. The data were analysed for number of nesting and major nesting site for each turtle base on the number of nesting recorded. From the tag data observed on females nesting at the study sites, both female with PTT tag did not land to nest at neither Ma' Daerah nor at Cherating. PTT location nearest to shore may indicate the female roaming the area but not landing to nest.

DISCUSSION

Tagging system

Observation in July and August showed that the data from PTT-ARGOS satellite system on turtle tracking was unreliable. After two months of deployment, most of the data received were within low quality location class. More than 155 dataset were received from the ARGOS satellite transmission but after selecting data set with proper positioning, a total of 155 dataset were used in this study which were from 1st to 31st August 2003. The best location class LC3 were 57 data set (36.8%), LC2 16 data set (10.3%) and LC1 15 (9.7%). The rest 43.2% were of LC0,LCA, LCB and LCZ. Overall approximately only 30% of the data were usable. When reflecting to the cost spent, this tagging system should be improved to increase the cost effectiveness of the money utilized.

The problem with this type of PTT were experienced during mounting and starting of the PTT. The PTT used did not respond, as it should in the manuals. It did not blink ten times during starting and the transmission detector did not give out the transmission beep at the same time. Due to this problem, the transmitter were dismount and remount twice for PTT 38619 and unluckily most of the LC3 data received were during the dismounting of the PTT in most the days in July 2003. The PTT 38620 was deployed and started but did not transmit properly giving only 8 good LC in August and was never heard since.

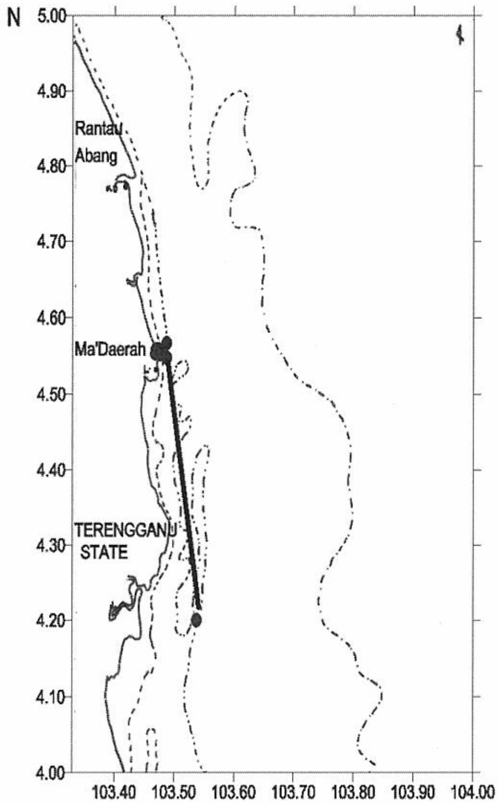

Fig. 2 The LC3 for the PTT38619 green turtle and the last position was approximately 40 km south from the nesting site at Ma'Daerah

Comparing the data from the PTT and inconel tag recorded from female turtle nesting no PTT attached females came up to the beach to nest in August at Ma' Daerah turtle sanctuary. Although most of the PTT's position were near the nesting site the turtle might probably just roaming the area before departing. From the inconel tag data, during the nesting season of Ma' Daerah from 31/3 to 28/9/2003, the PTT 38619 turtle had nested for seven times whereas the PTT 38620 turtle had nested only 3 times. But both did not come up to nest in August 2003.

PTT 38619 turtle started to nest on the 20th of May, 2nd June, 12th June, 21st June, 1st July, 11th July and 20th July. She laid her eggs seven to ten days apart from each nesting days. The last recorded nesting activity was on the 20th of July 2003. Due to problems in the starting of PTT the tag was not on any turtle until the 6th of July. When the location for this turtle was plotted, she was about to leave the nesting ground to the south (Fig. 1). This might indicate the probability of the southern part of peninsular was its grazing area.

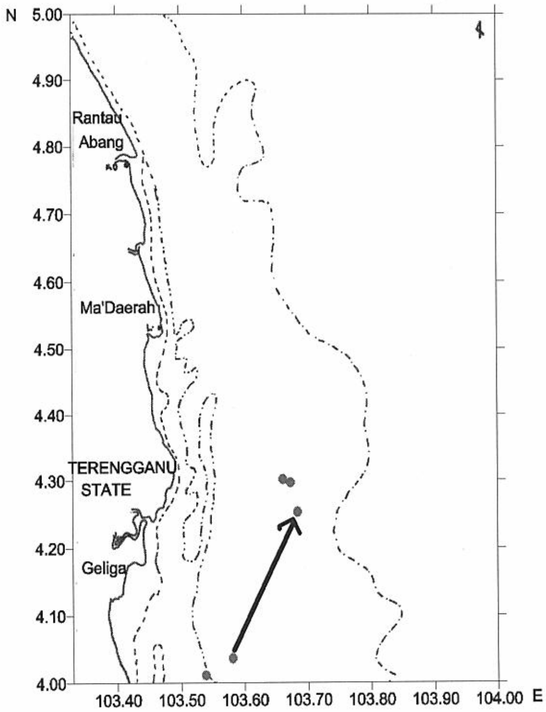

Fig. 3 Positions of PTT 38620 green turtle showing northward movement. These were position on the 7th and 8th of August 2003

PTT 38620 turtle started to nest on the 6th July, 17th July and 28th July. She only laid her eggs in July and the duration between her nesting days were eleven days. Unfortunately there were only twelve data received from this turtle. When the data were plotted, all locations indicated that the turtle was going northward from most probably Cherating, in the state of Pahang (Fig. 3). But landing was not recorded either in Cherating area or somewhere else in Pahang. These position showed that the turtles swam a far distance after nesting activities for an unknown reasons.

Nesting versus PTT observation

PTT positions were useful in detecting the movement of sea turtles but fin tag data was needed for confirmation of the turtle activities. Although the turtle were located near the nesting beach, it was confirmed that no nesting activities happened. The study also showed that there were no typical pre and post nesting activities for some of the turtles. Some might still be around the nesting sites for a duration of time before swimming away and some might swim away after a few nesting activities and the distance covered was quite far. The inconel fin tag on sea turtle was accepted by many as the tagging method of sea turtle but in some instances these tag did not last long as observation showed that there was three tag replacement for a single turtle occur at Ma' Daerah. Human errors might be one of the factors as improper tagging resulted in tag lost. Snagging, fish bite and severed limb can also cause the turtle to loose its tag.

Summary/Suggestion

1.Development of new system of tracking system which can give better and reliable position should be developed.
2.System developed must also be cost effective.
3.Standardization of tagging method should be carried out.
4.Tag loss condition should be thoroughly examined.

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Satellite tracking of immature loggerhead turtles in the Northwestern Pacific

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ABSTRACT

Five subadult loggerhead turtles (*Caretta caretta*) captured in the northwestern Pacific in 2002 and 2003 were tracked by satellite telemetry. Two juvenile loggerheads in age of 1+ and 2+ hatched and kept in an Aquarium were also tracked by satellite telemetry in the northwestern Pacific. Five subadult turtles moved at the average speeds of 1.1 to 2.1 km/h with the total distance ranged from approximately 2,200 to 8,800 km during total tracking of 132 to 186 days. The average speeds of 2 juvenile turtles were 2.1 and 1.0 km/h with the total distance of approximately 4,300 and 3,800 km during total tracking of 85 and 156 days, respectively. All subadult turtles moved rapidly the long distance along the Kuroshio Current and its extension and stayed in warm water mass for a long time. The warm water mass might be important feeding grounds of subadult loggerhead turtles. On the other hand, juvenile turtles migrated to higher latitudes than subadult turtles. The difference between subadult and juvenile turtles might result from the difference of feeding grounds by growth stage, body size, ability to swim, or individual career history of turtles.

KEYWORDS: loggerhead sea turtle, satellite tracking, migration, subadult, immature

INTRODUCTION

Sea turtles are widely distributed in tropical and subtropical waters in the world. Recently, incidental take of sea turtles by longline fisheries was noticed (Brogan, 2002). The Fisheries Research Agency of Japan attempts to develop mitigation measures for incidental take of sea turtles in tuna longline fisheries through research activities. In addition to management of incidental take of sea turtles, we have also worked on conservation of sea turtles on the nesting beach and studied ecology, nesting behavior, oceanic distribution and feeding ecology, of sea turtles, particularly loggerhead turtles (*Caretta caretta*). It is very important to make clear the oceanic distribution and migration route of loggerhead turtles for the conservation and management. Although many studies have been conducted on the movements of post-nesting female loggerheads (Japan Fisheries Resource Conservation Association, 1999; Hatase *et al.,* 2002), there is little information on the movements of immature turtles in the ocean. In this study, subadult loggerhead turtles captured in the northwestern Pacific and juvenile loggerheads hatched and kept in an aquarium were tracked by satellite telemetry.

MATERIALS AND METHODS

Two subadult loggerhead turtles (SCL: 62 and 65 cm) captured in the northwestern Pacific on May to June in 2002 and 3 subadult turtles (SCL: 64, 64 and 70 cm) in the same period and same area in 2003 were captured through longline operations by research vessels, Taikeimaru No. 2 and Kurosaki. These turtles were tracked by satellite telemetry in the northwestern Pacific. Two juvenile loggerheads in age of 1+ and 2+ (SCL: 40 and 53 cm) hatched and kept in the Port of Nagoya Public Aquarium were also tracked by satellite telemetry in the northwestern Pacific to compare with the behavior of subadult turtles. The satellite transmitters, Teronics model ST-6, ST-18 or Wildlife model SDR-T16, were attached to all turtles. Total distances, average daily distances and average speeds of all turtles were estimated by their movements between the average daily positions. The relationship between movements of turtles and two measures of oceanic conditions, oceanic flow and sea surface temperature which are data from the Japan Meteorological Agency and the Naval Research Laboratory, US Navy were examined. The frequency distribution of time spent in depth classes recorded by transmitters of 2 subadult and 1 juvenile loggerheads in 2002 were also examined.

RESULTS AND DISCUSSION

The results of satellite tracking of 5 subadult and 2 juvenile turtles are shown in Table1. The results of 2 subadults are May to the end of October 2003, but we keep tracking them at the time of writing. During total tracking of 132 to 186 days, 5 subadult turtles moved at average speeds of 1.1 to 2.1 km/h (Table 1). The total distance ranged from approximately 2,200 to 8,800 km (Table 1). On the other hand, the average speeds of 2 juvenile turtles were 2.1 and 1.0 km/h with the total distance of approximately 4,300 and 3,800 km during total tracking of 85 and 156 days, respectively (Table 1). Therefore, average daily speeds of juvenile turtles were similar to that of subadults.

The movements of 5 subadult turtles released in 2002 and 2003 are shown in Figures 1 and 2. These turtles stayed in small areas for a long time and moved rapidly a long distance to the north or east (Figs. 1, 2). On the other hand, the movements of 2 juveniles hatched and kept in the aquarium are shown in Figure 3. These juvenile turtles moved to the east and north and rarely stayed in a small area for a long time (Fig. 3). In the northwestern Pacific, the Kuroshio Current and its extension flow to the east and in some areas, there are warm water mass associated with the Kuroshio extension. Our results suggest that the 5 subadult turtles moved rapidly over long distances along the oceanic flow and stayed in the warm water mass for a long time (Fig. 4). Turtles remained in waters between about 17 to 23 degrees of sea surface temperature. Two juvenile turtles moved to the east and north as the sea surface temperature increased. This suggests that the movements of juvenile turtles were related to sea surface temperature rather than the flow of sea water. Juvenile turtles moved at lower temperature than subadults.

Subadult turtles stayed on warm water mass for a long time and moved to east around 35°N, while juvenile turtles migrated at higher latitudes, around 38 and 42°N, than subadult turtles (Figs. 2 and 3). The frequency distributions of depth recorded by transmitters in 2002 are shown in Figure 5 for 2 subadults and 1 juvenile. Although subadult turtles dived frequently over 26 m, juvenile stayed near the sea surface (Fig. 5). These results suggest that behavior of juvenile turtles was affected by sea surface temperature and there were differences in feeding habits between subadult and juvenile turtles.

CONCLUSION

The subadult turtles moved eastward along the flow of the Kuroshio extension and remained on warm water masses for a long time, and dived deep. In contrast, juvenile turtles moved to north and east depending on sea surface temperature and stayed at the sea surface. Our results suggest that the warm water mass which is an area of high productivity is a feeding ground for subadult loggerhead turtles. The difference between subadult and juvenile turtles might result from the difference of feeding grounds by growth stage, body size, ability to swim, or individual career history (wild or captive).

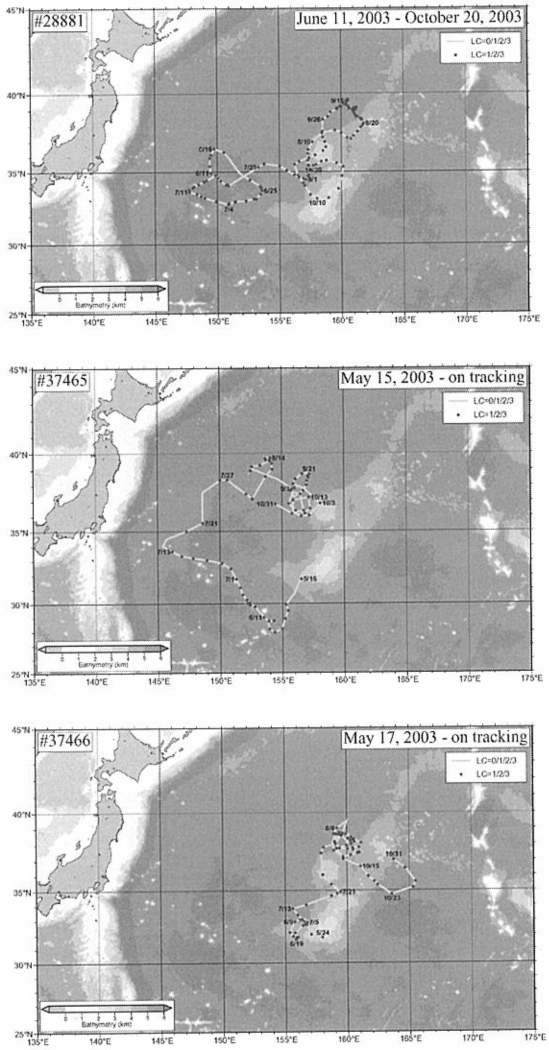

Fig. 1. Satellite tracking of 3 subadult loggerhead turtles (ID: 28881, 37465 and 37466) in 2003 (Estimated accuracy in latitude and longitude; Line: > 1 km, Dot: < 1 km).

Table 1. Movements of subadult and juvenile loggerhead turtles by satellite telemetry.

ID No.	Growth Stage	SCL (cm)	Body Weight (kg)	Tracking Date	Tracking Period (day)	Total Distance (km)	Ave. Daily Dis. (means±S.D. km)	Ave. Speed (means±S.D./km)
ID 07829	Subadult (wild)	62	43	29 May 02 - 30 Nov.	186	6536.3	35.3±25.9	1.5 ± 1.1
ID 07811	Subadult (wild)	65	41	14 Jun. 02 - 8 Dec.	178	8790.6	49.7±30.1	2.1 ± 1.3
ID 28881	Subadult (wild)	70	57.5	11 Jun. 03 - 20 Oct.	132	4920.7	37.6±25.6	1.6 ± 1.1
ID 37465	Subadult (wild)	64	46.5	16 May 03 - 31 Oct. (Continue)	169	2752.5	32.8±20.8	1.4 ± 0.9
ID 37466	Subadult (wild)	64	43.5	18 May 03 - 30 Nov. (Continue)	167	2177.0	26.2±18.5	1.1 ± 0.8
ID 07800	Juvenile (1+) (Captive)	39.7	8.7	29 May 02 - 21 Aug.	85	4275.3	50.9±36.8	2.1 ± 1.5
ID 27975	Juvenile (2+) (Captive)	53	19.8	8 Jun. 02 - 10 Nov.	156	3830.9	24.7±22.6	1.0 ± 0.9

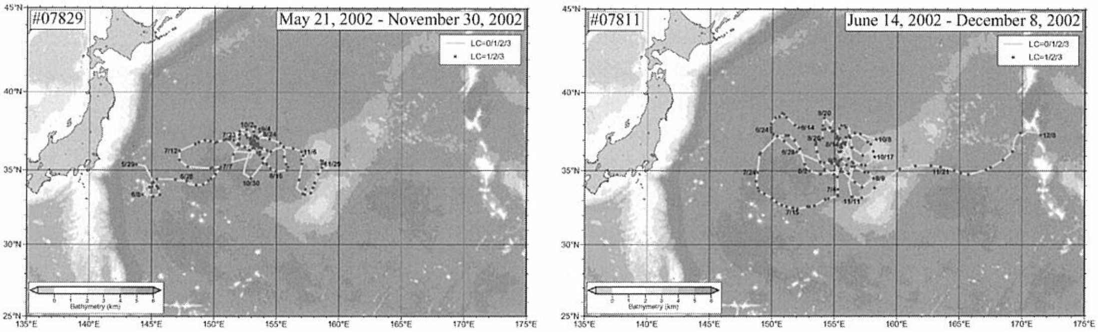

Fig. 2. Satellite tracking of 2 subadult loggerhead turtles (ID: 07829 and 07811) in 2002 (Estimated accuracy in latitude and longitude; Line: > 1 km, Dot: < 1 km).

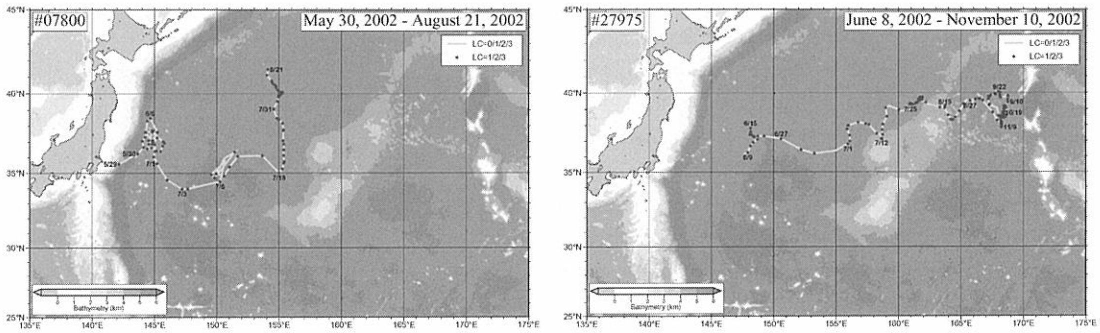

Fig. 3. Satellite tracking of 2 juvenile loggerhead turtles (ID: 07800 and 27975) in 2002 (Estimated accuracy in latitude and longitude; > 1 km, Dot: < 1 km).

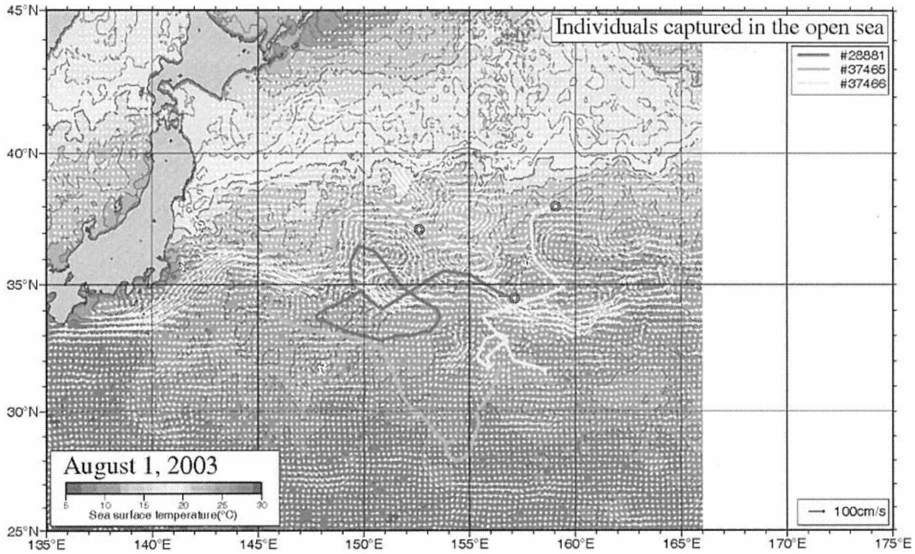

Fig. 4. Relationship between movements of 3 subadult turtles (ID: 28881, 37465 and 37466) and two measures of oceanic conditions, oceanic flow and sea surface temperature on August 1, 2003. Data of oceanic conditions were presented from the Japan Meteorological Agency.

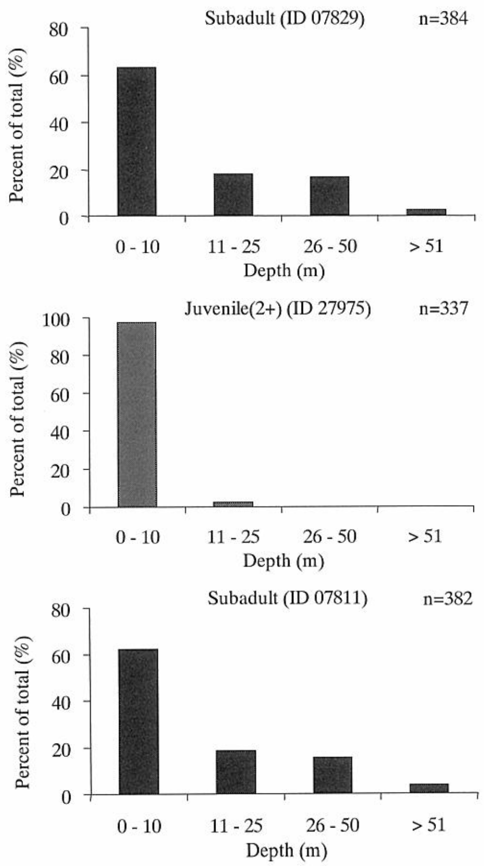

Fig. 5. Frequency distributions of depth for 2 subadult (ID: 07829 and 07811) and 1 juvenile (ID: 27975) loggerhead turtles in 2002.

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Oceanic migration of post-nesting loggerhead sea turtles (*Caretta caretta*) in the northwestern North Pacific tracked by satellite telemetry

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ABSTRACT

Two post-nesting loggerhead turtles which nested at Omaezaki beach, Japan were tracked during 2002 and 2003 in the northwestern North Pacific by satellite telemetry. The first loggerhead was tracked for 265 days from 29 July 2002 to 19 April 2003 with total distance of approximately 9,800 km. The turtle traveled eastward from the Pacific coast of Honshu to offshore after staying near its nesting site for a week. Then it remained in the offshore area around 36-37°N and 155-158°E from the end of September to the middle of November. In late November, the turtle moved eastward again, and turned to the south when it reached 170°E in the middle of December. Finally, it turned westward in February. Tracking of the second loggerhead tagged in 2003 is still in progress, although this loggerhead was released in a subsequent year, its tracks were similar to the first turtle. The relationship between movements of the turtles and oceanographic conditions (sea surface temperature and sea surface currents) were examined. Movement tracks of these turtles correlated with the Kuroshio Extension Current and seasonal changes of temperature in the Transition Region. The Transition Region is known as a highly productive area and may provide an important feeding ground for post-nesting loggerhead turtles.

KEYWORDS: post-nesting loggerhead turtle, satellite telemetry, oceanographic conditions

INTRODUCTION

Loggerhead sea turtles (*Caretta caretta*) are believed to travel great distances during their lives. In the North Pacific, nesting beaches of the loggerhead turtle are located almost exclusively along the middle and southern coast of Japan. Hatchling loggerheads disperses from beaches into the ocean. These juveniles grown to subadults in the eastern North Pacific have been confirmed using genetic analyses (Bowen *et al.,* 1995). Upon reaching adulthood, loggerheads migrate from the oceanic feeding area to nesting beaches in Japan. A portion of the post-nesting loggerhead population migrates for feeding to the East China Sea as documented by tagging-recapture methods (Kamezaki *et al.,* 1997). However, distribution patterns and migration routes of post-nesting loggerhead sea turtles are not well known. The study of migration routes for loggerhead sea turtles is important to demonstrate the seasonal changes in their distribution and feeding grounds.

In the present study, we investigated oceanic migration of post-nesting females by satellite tracking.

In addition, we examined the correlation between their migration routes and oceanographic conditions, sea surface temperature and sea surface currents.

MATERIALS AND METHODS

On 29 July 2002 and 18 July 2003, satellite transmitter (ST-6 and 18, Telonics Inc.) was deployed on two loggerhead turtles at Omaezaki beach, Shizuoka Prefecture, Japan referred to below as No. 1 and No. 2, respectively (Fig. 1). Satellite transmitters were attached with epoxy resin to

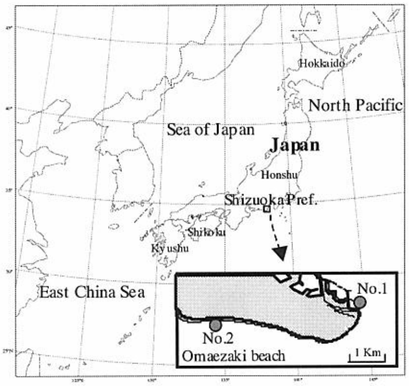

Fig. 1 Location of Omaezaki beach, Shizuoka Pref., Japan. Circles show the location of released points of turtles to the sea.

the carapace of each individual after they nested, and then released to the sea. Their straight carapace length (SCL) was measured with calipers to the nearest 1 cm, and their SCL were 75 and 82 cm, respectively. Tracking of No. 1 finished on 19 April 2003. Tracking of No.2 is still in progress, and here we use the data through October 2003 (Table 1). The loggerhead turtles were tracked using the Argos system, and locations with classes 3, 2, 1, 0, A and B accuracy were used to track. The daily travel distance was defined as the minimum straight line distance between daily mean positions on the sea surface. We used data from the Japan Meteorological Agency for examining the relationship between migration routes of turtles and oceanographic conditions, sea surface temperature and sea surface currents.

Table 1 Information on two loggerheads tracked by transmitter

Name	Strait Carapace length	Number of eggs	Deployment date	Date of last transmission	Duration of tracking days
No.1	75 cm	118	29 July 2002	19 April 2003	265
No.2	82 cm	100	18 July 2003	Continuing	75

RESULTS

Total travel distances of No. 1 and No. 2 were 9,787 and 4,535 km, and daily mean travel distances were 36.9 and 42.0 km, respectively. Maximum daily movement was approximately 200 km. Daily travel distance of each turtle consisted of repeated intervals of long and short distances (Fig. 2). From summer through autumn, both turtles displayed this pattern but after autumn, the movement distances of No. 1 gradually shortened. Although they were released in different years, their tracks were very similar (Fig. 3). We examined the relationship between oceanographic conditions and movement tracks of the turtle. The turtles remained in the area of the nesting site after they were released to the sea and then moved eastward from the Pacific coast of Honshu to offshore. The periods of eastward and offshore movement corresponded to the periods of long daily movement distances which for No. 1 was from mid to late-August, and for No. 2 was from

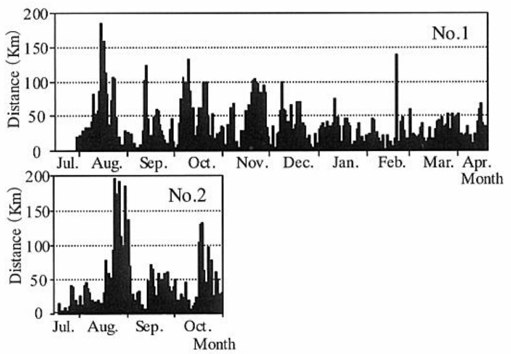

Fig. 2 Changes in daily movement distances of turtle No. 1 and No. 2 calculated by daily average position.

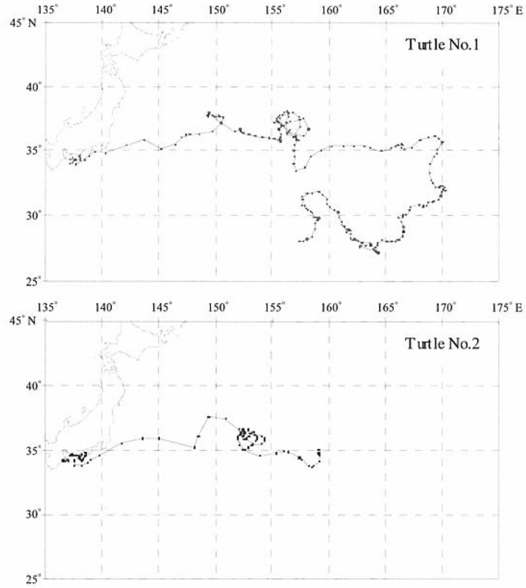

Fig. 3 Complete track lines of two post-nesting loggerhead turtles. The plot shows the daily position of each turtle.

mid-August to early-September (Fig. 2). At that time, the tracks of both turtles followed the Kuroshio Extension Current (Fig. 4). Afterward No.2 remained in the area around 35-36°N and 152-154°E north of the Kuroshio Extension Current where the sea surface temperature was approximately 23 (Fig. 5). Subsequently they moved eastward again, and No. 1 turned to south in the Transition Region around the 170°E (Fig. 6). Finally, it turned westward in the area of the North Equatorial Current with westward direction and weak flow (Fig. 7). Both turtles always remained within the southern part of the Transition Region where the temperature was from 17 to 23°C approximately rather than in the Subarctic and Subtropic Regions.

DISCUSSION

The loggerhead turtles released in Omaezaki migrated toward the northwestern North Pacific, and they remained for some time in this region. This indicates that after nesting on beaches in Japan, some post-nesting loggerheads migrate to the northwestern North Pacific, not to the East China Sea. Hatase *et al.* (2002) has shown using stable isotope analyses and satellite telemetry that larger females come from the East China Sea to the nesting beaches in Japan, and smaller females come from the North Pacific. However, it is not clear whether the turtles we tagged (75 and 82 cm SCL) would be considered large or small according to Hatase et al. (2002). Therefore, it is necessary to investigate the migration routes of post-nesting females of various sizes using the satellite telemetry.

In the present study, turtle's daily movement distances were repeatedly long and short. These movement patterns probably related to the speed of flow in the

Kuroshio Extension Current and North Equatorial Current. When No. 1 moved southward from autumn to winter, it probably reflected a change in the location of the southward of Transition Region associated with a decline in sea surface temperature. It is suggested that oceanic movements of post-nesting females were affected by the currents and seasonal changes in sea surface temperature in the southern part of the Transition Region. The Transition Region is known as a highly productive area, and is used by many pelagic fishes and squids as a feeding ground. Our findings suggest that this region may also provide important habitat for post-nesting loggerhead sea turtles.

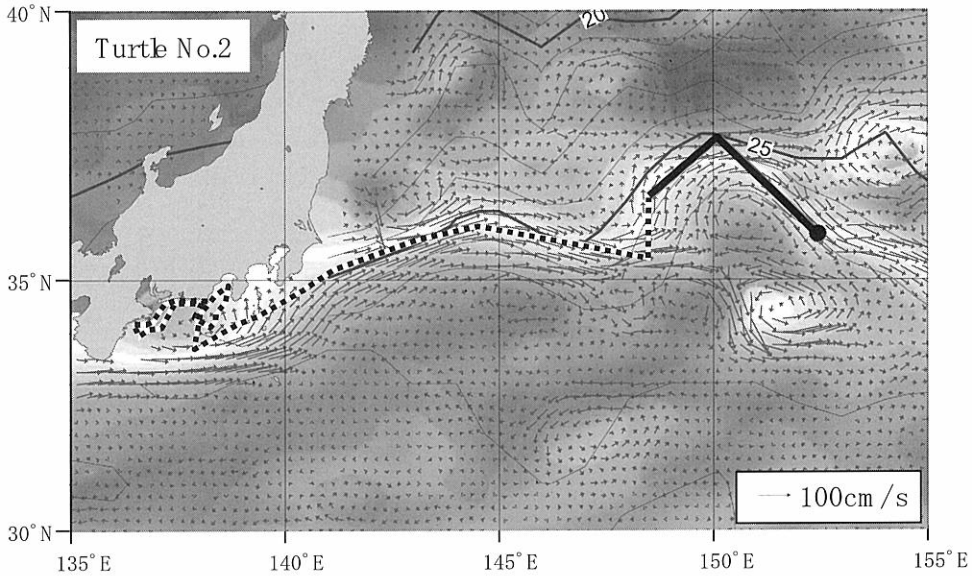

Fig. 4 Relationship between movement track of turtle No. 2 (solid line) and oceanographic conditions (sea surface temperature and sea surface current) from 29 August to 2 September 2003. The dashed line shows the track from 18 July to 28 August 2003.

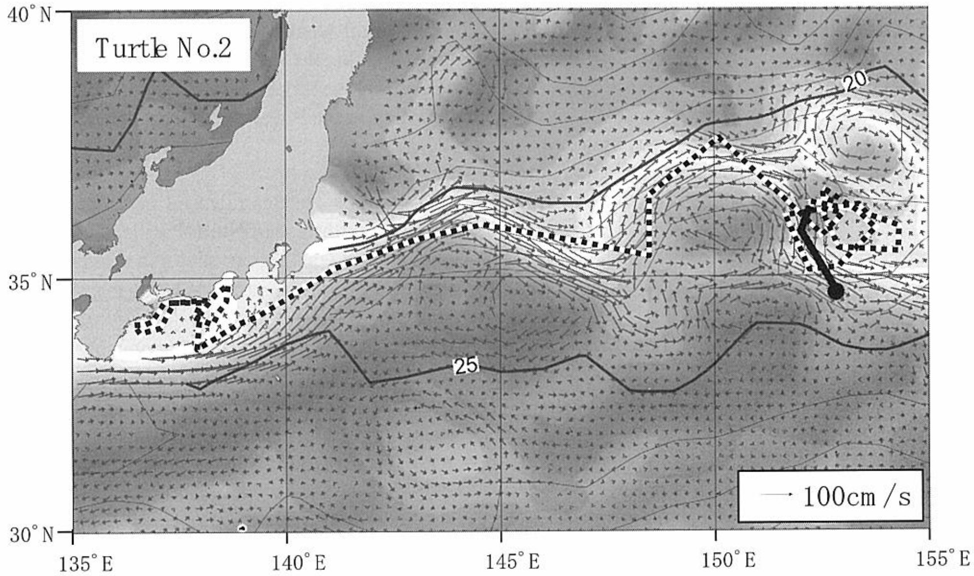

Fig. 5 Relationship between movement track of turtle No. 2 (solid line) and oceanographic conditions (sea surface temperature and sea surface current) from 13 to 17 October 2003. The dashed line shows the track from 18 July to 12 October 2003.

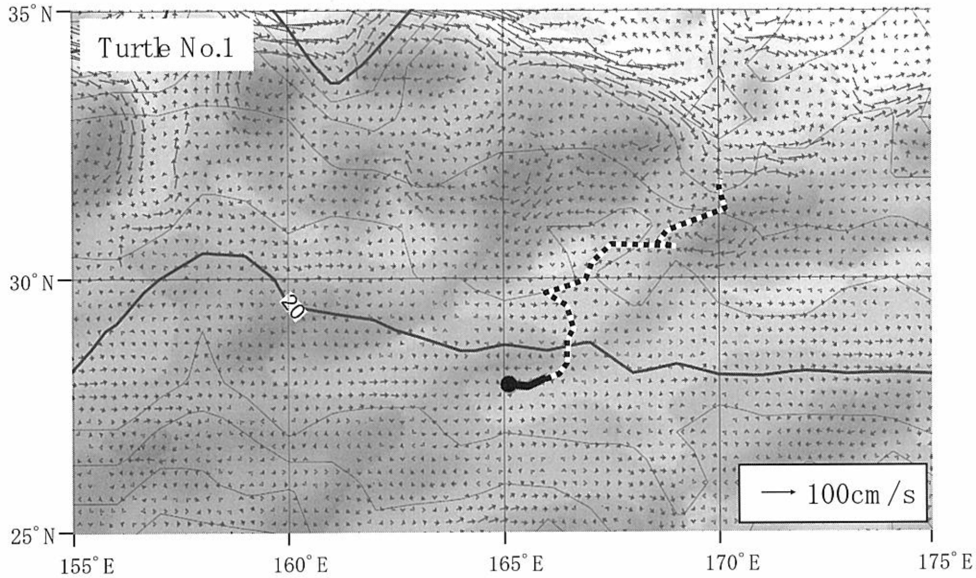

Fig. 6 Relationship between movement track of turtle No.1 (solid line) and oceanographic conditions (sea surface temperature and sea surface current) from 31 January to 4 February 2003. Dashed line shows the track from 1 to 30 January 2003.

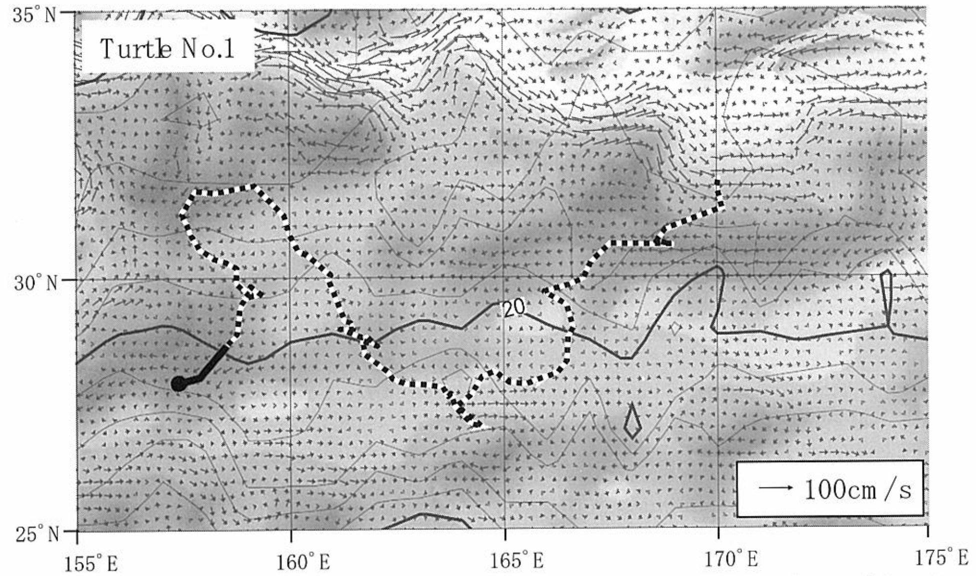

Fig. 7 Relationship between movement track of turtle No.1 (solid line) and oceanographic conditions (sea surface temperature and sea surface current) from 16 to 20 April 2003. Dashed line shows the track from 1 January to 15 April 2003.

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The conservation and management activities for sea turtles in Japan

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ABSTRACT
Five species of sea turtles are found in Japan. These are the loggerhead turtle, green turtle, hawksbill turtle, leatherback turtle and olive ridley turtle. The loggerhead, green and hawksbill turtle nest in Japan while the leatherback and olive ridley only inhabit the waters of Japan. Conservation of sea turtles in Japan by NGOs became popular in the late 1980s and the Government of Japan also got involved in the conservation and management of sea turtles. Conservation and research activities on sea turtles including monitoring of nesting sites, egg transplant, tagging by flipper tags, passive integrated transponders, and platform terminal transmitters, monitoring of sea turtle by-catch by tuna longline fishery, studies on mitigating sea turtle by-catch, and education campaigns regarding sea turtle conservation. These are conducted by NGOs, the Fisheries Agency, the Fisheries Research Agency, and the academe.

KEYWORDS: **sea turtles, loggerhead turtle, green turtle, hawksbill turtle, leatherback turtle, olive ridley turtle, conservation, management, Japan**

INTRODUCTION

Sea turtles are very familiar to the Japanese through legends and old tales from ancient times. The eggs and meat of sea turtles are consumed in Japan even today. Tortoiseshell of hawksbill turtles (bekko) has been used since the Edo era (about 300 years ago) and the tradition of high-grade skill of carving was established. However, many fishermen release unintentionally captured sea turtles with a tradition of sprinkling liquor as a welcome ceremony to the god of happiness.

Due to the decline of sea turtle nesting, conservation of sea turtles by non-government organizations (NGOs) became popular in the late 1980s. Conservation activities by NGOs include monitoring of nesting sea turtle beaches and sea turtle egg protection. The government of Japan also became involved in the conservation and management of sea turtles and promoted several conservation programs, which complemented the NGOs sea turtle conservation activities.

Sea Turtle Distribution

Five species of sea turtles are found in Japanese waters, the loggerhead turtle (*Caretta caretta*), green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), leatherback turtle (*Dermochelys coriacea*), and the olive ridley turtle (*Lepidochelys olivacea*). The loggerhead turtle, green turtle, and hawksbill turtle nest in Japan while the leatherback and olive ridley turtle only inhabit the waters of Japan.

Assessments of loggerhead nestings at major beaches in Japan, such as Yakushima Is. and Miyazaki, have been much conducted since the mid-1980s. The number of nesting increased in the late-1980s, then decreased in the early-1990s and at the bottom in the mid-1990s and it increased since then (Kamezaki et al. 2003, Shiode 2002). The early increase of nesting loggerhead turtle might be due to the increase of research effort.

Green turtles were abundant in the Ogasawara Islands in the 1800s as compared today. It has been harvested in the 19th century. The number of green turtles harvested decreased from around 1,500 in 1880 to 1900 to around 100 in 1980-1990 (Suganuma 1994). At present, the harvest of green turtle in the Ogasawara Islands is under regulation and managed by the Tokyo Metropolitan government since 1965. The Tokyo Metropolitan government promotes the sustainable use of sea turtle resource.

Hawksbill turtles are distributed around the Okinawa Islands of Japan and are historically harvested. The number of harvest ranged from about 50-120 during 1989 to 1993 (Kamezaki 1994).

Threats to Sea Turtle Survival

The different general threats to sea turtle survival on all its life stages both on the nesting area and at sea are summarized in Table 1. The different threats both in the nesting area and at sea are categorized to biotic factors, abiotic factors, and human activities.

Threats on the nesting site under biotic factors include predation, which affects the eggs and hatchlings, diseases and parasites, vegetation which affects the hatchlings, and other nesting turtles. In other nesting turtles, it does not pose a threat to sea turtle survival since the number of nesting in Japan is not large.

The abiotic factors include erosion and accretion, tidal inundation, heavy rains and typhoon, and thermal stress. Erosion and accretion is also caused by human activities. The construction of a barrier near the river to control soil erosion affects the supply of sand on the beach.

Threats of human activities in the nesting area include transplant of eggs, beach development, dredging, direct harvest, beach lighting, pollution, disturbance, collision with boats, and garbage. Beach development, like the use of tetrapods on beaches, pose a major threat on the eggs, hatchings, and nesters.

The general biotic threat factors at sea include predation, and diseases and parasites. The abiotic factors at sea are not yet identified. Factors at sea under human activities include artificial debris, direct fishery, coastal set and gill net, purse seine, tuna longline fishery, drift gillnet, trawl fishery, and collision with boats. Direct fisheries include those in the Ogasawara Islands where green turtles are harvested under regulation and in the Okinawa Islands where hawksbill turtles are harvested.

Table 1. Threats to sea turtles in Japan.

Factors	Life Stages Eggs	Hatchling	Juveniles	Adults	Breeders
Nesting site					
Biotic factor					
Predation	Yes	Yes	-	-	No
Diseases and parasites	?	?	-	-	No
Other nesting turtles	No	No	-	-	No
Vegetation	?	Yes	-	-	No
Abiotic factor					
Erosion, Accretion	Yes	No	-	-	Yes
Tidal inundation	Yes	No	-	-	No
Heavy Rains, Typhoon	Yes	No	-	-	No
Thermal Stress	Yes	Yes	-	-	No
Human activity					
Transplantation	Yes/No	?	-	-	-
Beach Development	Yes	Yes	-	-	Yes
Dredging	Yes	Yes	-	-	Yes
Direct harvest	Yes	No	-	Yes	Previously
Beach lighting	No	Yes	-	-	Yes
Pollution	?	?	-	?	?
Disturbance	No	Yes	-	-	Yes
Collisions with boat	No	No	-	Yes	Yes
Garbage	No	Yes	-	-	Yes
At Sea					
Biotic factor					
Predation	-	Yes	Yes	Yes	Yes
Diseases and parasites	-	Yes	Yes	Yes	Yes
Abiotic factor					
?					
Human activity					
Artificial debris	-	Yes	Yes	Yes	Yes
Direct fishery	-	-	Yes	Yes	Yes
Coastal set net	-	Yes	Yes	Yes	Yes
Coastal gill net	-	-	Yes	Yes	Yes
Purse seine	-	-	Yes	Yes	Yes
Tuna longline	-	-	Yes	Yes	Yes
Drift gillnet	-	-	Yes	Yes	Yes
Trawl fishery	-	-	Yes	Yes	Yes
Collisions with boat	-	-	Yes	Yes	Yes

Conservation Efforts/Measures (Table 2)

A. Protection by law

Several laws regarding and related to the protection of sea turtles have been enacted in Japan. These are the Fisheries Resources Protection Act of 1951, the Natural Monument Protection Act of 1919, and other local legislations within Japan.

In the Ogasawara Islands, the Tokyo Metropolitan Government manages the regulated harvest of green turtles. In the Okinawa Islands, the hawksbill fishery is managed by local government.

B. Cooperation and collaboration between the Government of Japan and NGOs

The government agencies involved in the conservation and management of sea turtles are the Ministry of Environment, the Ministry of Land, Infrastructure and Transport, the Fisheries Agency, and other local governments. The Ministry of Environment supports and promotes the conservation activities of the NGOs. The Ministry of Land, Infrastructure and Transport promotes the creation of gentle slope shores rather than the use of tetrapods for the protection of nesting sea turtles. The Fisheries Agency monitors fishery by-catch and promotes the development of methods to mitigate sea turtle by-catch by tuna longline fishery.

Research activities, such as tag and release and satellite tracking, have been conducted by the Fisheries Research Agency (FRA), Universities, Aquariums, and NGOs.

C. Monitoring of nesting areas

NGOs lead the monitoring of sea turtle nesting areas in Japan. The Japanese Society of Sea Turtle for example monitors the sea turtle nesting beaches in order to have an estimate of an annual number of nesting in Japan. Along with the monitoring activities, transplantations of eggs are also conducted for those eggs in danger of poaching, inundation, and predation. In the monitoring activities, the biometrics of the nesters are recorded and tagging is also conducted. In collaboration and cooperation with research institutes and Universities, monitoring of marine turtle movements by tagging and satellite telemetry are also conducted. Tracking loggerhead turtles by the use of satellite telemetry, conventional external flipper tags, and Passive Integrate Transponders (PIT) are being conducted by the National Research Institute of Far Seas Fisheries (NRIFSF), which belongs to FRA.

A study on the use of beach lights with different intensities had been conducted by the Ministry of Land, Infrastructure and Transport. It was recommended that low intensity lights should be used in sea turtle nesting beaches since nesting sea turtles prefer these instead of high intensity lights.

D. Monitoring sea turtle by-catch

The NRIFSF together with the Fisheries Agency conducts monitoring of sea turtle by-catch by tuna longline fishery and conducts studies to mitigate the by-catch.

Ishigaki branch of the Seikai National Fisheries Research Institute under the FRA conducts experiments for the modification of set nets to exclude sea turtle by-catch (Abe *et al.* 2003).

E. Other activities and studies

The NRIFSF and ELNA (Ever Lasting Nature; NGO) has been conducting satellite tracking of leatherback turtles in Papua, Iryan Jaya, Indonesia and also protects the nesting area of the leatherback turtles in Papua Iryan Jaya.

The National Center for Stock Enhancement of FRA conducts captive-breeding experiments on sea turtles in the Ishigaki Island of Okinawa.

Information and Education Campaign

The NRIFSF together with other government agencies and the Global Guardian Trust (NGO) conducted an Information and Education Campaign regarding sea turtles conservation in several places in Japan. The NRIFSF and the Fisheries Agency distributed sea turtle release manual to fisherman of tuna longline fishery in order to increase survivorship of sea turtles. Species identification sheets were also distributed to fisherman in order to improve the accuracy of species identification in sea turtle by-catch.

International Cooperation

A joint research program between Japan and Thailand, "SEASTAR2000" mainly focuses on the research of post-nesting movements/migration of green turtles from the Gulf of Thailand and the Andaman Sea. It showed that the migration paths of the post-nesters included the South China Sea, Sulu Sea, and the Java Sea. These migration paths showed the need for an international cooperation between various countries.

The World Tuna Longline Fishery Conference (WTLFC) held in Tokyo, on 26-27 August, 2003 reviewed the current situation surrounding the tuna longline fishing activities including the issue related to the sea turtle incidental catch. Representatives of major tuna longline fishing organizations in the world including Japan, Chinese Taipei, Korea, the Philippines, Indonesia and China and other relevant fisheries authorities were the participants of the WTLFC. After serious discussion, the participants of the WTLFC conference agreed to appeal internationally their legal fishing activities and to take actions to promote responsible fishing, jointly and cooperatively. The WTLFC adopted the joint declaration.

The FAO (Food and Agriculture Organization of United Nations) Inter-governmental Consultation for the conservation of sea turtles is going to be held in Thailand in 2004 sponsored by the Japanese Trust Fund.

Table 2. The conservation, management and research activities for sea turtles.

Conservation and management		
	Ministry of Environment	
		Support and promotion for the conservation activities of the NGOs
	Ministry of Land, Infrastructure and Transport	
		Creation of sandy beach rather than tetrapod
		Use of more weak streetlight along the beach
	Fisheries Agency	
		Monitors for fishery by-catches
		Promotion for the development of methods to mitigate by-catches by tuna longline fishery
		Education (Species ID sheet, Release Manual)
	Local Governments	
		Management for the harvest
	NGOs	
		Monitoring of nesting female and eggs
		Protection of nesting female and eggs (transplantation)
		Estimation of annual nesting number
Research		
	Fisheries Research Agency	
		Monitoring of by-catch by tuna longline fishery
		Experiment to avoid sea turtle by-catch (Circle-Hook)
		Satellite tracking, tag and release
		Experiment for the modification of trap net
		Experiment of stock enhancement
	Universities, Aquariums and NGOs	
		Biological measurement of nesting female
		Tag and release and satellite tracking of nesting female

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Seagrass meadow and green turtle in Cambodia

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ABSTRACT

Green turtle (*Chelonia mydas*) have been reported as an abundant species among five species of sea turtles in Cambodia's sea. Green turtle have been known as plant eaters. Mainly a few species of seagrass In Cambodia, four large seagrass meadows have been selected as demonstration sites in two provinces and one municipality. KKSG1 and KKSG2 were selected in Koh Kong province, KAMPSG1 in Kampot Province, and KEPSG1 in Kep Municipality. So far, there is no confident information that have been mentioned about seagrass species and specific seagrass species which are the most favored species for green turtle even some survey had been conducted. Becase the process of the survey did not continue, feeding ground zoning for sea turtles have not been set up yet. To address this issue, survey on seagrass species conducted in 2002 in KAMPSG1 and KEPSG1 by using three methods are 1. to interview with local people who are living around seagrass area, 2. seagrass net, and 3. mapping seagrass areas, in order to find out seagrass species and feeding ground for green turtle. As a result, eight species of seagrass found in the area, in which two of them are dominated species, are *Enhalus acoroides* and *Thalassia hemprichii*. Whereas from interview indicated that green turtle mostly found in Kep municipality and Kampot province, particularly in areas that is reach of *T. hemprichii*. Although, there is no quantities information on feeding ground and specific seagrass species for green turtle are strongly aware yet. However, future plan has been made to conduct more survey in other zones in order to get fully satisfied information on favored seagrass species and their location for green turtle. It is expected that, clear result from the future activities will be useful to set up feeding ground for sea turtle, particularly green turtle. Therefore, many activities need to be done in the coming future for the sack of protecting and conserving sea turtle population as well as their feeding ground in Cambodia Water and also in the Southeast Asia. But fund for activities is seeking from concerned agencies and NGOs.

KEYWORDS: seagrass meadow, green turtle,

INTRODUCTION

The Kingdom of Cambodia has 435 Km coastline, locates in the Gulf of Thailand, and extends between the Thai's border in the West and the Vietnam's border in the South. The Exclusive Economic Zone (EEZ) of the country is the area from the shore 200 nautical miles off shore covering 55,660 Km^2 (Smith. J, 2001).

Along the coastline, there are many natural resources such as beaches, mangrove forest, coral reef and seagrass beds which served as feeding grounds, spawning ground and habitats for marine lives.

Among these, seagrass beds are one of the main sources that play very important role in ensuring sustainability coastal resources and other endangered marine animals, particularly sea turtle population, moreover, also provides feeding ground and nutrient-rich habitat for divers and range of fauna and flora (Mckenzie, L. J. & Campbell, S. J. 2002).

According to Try (2002), it has been reported that there are five species of marine turtle in Cambodian sea, in which green turtle is the abundant species mostly encountered in seagrass areas and often accidentally caught by fishermen with the stingray hook line, surrounding net, trawling net and scomberomorus gill net (Try et al., 2002).

However, there has no the report that significantly indicated about information on relating to preferred /dominant of seagrass species in specific areas as a major feeding ground for sea turtles, particularly green turtle.

But, based on the report of research by DOF (2002), which indicates that there are four sites of seagrass beds, namely KKSG1, KKSG2, KAMPSG1 and KEPSG1. They are the biggest meadow in the Cambodia waters. The first two sites (KKSG1 and KKSG2) are located in Koh Kong province, and the second one (KAMPSG1) in Kampot province and the third site in

Kep Municipality.

In terms of preserving, knowing the crucial potentials of these existing seagrass bed as well as managing and conserving program in Cambodia on endangered species, especially sea turtles, two of four seagrass sites (KAMPSG1 and KEPSG1) selected to conduct a survey and research in 2002.

Respectively, clearer data and information related to the specific feeding ground or preferred species of seagrass of green turtle and other potentials of seagrass will be completely gathered in two more sites in Koh Kong province, provided that there will be any financial support funded to DOF under good joint collaborations with outsiders.

SURVEY ON FEEDING GROUND OF GREEN TURTLE

The initiative concept on sea turtle research and conservation just restarted in the past few years after the civil war in the country. Up to now, there hasn't been any quantitative information on the specific feeding ground of green turtle along the coastline of Cambodia. Fishermen living along the coastal area, particularly in Kampot province and Kep Municipality mentioned that basically, sea turtles have been seen in different habitats based on locations where they were accidentally caught. Of which, green turtle mainly caught in Kep City and Kampot province.

Therefore, in order to get advantages during the research program on seagrass meadow of coral-seagrass Component, the Sea Turtle Team requested coral-seagrass Team to conduct the survey and research together. Then, this suggestion was agreed by the Director of the Department of Fisheries and coral-seagrass team. This cooperative group was separated into two groups, in which one group is for the inland survey and the other is for the underwater research. Clearly, all activities and result mentioned in following procedures.

METHOD

Three methods were used to conduct the survey / research :

1. Use questionnaires and note taking to interview with local people who are resident around the seagrass sites.
2. Use GPS to record position to zoning and mapping.
3. Use Seagrass net method to determine species composition and percentage cover of seagrass by species.

RESULTS OF SURVEY RESEARCH

4.1. Area found species for green turtle
(*Thalassia hemprichii*)

Based on the survey/research on land and underwater about seagrass composition and specific feeding ground and preferred species for green turtle in Kampot province and Kep Municipality, there are six seagrass areas, namely in Preak Tnaot, Preak Ampil, Preak Kdat, Preak Koh Touch, Roluos and Phnom Dong in KAMPSG1 and there are two seagrass areas, namely Koh Tonsay and Koh Tbal in KEPSG1.

Eight seagrass species found in those areas such as *Enhalus acoroides, Cymodocea rotundata, Halodule pinifolia, Halodule uninervis, Halophila deciens, Halophila ovalis, Syringodium isoetifolium and Thalassia hemprichii,* in which Enhalus acoroides and Thalassia hemprichii are dominant species.

Generally, seagrass meadows are mainly growing inshore in sediment on the sea floor with clear shallow water. These meadows may be mono-specific or may consist of multi-species communities, and the other species were found in small amounts. At Preak Thnoat, Km12, Phnom Dong village in Kampot Province, around Koh Tonsay in Kep Municipality. Information on seagrass composition and seagrass abundance species within the two areas are still not reliable. According to this survey/ research, many green turtles have been caught and found in these two zones.

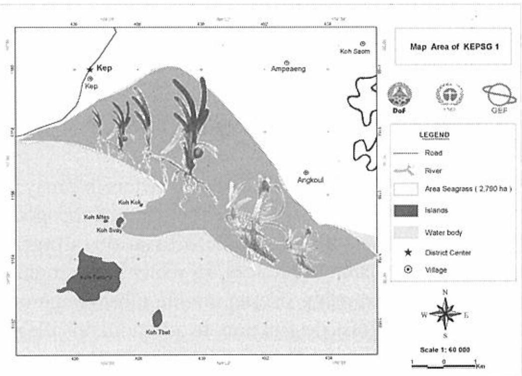

Figure 1. Seagrass area in Kep Municipality

4.2. AREA RICH IN *Thalassia hemprichii and Enhalus acoroides*

According to the data and information obtained from the underwater research shown that the areas where cover by *T.hemprichii* are Phnom Dong, Kilodabpi and Rolous in Kampot province, and group of Koh Tonsay islands at earthen part of KohTonsay and Koh Tbal in Kep Municipality.

4.3. AREA FOUND GREEN TURTLES *(Chelonia mydas)*

Referred to the on-land interview with residents around the selected site indicates that green turtle is a well-known species and can be found year round in their area. Also green turtle have been considered as abundant species in the sea. On the other hand, green turtles have been found broad expanses of shallow, sandy flats covered with seagrass or near seagrass beds in Phnom Dong, Rolous and Angkoul area, which are reported that the largest area

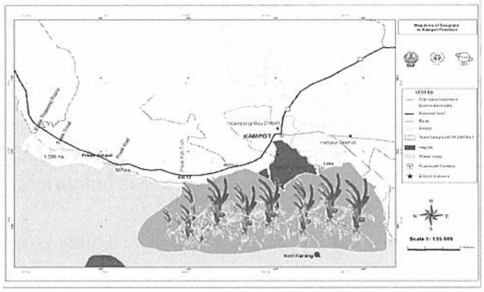

Figure 2. Seagrass area in Kanpot province

among all of areas where the underwater research has been conducted. However, information related to the specific feeding ground and specific species of seagrass for green turtle has not been completely obtained yet because local people have not known clearly about individual name of those seagrass even in Khmer. Clearly, many kind species of seagrasses were called the same name in Khmer as Smao Samut.

Even though, at least two more areas (Preak Ampil and Preak Kdat) were reported wheregreen turtle encountered as well.

4. 3. IMPACT TO SEAGRASS BED AND GREEEN TURTLE

From the survey result, there are several factors that may be causing negative impacts on seagrass beds by anthropogenic influences such as mangrove deforestation, stingray hook line, and fishing practices, in which only engine-pushed net and trawling fishing are the most dangerous activities on seagrass destruction. In addition, this illegal is not only caused degradation of diversity in the seagrass area, also reduced sea turtle population, particularly green turtle during their migration for feeding ground. Fishermen added that they found many green turtles in the past but now its number has been decreased after trawling fishing have been operated in these seagrass areas.

DISCUSSION

According to the survey/research in KAMPSG1 and KEPSG1 on percentage cover of seagrass composition and its relation to green turtle, even the study was randomly conducted in accordance with real situation at the survey/research sites, the result shows that eight species of seagrass beds have been found, of which two species are dominant species and many green turtle have been generally occurred in these two sites, especially in Phnom Dong, Preak Ampil and Preak Kdat areas.

Furthermore, it is expected that there are more than ten species of seagrasses have been presenting along the coastal area in Cambodia Water if other two (KKSG1 and KKSG2) in Koh Kong province will be completely conducted survey/research in the future. Clearly, based on Nelson (1999), it is mentioned that there are nine species of seagrass that have been found along coastline. With this regards, there is also a hope that more number of feeding ground and preferred species of seagrass for green turtle as well as other sea turtles will be found in Koh Kong water.

Thus, we hope that some of seagrass areas in this research site and others resulting from future research will be proposed to be protecting site, in order to ensure sustainability of marine fisheries resources, as specific feeding ground for sea turtles, particularly green turtle.

CONCLUSION

The research on seagrass beds in Cambodia might be able to say that this is a good initiative to set up any plan for future to prevent these seagrass beds from such crucial destruction through more closed collaboration with local communities and other government agencies even some cooperation have been done.

With this regards, such idea will also contribute indirectly to manage and conserve green turtle as well as other turtle species, because of seagrass beds are the main habitat for marine animals and other endangered sepecies, particularly feeding ground for green turtle. So, if these activities still continuously will be operated in the seagrass sites, the number of green turtle will be declined in the Cambodia waters.

Hopefully, this information from this seagrass beds survey/research will be useful for local or regional management and conservation program on sea turtles, other seegrass medow and marine endangered species as well.

RECOMMENDATION AND SUGGESTION

To ensure sustainability of our sea turtles, other marine natural resources as well as their natural habitat and feeding ground, emergent co-management and cooperation need to be implemented with friendly thinking in order to solve this matter, especially cooperatively eliminate any illegal action that may be caused danger seagrass beds and green turtle. Furthermore, public awareness campaigns and extension programs on the importance of our existing resources should be immediately disseminated to all levels.

In this connection, more research is needed on the feeding ground or areas which could be suitable for setting up to be protected zones for protecting and conserving sea turtles and their habitat in the future.

ACKNOWLEDGEMENT

The author wishes to express our sincere thank to Mr. Ing Try, Deputy Director of the Department of Fishery for his advised, commands and corrects this manuscript. And the author also would to express deep thank to all colleagues in Marine Working Group who has provide command and try all their bests to joint in the survey lead to completely success.

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Nesting populations of sea turtle in Ishigaki Island, Okinawa

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ABSTRACT
The current status of the nesting activity of sea turtles in Ishigaki Island, Okinawa, Japan, was investigated. It was revealed that the dominant nesting species was changing from loggerhead turtle, *Caretta caretta*, to green turtle, *Chelonia mydas* in the most of the southern part of Japan. The nesting populations were evaluated to be 10-20 females of *C. mydas* and 3-8 females of *C. caretta*, annually. On the average, *C. mydas* re-migrate to nest every 3.7 years. The total number of females in *C. mydas* nesting population in Ishigaki was estimated to be 75 at most. The minimal estimation was 25, and in this case several females with low nest site fidelity were expected to migrate every year in addition.

KEYWORDS: *Chelonia mydas*, *Caretta caretta*, nesting activity, nesting population, Okinawa

INTRODUCTION

Generally, three species of sea turtles, *Caretta caretta*, *Chelonia mydas* and *Eretmochelys imbricata*, nest in the coast of Japan (Uchida and Nishiwaki, 1982). Ryukyu Islands, including Ishigaki Island, are utilized as a nesting site by all three species (Kamezaki, 1989, 1991). To make up conservation and management plans for sea turtles, it is important to evaluate the population size and the current status of the local breeding populations. This study introduces the evaluation of nesting populations of sea turtles in Ishigaki, the most southern part of Japan.

MATERIALS AND METHODS

All major sandy beaches in Ishigaki Island were surveyed for sea turtle nests in the daytime during the nesting season of sea turtles from 1995 through 2003. Species of the nest was identified by using the morphology of nesting females, hatchlings, or adequately developed embryo in dead eggs.

Ibaruma beach (3km in length) in the eastern coast of the island (Fig.1) is the biggest nesting site in Ishigaki, (Abe *et al.*, 1998). Night patrols were done for tagging nesting sea turtles on Ibaruma during the nesting season, which starts in April and normally finishes in August. Plastic jumbo tags and inconel tags were used. Since 2001, passive integrated transponder tags (PIT; Trovan, Ltd.) were used concomitantly with the external tags. We also used the patterns, figures, and designs on the scutes of the carapace to identify nesting individuals.

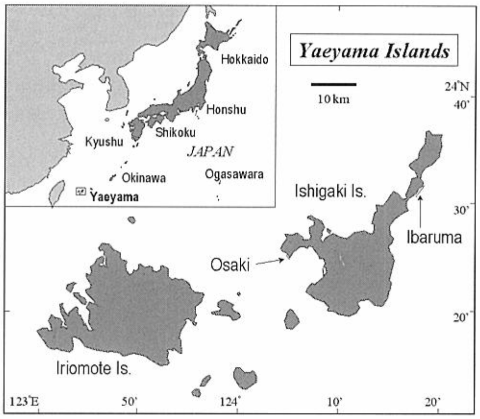

Fig.1. Study site, Ishigaki Island, Okinawa.

RESULTS AND DISCUSSION

1. Nesting activity of sea turtles in Ishigaki

Fig.2 shows the nesting activity of sea turtles in Ishigaki from 1995 through 2003. The nesting activity of *C. caretta* is low in the late 1990's, which turned to increase in early 2000's. The clutch number of *C. mydas* in 2002 increased drastically compared to the former years and restored to the former level in 2003. Although it looks there might be some increasing trend in both species, it is difficult to decide the tendency is showing the increase of the nesting populations or only yearly fluctuations at this time.

During the study, we found 569 nests of sea turtles. *C. mydas* occupied 76% (n=427) of the nests. Nests of *C. caretta* and *E. imbricata* were 17% (n=30) and 5% (n=14), respectively. The remaining 2% (N=14) was not able to identify species because of inadequate development of the embryos. In 1980's, the dominant nesting species of sea turtles was *C. caretta* in Ishigaki (Kamezaki, 1991). However, our result shows that the dominant nesting species in this island has been changed to *C. mydas* from *C. caretta* during late 1990's and early 2000's. The monitoring project of nesting turtles in Kuroshima Island since 1973, about 20km apart from Ishigaki, shows the similar tendency to shift from *C. caretta* to *C. mydas* (Kondo and Kuroyanagi, 2000). The similar shift of the dominant nesting species was observed in all over Yaeyama Islands (Shima *et al.,* 2001).

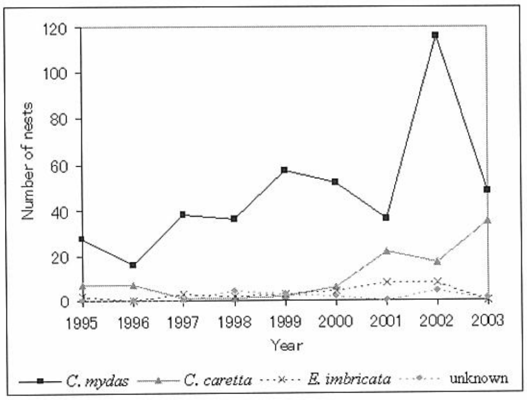

Fig.2. Nesting activities of sea turtles in Ishigaki.

The biggest nesting ground of *C. mydas* in Japan is Ogasawara Islands. In Ogasawara, annual nests of *C. mydas* are increasing, possibly because of the long term head starting project since 1976 and reduction of the fishing effort (Ogasawara Marine Center, 1999; Kondo *et al.,* 2002). Tagging project shows that *C. mydas* after breeding in Ogasawara migrate to the pacific coast of Japan Archipelago including Okinawa (Tokyo Metro. Fish. Exp. Station, 1986). *C. mydas* around the Ogasawara waters are known to have unique genotype comparing to the other Indo-Pacific and Atlantic populations (Bowen et al., 1992). It is necessary to clarify the relationships between the *C. mydas* nesting population in Ishigaki and those in Ogasawara for understanding of the population trends of *C. mydas* in the North Pacific.

It is reported that the clutch numbers of *C. caretta* had decreased along the coast of Japan during 1990's (Sato et al., Kamezaki et al., 2003). However, the numbers of *C. caretta* nest shows a tendency to recover in early 2000's in several major nesting ground in Japan (Shiode, 2002). The trend of *C. caretta* nesting activity in Ishigaki is similar to those in the other areas of Japan.

2. Nesting activities of sea turtles in Ibaruma

Ibaruma beach was nightly patrolled for tagging nesting turtles. The nesting season of *C. caretta* was from April through July, and that of *C. mydas* was from May through August, sometimes continues until December (Abe *et al.,* 1998). We had 15 to 38 nests of C. mydas and 0 to 8 nests of *C. caretta* in Ibaruma annually during 1995-2003 seasons. The numbers of nest were 28.0 ± 8.0 and 2.4 ± 2.7 for *C. mydas* and *C. caretta*, respectively (average ± SD). Nesting of *E. imbricata* was rare; only two nests were recorded during the study. We identified nesting females of 3 to 8 *C. mydas* and 0 to 2 *C. caretta* in Ibaruma every year.

Totally, 49 nesting females of *C. mydas* were tagged. The tag recovery was complemented with the photo identification. *C. mydas* can be identified using the characteristics of the carapace and the head, such as patterns, arrangement of scutes and scales, etc. This method is effective within the range of 10-20 nesting females per year. We can identify 100% of nesting females on the beach if we have their photographs. However, turtles without photographs in the early years of this study could not be identified if tags on them had been lost. The rate of those turtles without photographs was 22% (n=11).

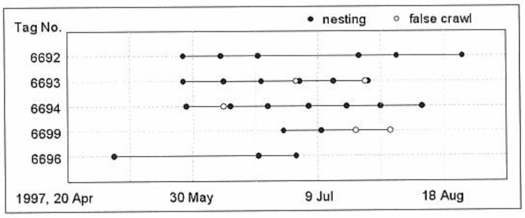

Fig.3. Examples of re-migration of nesting C. mydas in Ishigaki Island in 1997.

Fig.3 shows an example of the inter-nesting intervals of *C. mydas* in Ibaruma in a single nesting season. The upper 4 turtles in Fig.3 nested very regularly, with inter-nesting intervals of 11 or 12 days. Especially, No.6694 showed high nest site fidelity; her nests were not apart from each other by 50 m. On the contrary, No.6696 showed low nest site fidelity. At first she appeared in Osaki (Fig.1), the western coast of Ishigaki 50 km far from Ibaruma. She was found nesting in Ibaruma in the eastern coast 46 days later. And 12 days later, she went back to Osaki by 50 km. This result suggests that there are two types of nesting females. One type has high nest site fidelity and regularity. Another type is relatively migratory with low nest site fidelity. Some turtles tagged in Miyako Island, 120 km eastward from Ishigaki, were found in Ishigaki in a single nesting season (Kobayashi *et al.,* 2002), suggesting that turtles with low nest site fidelity sometimes migrate among islands even in a single nesting season.

3. Remigration between nesting seasons

In Ibaruma, 18 re-migrants of *C. mydas* were found. The 94% (n=17) of them came back 3 or 4 years after the former nesting season (Fig.4). On the average, they nested every 3.7 years (n=18, SD=0.6). There was no female returned more than 6 years after her last nesting. Therefore, we analyzed 13 nesting females identified before 1999, which were expected to come back until 2003.

The *C. mydas* identified before 1999 has been re-migrated to Ibaruma to nest by 69% (n=9). Other 31% (n=4) appeared once and has never been found in Ibaruma and the other beaches until the end of 2003. Of the 9 re-migrants, 33% (n=3) came back once, 44% (n=4) twice, and 22% (n=2) came back to nest three times.

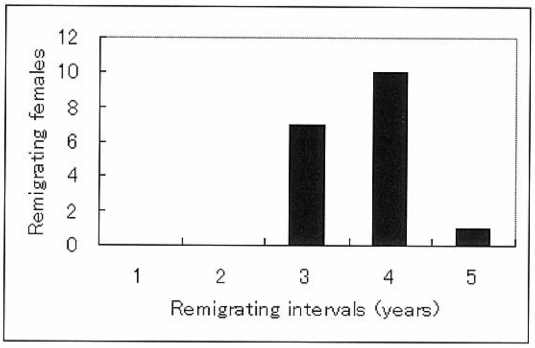

Fig.4. Frequency of re-migrating intervals of C. mydas nesting females in Ibaruma

4. Nesting populations in Ishigaki

On the average, *C. mydas* and *C. caretta* nested 4.9 and 3.1 times in a single nesting season in Ibaruma, respectively. Applying this clutch number per female, we evaluate that the annual numbers of nesting females in all over Ishigaki were 10-20 *C. mydas* and 3-8 *C. caretta*.

Normally, females of nesting populations are evaluated by N x Y, where N = number of nesting females per year, Y = average re-migrating years. In Ishigaki, we suggested two types of nesting females of *C. mydas*; i.e., those with high and low nest site fidelity. The numbers of nesting females with high nest site fidelity (H) was estimated as: H = N x P x Y, where P = proportion of nesting females with high nest site fidelity. In Ishigaki, 10-20 of annual nesting females of *C. mydas* were evaluated. For P and Y, we used 0.69 and 3.7, that is the re-migrating rate and average re-migrating years in Ibaruma, respectively. Therefore, the number of nesting females with high nest site fidelity was estimated to be 26-51.

We do not know those turtles with low nest site fidelity would migrate to another islands, or continuously stay in Ishigaki to nest in another beaches. In the latter case, the number of nesting females (L1) was estimated as: L1 = N x (1-P) x Y; i.e., 12-23 females. Totally, the number of females of the nesting population was estimated to be 38-74 by H + L1.

Or else, assume turtles with low nest site fidelity would accidentally migrate to and nest in Ishigaki only at once, the numbers of those turtles (L2) were estimated to be 3-6 per year by L2 = N x (1-P).

In conclusion, the number of *C. mydas* nesting females in Ishigaki was about 75 at most. The minimal estimation was about 25, and in addition, several females per year were expected to migrate to Ishigaki accidentally.

5. Conservation effort in Ishigaki

For conservation and research efforts of sea turtles, Ishigaki Tropical Station, Seikai Fisheries Research Station, Fisheries Research Agency (FRA) has been studying mitigation measures for bycatch of sea turtles with fisheries (Abe *et al.,* 2003). For stock enhancement of sea turtles, Yaeyama Station, National Center for Stock Enhancement, FRA has been rearing and releasing sea turtles in Ishigaki (Shimizu *et al.,* 2003). A non-profit organization, Sea Turtle Association of Japan has managed Yaeyama Marine Park Research Station in Kuroshima near Ishigaki, which has long been a carrier for conservation and research of sea turtles since 1973. A volunteer group Ishigaki-jima Sea Turtle Research Group has been monitoring sea turtle nesting activities in Ishigaki since 1993. These activities are expected to contribute conservation of sea turtles in Ishigaki.

In Japan, turtle egg poaching is illegal. However, licensed fishermen can catch sea turtle legally for local consumption in Okinawa Prefecture and some other localities. Annual catch for them is assigned every year, which are about 150 individuals in Okinawa. More than 90% of sea turtles captured in Okinawa are taken in Yaeyama Islands including Ishigaki. Most of them are immature *C. mydas*, which are harvested as meat and stuffed animals. Some hawksbill turtles are used as stuffed animals and tortoise shell. The restriction of the length is set only to the hawksbill turtle of less than 25cm in plastron length. The closed season is June and July. The impact of the fisheries on the local turtle population is still unknown. The evaluation of the population size done in this study is expected to contribute to assess impact of fisheries on the local turtle populations.

ACKNOWLEDGEMENTS

The members of Ishigaki-jima Sea Turtle Research Group (Mr. S. Yasumura, Mr H. Yanagida, Mr H. Yamagata, Ms. T. Suzuki, Ms A. Shinozaki) have done daytime patrol with the authors. Sea Turtle Association of Japan provided plastic jumbo tags and inconel tags. The Resource and Environment Research Division, Fisheries Agency of Japan partly supported this study.

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Study on population and distribution of two common sea turtles, green turtle and hawskbil turtle in Indonesia

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ABSTRACT
The green turtle and hawksbill turtle are the most common of six sea turtle species existing in Indonesian waters. These two populations seem to be declined after observation of the decreases of nested sea turtles from year to year in some place where the turtles had been nesting frequently. This is caused by the habitat degradation and the un-stopped mortality due to the incidental capture and hunting by fishermen.

KEYWORDS: population, distribution, nesting, green turtle, hawksbill turtle

INTRODUCTION

Sea turtles are long-lived species that mature late in life and move great distances during their lifetimes. As trans-boundary species, sea turtles are excellent navigators, frequently migrating hundreds or even thousands of kilometres between foraging and nesting grounds, crossing international boundaries. They spend their lives at sea but return to land to produce. Adult females nest in multiyear cycles, coming ashore several times to lay hundreds of eggs during nesting season. After about 50 to 60 days of incubation, the hatchlings emerge and head for the ocean to begin life as pelagic drifters. While maturing over the course of several decades, they move in and out of a variety of ocean and coastal habitats.

Indonesia is an archipelago country of approximately 17,500 islands and 81.000 km of total coastlines, each with different geographically and topographically. This nature benefits turtles in their wide range of choice of habitats. Of seven species of marine turtles in the world, there are 6 species, which have been identified to live and spread in Indonesian marine waters such as leatherback turtle (*Dermochelys coriacea*), olive ridley turtle (*Lepidochelys olivacea*), hawksbill turtle (*Eretmochelys imbricata*), loggerhead turtle (*Caretta caretta*), flatback turtle (*Natator depressus*), and green turtle (*Chelonia mydas*). Whereas Lepidochelys kempi is not found in Indonesian waters as this species only live in Atlantic Ocean around Mexico and American beaches. Consecutively, the most abundant species in Indonesia are the green turtle and hawksbill. The green turtles are suffered to the capture by fishermen, which bring them to the specific area (Bali) for the purpose of religious and culture. However, their population status and distribution are little known. This condition stimulated us to develop a study on this topic, for that this paper presented for the first step.

MATERIALS AND METHODS

Data presented in this paper were summarized from technical reports of some research activities that were conducted in some areas (Fig. 1), such as: Pangumbahan Beach (West Java), Alas Purwo National Park and Meru Betiri (East Java), Berau District (East Kalimantan), and Jamursba Medi Beach (Papua). The data that was analyzed from 1980 to 2000 included nesting sites, nesting season, and mortality.

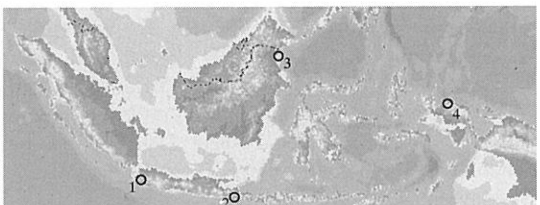

Fig. 1. Map showing the study sites: 1- Pangumbahan ; 2-Alas Purwo NP and Meru Betiri; 3-Berau District; 4- Jamursba Medi Beach.

RESULTS AND DISCUSSION

Green turtle

The green turtle with local name Penyu Hijau, Penyu Daging and Penyu Laut has traditional been utilized by coastal communities for centuries, particularly as a part of the Balinese culture. This turtle is commonly found and widely distributed throughout the Indonesian archipelagos and can be found to nest in a quite vast amount such as in

Berau district of East Kalimantan province; and in small and remote islands throughout Indonesia. In Berau district, this population has been long contributed economically both to the local community and the government. There are about 8 nesting sites for green turtle species throughout Berau district such as in Derawan, Sangalaki, Semana, Mataha, Belambangan, Bilang-bilangan, Balikukup and Sambit islands (Table 1). Sometimes Kakaban island which is located in southern part of Sangalaki island has also been used by the green turtle populations for laying their eggs even though the nests often have become inundated or covered by the high tide so that the embryos down inside the nests. Since January 2002, the local government of Berau District has stopped the concession activity and declared the Sangalaki Island and Derawan Island as protected important nesting site.

Table 1. Number of nests on the five concession Islands in Berau District between 1998 and 2000 (Turtle, Foundation, WWF and KEHATI 2002).

Islands	Number of Nests		
	1998	1999	2000
Sangalaki	6985	10346	5065
Belambangan	2602	3819	2314
Sambit	482	1050	430
BilangBilangan	4483	7847	3935
Mataha	2746	4058	2334
Total	17298	27120	14078

Pangumbahan in West Java is also one of the major green turtle nesting beach in Indonesia and the only remaining nesting beach of any importance on Java. However, the number of many largest rookeries has decreased in the last 50 years, due to over-harvest (Schulz 1984, Salm, 1984; Kitchener, 1996). As shown in the Figure 2, the green turtles nested in Pangumbahan with different peaks from year to year. There was a significant decrease of eggs laid from 1997 to 1998. This is due to the habitat degradation and indicates the decrease of green turtle populations. Green turtles were captured in several waters of Indonesia. Green turtles were captured accidentally by the fish net in Arafura Sea with values reaching 95 individual in 1999. Almost no turtles captured after utilization of Turtle Excluder Device (TED) since 2001. Although this species has been protected based on the Governmental Law No. 7/1999, the captures of sea turtles were happened illegally in some areas by using drift gillnet. There are no significant data available to estimate the number of population of the green turtle existing in Indonesian waters.

Hawksbill

There are several local names for hawksbill: Penyu Sisik, Fonu Koloa, Penyu Genteng, Penyu Kembang, Penyu

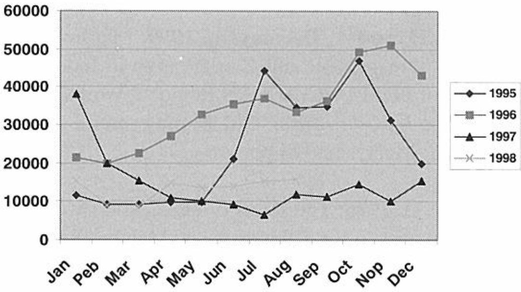

Fig. 2 Monthly fluctuation of green turtle eggs at Pangumbahan beach, West Java.

Katungkera and Wau. This species has been protected based on Ministrial of Forestry decree no. 882/Kpts-II/ 1992 that is more strongly based on the Governmental Law No. 7/1999. At present hawksbill can still be found throughout Indonesia in significant number as reported by Halim and Dermawan (1999). Important nesting areas are the many islands in the Anambas and Natuna-Riau; Lima Momperang, Pesemut-Belitung, Segamat Island-Lampung, South of Ujung Pandang, Birah-birahan, Derawan-East Kalimantan (Salm and Halim, 1984; Schulz, 1984; Soehartono, 1993; Halim and Dermawan, 1999). The hawksbill turtle is exceedingly difficult to monitor for long-term trend, for a number of reasons. First, all small number of animal's nest on wide variety of beaches across abroad geographic area. Secondly; hawksbill beaches tend to be remote, inaccessible and sometime so narrow that the turtle leaves no crawl trace. Finally, hawksbill also exhibits the large annual fluctuation in nesting counts characteristic of green turtles. The figure 3 shows the hawksbill nested in small quantity in three different locations such as, Alas Purwo National Park-East Java; Jamursba-Medi Beach-Papua; Sukamade beach, and Meru Betiri-East Java.

In some rookeries the nesting time of this species varied seasonally, for instance in Kepulauan Seribu NP it is on December-April, Segamat Island-Lampung on December-April, Belitung on January-June, Paloh-West Kalimantan on February-May and Tambelan, Riau on February-May.

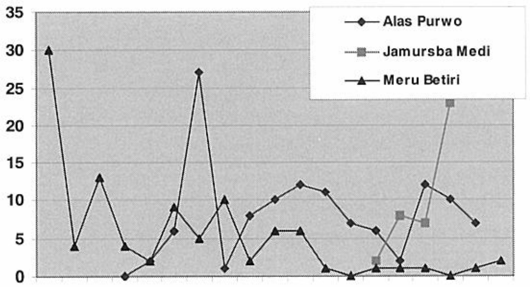

Fig. 3. Annual nesting trend of hawksbill turtles in 3 different places in Indonesia

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Marine turtles with foreign tags recaptured in the Philippines from 1993 to 2002

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ABSTRACT
The Pawikan Conservation Project (PCP) of the Protected Areas and Wildlife Bureau (PAWB)-Department of Environment and Natural Resources (DENR) is the government agency of the Philippines tasked to conserve and manage the marine turtle populations in the country. In 1989, the PCP started its nationwide tagging program in cooperation and collaboration with the DENR Regional and Field Offices, non-government organizations, the academe, and private individuals. This nationwide tagging program is supplemented and complemented by the PCP's information and education campaign regarding marine turtle conservation. Marine turtles with foreign tags recaptured in the Philippines from 1985 to 1993 were those from Yap, Micronesia; Yakushima Island, Japan; and Sabah, Malaysia (De Veyra 1994). An updated list of foreign tag recoveries reported to the PCP from 1993 to 2002 included those tagged from Palau, Guam, Japan, Taiwan, Malaysia and by the South Pacific Regional Environment Program (SPREP). These data further justify the need for an international collaboration to manage the shared marine turtle resource and suggests the Sulu Sea both as a feeding and developmental area for marine turtles.

KEYWORDS: Pawikan Conservation Project, tag recoveries, marine turtles, Philippines

INTRODUCTION

Marine turtle conservation in the Philippines is led by the Pawikan Conservation Project (PCP) of the Protected Areas and Wildlife Bureau (PAWB)-Department of Environment and Natural Resources (DENR). The PCP was created in 1979, which was then known as Task Force Pawikan (TFP). In 1989, the PCP started its nationwide tagging program in cooperation and collaboration with the DENR Regional and Field Offices, non-government organizations (NGO), the academe, and private individuals. Marine turtle tags were issued to the collaborators for this purpose. This nationwide tagging program is supplemented and complemented by the PCP's information and education campaign regarding marine turtle conservation. Through these efforts, the PCP generated the much-needed public support in conserving marine turtles in the Philippines.

Through the Field Action Officers of the DENR, the PCP received reports of marine turtles captured with foreign tags. De Veyra (1994) reported marine turtles recaptured in the Philippines, which were tagged from Yap, Micronesia; Yakushima Island, Japan; and Sabah, Malaysia. In this paper, the list of foreign tag recoveries in the Philippines is updated from 1993 to 2002. Since the Philippine-Sabah Turtle Islands is inferred as a well-defined green turtle (*Chelonia mydas*) rookery (Trono 1994), marine turtles with malaysian tags from Sabah encountered in the Philippine Turtle Islands were not included.

RESULTS AND DISCUSSION

Foreign tag recoveries in the Philippines reported to the PCP from 1993 to 2002 included marine turtles with tags from Palau, Guam, Japan, Taiwan, Malaysia and by the South Pacific Regional Environment Program (SPREP, Table 1). A map of the movements of these marine turtles is shown in Figure 1.

On March 20, 1989 a hawksbill turtle (*Eretmochelys imbricata*) was captured in the Sulu Sea near the province of Negros Occidental. The tags attached to its left hindflipper read Palau Japan, MMDC No. 477. The tag indicated that the turtle came from the turtle headstarting program of the Micronesia Mariculture Demonstration Center (MMDC which is now called Palau Mariculture Demonstration Center), which was supported by the Japanese government (Theo Isamu pers. comm. 2003). They said that the headstarting program targeted hawksbill turtles (Sato and Madriasau 2001) and the tag number represented the number of turtle released (Theo Isamu pers. comm. 2003). After four years in captivity, on May 14, 1993 the turtle was released in the Sulu Sea near Negros Occidental with tags RP6882 and RP6883 applied to the right and left frontflipper, respectively. Curved carapace length (CCL) was 41.3 cm and curved carapace width (CCW) was 37.5 cm at the time of release.

A hawksbill turtle with tag 738, Dalton Henley, England, Pat #894143, was recaptured in Sitio Puting Balas, Sugod, Tukuran, Zamboanga del Sur on August 28, 1991. The origin of the tag was not identified (De Veyra 1994). However, our review of the original report revealed that the tag was a TWIN tag attached to the left hindflipper. The above inscription was from the bottom tag, and the top tag read PALAU.JAPAN MMDC, TWIN Tag. The hawksbill turtle also came from the MMDC turtle headstarting program. The hawksbill turtle was released at the same area of recapture on January 16, 1992 but the captor removed the tag.

Ten green turtles originally tagged from Sandakan, Sabah, Malaysia were recaptured near the waters of Bacolod City, Palawan, Surigao City, Negros Occidental, and Antique. Communications with Sabah Parks of Malaysia were exchanged regarding these recaptures. A green turtle with tags from Sarawak, Malaysia was recaptured twice near the waters of Palawan within the Sulu Sea.

Green turtles with tags from the SPREP were recaptured in Southern Leyte (Visayas Region) and Oriental Mindoro (Luzon Region).

A green turtle with tags from Japan was recaptured near the waters of Brgy. Buenavista, Rapu-Rapu, Albay on February 28, 1998. The serial numbers of the tags were JPN7376 and JPN16132 in the right and left flipper, respectively. This turtle was originally tagged in Yomitan, Okinawa, Japan on August 25, 1997 (Hideshi Teruya pers. comm. 2002). It was released in Albay Gulf, Rapu-Rapu, Albay on March 05, 1998.

Another green turtle with tags from Japan was recaptured near the waters of Brgy. Bancao-Bancao, Puerto Princesa City, Palawan on September 27, 2002. JPN14638 was found in the right frontflipper and JPN25572 in the left hindflipper. Both tags were made from yellow plastic. The green turtle was originally tagged in Sakiyama, Iriomote Island, Okinawa, Japan on August 12, 1997 (Tatsuya Shima pers. comm. 2003). The green turtle was released at the bay of Brgy. Bagong Silang, Puerto Princesa City, Palawan on September 27, 2002.

A green turtle with a tag from Taiwan was recaptured in Tapel, Gonzaga, Cagayan (Northern Philippines) on November 19, 1994. The tag read TW-010-011 PO Box 7-215 Keelong Taiwan 20224 ROC. RP726A and RP725A tags were applied on its right and left frontflipper, respectively. The turtle was released on November 26, 1994.

On January 02, 2002, a green turtle with a satellite transmitter from Guam was recaptured in Kulisian, Pangutaran, Sulu (Mindanao Area). DENR Region 9 informed the Guam Sea Turtle Project of the said recapture in Philippine waters.

The marine turtle recaptures and release shows the effectiveness of the PCP's marine turtle tagging and conservation program and further justify the need for an international collaboration between countries where the marine turtle resource is shared. Also, the records show the importance of the Sulu Sea both as a feeding and developmental area for the marine turtle populations of Malaysia, Japan, and Palau.

ACKNOWLEDGMENT

The author would like to thank the secretariat and organizers of the 4th SEASTAR2000 workshop for the invitation, the Marine Fisheries Resources Development and Management Department (MFRDMD) of the Southeast Asian Fisheries Development Center (SEAFDEC), Malaysia for sponsoring the trip, and Mr. Bibiano Mejino for the map. The PCP acknowledges all the DENR Regional, Provincial, and Community Offices; NGO; LGU; the academe; and the concerned citizens who reported to the PCP all the data contained herein. Also, the PCP acknowledges Dr. Naoki Kamezaki and Assistant Director Tatsuya Shima of the Sea Turtle Association of Japan, Mr. Hideshi Teruya of Okinawa Tyuraumi Aquarium, Japan and Director Theo Isamu of the Palau Mariculture Demonstration Center for providing the original tagging records of the marine turtles with tags from their countries recaptured in the Philippines.

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Table 1. Marine turtles with foreign tags reported to the PCP from 1993 to 2002

Recovered tag(s)	Applied Phil. Tag(s)	Species	CCL and CCW	Recapture Area and Date of Recapture	Approximate Straight-line distance (km)
Palau **Japan**, MMDC No. 477 (LHF)	(RFF) RP6882 (LFF) RP6883	*E. imbricata*	CCL=41.3 cm CCW=37.5 cm	Sulu Sea; March 20, 1989 (near Negros Occidental); released on May 14, 1993	1352
(RFF) 37237 Sabah **Malaysia**	(RFF) RP9854 (LFF) RP9853	*C. mydas*	CCL=109 cm CCW=95 cm	So. Sibucao, Purok Rosas Pandan, Brgy. Banago, Bacolod City; December 20, 1993; 122°58'00" E 10°40'00" N	780
14213 RETURN TO TURTLE IS. ANOS NAT PARK BX 768 SANDAKAN SABAH **EAST MALAYSIA**				Brgy. Sabang III, Surigao City. Captured in 1993; 125°29'00" E 09°47'00" N	884
(LFF) 33863 Return to Turtle Island Park, Box 768, Sandakan, Sabah, E. **Malaysia**	(RFF) RP013B	*C. mydas*	CCL=110 cm CCW=97.5 cm	Green Island Bay, Roxas, Palawan; February 16, 1994; 119°23'00" E 10°16'00" N	520
33860 Turtle Island Park Box 768 Sandakan Sabah E. **Malaysia**			CCL=39 in CCW=30 in	Brgy. Babuyan, Puerto Princesa City, Palawan 1994 118°56'30" E 09°59'45" N	442
39098 Sabah **Malaysia**		*E. imbricata*	CCL=abt. 90 cm	near mouth of Babuyan River, Brgy. Babuyan, Puerto Princesa City, Palawan; October 28, 1994; 118°56'30" E 09°59'45" N	442
TW-010-011 PO Box 7-215 Keelong **Taiwan** 20224 ROC	(RFF) RP726A (LFF) RP725A	*C. mydas*	CCL=100 cm CCW=95 cm	Tapel, Gonzaga, Cagayan November 19, 1994; 122°00'00" E 18°16'00" N	832
(RFF) 47765 TURTLE ISLAND PARKS BOX 768 SANDAKAN SABAH **MALAYSIA**	(LFF) RP305B	*C. mydas*	CCL=100 cm CCW=89 cm	Brgy. Balaring, Silay City, Negros Occidental May 17, 1997; 122°58'35" E 10°48'00" N	676
(LFF) 48600 TURTLE ISLAND SANDAKAN SABAH **MALAYSIA**	(RFF) P13089 (LFF) P13090	*C. mydas*	CCL=102 cm CCW=98 cm	So. Tubog, Brgy. Lapaz, Hamtic, Antique February 10, 1998; 121°59'20" E 10°42'25" N	728
R-JPN7376 (metal) L-JPN16132 (plastic) Kushimoto Marine Park, Wakayama, **Japan**	(RFF) RP8587 (LFF) RP8586	*C. mydas*	CCL=85 cm CCW=66 cm	Brgy. Buenavista, Rapu-Rapu, Albay February 28, 1998; 124°07'45" E 13°11'20" N	1486
(RFF) 56490 (LFF) 56489 Sabah, **Malaysia**	(RFF) P14409 (LFF) P14408	*C. mydas*	CCL=99 cm CCW=92 cm	So. Meluang, Brgy. Lucbuan, Puerto Princesa City, Palawan; January 15, 2000; 118°54'30" E 09°59'30" N	442
5000 4999 Sarawak, **Malaysia**	(RFF) RP8412	*C. mydas*	CCL=123 cm CCW=75 cm	Brgy. Malinao, Narra, Palawan; May 19, 2000; 118°24'30" E 09°15'00" N	858
(RFF) 3464 Return SPC/SP REP BPDS NOUMEA CEDEX **NEW CALEDONIA** (and 3465)		*Unknown*		Brgy. Ambao, Hinundayan, Southern Leyte July 4, 2000; 125°15'00" E 10°23'30" N	
(RFF) 90708 Box 768, 90708 Turtle Island Park, Sandakan, Sabah, **Malaysia**	(RFF) P16376 (LFF) P16377	*C. mydas*	CCL=94 cm CCW=92 cm	Brgy. Panacan, Narra, Palawan March 09, 2001; 118°24'25" E 09°15'10" N	364
MY(S)2539 MY(S)2540 Turtle Islands Park Box 768, Sandakan, Sabah, **Malaysia**		*C. mydas*		Brgy. Binduyan, Puerto Princesa City, Palawan; December 07, 2001	442

(RFF) right frontflipper (LFF) left frontflipper (LHF) left hindflipper

Recovered tag(s)	Applied Phil. Tag(s)	Species	CCL and CCW	Recapture Area and Date of Recapture	Approximate Straight-line distance (km)
Satellite transmitter 439098 with inscription "**GUAM** SEA TURTLE PROJECT PLEASE DON'T KILL ME" Guam Sea Turtle Project, U.S.A. Return If Found (671)735-3987		*C. mydas*		Kulisi-an, Pangutaran, Sulu January 02, 2002; 10:00am 120°35'00" E 06°19'00" N	2804
JPN3484 **JAPAN**		*Unknown*		approx. 50m away from coastline east of Diogo Island on March 13, 2002	
4999 5000 Forest Development, Sarawak, **Malaysia**	(RFF) P16371 (LFF) P16372	*C. mydas*	CCL=50 cm CCW=46 cm	So. Borbon, Brgy. Panacan, Narra, Palawan; August 15, 2002; 11:00 am	858
(RFF) JPN14638 (LHF) JPN25572 (both yellow plastics) **JAPAN**	(RFF) P18761 (LFF)P18760	*C. mydas*	CCL=80.1 cm CCW=72 cm	Brgy. Bancao-Bancao, Puerto Princesa City, Palawan; September 27, 2002; 7:00 am	1768
(RFF) RMTP 649 SPC REP BPDS NOUMEA CEDEX **NEW CALEDONIA**	(LFF) P18875	*C. mydas*	CCL=107 cm CCW=94 cm	Dalahican, Roxas, Oriental Mindoro October 16, 2002; 121°32'00" E 12°36'30" N	

(RFF) right frontflipper (LFF) left frontflipper (LHF) left hindflipper

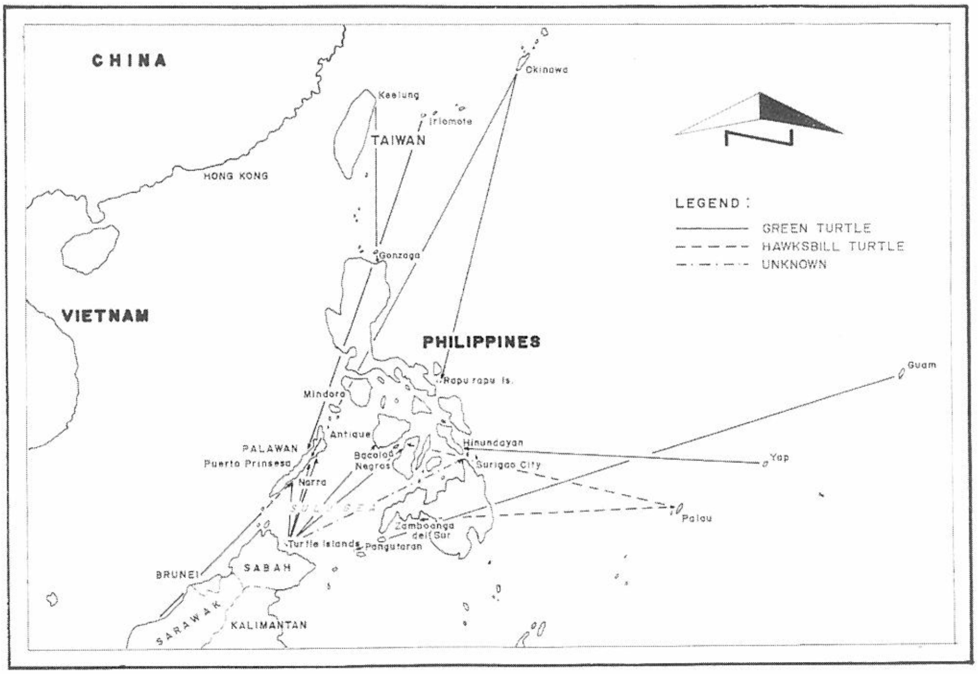

Figure 1. Plotted movements of marine turtles with foreign tags reported to the PCP from 1993 to 2002.

Emergence success of natural nests for olive ridley on sandy beach, Kadongalay Island in Myanmar

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ABSTRACT

The Kadongalay Island (15°49'N, 95°13'E) has existed since 1911. This Island is formed with deposited sand at the mouth of Bogalay River, Ayeyarwady delta in Bay of Bengal and it's close to Andaman Sea, Kadongalay Island is 5-miles length and three quarters mile in breadth, turtles laying the eggs on this island from September to March yearly. Department of Fisheries was undertaking sea turtle conservation and research started on Kadongalay Island in 1998. In Kadongalay Island, only olive ridley (*Lepidochelys olivacea*) attended to this Island for nesting. About 120 nests could be found each year along the sand beach. All nests have been preserved naturally. Nesting female turtles lay the eggs on the sand bank with white siliceous sand, three different kinds of places as lower slope, upper slope and dune. Data were recorded including nest location and date, and then watched until the time of hatching out. After the hatchlings were hatched out from clutches, the egg hatching rate and other parameters were examined immediately. Data for these clutches such as temperature, incubation period, emergence success and clutch sizes from three different areas were collected. The results showed that average temperature was 29.3°C, 51 days of incubation period and 96.17% of emergence success in dune. Average temperature was 28.53°C, 50 days of incubation period and 89.8 % of emergence success in upper slope. Average temperature was 27.4°C, 49 days of incubation period and 95% of emergence success lower slope. Digital thermometers and measuring tapes were used for these researches. All clutch sizes were not different from each other. Nesting turtles did not make deeply the body pits in the above mentioned sand.

KEYWORDS: **Kadongalay Island, natural nests on pure sand bank, white siliceous sand, olive ridley (*Lepidochelys olivacea*), temperature, incubation period, emergence success, sand temperature of clutches, digital thermometers and measuring tapes**

INTRODUCTION

Myanmar coastline lies from north to south and has length of about 2831.84 Km embracing many Islands and sand banks. Sea turtles build their nests and lay their eggs on those Islands and sand banks Figure 1.

Nests of sea turtle are observed around the Andaman Sea in Mon State and Tanintharyi Division, the Gulf of Mattaban (Gulf of Mottama) in Ayeyarwady Division and the Bay of Bengal in Rakhine State. In Ayeyarwady delta, the beach of Thameehla Island (Diamond Island) 15°51' N, 94°17'E, an Island at the mouth of Pathein River, hosts the most nesting green and some olive ridley turtles, but Kadongalay Island 15°49'N, 95°13'E, an Island at the mouth of Bogalay River, respectively hosts the only nesting olive ridleys. At the time of Maxwell's report (1911), the Kadongalay Island was in existence. This Island formed with deposited sand at the mouth of Bogalay River in Ayeyarwady delta. Kadongalay Island is 5 miles length and three quarters mile in breadth, turtles lay their eggs on this Island from September to March yearly, Department of Fisheries was undertaking for sea turtles conservation and research started on Kadongalay Island since 1998. Only olive ridley (*Lepidochelys olivacea*) has been found on Kadongalay Island when attended to this Island for nesting. About 120 nests could be found each year, along the sand beach in seasonal. All nests have been preserved naturally.

MATERIALS AND METHODS

Female turtles made their nests to lay the eggs, on the sand bank of Kadongalay island Figure 2.

The sand bank consists of a white siliceous sandy beach. Rookery area is 5 miles in length from east to north-west aspect cross bow shape and faced to the sea. There are three different kinds of places in the experiment lower slope, upper slope and dune on nesting area. Each nest was fixed pillars for date of laying eggs and serial number to recognize. At the same time they were recorded in data note book. Many data and causes included in this book for preservative nests. The data were recorded, such as egg laying date and time, nest pillar number, sector number for location of rookery approximate incubation period, number of death hatchlings, number of unhatched eggs, number of undeveloped eggs, number of total eggs; then other events and causes were recorded at tagging and tag recovering and nest examination forms. Eleven clutches were used respectively to submit this paper, from different kinds of places on the sandy beach such as lower slope, upper slope and dune. Above high tide level of the beach is known to be lower slope, dune is highest than the slopes of beach and small sand hills, upper slope lies between lower slope and dune. The clutches of nest pillar selected as number 32, 36, 42, 45 and 47 on the part of lower slope; nest pillar number 1, 3 and 4 on the part of upper slope and number 14, 23 and 31 on the part of dune, there were situated along the beach respectively.

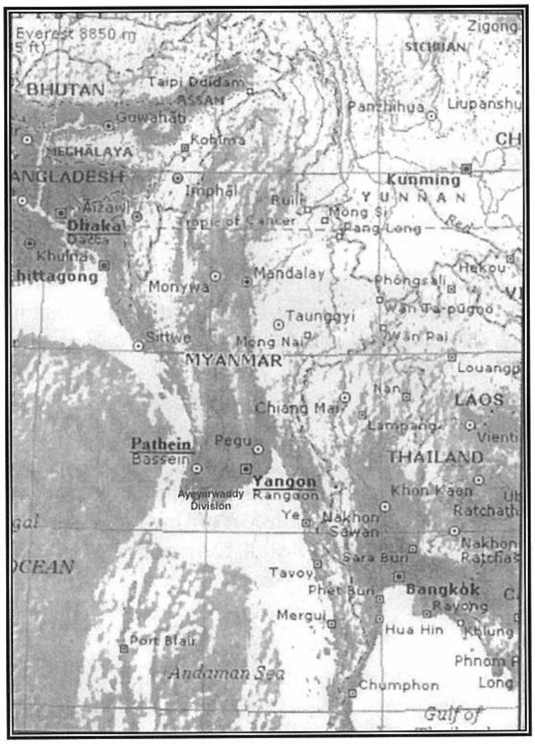

Fig. 1. Map of Myanmar.

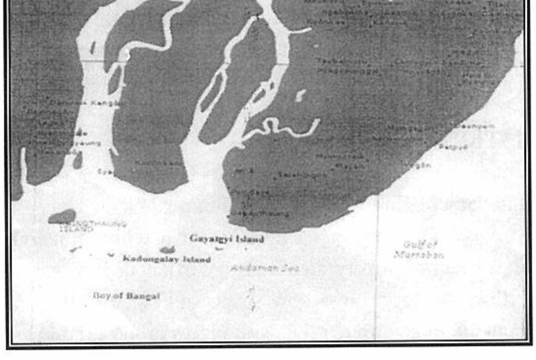

Fig.2. Situation of Kadongalay Island in Ayeyarwady Division

When the mentioned clutches hatched they were examined immediately, that of hatched eggs shells, unhatched and undeveloped eggs were counted. The nest temperature was recorded by digital thermometer. Neck and total depth of clutches were measured by flexible tape. The clutches of nest pillars from lower slope, upper slope and dune were recorded for each clutches (Table 2).

The nest pillars from lower slope, number 32, 36, 42, 45 and 47, each nest temperature recorded as 27.6°C, 27.2°C, 24.4°C, 27.3°C and 27.8°C respectively. Above mentioned clutches that of total number of eggs 125, 121, 124, 120, and 128; hatchlings 123, 118, 116, 113 and 117; death hatchlings recorded 2, 1, 2, 3 and 4; Unhatched eggs listed as Nil, 2, 6, 4 and 7; incubation period 53, 50, 50, 46 and 46 days respectively.

As for the nest pillars from upper slope, number 1, 3, and 4; each nest temperature recorded as 28.3°C, 28.4°C, 28.9°C ; total number of eggs such as 82, 121 and 113; hatchlings 78, 118 and 87; death hatchlings 1, Nil and 2; unhatched eggs 3, 3 and 4; incubation period 50, 52 and 50 days respectively.

Nest pillars from dune areas, number 14, 23 and 31 each nest temperature recorded as 29.1°C, 29.3°C, 29. 5°C and 29. 5°C; as for total eggs were 134, 136 and 100; hatchlings 128, 136 and 93; death hatchlings 1, Nil and 2; unhatched eggs 5, Nil and 5; incubation period 51, 52 and 50 days respectively.

RESULTS

The depth of each clutch was measured at the same time during the clutch inspection ,the neck of each clutch and total depth of clutches were measured and recorded. The depth of clutches collected from different locations but did not different to each other, according to their locations.The results of average total depths from different locations are already shown in Table 1.

Correlation between incubation period hatching success and temperature comparative data are shown in Figure 3.

Due to the data collected from different location of Kadongalay Island beach mentioned above, the presentation of the results, average condition of 11 sample nests are as follows;

(1) Average temperature of 11 clutches from three to location of beach
- Lower slope - 27.4 °C
- Upper slope - 28.5 °C
- Dune - 29.3 °C

(2) Average hatching period
- Lower slope - 49 days
- Upper slope - 50.6 days
- Dune - 51 days

(3) Average percentage of hatching
- Lower slope - 95 %
- Upper slope - 89.87 %
- Dune - 96.17%

(4) Average undeveloped eggs
- Lower slope - 4 Nos
- Upper slope - 10 Nos
- Dune - 3 Nos

(5) Average death hatchlings
- Lower slope - 2 Nos
- Upper slope - 1 Nos
- Dune - 3 Nos

(6) Average total death of clutches
- Lower slope - 13 inches
- Upper slope - 15 inches
- Dune - 18 inches

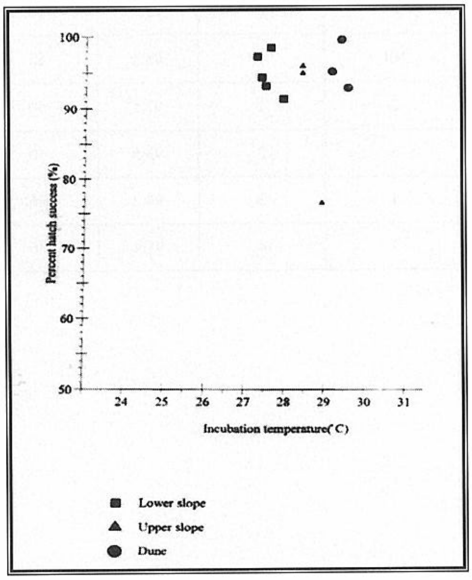

Fig.3. Variation in hatching success of olive ridley turtle eggs relative to incubation temperature in sandy beach of natural nests for three different locations.

DISCUSSION

Due to the above mentioned materials and methods applied we have come across the discussion on the following subjects.

(1) Comparing average total depth of clutches
While examining the clutch depth of 11 sample nests from three different locations on the beach. We found slight differences in average total depth at different location. Naturally, female turtles attend to move on beach for laying their eggs, that the instinct of female turtles to choose the right place of suitable moistures sand on beach for laying eggs . The average total depth of clutches from different locations can be calculated 15.3 inches which is shown in Table 2.

(2) Comparison in average temperature of clutches
The average temperature of clutches in lower slope is 27.5°C (n = 5, SD =0.24), as in upper slope is 28.5°C (n=3, SD=0.32), and for dune area location the average temperature is 29.3°C (n=3, SD=0.20). The average temperature in different zones are between 27.4°C and 29.3°C which is the most suitable in hatching success. Since also the average temperature ranges from 27°C and 29°C, the sex ratio of the hatchlings on Kadongalay Island beach in nature is equal to (Limpus *et al.,* 1983).

(3) Comparative percentage of hatching rate
Comparative percentage of hatching rate from three different locations results 95% in lower slope 89.87% in upper slope and 96.17% in dune respectively. At Kadongalay Island beach, the average percentage of the clutches hatching rate of 93.68% and seem to be excellent condition in Table 2 and Figure 3. Thus, from the result findings, it can be concluded the average hatching percentage on Kadongalay Island beach consists of siliceous sand is better than that on Thameehla Island beach consists of calcareous sand. Thameehla Island situated at the mouth of Pathein River, where the incubation was dune artificially and the average hatching percentage amounts 70% to 80% reportedly. During incubation period, with average temperature 28.6°C ± 0.5°C. Comparative results of the average hatching percentage is siliceous sand is 90.94 % and 78.55% as in calcareous sand (Gordon et al., 1985)

Olive ridley (*Lepidochelys olivacea*) the only species appears to attend on Kadongalay Island with siliceous sand beach for nesting, and hatched naturally, scrutinizing sea turtles. Olive ridley's eggs hatching on siliceous sand in nature such as; (1) Received satisfactory high percentage in hatching. (2) Average hatched temperature equalized to the sex ratio.

Therefore natural nest hatching of sea turtles on siliceous sand, it can be clearly summarize to be the most suitable condition for sea turtle conservation .

ACKNOWLEDGEMENTS

I would like to thank to Dr, Collin J. Limpus of kind assistance lecturing in training course on sea turtle conservation and management, in order to the guidance mergence success of natural nest for Olive ridley on sandy beach at Kadongalay Island and at the same time I would also like to thank gratefully to my field assistants, volunteers from Kadongalay, Gayetgyi and Thameehla Turtle Islands in Ayeyarwady Division.

Table 1. Average Measurement of the clutches from different location of Kadongalay Island beach

Nest location	Neck of clutch (inches)	Depth of clutch (inches)	Width of egg chamber (inches)	Remark
Dune	10.5	18	8.5	Average of 3 sample nests
Upper slope	8	15	9	Average of 3 sample nests
Lower slope	6	13	8	Average of 5 sample nests

Table 2. Hatching data collected from different locations of Kadongalay Island beach

Nest pillars No:	Date Laid	Location	Temp: °C	Total No: of eggs	Hatchling No:	Undeveloped eggs No:	Death hatchling No:	Hatched success (%)	Incubation period (days)
1	31.12.02	Upper slope	28.3	82	78	3	1	95.1	50
3	3.1.03	Upper slope	28.4	121	118	3	Nil	97.5	52
4	3.1.03	Upper slope	28.9	113	87	24	2	77.0	50
14	1.2.03	Dune	29.1	134	128	5	1	95.5	51
23	16.2.03	Dune	29.3	136	136	Nil	Nil	100	52
31	25.2.03	Dune	29.5	100	93	5	2	93.0	50
32	25.2.03	Lower lope	27.6	125	123	Nil	2	98.4	53
36	28.2.03	Lower lope	27.2	121	118	2	1	97.5	50
42	5.3.03	Lower lope	27.4	124	116	6	2	93.5	50
45	13.3.03	Lower lope	27.3	120	113	4	3	94.2	46
47	14.3.03	Lower lope	27.8	128	117	7	4	91.4	46

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The regional management model for ecotourism planning in the Rayong coastal area, Thailand

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ABSTRACT

In the coastal area with developing tourism, ecotourism is regarded as a means of the regional policy. To perform sustainable ecotourism needs to realize the management system on the basis of local's participation and willingness. In this study, the objective was to construct the regional management model on the basis of resident's perception and awareness to assess some important ecological and economic interlinkages between tourism, coastal environment and local society in the Rayong coastal area, Thailand. In addition, we suggested the ecotourism planning and regional management from the result of modeling. For the modeling we gathered the available statistical data and materials on tourism, environment, fishery, and local community. Furthermore, we conducted the questionnaire survey for 188 groups of tourists visiting to the Rayong coastal area, and 172 families living in the area. From this survey, some important problems in developing local community emerged, i.e. the garbage-waste problem, the economic disparities between the fishermen and the worker in tourism business. Based on these problems, we constructed the regional management model in the Rayong coastal area. According to this model, it was concluded that the ecotourism plans including the employment of the fishermen and the trash-picking program were effective to good community development in this area.

KEYWORDS: **ecotourism, area study, coastal management, questionnaire, fishery, tourism, local community**

INTRODUCTION

It's noted generally that natural environment are getting worse and worse with development of human society. In coastal area especially, we can see often the environmental deterioration because coastal zone is a point of contact between the land and the sea. In the various impacts on the coastal area, the tourism impact is rapidly increasing recently. Nature-based tourism is most popular among the tourists, in which marine tourism industry is rapidly growing. (Orams, 1999; Shackley, 1996). This trend of tourism development is expanding to the world. For developing countries, a rapid growing tourism industry has proved to be an increasingly important source of foreign exchange inflows. Nature-based tourism is an important tool for generating employment and income in underdeveloped, biodiversity-rich Third World regions because it requires comparatively small investments (Wunder, 2000). However, the tourism industry is increasingly having an ecological impact on the world's protected areas and the rising number of tourists presents both threats and opportunities (Goodwin, 1996).

Against this background, many regional managers and planners are beginning to seek the way to establish the regional management system which can realize environment conservation, tourism development, and local community development at all once. The good example of the regional management system is "Ecotourism". Ecotourism is compounded of many interrelated processes which influence the potential and success of ecotourism within a protected area and links between natural areas, the local people and tourism (Ross and Wall, 1999a). In the process of development of ecotourism, local perceptions will be an important factor influencing how its development proceeds (Campbell, 1999). Furthermore, if planning and decision-making do not involve local populations, then ecotourism will not succeed, and may even be detrimental to local communities (Ziffer, 1989). Therefore, the local perception is important key to consider the possibility of ecotourism success. Additionally, to date, although many studies have been performed about areas which are developing as an ecotourism spot, just a few have assessed how the sustainable ecotourism is realized in the place where the ecotourism is introduced in the future.

In this study, we conducted the questionnaire survey for the residents and the tourists in the Rayong coastal area which locates in the east part of Thailand. The objectives were to construct the regional management model on the basis of the resident's and the tourist's perception to assess some important ecological and economic linkages between environment, tourism, and local society in the Rayong coastal area.

In addition, we suggested the ecotourism planning from the result of modeling.

STUDY AREA

Rayong province locates at the southeast, 210 km from Bangkok faces south onto the Gulf of Thailand. Many tourists visit this area to enjoy the marine sports and their relaxation. The number of tourists increases at approximately 4% per year in the past five years. In 2002, there were approximately 2.4 million tourists (Tourism Authority of Thailand, 2003).

Rayong province has another aspect of industrial area. In 1982, Thailand government has formulated projects to develop the coastal area. Rayong province was determined to be an important stronghold for the heavy industrial development. The agricultural areas were replaced by heavy and continuing industries. And more than 6,500 rai (2,535 acres) of marine areas have been reclaimed. In 1991 when Rayong province was also developing as the tourist spot, marine areas were utilized as the reservoir of waste sink for heavy industries. This industrial development caused environmentally poor outcome in the air, the rivers and the sea (Sawasdee Foundation 2001). Although the scientific basis is not enough, this development is able to affect the ecological balance of the sea area. The area affected mostly was the coastal area, in which the resident's economic living by fishery was gotten collapsed. The total quality of marine fish landing was 166,270 tons at peak year in 1994, and then was decreasing to 79,943 tons in 1999 (Department of Fisheries, Thailand, 2002).

METHODS

The questionnaire survey was conducted in the Rayong coastal area from 20 February to 10 March 2003. The questionnaire was prepared in Thai and in English. The questionnaire survey for the residents was conducted in villages and towns along the coast. For the tourists, we conducted in 5 points; "Ban Phe", "Mae Pim Cape", "Samet Island", "Mannai Island", "Mannork Island" (Fig. 1). We interviewed 172 residential households and 188 tourist groups, of which 171 and 186 were valid respectively. The contents of the questionnaire were the personal evaluation about natural environment, economic condition and social infrastructure in the 10 years ago, at present, and in 10 years respectively, and about the environmental problem in the Rayong coastal area. Furthermore, we asked for respondent's opinion on these contents by the open question. For the residents in fishing villages, we interviewed additionally about recent fishery. The valid respondents of this questionnaire were 24 households. As for questions that were not filled out or inadequate, we excluded these responses from consideration.

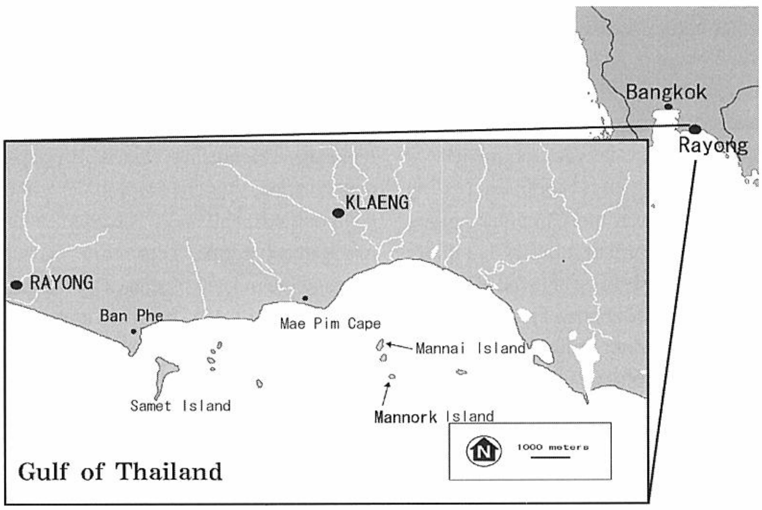

Fig. 1. The Rayong coastal area. This area locates at the southeast 210 km from Bangkok

RESULTS AND DISCUSSION

The current situation of local community form the perspective of the residents

We asked the residents for the personal evaluation about natural environment, economic condition and social infrastructure in the 10 years ago, at present, and in 10 years respectively. The number of valid responses was 170 respectively. Figure 2 shows the result of the resident's evaluation about natural environment and economic condition.

As to natural environment, many residents felt the past condition had been bad, and the current condition was better than the past. The perceptions of the future condition tended to vary with each respondent. Residents' perceptions toward the past and current economic conditions were similar to the ones toward the natural environment. In point of future, the residents tended to have optimistic feeling, although the responses varied to some extent. As for social infrastructure, many residents felt that the past condition had been bad, and the current condition was better than the past, moreover the future condition would be better than the current. According to these results it was considered that the perception about natural environment and economic condition varied with the individuals. Consequently we considered the resident's evaluation additionally on the basis of the resident's socio-demographic data.

The difference of the perception between the fishing households and the worker of tourism industry

As a result of the analysis the resident's perception on the basis of each socio- demographic data, the difference of the perception between the fishing households and the worker of tourism industry emerged. Most residents' jobs in this area were related to either fishery (n = 44) or tourism industry (n = 90). Many of the workers of the tourism industry tended to have optimistic feeling about natural environment and economic condition at present and in the future respectively. On the other hand, many of the fishing households have pessimistic feeling. As for the present natural environment, the difference between them was significant at 0.5 % by the chi-square test. As for the future natural environment, the present and the future economic condition, the differences was significant at 0.1 % respectively. These differences of the resident's perception are supported because the fishery was falling into the decline in this area (Department of Fisheries, Thailand, 2002), while the tourism industry was developing (Tourism Authority of Thailand, 2003).

There are many fishermen's opinions concerning the decrease of the marine fish landing in the questionnaire. As to the current condition of fishery, 66 % (16 of 24 respondents) answered the fish landing decreased compared with the past. Only 1 respondent answered" Unchanged". The others unanswered. As to the fishery in future, 88 % (21 of 24 respondents) answered the fish catches will be decreasing. And the other answered "No idea". Additionally, we asked 13 respondents who answered the fish landing would be decreasing about the future fishery. According to this result, 62 % (8 of 13 respondents) answered they would continue fishing here, from which we can see the fishermen persist in fishing in this area. As for the reason of the decreasing of fish catches, there is a opinion that vessel's trawling have possibility to decline the quality of the marine fish landing.

In terms of the resident's income, the average monthly income per household in Rayong province in 2000 was 14,739 Bahts (National Statistical Office, Thailand, 2002).

According to the questionnaire data, the average monthly income of fishing households (n = 22) was 12,850 Bahts, while the one of the worker of tourism industry was 18,458 Bahts. We can see the economic disparity between the fishing households and the worker of tourism industry. It was clarified that the fishing households had anxiety about their living and the fishing in future because of small income compared with the other, the decreasing of the fish catches, and the futureless of the fishing in this area.

The environmental condition form the perspective of the residents and the tourists

The environmental perception of the residents had difference between the fishing households and the worker of tourism industry as we had mentioned above. This difference was the most in perception for the future.

In addition, we interviewed the residents about the most important environmental problem in this area. The valid responses were 151 samples. In the whole, there

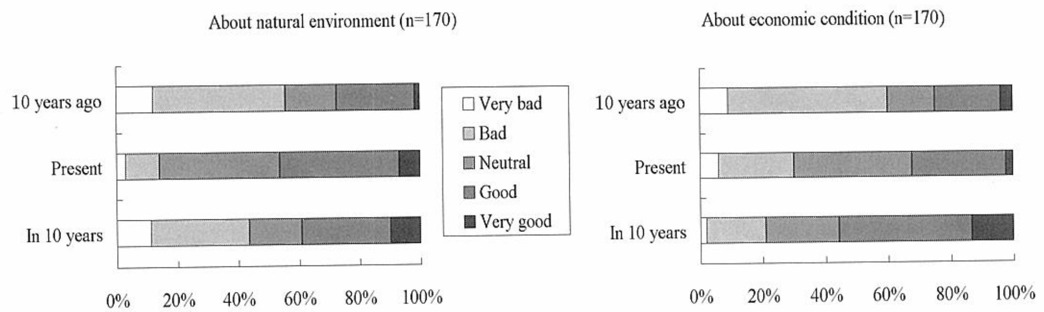

Fig. 2. Resident's evaluation about natural environment (left) and economic condition (right)

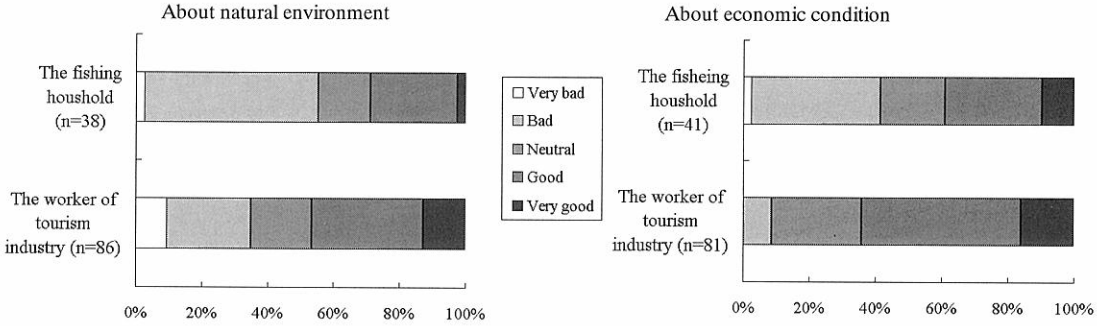

Fig. 3. The differences of the perception about natural environment (left) and economic condition (right) in 10 years between the fishing households and the worker of tourism industry (the differences were significant at 0.1% respectively by the chi-square tests)

are 40 % of the residents who answered "Garbage / Bad smell". The second and the third opinion were "Air pollution", "Decrease of marine species", the percentages of which were 21 % and 12 % respectively. The percentages of respondents answered "Nothing" were 12 %. These results show the residents in the Rayong coastal area have high level of awareness about the garbage problem.

For the purpose of the research on the tourist's evaluation of natural environment in the Rayong coastal area, we interviewed the tourists visiting this area. The number of valid responses was 176 samples. Although the responses varied by the questionnaire spots, there are more unfavorable responses of "Very bad", "Bad" than "Very good", "Good" in each questionnaire spots except "Samet Island" which is designated as the ocean national park. In the next, we asked them about impression on the Rayong coastal area by the open question. As for positive remark (n = 102), the answers were something about "Beach", "Clean Sea", "Nice climate", "Food", and "Good access". On the other hand, as for negative (n = 105), many responses were concerned with the garbage problem, the percentages of which were even 61 % of respondents who remarked negatively. In other responses, there were "Too many tourists", "High-priced". These results suggest that the environment in the Rayong coastal area was not good from the perspective of the tourists and the garbage was important problem for developing the tourism industry.

"Garbage" which mattered among the residents and the tourists is scattered along the street, on the beach, over the sea, and around the villages. Except the garbage over the sea, large part was thrown away by the residents. This garbage is much amount, to the extent which we cannot collect or clean up easily. Especially around the fishing villages there are in excess amount of the garbage. Some of the fishing households live in the house built over the garbage. Furthermore, the garbage condition got worse and worse because stray dogs foraged for food.

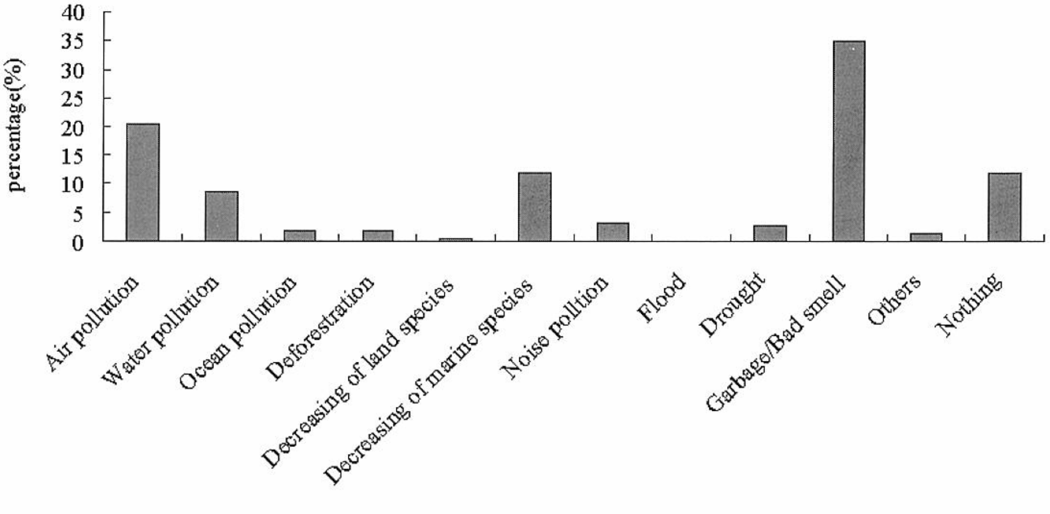

Fig. 4. The most important environmental problem in this area from the perspective of the residents: n=151

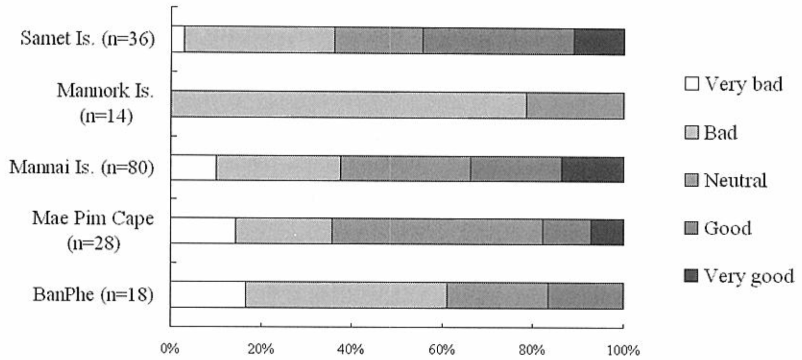

Fig. 5. The tourist's evaluation of natural environment in the Rayong coastal area (Samet Island, Mannork Island, Mannai Island, Mae Pim Cape, Ban Phe)

CONCLUSION

The regional management model in the Rayong coastal area

Based on these problems and some statistical data, we constructed the regional management model in the Rayong coastal area. This model's components are "Natural environment", "Residents", and "Tourists" (Fig. 6). As a subclass of "Natural environment", there are "Fishery resources", and "The amount of Garbage". And as a subclass of "Residents", there are "Fishing households", and "Worker of tourism industry". The interlinkages between all components show certain impact of one to the other, e.g. economical revenue, environmental destruction, and increment of the tourists. Introduction of ecotourism creates new linkages in this model.

The current situation of tourism is very well and if the Rayong coastal area develops under the present circumstances, it is expected that the tourism industry grows and with which the number of the tourists is increasing for some time in the future.

Although it is not clear whether the ocean pollution gets better or worse, it is suspected that the decrease of the fishing catches still remain for a while. Some measures toward the coastal fishery and the fishing households are required quickly.

A lot of tourists, especially the foreign tourists, are displeased for the garbage. Recently the eastern coastal area in Thailand is being developed as a tour spot, for example Chanthaburi province and Trat province. The neglect of the garbage problem will cause the drain of the tourists to the other tour spots. The effect of the tourists on environmental doesn't come to the surface yet. But, the region managers or planners have to pay attention to the environmental pollution and the garbage problem caused by the tourists. Therefore, it is considered that the garbage problem was dealt with seriously from the resident level.

In terms of the resident's income, the income of the worker of tourism will increase as tourism develops in this area. In the other hand, the income of the fishing households will decrease as fishery gets into a decline. This income gap is expected to widen more and more in the future. From the result of the questionnaire, most of the residents are natives. Some emigrated to work from other area. Immigrant flow is getting to extend, and in the future this trend will go on because the tourism industry will also develop. The important thing is to provide economic and social revenue to the residents accurately, not to the tourism companies. Additionally, it is important to give alternative income sources to the poor fishing households.

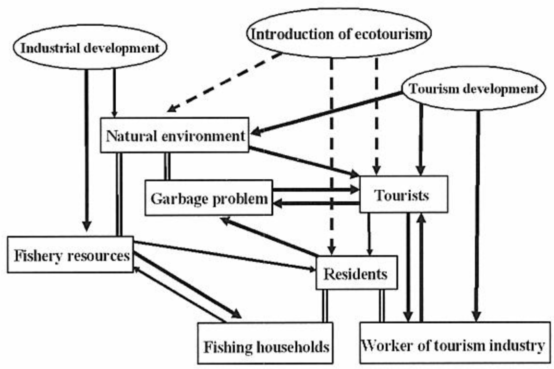

Fig. 6. The regional management model in the Rayong coastal area.

Ecotourism planning in the Rayong coastal area

To date, the definition of Ecotourism has been arranged by lots of scientists (Boo, 1992; Ceballos-Lascurain, 1991; Cater, 1994; Ziffer, 1989), and the concept was modeled by Ross (1999b). However, the reality varied with each land characteristic and the main purpose of ecotourism. In this study, considering the ecotourism planning in the coastal area, it was clarified that the local community had some groups which had different aspects. In the case there are some local groups related with ecotourism like the Rayong coastal area, it is considered that the relationships between local groups or their occupations are very important. Additionally in case there are many low-income fishing households like this, even if they are related to ecotourism directly, their livings should not be oppressed with the development of ecotourism. By contrast, we have to make a ecotourism plan which can present new employment opportunities to them.

As Campbell (2002) said, local perceptions will be important factor in promoting to develop on the ecotourism. On the basis of this concept, the fact that the fisheries households feel good about the environmental and economic condition will fuel their motivation so much to participate in ecotourism. Meanwhile, although the local people tended to have further income, but not want any life-altering risk in this area (Okuyama *et al.,* 2003). Additionally, we can see the fishermen persist in fishing in this area. This implies that the difficulty in introducing ecotourism into the Rayong coastal area, because their hope for not altering the present life could motivate them to avoid new things. To make the fisheries households to be willing to develop ecotourism by themselves, ecotourism will have to be something appealing that they can benefit from. Therefore, when we will introduce ecotourism, whether we can make a program which gives another job that the fishing households want (for example, the short time job which we can employ many people) to them can be the key to the success of ecotourism.

To solve the garbage problem and the economic discrepancy is the best way to manage this regional area. In order to realize ecotourism, it should make the ecotourism planning including the solution of these problems. Now the Sea Turtle Conservation Station in Mannai Island is promoting the project to gather the tourists (ex. constructing the information center). The prospective scenarios in introducing ecotourism in the Rayong coastal area are as follows; to increase the tourists because the tourists get another chance to visit to this area, to secure the resident's income, especially the fisheries households, because the employment opportunities are increased. Concretely, the employment as a reception in the information center, the boatman to some Islands and the cleaner in the Rayong coastal area are considered as the appropriate ecotourism planning.

ACKNOWLEDGEMENT

The author's research is supported by all of the members of the Sea Turtle Conservation Station, Eastern Marine and Coastal Resource Research Center. Thanks are extended to the National Research Council of Thailand who approved this study.

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EMCOR Information Center at Mae Pim Beach, Rayong, Thailand

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ABSTRACT
An Information Center was constructed at Mae Pim beach in the province of Rayong, Thailand in order to address the lack of knowledge of the coastal communities within and adjacent Rayong province regarding the sustainable use of marine and coastal resources. The information Center was realized through the efforts of the Eastern Marine and Coastal Resources Research Center (EMCOR) in cooperation with the Sunthonphu district and Ford Motor Company. Information regarding the biology, ecology, and conservation of marine endangered species; marine ecology; and researches conducted by EMCOR can be found in the Information Center.

KEYWORDS: information center, Rayong province, east coast of Thailand

INTRODUCTION

In the past centuries, Thailand's marine and coastal resources had been exploited haphazardly resulting in the decrease in mangrove forests and sea grass beds (which serve as nurseries for fishes), and destruction of coral reefs among others contributing to the decline of biodiversity as in figure 1. There are some causes of declining of marine animals such as sea turtle, dolphins, whales and dugong. More over some human activities such as fishing gears, environmental pollutions from industry and municipality discharge and boat travelling around shallow water are the cause of decreasing of dugong (Adulyanukosol, 2545; Intarasook, 2546) On October 2002, the Ministry of Natural Resources and Environment and the Department of Marine and Coastal Resources (DMCR) was established. The DMCR was mandated to develop relevant regulations regarding marine and coastal resource utilization with the objective to look after the marine and coastal resources through conservation, rehabilitation, and to ensure socio-economic integrity for future generations.

Activities in the management plan of the DMCR include mangrove reforestation and educating and inspiring the public to participate in the activities of the Department in promoting sustainable marine and coastal resource utilization.

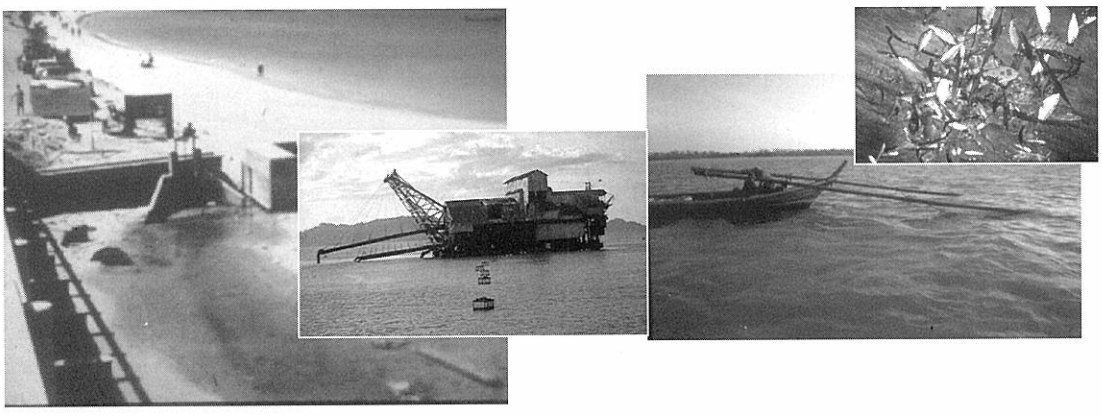

Fig. 1 Sample of haphazard exploitations

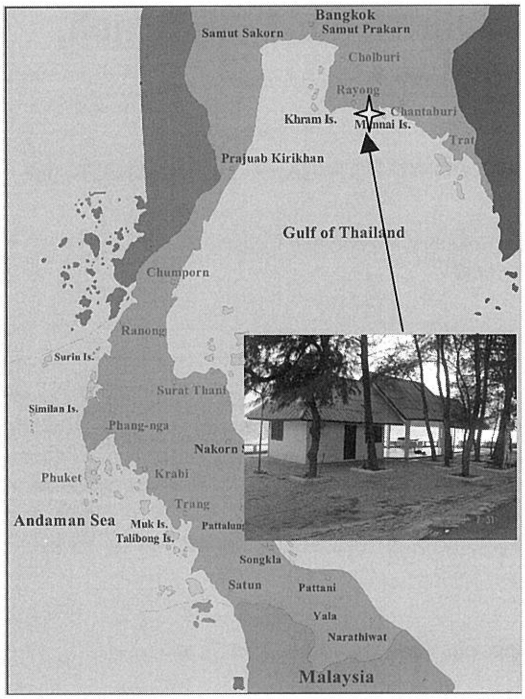

Fig. 2. General location of Information Center in Rayong province

EMCOR INFORMATION CENTER

In order to effect the education and information dissemination component, the Eastern Marine and Coastal Resource Research Center (EMCOR) of DMCR in cooperation with the municipality of Sunthonphu district and the Ford Motor Company established an information center in Mae Pim beach, Rayong province, east coast of Thailand. The EMCOR Information Center was established in Mae Pim beach in order to facilitate an easy access in communication and information within and adjacent Sunthonphu district and to promote Rayong province as a tourist destination.

OBJECTIVE OF THE EMCOR INFORMATION CENTER

1. To provide a venue for public service in the field of marine and coastal resource management and to serve as focal point for the involved local stakeholders of Rayong, the government, academe, and non-government organizations.

2. To promote understanding and awareness of the threats and degradation in marine and coastal resources and to inspire public participation in marine and coastal resources and to inspire public participation in marine and coastal resource rehabilitation and conservation.

CONSTRUCTION OF THE EMCOR INFORMATION CENTER

The EMCOR Information Center is furnished with molded statues of marine endangered species that include sea turtles, dugongs, dolphins, and whales. Also, a computer and videos for film showings are furnished the Information Center as in figure 3 and figure 4. Information concerning the biology, ecology, and conservation of marine wildlife; marine ecology; sustainable use of coastal and marine resources; and studies conducted by EMCOR are offered in the Information Center. Also, tourist destinations in Rayong province are provided as in figure 5.

CONCLUSION

The EMCOR Information Center embodies the interests of the local government of Rayong, non-government organizations, and other concerned citizens to support the National Government in its cause to promote conservation and sustainable use of marine and coastal resources in the country.

Fig. 3. Location of molded statues in the Information Center

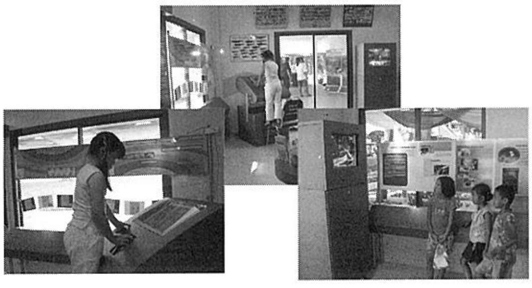

Fig. 4. Location of computer and videos in the Information Center

Fig. 5 Position and style of Information charts in the Information Center

ACKNOWLEDGEMENTS

The authors acknowledges EMCOR-DMCR, the municipality of Sunthonphu district, the Ford Company, the graphic designers for the posters and computer information provided for the Information Center, and finally the sculptors of the marine wildlife statues.

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The primary assessment on the dugong population in Viet Nam

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ABSTRACT
The biggest dugong reaches to 3m in length and weighs more than 500 kilograms. Dugongs swim in the shallow coastal waters of southern part, which have protected them from large waves and storms. Dugongs float up only to breathe, and never come on to land. There is still lack of information on the population status of dugong. The Research Institute for Marine Fisheries (RIMF) and other institutions estimated that there are approximately 25 to 100 dugong individuals still living in the Southern part of Viet Nam. However, 5-6 dugongs were incidentally died each year in Phu Quoc, Con Dao and Tho Chu Islands as well as their adjacent, where are the most important seagrass meadows in Vietnam Seawaters. Dugongs are considered as a protected species listed in "Red Data Book" of Viet Nam as well as listed by CITES under the highest at-risk category. They only live in or in the vicinity of plentiful seaweed and seagrass, which has been destroyed due to the pollution, dredging and farm soil being washed into the sea. Dugongs have the dramatic decline in their numbers. Serious threats include the environmental degradation, serious typhoons (*Linda* hurricane for example), which destroy their favor habitats, and the accidental catch of dugongs in fishing operations, especially by trawling with big mesh-size and open-mouth net. The results of this study add important information about this species to the sparse information currently available, and recommend further research required particularly for Vietnam and neighbouring countries. Additionally, exchanging information, experiences and constructive discussions on proper actions and cooperation in terms of the scientific research, coastal management and the responsible fishing operation will be positive direction towards a better future for the dugong population in Vietnam.

KEYWORDS: **Dugong (*sirenian*), family *Dugongidae*, calf, seagrass meadow, *Thalassia hemprichii* (Co bo bien), *Enhalus acoroides* (Co dua bien), *Halophyla ovalis* (co xoan), "cao bay" trawling net, Phu Quoc and Tho Chu (Kien Giang Province) and Con Dao National Park (Ba Ria-Vung Tau), Marine Protected Area (MPA).**

INTRODUCTION

There are few scientific records available about the distribution, abundance and ecology of dugongs in Vietnam. Dugongs are referred as "Sea Cows", because they graze on seagrass. They are the only mammals that eat large amounts of seagrass, leaving behind feeding trails of bare sand and uprooted seagrass. Primarily foods of dugong are sea grasses and sea algae (Koike, 1999). Dugong (*Dugong dugon*) has wide range of distribution, from longitude 30°E to 170°E and between the latitude of 30°N to 30°S. Dugongs are the only Indo-Pacific sirenian species alive today, occurring in limited numbers in various locations of Indonesia, Malaysia, Thailand, Myanmar, Papua-New Guinea, Philippines, Australia, Japan and Viet Nam (Nick Cox, 2002).

However, their population is thinly distributed in scattered groups within this range of seawaters. The dugong population is fast thinning in their range of distribution and is definitely an endangered species that are close to extinction.

The World Conservation Union (IUCN) has classified dugong as a vulnerable species for several years (Anonymous, 2000). Dugongs are a protected species also in Viet Nam. Dugongs only live where there is abundant seaweed and seagrass, which is being destroyed by dredging, farm soil and pollution being washed into the sea. They are also accidental victims of trawler net fishing (Cao bay) and gill net (Nguyen Long, 2003).

There is an increasing demand to use coastal zone for residential, recreational, and agricultural purposes. These activities will make the coastal zone more susceptible to the pollution, which cause the destruction and degradation of the seagrass beds. Pollution can also affect dugong physiologically through the bioaccumulation of toxic compounds. Dugong has been reported to accumulate mercury and chlorine compounds in the muscles (Anonymous, 2003).

Fig. 1. Location map for Southern Vietnam and Cambodia (modified from Marsh et. al., 1999)

The purpose of this study is to present a brief overview of the status of the dugong and its management in Viet Nam. We intended to provide comparative information that will enable us to develop our national conservation plans for dugong and other listed species.

This paper contains little information of previous survey on dugong biology, distribution and abundance, threatening processes, legislation, and existing and suggested research and management proposals for Viet Nam.

The special objectives of this study are:

- To identify areas that still appearing significant numbers of dugongs;
- To consider how the negative impacts on dugongs can be minimized and their habitat protected;
- To identify the suitable areas for dugong conservation;
- To foresee and consider coordinative management plans for dugongs across neighboring water bodies if required.

MATERIALS AND METHODS

The range of dugong distribution is huge and scattered, making the data of the population dugong is quite difficult and costly. Aerial survey is the best method of assessing their population, but it is never used in Viet Nam because it is highly dependent on the weather conditions, the transparency of water and the available facilities. Therefore, within this research, the following way has been used to the primary collection of the related information:

- ✓ Field survey on the fisherman boats, assess the using fishing gear and their impacts,
- ✓ Gather and collect information from logbook of fishing boats,
- ✓ Collect information and news from Navy Force, Marine Investigator, Local Fishery Department,
- ✓ Interview and discussion by face-to-face, telephone, mobile phone, email in relation to dugong topic,
- ✓ Use questionnaires and analysis feedback,
- ✓ Take picture of specimen and habitats.

Phu Quoc and Tho Chu (Kien Giang Province) and Con Dao National Park (Ba Ria-Vung Tau), which situate in the Southern part of Viet Nam seawaters (see more in fig. 4), have been selected as the study areas for data collection from 1997 till 2003.

RESULTS AND DISCUSSIONS

Phu Quoc, Tho Chu and Con Dao archipelagoes in southern Vietnam, are locations in the country where dugongs are regularly seen. Recent seagrass surveys in the coastal waters of Con Dao, Tho Chu and Phu Quoc Island, recorded several apparent dugong feeding trails (Pham Ngoc Tuan, 2003), and evidence of the existence of dugongs around those areas are supported by reports of locally caught dugong meat being sold openly in local markets. Previous results from local fisher surveys conducted in Cambodia suggest the existence of a dugong population around Kep and Kampot, near to the Vietnamese border and Phu Quoc island (Beasley *et al.,* 2001).

Interviews for local fishermen were conducted in 2003 in Phu Quoc-Tho Chu (Kien Giang province) and Con Dao (Ba ria-Vung Tau province) revealed that dugongs were seen much more regularly and in greater abundance 10-25 years ago than they are now. Whilst it appears that dugongs were often hunted specifically for meat and medicinal purposes, dugongs caught now, are done so accidentally, and mortality is presumable as a result of drowning in nets. More than thirty dugong carcasses were recorded in Phu Quoc, Tho Chu and Con Dao between 1997 and 2003.

SOME BIOLOGICAL CHARACTERISTICS

Dugong dugon belongs to the family Dugongidae. Sirenians are lonely, travel in pairs, or associate in groups of three to about six individuals. Generally slow and harmless, they spend all their life in the water (Lang Van Ken.

1997). They are vegetarians and feed on various aquatic plants (Kasuya *et al.,* 2000).

Dugongs surface only to breathe, and never come on to land. Female Dugongs give birth underwater to a single baby. Birth takes place in shallow water and the baby dugong is able to swim to the top layer of the water for its first breath. Baby dugongs are about 100 to 120cm long and weigh 10 to 30 kg. The calf stays with its mother, drinking milk from her teats and following close by until 18-24 months of age (Aquino. 1998).

Based upon our staffs' observation in October and November, 2003 described that feeding dugong occurs primarily at night, when animals enter shallow waters to graze. Dugongs require about 25-30 kilograms of food per day (estimation based upon on their weight). In addition, when grazing, the dugong "walks" along the seabed with its flippers. The average swimming speed is about 2-7 km per hour, but if pressed this speed can be nearly doubled over short distances. Dives generally last 1-3 minutes, surfacing for very short periods per breath. Destructive behavior is very rare. Language, including whistling sounds and bleats, are generally only used when frightened. Breeding may occur throughout the year, although many births occur between July and September, annually (Nick Cox, 2002). Young animals hitch rides on their mother's backs, surfacing and submerging in enforced harmony. Although the drinking of milk continues for a year and a half, young dugongs begin sampling sea grasses at about three months of age. Dugongs feed strictly on submerged vegetation-leaves, roots, and rhizomes of seagrasses and sometime seaweed. Babies of dugongs are breast-fed for about 18 months and after weaning will stay with the mother until new calves are born (Adulyanukosol *et al.,* 1998).

With the low reproductive rate, long generation time and a large investment in each offspring, it is estimated that the maximum rate of increase is likely to be about 5 % per year (Anderson, 1981). As such, they are susceptible to over-exploitation. Their vulnerability increased by the dependence on a specialized environment, the sea grass habitat. In Vietnam, dugongs reache 3m in length and weighs more than 500 kilograms. Dugongs swim in the shallow coastal waters of southern part were they find protection from large waves and storms. Dugong males have ivory tusks used for fighting during male-male competition and caused of injure by themselves as well as for uprooting seagrasses (Nick Cox *et al.,* 2003).

SEAGRASS ASSESSMENT

Seagrass play an important role in terms of adjustment and balance for coastal ecosystem; accretion and building up of sea substructure and as living habitats for dugongs. In addition, their functions have been recognized in the national strategies for sustainable fisheries development. There are 10 species of seagrasses had been found at those studied locations, namely: *Enhalus acoroides, Halophyla decipiens, H. minor, H. ovalis, Thalassia hemprichii, Cymodocea serrulata, C. rotundata, Halodule uninervis, H. pinifolia, Syringodium isoetifolium.* Total area of alone seagrass ecosystem is approximate 1930 ha in Phu Quoc, Con Dao and Tho Chu Islands as well as their adjacent seawaters (Nguyen Xuan Hoa, 2003 and Nguyen Van Tien, 2003).

Due to the poor perception and together with many kinds of mismanaged operations, those resources, however, have being exploited and reduced, environment polluted, habitats of aquatic animal seriously decreased and degraded. The best ways to preserve seagrass is by leaving it undisturbed, mainly by preventing trawling, maintaining water quality by reducing nutrient and suspended solids loads and by using appropriate fishing gear.

The value of the products and ecological services provided by the seagrass systems of the South China Sea is estimated at US$ 22,400 per ha.year. The area of seagrass is not known precisely and improving estimates of the area and economic value of seagrass beds in the South China Sea is a key to improving their management (Fortes, 1993).

Table 1: Area of seagrass at three studied sites

Index	Con Dao	Phu Quoc	Tho Chu	Others	Total seagrass of Viet Nam
Area (ha)	644	966	322	2668	4600
Percentage (%)	14	21	7	58	100

Table 2: The eyesighted dugong during period of 1997 till 2003

Index	1997	1998	1999	2000	2001	2002	2003	Average per year
Eyesighted dugong	77	82	34	56	71	63	49	61 ± 1

DUGONG IMPACTED BY HUMAN

The result survey conducted by Research Institute for Marine Fisheries (RIMF)'s researchers suggested that the predictable amount of 5-6 dugongs were killed each year in Phu Quoc, Tho Chu and Con Dao Islands and their neighboring, which is the most important dugong school in Viet Nam Seawaters. Although communities are not dependent upon the harvesting of dugongs, these animals are highly prized as food items. Since there is the weak enforcement of regulation to restrict the use of modern equipment, efficient hunting is possible. If the rate of died dugong population is greater than the renewable rate of dugong population of 10 % per year, then the dugong population is dropping.

Dugongs are slow moving and have little protection against predators. Being large animals, however, only large Sharks, Saltwater Crocodiles and Killer Whales are dangerous to them, but main Predators are humans. Threatened until recently by hunting for its meat (which is said to taste like beef), leather-like cover or fur-suit, oil (24-56 liters per adult), and bones and teeth, which are used to make healthy glues.

In the previous years, the southern Viet Nam seawaters (including Phu Quoc, Tho Chu and Con Dao island) population dugong was counted that there had been attached approximately 42 individuals since 1990's (Nick Cox, 2002 and Pham Ngoc Tuan, 2003). The recorded data were collected in relation to dugong appearances during the period of 1997 till 2003, based upon the locally fisherman interviews, logbook on the fishing boats had been made by the concerning officers of those Provincial Department of Fisheries Protection that listed in table 2.

The major kind of fishing gear is the gill net and trawling net (which consist of 72% of total multigears) has reduced population off the coastal areas in southern Vietnam. The especial trawling with big mesh-size net "Cao bay" has significant reported to accidentally kill the dugongs (Nguyen Long, 2003).

Fishermen at Phu Quoc accidentally trapped an adult dugong on 10th December 2002. Other 9 of dugongs were attached during period of 2002 in the northern part of Phu Quoc Island (Ham Ninh seawater). Local fishermen trapped them and sold their meat with price of VND 25-35 thousands. Local informants always observe dugong and some of them think that they are only appearing in Ham Ninh seawater nearby a great seagrass meadows, which elongate approximately 20 km from Ham Ninh to Hon Son. This area maintain 3 species of sea grass, namely *Thalassia hemprichii* (Co bo bien), *halophyla ovalis* (co xoan) and *Enhalus acoroides* (Co dua bien) that is the most favor food of dugong (Fonseca, 1987).

During the field survey, the informant also mentioned that dugong usual appear during July till November (Summer- Autumn). In addition, dugong is couple or group and one of them was caught, another turned around to look for missing one. That is a reason why dugongs have been trapped nearly entire group. According to the analyzed results from those studied areas, the distribution of dugong in Viet Nam are showed in table 3 and figure 2.

According to our result, there is a close relationship between eyesighted dugong and seagrass abundance (see table 4 and figure 3 below).

From the figure 3 showed that there is a close relationship between the abudance of seagrass and frequency of dugong eyesight at the studied location.

Table 3. Distribution of dugong in Vietnam Seawaters during period of 1997-2003

Location	1997	1998	1999	2000	2001	2002	2003	Locally average appearance per year
Con Dao	15	21	17	23	19	16	15	18 ± 1
Phu Quoc	35	31	11	19	28	26	32	26 ± 1
Tho Chu	27	35	6	14	24	31	2	19 ± 2
Total	77	87	34	56	71	73	49	63 ± 2

Table 4. Abundance of seagrass and frequency of dugong observation at three studied sites

index	Con Dao	Phu Quoc	Tho chu
Percentage of seagrass (%)	14	21	7
Frequency of dugong (%)	18	26	20

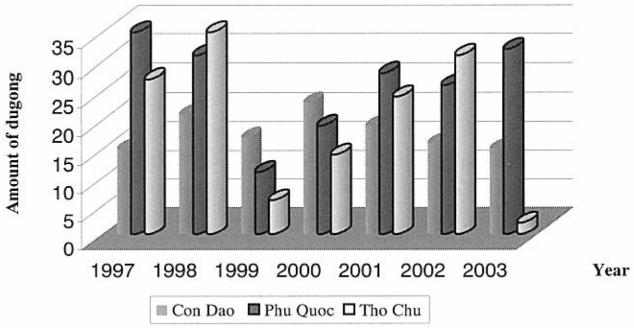

Fig. 2. Distribution of dugong in Vietnam Seawaters

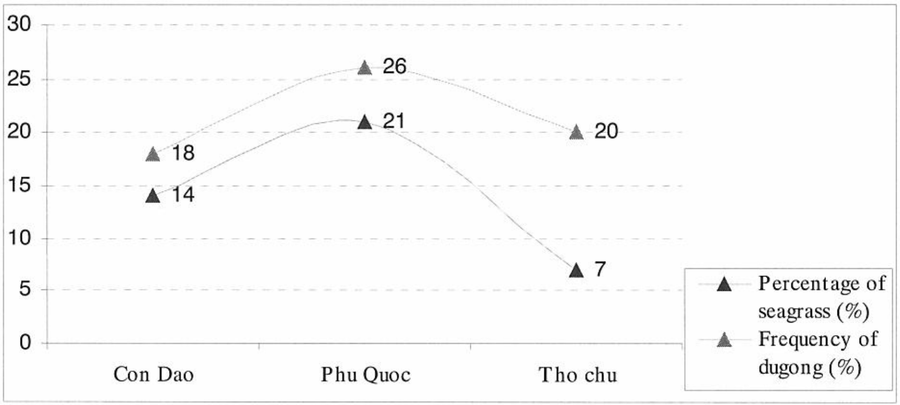

Fig. 3. Abundance of seagrass and frequency of dugong observation at three studied sites

MANAGEMENT APPROACHES

The dugong population is declining and they are in serious risk of extinction in Viet Nam due to limit of proper management in controlling of the fishing operation and nowhere to be found they are properly protected. Without conservation measures taken in Viet Nam such as prohibiting harvest and protection of its habitats. A questionnaire survey of dugong abundance in southern part of Kien Giang, Con Dao and Phu Quoc have been conducted by local authorities since 1998 due to the general concern about the local status of the dugong population. Additionally, those were followed by boat surveys that had been conducted since 2000.

Research

The research is to acquire information to assist in the recovery and maintenance of dugong populations. An integrated research project has been initiated since 1997, which reflect a wide range of priorities among managers, researchers and stakeholders with interests in dugongs. This project has been incorporated into the Dugong Research Strategy for Viet Nam in the forthcoming year. The categories include:

- ✓ Project designed to assess the effectiveness of the current dugong protection measures,
- ✓ Project likely to result in information, which will directly assist in maintaining dugong numbers,
- ✓ Project that will assist with the development and implementation of cooperative management arrangements,
- ✓ Project designed to minimize the impacts of man agement decisions on affected groups.

High priority should be given to monitoring dugong distribution and relative abundance using regular boat surveys and questionnaire circulation. Regular seagrass surveys are also required to assess temporal changes in seagrass meadows, and the impacts of events on dugong habitats in the Vietnam Seas. Research is also to study seasonal changes in seagrass growth rates and productivity with a view to developing a model of dugong grazing. Satellite tracking of dugongs in key areas is not available but those will provide detailed information on dugong habitat use, but has to get the permission from Ministry of Defense. Such information will be very useful for assessing the local impacts, for proposing the developments on dugongs and for other wildlife species.

Local Management

There is still a strong desire within the local communities to hunt dugongs as they are economic importance. All groups involving recognize the need for the development of cooperative managements and arrangements for marine resources between management agencies and local peoples. The success of cooperative managements and arrangements will involve communities being a full partner in all stages of the management process, bringing together customary owners, science and management. The next step in this process is a formal agreement between the partnerships, which will need to provide the resources required to operationally cooperative management.

In order to develop a better understanding of small scale population changes in dugong populations, community-based dugong preservation programs will have to be developed incorporating local expertise, provided personnel are available to coordinate such programs. This activity would contribute to developing appropriate mechanisms and tools for integrating local knowledge and scientific data.

Fishery Interactions

The effectiveness of the mesh netting restrictions and attendance in the Marine Protected Areas (MPAs) need to be monitored. It is important to note that a significant proportion of dugongs along the south coast of Viet Nam occur outside these Marine Protected Areas.

Therefore, management regimes for the dugong's area of possession but outside the MPAs need to be considered if the objective of management is to minimize human impacts on dugongs.

Regulation and enforcement

Viet Nam are supporting the following initiatives to maximize the effectiveness of fishing closures in the Marine Protected Areas (MPAs):

- ✓ Legislation of attendance at net rules under the Fisheries Resource Protection ordinance, which propagated in 1989;
- ✓ The enhancement of surveillance and enforcement patrols to focus on the MPAs. The intensity of patrolling and surveillance varies based on programmed priorities (i.e. knowledge of illegal activity and records of dugong deaths);
- ✓ Severe penalties for breaking netting regulations;
- ✓ The development of performance indicators to assess the impacts of the MPAs;
- ✓ The introduction of further measures to address impacts on dugongs other than mesh netting, especially in the MPAs (i.e. coastal runoff, habitat degradation);
- ✓ An independent socio-economic investigation of the operations of fishers with netting endorsements that are operating nearby the MPAs. The study will include an investigation on which fishers are using the current MPAs. A social impact assessment on resource used to (commercial and recreational fishing and tourism) in each of the MPAs to assess the implications of any further modifications to regulations in the MPAs;
- ✓ An investigation of how the current regulations in the Marine Protected Areas could be further modified to reduce adverse impacts on dugongs.

National framework Management

The effectiveness of the mesh netting closures and restrictions depends on there being no overall movement of dugongs from the one to other areas. To minimize the risks of this happening, it is particularly important to conserve dugong habitat, especially in the Marine Protected Areas.

The relevant management should collectively review the zoning of the relevant sections of the Marine Protected Areas and Fisheries Habitat Areas with a view to assessing their capacity to protect dugongs and their habitats. Key areas should be the focus. This initiative will provide resolve in the selection of seagrass and dugong habitat for inclusion in highly protected zones of the Marine Protected Areas.

The Marine Protected Areas will be zoned in consultation with user and interest groups, and will enhance the prospect of dugong survival in the area. Seagrasses and mangroves are given specific protection in Fisheries Habitat Areas, where all marine plants are protected, and can only be damaged or removed under permit.

CONCLUSION AND RECOMMENDATION

The Con Dao, Phu Quoc and Tho Chu National Park have been identified that still appearing significant numbers of dugongs. Those locations are the highest amount of dugong population, because of being distributed seagrass bed, the feeding habitats. The National Park Authorities controlled the harvesting of dugong by the national regulation system. Dugong is now endangered and being strictly protected. A proposal recreation of aquarium is needed, for display and research purpose will be succeeded in taking care of these animals for few years. The long-term effectiveness of those areas will depend on community support and the maintenance of the dugong habitat by the marine protected area (MPA) establishment and management. It is important to have a high precision of population estimates for this vulnerable species. Precautionary management measures should be taken to minimize the continuing harvest and reduce the negative impacts on dugongs. It is recognized that it will be essential addressed for the socio-economic balancing adjustment to dugong conservation from governmental authorities. Finally, exchanging information, experiences and constructive discussions on proper actions and cooperation in terms of the scientific research, coastal management and the responsible fishing operation will be positive direction towards a better future for the dugong population in Vietnam and other countries in our region.

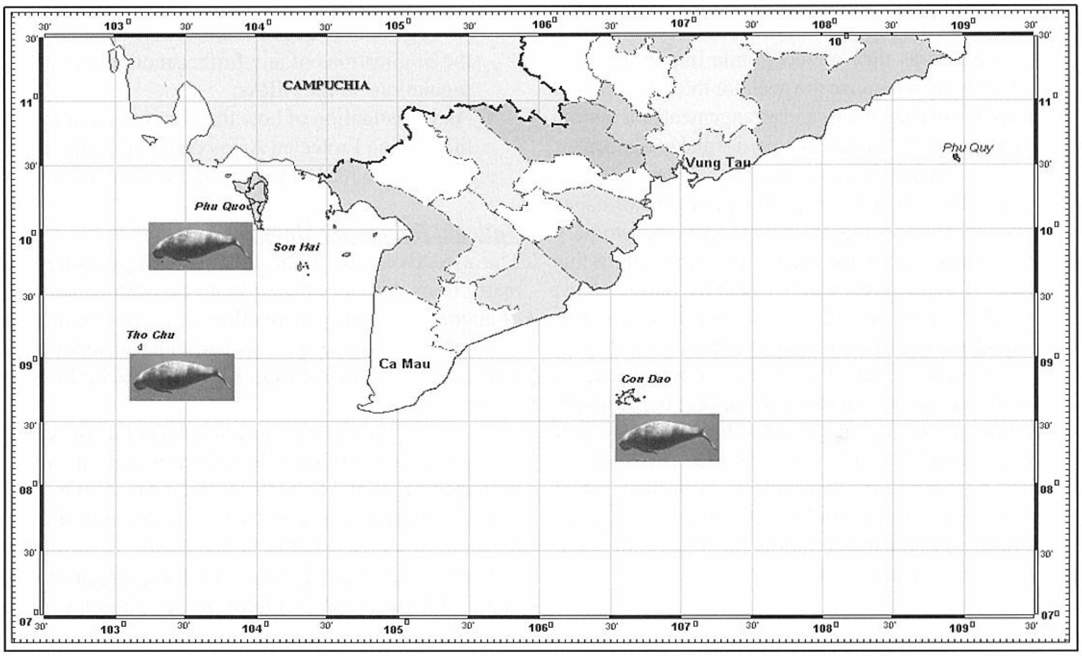

Fig. 4. Primary Map of Dugong distribution in Southern Part of Viet Nam

Fig. 5. Typical surfacing, and submerging sequence of dugong in Con Dao National Park

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Acoustical analyses on the calls of dugong

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ABSTRACT

Dugong, *Dugong dugon*, has become one of highly endangered species in the world. It is said that the decrease in the number of dugong population is mainly due to accidental catches by fishnets. A breakthrough to avoid the accidental catches, by-catches, is in urgent need. In this study, we described the technique to detect the direction of vocalizing dugong and the acoustical characteristics of dugong calls. This study can lead to a new observation method of wild animals. A number of dugong calls were recorded around Libong Island, Trang, Thailand, using two sets of dual channel stereo hydrophones on two research vessels. The center frequency of dugong calls ranged from 3-8 kHz, and the duration of the calls was classified roughly in two: 100-500 ms and over around 1000 ms. Vocalization intervals were classified in two patterns: 0 - 5 s and about over 20 s between each call. We applied the phase difference analysis to dugong calls recorded by a stereo hydrophone. The preliminary results suggested that the acoustical analyses on the dugong calls will be a powerful method to locate the vocalizing dugongs without any impact on them at all.

KEYWORDS: **passive acoustical observation, acoustical characteristics, vocalization interval, direction analysis, arrival direction, arrival phase difference, sound pressure level**

INTRODUCTION

Dugong, *Dugong dugon*, is one of the endangered species. They live in warm and shallow seawaters distributing throughout the world. The northern limit of their habitat is around the main island of Okinawa, Japan. The population of dugong in Okinawa, however, is said to be less than 50 (The mammalogical society of Japan), which is very small compared to other dugong habitats in many parts of the world. The decrease in the number of dugong population is mainly due to accidental catches by fish-nets and a death of an individual can cause a significant damage to the population. It is also of great interest to the fishermen in Okinawa, the area where the most sightings of dugong have been reported overlaps the main fishing area, which is off the north-east coast of the main island of Okinawa. Dugong protection and fishing restriction are the two conflicting matters to be solved. A powerful breakthrough to prevent dugong from these by-catches is in urgent need.

To protect the dugong population, we need to know their behavioral ecology such as moving paths and the usage of seagrass beds in the proposed area. The ecology of dugong, however, is not well-known, yet. Recently, passive biotelemetry techniques using underwater acoustics to locate or to observe presence of vocalizing marine mammals have been developed rapidly. Passive acoustic observation has been applied extensively for non-observable animals such as manatees (Phillips et al., 2004). In the manatee case, collision with boats has been a major cause of its deaths. To avoid the collisions, manatee calls are automatically detected out of the background noise in order to warn boaters of presence of manatee. We applied this technique to study the behavioral ecology of dugong. The passive acoustic observation uses arrival time difference at separated hydrophones to calculate arrival direction of a call. Its' main advantage is that it has no effect on behavior of the animal of study and it can be used to monitor vocal behavior of several individuals at once. To perform an effective monitoring, the animal of study must vocalize frequently and their calls must be easily separated from the background noise.

In this study, detection of arrival direction and acoustic characteristics of dugong call are described. These aspects are necessary in designing a new monitoring device to identify each individual and to warn fishermen of presence of dugong. This study will lead to an innovative monitoring method for dugong.

MATERIALS AND METHODS

Study site

For our survey, behavioral records and vocalization data are indispensable. Because the population of dugong in Okinawa is too small to perform a successive survey, we set our study site around Libong Island, Trang, Thailand (longitude N07°12'58.4" latitude E99°24'21.9"), where many sightings of dugong were reported beforehand. We set 5 study areas (#0 - #4) around the Libong Island (Fig. 1). The survey was conducted from 3rd of March to 6th of March. On the first day (3rd, March), recording was performed around #0, #1, and #2. But the background noise including pulse sounds was very loud and neither sightings of dugong nor the dugong vocalization was observed. On the second day (4th), we moved to the southern part of the Island (#3 and #4), where many sightings of dugong were reported during the proceeding survey that was conducted from 23rd to 29th of January, 2003. The background noise at station #3 was also too loud to record dugong call. Station #4 best suited the survey condition in the matter of recording and the number of dugongs sighted. So, for the rest of the survey (5th and 6th), the recordings were conducted in station #4.

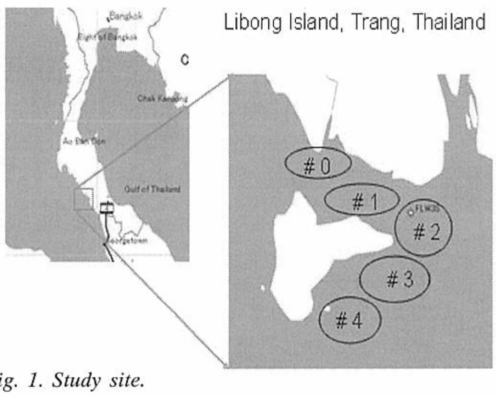


Fig. 1. Study site.

Equipments

Each of the two research vessels (vessel - A, B) were equipped with a set of two dual channel stereo-hydrophones (OKI ST1020), an amplifier (OKI SW1020), a digital audio tape recorder (SONY TCD-D8), GPS (Garmin GPS III), an echo sounder (HONDEX HE-5620), a compass and a distance meter. The array distances of the hydrophones were 5.2m (vessel - A) and 7.0m (vessel-B). (See Fig. 2 for the block diagram of the devices.)

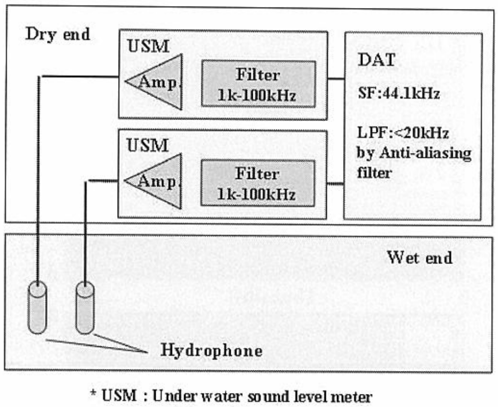


Fig. 2. Block diagram of the recording system.

Aerial survey

An aerial survey was performed simultaneously to support the visual observation from the research vessels. It is one of the most effective methods to observe the presence of marine mammals. Micro Lite flew at right angles to the shore repeatedly to perform an aerial survey at the same time as the recording of the underwater sound. The pilot of Micro Lite sat in front and the passenger in the back. Since the pilot had a good look out ahead and sideways, the pilot watched the front and the sides, and the passenger watched the both sides. When the observers on the Micro Lite found dugongs, the number of dugongs and their behavior were reported to the recording vessels using mobile phones. Micro Lite flew twice a day, in the morning and the afternoon. The flight duration varied depending on the number of the animals they found.

Recording

Recordings of underwater sound were started soon after the vessels reached the study site, using the DAT recorder, TCD-D8, with sampling rate of 44.1 kHz. The hydrophones were set at 1 m deep. The recording range was 120 dB, and 1 kHz high pass filter was applied. The vessels were anchored to keep the distance between each vessel in 100-300 m. The distance between the research vessels was measured with a distance meter. The direction from vessel - A to vessel - B was measured with a compass. When the observers in the vessels found dugongs, the distance and the direction to dugongs were measured. At the same time, the heading directions of the research vessels were recorded using a compass.

Wave pattern analyses

Wave pattern analyses were done using Cool Edit Pro 2 (CEP2 for short) and Ishmael 1.0 (ISH for short). CEP2 shows the sonar grams of dugong call, in which the horizontal axis is time and the vertical axis is frequency (Fig. 3). Center frequency, duration, and sound pressure level of a call were calculated using CEP2.

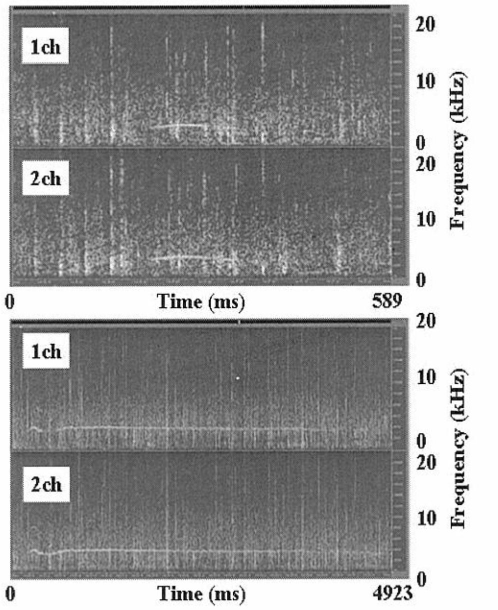
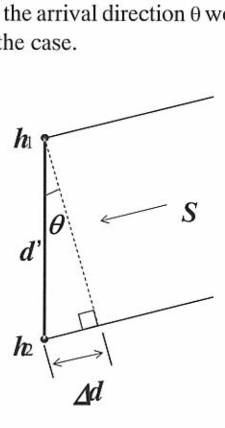


Fig. 3. Sonar grams of dugong call, which is shown in horizontal white lines. A typical example of short duration call with duration and frequency approximately of 1.9 s and 3.6 kHz respectively (upper) and long duration call with approximately of 4.6 s and 3.8 kHz (lower).

Then, phase difference between the two hydrophones in each vessel was calculated by cross-correlation using ISH to have the corresponding time difference. The arrival direction of a call at each vessel is calculated using trigonometric function as follows, where the two hydrophones are h1 and h2, and d' is distance between the hydrophones and $\Delta\tau$ is the arrival time difference and C is the underwater sound speed (1500 m/s). The calculation is done under assumption that the call is coming from S and the source of the sound is far enough to treat the sound wave as a plane wave (Fig. 4). There is one ambiguity in this calculation. It should be noted that the S can be on the other side of the hydrophone array, for the arrival direction θ would be exactly the same value in the case.



$$\sin\theta = \frac{\Delta d}{d'}$$

$$\Delta d = \Delta\tau \times C$$

Fig. 4. Geometry of calculating arrival direction θ.

RESULTS

Total of 1175 audible calls were recorded through the survey. There's a risk that CEP2 and ISH fail to distinguish between dugong calls and short pulse sounds from the background noise. To avoid this confusion, only the calls with frequency of over 1 kHz and duration of over 50 ms were selected for the analyses. The reason for the threshold is that a 1 kHz high pass filter was applied to the original recordings and the duration of typical pulse sounds was around 40 ms. The number of the calls became 774 after the selection. No available data was obtained from the recordings on 3rd of March.

Acoustical characteristics of dugong call

Figure 5 and Table 1 show the acoustical characteristics of dugong call. The calls of dugong were categorized roughly in two in the matter of duration. One was a short call with duration of 100-500 ms and the other was a long call with over around 1000 ms. The center frequency of dugong calls ranged from 3 to 6 kHz. Only in the short calls, 8 kHz calls were observed.

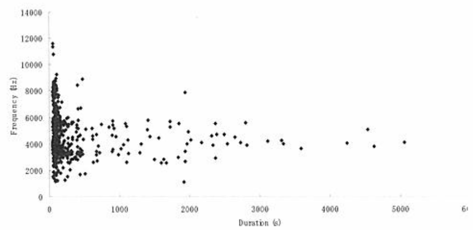


Fig. 5. Duration vs frequency of dugong call.

Table 1. Acoustical characteristics of dugong call

Duration	100-500ms	1000ms-
Number	704	74
Average of duration	126	1737
S.D of duration	87	1049
Average of frequency	4521	4152
S.D. of frequency	1615	1111

Figure 6 shows the distribution of vocalization intervals. Horizontal axis is time between each call in seconds. Vertical axis is number of call. Dugongs were most likely to vocalize once in 0 - 5 seconds.

Figure 7 shows the vocalization intervals on 4th and 5th of March. Horizontal axis is elapsed time from the start of recording. Vertical axis is accumulated number of vocalization. The steep parts of the slope mean that dugongs were vocalizing frequently. The steep parts on the 4th (2.0 s between each call) and the 5th (1.69 s, 1.74 s, 1.93 s, 1.71 s chronologically) of March had very similar slope. On the other hand, the value of the moderate parts ranged widely from 7 to 180 seconds between each call. Dugong had started vocalize very frequently at some points. It has been made clear that dugong had two patterns in vocalization interval

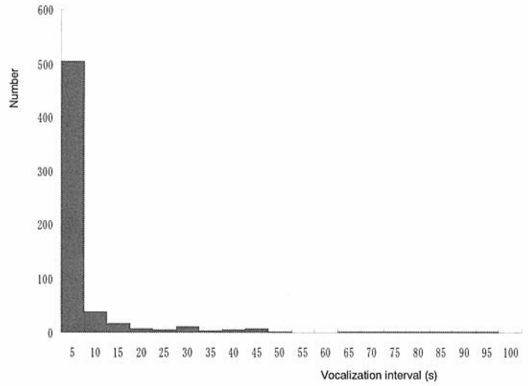


Fig. 6. Distribution of vocalization interval.

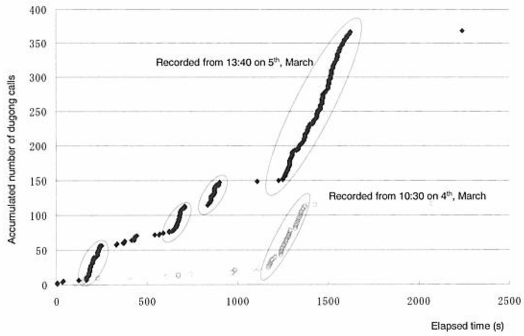


Fig. 7. Vocalization interval on 4th and 5th, March. ○,◆ corresponds to the data recorded from 10:30 on 4th, 13:40 on 5th respectively.

Actually, according to both the visual observations from Micro Lite and from our research vessels and to overlapping calls in the sonar gram, there had been more than one dugong near the ships on 4th and 5th of March (Fig. 8).

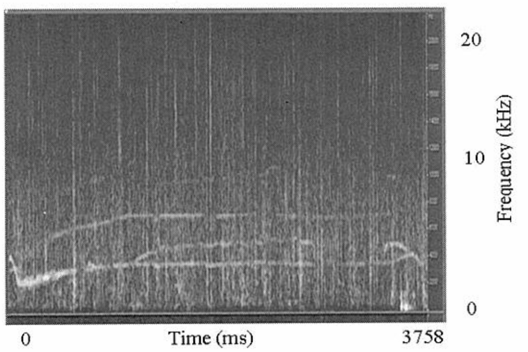


Fig.8. Overlapping calls. A long duration calls overlaps the first call in the middle. In the last moment, a short duration call overlaps the long calls.

Direction analyses

For the direction analyses, vocalization data recorded from 12:25 on the 6th of March were used. On 6th, there had been apparently only one individual nearby our research vessels according to the visual observations and no overlapping calls.

Figure 9 shows the change in the arrival direction and the sound pressure level at vessel-A. Horizontal axis is elapsed time from the start of the recording. Vertical axis is sound pressure level (dB) and arrival direction (degree), which are shown in the upper and lower graphs, respectively. The arrival direction of the dugong call is changing moderately as time goes by. The sound pressure level increased accordingly to the change in the arrival direction.

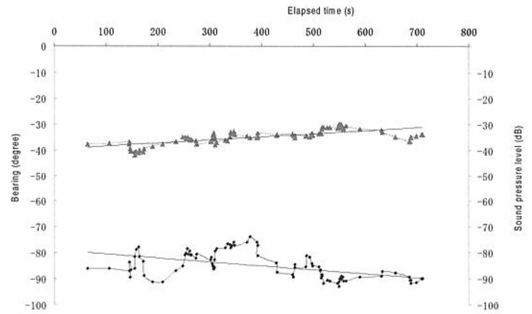


Fig. 9. Change in the sound pressure level (upper) and the arrival direction (lower).

Figure 10 shows the vocalization interval (upper) and the sound pressure level (lower). The frequency of vocalization is low at first, and is high for the next 2000 s and is low again at last. This alternation in the vocalization rate is due to the detectability of the recording devices. The farther the distance between dugong and the vessel, the less audible vocalizations are recorded. These preliminary results suggest that a dugong was coming closer at a steady angle to the research vessel.

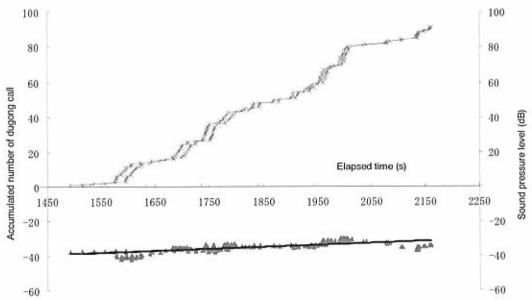


Fig. 10. Vocalization interval (upper) and the sound pressure level (lower).

DISCUSSION

The acoustical characteristics of dugong calls were described.

Vocalization interval

The values of short intervals showed very similar range: 0-5 s between each call. Periods of long interval, or almost non-vocalizing were also observed. There were sudden changes in the vocalization frequency on 4th and 5th of March, when a number of dugongs were observed near the research vessels. It was suggested that dugong had started to vocalize frequently on a certain occasion. Subjectively speaking, the occasion might have been an encounter with another individual. These preliminary results made the authors to think that dugong appear to be exchanging their calls with each other.

Duration and frequency of calls

Short calls lasted for 100-500ms and long calls were over around 1000ms. Frequency band was very narrow, ranging 3 to 6 kHz, and about 8 kHz just in the short calls. High frequency modulated call can easily be masked in the background noise. The length of the calls may be decided according to the distance between the vocalizing individual and the others. If the distance between individuals is far, short and successive calls are easier for the receiver individual to recognize the calls. In close distance to each other, the long calls may be vocalized.

Direction analyses

Movement of a dugong was described with the change in the arrival distance at vessel-A. With the results of the direction analyses from more than one research points, some intersection points of the directions for each call can be obtained, which can be supposed as a position of a dugong. Using a number of hydrophones eliminates the ambiguity that has been mentioned before.

The basic concept of the positioning of a vocalizing dugong is shown in figure 11, where the dugong calls are to be recorded by the sets of dual-channel hydrophones at each of A (0, d) and B (0, 0), and d is a distance between A and B. θ_1 and θ_2 are the arrival directions of a call at site A and B, and the position of the sound source is S (x, y).

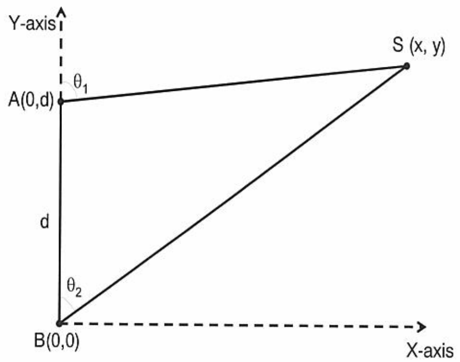


Fig. 11. Geometry of dugong positioning using trigonometry.

The unknown position S is estimated using trigonometric function as shown in Eq. (1.a), (1.b), (2.a) and (2.b).

$$\tan\theta_1 = \frac{x}{y-d} \qquad (1.a)$$

$$\tan\theta_2 = \frac{x}{y} \qquad (1.b)$$

These simultaneous equations are solved and then tan θ is converted to result in Eq. (2.a) and (2.b).

$$x = \frac{\sin\theta_1 \cos\theta_2}{\sin(\theta_1 - \theta_2)} d \qquad (2.a)$$

$$y = \frac{\sin\theta_1 \sin\theta_2}{\sin(\theta_1 - \theta_2)} d \qquad (2.b)$$

Once the positions of vocalizing dugongs are obtained, by plotting the located positions in chronological order, the swimming path of dugong would be described. If the moving path is described, we would be able to study the behavior of dugong that is directly related to their vocal activity. This innovative tracking technique is completely new in monitoring dugong and does not affect the behavior of dugong at all. It is, then, possible to warn the fishermen of the presence of dugong before the animal is accidentally caught in the fishing net, and to rescue the dugong before drowning. The authors believe that the proposed technique contributes greatly as a first step to achieve peaceful coexistence of dugong protection and coastal fishing.

ACKNOWLEDGEMENTS

This study was partly supported by a Grant-in-Aid for Scientific Research (13375005, 12556032 and 14560149) and Information Research Center for Development of Knowledge Society Infrastructure, the Ministry of Education, Culture, Sports, Science and Technology. The authors thank Ms. Kanjana Adulyanukosol for all her coordination in Thailand.

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Identification of dugong (*Dugong dugon*) tissues using isozymes

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ABSTRACT
Two tissue specimens, suspected of being dugong were tested by analyzing isozymes. The first tissue specimen was collected from Ban Paklok, Phuket on 26th of October, 2000 and the second one was collected from a fresh market in Phuket town on 29th of October, 2000. The suspected tissues were compared with known tissues of five dugongs (*Dugong dugon*), three cows (*Bos taurus*), three pigs (*Sus scrofa*), three chickens (*Gallus domesticus*) and one finless porpoise (*Neophocaena phocaenoides*). The study employed seven enzymes namely dihydrolipoamide dehydrogenase, glucose-6-phosphate isomerase, lactate dehydrogenase, isocitrate dehydrogenase, malate, mannose-6-phosphate isomerase and phosphoglucomutase.Using the zymograms of these seven enzymes, the first tissue specimen was identified as dugong tissue, while the second tissue specimen was not. Due to incompatibility of protein patterns, we were unable to assign the second tissue specimen to any of the compared organisms. An electrophoretic analysis of isozymes has proven to be an effective tool for recognition of dugong tissue and shows potential for identification of other conserved organisms that are poached.

INTRODUCTION

In Thailand, dugong (*Dugong dugon*) is one of the protected sea animals by the Fisheries Act 1947 and under CITES in 1983. Hunting and possession of dugong including its remains are illegal (Adulyanukosol, 2001). In the past, dugongs contributed to the diet of villagers along both coastlines of the Andaman Sea and the Gulf of Thailand. However, the chance of catching dugong is very low because of the present small numbers. Although dugongs have not been hunted, they are caught after becoming entangled in fishing gear especially gill nets (Boonprakob *et al.*, 1983; Chantrapornsyl and Adulyanukosol, 1994; Adulyanukosol 1995 and 1999).

Most of the dugong's muscle systems resemble closely those of manatees, except the shoulder muscles that are quite different (Domning 1977 in Nishiwaki and Marsh, 1985). Although fresh meat of dugong and the appearance of both texture and pink-reddish color are very similar to pork, the dugong's meat has lesser fat than pork (Adulyanukosol, *unpublished information*). Furthermore, pork seems to decompose easier than dugong's flesh and generally pork is smellier than dugong. However without skin, it is quite difficult to distinguish the two species. Soon after the local villagers find a dead dugong, sometimes they illegally sell the meat on the black market or alternatively distribute meat inside the village.

Recently in late October 2000, we received two samples of unknown tissues, which were suspected to be dugongs' meat. This paper evaluates electrophoresis of isozymes as a tool for identification of dugong samples.

MATERIALS AND METHODS

The tissues

The two tissues, suspected of being dugong, were collected from Ban Paklok and a fresh market, Phuket province on 26th and 29th of October, 2000, respectively. These two tissues were suspected as dugong material because of the pink-reddish color, which is the normal color of dugong muscle. The tissues were sent to the electrophoresis laboratory at PMBC in fresh condition. The suspected tissues were compared with five known species tissues samples, *i.e.* five dugongs, three cows (*Bos taurus*), three pigs (*Sus scrofa*), three chickens (*Gallus domesticus*), and one finless porpoise (*Neophocaena phocaenoides*) (Table 1).

Electrophoresis

The analysis was carried out on 7-8th of November 2001. A total volume of 30-60 ?l of 1 % polyvinyl pyrrolidone (PVP) was added to the tissue samples together with a small amount of cleaned sand before homogenizing. After centrifuging at 4,105 g for 5 minutes, the supernatants were absorbed onto paper wicks, which then were inserted into starch gels. Starch gels were prepared with 12% starch

(Sigma S-4501) in tris-citrate buffer pH 7.0 (Benzie, 1993). The proteins were separated at 600 volts and 80 mA for 3 hours. Staining was done with seven enzyme staining recipes i.e., dihydrolipoamide dehydrogenase (DDH or diaphorase DIA, EC 1.8.1.4), glucose-phosphate isomerase (GPI, EC 5.3.1.9), lactate dehydrogenase (LDH, EC 1.1.1.27), isocitrate dehydrogenase (IDH, NADP EC 1.1.1.42), malate dehydrogenase (MDH, EC 1.1.1.37), mannose-6-phosphate isomerase (MPI, EC 5.3.1.8), phosphoglucomutase (PGM, EC 5.4.2.2). The staining recipes were described by Harris & opkinson (1976) and Manchenko (1994).

Table 1. Collecting sites and condition of the known-species tissues used as references for identification of suspected tissues. Field numbers are identification codes for specimens kept at Phuket Marine Biological Center.
Type: M=muscle, L=liver

Species	Field No.	Type	Collecting place	Tissue condition
Dugong dugon (5)	Du- 119	M	Toloyai Island, Trang	Decomposed, 9-month frozen
	Du- 120	M	Laem Yong Lam, Trang	Semi fresh, 8-month frozen
	Du- 048	M	Kam Island, Ranong	Semi fresh, 56-month frozen
	Du- 074	M	Wean Island, Trang	Semi fresh, 33-month frozen
	Du- 084	M	Port of Phuket, Phuket	Fresh, 26-month frozen
Suspected tissue 1	-	M	Paklok, Phuket	Fresh, 1-week frozen
Suspected tissue 2	-	M	Fresh market, Phuket	Fresh, 1-week frozen
Neophocaena phocaenoides (1)	FINP 166	M	Phangnga	Fresh, 13-month frozen
Bos taurus (3)	-	M, L	Fresh market, Phuket	Fresh, not frozen
Sus scrofa (3)	-	M, L	Fresh market, Phuket	Fresh, not frozen
Gallus domesticus (3)	-	M, L	Fresh market, Phuket	Fresh, not frozen

Zymogram interpretation

A zymogram is defined as a strip or band of electrophoretic medium showing the pattern of enzymes or isoenzymes after their separation by electrophoresis (Harris and Hopkinson, 1976). Band separation is mainly due to the net charge, size and shape of protein. A protein with negative charge will run to the anode while proteins with positive charges will run to the cathode. The higher the charge a protein contains, the faster it can run. In contrast, the bigger the molecular size of a protein, the slower it can move along an electric field. A zymogram derived from each enzyme-specific staining method can possess more than one locus or system. Within a locus, each individual possesses one to several bands depending on whether it is heterozygote versus homozygote as well as on forms of proteins e.g. monomere, dimere and trimere (Richardson *et al.,* 1986). These bands are phenotypes of alleles or genes. However, not every band is counted as an allele. Bands of alleles at each locus can be designated numerically with the fastest anode-migrating band denoted "1", the second fastest "2", and so on. The tissue specimens were assigned as or differentiated from dugong tissues by visual comparison of the bands' locations with those of other organisms. As a general rule, zymograms of conspecific organisms tend to share the same locations, while the ones of different species tend to locate distinctly (Hartl and Clark, 1989). However, it has to be emphasized that identical migration rate does not necessarily indicate identical amino acid composition of the proteins.

RESULTS

Zymograms of seven-enzymatic stains are shown as Figure1. Bands of suspected and dugong tissues were developed well for all enzymes except IDH. Most enzymes exhibited both anodic and cathodic migrating bands except GPI which possessed only protein bands with positive charges. Referring to MDH, DDH, LDH, MPI, and PGM, the first suspected tissue (U1) was assigned as dugong tissue whereas the second one (U2) could not be assigned to any of the compared organisms.

MDH: This enzyme was one of the best enzymes to differentiate dugong tissues from other compared organisms. Two zones were observed, probably representing two loci. The first locus (anodic migrating, line 1-6) had six alleles and the second one (cathodic migrating, line 7-10) had four alleles. For the first locus, band of U1 located at the 6th line was common with the ones of dugong tissues while it differed from other compared organisms. U2 was not compatible with any of compared organisms. D3 did not show any bands. The second locus showed pale bands but was still possible to score. At this locus, U1 was located on the same line as dugong tissues (line 7), while differentiated from other organisms.

DDH: Two zones were observed, probably representing two loci. However, there were only heterozygotes in hens' muscles in the second loci (cathodic migrating, line

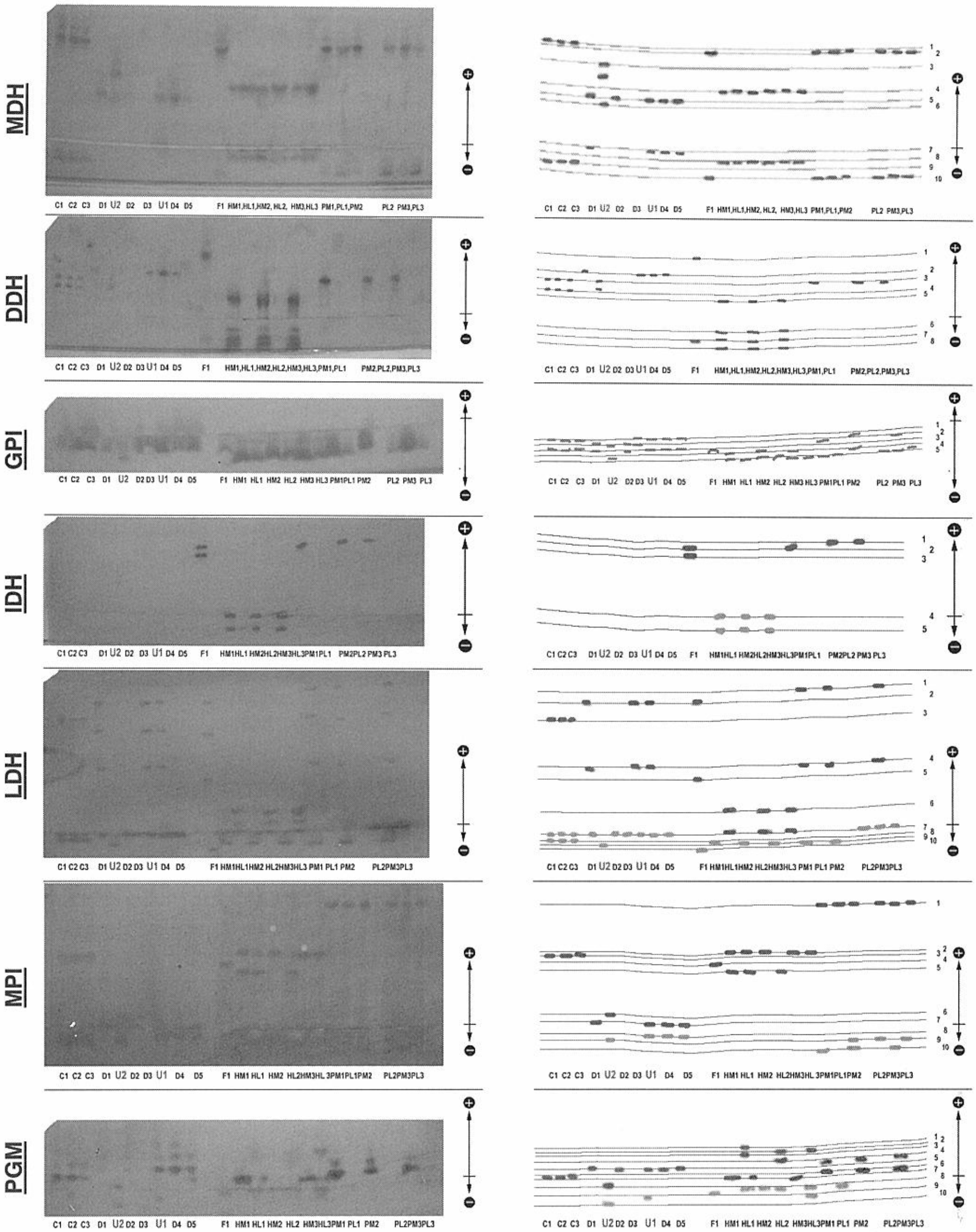

Fig. 1. Electrophoretic comparisons of two unknown specimens (U1 and U2) to known specimens of 5-dugong muscles (Dugong dugon, D1=Du-074, D2=Du-048, D3=Du-119, D4=Du-128, D5=Du-120), 1-finless porpoise muscle (Neophocaena phocaenoides, F1), 3-cows (Bos taurus, C1-3), 3-pigs (Sus scrofal, P1-3) and 3-chickens (Gallus domesticus, H1-3). L and M are liver and muscle tissues respectively. Minus and plus signs indicate the charges of electric field and the horizontal mark in between indicates the starting line. The figures on the left panel show original zymograms, while on the right pane are zymogram interpretations.

6-8). In the first locus (anodic migrating, line 1-5), U1 was located in the same line (line 2) with the other dugongs (D4 and D5). D1 had very pale band, while D2 and D3 were absent. U2 possessed very pale bands, which were located similar to cow tissues (C1-3). In chickens and pigs, the bands only developed in muscle tissues but not in liver tissues.

GPI: One zone was observed, probably representing locus (anodic migrating, line 1-5). All the muscle tissues exhibited heterozygotes except the liver tissues, which were homozygote. The known dugong tissues, as well as

U1, had 3 alleles located at line 1, 2 and 3. These dugong alleles resembled the ones of cows. However, they were significantly different from alleles of chickens and pigs. U2 had two alleles. The first allele was close to line 2, while the second one was between line 4 and 5.

IDH: Two zones were observed, again most likely representing two loci (anodic migrating locus, line 1-3 and cathodic migrating locus, line 4-5). No activities were obtained from suspected tissues or from dugong tissues.

LDH: Two zones were observed, again most likely representing two loci (anodic migrating locus, line 1-7 and cathodic migrating locus, line 7-10) In locus 1, heterozygotic alleles of U1 resembled the ones of dugong tissues (line 2 and 4) and differentiated from other organisms. In locus 2, dugong tissues as well as U1 shared the same alleles with the ones of cows, and pigs (line 7). U2 appeared only in locus 2 and shared the same position (line 9) with chicken tissues.

MPI: Two zones were observed, again most likely representing two loci (anodic migrating locus, line 1-7 and cathodic migrating locus, line 8-10). In locus 1, U1 was on the same line as dugong tissues (line 7) and could be distinguished from other compared organisms as well as U2. In locus 2, the bands were pale and located close to each other. This locus was not employed for the determination.

PGM: Two zones were observed, again most likely representing two loci (anodic migrating locus, line 1-7 and cathodic migrating locus, line 8-10). The locus 1, U2 revealed a band located on the same line as the ones of compared dugong tissues (line 5) and could be distinguished from other compared organisms including U2. In locus 2, the bands were pale and not used for determinations.

CONCLUSIONS

Isozyme electrophoresis has been proven to be an effective tool in detecting the suspected dugong tissue. Our study successfully employed five out of seven enzymes staining recipes to assign the suspected tissue as dugong tissue and to differentiate it from other compared organisms i.e. finless porpoise, cows, chickens, and pigs. Among five enzymes, MDH revealed the best result in both band intensity (easy to detect) and separating potential (good separation from other compared organisms). However, in most cases, the authors suggest employing all five enzymes for accurate detection.

Variation of band intensity reflects the activity of enzymes contained in tissues, the fresher the original sample, the higher intensity. The dugong tissues used in this study varied in their initial freshness (fresh to decomposed) and also terms of duration kept in a -20oC freezer (8-56 months). The study demonstrated that fresh-collected dugong tissue frozen for 24 months as well as semi-fresh-collected samples frozen for up to 33 months, are sufficient for isozyme electrophoresis. Longer preservation of semi-fresh tissue may not give useful results, while samples stored storing at -20oC for 56 months showed no activity in most enzymes. The decomposed dugong tissue (Du-119) proved almost useless for isozyme analysis.

ACKNOWLEDGEMENTS

We are grateful to villagers of Ban Paklok and Mr. Chatchai Sarikhapan, staff of PMBC for providing the samples from Ban Paklok and fresh market, respectively. Mr. Niyom Lohakarn, chief of Phuket Provincial Fishery Office, and Mr. Thongchai Pathanakul, head of the conservation of Fishery Resources Section, the Phuket Provincial Fishery Office, are acknowledged for their co-operation in dugong research and conservation in Phuket province. We also appreciate the editing assistance of Vibeke Simonsen at Aauhus University, Babara Brown at New Castle University, as well as Ellen Hines, Yvette Alva, and Frank Cipriano at San Francisco State University.

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Mekong giant catfish tracking project 2003 in the Mekong River

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ABSTRACT
Mekong giant catfish *Pangasianodon gigas* is one of the largest freshwater fish in the world. The fish is endemic to the Mekong basin and becomes high-degree endangered species listed in the IUCN Red List. Nevertheless little is known of the behavior. Ten Mekong giant catfish (TL: 76.5 to 88.5 cm, BW: 3.5 to 5.8 kg) were implanted with coded ultrasonic transmitters (Coded V16, Vemco Ltd.). Five monitoring receivers (VR1, Vemco Ltd.) were installed at Kong Chiam, Nakhon Phanom, Sri Chianmai, Sang Khong, and Chiang Khong along the Mekong River. The fish were released at Nakhon Phanom on 11 May, 2003. Three fish were recaptured by fishermen using set nets. One of the fish was recaptured at 100 km upward from the release point one week after release. This shows high performance of upward swimming of Mekong giant catfish in the Mekong River. Since 24 May, 2003, all fish are missing, unfortunately. Currently, the receivers are still waiting for the fish's coming.

KEYWORDS: Mekong giant catfish, biotelemetry, tracking, coded ultrasonic transmitter

INTRODUCTION

Mekong giant catfish *Pangasianodon gigas* is one of the largest freshwater fish in the world and grows up to 3 m in length and 300 kg in weight. The fish is endemic to the Mekong basin and becomes high-degree endangered species listed in the IUCN Red List. Nevertheless little is known of the behavior. Biotelemetry study on the Mekong giant catfish started with the background by the request of the Department of Fisheries, Ministry of Agriculture and Cooperatives of the Thai government in 2001. Ten Mekong giant catfish with coded ultrasonic transmitters were released in the Mekong River in 2002. Four fish were detected 6 to 9 days after the release by a receiver that was installed at the point 60 km upward of the release point. This shows high performance of upward swimming of Mekong giant catfish in the Mekong River. In 2003, another ten Mekong giant catfish were released. Preliminary results in 2003 were introduced in this paper.

MATERIALS AND METHODS

Artificial seed reared in the Karasin Freshwater Research Station, Thailand were used. Details of each fish are given in Table 1. The fish were anesthetized and implanted with a coded ultrasonic transmitter (Coded V16, Vemco Ltd.) into the body cave on 10 May 2003. Details of implanting method were the same as Mitamura et al. (2002a). The transmitters weighed 10 g in water, was 16 mm in diameter, 65 mm length. The transmitters emit a train of six pulses for identification. Five monitoring receivers (VR1, Vemco Ltd.) were installed at points along the Mekong River, Kong Chiam, Nakhon Phanom, Sri Chianmai, Sang Khong and Chiang Khong (Fig. 1). The receivers decode ID numbers of the fish implanted with the transmitters in their detection zone within a radius of 300 m and record the number and time stamp in a flash memory. The fish were released at Nakhon Phanom on 11 May, 2003.

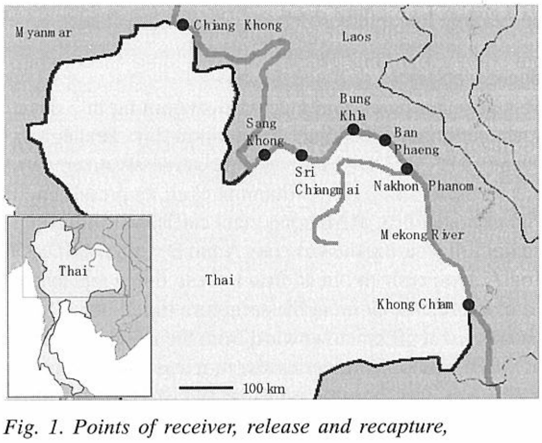

Fig. 1. Points of receiver, release and recapture,

Table 1. Details of the fish.

Fish ID	TL (cm)	BW (kg)	Recapture	Time	Point	Re-release	Time
31	81.0	4.3					
32	76.5	3.5					
33	83.0	4.6					
34	81.5	4.1					
35	88.5	5.8					
36	80.5	4.6					
37	81.0	4.4					
38	79.0	3.8					
39	81.0	4.5					
40	78.5	4.5					
A	75.0	3.5	18 May	10.00	Bung Khla	19 May	13.00
B	75.0	3.3	19 May	10.00	Bung Khla	19 May	13.00
C	75.0	3.3	20 May	8.30	Ban Phaeng	21 May	12.00

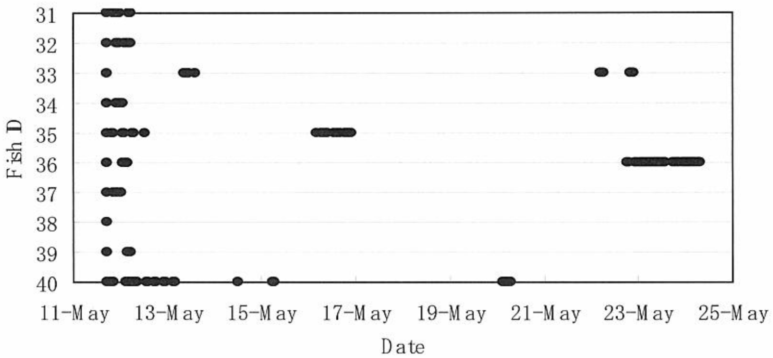

Fig. 2. Records of the receiver installed at Nakhon Phanom.

RESULTS

The records were downloaded once in July. Figure 2 shows records by a receiver installed at Nakhon Phanom Fish ID: 33 and 38 moved outside of the detection zone just after the release. The other fish stayed around the release point for 1 or 2 days and then moved outside of the detection zone. Some fish (ID: 33, 35, 36, and 40) returned to the release point again. Finally, fish ID: 36 stayed around the release point until 24 May. Later, all fish were missing until now, unfortunately. Three fish are recaptured by fishermen using set nets 7 to 10 days after release. Details of each fish (A, B, and C) are given in Table 1. Recapture points were shown in Figure 1.

DISCUSSION

Fish A performed 100 km upward swimming in 7 days. The swimming speed was about 14km/day. This agrees the result in 2002 that Mekong giant catfish swam upward at a speed of 10km/day (Mitamura et al., in press). High swimming ability of Mekong giant catfish was observed again. Considering the size, fish A and B were fish ID: 38 and 32, respectively. In addition, these fish ware absent from the release point at the recapture time. Fish C was recaptured at 50 km downward from the re-release point of fish A and B. Considering the re-release and recapture time, Fish C was the same as the fish B. Fish B must be tired because of the capture. The fish might move downward after re-release and was recaptured again. Since 24 May, all fish were missing. Some fish might be captured by shy fishermen. Some fish might pass Laos side where is the outside of the detection zone of the receivers. Some fish might stay the point between 2 receivers. The transmitter will last until June, 2004. Currently, the receivers are still logging and waiting for the fish's coming. The missing fish will be detected sometime, somewhere.

ACKNOWLEDGEMENTS

The authors wish to thank staff of the Freshwater Research Stations for their all help in the experiment in Thailand. The first author especially thanks Mr. Lhan, Mr. Sombat, Mr. Dong and Mr. Ohm. This study was supported by a Grant-in-Aid for Scientific Research (15780138), the Ministry of Education, Culture, Sports, Science and Technology.

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Pilot study on the movement of Mekong giant catfish in the reservoir

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ABSTRACT

Mekong giant catfish *Pangasianodon gigas* is endangered species. It is urgently necessary to learn more about the movement pattern of the catfish to conserve. We started the Mekong giant Catfish Tracking Project (MCTP) that is ecological research cooperative with Thai government at 2001. In this paper, the first results of MCTP are introduced. Horizontal and vertical movements of Mekong giant catfish were determined using pressure-sensitive ultrasonic transmitters in the reservoir. We found the clear daily movement patterns of the catfish. The catfish appeared to favor relatively deep areas and had 2-3 km excursions at night. The catfish exhibited the ascent to the surface at dusk and the descent to the thermocline at dawn in the reservoir. These behaviors of the catfish might be related to the feeding behavior.

KEYWORDS: **Mekong giant catfish, endangered species, vertical and horizontal movement**

INTRODUCTION

The Mekong giant catfish *Pangasianodon gigas* is endemic to the Mekong River and growing to colossal size. The catfish shows one of the fastest growth rates of any fish in the world, reaching 150 to 200 kg in 6 years (Walter *et al.*, 1996). The catfish is also one of the largest freshwater fish in the world, measuring up to 3 m in length and weighing in excess of 300 kg. The catfish is known to feed on algae and planktons, occasionally swallows algae-covered stones inadvertently. The catfish may also eat insect larvae and periphyton attached to the stones (Walter *et al.*, 1996). The catfish used to be distributed throughout the Mekong River basin from Yunnan Province, China to Vietnam. Currently, the catfish seems to be limited to the Mekong River and its tributaries in Thailand, Laos and Cambodia (Fig. 1).

Although, in Cambodia, Cambodian law forbids the capture, sale, and transport of the endangered species including Mekong giant catfish, the fishermen capture the catfish by incidental catch every year in Tonle Sap Lake and its tributaries (Zeb et al., 2001). To prevent the catfish from becoming extinct, the catfish was tagged in the hope that the catfish would be recaptured these days. In Thailand, Thai law allows the capture of the Mekong giant catfish. It is generally said that the spawning grounds of the catfish are located near Chiang Khong District, the northern part of Thailand. Now in Thailand, there is the only fishery cooperative of Chiang Khong District that is allowed to capture the wild catfish in the Mekong River. The fishermen in this cooperative use a gill net with a height of 3 m and mesh width of 40 cm to capture the catfish. The peak fishing season of the catfish starts from April to the end of May because the catfish migrates upstream to this district in this season to spawn. The river at this area is deeper and narrower, causing the current to flow swiftly. The fast current sweeps the catfish into the gill net and makes it difficult for the catfish to escape. In other districts, the catfish happens to be captured by incidental catch. The number of the wild catfish in the Mekong River has decreased due to the development of the Mekong River these days and so on. The behavior of the catfish, however, has been full of mystery.

As ecological researches are urgently necessary to conserve the catfish, the Mekong giant Catfish Tracking Project (MCTP) started in 2001, which is cooperative with Thai government. We have conducted the telemetry experiments at two study sites, the Mekong River and the Mea peum reservoir that are located in Phayao province, a northern part of Thailand (Fig. 1). The Mea peum reservoir is the enclosed waters. Enclosed waters can be the suitable site for the behavioral ecology of the catfish because continuous tracking is possible. The objective of this paper is to introduce the first results of MCTP in the Mea peum reservoir.

MATERIALS AND METHODS

Study site

This experiment was conducted at the Mae Puem reservoir, which is located in Phayao province, a northern part of Thailand. This reservoir was constructed by damming up a river. The area of this reservoir is approximately 8.3 km2. The maximum depth is approximately 15 m. We surveyed the bottom topography all over the reservoir using an echo sounder.

Table 1. Summarry of treament, body length, body weight, date tagged and date of track start.

ID	Total length (cm)	Body weight (kg)	Date tagged	Date of track start
42	108	13	18-May-03	20-May-03
43	103	13.5	18-May-03	20-May-03
44	116	14.8	18-May-03	20-May-03
45	116	17.6	18-May-03	20-May-03
46	120	18.8	18-May-03	20-May-03
47	113	16.2	18-May-03	20-May-03
49	110	17.2	18-May-03	20-May-03
50	111	14.2	18-May-03	20-May-03

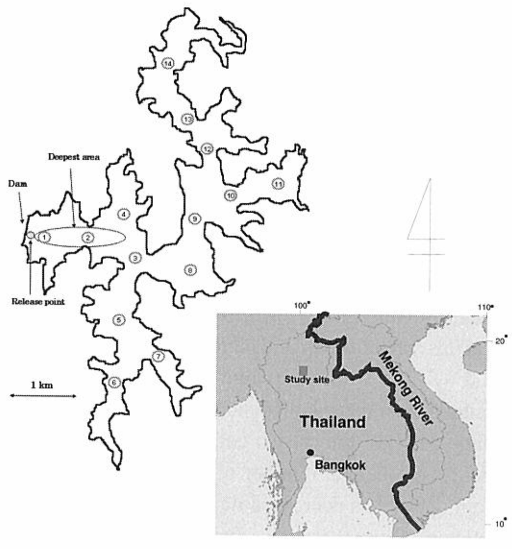

Fig. 1. Map of study site, Mea peum reservoir. This reservoir is located in Phayao province, a northern part of Thailand. This reservoir was constructed by damming up a river. The area of this reservoir is approximately 8.3 km2 and maximum depth is about 15 m.

Tagging and coded ultrasonic transmitters

Recently the Mekong giant catfish has been bred in captivity by Thai government and widely introduced through Thailand. Because it is difficult to capture the wild one, all cultivated fish (Table 1) were used in this study. All the catfish (n = 8) were about 1 m of total length, 6 to 11 years old and immature.

We used ultrasonic coded transmitters that were 16 mm in diameter, 108 mm long and weighed 16 g in water (V16P, Vemco Co., Ltd.). The frequency of the transmitter was 69 kHz. The power of the acoustic signals was 159 dB. The interval of the transmission was about 40 seconds. The transmitter transmits complex codes consisting of eight pulses in a transmission. So the receiver can identify and record the ID number of a transmitter and the depth of the sample fish swimming. This allowed us to identify up to potentially 256 different fish using the same frequency (Vogeli *et al.,* 1998).

Transmitter Attachment

In May 2002 the experiment on the dummy transmitter was carried out to find the ideal attachment method, external or surgical internal attachment (Moore *et al.,* 1990). We attached the dummy transmitter to the pectoral fin of the five fish for external attachment. We inserted the dummy transmitter to the peritoneal cavity of each 5 fish for the internal attachment. Each group of the catfish was reared for the external and internal attachment in the fish pond. Five intact fish were also reared for the contrast experiment under the same condition. About a month after the attachment, we concluded that the surgical implantation was better than the external attachment because all the external tags were removed and the change of the body weight of internal fish was not significantly different from the intact fish.

For the release experiment, the transmitter was implanted surgically into the peritoneal cavity of the catfish under the anesthesia following our previous method (Mitamura *et al.,* 2002). After the surgery, the fish were kept in a pool for about one day to allow them to recover. The catfish showed no observable effect of the surgery on their behavior. The release experiment was carried out on May 20 2003. The catfish were released one at a time at the surface of the reservoir at the dam side (Fig. 1).

Tracking system

We used 14 VR2 systems (Vemco Ltd., Nova Scotia, Canada) for tracking tagged fish. The VR2 systems logged data on the presence of fish tagged with the coded transmitter. The dimension of the VR2 system is 60 mm in diameter with 205 mm length. The system has flush memories to record data and is powered by the lithium battery that lasts for up to 180 days. The receiver was installed at mid-water depth in a location in advance. The ID number, the date and time were recorded when the tagged fish passed within approximately 400 m of the receiver. We installed 14 VR2 systems in the Mea peum reservoir to cover all over the reservoir (Fig. 1). The areas around Sts. 1-4 and 9-12 were relatively deep, more than approximately 10 m. In contrast, other areas were shallow, up to 2 m deep. The data from VR2 systems were downloaded on 29-30 July 2003.

Water temperature

We measured the water temperature of the surface and the bottom of St. 1 in the reservoir during our experiment with two DT loggers (UME-190T, Little Leonard Co. Ltd.). This DT logger can record the ambient temperature and depth. Sampling intervals were 255 seconds. We also measured a vertical profile of the water temperature near St. 1 using another DT logger on 29 July 2003. In this measurement a sampling interval was 1 second.

RESULTS

Water temperature

Figure 2 shows water temperature of the surface and the bottom in the reservoir during our experiment. Average temperature of the surface and the bottom were 30.2 (±1.1 SD)°C and 23.6 (±0.6 deg. SD)°C respectively. Figure 3 shows the depth-temperature profile at the deepest area in the Mae peum reservoir nearby St. 1. Water temperature was stable from the surface layer to the depth of 6 m. However, it changed sharply at 6 m deep (Fig. 3).

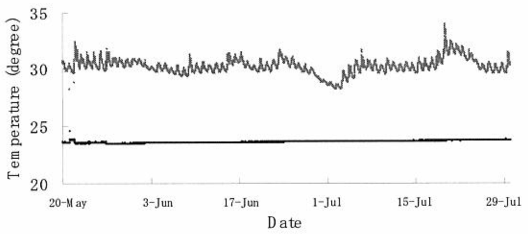

Fig. 2. Temperature of the surface and the bottom in the deepest area of the reservoir during approximately 70 days. Upper and lower lines indicated the temperature of the surface and the bottom, respectively.

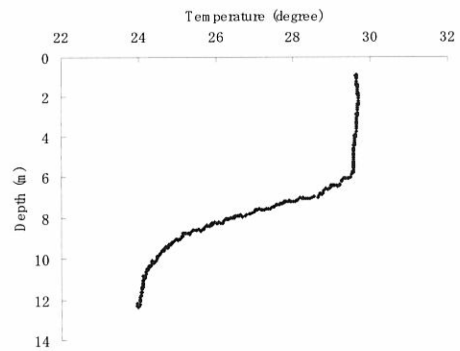

Fig. 3. Temperature profile in the deepest area of the reservoir.

Horizontal and vertical movement of Mekong giant catfish

All 14 receivers recorded the signals from the transmitters of tagged catfish when the data was downloaded approximately 70 days after the release.

The upper graph of Fig. 4 shows the horizontal movement of catfish 42 during our experiment. The catfish (ID 42) stayed mainly around Sts. 1-4 areas, which is the deepest in the reservoir. All tagged catfish appeared to favor relatively deep areas around Sts. 1-4 or Sts. 8-12 areas. The catfish (ID 42) generally favored deep areas, but the fish migrated all over the reservoir (Fig. 4). The lower graph of Fig. 4 shows horizontal movement of the catfish for a week after the release. The catfish migrated to other areas (Sts. 9-12) three times for a week although the catfish stayed mainly around Sts. 2-4. The fish conducted these 2-3 km excursions at night (Fig. 4). All catfish tended to have these short excursions at night although some excursions were made in the daytime.

Figure 5 shows the vertical movement of catfish 42 for a week after the release. There was clear vertical movement pattern during our experiment. The catfish swam upwards to the surface layer at dusk and remained below the surface at night. At dawn the catfish descended to depths around 6 m and remained there until the following dusk (Fig. 5). This catfish usually preferred deep areas where maximum depth is about 15 m (Fig. 4). However this catfish did not dive deeper than 6 m. The vertical profile of water temperature indicates that the mix layer was from surface layer to 6 m deep and that there was a sharp thermocline 6 m deep. This thermocline seems to be limited to the vertical movements of this catfish. This catfish appeared to spend the majority of all the time above the thermocline (Fig. 5). All other fish also exhibited the remarkable pattern of the vertical movement similar to ID 42. The clear day-night vertical movement may be common characteristic for Mekong giant catfish in the Mae peum reservoir.

DISCUSSION

Our results indicate that the catfish favored relatively deep areas and exhibited the vertical movements above the thermocline in the reservoir.

The Mekong giant catfish is known to feed on algae, occasionally swallows algae-covered stones inadvertently. The catfish may also eat insect larvae and periphyton attached to the stones (Walter *et al.,* 1996). In the Mae peum reservoir, some kinds of algae grow in the shallow areas and along the shore. Tagged catfish tended to migrate to other shallow areas from the main habitat or ascended to the surface at dusk. This movement to the shallow layer may be the movement to the shore from the deeper layer. In other words, the catfish may remain at the depth of 6-8 m above the thermocline in the daytime and move to the shore to feed on algae at night.

The Mekong giant catfish is also reported to feed on planktons (Walter *et al.,* 1996). Some of zoo plankton generally remains at the deep layer in the daytime and remains at the surface layer in the night time in both the sea and the lake (Hattorori, 1989, Gliwicz, 1986, Bollenz *et al.,* 1989). The Mekong giant catfish might vertically migrate to forage the zoo plankton in accordance with the movement of the zoo plankton. In order to learn more about the movement of the Mekong giant catfish it would be necessary to analyze stomach

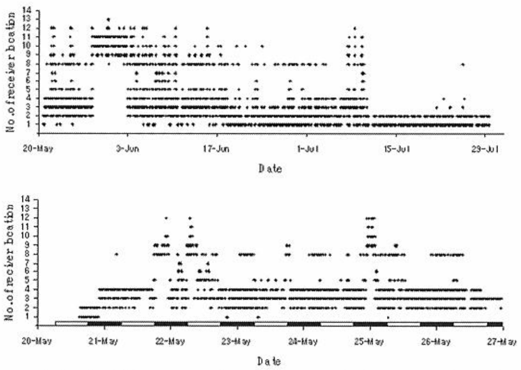

Fig. 4 Typical horizontal movement of the tagged catfish (ID 42). The dark horizontal bars indicate night time.

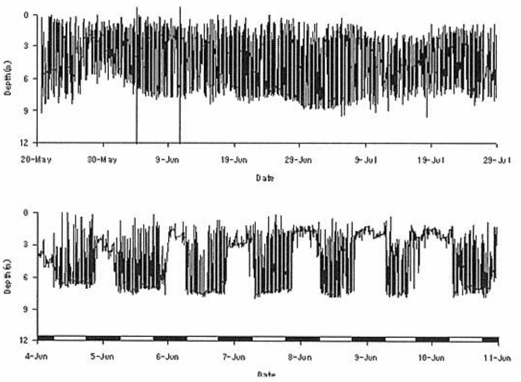

Fig. 5 Typical vertical movement of the tagged catfish (ID42). The dark horizontal bars indicate night time.

contents of the catfish. Additional experiments are needed to understand what and nowthe Mekong giant catfish feed on in the reservoir.

Horizontal and vertical movements of some fishes, for example Yellowfin tuna *Thunnus albacares* and bigeye tuna *Thunnus obesus*, were studied using ultrasonic transmitters and archival data loggers (Block *et al.,* 1997, Brill *et al.,* 1999, Dagorn *et al.,* 2000, Musyl *et al.,* 2003). These tunas exhibit clear vertical movement similar to the Mekong giant catfish. These tunas descend below the thermocline to forage and then return to the mixed layer in the daytime although they remain at the mixed layer at night. The thermocline limits the vertical movement of the tuna because tuna could not maintain body temperature for a long time below the thermocline. Therefore, these tunas spend major time above the thermocline. In the Mae peum reservoir, the change of temperature of thermocline is approximately 5-6 degree (Fig. 3). This change might limit the movement of the catfish.

In this study, we found that the catfish favored relatively deep areas and exhibited the vertical movements above the thermocline in the reservoir. These behaviors of tagged catfish might be associated with the feeding behavior.

ACKNOWLEDGEMENTS

This study requires the help of many people. We especially thank the staffs of Phayao inland fisheries station. The research was financially supported by the Sasakawa Scientific Research Grant from The Japan Science Society. We thank Dr. W. Sakamoto for kind comments and advice. We thank the staff and students of the Laboratories of Biosphere Informatics, Graduate School of Informatics, and Fisheries and Environmental Oceanography, Graduate School of Agriculture, Kyoto University, for their kind support.

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A study plan of development of a new device for recapturing free swimming fish

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ABSTRACT

Mekong giant catfish is one of the largest freshwater catfish in the world. It is endemic to the Mekong basin, and is endangered species. We have studied the Mekong giant catfish to conserve and enhance its resource by biotelemetry since 2001. In the Mae peum Reservoir in 2003, we found that the catfish vertically moved down only above the thermo cline in the daytime and up to the surface layer in the nighttime daily. This diel vertical movement appears to be related to the foraging behavior. However, the foraging behavior and prey items of the catfish are still unknown. One of the methods to clarify the foraging behavior and the prey items is to examine the stomach contents of the catfish in the daytime and the nighttime respectively. In order to examine the stomach contents transition hourly, we must be able to recapture the catfish at any time. Therefore, we made a plan to develop the new device named an Automatic Fish Recapture System (AFR System) to recapture the free swimming fish at the set time. And we will apply this device to the catfish and examine the stomach contents of the catfish and simultaneously study the migration of the catfish by incorporating with the biotelemetry system. Consequently, we will clarify the foraging behavior and the prey items of the catfish. In this paper, the outline of the AFR System and study plan of the catfish using this system is introduced.

KEYWORDS: **Mekong giant catfish, diel vertical movement, Automatic Fish Recapture System (AFR System), stomach contents**

INTRODUCTION

Mekong giant catfish (Pla Buk in Thailand), *Pangasianodon gigas* (Chevey, 1930), is endemic to the Mekong basin. The catfish is one of the largest fresh water fish in the world and the biggest record is 293 kg with the total length 3 m. It is said that this catfish feeds on plankton and algae (Walter *et al.,* 1996), but it is not known many details. The catfish is delicious and is also valuable animal protein resources for the residents in the north of Thailand. However, due to the watershed development of the Mekong River these days and due to the incidental catch and so on, the number of the wild catfish in the Mekong River has decreased year by year (Niklas S. Mattson *et al.,* 2000). Therefore, the catfish is listed on IUCN Red List for Critically Endangered and is included in CITES Appendix for most endangered species. So the import and export is strictly regulated. Also, in Thailand the catches of the catfish is strictly restricted, for example, only fishery cooperative of Chaing Khong District, the north of Thailand is allowed to capture the wild catfish only from April to June when the water level rises. In order to conserve and enhance the catfish resource, Thai government has put above mentioned fishing restrictions on and conducted artificial hatching study to increase the catfish resource since 1970s. In 2001, they succeed in producing second filial generation (F2) from first filial generation (F1) of the catfish. But behavior of the wild catfish, particularly habitat of young fish, is still unknown. Additionally when they release artificial hatching fish, we can't grasp his migration after releasing.

As researches are urgently necessary to conserve the catfish, the Mekong giant Catfish Tracking Project (MCTP) started at 2001 which is cooperated with Thai government. The first research was conducted in the Mekong River in 2002. It was revealed that the catfish widely migrated in the Mekong River (Mitamura *et al.,* 2002; Mitsunaga et al., 2003). In 2003, the second research was conducted in Mae peum Reservoir where is located in Phayao province, the north of Thailand (Fig. 1). We found the following diel vertical movements of the catfish by biotelemetry. First, the catfish actively migrated during the nighttime. Second, main habitat of the catfish was deep area. Third, the catfish descended to the deep layer at dawn and ascended to the surface layer at dusk (Mitamura *et al.,* 2003). These movements may be related to the foraging behavior and the prey items. The distribution and the movement of the prey items have a great impact on the catfish's movement because the catfish traces the prey items to eat. However, the foraging behavior and the prey items of the catfish are still unknown. If the foraging behavior and the prey items of the catfish are clarified in natural environment, we could definitely take measures to conserve the catfish, for example, to protect the area where main plants are distributed.

In order to clarify the foraging behavior of the catfish, it is necessary that the stomach contents every daytime and nighttime are examined. Therefore, 1) we will develop the new device for recapturing free swimming fish at any time. 2) We will apply this device to the catfish. 3) We will study the migration of the catfish by using biotelemetry system which we have already had. So, the objectives of this study are to clarify the foraging behavior and the prey items of the catfish.

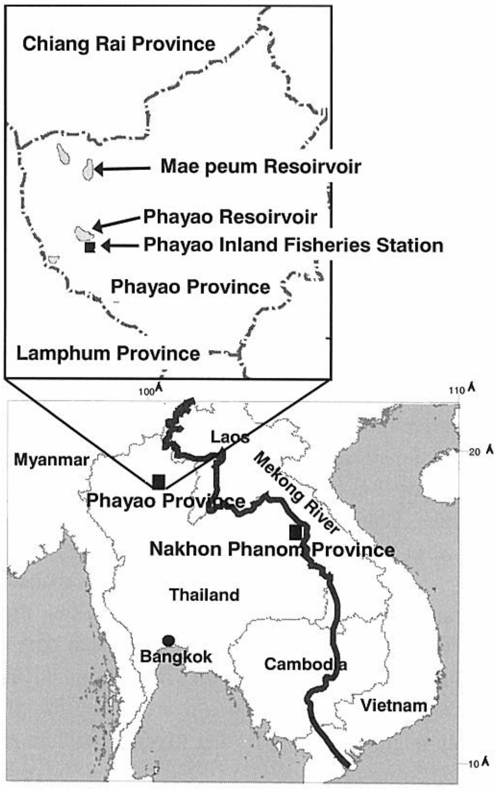

Fig. 1 Map of study site, at Phayao Inland Fisheries Station and Mae peum Reservoir in Phayao Province, the north of Thailand, and at Nakhon Phanom inland Fisheries Station in Nakhon Phanom Province.

MATERIALS AND METHODS

1. Development of Automatic Fish Recapture System (AFR System)

1-1 Overview of AFR System

We will develop a new device to recapture the free-swimming fish at any time. This device is named Automatic Fish Recapture System, for short, AFR System. Materials for development of the AFR System are an inflatable life jacket, a carbon dioxide (CO2) cylinder and an ignition device with a timer. Mechanism of the AFR System is the followings. (1) We set the timer at the time when we want to recapture the catfish. (2) We attach the AFR System to the catfish. (3) We release the catfish into the reservoir. (4) When it comes at the set time, the ignition device will break the cover of the CO2 cylinder. (5)Consequently, CO2 is injected into the life jacket inside from the cylinder and the life jacket is inflated. (6) As a result, the catfish will be taken to the surface and be recaptured.

In order to develop the AFR System, as a matter of first priority, it is necessary to know minimum buoyancy to take the catfish to the surface, because buoyancy, weight and size of the AFR System interfere with the swimming of the catfish. Therefore, the trade-off between buoyancy, weight and size AFR System arises. So it is necessary to calculate minimum buoyancy required for the AFR System which is found by specific gravity of the catfish.

1-2 Specific Gravity Measurement

On 16th December 2003 at Phayao Inland Fisheries Station in Phayao Province, the north of Thailand, we conducted specific gravity measurement of the catfish (Fig. 1). Sample fish are 9 catfish, total length 60.0-81.5 cm, stocked at Phayao Inland Fisheries Station. Measured items are fork length, total length, body weight (on the ground) and volume (Table 1).

Table 1 Result of measurement. FL: Fork Length, TL: Total Length, BW: Body Weight, V: Volume, SG: Specific Gravity, SD: Standard Deviation

Fish No.	FL (cm)	TL (cm)	BW (g)	V (cm^3)	SG (g/cm^3)
1	57.0	64.0	2500	2772	0.9019
2	56.0	65.0	2300	2376	0.9680
3	70.0	79.0	4200	4356	0.9642
4	64.0	73.0	3500	3168	1.1048
5	69.5	78.0	3900	3960	0.9848
6	53.0	60.0	2100	1980	1.0606
7	66.0	73.0	3500	3564	0.9820
8	67.0	74.0	3800	3168	1.1995
9	73.0	81.5	5100	4752	1.0732
			Average of SG		1.0266
			SD of SG		0.0908

1-3 Preliminary Test of AFR System

In June 2004, the first operation check of the AFR System will be conducted at the pool attached Kyoto University gymnasium center. The pool is a rectangle 25 m by 12 m with a depth of 1.6m. We will check whether the AFR System operates accurately underwater or not, and whether the object is taken to the surface by the AFR System or not. The AFR System will be attached to a sandbag of weight about 5-10 kg.

In August 2004, we will conduct the second operation check of the AFR System at the pond of Phayao Inland Fisheries Station in order to check whether the AFR System is not omitted from the catfish while it swims and whether the AFR system can actually take the catfish to the surface. And the AFR System attached to the catfish is possible to interfere with the migration of the catfish. To evaluate the effects of attached the AFR System, we will compare the growth rates of the catfish from the catfish with the AFR System from the control catfish without the AFR System. We use 12 catfish stocked at Phayao Inland Fisheries Station as sample fish. Three catfish are attached the AFR System, and the other 10 control catfish aren't. The catfish are attached the AFR System which is set up the timer to the back of the catfish and are released at the pond of Phayao Inland Fisheries Station. We stock these sample fish for 1 month.

1-4 Field Test of AFR System

In October 2004, at the Mae peum Reservoir in Phayao province of north Thailand (Figs. 1 and 2), field test of the AFR System will be conducted. The reservoir is constructed by damming up a river. As above mentioned, we attach the AFR System to 2 catfish stocked at Phayao Inland Fisheries Station. After we check the sample fish for any errors, we set one timer at 8:00 1 week later and another timer at 20:00 1week later. Then we release the catfish at the reservoir. At the set time, we will be able to recapture the sample fish taken to the surface.

2. Stomach Contents Research

2-1 Plankton Research over the Whole of Mae peum Reservoir

The catfish feed on plankton and algae. In habitat of the catfish (in the Mae peum reservoir in this study), it is very important to know the species, the habitat and the time zone of plankton. Plankton are closely related to the reservoir environment such as dissolved oxygen, water temperature, transparency. If we research the above, temporally distribution of plankton is maybe clarified. On the basis of this temporally distribution of plankton and the stomach contents research of the catfish mentioned in next chapter, 2-2, we can know whether the catfish selectively feeds on plankton and algae or not. Also, we can know when, where and what plankton the catfish feeds on. Thus, we can clarify whether the foraging behavior of the catfish causes the diel vertical movement of the catfish or not.

In June, August, October and December 2004, we have conducted and will conduct the plankton sampling twice a day (daytime and nighttime) for 1 week. We draw the line east-west and north-south to map of the reservoir and the cross-points are the points obtaining plankton (Fig. 2). We obtain them with a plankton net in both surface layer and bottom layer of each point. The plankton obtained are fixed with lugol's solution and identified by the microscope.

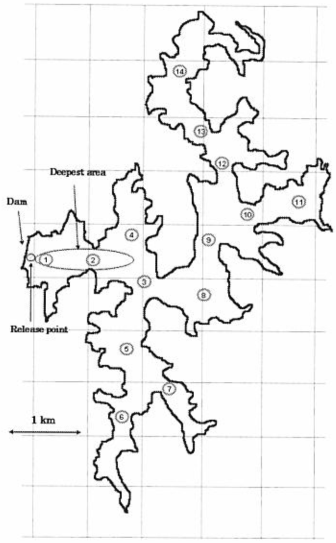

Fig. 2 Map of study site, at Mae peum Reservoir located in Phayao Province, the north of Thailand (Fig. 1). The numbers 1 through 14 suggest receivers (VR2) to log data of the transmitters.

2-2 Stomach Contents Research (1-4: at the Field Test)

We will obtain the stomach contents from the sample fish which are recaptured at the field test (1-4) and clarify the prey items of the catfish. At the first stomach contents research, in order to know all stomach contents, we cut the stomach and intestine and obtain the stomach contents. We attempt to obtain the stomach contents by using a syringe from next research, because we may be able to keep the catfish alive after we obtain stomach contents. The obtained stomach contents are fixed with lugol's solution and specified by using an optical microscope.

3. Biotelemetry Study (1-4: at the Field Test)

At the field test in the Mae peum Reservoir, in order to record the horizontal and vertical movement, we will also conduct the biotelemetry study. We use the coded ultrasonic transmitter which transmits transmitter's ID number and the swimming depth of the sample fish. The transmitters are attached to the AFR System when we attach the AFR System to the catfish at the field test (1-4). Also, we will use 14 receivers (VR2) to log data of the transmitters. We install the VR2 in the Mae peum Reservoir to cover all over the reservoir (Fig. 2). The VR2 continuously records automatically during 2 weeks. After we recapture the sample fish, we download the data of the VR2. We will analyze the horizontal and vertical movement of the catfish and clarify the behavior of the catfish in the reservoir.

RESULTS AND DISCUSSION

1 Results of Specific Gravity Measurement

1-2 Specific Gravity Measurement

The average of specific gravity of all 9 sample fish was 1.0266 g/cm3 and the standard deviation of the 9 sample fish was 0.0908 (Table 1). Figure 5 shows the linearization by least-square method, in which y-axis shows body weight and x-axis shows volume. The factor of x which was equivalent to specific gravity was 1.0267 and the R square value was 0.91. In these results, a certain relationship between volume and body weight of the catfish was recognized. Therefore, if we only measure body weight of the catfish, we can also estimate volume of the catfish and underwater weight of the catfish. We can estimate sufficient buoyancy to take the catfish to the surface.

A life jacket for human has about 7 kg and 10 kg buoyancy. If we attach the AFR System which causes 10 kg buoyancy to the 5 kg catfish, buoyancy of the catfish is two times as many as its own buoyancy. Therefore the catfish might not be able to swim to the bottom. We will conduct preliminary test and estimate minimum buoyancy to take the catfish to the surface in the future.

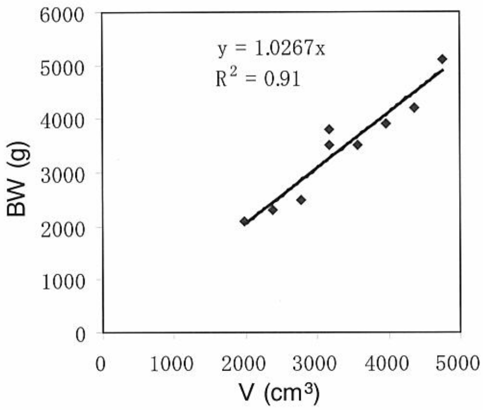

Fig. 3 The linearization by least-square method, in which y-axis is BW: Body Weight and x-axis is V: Volume.

2 Expected Result

We have already found that the catfish widely migrated along the Mekong River and the catfish diurnally migrated between the deep area and shallow area vertically (Mitamura *et al.,* 2003 and 2004). However, the diel vertical movement of the catfish which may be related to the foraging behavior and the prey items is full of mystery. We can recapture the free swimming fish at any time by using the AFR System presented in this paper. Therefore we can research the stomach contents of the catfish every daytime and nighttime and the detailed prey items will be clarified. Results of both above mention and the biotelemetry experiments will indicate whether the catfish migrate to feed between deep area and shallow area. And these results will contribute to aquaculture of the catfish at lakes in Thailand. Furthermore, applying the results of this study to Mekong River, we will also contribute to conservation of the wild catfish.

We can't eradicate the effects of the attached the AFR System. However, further modification of this AFR System with a smaller lifejacket and smaller microelectronic devices should decrease its size. And the attached AFR System doesn't have large effects on the catfish. This method allows one to conduct the studies on different fish and diving animals.

ACKNOWLEDGEMENTS

We are indebted to the participants in the studies for their gracious cooperation. We especially thank the staffs of the Phayao Inland Fisheries Station. We also acknowledge the assistance of Mr. Michihiko Suzuki and Mr. Naoki Sugiyama for device fabrication and drawings. We would like to acknowledge the support and advice of Dr. Wataru Sakamoto. We thank the staff and students of the Laboratories of Biosphere Informatics, Graduate School of Informatics, and Fisheries and Environment Oceanography, Graduate School of Agriculture, Kyoto University, for their kind support.

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The editing work was supported by many graduate students of Kyoto University. The editor thank to Hiromichi Mitamura, Tohya Yasuda, Junichi Okuyama, Kotaro Ichikawa, Yukiko Yamagishi, Chika Tsutsumi and Takashi Yokota.

SEASTAR2000 is partly supported by a Grant-in-Aid for Science Research (16255011 and 16658081)