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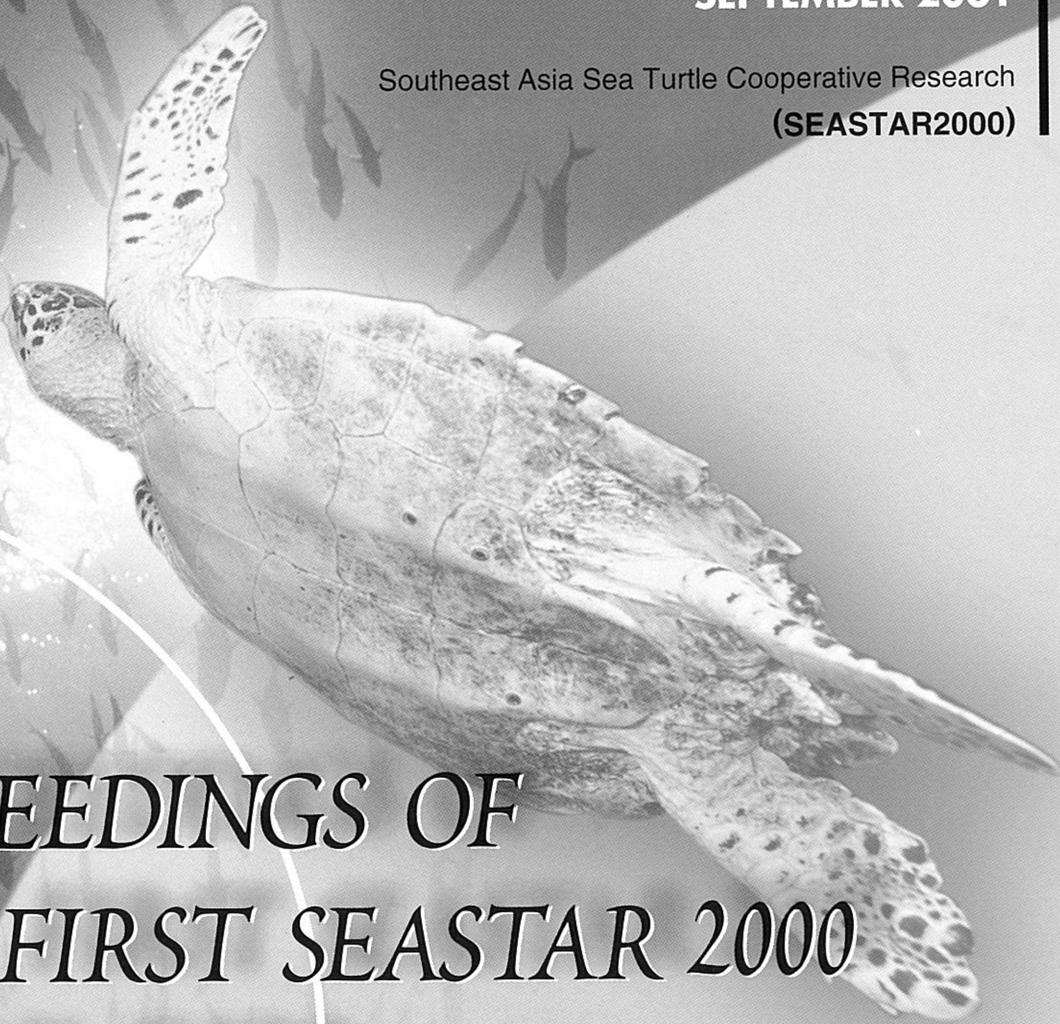

PROCEEDINGS OF THE FIRST SEASTAR 2000 WORK SHOP

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CONTENTS

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Sex determination of green turtle, *Chelonia mydas*, related with nest temperature

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Abstract We could find a seasonal change of sex ratio with an air temperature by examining sex of 443 dead bodies among hatchlings of green turtle, *Chelonia mydas*, collected from October 1998 to October 1999 on the Khram Island, Thailand. A percent female was under 50% at an air temperature below about 28 ℃. Sand temperatures beside three nests were recorded by data loggers. As compared with indexes among Yntema (1979), Mtasuzawa (1998) and our two ideas, we proposed our index as a reference incubation temperature, because of easy calculating the index and having a hatching process to differentiate into each sex. The index is an average daily sand temperature in a period from nesting day to the metabolic heating day. Effect of shade by a plastic net over four nests to a percent female was examined. A percent female (30-100%) under shade was lower than that (100%) under sunshine.

Keywords: green turtle, data logger, sex ratio, TSD, reference incubation temperature, shading effect

Introduction

It is well known that the incubation temperature does not influence only both on incubation period and hatching rate, but also on hatchling sex ratio (Mrosovsky,1994; Ackerman,1997). Matsuzawa (1998) proposed his empirical model which was able to estimate both a female and a male hatchling number by following data; time series data of sand temperature, daily numbers of new egg-laying nests and a clutch size for the loggerhead sea turtle, *Caretta caretta*. It is most important to record temperature data in sand beside a nest and also to find a functional relationship between hatchling sex ratio and sand temperature in his model.

We planed to apply his idea to estimate both a female and a male hatchling number for the green sea turtle, *Chelonia mydas*, in Thailand. However, we had no information on temperature-dependent sex determination (TSD) for the green turtle in the field. In this paper, we introduce our preliminary results on hatchling sex ratio of green turtle related with nest temperature by a data logger from 1999 to 2000 on the Khram Island.

Seasonal changes of hatchling sex ratio

Sex of 443 dead bodies among hatchlings collected from October 1998 to October 1999 on the Khram Island were identified by a histological method. A percent female in 12 months was 65.5% in average. This percent female changed seasonally as a highest percent female was 87% in August nesting and lowest 45.5% in October (Fig.1). A relationship between this percent female and an average air temperature at next month after nesting was shown in Fig.2. The highest air temperature was 29.9 ℃ at March 1999 and the lowest 26.3 ℃ at December 1998. The difference of temperature was only 3.6 throughout the year. A percent female was under 50% at an air temperature below about 28 ℃. We may consider that pivotal value for sex differentiation in green turtle is in roughly 28 ℃ as based air temperature.

We could find out what a hatchling sex ratio on green turtle was dependent of an air temperature in the case of Thailand.

Hatchling sex ratio related sand temperature

Sand temperatures were recorded in sand beside three nests on the Khram Island from May to July, 1999, by a data logger of temperature (Fig. 3). The clutch size in each nest was 89, 90 and 112, respectively (Tab.1). Sex of hatchling was examined by a histlogical method. The range of percent female was 40% to 60%. A reference incubation temperature should be decided to look for relationship between sex retio and nest temperature. The sensitive period for the effect of temperature on sexual differentiation appears to occur around in the middle third of incubation temperature under the constant temperature condition (Yntema,1979; Yntema and Mrosovsky,1982). We could find that metabolic heating arose from hatching also occurs in this period by data logger (Fig.3). Matsuzawa (1998) used a data logger to measure sand temperature beside nest. He proposed an average daily sand temperature in a period between 192.9 ℃ and 262.7 ℃ of integrated sand temperature over 19.8 ℃ day by day as this incubation temperature. However, we could not understand his integrated temperature to TSD. And also it was difficult to find or calculate exact integrated temperature value proposed by him. Then we thought out two indices to a reference incubation temperature. One of them is an average daily sand temperature in two weeks after the day when metabolic heating occurred. But, we could not find the metabolic heating day in some cases. Second index is an average daily sand temperature in a period from nesting day to the metabolic heating day. When we could not find the metabolic heating day, we used an average sand temperature in three weeks since nesting day as this index. These four reference incubation temperatures are listed in Tab.1.

It was suggested that a percent female may become higher as a reference incubation temperature becomes warmer in all cases. As compared with these indexes, we want to propose our second index as a reference incubation temperature on the grounds that it is easy to calculate the index and the period may have a hatching process to differentiate into each sex.

Effect of shade over a nest to a percent female

Effect of shade by a plastic net over four nests to a percent female was examined on the Khram Island from May to September, 2000. We set a data logger in the center of nest on this experiment. An average nest temperature under a shade condition was lower than that under sunshine as a control condition (Fig.4). Number of days (49-53days) for hatching under shade may be longer as comparing with that (46-47days) under sunshine with a warmer incubation temperature. A percent female (30-100%) under shade was lower than that (100%) under sunshine.

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Table 1 Parameters on hatching process, sand temperatures and reference incubation temperatures on three nests on the Khram Island from May to July, 1999, Thailand.

	Name of Nest		
	No.1	No.2	No.3
1. Parameters on hatching process			
clutch size (NO. of egg)	89	90	112
hatching rate (%)	78.7	84.4	73.2
emergence rate (%)	100	100	100
% female	60	50	40
2. Sand temperature (℃)			
range	29.38-31.89	29.16-32.17	28.86-31.05
average	31.65	30.95	30.50
3. Reference incubation temperature (℃)			
Yntema (1982)	31.30	30.11	29.79
Matsuzawa (1999)	30.76	29.84	30.17
this study-index 1	31.39	30.09	30.66
this study-index 2	30.40	29.50	29.28

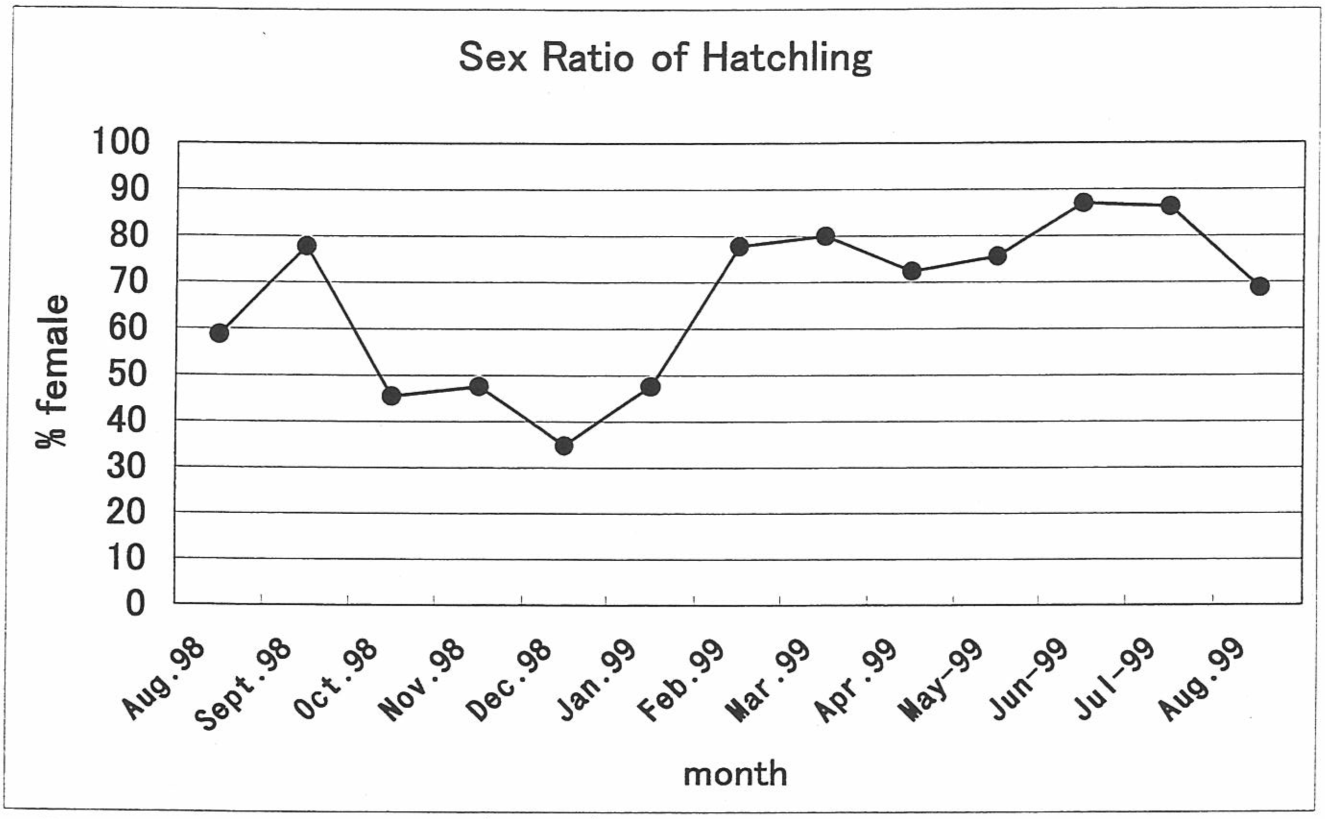

Fig.1 Seasonal change of sex ratio (% female) of green turtle hatching from August 1999 on the Khram Island Thailand.

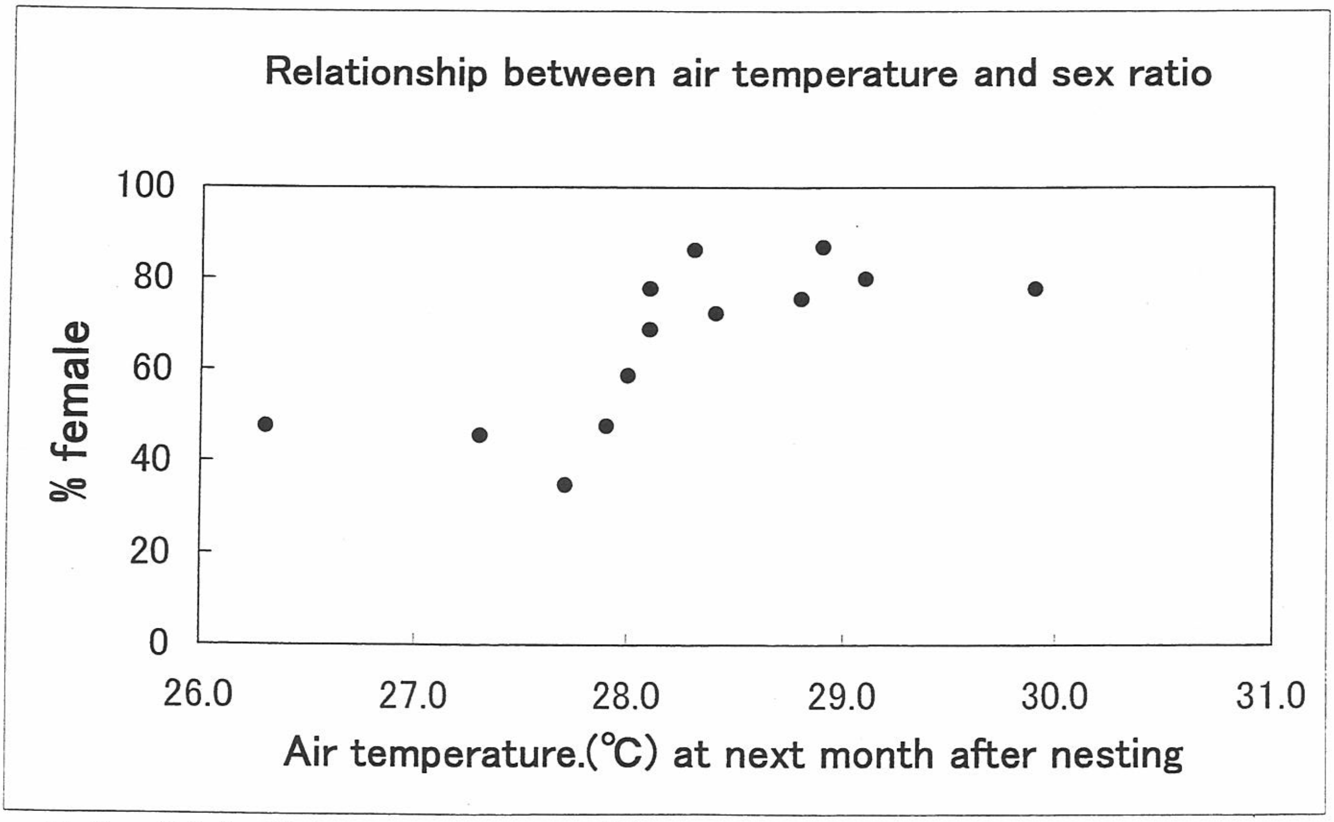

Fig.2 Relationship between air temperature (℃) at next month after nesting and sex ratio (% female) of green turtle hatching in the Khram Island.

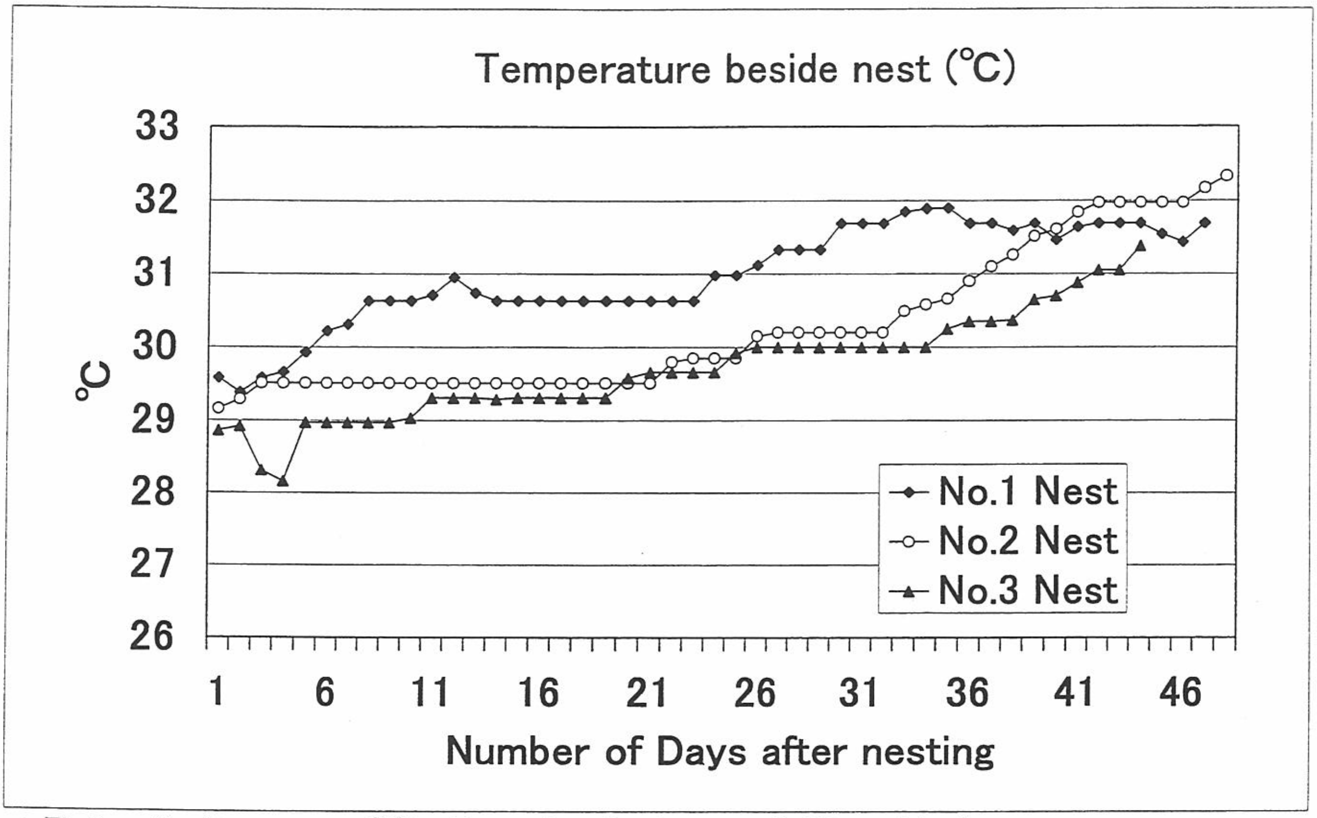

Fig.3 Snad temperature (℃) beside nest by a data logger on the Khram Island.

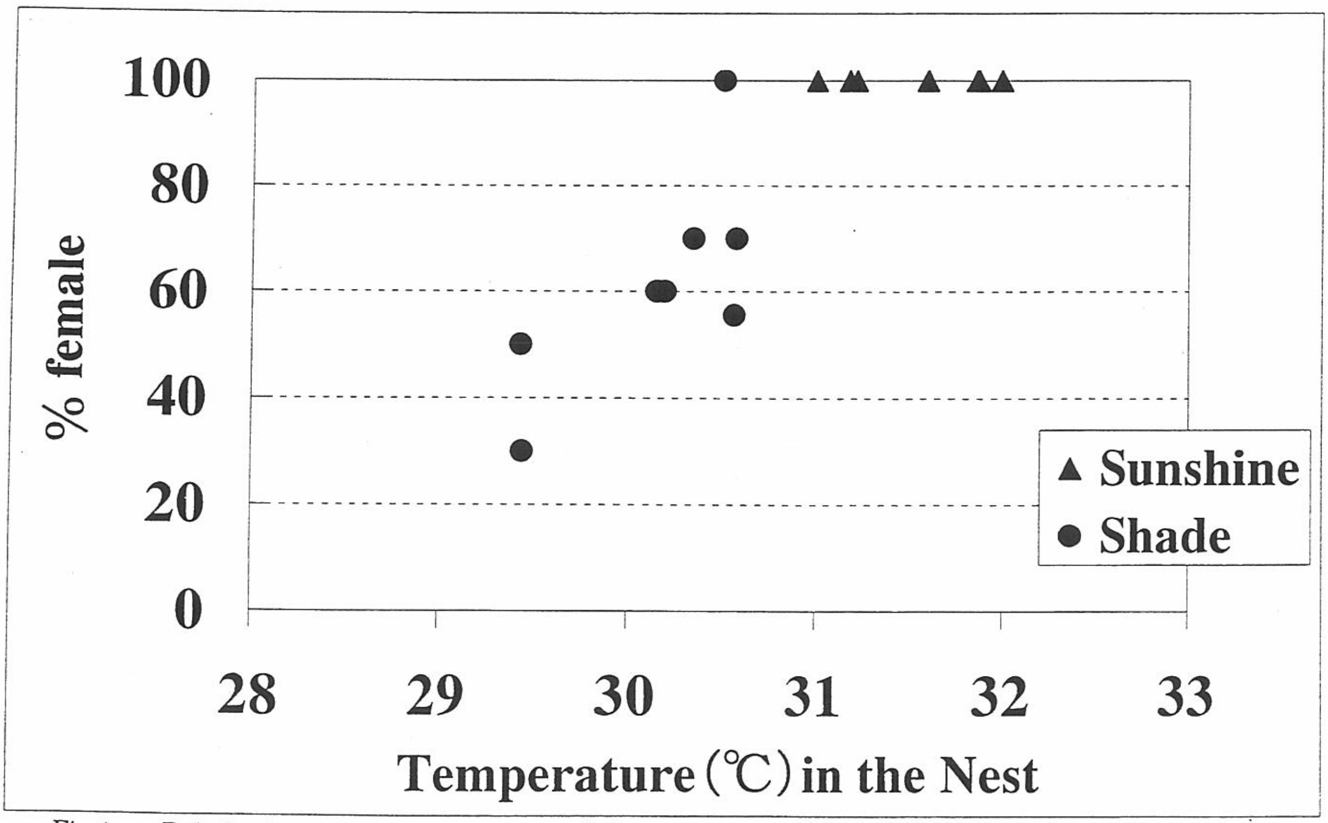

Fig.4 Relation between nest temperature (℃) and sex ratio (% female) of green turtle hatching under shade or sunshine condition

Reproductive biology of green turtle at Ko Khram Island, Chonburi Province, Thailand.

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Abstract

Survey on green sea turtle nesting at Ko Khram Island, Chonburi Province was undertaken by using electronic microchip tag during the nesting season of 1994-2000. Some green turtles returned ashore to nest on the same beach up to 5 times with inter-nesting interval of mostly 10-12 days. Nesting cycle in between breeding season shows a remigration of 2-5 years periodicity. The nesting females average 97.6 cm in curved carapace length and grow slowly at a mean rate of 0.36 cm per year. No trend of growth increasing in yearly mean carapace length for green turtles nesting during 1986-2000 was examined. The results seem that the nesting female population may have the recruitment for each year, otherwise the trend of size average in many years should be increase into a consistency of growth. However, the number of egg collection in last over 10 years at Ko Khram Island showed a little decline. More information of tag return, including the turtle recapture from feeding ground, are entirely needed in order to determine and estimate the population of sea turtle in the future.

Key words : green turtle, reproductive biology

Introduction

Ko Khram Island, Chonburi Province (12° 42' N, 100° 47' E) is one of the biggest nesting sites of sea turtle in the Gulf of Thailand. There are only two species reported nesting, green turtle *Chelonia mydas* and hawksbill turtle *Eretmochelys imbricata.* Due to the habitat protection program of sea turtle in Thailand since 1956 the activities of sea turtle conservation on Ko Khram Island have been undertaken. (Penyapol, 1957; Phasuk, 1992; Monanunsap and Charuchinda, 1994; Charuchinda and Monanunsap, 1998). The nesting beaches in this area have long been protected by the Royal Thai Navy and the Department of Fisheries. The purposes of this study were to summarize on the nesting cycle and reproductive biology of green sea turtle nesting at Ko Khram Island and determine the trend population of female turtle in order to provide further information on sea turtle conservation.

Materials and Methods

The long-term tagging on female green turtle at Ko Khram Island, a 12-km^2 Island located in the inner gulf of Thailand was carried out during nesting season (April-August) between 1994 and 2000. Passive integrated transponders (PITs) tagging technique have been conducted by using electronic microchip injection to under-skin layer on base of left front flipper of the female. The handle scanner is always used to identify the number of PITs tag within distance closed to 3-5 inches. Flipper tag or gum cement with a plate number was also attached to each female for external search tagging. Nesting behavior and egg clutch of the turtles was directly observed. The location and time of nesting was recorded. Th turtles were measured for carapace length and width in both curved and straight-line. If convenient, the body was weighed by hand balance. Growth of turtle was measured from the carapace length and time each between first and last found of the season. Linear regression of the body weight and carapace length was performed on log-transformed data to test fit in the model : $\log W = b \log L + \log a$, where a is the Y intercept and b is the slope

Results

Nesting cycle

A hundred and thirteen female green turtles were tagged with microchip tags during nesting season at Ko Khram Island in 1994-2000. Table 1 shows the periodicity of tagged female remigration back to the same areas both inter-nesting period and between breeding season. Some females could return to nest for up to 5 times in the same year of nesting season. The inter-nesting interval was found mostly in 10-12 days with a long interval of 8-51 days. For the data of remigration in between nesting season, there were only ten green females seen again on the nesting beach in last 3-years period (1998-2000). The remigration interval of turtles ranged between 2-5 years : 2 years for 2 females, 3 years for 4 females, 4 years for 2 females and 5 years for 2 females. (Table 1)

Table 1. Nesting records of green turtle at Khram Island, Chonburi in 1994-2000.

Year	No.of female tagged	No.of tagged female back in between season	No. of female returned to nest again in the same year of season in each times					Inter-nesting interval (days)	Between season interval (years)
			1	2	3	4	5		
1994	11	-	9	1		1		9 - 16	-
1995	25	-	12	5	6	1	1	8 - 12	-
1996	16	-	11	3	2			8 - 12	-
1997	21	-	7	8	4	2		9 - 20	-
1998	13	2	13	1	1			10 - 28	2 - 3
1999	15	6	6	5	4	2	4	10 - 48	2 - 5
2000	12	2	5	3	4	2		10 - 51	3
Total	113	10	63	26	21	8	5	8 - 51	2 - 5

Size and growth of nesting female

Body size of nesting females at Ko Khram Island measured in 1994-2000 was summarized in Table 2. The carapace lengths of green females were between 78.5-104.5 cm in straight-line and 85-109 cm in curved-line. Correlation between the length in straight-line against to the curved-line was very high. The straight length was about 93.5% of the curved carapace length. Range of body weight of female found between 74-140 kg with averaged of 101.7 kg (N=36). The relation between curved carapace length and body weight calculated in term of log value is the equator of $\log W = 2.9349 \log L - 3.8272$. Mean clutch size of Ko Khram green female was 98.9. Increase in curved carapace length (cm/yr) was very little. From the remigration of nesting female between breeding season the mean growth rate was 0.36 cm/yr with the range of 0-0.66 cm/yr.

Table 2. Body size and egg fecundity of green turtle nesting at Khram Island, Chonburi Province during 1994-2000.

	N	Mean	Standard Deviation	Range
Carapace length in Straight-line (cm)	117	91.5	5.08	78.5 - 104.5
Carapace length in curved-line (cm)	71	97.6	5.15	85 - 109
Growth rate in the curved length (cm/yr)	9	0.36	0.18	0 - 0.66
Body weight (kg)	36	101.7	15.4	74 - 140
Clutch size in nest (eggs)	142	98.9	21.7	32 - 161

Ko Khram Island green females comparing to the other nesting areas, such as Sarawak of Malaysia or Costa Rica in Caribbean Sea, were almost the same size of carapace length. The Sarawak green averaged in 95 cm in curved carapace length and 105 eggs in clutch. The Costa Rica female was 100 cm in mean length and 110 eggs in average and growth rate was ranged in 0.3-0.4 cm/yr (Hendrickson, 1958; Carr and Goodman, 1970; Phasuk, 1992).

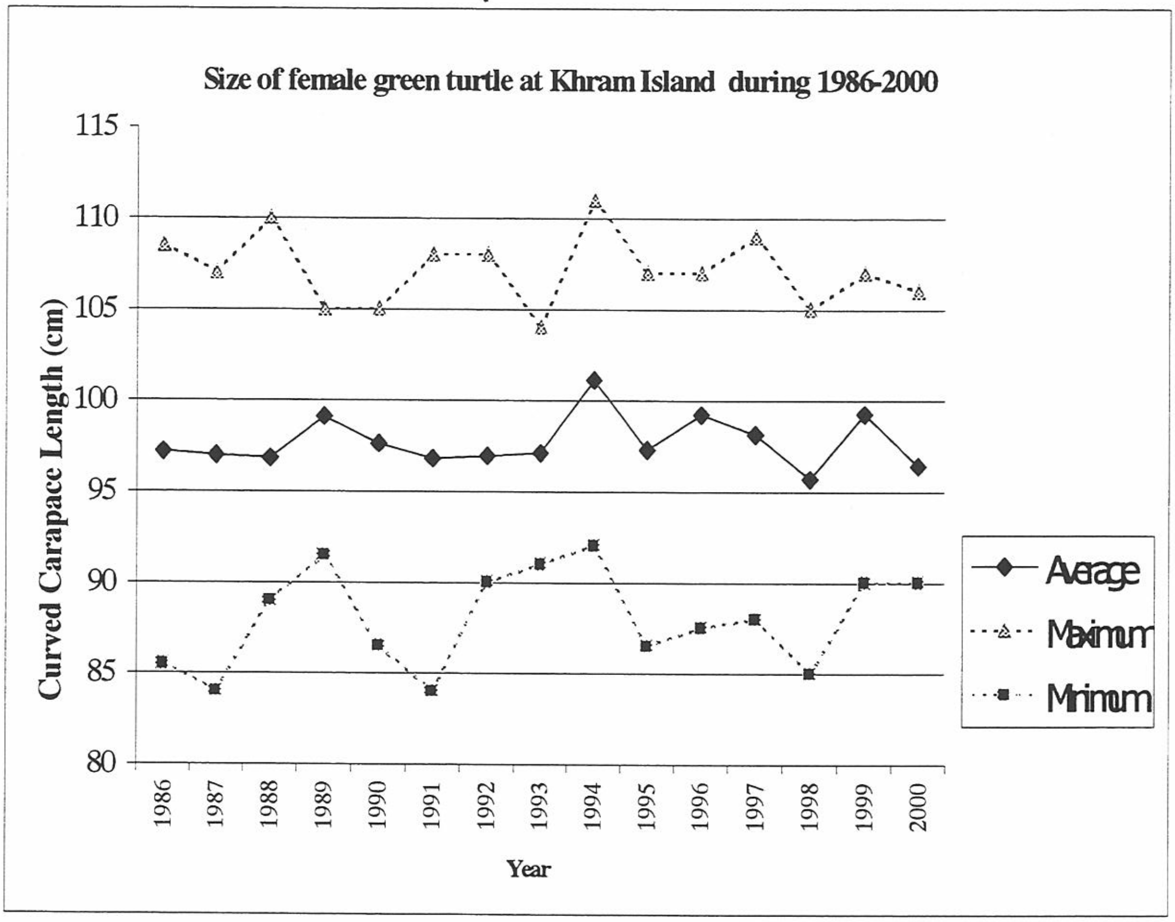
Trend estimation of nesting female

The record of female nesting in Ko Khram Island during 1983-2000 showed that number of nesting females seem to be decreasing. The high peak of yearly nests found in 1986 and 1988. (Table 3) The number of females each year may be estimated by using the basic knowledge of nesting cycle and the number of eggs found in the nesting site. During last 5 years (1995-1999) the number of eggs was found less than 300 nests a year and the number of clutch for one female during the same season could be not less than 3 times. It mean that Ko Khram green females are not more than 100 individuals each year. If the nesting cycle between season is 3-years period the total number of nesting turtle should be less than 300 females.

Table 3. Records of egg collection and incubation of green turtle found in Khram Island, Chonburi Province during 1983-2000. (until August for year 2000)

Year	No. of nests found	No of eggs found	No of eggs incubated	% of eggs incubation from all found
1983	365	31,381	5,328	16.98 %
1984	496	38,774	6,244	16.10 %
1985	380	31,009	3,365	10.85 %
1986	933	80,335	12,725	15.84 %
1987	251	21,677	3,093	14.27 %
1988	904	83,742	7,290	8.70 %
1989	289	24,593	2,600	10.57 %
1990	259	25,043	3,392	13.54 %
1991	411	38,534	5,366	13.92 %
1992	295	28,970	14,651	50.57 %
1993	478	43,460	25,766	59.29 %
1994	215	24,070	24,070	100 %
1995	238	23,558	23,558	100 %
1996	223	22,124	22,124	100 %
1997	257	25,089	25,089	100 %
1998	235	21,978	21,978	100 %
1999	292	28,836	28,836	100 %
2000	134	12,735	12,735	100 %
Mean	369.7	33,661.6	13,789	40.97 %

The mean carapace length of nesting females each year may be determined for the trend of the new turtle recruited in the nesting site. Figure 1 shows data of carapace length of green females recorded at Ko Khram during 1986-2000. The mean length of females now has remained the same as that for the last over ten years. It mean that there may some recruitment occurred in this area, otherwise the mean length should be a little increase tending to the growth rate of females. However, The number of eggs found is also the important indicated for the female population in this area. In order to determine population of sea turtle, more information of tag returns and the reproductive output of nesting site is therefore needed for estimation on the number of sea turtles.



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Migration Paths of Adult Female Green Turtles Detected by Satellite Telemetry

By

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Abstract

Study on migration paths of adult female green turtle was conducted by using satellite telemetry in the Gulf of Thailand during the year 2000. Five post nesting green turtles were attached, four from Khram Island, Chonburi Province and one from Mannai Island, Rayong Province. The results of this study found four different of migration patterns; The first pattern was found from 2 female which were attached at Khram Island, they still stayed around the nesting area. The second pattern was found from one turtle that was attached at Mannai Island, she traveled pass through the Gulf of Thailand heading to the south. The third pattern from another 2 female, one went to the southeastern coast of the Gulf to Vietnam Peninsula after that she traveled to the east cross South China Sea to the north of Sabah of East Malaysia, the other one went to the same direction as the first one but stopped travel and October she stayed around the Rong Island of Cambodia until the last signal. The fourth pattern from the female turtle which was captured by accident after releasing she swam cross the Gulf to the western coast and went down. Results from this study can be pointed that the female turtles which coming to nest in the Gulf of Thailand migrated long distances from different feeding grounds and habitats but still in the region.

Key words: satellite tracking, telemetry, migration, green turtle, Gulf of Thailand

Introduction

Sea turtle is one of the important protected marine animals under the CITES agreement in the Asean Region, each Asean Member Country has established his own program on the conservation and management. Sea turtles are highly migratory species which can move from water of each country to another, the information of research studies on feeding, foraging habitats and migration patterns of these animals in each country are still unknown in this region.

The satellite telemetry is one of the methods which is used for study the migration paths and foraging habitats of sea turtles in many areas. The aim of this study also used the satellite telemetry for adult female green turtles in the Gulf of Thailand.

Methods

- Equipment used

Two models of satellite transmitters called PTTs (Platform Transmitter Terminal) with a salt switch option that assures synchronization of the Argos transmission with surfacing. The switch also suppresses transmissions while the unit is under water, thus saving power and maximizing operational life of the configuration. The power savings associated with the salt-water switch (Suppressing transmissions while the animal is under water) is additive to the power savings associated with duty cycling.

- First model PTT from Telonics : ST-18 (Model A-400); Weight 200 gram; Duty cycle / day: 8 hours on and 16 hours off; Power sending 0.5 watt. (Fig. 1)
- Second model PTT from New Zealand : KiwiSat101; Weight 600 gram; Duty cycle / day : 24 hours; Power sending 1.0 watt. (Fig. 2)

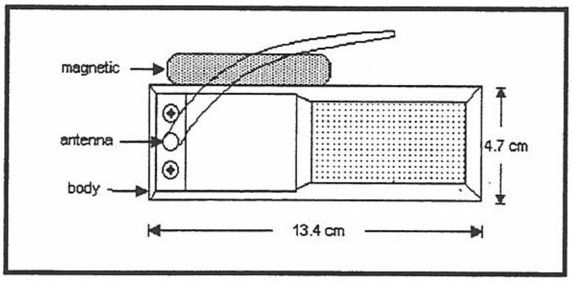

Figure.1 PTT from Telonics type ST-18

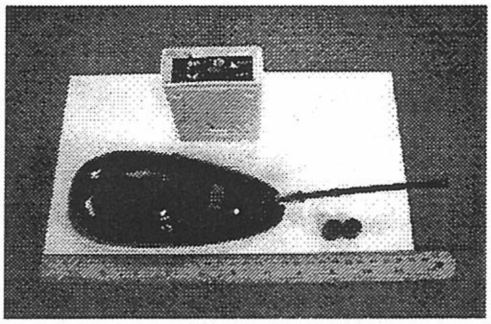

Figure.2 PTT from New Zealand type KiwiSat 101

The longer the turtle remains on the surface while the receiving satellites were overhead, the better accuracy of the fixes obtained. As told by the Argos to the users, the fixes are assigned to six location classes (*i.e.* *3, 2, 1, 0,* A and B), according to the estimated accuracy of the locations obtained. For classes *3, 2* and *1* Argos gives the degree of accuracy (for one standard deviation) as 150m, 350m, and 1 km. Respectively.

- Turtle tagging

PTT is glued at the dorsal carapace of the turtle after her last nesting (or nearly the last) on the beach. Before releasing to the sea each turtle was measured the carapace length(CCL)and weight then tagged with microchip (PIT tag) and inconel tags.

Four post nesting from Khram Island and one incidental capture from Sriracha, Chonburi Province and one post nesting from Mannai Island, Rayong Province were done in the year 2000.

Table. 1 Tagging on green turtle by PTTs in The Gulf of Thailand in the year 2000

Name	Species	Microchip No.	Inconel No.	ID code of PTT	CCL weight (cm) (kg)	Date	Time released
1.Sampreang	Green turtle	116 835 593A	TH0493	16724	91x104 125	18/5/00	11:20
2.Sri Koa Khram	Green turtle	116 874 117A	P0039	28534	85x98 115	29/6/00	10:40
3.Sri Sattahip	Green turtle	116 918 551A	P0040	28533	86x94 90	29/6/00	10:55
4.Sri Chonburi	Green turtle	116 911 111A	P0041	28532	89x100 130	29/6/00	11:05
5.Chao Samut	Green turtle	116 911 594A	TH0557	16723	86x98 110	12/9/00	10:25
6.Sri Racha	Green turtle	115 222 122A	TH0559 TH0560	29679	76x84 59	3/11/00	09:20

Results

Sampreang

The first turtle we attached by Telonics ST-18 (ID code no. 16724) after the fourth nesting on 18 May 2000. She had not finished nesting for the season yet so she came to nest again. She started to migrate on 20 May 2000 heading to the south. She went pass through the Gulf of Thailand in 27 days and reached Kuala Terangganu in Malaysia and then passed to Pahang heading to the Malaga strait. The last signal we received she stayed at Malaysian Peninsula which closed to Singapore. Total distances about 1,226 Kilometer within 48 days. (Fig.3)

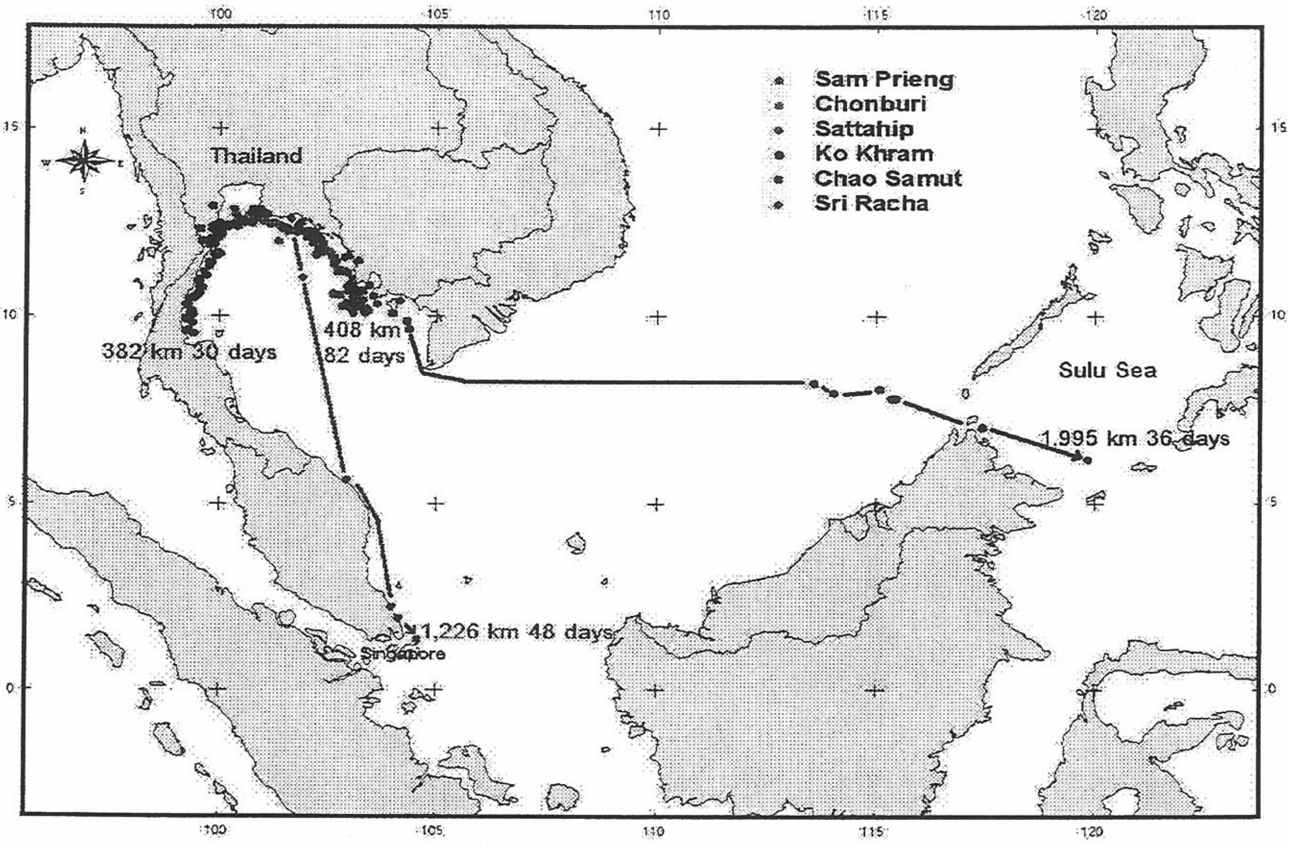

Figure. 3 Map of the migratory routes of adult female green turtles attached by satellite telemetry in the year 2000 from the Gulf of Thailand

Sri Koa Khram

She was attached by Telonics ST-18 (ID code no. 28534) on 29 June 2000 at Khram Island in Chonburi Province after released she still stayed around Khram Island about 5 days and started heading to the southeast pass through Trat Province, Thailand and Cambodia waters, then she went down to Vietnam Peninsula after that she traveled to the east cross South China Sea to the north of Sabah of East Malaysia and Sulu Sea on 8 Aug. within 36 days. The last signal on 17 Aug. showed that she stayed around the Islands in Sulu Sea. Total distance of the further route was about 1,995 kilometer. (Fig.3)

Sri Sattahip

She was attached by Telonics ST-18 (ID code no. 28533) on 29 June 2000 at Khram Island in Chonburi Province. The signal of this turtle could receive only 2 times in 9 days and she still stayed around Khram Island (Fig.3)

Sri Chonburi

She was attached by Telonics ST-18 (ID code no. 28532) the same day as Sri Koa Khram and Sri Sattahip on 29 June 2000. The signal could detect only 11 times in 40 days. She still stayed around Khram Island. (Fig.3)

Chao Samut

She war attached by KiwiSAT101 (ID code no.16723) on 12 September 2000 at Khram Island, Chonburi Province. The first 2 days she started to go to the west and then she designed to come back to the releasing area. On 17 Sept. she began to travel again but this time she went to southeast passed Rayong, Chantaburi and Trat Province. Passed Thailand to Cambodia on 25 Sept. and still went down not far from the shore, on 3 October she stayed around the Rong Island of Cambodia until 4 Dec. (last signal) she still stayed there. Total distance of the further route was about 408 kilometer. (Fig.3)

Sri Racha

She was attached by KiwiSAT101 (ID code 29679) on 3 November, this turtle was caught by incidental and rearing in the outdoor pool about 5 months at Sriracha District, Chonburi Province. After releasing she started to swim cross to the western coast of the Gulf closed to the shore of Prachaup Khiri Khun Province and then went down. The last signal on 18 Dec. showed that she stayed around the islands of Chumporn Province. Total distance of the further route was about 382 kilometer. (Fig.3)

Discussion

Results of this study showed that the adult female turtles which coming to lay their eggs in the Gulf came from different feeding grounds and habitats, these turtles migrated long distances from different places of their foraging habitats to the nesting ground in the Gulf of Thailand. This paper presents the ordinary data of the migration patterns of adult female green turtles which traveled back to the feeding and foraging habitats after nesting. For further studies in more details on some behaviors such as navigational abilities breathing and swimming behavior will be discussed in subsequent publications.

REPORT ON PTT-ATTACHED GREEN TURTLES *CHELONIA MYDAS* IN THE ANDAMAN SEA

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ABSTRACT

Three models of Platform Transmitter Terminals (PTT) were attached to four green turtles (*Chelonia mydas*) living in the Andaman Sea in 1995 and 2000. After released from Phuket and Similan Islands, each turtle revealed its unique migrating route. Two turtles (a 6-month old and an sub-adult female reared in captivity for 6 years) went to southwestern coast of Thailand while the third post-nesting one went to northwestern coast. The fourth post-nesting turtle went to Andaman Islands, India. The destinies of these turtles were sea grass habitats. The duration of PTT signal was 3-32 days. During cruising and feeding, the adult turtles swam 18-66 and 2-12 km/day, respectively. The fourth turtle spent 9±2 % on the sea surface each day. The surface time was highest after sunset and decreased exponentially onward. Since this study revealed that the post-nesting turtles migrated to several feeding grounds. The collaboration among countries within the region is required to guarantee the survival of sea turtles in this region.

Keywords: PTT, satellite tracking, migration, green turtle, Andaman Sea, swimming speed, surface time

INTRODUCTION

Migration pattern is known as an important tool for conservation and management of sea turtles. Several studies employing satellite transmitters revealed that the turtles migrated for very long distance between feeding and nesting grounds (Balazs 1994; Balazs *et al.* 1995; Luschi *et al.* 1996). The result of having such long migrations leads to collaboration among countries for efficient conservation of sea turtles in each region (Liew *et al.* 1995). Studies employing molecular markers revealed that there was a great separation between green turtles living in Atlantic Ocean and Pacific Ocean (Bowen *et al.* 1992; Bowen & Karl 1997). Unfortunately, most recent studies neglected an important nesting area, Indian Ocean.

In order to add a piece of jigsaw to migration patterns of green turtles, we employed platform transmitter terminals (PTT) to the green turtles living in the Andaman Sea. The major aim of this study is to determine the migration routes of nesting green turtles. Additional information such as swimming behavior, surface time and sea surface temperature were also reported.

MATERIALS AND METHODS

Three models of PTT were employed: the Trial, Telonics ST18 and Kiwisat101. The specification of these PTT was listed in Tab 1. The Trial PTT was connected to the turtle with a monofilament that tied to a man-made hole on a posterior scute. The other two models were attached to the cleaned second mid-scute of the turtles. Putty and epoxy glue were used to adhere the PTT. Later on, carbon fiber clothes soaked with epoxy glue were covered over the PTT and part of the mid-scute. To assure that the glue was fully hardened, the turtles were kept dry at least 1-2 hr before releasing. In addition, the turtles were tagged with external Inconel tags and internal microchip tags (Tab. 2). The position signals from the PTT were obtained via ARGOS.

Four green turtles (*Chelonia mydas*) namely Panwa1, Panwa2, Sri Nuan and Kayano were attached with PTT as shown in Tab 2. Panwa1 was a 6-month old turtle. Panwa2 was caught from the sea around Phuket and reared at Phuket Marine Biological Center for 6 years. Sri Nuan and Kayano were wild females came to lay eggs at Huyong, Similan Islands. At the time we were tagging, Sri Nuan had laid eggs for the 6th time in that year. The record from The Third Fleet of Royal Thai Navy showed that Sri Nuan also came to lay eggs at the islands 3 years ago. While, Kayano was recorded as her first egg laying in that year and there was no record to lay eggs at the islands during past 4 years.

The position data were plotted with global information system (GIS) program. The additional information on sea grass habitats in Thailand was obtained from Chansang & Poovachiranon 1994 and Poovachiranon & Chansang 1994. The minimum accumulated migrating distance (D_m) in kilometer was calculated as $A \times \sum_{i=1}^{n} \sqrt{(y_{i+1} - y_i)^2 + (x_{i+1} - x_i)^2}$, where; A is a conversion constant from a degree to km, which equals to 111.12; Y_i and X_i are decimal degree of latitude and longitude, respectively. The swimming speeds were interpreted from slopes between accumulated migrating distance and time. All sampling errors were calculated as confidence interval at 95%.

Table 1. Specification of three platform transmitter terminals (PTT) employed in the study

Company	Model	Duty cycle (hr/day)	Sending Power (watt)	Salt-water switch	L cm	W cm	H cm	WT g	Battery life, day	Obtained information
NTT CODOMO and Kyoto University	The Trial	24	NA	No	4	3			180	Position
Telonics, USA	ST18	8	0.5	Yes	13.4	4.7	2.1	200	255	Position
Sirtrack Limited, New Zealand	Kiwisat101	24	1.0	Yes	18	8.5	5	610	150	Position, surface time and surface temperature

Table 2. Information of PTT-attached green turtles (*Chelonia mydas*) from the Andaman Sea

Turtle Name	Sat ID	PTT	External Tag	Internal Tag	Attached Date	Released Place	WT kg	L cm	W cm
Panwa1	-	NTT	-	-	Sep 15th, 00	Phuket			
Panwa2	19277	Telonics ST18	*Left* TH/P 0471 *Right* TH/P 0470	*Left* 116479195A *Right* 116563472A	Mar 7th, 00 10:05	Phuket	93	88	78
Sri Nuan	19278	Telonics ST18	*Left* TH/P 0417 *Right* TH/P 0420	*Left* 017-864-343 *Right* 020-341-840	Jun 10th,00 4:45	Similan Islands	-	119	100
Kayano	18683	KiwiSat 101	*Left* TH/P 0470 *Right* TH/P 0477	*Left* 116479195A *Right* 116563472A	Sep 5th, 00 18:50	Similan Islands	-	110	90

RESULTS AND DISCUSSION

The PTT

The signal durations from PTT-attached turtles lasted much lesser than the specification (*see* Tab. 1, the Trial: 3 days, Telonics ST18: 21 days, Kiwisat101: 32 days). Several reason can be assumed: 1) Since, the Trial PTT was connected to the turtle by a monofilament, a chance that it will tear apart was high; 2) the Telonics ST18 and Kiwisat101 may be detached when the turtles rubbed their backs on hard substrates or during mating; 3) The turtles may be caught by fishing gears.

Comparison between Kiwisat101 and Telonics ST18 showed that Kiwisat101 sent twice higher number of data per day than Telonics ST18 (4.0±0.9 times/day VS 1.6±0.3 times/day). However, this is because Kiwisat101 has higher sending power (1 watt) compared to Telonics ST18 (0.5 watt). Besides, Kiwisat101 was turned on 24 hr a day while Telonics ST18 was turned on 8 hours a day only. The number of signal was high during 4:00-11:00 and 16:00-21:00 (local time).

The tracks and speeds

All PTT-attached turtles migrated to different directions (Fig. 1).

Panwa1 went to a small island (98°24'N 7°45'E), 4.3 km far from the released point. There were only 2 signals received. The swimming speed was 1.4 km/day.

Panwa2 swam average 18 km/day to the southeastern direction and reached the sea grass habitats 8 days later. She spent 3-4 days in this habitat. D_m was 215 km in 12 days. The last position recorded was 98°24'N 7°45'E.

SriNuan went to the northeastern direction from Similan Island and reach to a sea grass habitat in 3 days. She had spent about 7 days feeding in this area before went back to lay eggs for the 7th time in this year at Similan Island (13 days after the previous eggs laying). Later on, she went to the same feeding ground. Her last position was detected at 98°13'N 7°27'E. SriNuan swam 35-46 km/day when cruising between nesting and feeding grounds. During staying in feeding ground, she swam 2-4 km/day. D_m was 524 km in 27 days.

Kayano traveled to Andaman Islands, India (640 km far from Similan Islands). She swam 66 km/day for 15 days to reach the destination (Woodmason bay, Rutland Island, Andaman Islands) and stayed there until the signal was ceased at 92°37'N 11°26'E. D_m was 1,174 km in 31 days. It was suspected that there would be a sea grass habitat in that area.

This study revealed that green turtle from at least two feeding grounds (Andaman Islands and west coast of Southern Thailand) lay eggs at Similan Islands. Thus, conservation of green turtle in the Andaman area would require collaboration among countries in the region.

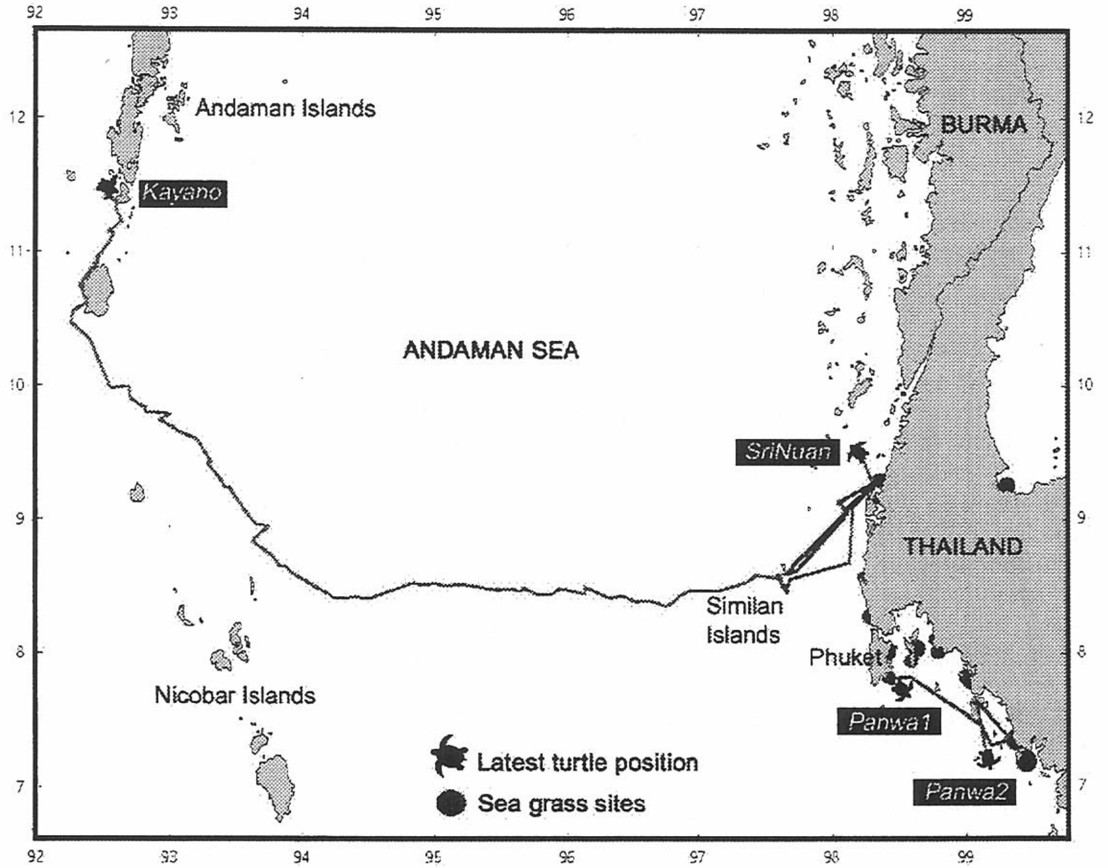

Figure 1. Migration routes to PTT-attached green turtles (Panwa1, Panwa2, SriNuan and Kayano) released from Phuket and Similan Islands in 1995 and 2000.

The surface temperature and sea surface time

The sea surface temperature was quite constant at 29.6±0.1°C. Surface time counter in PTT attached to Kayano showed that she spent 9±2 % each day. Diurnal pattern of surface time demonstrated that Kayano spent highest surface time as soon as it was dark (Fig. 2). The average surface time during day (6:00-18:30) was 6±1 % and 16±5 % at night. The lower surface time during day may be explained by feeding behavior and mechanism to avoid enemy.

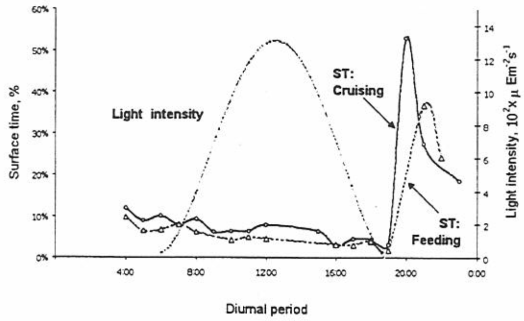

Figure 2. Diurnal pattern of sea surface time obtained from surface time counter in PTT attached to the post-nesting green turtle, Kayano.

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POPULATION DYNAMICS AND MANAGEMENT OF FISHERIES RESOURCES

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Abstract We investigate importance to monitor the relative population size for population management. If we assume the stationary population, the degree of overexploitation is usually underestimated. Cuban Hawksbill turtles was this case. However, if we know the trends in relative population dynamics, we can improve estimate of fishing mortality and absolute population size.

***Keywords*:** adaptive management, Hawksbill turtle, life table, monitoring, overexploitation

Introduction

In fisheries resources including marine turtles, there is large uncertainty in life history, population sex ratio, survivorship curve, growth curve, population size, and age structure. In addition, these parameters will be variable in time and space, and among individuals. The magnitude of variation is often entirely uncertain.

Recently, adaptive management has been recognized as a useful and practical method to manage population or ecosystem with uncertainties. Adaptive management consists of accountability for uncertainties, adaptability for dynamical change of stock status, and continuous monitoring (Christensen et al. 1996). Data obtained from commercial fishery are indispensable in adaptive management. Successive monitoring is also important. We first introduce theoretical concerns with a fisheries model for harvest of Hawksbill turtles in the Cuban Archipelago (Doi et al. 1992, Heppel and Crowder 1996). We discuss a harvest-based estimator for absolute population size in fisheries and wildlife management.

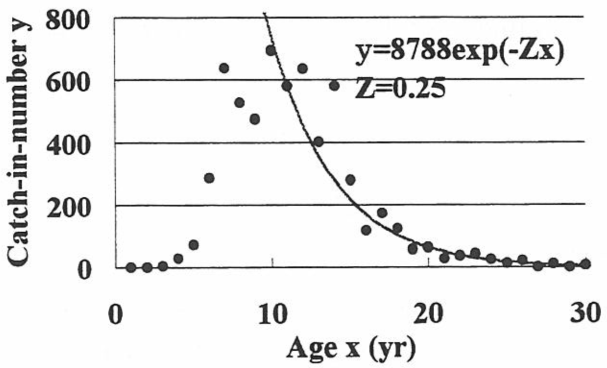

Fig. 1. Catch-n-number and estimation of total mortality coefficient Z from DOIRAP method (Doi et al. 1992, see also Tokunaga 2000).

DOIRAP Method

If we obtain catch-at-age (the number of harvested turtles at each age) data of sea turtles for a single year, how to make diagnosis of this stock? Doi et al. (1992) developed "DOIRAP" method under assumptions that (1) age identification is correct; (2) age-structure is stable; (3) fishing mortality on adult is identical irrespective of ages; and (4) population size is kept to be constant (see also Heppel and Crowder 1996, Tokunaga 2000). We obtain the regression line of log-linear relationship between age x year and catch-in-number ($y(x)$) as $\hat{y}(x)=8788e^{-Zx}$, for $x \geq 10$, where Z is 0.25/yr and is the total mortality coefficient (Fig. 1). The relative fishing mortality under age 10 years is assumed to be given as $y(x)/\hat{y}(x)$. From the age of maturity (x_m), rate of maturity ($E(x)$) and body weight ($W(x)$) at age x, Doi et al. (1992) estimated the natural mortality coefficient M after recruitment where population biomass is maximized at age of maturity $W(x_m)\exp(-Mx_m)$. They expected a life history parameter x_m is evolutionarily determined to maximize the expected number of offspring per mother. However, many species of fisheries resources including turtles, bivalves and iteroparous fishes grow after the age of maturity, which is called indeterminate growth. For organisms with indeterminate growth, the mortality that maximizes population biomass at the age of maturity is not optimal. Anyway, the fishing mortality coefficient $F(x)$ is obtained as $F(x)=Z-M$ for $x \geq x_m$ and $F(x)=(Z-M)y(x)/\hat{y}(x)$ for $x<x_m$. The survival rate from recruitment to age x ($S(x)$) is $S(x)=\exp[-□_t(M+F(t))]$

Under these assumptions, Doi et al. (1992) investigated effects of fisheries on the turtles stock. We can also estimate spawning stock biomass per recruit (SPR) from parameters x_m, $W(x)$, $E(x)$, $F(x)$ and M as SPR = $□_x\ W(x)E(x)S(x)$ if the fecundity is proportional to body weight of an individual. For the Cuban Hawksbill turtles in 1992, the ratio of SPR under fished to SPR under unfished (F=0 for any age), usually denoted by %SPR (Mace 1994), is less than 25%, which implies strong overfishing (Tokunaga 2000)

The real %SPR is probably smaller than 25%, because DOIRAP method assumed the stationary population. If the population is declining, the total mortality coefficient is underestimated. Table 1 illustrates a hypothetical example. If the annual survival rate s=70%/yr and the population decline rate d=10%/yr, the ratio of $N(a+1,y)$ to $N(a,y)$ is $s/(1-d)$=77.8%. Underestimation of Z results in underestimation of the degree of overfishing and %SPR (Tokunaga 2000).

Harvest-based estimator of population size

Table 1. The stock-in-number at age a in year y of a hypothetical population.

$N(a,y)$	2000	2001	2002	2003	2004
1	1,000	900	810	729	656
2	778	700	630	567	510
3	605	544	490	441	397
4	471	423	381	343	309
5	366	329	296	267	240

Cuban Hawsbill turtles have been conserved since 1995. The average number of harvested turtles was 4700 during 1968-1990, while that was 399 during 1995-1999. The total population size is still uncertain.

If we estimate the population declining rate, the above method could be improved and avoid farther overexploitation by setting a threshold of relative population size (management plan in Hokkaido Island, see http://www2.ori.u-tokyo.ac.jp/~matsuda/deer-e.html). Trend in relative population size is important for decision-making.

In addition, if we use trends in relative population size (denoted by P_t), the number of catch (C_t), and the rate of natural population increase (r), then we can roughly estimate the absolute population size (N_t). The number of individuals in year t is given as $N_t = rN_{t-1}-C_t$. Since $(P_t/P_{t-1}) = (N_t/N_{t-1})$, $N_t = C_{t-1}P_t/(rP_{t-1}-P_t)$. Despite of a large uncertainty in the estimate of P_t, trends in relative population size and catch data will give lower and upper limit of absolute population size.

If we know the sex ratio and/or age composition in catch data, these are also useful in a better population estimator. Catch per unit effort (CPUE) and the number of egg-laying sites are good indicators of relative population size. Catch data and CPUE in the age of overexploitation are also useful, because the larger change of exploitation rate gives the better information in the absolute population size. We regard change in management action as an experiment. The overexploitation era will be an object lesson to adaptive management, if we collect and publish the data at the age of overexploitation.

If we execute an effective management for a long-lived animal, we should note that the population decline continue after the beginning of the management action. This is because the number of recruits that are born before the management action may continue to decline after the management action is introduced. This is called the momentum in demography. We introduce a new method of population estimation, and the momentum in demography for fisheries management.

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Research and Conservation of Dugong in Thailand

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ABSTRACT

Dugongs are rarely seen in Thailand, although they have distributed along coastlines both in the Andaman Sea and the Gulf of Thailand. The most abundant area of dugong is at Talibong-Muk Islands, Trang Province. Aerial surveys of dugong population along the Andaman Sea coast in 1997 and 1999 have been conducted and 50 and 38 dugongs were observed, respectively. So far, age determination had been made on 12 dugongs and the range of their ages was 1-43 years. Recently stomach contents of 6 dugongs have been investigated and 9 species of seagrasses were found in their stomachs. The composition of seagrasses found in dugong stomachs may be affected by the composition of seagrasses presented in dugong's feeding ground.

Dugongs were occasionally entangled in fishing gears. Among various types of fishing gears, gill nets were the main cause of the death of dugongs. The principal strategies to conserve the dugong in Thailand are: 1) to act of limiting or reducing some activities, which do harm dugong lives, such as the type of fishing gear, illegal fishing, speed boat, and tourism activity in seagrass beds and dugong habitats, 2) to promote the specific areas as national dugong sanctuaries, for instance, Talibong-Muk Islands in Trang Province, Sriboya-Cham-Pu Islands in Krabi Province, 3) to provide education and to increase public awareness on dugong and seagrass resources conservation, and 4) to promote a network of well-managed marine protected areas, which will conserve key dugong feedings sites through the both coastlines.

Key words: Dugong, aerial survey, distribution, conservation and management

INTRODUCTION

Among the most compelling and inspiring of creatures, dugong (*Dugong dugon*) is one of the "flagship" for marine species conservation in Thailand. This long-lived, magnificent marine mammal used to be generally found along both coastlines of the Andaman Sea and the Gulf of Thailand. However, dugongs are recently rare and only confined in some areas (Nateekanjanalarp and Sudara, 1992; Chantrapornsyl and Adulyanukosol, 1994; Adulyanukosol, 1995, 1998, 2000; Adulyanukosol et al., 1997, 1998, 1999a). Dugongs feed mainly on seagrass species and spend most time of their life in seagrass beds and adjacent areas.

Unfortunately, in Thailand dugongs being nearly extinction; their habitats are threatened by tourism development, settlements and fishing operations. At the present, the country has still lacked a well working conservation program and its existing laws are poorly enforced.

Objectives of Dugong Project
Research

The primary purpose of the study on dugong of Phuket Marine Biological Center (PMBC), Department of Fisheries (DOF) is to support the biological knowledge on dugong needed for the conservation and management plan of this animal in Thailand. DOF had provided budgets for 5 years of dugong and seagrass researches under the "Seagrass Resource Management and Dugong Conservation Project" during October 1995 to September 2000. The main objectives of dugong researches are as follows:

1. To study the distribution of dugong together with estimating their population using the data of interview, ship survey, aerial survey, available skeleton and stranded specimens.
2. To studying the biology of external and internal characteristics of stranded dugongs. This knowledge is needed to fill up the basic biological data, which is necessary for dugong conservation plan in Thailand.
3. To study on skeletons, the allometry of skulls and the age from their hard tissues in order to know the allometric variation, sexual dimorphism, age and geographical variation between the specimens from Thailand and other areas.
4. To analyze the stomach contents in order to identify their selective preference food and feeding grounds.
5. To analyze the level of heavy metal and organochlorine in dugong tissues in order to know the toxic contaminants in dugongs.
6. To compare dugong population in Thailand to those from other countries by mean of the application of molecular makers (e.g. mt-DNA) in order to reveal possible divergence of each population.

RESEARCH OF DUGONG IN THAILAND

Distribution of dugong
Andaman Sea (Figure 1)

Aerial survey of dugong was firstly conducted in Trang Province during 1991-1992 and 61 dugongs were observed (Aueng *et al.*, 1993). Subsequently, Adulyanukosol (1995) gathered the general information of dugong by making interviews to local villagers, from 200 families, inhibiting along the Andaman Sea coast. She found that the number of dugongs was rapidly declined over period of the least 20-30 years and recommended the areas critically needed for an aerial survey of dugong.

Since then, the attempts to survey the number of dugongs and to study their behavior were initiated by PMBC in 1997. Adulyanukosol *et al.* (1997) conducted the aerial surveys at 8 seagrass areas within 4 provinces, *i.e.*, Phangnga, Krabi, Trang and Satun, using the "Polaris Flying Boat" (inflatable boat with wings and 64 HP engine) in 1997 and found a total of 48 dugongs including 5 calves. With the incorporation from the Royal Thai Navy, the other aerial surveys had also been conducted in 1997 and 1999 using either helicopter (Bell and S-76B) or Dornier-228 (fixed-wing aircraft with capacity of 8 passengers) (Adulyanukosol *et al.*, 1999a). The large assemblage of dugongs was found at Talibong-Muk Islands, Trang Province. The results from overall surveys made in 1997 and 1999 revealed an actual number of 50 and 38 dugongs being seen, respectively. Additional flights were conducted around the seagrass areas of Sriboya-Cham-Pu Islands, Krabi Province in March 2000 using a microlite (Airbone; microlite with 3 wheels and 64 HP engine) and 6 dugongs including 1 calf were observed (Adulyanukosol, unpublished data).

Gulf of Thailand (Figure 1)

There are few researches conducted on dugong in the Gulf of Thailand. Dugongs used to be found at Kung Krabaen, Chantaburi Province, and Makhampom Bay, Rayong Province, on the east coast of the Gulf of Thailand. (Nateekanjanalarp and Sudara, 1992). Nevertheless, dugongs were occasionally found at Makhampom Bay and Prasea River Mouth, Rayong Province. Dugongs were often seen during feeding on seagrass at Kung Krabaen Bay around December-January. Each year about one dugong is dead by trawler or other fishing operations in Rayong Province. In Trat Province, one and 5 carcasses of dugongs were found in 1996 and 1997, respectively. Recently in Chonburi Province, a dead calf, of about 30 kg in weight, was found at Chong Samae San, in April 1999 and a female calf of 108.5 cm in length was dead in June13, 2000 at Sattahip Bay (Adulyanukosol, 1999, and unpublished data).

On the west coast of the Gulf of Thailand, a dugong was reported to die causing by trawler at Khanom District, Nakhon Si Thammarat Province in 1996. During 1997-1998, three dugongs died from trawlers at Samui Island, Surat Thani Province. A rotten male dugong was found floating in the sea off Lamae District, Chumporn Province in February 1998 and, in the same year, another freshly dead female was stranded in the same district (Adulyanukosol, 1999).

The living dugongs have never evidently been observed so far: this might be because of their rarity in nature or inadequate survey program. However, on the evidence of dead individuals from several localities in the Gulf of Thailand, as pointed out above, it is believed that a viable population might be established either along the east coast or the west coast of the Gulf of Thailand.

The aerial surveys showed that the diurnal inshore feeding is normal for dugongs living in the Andaman Sea coast. During feeding activities, they ascended to surface for breathing every few minutes. The relationships between mothers and calves were closely observed during the flights using the Polaris Flying Boat, particularly at Cham, Pu and Sriboya Islands in Krabi Province and at Muk-Talibong Islands in Trang Province. The cow-calf pairs were seen together feeding on seagrass, swimming and surface breathing. During surface breathing, calves stayed beside their mothers or on the dorsal of mothers (Adulyanukosol *et al.*, 1997). In an observation during low tide, the dugongs appeared at the distance of about 4-6 km from shore (Adulyanukosol *et al.*, 1999a).

The main problems concerning the aerial survey in Thailand are: 1) the extremely high operating cost, 2) the lack of personnel and 3) a long period for discovering dugong populations. Since a small number of dugongs in Thailand, it might be very difficult to assess the actual number using systematic method such as the fixed-width aerial transect. To conduct aerial surveys using aircraft for long distance area and using helicopter, Polaris Flying Boat, microlite and balloon for survey or studying dugong behavior in specific areas are recommended.

Dugong in captivity

PMBC is probably the first institute in Thailand that had involved in marine mammal work since 1979. Four dugongs had been brought to PMBC during 1979-1982 and 3 of them survived in captivities for 77-153 days. *Halophila ovalis* was the preference-food species for those dugongs among several other offering seagrass species (Boonprakob *et al.*, 1983). PMBC has occasionally received the entangled dugongs since then and the attempts to rearing them in captivities had been conducted by Boonyanate (1994) and Adulyanukosol and Patiyasevi (1994).

The maximum survival-keeping period for a captive dugong was 200 days. Over the period, the dugong consumed mainly *H. ovalis* for 6.7 kg/day in average. It gained 15.5 kg in weight and 2 cm in length during keeping time (Adulyanukosol and Patiyasevi, 1994). Furthermore, the breathing pattern of this captive dugong was observed and shown that the average breathing interval was 102.5 sec/time and the maximum diving time was 480 sec (Adulyanukosol, 1997). The major problems concerning the keeping dugong in captivity were; foods, size and type of enclosures, injuries inflicted during catching and transportation, susceptibility to diseases, and medical treatments (Boonprakob *et al.*, 1983; Adulyanukosol and Patiyasevi, 1994).

Age determination of dugong

Dentinal growth layers group (GLGs) of dugong tusks were examined from 12 stranded animals (6 in each sex) for the purpose of age determination. Body length of the specimens ranged from 1.60-2.73 m, and the tusk length varied from 1.6-21.0 cm. The GLGs counts ranged 1-43 for the female and 2-16 for the males. The oldest female obtained from Ranong Province was 2.71 m in body length and 293 kg in weight. The Von Bertalanffy growth curve was calculated as the following equation; $L = 2.747 (1-\exp(-0.265 (A+1.125)))$, where L is body length in m and A is age in year (Adulyanukosl *et al.*, 1998).

Decrease in number

Since 60 years ago, local people in Rayong Province had killed dugongs and consumed their meat as for protein source. The fishermen had to chase the dugongs into shallow water or river mouth and hit them or pierced them with harpoons until they died. In the southern part of the Andaman Sea coast, fishermen used to chase the dugongs into the shallow water together with an operation of enclosing net (Adulyanukosol, 1999).

Dugongs are no more killed for food at present; however, they were occasionally caught in fishing gears. They easily died while being entangled in fishing gears, particularly in various types of gill nets. They generally tried to be free and finally drowned. For the case of being trapped inside a stake trap, they tried to leave, but always got hurt by bamboo and net of the trap and then finally died (Adulyanukosol, 1999).

The dugongs have a maximum longevity of about 70 years and a minimum prereproductive period of 9-10 years for both sexes. A single calf is born after a gestation period of about 13-14 months and estimate of calving interval ranges from 3-7 years (Nishiwaki and Marsh, 1989). Since the low number of dugongs in Thai waters, a small number of new calves may not enough to replace the loss number.

Therefore, the dugongs in Thailand are considered to be critical in danger of extinction.

Analysis of stomach content

Adulyanukosol *et al.* (2000) had studied the stomach contents from 6 stranded dugongs, collected in Trang Province during January 1997- January 1999. Basing physio/morphological characters of leaves and epidermal cells, seagrass fragments were identified down to species under stereo- and compound-microscopes. They reported that nine species of seagrasses were found in dugong stomachs and their biomasses were determined in terms of dry weight. The percentage dry weight of each species (eight out of nine) found in the stomach contents was as follows: *Halodule* (*H. pinifolia* and *H. uninervis*) 0.84-44.99%, *Halophila ovalis* 3.11-29.60%, *Thalassia hemprichii* 3.50-28.69%, *Cymodocea* (*C. serrulata* and *C. rotundata*) 5.06-42.52%, *Syringodium isoetifolium* 0.42-22.39%, and *Enhalus acoroides* 31.76-41.39%. The biomass of *Halophila decipiens* was not determined because of its scarcity.

In addition, algae was found in almost all stomachs but, interestingly, polycheate tube was found in only one stomach in the void of algae. The composition of seagrasses found in dugong stomachs may be affected by the composition presented in dugong's feeding ground. The species of seagrass predominated in stomach contents seemed to coincide with the dominant species found in the seagrass area nearby the places where the stranded dugongs were collected (Adulyanukosol *et al.*,2000).

CONSERVATION AND MANAGEMENT OF DUGONG

Vision for future

At present, PMBC is a center of marine mammal (dugong, dolphin and whale) research in Thailand. PMBC is preparing to provide a network of marine mammal research and conservation covering all coastal provinces of Thailand. Moreover in future, PMBC plans to extend this network to Southeast Asia region e.g.. Cambodia, Vietnam, Myanmar, Malaysia. The success of these purposes will not happen, if there is a lack of the cooperation among various groups, for instance, government officers, Non Government Organizations (NGOs), and local communities.

Dugong feeding sites will be jointly managed and provide tourism benefits to communities, local governments and the private sector. Some of the following conservation and management strategies are raised after obtaining the basic biological information of dugongs.

For Thailand's dugong and the nation's natural heritage

1. To minimize the fishing gears, which cause harm to dugongs around dugong's feeding ground such as gill nets, fish traps, and illegal fishing operations.
2. To promote certain fishing gears, which do not cause harm to dugongs around dugong's feeding ground such as small traps (fish, squid and crab) and hand lines.
3. To ban the fishing operations, which cause damages to seagrass beds such as power push net fishery.
4. To promote the specific areas as dugong sanctuaries of Thailand such as Talibong-Muk Islands in Trang Province, Sriboya-Cham-Pu Islands in Krabi Province.

5. To promote a network of well-managed marine protected areas, which will conserve key dugong feedings sites through the both coastlines (the Andaman Sea and the Gulf of Thailand).
6. To provide education and to increase public awareness on dugong and seagrass resources conservation.

For communities, government and businesses

1. Environmental tourism will increase, and tourism-related business will grow, as people come to see revived dugong-feeding sites.
2. Communities near dugong feeding sites and habitats will enjoy sustainable economic benefits from both fisheries and tourism.
3. Local governments will command more respect and be strengthened by better enforcement of the laws.
4. The seagrass resources and their biodiversity values will be maintained.

CONCLUSION AND DISCUSSION

Dugongs are rare and confined to some areas of both coastlines of Thailand. In the Andaman Sea, they have been found along the coast from Ranong to Satun Provinces. In the Gulf of Thailand, they have been found in several coastal provinces, namely, Chonburi, Rayong, Chantaburi, Trat, Chumporn, Surat Thani and Nakorn Si Thammarat. Although, the systematic and comprehensive aerial survey on dugong population in Thai waters has not been conducted yet, they are believed to present more in the Andaman Sea than in the Gulf of Thailand.

Dugongs are still found at a substantially high number at Talibong-Muk Islands, Trang Province. This seems likely be the last place in Thai waters where exists the large viable population of dugongs. Thus, it is critically needed to conserve and manage the area. In particular, the fishing practices that might cause violation to dugongs should be either regulated or prohibited in the dugong habitats. Dugongs will soon vanish from Thai waters if conservation strategies of dugong are not succeeded. The recommended areas to be established as the National Dugong Sanctuary are the areas around Talibong –Muk Islands, Trang Province and Sriboya-Cham-Pu Islands, Krabi Province in the Andaman Sea.

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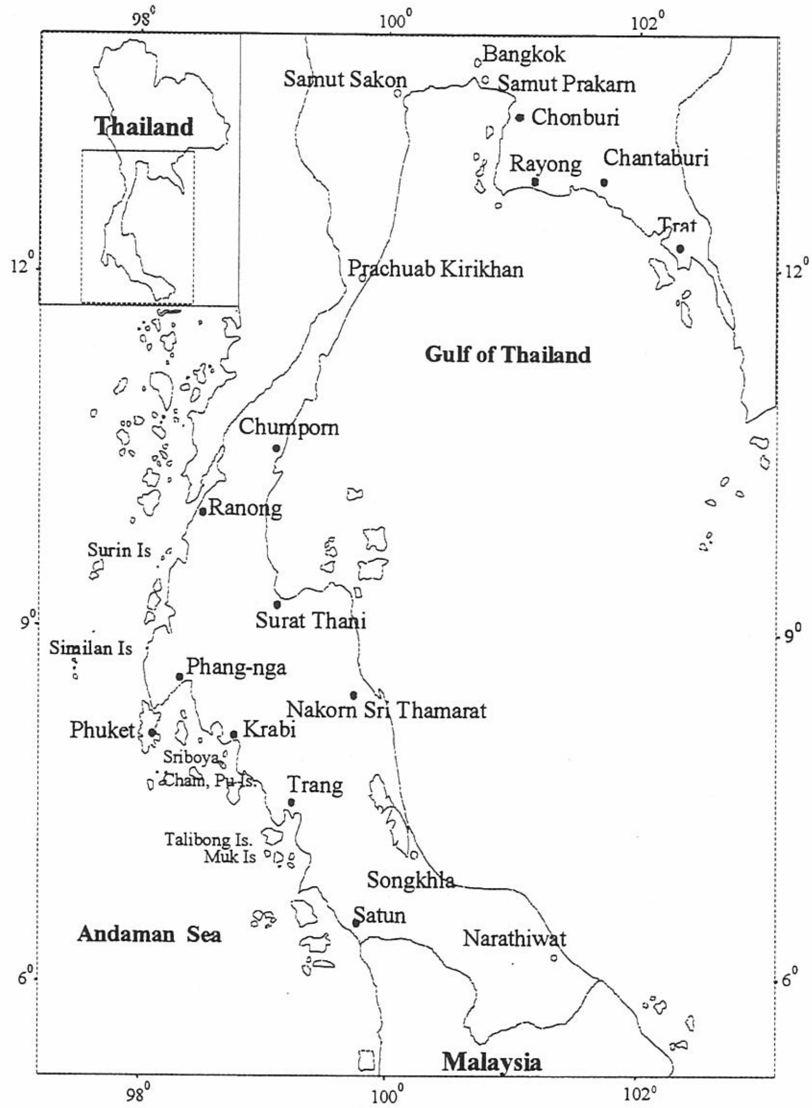

Figure 1. Map of Thailand showing the both coastlines; black circle indicates the province in which dugongs have been found.

Correlation between the Sea Turtles and Shrimp Trawl Fishery in Thailand

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Abstract

Shrimp trawl fishery has been operated along the coastal area in Thai water.Otter-board trawl net with boom has been used in shrimp fishing vessel size range less than 14 meters in length. The catch compositions are large shrimp and small shrimp. Large shrimp mainly composed of *Penaeus merguiensis, P.semisulcatus, P.monodon, P.latisulcatus,Metapenaeus ensis, M. affinis* and *M. intermedius*. Small shrimp mainly composed of *Metapenaeopsis spp., Trachypenaeus spp.* and *Parapenaeopsis spp.* Sea bottom characteristics were analyzed with catch rate data to investigate the distribution of species. *P.merguiensis* and *Metapenaeus spp.* were distributed in muddy area while *P.semisalcatus* and *P.monodon* were mainly found in muddy-sand area. *P. latisalcatus* was mostly found in sandy-mud or sandy area. *Metapenaeopsis spp.* was normally found in muddy-sand or sandy-mud area while *Trachypenaeus spp.* and *Parpenaeopsis spp.* will be found in muddy area. Furthermore, environmental information such as temperature, salinity , water depth, water current and wave of surface sea water will be used for further analysis. The objective of this study is to investigate the correlation between the sea turtle and shrimp trawl fishery . Hence, the results of tracking or migration path of sea turtle will be need and very important for this study.

Key words: Sea turtle, shrimp trawl fishery

Introduction

Shrimp trawl fishery in Thailand has been operated along the coastal area both of in the Gulf of Thailand and Andaman Sea. The fishing gear used is otter-board trawl net with boom in nighttime (Figure 1). The size of shrimp trawl fishing boat is normally less than 14 meters in length. Target species of this trawl is shrimp . However, others groups of species such as fishes, squids, cultle-fishes and crabs are also in the catch composition. Trash fish is high amount and composed of small economic species. Shrimp trawl is prohibited to operated withtin 3,000 meters from shoreline and islands. Sea turtles are endanger species and has been protected by law .The incidental catch of sea turtles by trawl net has been found because the feeding area or migration path of sea turtle is overlapped with shrimp fishing ground. (Figure 2) . However, this is still in question because of shrimp trawl net in nighttime or fish trawl net in daytime. Hence, the correlation between the sea turtle and shrimp trawl fishery has been studied by analysis of shrimp fishing ground, environmental information and migration path of sea turtle.

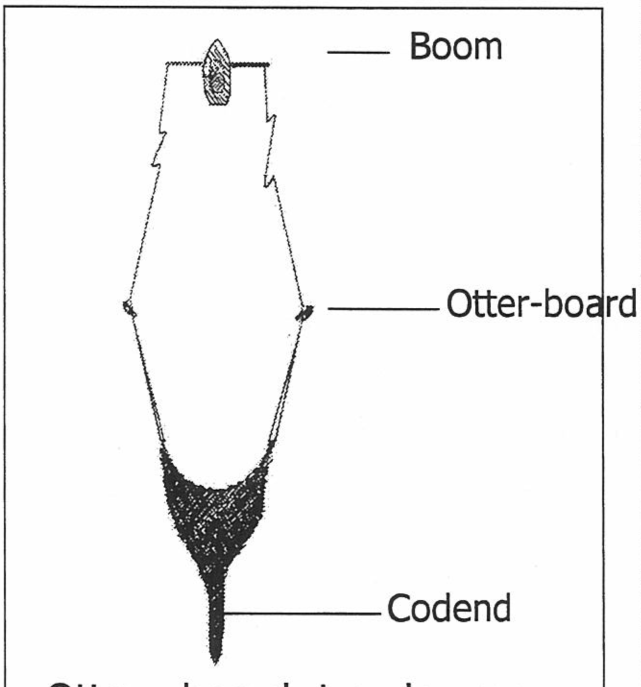


Figure 1.- Otter-board trawl net with booms

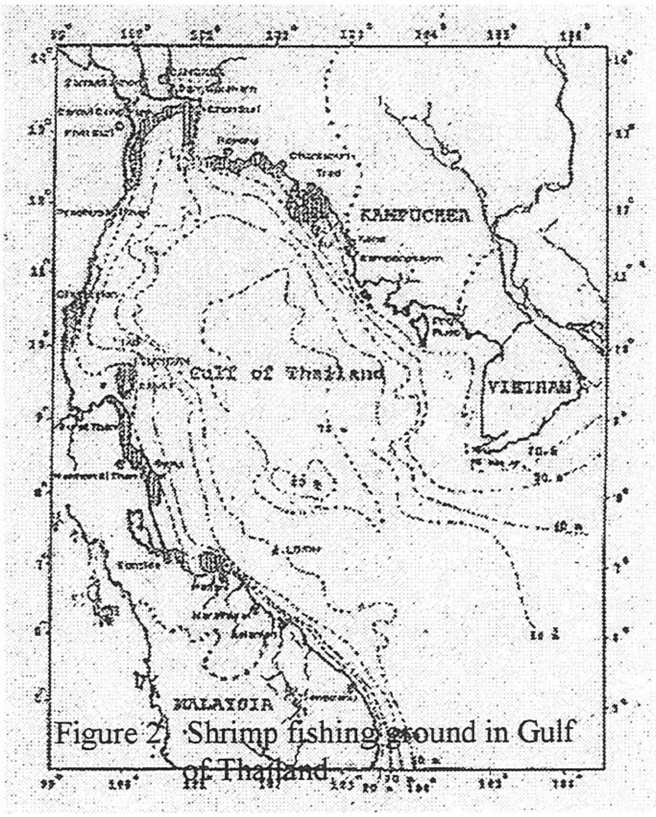


Figure 2) Shrimp fishing ground in Gulf of Thailand.

Methods.

The data used in this analysis are 1) Catch composition of shrimp from trawl survey by research vessel of Marine Fisheries Division, Department of Fisheries in 1995. 2) Environmental information from the Royal Thai Navy (Oceanographic Division, 1995) 3) Wave height and surface water current in 1999 from the Royal Thai Navy.

Results

The Marine Fisheries Division, Department of Fisheries has monitored the distribution, abundance and change in species composition of shrimp from trawl net in the Gulf of Thailand from 1967 up to the present. Otter-board trawl net has been used as the standard fishing gear. The survey has been conducted in nighttime by grid sampling method. Shrimp distributed in the shallow water along the coastline in the water depth not more than 30 meters. High abundance was found in the eastern part of the gulf, in the inner gulf and in the lower part of the Gulf of Thailand (Figure 3).

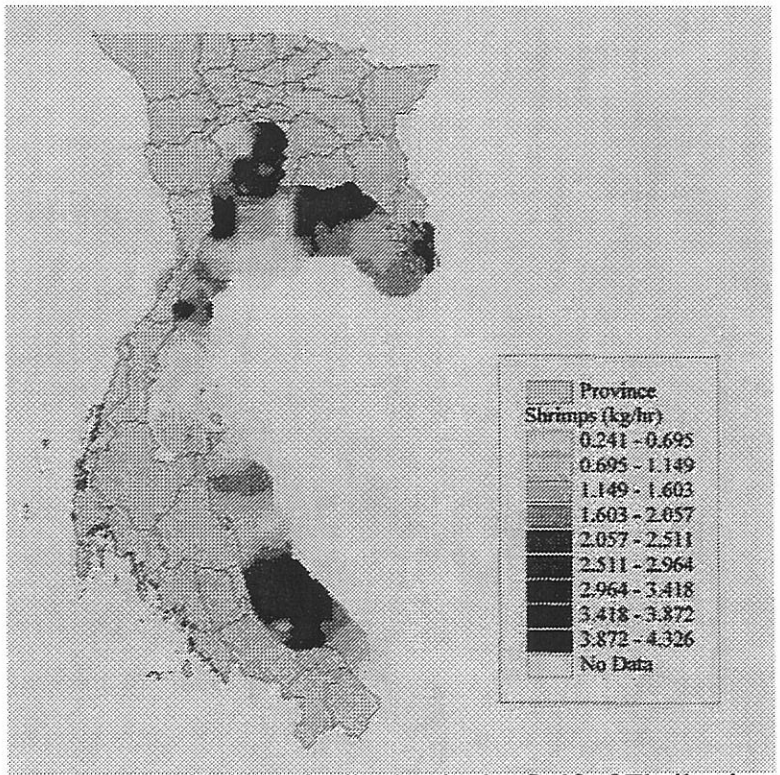
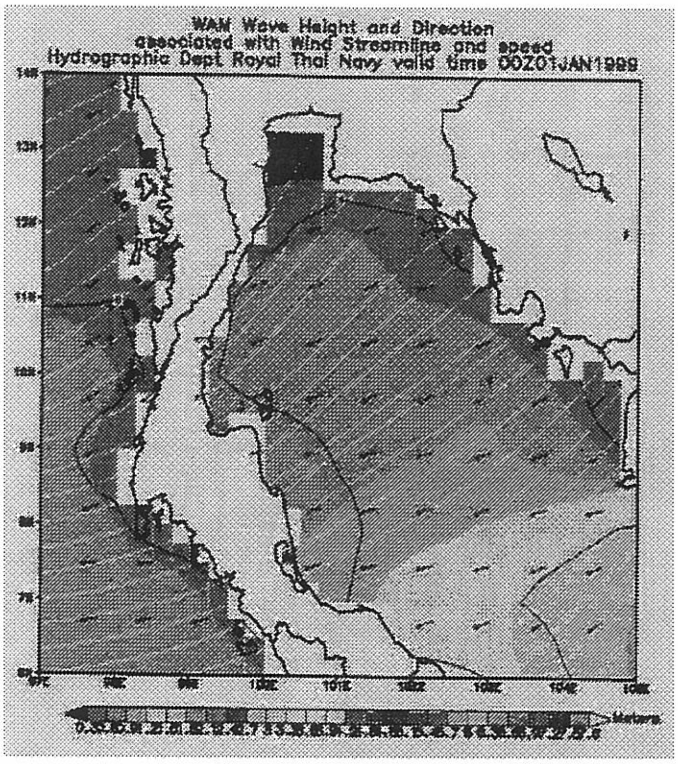


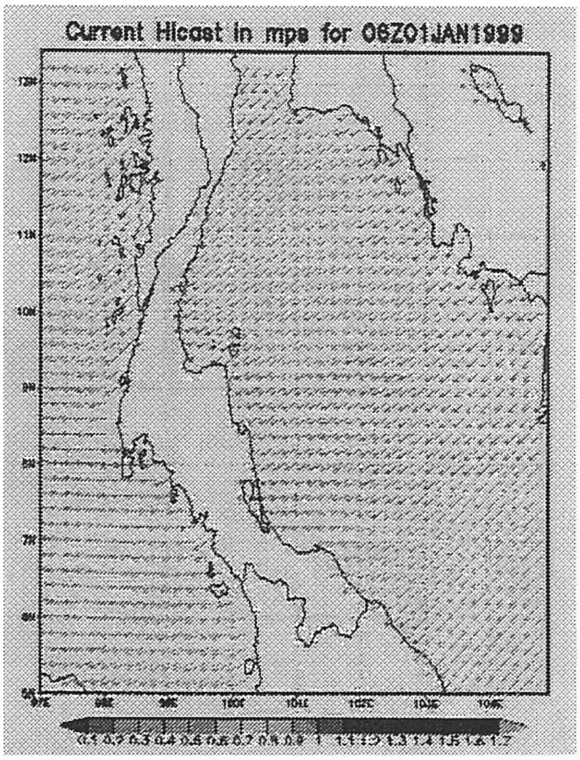
Figure 3 Shrimp distribution in the Gulf of Thailand

White shrimp (*P.merguiensis*) and *Metapenaeus spp.* (*M.ensis, M.affinis* and *M. intermedius*) will distributed in muddy area especially in the inner gulf and the southern part. The fishing ground of Black tiger prawn *(P.monodon*) and Tiger prawn (*P.semisalcatus*) are very wide. They like to live on muddy-sand area. Yellow shrimp (*P.latisulcatus* and *P.longistylus*) were found in sandy-mud and sandy area in the eastern part of the gulf and will be found very few in others area. For small shrimps, *Metapenaeopsis spp.*was normally found in muddy-sand or sandy-mud area while Trachypenaeus spp. And *Parapenaeopsis spp.* will be found in muddy area.

The environmental information are available such as depth of water, bottom topography, surface temperature, surface salinity, dissole O_2 at sea surface, wave height and direction (Figure 4) and surface water current (Figure 5). The distribution of shrimp by species rather related with bottom topography, and water salinity. *P.merguensis, M.affinis* and *Trachypenaeus spp.*were found in the area which water salinity was low, especially near the mouth of river.



In the Gulf of Thailand and Andaman sea during northeast monsoon season.



of Thailand and Andaman sea during northeast monsoon season.

Discussion

In this progress report, the correlation between the sea turtle and shrimp trawl fishery can not be analyzed because the result of migration paths of sea turtle has not been finished. However, surface water current, wave height and direction should be the important for the migration paths of sea turtle. From the night trawled monitoring survey by research vessel during 1967-1996, there was not any sea turtle in the catches (Marine Fisheries Division, 1997). Moreover, there was significantly no relation between sea turtle instating and number of shrimp trawlers in Cholburi Province, east coast of Thailand (Sujittosalul T.and S. Sanaluk, 1997). This study will be continued by analysis of the data of shrimp fishing ground, environmental information concerned and migration paths of sea turtle to find out whether there is the correction between sea turtle and shrimp trawl fishery or not.

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GIS MAPPING TECHNIQUES TO AVOID BYCATCH

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Abstract A tracking system on the Internet of green sea turtles was developed. The system can display turtle migration paths automatically on the Internet. To analyze the green turtle behavior and to avoid bycatch, I conducted GIS technique. GIS is Geographic Information System. On the map much information is integrated and analyzed. It is important to know the relationship between turtle migration and bycatch caused by shrimp trawling.

Keywords: Internet, PTT, GIS, bycatch, sea grass bed

Introduction

It is said that shrimp trawling causes bycatch of sea turtles. To avoid bycatch it is important to know migration paths of the sea turtles and fisheries ground. To know the migration paths ARGOS system seems to be powerful. Because ARGOS system teaches us the location of turtles attached PTTs by using satellite communication, we know the location of the turtle all over the world. ARGOS system gives such data as, the location, date time, SST, staying hours at surface when PTT sends radio waves to satellite NOAA. I used ARGOS system and its data to know green sea turtles migration paths and avoid bycatch. To avoid bycatch I will use GIS technique. To integrate and overlay the migration paths and fisheries information on the map, I will try to research the relationship between the migration paths and bycatch.

1. Tracking System on the Internet

We developed a new system that can renew and display the satellite tracking of green sea turtles automatically on Internet. (Figure.1, 2 and 3) This system can display current location of 7 turtles with the ID umber. Six of the turtles, 16724, 28532, 28533, 28534, 16723 and 26796 were in the Gulf of Thailand. (Table 1) The 18683 is in the Andaman Sea. This system can tracked many turtles at the same time. The location is automatically renewed. The system can display the migration paths as break lines and the surface time, surface temperature, the date and time when the PTTs uplink a satellite.

You can make a access this system easily by the Internet and the URL is the following.

http://bg66.soc.i.kyoto-u.ac.jp/shiba/seastar2000/index.htm

2. GIS Mapping Technique to Avoid Bycatch

Geographic Information System is a tool to analyze and integrate much information on map. We applied the GIS to avoid bycatch caused by shrimp trawling. To examine the relationship between the migration paths of the green sea turtles and sea surface temperature, the SST and the depth of the Gulf of the Thailand, both seem not to affect the migration of the green sea turtles since SST of surface in the Gulf of Thailand keeps around 29 degrees centigrade through the year. The depth is shallow everywhere (even the deepest point has less than 100 meters). Therefore the temperature and the depth seem not to have much influence on the migration of green sea turtle.

The sea grass bed seems to have much influence on the migration because in one tracked turtle (ID number 18683) in the Andaman Sea swam straight to one sea grass bed after another and stayed for a long time sea grass bed area. The sea grass bed seems to be so important to understand the migration of the green sea turtle. The growth of the sea grass bed depends on the depth and bottom environment. The depth affects photosynthesis because too deep area has less light for sea grass to grow. In addition the bottom environment affects the growth of sea grass.

On the other hand, the trawling area is important to avoid bycatch because shrimp trawling causes bycatch. The shrimp trawling area is changed seasonally and is different according to the shrimp species. This trawling area is necessary to know relationship between the shrimp trawling and the migration paths of the green turtles and to avoid bycatch.

Therefore I need more information about the sea grass bed and fisheries information such as trawling areas, CPUE, the trawling seasons in the Gulf of Thailand in examining and analyzing.

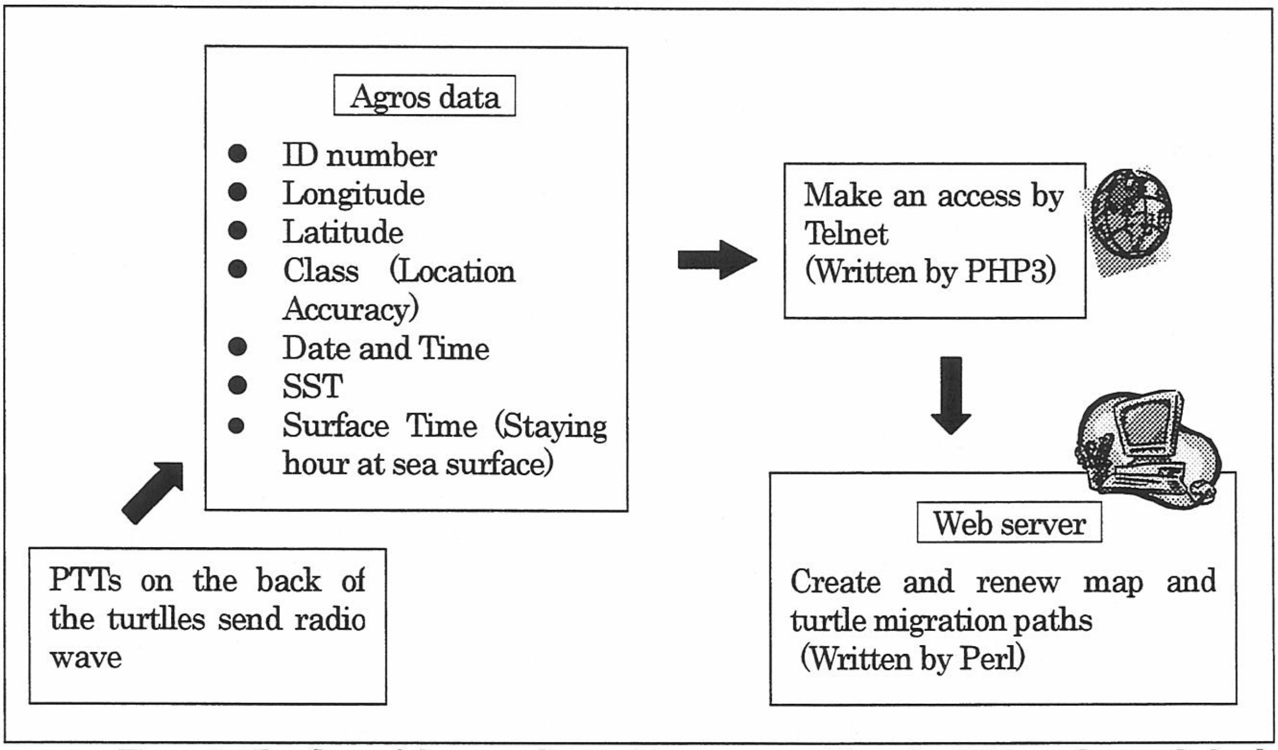

Figure1. The flow of data on the tracking system. First the PTT on the turtle back sends radio wave to satellite NOAA. The radio wave includes Argos data such as ID number, location information including longitude, latitude and classes (location araucarias), date and time when radio wave sends, the SST and the surface time. The web server that has the tracking system gets Argos data by Telnet and creates and renews map and turtle location.

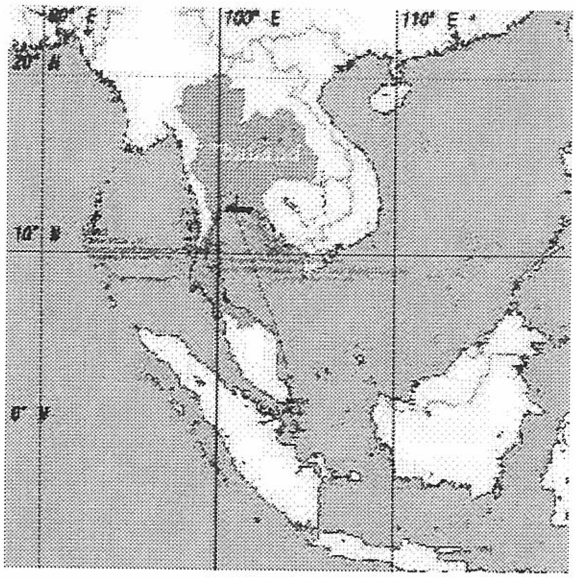

Figure 2. Interface of the system. 7 turtles are tracked on the system. Each migration path of turtle is displayed as different colors according to each ID number. On the digital map the location of turtle is drown as the points. The migration paths are created as break line that links each point showing the location. This map is clickable map and users can enlarge anywhere they like.

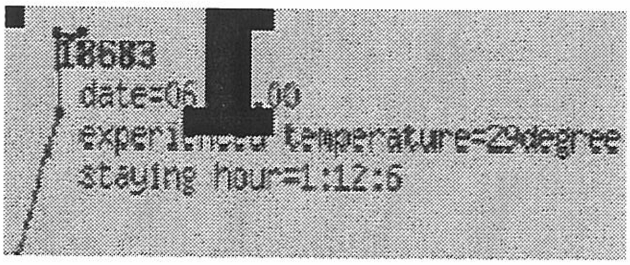

Figure3. Enlarged map. Of the tracking turtles 2 turtles, ID number 18683 and 26769 display such data as date and experienced SST, surface time. Surface time means a turtle staying hour at the sea surface.

Turtle Name	ID number	PTT types	Released Point	CCL (cm)	Weight (kg)
Sampreang	16724	ST-18	Mannnai Island	91x104	125
Sri Koa Khram	28532	ST-18	Khram Island	85x98	115
Sri Sattahip	28533	ST-18	Khram Island	86x94	90
Sri Chonburi	28534	ST-18	Khram Island	89x100	130
Chao Samut	16723	ST-18	Khram Island	86x98	110
Sri Racha	29679	KiwiSAT	Mannnai Island	76x84	59
Kayano	18583	KiwiSAT	Similan Islands	90x110	–

Table 1. Tracked turtles data. Turtle names, ID number, released point, CCL and weight. ST-18 is manufactured by Telonics Co. Ltd. KiwiSAT is manufactured by SirTrocle.

DEVELOPMENT OF THE NEW DEVICES FOR MARINE BIOTELEMETRY

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Abstract We challenged to adopt several micro-electronic devices to measure aquatic lives. The devices included data storage tags, ultrasonic tags, and satellite PTTs for the red sea breams , Adélie penguins *Pygoscelis adeliae*, the Lake Biwa catfish *Silurus biwaensis*, and sea turtles *Caretta caretta*. Based on these results, new devices for marine biotelemetry are under development. They are a visual data storage tag and a magnetic field sensor accelerometer tag. We have a plan to test the prototypes in Thailand coming February.

***Keywords*:** data storage tag, CCD, MR sensor, accelerometer, biotelemetry

Introduction

Recently, due to drastic development of microelectronics, we can use very smart devices to measure behavior of marine lives. We challenged to adopt several micro-electronic devices to measure aquatic lives. The devices included small data storage tags, ultrasonic tags, and satellite PTTs for the red sea breams (Mitsunaga et al., 1999), Adélie penguins *Pygoscelis adeliae* (Arai et al., 2000), the Lake Biwa catfish *Silurus biwaensis* (Takai et al., 1997), and sea turtles *Caretta caretta* (Sakamoto et al. 1997). These techniques were very useful to understand the correlation between ambient fluctuation and their behavior.

Based on the successful results, we attempted to develop two types of new devices for marine biotelemetry. One is a visual data storage tag and the other is a magnetic field sensor accelerometer tag.

In this paper, I introduce our recent research works and a concept of the new data storage tags.

Methods

A data storage tag, PD2GA (Little Leonardo Co. Ltd., Tokyo) originally designed for the Adélie penguin in the Antarctica was attached to a red sea bream. The tag weighed 17.7 g in water, were 20 mm in diameter with 122 m length, and had 32-Mbit flush memories inside to store four channel data including surging and swaying acceleration ($\pm$ 4 gravity), revolution of a screw (revolution per second), and swimming depth (0 – 200m). The acceleration data represented longitudinal and lateral oscillations, respectively. These data were converted into 12-bit digital data and archived by a microprocessor inside. The sampling rate was variable ranging from 0.0078 s to 2.0 s according to the purpose of the experiment. We adopted 0.09375 s for sampling rate of acceleration to estimate tail beat frequency, and every one-second for depth and speed data in this study. The experiment was performed in a fishpond which was a rectangle 125-m by 42-m with 3-m depth. The fishpond had been used for a salt farm then reformed for the fisheries experiments. Therefore, seawater in the pond was drained off after experiments to recovery experimental fishes. An experimental red sea bream weighed 2.6 kg and 53-cm fork length was released in the fishpond at 13:57 5th October 1998 and recovered at 10:21 7th. The data storage tags were attached to the dorsal muscles in front of the dorsal fin.

Results and discussion

We picked out the speed data over 0.5 m s^{-1} since the screw of the tags began to rotate mechanically over around 0.4 m s^{-1}. Forty three times of swimming events were summed up in the data. The 43 events were classified in several patterns as type 1: simply dash over 1 m s^{-1} and stop, type 2: dash over 1 m s^{-1}, moderate swim, and stop, type 3: moderate swim, dash under 1 m s^{-1}, and stop, type 4: moderate swim, dash over 1 m s^{-1}, moderate swim again, and stop, type 5: others.

Why did the red sea bream indicate these patterns? Did the red sea bream see baits, predators, and/or shelters to hide in the water? To answer these questions, we have to see what the red sea bream see in the water. Therefore the visual data storage tag is necessary to reply the questions.

We can calculate swimming distance of the fish by integration of surging acceleration as a simple equation as follows,

$$S_n = S_{n-1} + 1/2\ at^2,$$

S: swimming distance (m)

a: surging acceleration (m/s^2),

t: time (s).

Fig.1 shows observation data of the surging acceleration, swimming speed, and depth, and calculation data of the acceleration. Fig.1-e shows differential between observation depth and calculated distance. The differential may indicate the horizontal moving distance. That is Fig.1-f shows total moving distance of the fish as time elapsed and Fig.1-g shows 2-D position of the fish. This result suggests that we could calculate 3-D position of the fish if we take 3-D acceleration data.

Concept of new devices

We are now developing the new devices such as a visual data storage tag and a magnetic field sensor accelerometer with Allec Electronics Co. Ltd.

The visual data storage tag is installed with CMOS CCD device that can take 100 pictures with 28000 pixels. The dimension of the tag is 92 x 40 x 28 mm^3 with ca. 200g. It has an IrDA interface to transfer pictures to PC. A prototype model has capacity to 100 m pressure.

The magnetic field sensor accelerometer has a MR sensor and two accelerometers in it. The MR sensor can detect 3-D magnetic field to transform into 3-D direction data. We can calculate 3-D position combining the 3-D direction data and 3-D acceleration data. The dimension is 54 mmø x 178 mm. A diagram of its circuit was just completed.

We have a prospect to complete both of the tags in a few months. If everything goes well, we would like to bring the tags to Man-Nai Is. to test with green sea turtles coming February.

Acknowledgment

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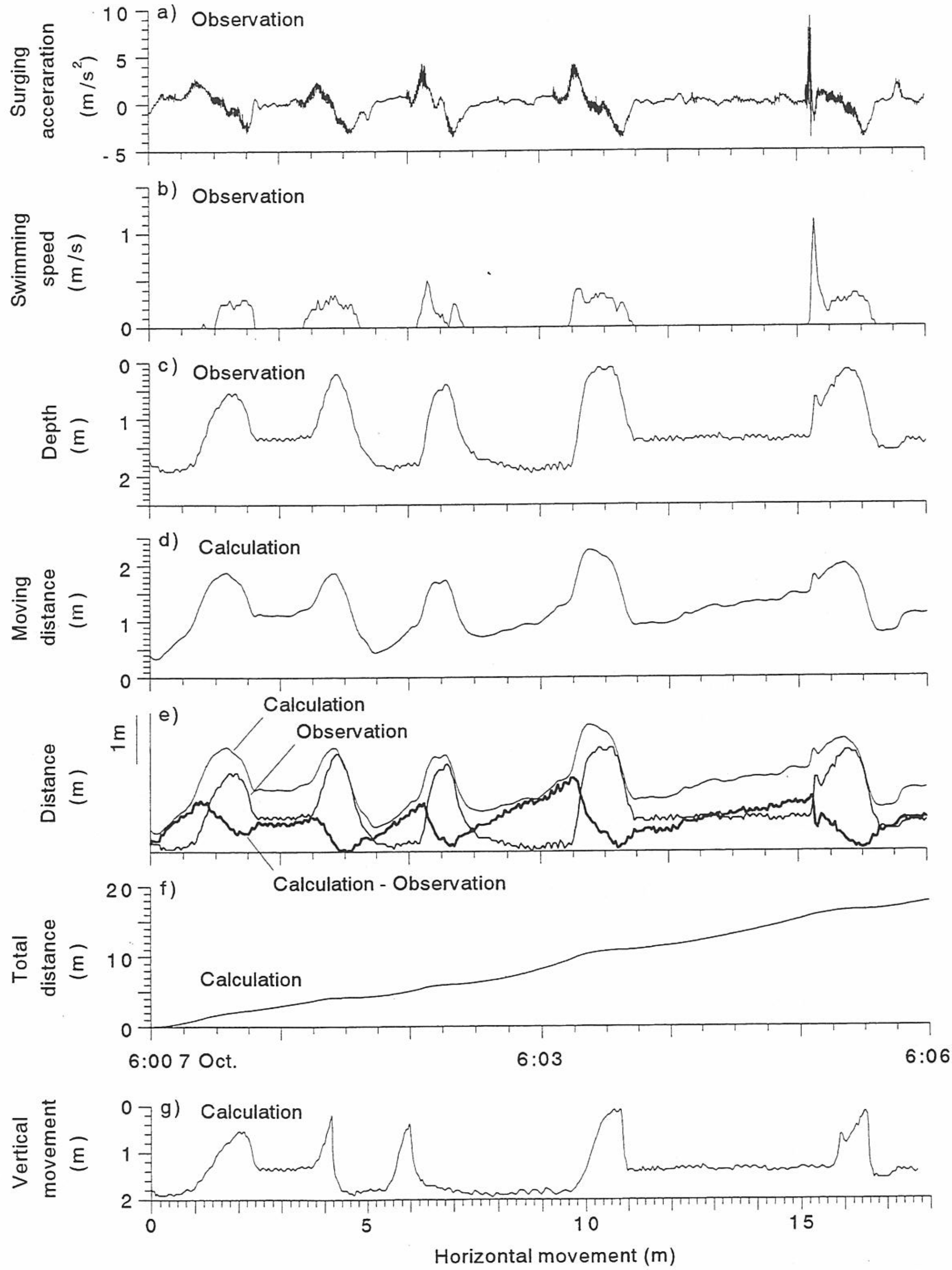
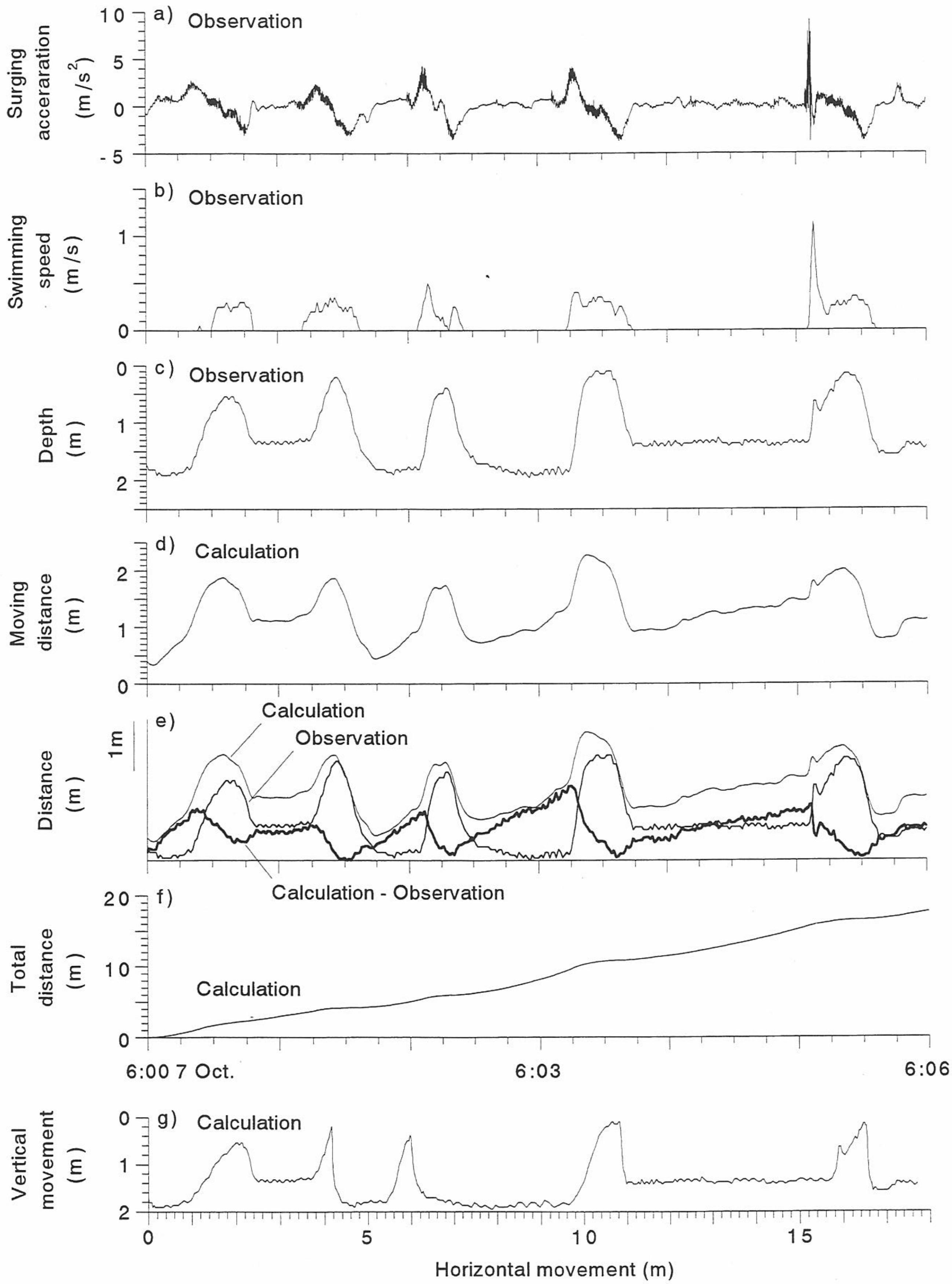


Fig.1. Time series records using a data storage tag attached to a red sea bream. a) – d) show observation data and e)- g) show calculated values from surging acceleration.



a) Observation
Surging accararation (m/s²)
10
5
0
-5
b) Observation
Swimming speed (m/s)
1
0
c) Observation
Depth (m)
0
1
2
d) Calculation
Moving distance (m)
2
1
0
e)
Calculation
Observation
Distance (m)
1m
Calculation - Observation
f)
Total distance (m)
20
10
0
Calculation
6:00 7 Oct.
6:03
6:06
g) Calculation
Vertical movement (m)
0
1
2
0
5
10
15
Horizontal movement (m)

STATUS AND CONSERVATION OF SEA TURTLES IN THAILAND

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ABSTRACT

Conservation attempts are being made for the four remain species of sea turtles in Thai waters, which are green turtle (*Chelonia mydas*), *hawksbill turtle* (*Eretmochelys imbricat*), olive ridley turtle (*Lepidochlys olivacea*) and leatherback turtle (*Dermochelys coriacea*). Green and hawksbill turtles are abundant in the Gulf of Thailand, nesting activities occurs all year round with a peak from May to July. Olive ridley and leatherback turtles are found at the Andaman Sea coast of Thailand, their nesting season is a short period between October and March. Populations of the sea turtles in Thailand have been found drastically declined, which more seriously for the olive ridley and leatherback. The declination caused by several factors. Laws and regulations have been registered in order to conserve sea turtle. Public information on sea turtle biology and conservation have been conducted to increase public awareness.

STATUS AND THREAT

Five species of sea turtles have been recorded in Thai waters; leatherback turtle (*Dermochely coreacea*), green turtle (*Chelonia mydas*), hawksbill turtle (*Erethmochelys imbricata*) olive ridley turtle (*Lepidochelys olivacea*) and loggerhead turtle (*Caretta caretta*) Phasuk and Rongmaungsart, 1973). There are two main nesting sites of sea turtles in Thailand which are;

In the Gulf of Thailand, nesting sea turtle occurs at Khram island (Fig. 1). The island located at the inner Gulf of Thailand, Chonburi Province. It is the important nesting area for green and hawksbill turtles. No other specie has been recorded in this area. Nesting green and hawksbill turtles occurs throughout the year with a peak from May to August (Manansap and Charuchinda, 1994). The whole island is occupied by Thai Navy, entering the island is prohibited. Natural predators are mainly by lizards and ghost crabs. The main problem affected to sea turtle populations in the Gulf of Thailand are the heavy fisheries activities.

The beaches are patrolled the turtle eggs are removed to the hatchery at the Navy base to avoid the predators and erosion of the beach. The baby turtles are rearing for a period of times before released to the sea (Monanunsap and Charuchida 1988).

In the Andaman sea coast and adjacent islands of Thailand (Fig. 1), four species of sea turtles had been recorded nesting in this areas. The olive ridley and leatherback turtles are landing along the coastline of Phuket and Phang-nga provinces while the green and hawksbill turtles are found in the remote islands. They were recorded nesting along the beaches of Surin and Similan Islands. Nesting season of leatherback and olive ridley turtles found a short period during October to March (Chantrapornsyl, 1992b). The nesting areas along the Andaman sea of Thailand can be separated to 4 major nesting sites. 1) Phrathong island, located at the northwest of Phang-nga Province 2) Thaimuang beach, which is located along the western coast of Phang-nga Province. 3) Phuket island: Sea turtle nests at the beach along the west coast of Phuket island.

The number of leatherback and olive ridley turtles are seriously declined, caused by many factors. The nature predator are the beach crabs and dogs. The main threats to sea turtles in this area are include the fishing activities, housing and hotel development egg poachers are the one serious problem. The incidental catches of turtles in gill nets and long-line hooks are also problem here.

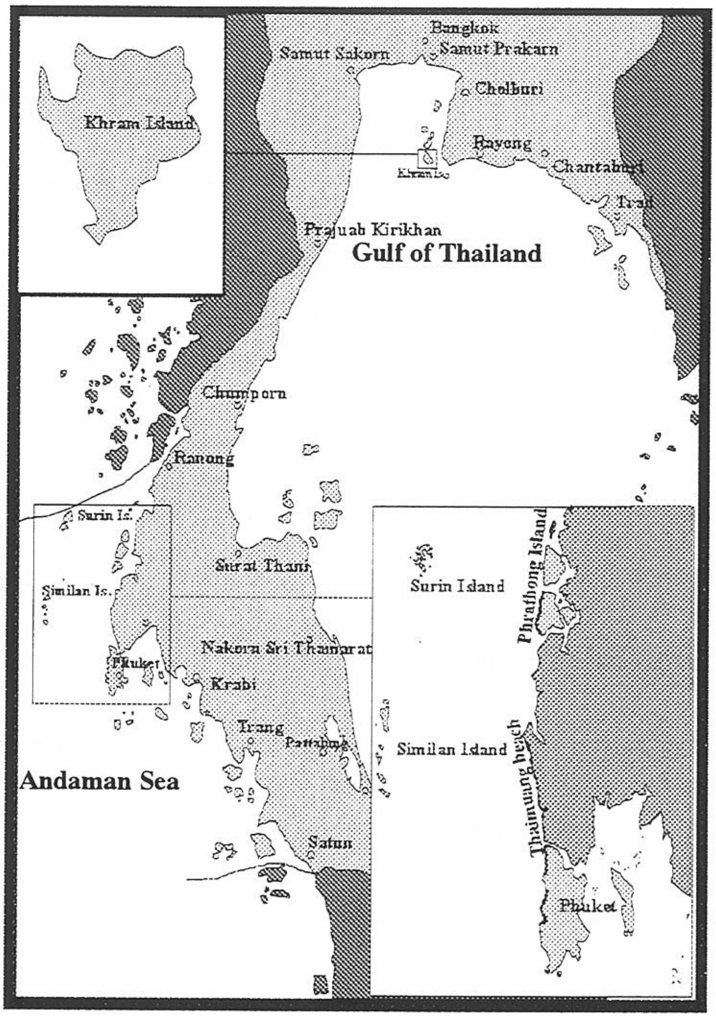

Fig. 1. Map of the coastline of Thailand shows nesting areas of sea turtles of Thailand

The beaches also are patrolled all years against the poachers. The eggs are removed to the hatcheries which is on the selected area of the beach. About 50% of the hatchlings be released directly to the sea, and the rest are transferred to the head-started programme at Phang-nga Province and the Phuket Marine Biological Center.

LAWS AND LEGISLATION

Awareness of declination of sea turtle population in Thailand lead to raise serious attempts to conserve sea turtles. The sea turtle conservation project has been conducted at Phuket Marine Biological Center since 1971 (Phasuk, 1992; Phasuk and Rongmuangsart,

1973) follow by establishment of sea turtle conservation station at Man-Nai Island in the Gulf of Thailand. Since then, biology of sea turtle have been studied. Sea turtle nesting sites were protected and some areas have been declared as National Park in order to better protect. Laws and regulations have been registered including educational and campaign are provided to public. Many laws and regulations have been conducted and strictly enforced. The protection of sea turtles was officially implemented as follow:

- Ministry of Agriculture and cooperative Enactment 1947: Sea turles have been listed as protected animal. Kill of the turtle and eggs collecting are prohibited.
- Fisheries Act 1972: commercial fishing within 3 kilometers of the coastline was prohibited.
- Ministry of Commerce Enactment 1980: The export of sea turtle was prohibited.
- Conservation and protected of living resources Enactment 1992, Act No. 19: Collecting of sea turtles, their products and carcasses are prohibited.
- Thailand has been signed up to CITES member in 1983.
- The use of Turtle Excluder Device (TED) in shrimp trawling have been enforced in 1996.

PRESENT CONSERVATION INSTITUTES

There are many agencies responsible for implementation and enforcement of sea turtle conservation in Thailand including:

- Sea turtle conservation station, Man-Nai Island, in the Gulf of Thailand. The station belongs to the Department of Fisheries. The station responsible for research and conservation of green and hawksbill turtles in the Gulf of Thailand.
- Sea turtle conservation programme at Khram Island, Chonburi Province and sea turtle conservation programme at Tublamu, Phang-nga Province, These project are conducted

by the Royal Thai Navy the aim is protect hawksbill and green turtles at Khram Island in the Gulf of Thailand and the Similan Island, in the Andaman Sea.

- Phuket Marine Biological Center (PMBC) is belongs to the Department of Fisheries. The Center responsible for research and comservation in the Abdaman Sea.
- Kao Lumpee - Thaimuang Beach National Park: Located at west coast of Phang-nga Province. Sea turtle has been protected by the National Park authority.
- Sirinarth National Park, Phuket Island The National Park authority together with Phuket NGO group try to protect the leatherback and olive ridley turtles in this area.
- Non-governmental organizations: NGO groups concerning sea turtle conservation in Phuket, Thailand.

FUTURE RESEARCH AND MONITORING.

- Long term monitoring survey nesting population
- Tagging and satellite tracking programme
- Study on the inter-nesting behaviour and feeding behaviour.
- Study on incubation and sex ratios of sea turtles.
- Study on genetic population of sea turtles.
- Awareness building and education programme

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FUTURE PLAN FOR THE SEASTAR2000

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Planning

In 2000, we have discussed 5 subjects on the workshop in Kyoto for the green turtle research and conservation to avoid by-catch by shrimp trawl net in Thailand. The subjects were as follows:

1) Tracking of post nesting adult females to understand the migration paths from nesting beach to foraging ground. The migration paths will be superimposed on the fishing ground of shrimp trawl, sea grass distribution, and environmental physical information such as water temperatures or surface current using GIS.
2) Sand temperature fluctuation to monitor the nesting condition such as, sex ratio, success of hatchling and escapement from nesting beach to the sea. They are all depended on the sand temperature in the nest.
3) Correlation between shrimp fishery and species of shrimp around the Gulf of Thailand. They are useful to develop GIS system to avoid by-catch.
4) Correlation between sea grass density distribution and migration paths of green turtles since they eat mainly sea grass. The post nesting migration paths are thought closely correlated with the sea grass mat density distribution along the coastal zone.
5) Estimation of local population size based on DNA analysis of green turtles in the Gulf of Thailand.

In 2001, all of these scientific subjects will be continued by the similar method as tried in 2000.

Each research subject described above will be tried by each group consisting in several scientists under the collaborative supporting with Thailand and Japan and the results should be arranged until November 2001, when we have workshop.

1) The first subject, tracking of adult female turtles in post nesting periods, will be

carried out two different seas in Thailand; the Gulf of Thailand and the Andaman Sea using platform terminal transmitter (PTT). The satellite PTTs will be provided by Japanese scientists, although they cannot estimate available number of devices since there are no information of scientific fund to support this project. We hope to use 4 PTTs at least both seas. The scientists of PMBC and Mannai Island (MI) will participate the tracking work with the Japanese researchers of Kyoto University and Ocean Research Institute, Tokyo University (ORI).

2) The second subject, monitoring sand temperature using data loggers, will be tried by sea turtle researchers in Mannai Island and ORI, Matsuda and Tatukawa The scientists of PMBC will support the work if necessary.
3) The third subject, research of shrimp trawl in the Gulf of Thailand, is consisted mainly of the data collection by fisherman along the coastal zone of the Gulf of Thailand, and will be carried out by two scientists, Wannakiat and Shiba.
4) The research of sea grass density distribution in the Gulf of Thailand will be tried by Komatsu, of ORI.
5) DNA analysis to distinguish the local population of green turtle is not yet tried. However this work will need to understand the migration pattern of each local population. The research plan will soon be discussed with Kongkiat (PMBC) and Kinoshita (Kyoto University).

In addition to these works, in 2001, we will test the different new devices such as the micro-CCD logger and the geomagnetic recording logger to attach on the carapace of sea turtles. This work will be carried out at first in the experimental big pond located in the Mannai island by Arai, Togawa and Mickmin. Finally, in the late of autumn in 2001, we will have the second workshop in Thailand.