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A GUIDE TO SET-UP AND MANAGE SEA TURTLES HATCHERIES IN THE SOUTHEAST ASIAN REGION

by
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Southeast Asian Fisheries Development Center (SEAFDEC)
2004

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Preface

Ideally sea turtle eggs should be incubated in natural nest. Relocation of eggs to a protected hatchery site should be undertaken only as the last resort and only in case where *in situ* protection is impossible.

Once a clutch of sea turtle eggs has been laid, the female leaves the beach, offering no protection to eggs or emergent hatchlings. From this point forward, eggs and hatchlings are subjected to a number of natural threats. At most rookeries in this region, egg relocation or hatchery programs benefit clutches deposited in dangerous circumstances such as those laid below high tide level, in erosion-prone area and egg depredation by people or animal so intensely that mortality approaches 100% in any clutches not being relocated to any enclosed hatchery.

Without proper planning and management, hatchery programs can produce a net negative impact on sea turtle populations. These include producing unbalance sex ratio of hatchlings (hatchlings sex ratio are often skewed towards one sex), lower hatching success, as well as unhealthy and weak hatchlings. Improper methods of hatchling release will produce high rates of mortality.

To ensure the hatchery programs in this region produce healthy hatchling, balance sex ratio as well as higher emergence success, it is important that, a standard and appropriate guidelines be employed by researchers and managers who are directly or indirectly involved in sea turtle conservation, management and enhancement activities. This book provide some important information as well as guideline to set-up and manage sea turtle hatchery program in this region based on local experience as well as information and knowledge gathered from other regions.

This book is the outcome of a project on Conservation and Management of Sea Turtles in Southeast Asian Countries conducted from 2001 until 2003. The project was led by the Marine Fishery Resources Development and Management Department, Southeast Asian Fisheries Development Center, (SEAFDEC-MFRDMD) in Terengganu, Malaysia and was financially supported by the Japanese Government under the ASEAN-SEAFDEC Fisheries Consultation Group Mechanism.

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This book was made possible based on the knowledge and experiences of the authors through their studies, especially in Malaysia, and accumulated information from researchers from member countries as well as references made from various sources available locally as well as internationally.

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SEA TURTLES

Taxonomy and Species Identification

Six of seven species of living sea turtles in the world were confirmed to nest or inhabit the Southeast Asian waters. These are leatherback (*Dermochelys coriacea*), green turtle (*Chelonia mydas*), olive ridley (*Lepidochelys olivacea*), hawksbill (*Eretmochelys imbricata*), loggerhead (*Caretta caretta*) and flatback turtle (*Natator depressus*). The flatbacks are known to nest in Australia but the foraging areas are in the Indonesian waters.

Figure 1: Adult Sea Turtles Species in the Southeast Asian Region

Dermochelys coriacea (Leatherback turtle)

Lepidochelys olivacea (Olive ridley turtle)

Eretmochelys imbricata (Hawksbill turtle)

Caretta caretta (Longgerhead turtle)
Photo courtesy of Ian Beattie/Auscape

Natator depressus (Flatback turtle)
Photo courtesy of C.J. Limpus

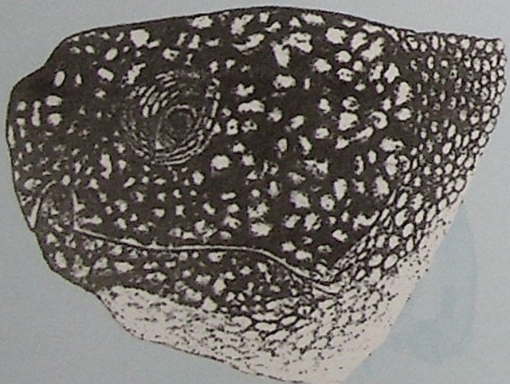
Chelonia mydas (Green turtle)

External Morphological Structures and Taxonomic Characters

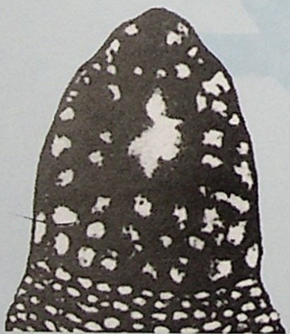
If a turtle is seen, it can be identified from features specified in the identification keys. Identification is fairly straightforward when the turtle or carapace can be examined. Carapace lengths, number of costal scutes and number of prefrontal scales are critical to the identification of the species.The shape of the central or vertebral scutes also provides clues to the identification. In loggerhead and olive ridleys, these scutes are narrow, and hence the first costal (lateral) scute comes into contact with the nuchal scute. In green and hawksbill turtles, the vertebral are rhomboid, and the first costal does not touch the nuchal scute.

Hatchlings can be identified using the same characteristics as adults (number of costal scutes, etc) but one needs to be careful since coloration can vary considerably. Figure 2 shows anatomical features of adult sea turtles heads noting the location of the prefrontal and postorbital scales which are diagnostic in the identification of the species. Figures 3 and 4 show an illustrated guide to external morphological features of adult sea turtles including carapace (upper shell) and scutes of the plastron (lower shell).

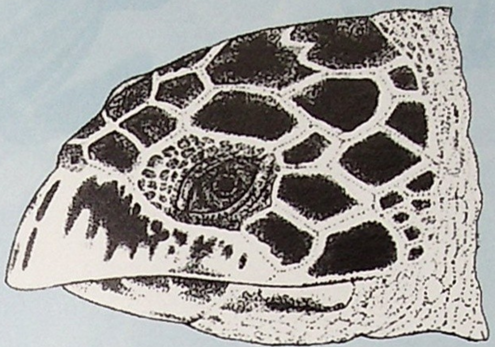
Figure 2: Side and Top View of Sea Turtles Head (Illustration Courtesy of Pritchard and Mortimer, 1999)



Dermochelys coriacea (Side View)

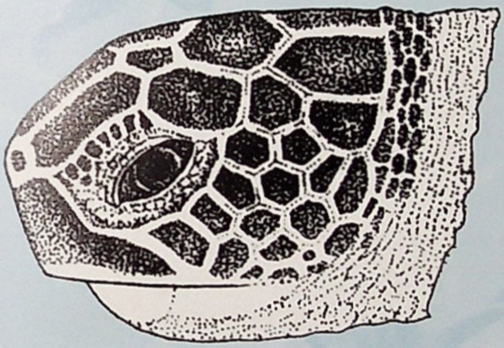


Dermochelys coriacea (Top View)



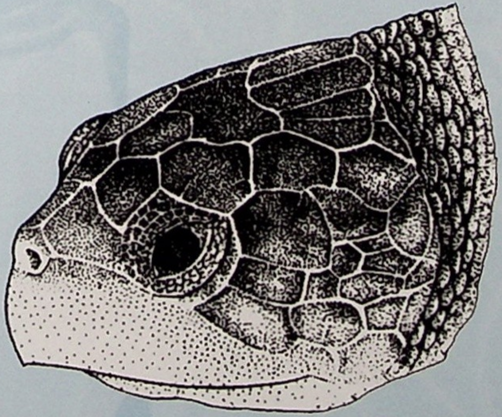
Eretmochelys imbricata (Side View)

Eretmochelys imbricata (Top View)

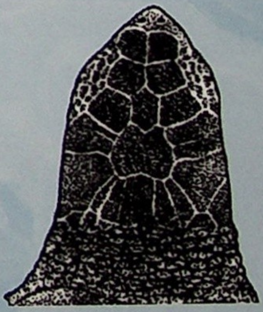


Chelonia mydas (Side View)

Chelonia mydas (Top View)



Lepidochelys olivacea (Side View)



Lepidochelys olivacea (TopView)

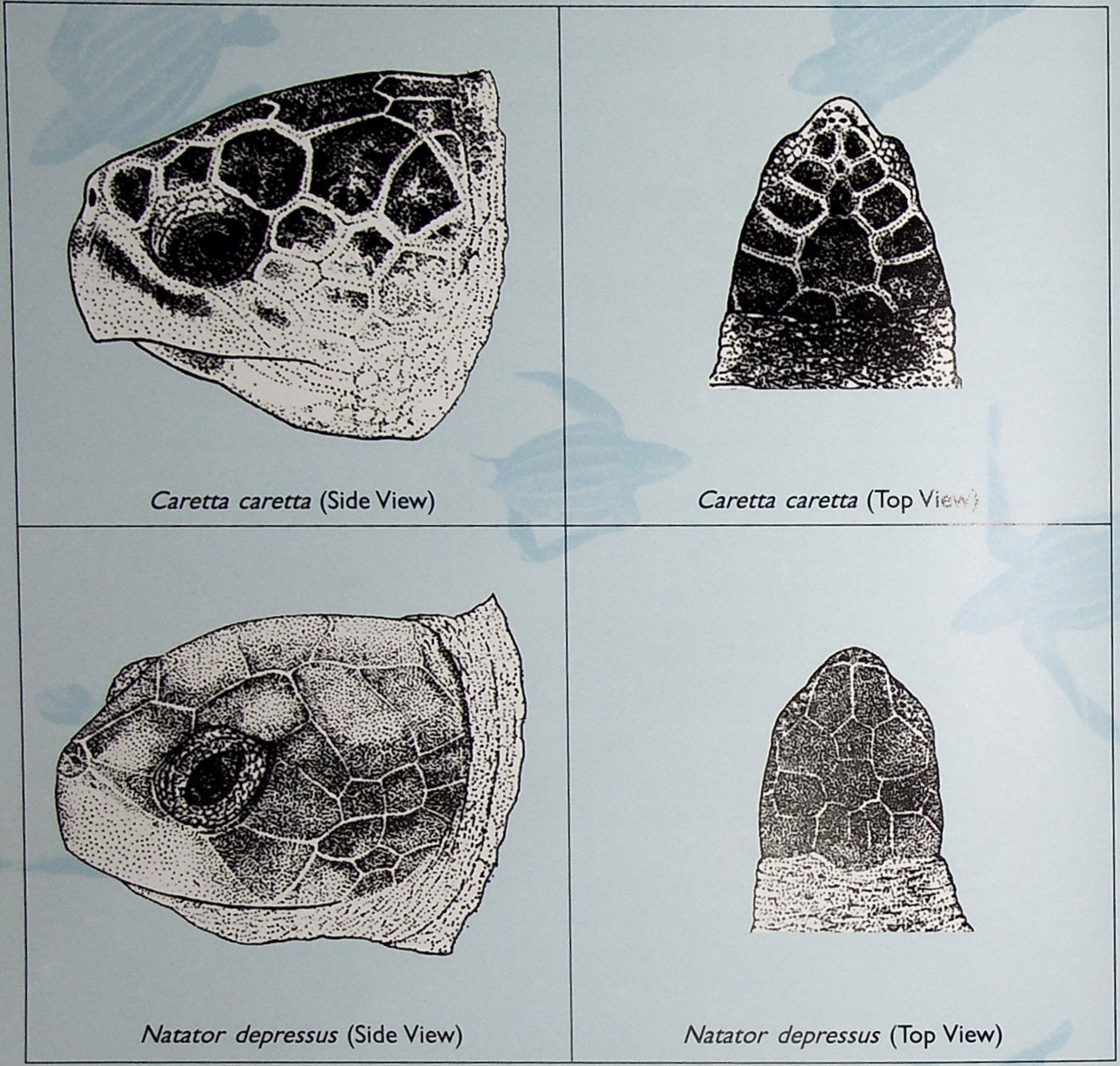
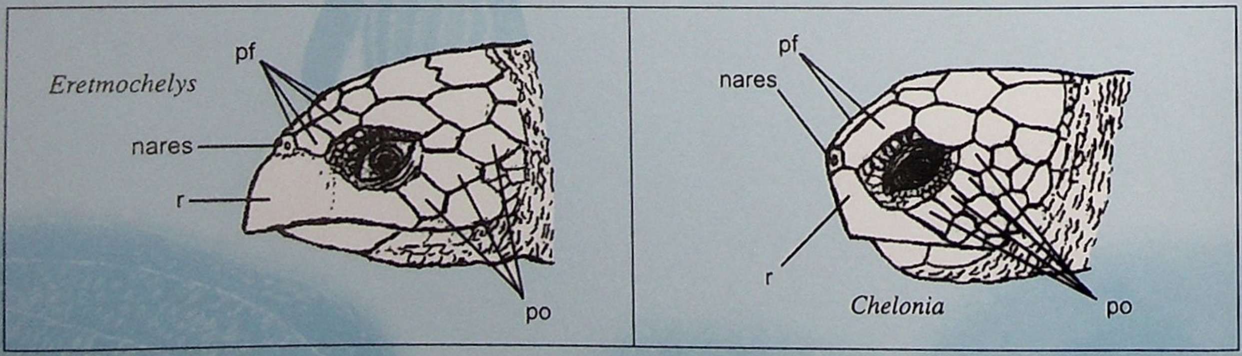
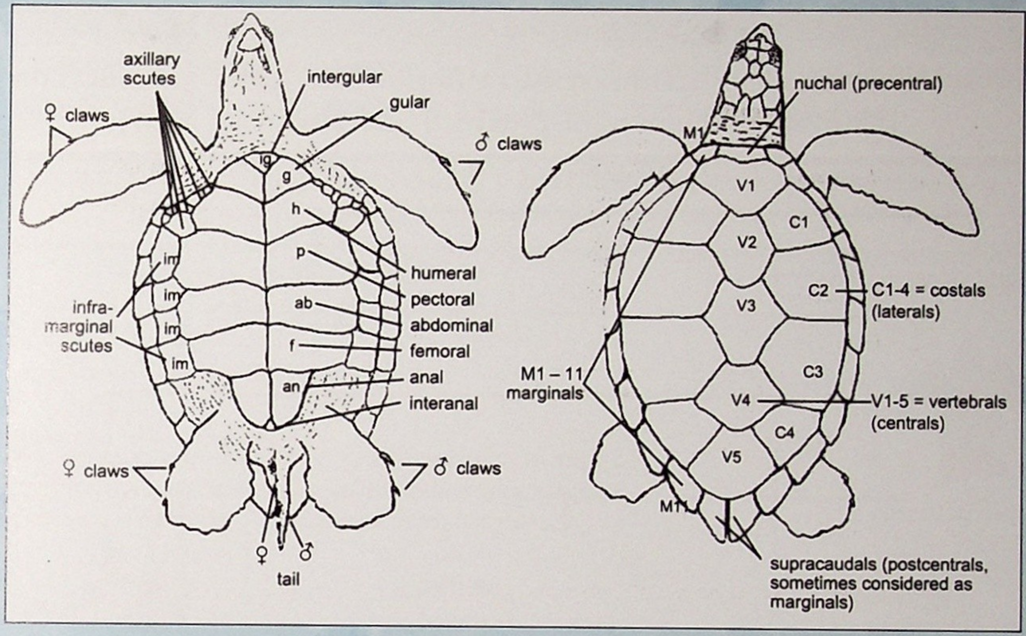


Figure 3: Anatomical features of sea turtle heads noting the location of the prefrontal and postorbital scales which are diagnostic in the identification of some species. (Illustration and Text Courtesy of Pritchard and Mortimer, 1999)



(pf = prefrontal scales, r = rhamphopheca, po = postorbital scales)

Figure 4: External Morphological Features of Adult Sea Turtles Plastron (Lower Shell) and Carapace (upper shell) for Family Chelonidae. (Illustration and Text Courtesy of Pritchard and Mortimer, 1999)

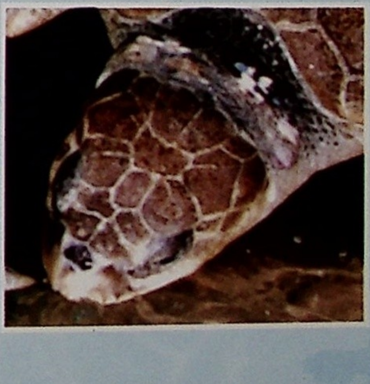


Anatomical features of adult sea turtles head.

Green turtle

Hawksbill turtle

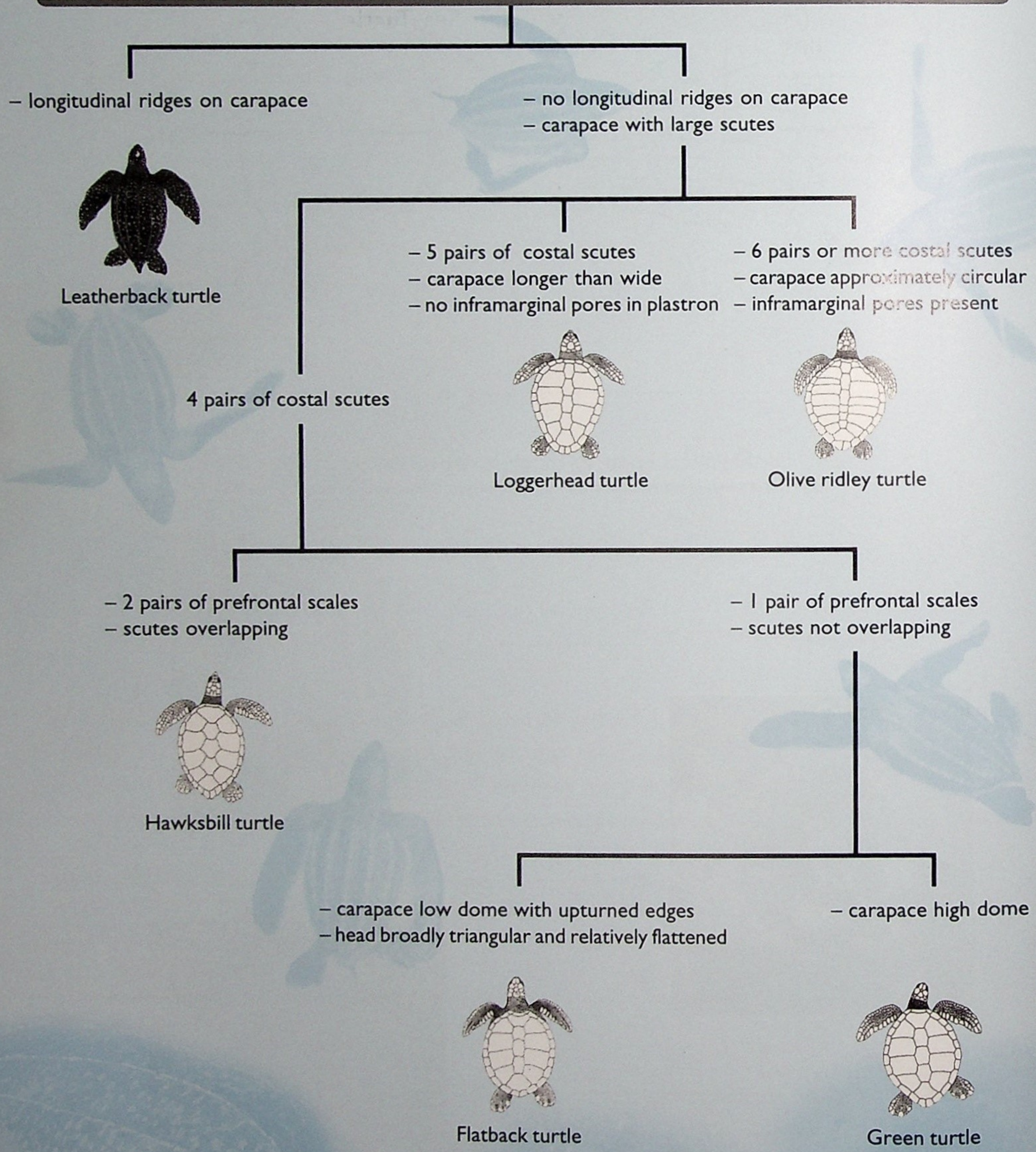
Olive ridley turtle



Key To Identification of Adult/ Subadult

The following key is designed to identify sub-adult or adult sea turtle spotted briefly at the beach during nesting season or stranded.

Figure 5: (Adult/Subadult) Southeast Asian Region Sea Turtle Identification Key (Illustration courtesy of Pritchard and Mortimer, 1999)

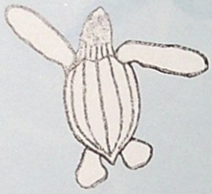


Key To Identification of Hatchlings

The key characters for identifying hatchlings (apart from color) are similar to those used for subadults and adults, although samples of hatchlings show greater variation in the numbers and configuration of the carapace scutes. Colour is an important character in the identification of turtle species of hatchling as for green turtle, leatherbacks and flatback have white plastrons. Another species such as olive ridleys, hawksbills and loggerheads have dark or light brown plastrons.

Figure 6: (Hatchlings) Southeast Asian Sea Turtles Identification Key
(Illustration courtesy of Pritchard and Mortimer, 1999)

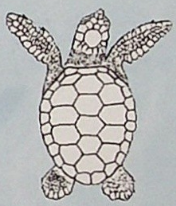
– black with white markings on the carapace ridges
– longitudinal ridges on carapace,
– mottled black and white plastron



Leatherback turtle

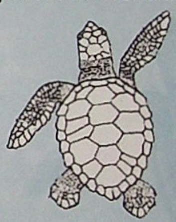
– no longitudinal ridges on carapace

– 5 pairs of costal scutes
– dark brown dorsally
– light brown ventrally



Loggerhead turtle

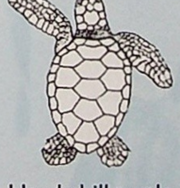
– 6 pairs or more costal scutes
– black dorsally
– light brown ventrally



Olive ridley turtle

4 pairs of costal scutes

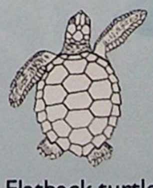
– 2 pairs of prefrontal scales
– scutes overlapping
– dark brown dorsally and light brown ventrally



Hawksbill turtle

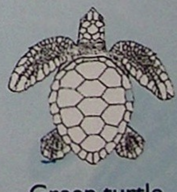
– 1 pair of prefrontal scales
– scutes not overlapping

– carapace low domed
– light olive-yellow carapace
– white with a pheripheral yellow band plastron



Flatback turtle

– carapace high dome
– light black carapace
– pure white plastron



Green turtle

BIOLOGY

Introduction

Sea turtles are reptiles and of the same group as snakes, lizards and crocodiles with their body temperature generally the same as the surroundings. It begins its life as a newly emerged hatchling on land and thereafter spends nearly all its life in the sea. Only female turtles will return to the beach to lay eggs while the males are seldom seen on land again except for basking to increase their body temperature in temperate country. They have scales (except for the leatherback, only ridges), breath air and lay eggs. They have no teeth, but their beaks have keratinized sheathes. They have an acute sense of smell but not of taste. They have well developed eyes with colour vision. They have single ear bones but no external ears. Hearing is restricted to very low frequencies. Sea turtles do not have parental care, with female deposits the eggs on beach and leave the rest to nature.

Healthy Sea Turtle Hatchlings

Loggerhead turtle
(Photo courtesy of David Miller/Auscape)

Hawksbill turtle

Leatherback

Green turtle

NESTING SEASON

In most population, nesting is seasonal and occurs during dry non-monsoonal periods. Each female move to an area adjacent to her selected nesting beach and commences making eggs, fertilizing them from her sperm store. Because of the mixture of the sperms she carries, several males usually contributed to the fertilization of any one clutch. The summary of nesting seasons for sea turtles species in Southeast Asian region is shown in Table 1.

Adult male olive ridley turtle showing muscular tail which extends well beyond the margin of the carapace.

Adult male hawksbill turtle

Olive ridley turtle mating in captivity

Green turtle mating in the wild (Photo courtesy of Sabah Tourism Promotion Corporation)

Table 1: Nesting Seasons of Sea Turtles Species in the Southeast Asian Region

Country	Green	Leatherback	Loggerhead	Hawksbill	Olive Ridley
BRUNEI	Nov. - June	-	-	-	Nov. - June.
CAMBODIA	Sept. - April	-	-	Sept. - April	-
INDONESIA					
Pengumbahan, West Java	June - Nov.	-	-	-	-
Kepulauan Seribu	-	-	-	Dec. - April	-
Segamat Island	-	-	-	Dec. - April	-
Belitung	-	-	-	Jan. - June	-
Paloh, West Kalimantan	-	-	-	Feb. - May	-
Tambelan, Riau	-	April - Sept.	-	Feb. - May	-
Jamursba-Medi	-	-	-	-	-
MALAYSIA (Peninsular Malaysia)					
Terengganu	Mar. - Oct.	Mar. - Sept.	-	Mar. - August	Mar. - Sept.
Pahang	Mar. - Oct.	Mar. - Sept.	-	Mar. - August	-
Johor	Mar. - Oct.		-	Mar. - August	-
Perak	Mar. - July		-	-	-
Pulau Pinang	Mar. - July		-	-	-
Kedah	Mar. - July		-	-	-
Malacca	-		-	Mar. - July	-
(Sabah) Turtles Island	Jan. - Dec.		-	-	-
Sarawak	Jan. - Feb.		-	-	-
MYANMAR	Aug. - Feb.	-	Nov. - Feb.	-	Sep. - Mar.
PHILIPPINES	Jan. - Dec.	-	-	-	-
THAILAND					
Gulf of Thailand	Jan. - Dec.	-	-	Jan. - Dec.	-
Andaman Sea	Oct. - Mar.	Oct. - Mar.	-	-	Oct. - Mar.
VIETNAM					
Hon Tai	Mar. - Nov.	-	-	-	-
Hon Bay Canh	April - Nov.	-	-	-	-
Hon Cau	April - Nov.	-	-	-	-
Hon Tre Lon	Jan. - Dec.	-	-	-	-
Truong Sa	Mar. - August	-	-	-	-
Catba Island	-	-	-	Feb. - May	-
Hoang Sa	-	-	Feb. - May	Feb. - May	-
Con Dao Island	-	-	-	Feb. - May	Feb. - June
Phu Quoc Island	-	-	Feb. - May	Feb. - May	-
Nha Trang	-	-	Feb. - May	-	-

Sources: Sabri, (1999); Sukarno, (1996); Mohd Najib and Kevin, (1999); Cho and Ohn, (1999); Agus, (2004); Cruz, 1996; Chu and Pham, (1999); Longdy, (2002)

Selection of Nesting Area and Nesting Activities

The female comes ashore usually at night, to nest several weeks after her first mating. For those beaches fronted by reef flats, nesting coincides with higher tidal levels. Each female usually chooses to return to the same beach or island to lay several clutches within one nesting season.

Nesting Behaviors

Females lay their eggs high up on the beach usually adjacent to or within vegetated strand. No parental care is exercised. The complete nesting process of the turtle can be divided into eight stages.

Stage 1 Emerging from the sea and selecting a course to nest.

(Note: Sea turtle are very sensitive and may return to the sea without nesting if they are being disturbed while stranding or excavating the nest. During this period up to stage 5, workers should be very careful of not disturbing the turtle with lights or movement).

Stage 2 Selecting a nesting site above the high tide level.

Stage 3 Clearing the site with sweeping motions of the front and sometimes hind flippers to enclave herself in the body pit.

Stage 4 Excavating the egg chamber with her rear flippers to a suitable depth (depending on species).

Stage 5 Laying egg. The turtle should not be disturbed.

(Note: Where there is an opportunity to collect eggs as they are laid, some workers catch egss by hand as they drop from the cloaca and place them gently in a bucket. Taking care and do not disturb the turtle.

Stage 6 Filling, covering and packing the nest cavity with sand.

Note: When egg laying (oviposition) is completed, she usually will not react even if she is handle gently. Collection of eggs, tagging and tissue sample collection can all be carried out during this time.

Stage 7 Filling of the body pit and concealing of the nest site. Concealment of the nest is so well done that it is extremely difficult for predators to locate it.

Stage 8 Return to the sea.

Note: In some cases, the turtle only completed activities at stage 1 to 2 and then, return prematurely to the sea. Scientist believed that the turtles choose the nest place in advance of its later laying activities or they are disturbing factor such as noise, light, human, and animals activities, erosion, of the nesting beach creating a steep bank or incline, or tree roots and dense bushes hinder turtle access to its selected nest site. This activity is call false crawl. However, there are also cases where the turtle returns back to the sea without laying any eggs after completing stage 1 to 3. This is calls false nest.

False Nest

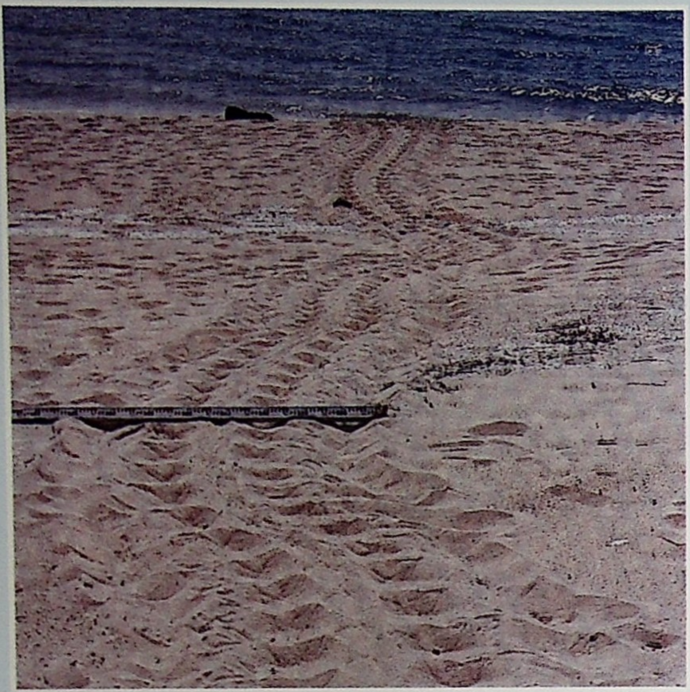
TRACKS ON BEACH

Experienced researchers can identified the species only by observation of tracks on the beach. Even though, this can be difficult particularly with loggerheads, hawksbills and olive ridley. The tracks can vary between populations and even between individual animals, and hence it is essential for field personnel to observe nesting turtle and note the characteristics of the tracks. Important features of a track are its width, body pit, and symmetry (Shanker, et al, 2003).

Impressions alternating for loggerhead, hawksbill and olive ridley make shallow body pits, and impressions opposite for green turtle and leatherback make large deep body pits. A symmetrical track is formed when the front flippers of the turtle move synchronously to pull the turtle forward, while an asymmetrical tract is formed when the front flippers move alternately.

Green turtle track is about 100-130 cm, deeply cut, with symmetrical diagonal markings made by the forelimbs. Straight, central tail drag marks present, either as a solid or a broken line. (Pritchard and Mortimer, 1999).

- ❑ Loggerhead track is about 70-90 cm wide, moderately deep, with asymmetrical diagonal marks made by forelimbs. Tail drag mark usually absent; when ashore they moved with an alternating gait.
- ❑ Hatchlings green turtle walk with an alternating gait while larger turtle, when ashore, move with a breaststroke gait. Adult green turtle tract is about 100-130 cm wide, with symmetrical diagonal marks made by forelimbs. Tail drag solid or broken line (Shanker, et al, 2003). The adult green turtle track in Malaysia is about 100 cm.
- ❑ Olive ridley track is about 70-80 cm wide, light, with asymmetrical, oblique marks made by forelimbs, tail drag mark lacking or inconspicuous. Olive ridley track in Malaysia is about 70-80 cm wide.
- ❑ Flatback: Hatchlings walk with an alternating gait while larger turtle, when ashore, move with a breaststroke gait (Limpus, 1997).



Leatherback track is about 150-200 cm wide, deep and broad, with symmetrical diagonal marks made by forelimbs, usually with deep median groove from the long tail (Shanker, et al, 2003).

Hawksbill turtle track is about 70-85 cm wide, shallow, with asymmetrical (alternating) oblique marks made by forelimbs, tail marks present or absent. Often hard to distinguish from tracks of ridleys, but the two species nest in very different beach types (Shanker, et al, 2003). Hawksbill track in Malaysia is about 75-80 cm width.

POPULATION STABILITY

To maintain population stability, a minimum 70% of the clutches of sea turtle eggs are needed to successfully produce hatchlings into the sea. If a country intend to increase the size of the depleted population, the goal will be to have greater than 70%, perhaps as high as 100% for the clutches of leatherback, to successfully produce hatchlings.

Successful producing healthy hatchlings from *in situ* programmes or hatcheries for all sea turtle species is now necessary in order to maintain population stability.

Green turtle hatchlings from *in situ* nesting at Mak Kepit beach, Redang Island in Terengganu, Malaysia.

In situ nesting beach at Mak Kepit, Redang Island. Each nest is marked with a pole.

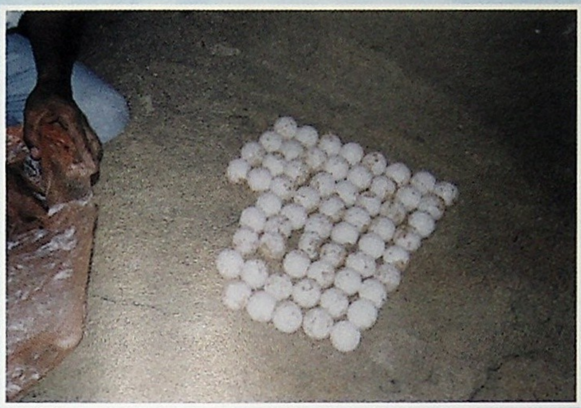
WHY HATCHERY IS NEEDED?

In habitats with consistent high hatching success, sea turtle eggs should be left undisturbed inorder to incubate naturally (*in situ*) to ensure a natural sex ratio for the population. Hatchery is practical where excessive egg harvest or mortality can not be effectively reduced by leaving eggs in the natural state on the beach. These included:

Clutches laid below the high tide level or below the storm surge/erosion line.

Clutches laid in areas with an extremely high probability of being dug into by another nesting turtle.

Clutches lay in areas with a high probability of being collected by people.



Preyed upon by dogs, pigs, varanid lizards or similar predators.

Clutches laid in sand/soil with a high microbial content.

Advantage of Hatcheries

Hatcheries have several advantages and these included:

Certain proportion of eggs is guaranteed to be protected from risk on nesting beach, such as predation by animals, crabs, people, beach erosion, flooding by high tide, etc.

Number of eggs protected and hatchlings released is documented; hence there is some known measure of success.

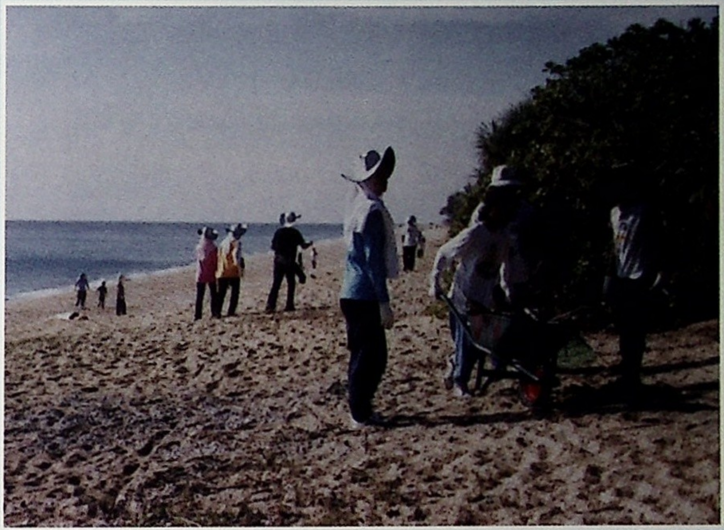
Involvement of volunteers and other personnel in conservation related activity. It has positive effect on spreading awareness.

The hatchery provides physical focus for conservation activity related to the coast, and can be used for public education and awareness programmes.

Hatchling are available at a known time and place for use in education and awareness programmes.

HOW TO SET UP A HATCHERY?

Hatcheries are expensive to maintain and depend on well-trained and reliable staff. At an established area for hatchery, authorities should place permanent or temporary staff to control the beach as well as to collect and transport the eggs to the hatchery as soon as possible. A training course should be conducted for staff to show them the correct procedures for operating a turtle hatchery. The main duty of staff include:

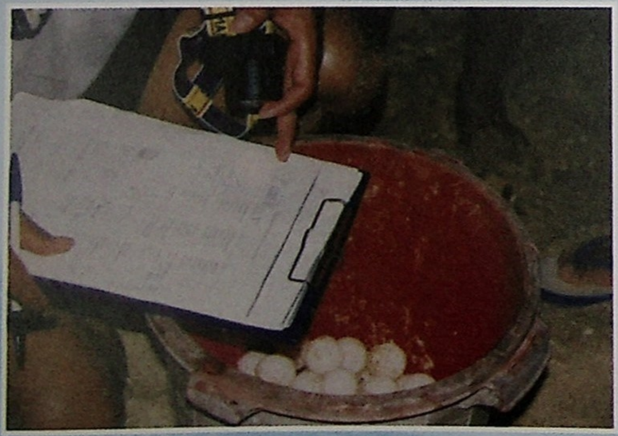


Cleaning nesting beaches especially at early nesting season.

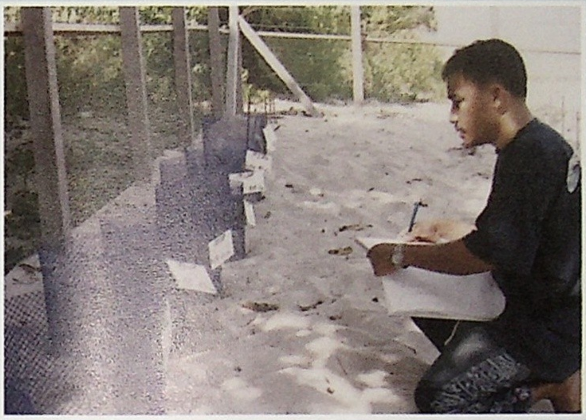
Watching for turtles.

Record the turtle curve carapace length (CCL), curve carapace width (CCW) and other relevant information.

Relocate the eggs from nesting beach to the hatchery.



Record all information relevant to nest and hatchling such us date of laying, emergence success etc.



Record the number of hatchling released into the sea.

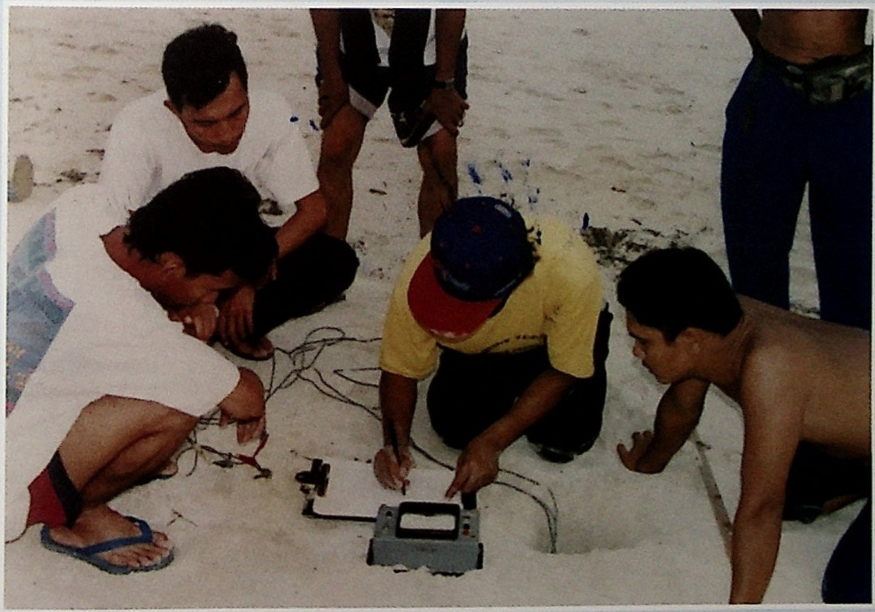
Choosing a Hatchery Site

Hatchery site should replicate natural nesting habitat. Artificial nest should also be the same as natural nest in terms of depth and width for the species. All vegetation (grass and vines) growing within 0.5m radius (minimum) of the artificial nest should be removed. Plastic or non metal fence/cages can be used to protect the nests. Metal fences around the nest sites have the potential for altering the earth's magnetic field around the nest and hence altering hatchling imprinting. The location of hatcheries should be changed approximately on yearly intervals to minimize accumulation of microbial organism such as fungi and bacteria in the sand. The guidelines for establishing a hatchery program are shown below:

The hatchery site should duplicate the natural situation as much as possible. If an area has proved unsuitable for nesting in the past, it is probably not suitable now. There is usually a good reason why turtles do not nest in that particular area.

Be sure that the hatchery will not be flooded by either salt or fresh water. The site should be on a well-drained stretch of beach, with enough elevation that prevent flooding by ground water. The shade should be placed well above the spring high tide level. It should not be subjected to erosion by high tides or storm waves.

If possible a survey should be conducted to determine the temperature of the environment of the natural nesting habitat along the entire beach throughout nesting season.



Construct as many hatcheries as possible in order to insure that the eggs incubate under a variety of conditions.




The hatchery site should not be placed near vegetation, in order to avoid roots growing into the egg clutch.


The hatchery should be shielded from artificial light to avoid disorientation of hatchlings.

The distance between hatchery site and nesting beach should be as close as possible. Longer distance may result in lower hatching success due to excessive handling.

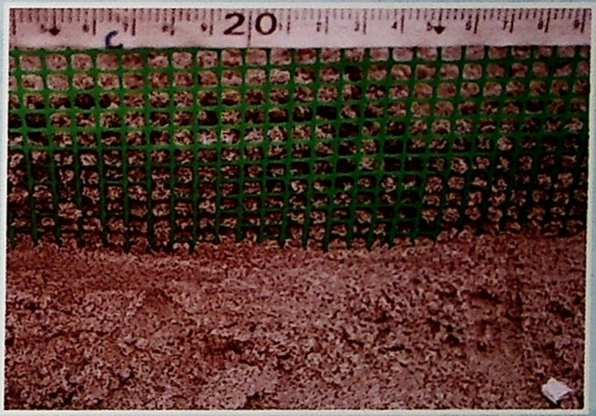
Better to use hatcheries than styrofoam boxes to incubate the eggs. Styrofoam should be used only in an emergency.

HATCHERY DESIGN

There are no specific designs for sea turtle hatchery. If there are feral dog, wild boar, monitor lizard or others predator, the hatchery can be enclosed by chain link fence or plastic mesh. To prevent the entry of crabs and other burrowing predators, plastic fence (0.5 cm mesh size) can be used. (Ahmad and Kamarruddin, 2002)

Hatchery with plastic fence (2 cm mesh size).

Hatchery with plastic fence (0.5 cm mesh size).



Ideally, the hatchery should be located and oriented in such a manner to provide the greatest diversity of microhabitats for the nests. The shape of hatchery depends on local condition. If the beach is narrow, then the hatchery perforce has to be rectangular with the long side parallel to the sea. Some hatcheries use sun shade to reduce sand temperature which can affect sex ratio especially during the first 3 week of incubation.

Shading

Shading is important if the nest temperature consistently approach 32 °C or higher to ensure that eggs are not killed by heat stress. At nest temperature above 33 ° C, all eggs are killed (Limpus et al., 1985). It has been demonstrated irrevocable that sex determination in six species of sea turtles is temperature dependent. Cool incubation temperature are known to produce males while warm temperatures produce females (Janzen and Paukstis, 1991).

Hatchery with sun shade.

Open hatchery.

TEMPERATURE DEPENDENT SEX DETERMINATION

Like many other reptiles, sea turtle also posse's temperature dependent sex determination.The sex of the hatchling is determined during the middle third of the incubation period by the temperature of the nest of loggerhead (Yntema and Mrosovsky, 1980); green turtle (Miller and Limpus, 1981); hawksbill (Mrosovsky, et al., 1992); olive ridley (Mc Coy et al., 1983) and leatherback (Mrosovsky, 1984)

The pivotal temperature is the theoretical constant incubation temperature that would produce an equal proportion of male and female hatchlings.The pivotal temperature is not a constant for all sea turtle species but varies among the species and can vary among populations within a single species. Based on incubation data for Terengganu leatherback, it is predicted that the pivotal temperature is in the range berween 29.2-30 °C (Chan, 1993); loggerhead turtle for the eastern Australia stock is 28.6 °C, green turtle for the Great Barrier Reef stock is 27.6 °C and flatback for eastern Australia stock is 29.3 °C (Limpus, 1997);

For all species, nest temperature above the pivotal temperature produce mostly female hatchlings while below the pivotal temperature will produce mostly male hatchlings. At very low nest temperatures, approaching 26 °C, all species produce 100% males and at very high temperature approaching 32 °C, all species produce 100% females.

Incubation temperature for sea turtle eggs is highly variable parameter, being a function of the latitude of the beach, sand colour, orientation to the sun, degree of shading, nest depth, time of year, rainfall etc. However, on any one beach prediction can be made once detailed temperature profiles have been quantified.The temperature regime of nests and hence hatchling sex ratios can easily be altered by:

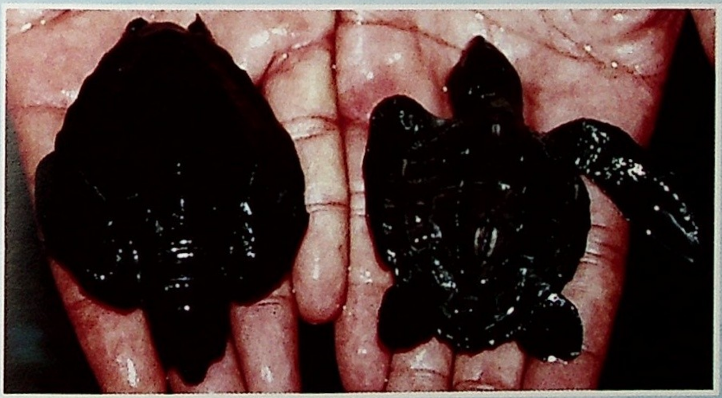
- Transferring eggs from natural nests to artificial nests.
- Altering the vegetation of the nesting habitat and hence altering the extent to which nests are exposed to the sun or shaded.
- Altering access of turtles to nesting sites (by the presence of rock walls, buildings, bright lights) and forcing the turtles to choose alternate nesting sites.

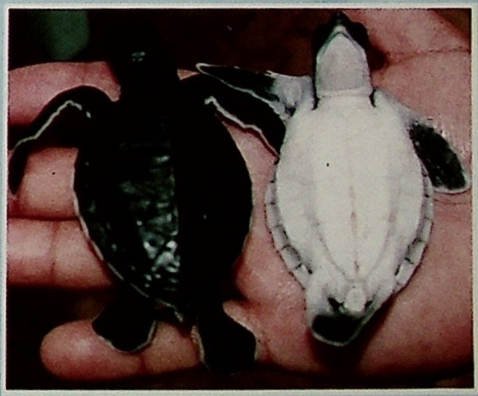
NATURAL SEX RATIO

Since hatchling sex ratio can be varying greatly from beach to beach the sex ratio from an entire population will be difficult to estimate (Limpus et al., 1983). In recent years, the sex ratio of wild populations of immature sea turtles in their feeding areas has been measured. The measured sex ratios are strongly biased to female at most sites and for most species. In central and south Queensland, the female percentage are 84%, 77%, 67%, 63% and 54% (Limpus et.al., 1985). However, in Hawaiian Archipelago only 51% are female (Wibbels et al, 1993). The percentage of female hawksbill in the southern and northern Great Barrier Reef is 72% and 80% respectively (Limpus, 1992). For loggerhead, 29% and 35% female were recorded at different habitats in the south Queensland, Australia (Limpus, 1985) and 68% of the female recorded in the eastern USA waters (Wibbels et al, 1991). Base on these information, a hatchling sex ratio of 70± females is recommended (Limpus, 1993).

When the pivotal temperature is not known, the eggs must be incubated from a full range of natural habitats, especially with regards to natural shading. Hatcheries provide artificial nest sites with a range of sand temperature available to the eggs. Endeavor should be made to provide same range of sand temperature which is similar at natural nest sites. These can be done by using more than one hatchery. Every hatchery should use shade of different intensities to create sections of the hatchery so that one section produces all males (26-27 °C) and another produces all females (30-31 °C). Low cost shading can be provided with palm fronds. Shade cloth sheeting is recommended because easy to move to allow altering intensity of shade in response to changing sand temperature.

Male or female





RELOCATION OF EGGS FROM NATURAL NESTS TO THE HATCHERY SITE

Sea turtle eggs are not designed to be moved after they were laid. Wherever possible, the sea turtle eggs should be left to incubate where they are laid. If the circumstances are such that the eggs need to be moved in order for incubation, thus it is best to complete the movement of the eggs within two hours of them being laid and with no rotation of the eggs. The delicate embryomic membranes of older eggs are easily torn if the eggs are rotated or jarred. Dislodgement of the embrio results in death. Precaution should include marking the top of the egg with a soft grease pencil and transfering the eggs carefully into the incubation hole.

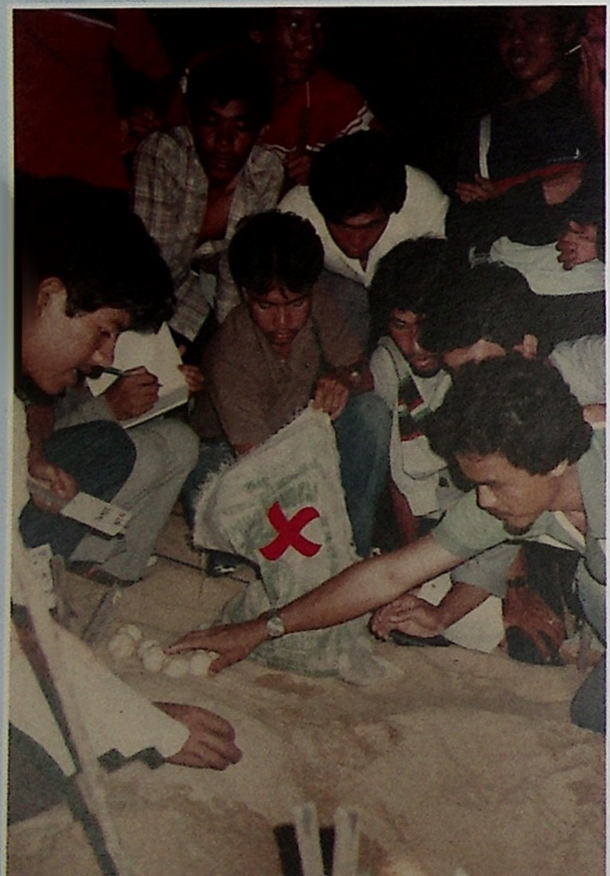
In Australia, cooling of newly laid egg cluthes to a temperature of 7-10°C within a few hours of oviposition was found to delay formation of embryonic membranes long enough to allow long distance (> 1000 km) translocation of egg clutches without reducing viability (Harry and Limpus, 1989).

If a clutch of eggs is to be relocated to hatcheries, these guidelines should be followed closely:

Although nests are easy to find, the eggs can be difficult to locate once the turtle has covered up the nest. If the workers have found a nesting turtle, it is best to collect the eggs during oviposition or slightly after she finished laying eggs.

Complete the movement within 2 hours of the eggs being laid and certainly no later than 5 hours after they have been laid.

Avoid rotation of the eggs, especially vertical rotation. If carrying eggs in vehicles, place containers on cushions or foam and drive with care.



Use a stiff sided container to carry the eggs. Use bucket rather than cloth sacks.

Do not wash the eggs, especially in sea water. Hand should be clean and dry before handling the eggs.

Avoid the use of probing rods when fining the eggs. The broken eggs can contaminate the rest of the clutch.

If possible they should be buried at the same depth as the natural nest, which vary depending on the species of turtle. Table 2 shows the depth of natural nest depth for various species of sea turtles.

Table 2: Natural Nest Depth of Different Sea Turtles Species

Green	Leatherback	Loggerhead	Hawksbill	Olive Ridley	Flatback
69 cm[1] 44-60 cm[2] 77 cm[3]	88 cm[1]	58 cm[1] 45 cm[4]	45 cm[1] 44-60 cm[2]	9 cm[1]	55 cm[1]

Sources: Limpus, 1977[1]; Mananunsap and Rongmuangsant, 1988[2]; Ahmad and Kamarruddin, 2002[3]; http://tofino.ex.ac.uk/euroturtle/outline/logger4.htm[4]

MOVEMENT INDUCED MORTALITY OF SEA TURTLE EGGS

Each egg contains a very small embryo (gastrula) that has temporarily ceased development (Miller, 1985). At this stage of development a sea turtle egg can survive the bumping and rolling associated with being laid. However within 2 hours of being laid the embryo recommences development. From this time onwards, rotation of the egg may cause its death. The eggs continue to be very susceptible to movement and induced mortality for the next few weeks of incubation (Limpus et al., 1979; Limpus, 1993). Most failure of eggs to hatch in hatcheries is the result of disruptions of subsequent embryonic development (i.e. early embryonic death), and not due to infertility. Microscopic examination of the embryo in turtle eggs as they laid shows that infertile eggs are usually extremely rare at most rookeries. However, in some localities such as at Rantau Abang in Malaysia, infertility of leatherback eggs may be a problem.

Unfertilized eggs contributing to low hatching success of leatherback turtle at Rantau Abang beach, in Terengganu, Malaysia.

REBURIAL

Incubation Hole

The nest should be constructed in the shape of the natural nest i.e with a narrow neck and a flask shape bottom. The mouth of hole is about 20 cm wide, increasing to about 30 cm at the bottom. The hole is about 60 -70 cm deep, which very depanding on the species of turtle. The eggs are carefully placed by hand into the hole, which is covered with moist and then dry sand at the top level. A plate with information of serial number of nest, date of collection and number of eggs transplanted is placed on top of the clutch. Nest should be relocated in low densities in hatchery, which at least one meter between nest, so that they do not affect each other during development. By doing so, the hatchery workers can move about without stepping on the nests.

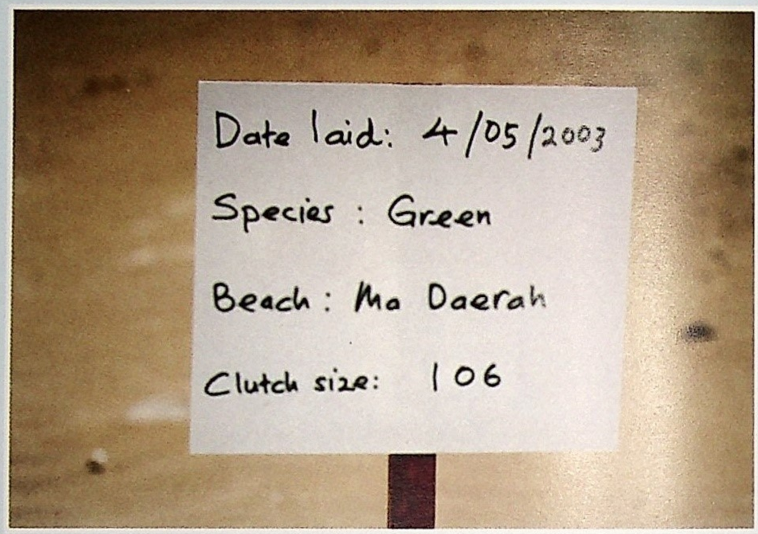
Constructed nest with narrow neck and a flask shape bottom. If nest excavation is hampered by cave-ins during periods of very dry weather, pour a bucket of freshwater into the unfinished nest and then continue nest construction.

Hatchery nests should be situated at least one meter apart to minimize their impact upon one another and to allow room for hatchery workers stepping on the nests.

Recording the Nest

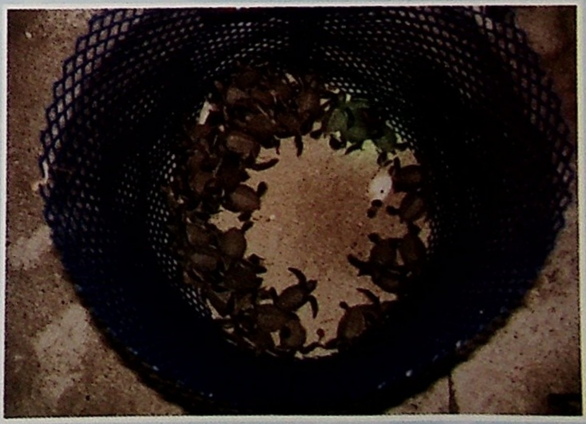
Each nest in the hatchery should be numbered and recorded in a data sheet or book (at particular date of laying and number of eggs. This is to accurately estimate date of emergence. The following data should be recorded for each nest:

- Date laid
- Species of turtle
- Beach name
- Clutch size
- Nest location



DEVELOPMENT OF EMBRYOS IN THE EGGS

When the egg is laid the yolk and the white can be seen in the shell. At the top of the yolk is a small white spot. This is where the baby turtle forms. Within 2-6 hours after the egg has been laid, membrane start to grow and attach the yolk to the inside of the eggshell. If the egg is turned over, or even shaken, these membranes will be torn. If that happens the egg dies.



Incubation Period

In normal condition incubation period varies by species and depends on the temperature, humidity and depth of the clutch. Table 3 shows the incubation period of different sea turtles species.

Table 3: Incubation Period of Different Sea Turtle Species

Green	Leatherback	Loggerhead	Hawksbill	Olive Ridley	Flatback
54-87 days[1] 44-49 days[2] 49-76 days[5]	49-70 days[1] 54-58 days[4]	45-70 days[1]	51-61 days[1] 47-54 days[2]	49-70 days[1] 58-64 days[3]	about 56 days[1]

Sources: Limpus, 1997[1] ; Mananunsap and Rongmuangsant, 1988[2]: Chantrapornsyl, S. 1992[3]; Chan and Liew, 1995[4]; Kamarruddin and Abdul Rahman, 1994[5];

Several essential environmental conditions are required to achieve the most successful incubation of sea turtle eggs under natural condition (Limpus et al., 1985; Limpus 1993 and Miller 1985). These are as follows:

- Sea turtle eggs require well ventilated, low salinity, high humidity sand that surround the nest.

  Sea turtles usually lay their eggs above the level of tidal inundation and at least 50 cm below the beach surface (depth varies among the species). Sand that is regularly washed over by sea water during high tide can be too salty and reduce the incubation success of the eggs.

- Sea turtle eggs are killed by flooding with either salt water or fresh water

  Flooding by either sea water or fresh water for a few hours will usually drown the eggs. It is important that the air spaces between the sand grains do not become filled with water. Nest need to be above the water table, normal high tide and /or storm surge level.

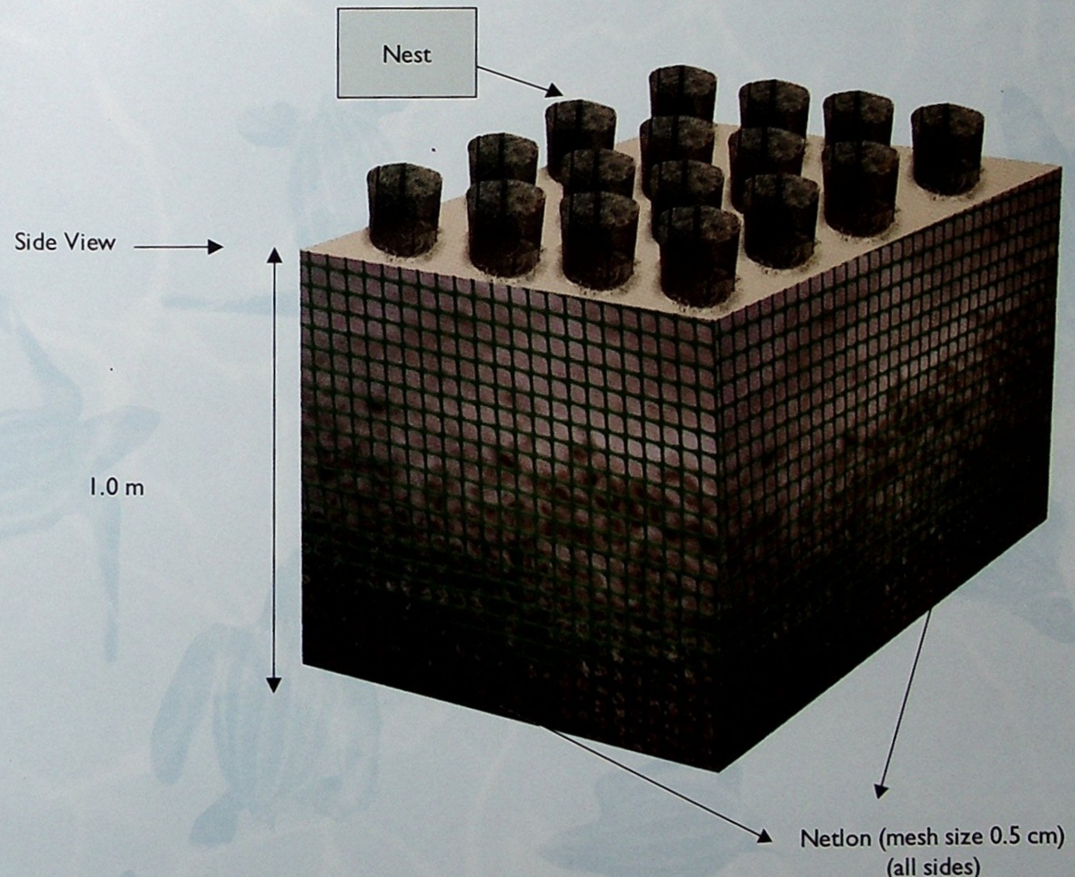
- Fertilized sea turtle eggs can be expected to have more than 90% incubation success when nest temperature are in the range of 25-31° C (without predator, etc).

- There is a high probability that some fungi and bacteria, when present in the sand of the nesting beach, can reduce the incubation success of some species of turtle eggs.

MANAGEMENT OF PREDATORS IN HATCHERY

The main predators in the hatcheries in this region are red ant, termites and ghost crab. If crabs are a problem in hatcheries, enclosed the hatcheries in a small-mesh (0.5 cm) netlon/ plastic and buried down to one meter deep under sand surface (Ahmad and Kamarruddin, 2002). The most effective idea to keep red ant from hatchery is to keep the hatcheries clean from any kind of materials that attract them. These include waste food, wood etc.

Design of the crab fence.



HATCHING

After piping, the hatchlings take between 2-5 days to dig and emerge at the surface. They works together to crawl up to the surface of the sand. They maintain an air chamber in the sand (sort of like an underground room). They scrape away the ceiling of the room, and pound the sand down onto the floor of the room. This is to force the room to move upwards through the sand, with the baby turtles inside. When the group of hatchlings comes close to the surface of the sand, and if they encounter high temperatures, the turtles will stop moving and wait until the sand cools down. Hatchling emergence, usually a group, occurs at night on which they would rapidly head towards the sea.

Expected dates of hatchling emergence can be estimated from the date of collection, or condition made by the "caving in" of the sand surface above the nest when hatching begins. A week before hatchling expected to emerge, netlon mesh cylinders with mesh size of 1.0 cm, should be placed around each nest. This made easier to collect hatchlings as they emerge from the sand. Small mesh size is recommended so that the hatchlings cannot put either their heads or their flippers through the openings. Cylinder should be buried to a depth of about 10 cm to discourage crabs from burrowing into the enclosure.

Expected dates of hatchling emergence can also be predicted by the "caving in" of the sand surface above the nest.

Hatchlings fence made from netlon (1-0 cm mesh size). Netlon mesh should be cut into pieces approximately 40 cm in height and 195 cm in length to form a cylinder 60 cm in diameter. A rope can be used to join the ends of the mesh to form a cylinder and secure it into the substrate. The mesh should be buried about 10 cm into the sand to reduce entry by burrowers, such as ghost crabs.

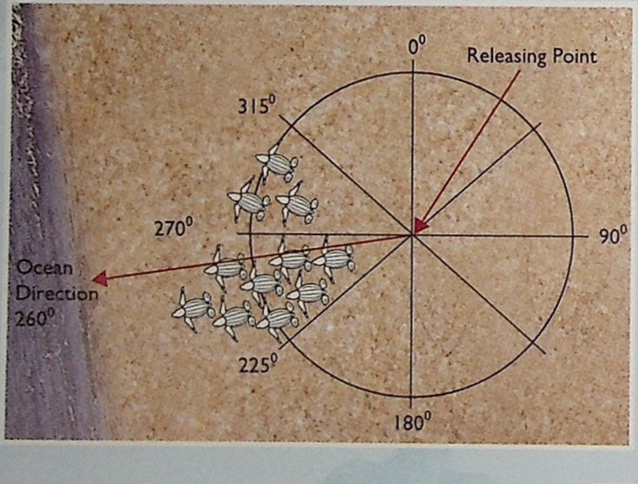
Hatchlings ready to emerge.

Hatchlings ready to be released.

LIGHTS DISORIENTED HATCHLINGS

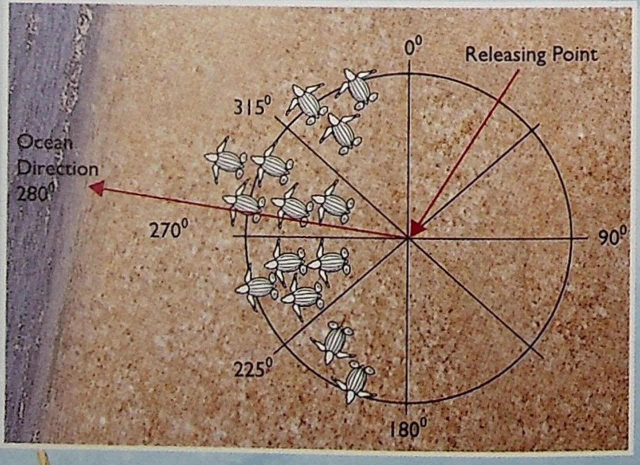
Hatchling orientation study conducted at two different beaches in Terengganu and Perak showed that lights from various sources disoriented hatchlings at Segari, Perak compared to isolated beach at Mak Kepit, in Redang Island. Here the hatchlings crawling direct to the sea.

Lights disoriented hatchlings.



Hatchling orientation at Mak Kepit beach, Redang Island, Terengganu.

Hatchling orientation at Segari, Perak.



RELEASING OF HATCHLING

Hatchling and Imprinting Process

Hatchlings must be released as soon as possible after they break through the sand and should be released on the same night that they emerge. Hatchery personel should anticipate hatchling emergence and check mesh enclosures of frequency intervals every 30-60 minutes during periods of anticipated emergence. (Note: Not for those hatchlings emerge in the styrofoam box). The sooner they are released, the more energy they will have to swim out from shore, into deep water and away from predators. Hatchlings should run down the beach, to allow for the possibility that they "imprint" onto the beach. To minimize hatchling mortality to predators, they should be released at different spots to avoid feeding station of predators. Hatchling must be released in groups to help saturate the predators.

If and when immediate release is not possible, hatchlings should be kept in styrofoam box or in other boxes and, keep in cool and dark places. They should not be placed in buckets of water as they will swimming in frenzy behavior in the bucket and exhaust their yolk reserves. They should not be kept in cage so that the head or flipper will not get stuck.

Do not keep hatchlings in sea water

PREDATORS

There are many dangers awaiting the hatchling on their way to the sea to begin their long life cycle. A small percentage of hatchlings are lost to the terrestrial predators during the beach crossing. In coral reef areas when the hatchlings are crossing the reef flat, they are probably expose to the greatest level of predation during their life cycles.

Hatchlings are almost defenseless if detected by marine predators. They have no parental protection and do not posses defence mechanisms against being swallowed whole. There is no aquatic schooling behavior to swamp or confuse predators and the need to breathe air precludes diurnal vertical migration and concealment in the deep dark water. The only survival strategies available to small turtles are initial predator swamping from the natal beach followed by predator avoidance or concealment. Predator density is lowest in mid-ocean which presents a relatively safe habitat for small turtles.

The attack of ants after hatching and on their way up out of the clutch.

Marine predator when they are in the sea.

Hatchlings attack by ghost crab.

CLEANNESS OF HATCHERY

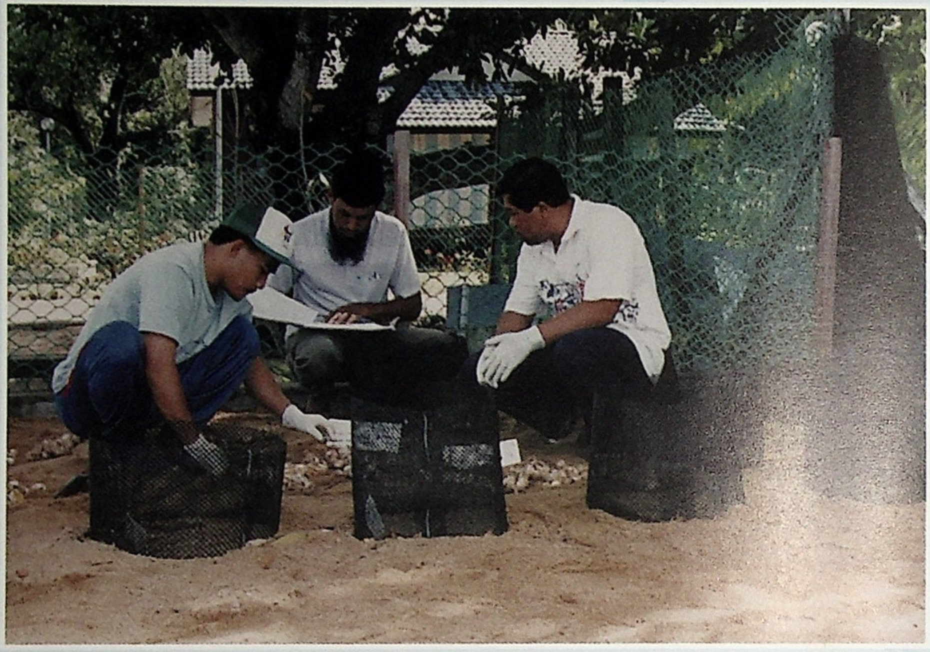
After about a week the hatchlings have emerged, every nest must be excavated, examined and all broken shell, un-hatched eggs and death hatchling should be removed. They should be buried or burn as far away from the hatchery site. The following data should be recorded:

- Date laid
- Date excavated
- Depth from surface of the sand to the bottom of the nest after excavation
- Number of live and active hatchling
- Number of dead hatchling
- Number of weak hatchling
- Number of empty egg shell (i.e. from which hatchlings had successfully emerged)
- Died pipping (i.e, embryos that died in the process of hatchling from the egg)
- Intact eggs (Each intact egg should be broken, open over a screen, rinsed and assigned to one of the following categories:)

  a. Yolk only; no sign of embryo
  b. Embryo without pigmentation; not yet shaped like a turtle; no carapace; generally less than 2.5 cm long. (Total length should be recorded)
  c. Embryo poorly pigmented, but possessing a carapace; and
  d. Embryo completely pigmented.

Examination of the nest after hatchling have emerged

Data recording at each nest.



Recording intact eggs.

INCUBATION IN STYROFOAM BOXES

The result of incubation in styrofoam box and incubator some time very successful if the eggs are handled carefully. However this technique is not recommended because it produce weak hatchlings. They may also be significant problems with regard to sex ratio and the imprinting depending on the structure used for housing the boxes during incubation. However, styrofoam boxes do contribute in the improving incubation success of clutches especially at beaches that are remote from the hatcheries.

After 4 weeks, the incubation boxes should be transported to the hatchery with extreme handling care. Then, transfer the eggs to a nest site within the hatchery. The eggs should not be rotated during the transfer. Incubation of the eggs in the hatchery for the last half of the incubation period, will ensure correct oxygen/carbon dioxide exchange between the eggs and the sand when their metabolic requirements are greatest. This should ensure normal hatchlings that are vigorous and correctly imprinted to the nesting beach (Limpus, 1998).

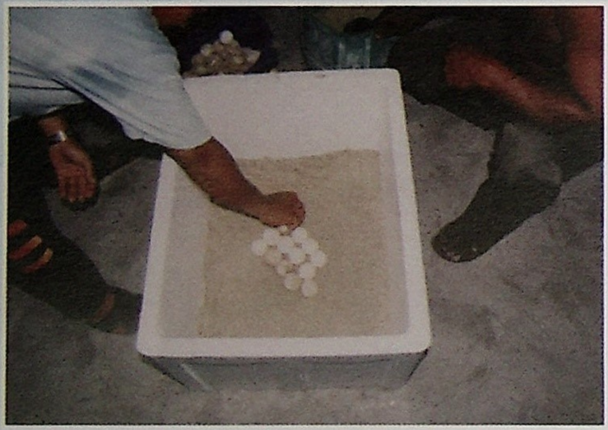
If flooding at the beach hatchery site is likely to occur, the eggs may be placed in styrofoam boxes. Precaution steps are taken as follows:

Step 1 Use of styrofoam box with dimension: 36cm X 21cm X 23cm.

Step 2 Punch one hole for every 4 square cm at the bottom and lid of the box.

Step 3 Place sand in the bottom of the box to a depth of 2 cm.

Step 4 Place eggs on top of the sand.



Step 5 Place a piece of nylon mesh cloth over the eggs.

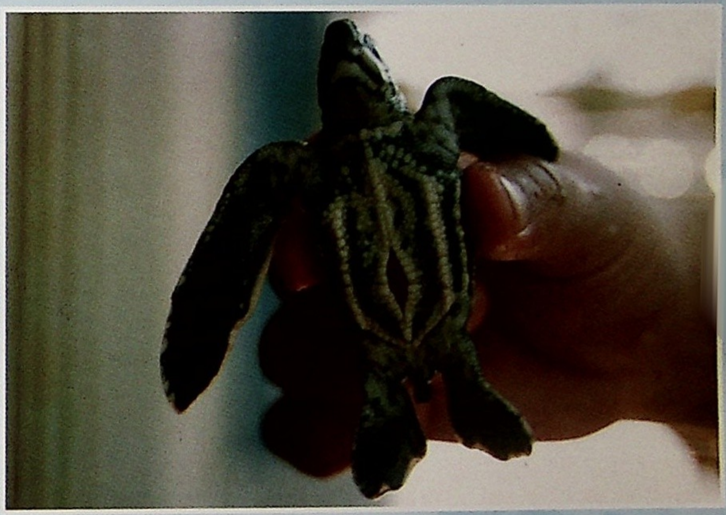
Step 6 Place 2 cm of sand on the top of the cloth.

Step 7 The sand should be moistened with fresh water, 2-3 times during the first 30 days (Try to keep the sand at approximately the same moisture as that found at nest level on the beach). If the sand is too wet, fungus will attack the eggs. If the sand is too dry, the eggs will die from dehydration.

Step 8 About two days before the eggs are expected to hatch, the top layer of sand and nylon cloth should be removed. Keep the lid on the box.

Note: The lid should remain on the box throughout incubation.

Step 9 After the hatchlings emerge, leave them in the box for additional two days, in order to let them absorb their yolk sac. (Normally the yolk sac would be absorbed during the time the hatchlings make their way up to the surface of the sand).



Step 10 Release the hatchlings at night in the normal fashion as described earlier in the text.

Incubation in Styrofoam Boxes.

CAPTIVE REARING (HEADSTARTING)

The captive rearing of sea turtles for subsequent release is very costly and depend on well-trained and reliable staff. This has not been validated as an effective restocking method for any species. Any captive rearing should be recognized as experiments or for educational purposes. In theory, headstarting allows hatchling turtles to grow to a size at which they are relatively safe from majority of predators. In practice, confinement of hatchlings in tank or aquaria at such a critical stage in the life cycle may disrupt their natural behavior patterns later in life and make them either unable to forage properly in the open sea or unable to engage in successful reproduction.

Feeding of juvenile leatherback turtles in captivity

Young leatherback turtle in captivity

A juvenile leatherback turtle rear in captivity.

Releasing of juvenile green turtles.

A juvenile olive ridley turtle.

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