

## Decline of the Leatherback Population in Terengganu, Malaysia, 1956–1995

ENG-HENG CHAN<sup>1</sup> AND HOCK-CHARK LIEW<sup>1</sup>

<sup>1</sup>SEATRU (Sea Turtle Research Unit), Faculty of Applied Science and Technology, Universiti Kolej Terengganu, 21030 Kuala Terengganu, Malaysia [Fax: 609-669-6694; E-mail: ehchan@upmt.edu.my]

**ABSTRACT.** – The Rantau Abang leatherback population in Terengganu, Malaysia is now severely depleted, with current nestings representing less than 1% of levels recorded in the 1950s. Major causes of decline are mortalities attributed to fisheries operations in the high seas as well as within the territorial waters of Malaysia, and a long history of egg exploitation. These problems have been compounded by loss of suitable nesting habitat due to tourism-related development, marine pollution, and sub-optimal hatchery practices leading to reduced hatch rates and sex-biased hatchling production. The global moratorium on driftnet fisheries and complete protection of eggs to ensure optimal hatch rates and production of hatchlings with balanced sex ratios offer some hope for the eventual rehabilitation of the depleted population.

**KEY WORDS.** – Reptilia; Testudines; Dermochelyidae; *Dermochelys coriacea*; sea turtle; nesting trends; threats; hatchery practices; conservation; management; Terengganu; Malaysia

The leatherback population of Rantau Abang, Terengganu, Malaysia, was celebrated as the only remaining leatherback population of importance in the world in the 1950s (Wyatt-Smith, 1960). However, the once healthy total of over 10,000 nests per year (in 1956) has collapsed to fewer than 100 (averaged from 1993–95) in recent years. This tragic decline is a classic example of the plight of a modern-day endangered species.

The dramatic decline of the Rantau Abang population spanning the last several decades has been well documented by Malaysian scientists (Brahim et al., 1987; Chan, 1987a, 1987b, 1991; Chua, 1988a). This decline, brought to the attention of local authorities in the late 1980s, has caused much concern, resulting in the intensification of conservation efforts. Whether or not attempts to save the population from extirpation bear fruit remains to be seen.

This paper collates available information on the Rantau Abang leatherback population to date, analyzes causes of population decline, and discusses the development and evolution of conservation measures for the leatherback in Malaysia.

### NESTING TRENDS

*Temporal Trends from 1956–95.* — The earliest quantification of leatherback egg production in Terengganu resulted from a survey conducted by Hendrickson and Alfred in 1956. The estimated annual egg production was 853,000 eggs (Hendrickson and Alfred, 1961) or 10,155 nestings, assuming an average clutch size of 84 eggs (Chua and Furtado, 1988). Between 1956–66, no records were available. In 1967, the Fisheries Department of Terengganu initiated a tagging program which lasted ten years, providing records of annual nestings between 1967–76 (Chua, 1988b). Following this, Siow and Moll (1982) reported an annual production of 294,000 eggs (or 3500 nestings) in 1978, based on interviews with licensed egg collectors. Subsequent surveys (Siti and de Silva, 1985) yielded nesting data

from 1979 to 1984. The Fisheries Department of Terengganu initiated systematic collection of nesting statistics in 1984, and thereafter data became available for different tendered beaches on a yearly basis.

After collating data from the various sources, population trends became apparent (Fig. 1). The decline from 1956 to 1995 has been precipitous, with 1995 nestings (37) representing only 0.4 % of the levels recorded for 1956 (10,155). The annual decline averaged 260 nests per year over the 39 year period.

Three-year running averages of nestings have been calculated to smooth out yearly differences in the declining trends (Fig. 2). The single data-year of 1956 has been omitted here. As shown in the histogram, there have been two periods of especially sharp declines, one from 1972–74 and the other from 1978–80.

Between 1972 and 1974, the rate of decline averaged 723 nestings per year or 21% annually. This period coincided with the period of rapid development in the fishing industry in Terengganu. Trawling was first introduced to the state in the early 1970s and thereafter, marine fish landings increased dramatically (Ministry of Agriculture Malaysia, 1978). The negative impact of fishing gear on leatherbacks and other turtles in Terengganu has been documented by Chan et al. (1988).

Between 1978 and 1980, nestings dropped at an average rate of 469 nests per year or 31% annually. This coincided directly with the introduction of the Japanese high seas squid driftnet fishery of the North Pacific in 1978 (Yatsu et al., 1991). This fishery is presumed to have impacted the Malaysian leatherback population, since tagged individuals from Rantau Abang have been recovered from as far away as Taiwan, Japan, and Hawaii (Leong and Siow, 1980). Similar fisheries operating within the South China Sea must have compounded the problem. After these two periods, rates of decline averaged 64 nests per year or 16% annually, suggesting continuing threats from fisheries operations.

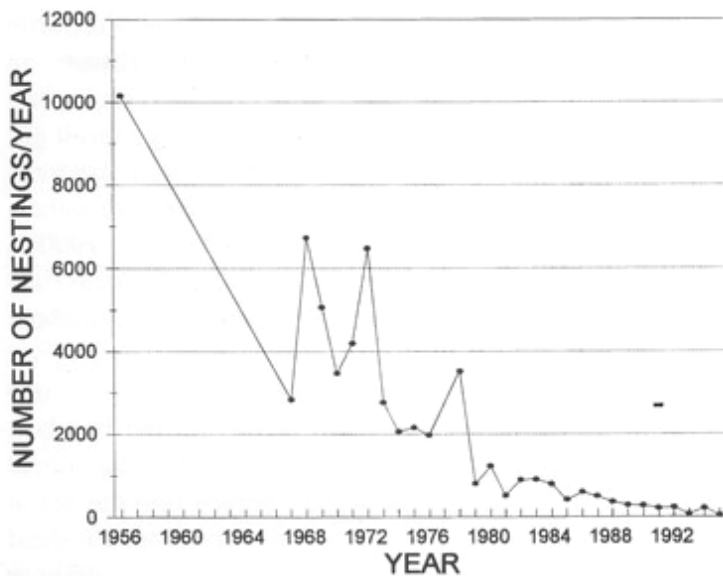


Figure 1. Nesting trends in the Terengganu, Malaysia, leatherback population from 1956–95.

The pattern of decline from 1967 to 1995 can be represented by a quadratic equation (Fig. 3) :

$$y = 80.662 - 3.526t + 0.0371t^2$$

with a mean square error of 64.989 and where  $y = \sqrt{\text{nestings}}$  and  $t = (\text{year} - 1966)$ . Based on this equation, it is predicted that population extirpation may occur in the year 2003 if present trends persist. However, trend reversals in leatherback populations of St. Croix (Dutton and McDonald, 1992; Boulon et al., 1996) and Tongaland (Mrosovsky, 1983; Hughes, 1996) following beach protection offer some hope to the depleted Rantau Abang population.

*Spatial Trends from 1984–95.* — Locations of leatherback nesting beaches are shown in Fig. 4 while Table 1 provides nesting statistics for the beaches between 1984–95. The Rantau Abang Turtle Sanctuary (14 km long) comprises Rantau Abang I and II and the Government Reserve, which is a 0.5 km stretch reserved for egg collection by the Fisheries Department.

Cumulative nesting data from 1984 to 1995 show that the sanctuary is the most important nesting site, accounting for over 70% of the total nestings in Terengganu. However, a year to year analysis shows that sanctuary nesting contributions have declined in recent years. Between 1992–94, sanctuary nestings accounted for only 29–48% of the total nestings, compared to 80–84% from 1984–86 (Table 1). In 1995, however, sanctuary nestings accounted for 68% of total nestings. Nestings north of the sanctuary are relatively insignificant, accounting for only 3–15% of total nestings. Beaches south of the sanctuary, however, have shown increasing percentage contributions, particularly from 1992 to 1994 when contributions have ranged from 43–67% of total nestings for the state.

The overall decline in the Terengganu leatherback population is due primarily to nesting trends within the sanctuary area, and to a lesser extent, along the beaches north of the sanctuary. Nesting density south of the sanctuary has

not shown the same decline, but instead appears to have been roughly stable between 1984 to 1994. This analysis points to two possibilities; either only the population within the sanctuary area is suffering the bulk of the decline, or the decline is uniform in Terengganu, but is manifested only within the sanctuary area because of emigration of turtles to beaches located south of the sanctuary. Although leatherbacks, like other sea turtle species, exhibit some reproductive philopatry (nest site fidelity), straying or switching to other nesting beaches ranging from a few to over 100 km apart have been documented. Pritchard (1973) reported 14 cases of leatherbacks which displayed counter-current intra-seasonal interesting shifts between Surinam and French Guiana beaches 100–120 km apart. Likewise, Eckert et al. (1989) reported that 0–27.3% of the nesting population in the West Indies shifted to other beaches or islands each year, with distances ranging from 30–90 km. Once a switch had been made, the turtles did not subsequently return to the beach of initial choice (Eckert et al., 1989). In the Rantau Abang population, Chan et al. (1991) found one radio-tracked leatherback straying more than 20 km to lay a subsequent clutch of eggs.

Since the entire Terengganu leatherback population is subject to similar pressures in the open-ocean environment, it is more likely that the overall population has suffered the decline exhibited, rather than just the animals nesting in the sanctuary. Based on the additional evidence of nesting beach switches, we hypothesize that nesting beaches south of the sanctuary are also losing turtles at similar rates, but that their rates of decline are buffered by arrivals of sanctuary turtles which have switched nesting location. In Terengganu, only the sanctuary area is subject to tourism and hence human disturbance. The Government Reserve area, once the site of highest nesting activity (Chan, 1987b) is now an open-access area where vendors and tourists are allowed free access. Beach

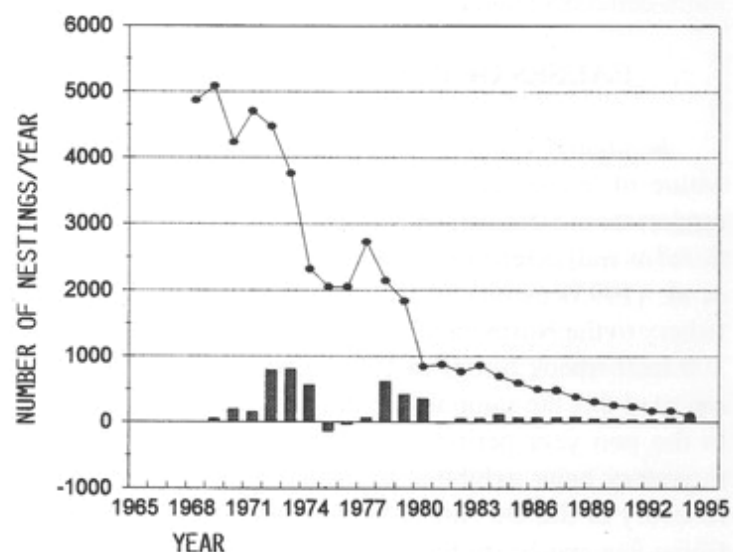
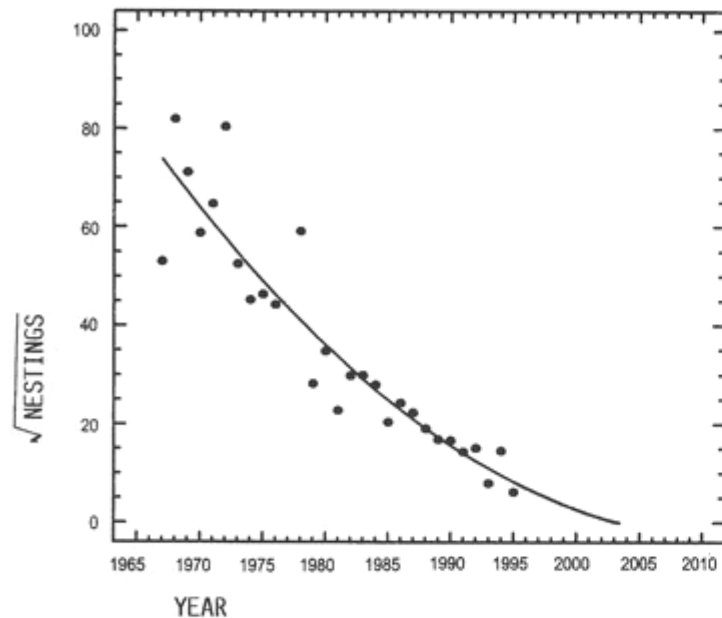


Figure 2. Declining trends in the Terengganu, Malaysia, leatherback population based on 3 year running averages of nestings. Line graph shows the average number of nestings per year while the histogram depicts rates of annual decline by average number of nestings per year, with negative numbers indicating population increases.



**Figure 3.** Quadratic trend analysis of Malaysian leatherback nestings, predicting possible population extirpation by about 2003.

chalets with unshielded lights have been built there to provide accommodation and other facilities for tourists.

The highly publicized Rantau Abang Sanctuary is visited by thousands of tourists during the nesting season, with up to 1000 people watching a single nesting turtle (*pers. obs.*). Through the provisions of the Turtles Enactment 1951 (Amendment) 1987, turtle watching is subject to rules enforced by officers of the Terengganu Fisheries Department. However, because of large crowds and limited enforcement personnel, turtle watching rules are more frequently flouted than followed. As a result, tourism and its related activities remain a major disturbance within the sanctuary. Furthermore, sanctuary personnel conduct all-night patrols throughout the sanctuary beaches using noisy ATVs (all terrain vehicles) with strong headlights. With such intense disturbance, it is not surprising that the turtles have switched to more conducive and remote sites.

### CAUSES OF POPULATION DECLINE

*Incidental Captures in Fishing Gear.* — The pelagic nature of leatherback turtles throughout their life history renders them extremely vulnerable to fishing gear in international as well as territorial waters of coastal states. Wetherall et al. (1993) estimated that the Japanese squid driftnet fishery in the North Pacific accounted for the death of over 200 leatherback turtles in 1989, while Yatsu et al. (1991) reported that the same fishery killed over 500 leatherbacks in the two year period from 1989–90. Given the highly migratory habit exhibited by leatherbacks and records of recovery of Rantau Abang-tagged individuals in the South China Sea and North Pacific (Leong and Siow, 1980), it is almost certain that these driftnet captures involve the Malaysian population, at least in part.

The rapid development of the fishing industry in Terengganu within the last three decades has also been a major factor in the decline of the Malaysian leatherback.

Chan et al. (1988) provided the earliest estimates of turtle mortalities in fishing gear (mostly trawl and driftnets) in Terengganu, followed by Jabatan Perikanan Terengganu (1989) which highlighted threats posed by large-mesh gill nets for the capture of rays. More recently, sunken fish traps have been identified to be especially dangerous to leatherback turtles (Mortimer, 1989; Chan and Liew, 1990a). Gravid females are particularly vulnerable to the local fishery during the nesting season when they reside in inshore waters for long periods.

Besides the adults, newly emerged hatchlings are also vulnerable to fishing activities near the nesting beaches, especially those that utilize bright lights at night. Hatchlings are strongly phototactic and when released into the sea at night, they would swim towards lighted fishing boats instead of heading straight towards the relatively safer offshore waters (Chan and Liew, 1990a).

Fishing gear impacts need to be addressed at both the local and international levels. If mortality of adults and sub-adults is not reduced, even complete protection of eggs at the nesting beaches would be rendered ineffective (Wetherall et al., 1993).

*Past Patterns of Egg Exploitation.* — Coastal villagers in Terengganu have been engaged in the collection of leatherback eggs for consumption and sale since time immemorial, with egg harvests approaching 100% for many decades. Egg harvesting became an organized, state-controlled economic activity with the promulgation of the Turtles Enactment in 1951. The enactment provided for the division of nesting beaches into lots, with each lot tendered to the highest bidder.

It was only in 1961 that the first hatchery for leatherback eggs was established (Hendrickson, 1962). However, as evidenced by the population crash today, the hatchery program has been ineffective in sustaining the population. The state government has banned the commercial sale and consumption of leatherback eggs since 1988, with close to 100% of the eggs deposited retained for incubation (Table 2).

*Past Hatchery Practices.* — Hatchery operation as a conservation technique has failed to sustain population levels in Rantau Abang. The ineffectiveness of the practice has been attributed to low percentages of eggs incubated in the early years of the hatchery program (Table 2), poor hatch rates, and high temperature regimes in hatcheries, resulting in strong female-biased hatchling production (Chan, 1991).

Hendrickson and Alfred (1961) estimated that as little as 2% of total egg production could provide the necessary population recruitment while Siow and Moll (1982) suggested 15%. In a healthy population, C. Limpus (*pers. comm.*) estimated that at least 70% of the eggs be protected to sustain population size. For severely depressed populations, it is critical that all eggs be protected and optimal hatch rates ensured.

Records of actual numbers and percentages of eggs incubated, numbers of hatchlings released, and hatch rates are shown in Table 2 and Fig. 5. Between 1966 and 1976, good numbers of hatchlings were released from Rantau Abang. Assuming a 20 year maturation period for leatherbacks, these hatchlings should already be recruiting into the

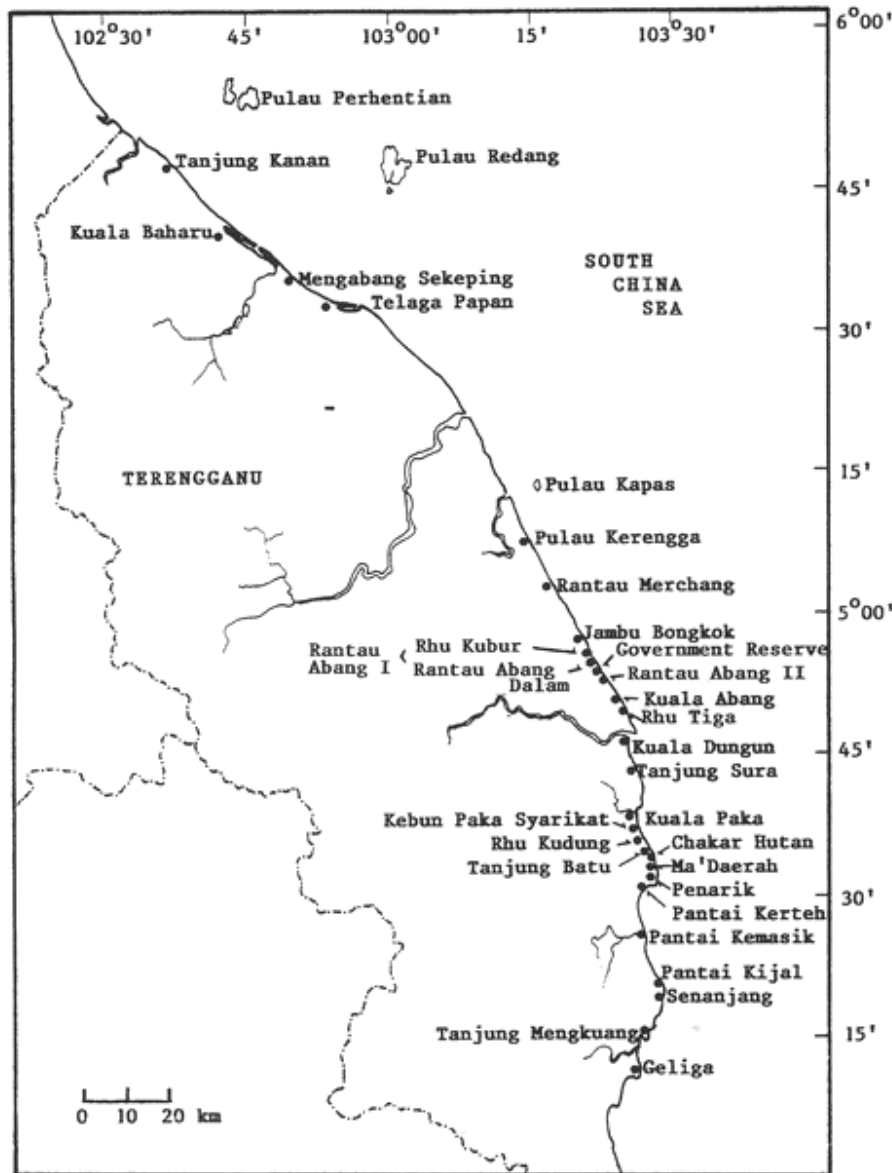


Figure 4. Location of leatherback nesting beaches in Terengganu, Malaysia. The Rantau Abang Turtle Sanctuary extends from Rantau Abang I to Rantau Abang II.

breeding population. However, persistent population declines indicate no evidence of recruitment. Given the highly pelagic nature of leatherbacks throughout their life history, the thousands of Rantau Abang hatchlings released may have eventually fallen prey to high seas fisheries operating in the South China Sea and North Pacific. By comparison, green turtles which spend only the first few years of their life in the pelagic zones have staged an impressive population recovery in the Sabah Turtle Islands since 1988, after approximately 20 years of intensive hatchery operation (Basintal and Lakim, 1994).

Current population levels in Rantau Abang represent only about 1% of levels in the 1950s. It is clear that unless leatherback mortalities in high seas fisheries can be effectively controlled, the 100% egg incubation practiced now cannot significantly rehabilitate the population.

There has been a general decline in hatch rates attained in the Rantau Abang hatcheries even though hatchery practices have improved. Based on the finding that leatherback eggs can withstand rough handling only within five hours of oviposition (Chan et al., 1985), sanctuary eggs are now

transported to the hatcheries within three hours of oviposition. Chan (1991, 1993) partially attributed low hatch rates to egg infertility. Between 1987–91, about 18.8% of the clutches were found to be completely infertile, while within fertile clutches, an average of 30.5% of the eggs were infertile. After accounting for inter- and intra-clutch infertility, it was estimated that hatch rates attainable in Rantau Abang could not exceed 56.4% (Chan, 1993).

The hatcheries in Rantau Abang have been postulated to previously produce hatchlings which were practically 100% female (Chan and Liew, 1995a). Since all hatchlings released have been produced from hatcheries, the resulting adult population would be male-impooverished. In such a scenario, female turtles which do not have adequate mating chances will eventually deposit eggs which are largely infertile. Egg infertility due to sex-ratio imbalance has indeed emerged as a unique problem in Rantau Abang and presents an additional constraint to the survival of the population.

*Tourism-Related Activities and Switching of Nesting Beaches.* — Although the leatherback population in Rantau Abang has been severely decimated, its nesting beaches

**Table 1.** Annual leatherback nestings along tendered beaches in Terengganu from 1984–95. Beaches are listed from a south to north direction. (Source: Fisheries Department of Terengganu).

Tendered Beach	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Total
<b>Southern Beaches</b>													
1 Geliga	0	1	2	2	0	0	3	5	0	8	0	0	21
2 Tanjung Mengkuang	0	0	0	0	0	0	5	0	0	0	0	0	5
3 Senanjang	0	2	0	0	2	1	0	0	0	0	0	0	5
4 Kijal	0	16	1	14	15	0	12	5	19	8	24	0	114
5 Pantai Kemasik	1	0	0	0	0	0	0	0	0	0	0	0	1
6 Pantai Kerteh	0	5	0	0	1	0	0	1	3	0	7	0	17
7 Penarik	1	0	0	0	0	0	0	0	0	0	0	0	1
8 Ma' Daerah	18	3	23	13	25	4	17	2	12	0	21	0	138
9 Chakar Hutan	11	3	6	0	12	1	7	4	5	0	14	0	63
10 Tanjung Batu	0	0	14	3	13	2	6	8	7	4	3	0	60
11 Rhu Kudung	1	2	1	0	10	12	13	4	8	5	5	1	62
12 Kebun Pakar Syt.	4	0	0	1	1	2	3	4	14	2	2	3	36
13 Kuala Paka	26	1	2	7	7	8	15	2	5	0	0	0	73
14 Tanjung Sura	8	0	0	0	2	19	19	16	17	4	22	1	108
15 Kuala Dungun	3	1	1	6	6	1	9	7	6	5	8	0	53
16 Rhu Tiga	17	14	15	33	8	9	1	3	0	2	14	3	119
17 Kuala Abang	0	2	6	4	5	1	2	1	4	1	3	0	29
<b>Rantau Abang Sanctuary</b>													
18 Rantau Abang II	165	133	134	161	144	80	75	54	76	4	41	19	1086
19 Government Reserve	65	17	22	41	17	0	10	9	3	1	4	1	190
20 Rantau Abang I	400	200	345	183	86	103	67	73	33	12	38	5	1545
<b>Northern Beaches</b>													
21 Jambu Bongkok	44	11	16	16	10	24	11	4	4	1	3	0	144
22 Rantau Merchang	12	2	6	13	1	13	3	5	5	1	2	4	67
23 Pulau Kerengga	12	3	2	4	2	4	2	0	3	0	0	0	32
24 Tanjung Kanan	0	2	0	0	0	0	0	0	0	0	0	0	2
25 Kuala Bharu	0	0	0	0	0	1	0	0	1	0	1	0	3
26 Mengabang Sekeping	0	0	0	0	0	1	0	0	2	0	1	0	4
27 Telaga Papan	0	0	0	1	0	0	0	0	4	0	0	0	5
<b>Grand Total</b>	<b>788</b>	<b>418</b>	<b>596</b>	<b>502</b>	<b>367</b>	<b>286</b>	<b>280</b>	<b>207</b>	<b>231</b>	<b>58</b>	<b>213</b>	<b>37</b>	<b>3983</b>
<b>Turtle Sanctuary</b>	<b>630</b>	<b>350</b>	<b>501</b>	<b>385</b>	<b>247</b>	<b>183</b>	<b>152</b>	<b>136</b>	<b>112</b>	<b>17</b>	<b>83</b>	<b>25</b>	<b>2821</b>
<i>% Contribution</i>	<i>80</i>	<i>84</i>	<i>84</i>	<i>77</i>	<i>67</i>	<i>64</i>	<i>54</i>	<i>66</i>	<i>48</i>	<i>29</i>	<i>39</i>	<i>68</i>	<i>71</i>
<b>North of Sanctuary</b>	<b>68</b>	<b>18</b>	<b>24</b>	<b>34</b>	<b>13</b>	<b>43</b>	<b>16</b>	<b>9</b>	<b>19</b>	<b>2</b>	<b>7</b>	<b>4</b>	<b>257</b>
<i>% Contribution</i>	<i>9</i>	<i>4</i>	<i>4</i>	<i>7</i>	<i>4</i>	<i>15</i>	<i>6</i>	<i>4</i>	<i>8</i>	<i>3</i>	<i>3</i>	<i>11</i>	<i>6</i>
<b>South of Sanctuary</b>	<b>90</b>	<b>50</b>	<b>71</b>	<b>83</b>	<b>107</b>	<b>60</b>	<b>112</b>	<b>62</b>	<b>100</b>	<b>39</b>	<b>123</b>	<b>8</b>	<b>905</b>
<i>% Contribution</i>	<i>11</i>	<i>12</i>	<i>12</i>	<i>17</i>	<i>29</i>	<i>21</i>	<i>40</i>	<i>30</i>	<i>43</i>	<i>67</i>	<i>58</i>	<i>22</i>	<i>23</i>

remain extremely popular for turtle watching among foreign and local tourists. This is clearly attributable to their easy accessibility, with the main road running parallel to the nesting beaches. Tourist arrivals have no doubt generated substantial income for the local inhabitants, but they have also created immense problems for the turtles which, by nature, seek dark, quiet, and undisturbed beaches for nesting.

The core nesting area, designated the Government Reserve, has been developed for tourism and for many years, the nesting turtles were left vulnerable to the uncontrolled and unsupervised activities of large crowds of ill-informed tourists and their guides. In spite of the enforcement of the Turtles Enactment 1951 (Amendment) 1987, tourism and its related activities remain a significant disturbance factor in the sanctuary. Because of this, the turtles appear to have shifted south along the coast to nest (see section above on "Spatial Trends"). However, this emigration will be short lived as the southern beaches are also being developed for industry, tourism, and housing.

*Direct Hunting of Leatherbacks in Neighboring Countries.* — Leatherbacks are not directly hunted in

Malaysia, as consumption of turtle meat is prohibited in Islam. In neighboring countries, however, leatherback turtles are reported to be more frequently hunted and in greater numbers now because of loss of traditional sources of protein through deforestation. Suarez and Starbird (1995, 1996) estimated that approximately 200 leatherbacks are killed per year in traditional fisheries in Maluku, Indonesia. There is no evidence as of now that the Malaysian leatherbacks are impacted in this take, but research using flipper tagging or genetic techniques may reveal some answers.

*Marine Pollution and Non-Degradable Marine Debris.* — The South China Sea is polluted with tar and dissolved hydrocarbons (Law and Rahimi, 1986; Liew and Chan, 1994). The effects of oil pollution and fatalities caused by the ingestion of tar by young turtles has been well documented (see sources cited in Chan and Liew, 1988). Entanglement in discarded fishing gear and marine debris, toxicology, and ingestion of plastics and other debris have been reviewed in National Research Council (1990). These effects have not been assessed in Malaysia, but must undoubtedly impact the leatherbacks of Terengganu.

**Table 2.** Leatherback hatchery data from 1961 to 1995. (Source: Fisheries Department of Terengganu, Malaysia).

Year	No. of Eggs Incubated	% of Total Eggs Deposited	No. of Hatchlings Emerged/Released	Hatch Rate (%)	3-Year Average Hatch Rate (%)
1961	8,366		3,699	44.2	
1962	11,654		6,300	54.1	
1963	9,956		5,580	56.1	
1964	11,535		3,803	33.0	47.7
1965	10,671		7,199	71.5	
1966	31,250		16,477	52.7	
1967	15,650		9,215	58.9	61.0
1968	40,000		18,331	45.8	
1969	38,008	9.5	15,930	53.1	
1970	31,050		17,089	55.0	51.3
1971	47,391		30,260	63.1	
1972	60,000		37,193	62.0	
1973	72,260		30,699	42.5	55.5
1974	91,147	30.4	42,616	46.8	
1975	85,922		40,565	47.2	
1976	69,480		44,480	64.0	52.7
1977	7,803		4,578	58.7	
1978	34,391	16.3	14,878	43.3	
1979	24,739		11,509	46.5	49.5
1980	29,387		10,118	34.4	
1981	24,713		9,526	38.6	
1982	41,812	35.2	20,176	48.3	40.4
1983	11,119		5,335	47.6	
1984	14,563		6,928	47.6	
1985	16,100	44.7	7,245	45.0	46.7
1986	25,794	53.5	12,823	49.7	
1987	30,211	72.0	14,011	46.4	
1988	26,254	85.3	9,420	35.2	43.8
1989	28,321	100.0	9,776	34.5	
1990	20,560	86.4	8,028	39.0	
1991	17,210	98.3	4,304	25.0	32.8
1992	18,149	91.2	6,797	37.5	
1993	4,886	91.9	1,135	23.2	
1994	18,177	100.0	8,499	46.8	35.8
1995	2,928	100.0	632	21.6	
Total	1,031,537		495,154		

### LEATHERBACK CONSERVATION IN MALAYSIA

Conservation efforts on the Malaysian leatherback started in 1961 when the Malayan Nature Society first proposed the establishment of a hatchery in Rantau Abang (Wyatt-Smith, 1960). Hatchery operation remained the sole conservation measure for more than 25 years. This has proved to be ineffective in sustaining the population (see above) as evidenced by the population crash highlighted by Brahim et al. (1987), Chan (1987a, 1987b, 1991) and Chua (1988a).

The late 1980s saw a recognition of the need to intensify conservation work on the leatherback. Through support from a private agency, a major sea turtle research and conservation project was initiated by Universiti Kolej Terengganu (formerly Universiti Pertanian Malaysia Terengganu) in 1985. The project launched an educational campaign whereby brochures depicting the plight of the leatherback and the population crash were mass-produced for distribution. A turtle coloring book was also published for distribution in local elementary schools (Chan, 1987c, 1988; Chan and Liew, 1990b).

Through the awareness created, the local authorities (Terengganu State Economic Planning Unit and the Fisher-

ies Department of Malaysia) convened a National Workshop on Sea Turtle Conservation and Management in 1987. The State Legislature of Terengganu also adopted the Turtles Enactment, 1951 (Amendment) 1987 to provide for more stringent measures for the protection and management of sea turtles in the state.

Through the provisions of the Amendment, the Rantau Abang Turtle Sanctuary and the Turtle Sanctuary Advisory Council were established in 1988. The council serves to advise the state government on matters pertaining to the conservation and management of sea turtles in Terengganu. The sanctuary covers 14 km of nesting beaches and was created to curb further development within its premises. Turtle watching regulations have been introduced to control the activities of the tourists within the sanctuary, but these have been ineffective due to limited enforcement personnel and capacity.

In view of the population crash recognized by the state government, the commercial sale and consumption of leatherback eggs were legally banned in Terengganu in 1988 in order that 100% of the eggs deposited could be saved for hatching. Hatchery practices have been fine-tuned to enhance hatch rates. To counteract the effects of previous all-female hatchling production, 4–15% of the eggs have been

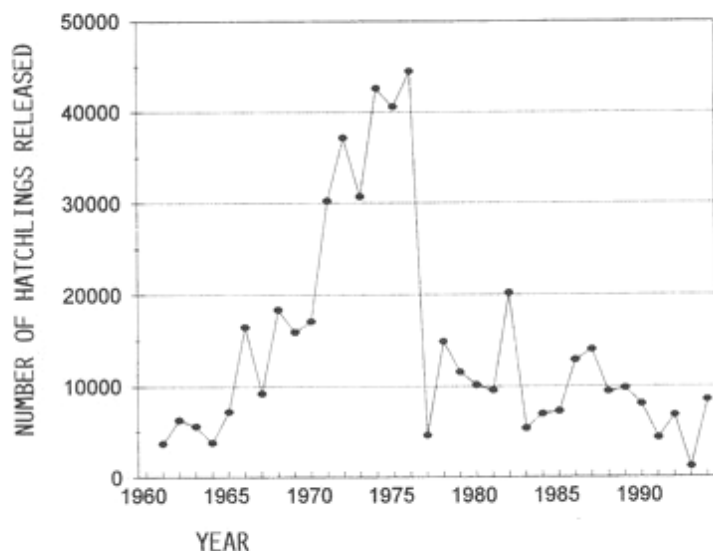


Figure 5. Number of leatherback hatchlings released in Terengganu from 1961–94.

incubated annually in styrofoam boxes with male-producing temperature regimes (Jabatan Perikanan Terengganu, 1991, 1992, 1993, 1994).

To further intensify conservation efforts on the leatherback, World Wildlife Fund Malaysia launched a "Save the Sea Turtles" campaign in 1989. This campaign has enhanced public awareness of the plight of the turtles and produced several management plans for sea turtle conservation not only in Terengganu, but for various other locations in Malaysia as well.

Two fishing regulations are in effect in Malaysia to provide protection from fishing gear within territorial waters. The Fisheries Regulations (Prohibition of Fishing Methods) 1985 Amendment 1989 specifically bans the use of large-meshed (in excess of 25.4 cm) driftnets throughout the coastal waters of Malaysia while the Fisheries (Prohibited Areas) (Rantau Abang) Regulations 1991 was gazetted to provide offshore protection to leatherback turtles during the internesting periods (Chan and Liew, 1995b). Given that leatherback nesting has become so diffused over the mainland coastline of Terengganu in recent years, the offshore sanctuary at Rantau Abang may now be of limited application.

At the international level, it is anticipated that the global moratorium on high seas driftnet fisheries that commenced in December 1992 may offer some reprieve to the severely depleted population.

## CONCLUSIONS

The Rantau Abang population continues to decline. If current rates of decline persist, population extirpation is predicted by the year 2003, as demonstrated in the quadratic trend analysis of annual nestings over the last 28 years.

It is clear that the battle to save the Malaysian leatherback lies not solely in ensuring that 100% of the eggs are protected and incubated under optimal conditions with the production of hatchlings with balanced sex-ratios. Efforts on the nesting beaches will come to nought if adult and sub-

adult mortality is not reduced. The international community has a role and responsibility in addressing the mortality of Malaysian leatherbacks in high seas fisheries.

With control of fisheries and complete protection of eggs, there is hope that the rate of decline can be arrested to ensure population stabilization and eventual recovery. The recovery of the Tongaland leatherback population from about 5 nesting individuals in 1966 to over 80 in 1979 and 124 in 1995 (Mrosovsky, 1983; Hughes, 1996) shows that trend reversals are possible and offers some optimism for the Rantau Abang leatherback population.

## Acknowledgments

This paper has been extracted from the senior author's doctoral dissertation entitled "The conservation-related biology and ecology of the leatherback turtle, *Dermochelys coriacea* in Rantau Abang, Terengganu, Malaysia," Kagoshima University, supervised by G. Kawamura and H. Kawatsu. The authors are indebted to the Fisheries Department of Terengganu for making available turtle statistics through their reports to the Turtle Sanctuary Advisory Council of Terengganu, and to ESSO Production Malaysia Inc. for a sea turtle grant in 1985, which has spawned a life-long interest in sea turtles.

## LITERATURE CITED

- BASINTAL, P., AND LAKIM, M. 1994. Status and management of sea turtles at Turtle Island Park. In: Načič, A., Trono, R., Palma, J.A., Torres, D., and Agas, F., Jr. (Eds.). Proc. First Asean Symposium-Workshop on Marine Turtle Conservation, Manila, Philippines, pp. 139-150.
- BOULON, R.H., JR., DUTTON, P.H., AND McDONALD, D.L. 1996. Leatherback turtles (*Dermochelys coriacea*) on St. Croix, U.S. Virgin Islands: fifteen years of conservation. *Chelonian Conservation and Biology* 2(2):141-147.
- BRAHIM, S., CHAN, E.H., AND RAHMAN, A.K. 1987. An update on the population status and conservation of the leatherback turtle of Terengganu. In: Sasekumar, A., Phang, S.M., and Chong, E.L. (Eds.). Towards Conserving our Marine Heritage. Proc. Tenth Ann. Seminar, Malaysian Soc. Marine Sciences, Kuala Lumpur, Malaysia, pp. 69-77.
- CHAN, E.H. 1987a. The sea turtles of Malaysia. *Nature Malaysiana* 12(1):4-9.
- CHAN, E.H. 1987b. Status of the leatherback turtle, *Dermochelys coriacea*. Workshop on Sea Turtle Conservation and Management in Malaysia, 14-17 December 1987, Tanjong Jara, Terengganu, Malaysia.
- CHAN, E.H. 1987c. Why our sea turtles are disappearing. A brochure developed to increase public awareness on the plight of Malaysian sea turtles, published in English and Bahasa Malaysia for free distribution to visitors at the Turtle Information Centre. Sea Turtle Research and Conservation Project, Universiti Pertanian Malaysia.
- CHAN, E.H. 1988. Sea turtles of Malaysia, a colouring book in Bahasa Malaysia and English. Universiti Pertanian Malaysia, Kuala Terengganu, Malaysia, 18 pp.
- CHAN, E.H. 1991. Sea turtles. In: Kiew, R. (Ed.). The State of Nature Conservation in Malaysia. Malayan Nature Society, Kuala Lumpur, Malaysia, pp. 120-135.
- CHAN, E.H. 1993. The conservation-related biology and ecology of the leatherback turtle, *Dermochelys coriacea* in Rantau Abang, Terengganu, Malaysia. Ph.D. Thesis, Kagoshima University, Japan.
- CHAN, E.H., ECKERT, S.A., LIEW, H.C., AND ECKERT, K.L. 1991. Locating

- the interesting habitats of leatherback turtles (*Dermochelys coriacea*) in Malaysian waters using radiotelemetry. In: Uchiyama, A., and Amlaner, C.J. (Eds.). Biotelemetry XI: Proc. Eleventh International Symposium Biotelemetry, Yokohama, Japan, pp. 133-138.
- CHAN, E.H., AND LIEW, H.C. 1988. A review on the effects of oil-based activities and oil pollution on sea turtles. In: Sasekumar, A., D'Cruz, R., and Lim, S.L.H. (Eds.). Thirty Years of Marine Science Research and Development. Proc. Eleventh Annual Seminar, Malaysian Society of Marine Science, Kuala Lumpur, Malaysia, pp. 159-167.
- CHAN, E.H., AND LIEW, H.C. 1990a. The offshore protection of Malaysian leatherback turtles. In: Phang, S.M., Sasekumar, A., and Vickineswary, S. (Eds.). Research Priorities for Marine Sciences in the 90's. Proc. Twelfth Annual Seminar, Malaysian Society of Marine Science, Kuala Lumpur, Malaysia, pp. 213-218.
- CHAN, E.H., AND LIEW, H.C. 1990b. Educational materials on sea turtles produced by the Sea Turtle Research and Conservation Project, Universiti Pertanian Malaysia. In: Phang, S.M., Sasekumar, A., and Vickineswary, S. (Eds.). Research Priorities for Marine Sciences in the 90's. Proc. Twelfth Annual Seminar, Malaysian Society of Marine Science, Kuala Lumpur, Malaysia, pp. 289-290.
- CHAN, E.H., AND LIEW, H.C. 1995a. Incubation temperatures and sex-ratios in the Malaysian leatherback turtle, *Dermochelys coriacea*. Biol. Conserv. 74:169-174.
- CHAN, E.H., AND LIEW, H.C. 1995b. An offshore sanctuary for the leatherback turtles of Rantau Abang, Malaysia. In: Richardson, J.L., and Richardson, T.H. (Compilers). Proc. Twelfth Annual Workshop Sea Turtle Biology Conservation. NOAA Technical Memorandum NMFS-SEFSC-361, pp. 18-20.
- CHAN, E.H., LIEW, H.C., AND MAZLAN, A.G. 1988. The incidental capture of sea turtles in fishing gear in Terengganu, Malaysia. Biol. Conserv. 43:1-7.
- CHAN, E.H., SALLEH, H.U., AND LIEW, H.C. 1985. Effects of handling on hatchability of eggs of the leatherback turtle, *Dermochelys coriacea* (L.). Pertanika 8(2):265-271.
- CHUA, T.H. 1988a. On the road to local extinction: the leatherback turtle (*Dermochelys coriacea*) in Terengganu, Malaysia. In: Sasekumar, A., D'Cruz, R., and Lim, S.L.H. (Eds.). Thirty years of Marine Science Research and Development. Proc. Eleventh Ann. Seminar, Malaysian Society of Marine Sciences, Kuala Lumpur, Malaysia, pp. 153-158.
- CHUA, T.H. 1988b. Nesting population and frequency of visits in *Dermochelys coriacea* in Malaysia. J. Herpetol. 22(2):192-207.
- CHUA, T.H., AND FURTADO, J.I. 1988. Nesting frequency and clutch size in *Dermochelys coriacea* in Malaysia. J. Herpetol. 22(2):208-218.
- DUTTON, P. AND McDONALD, D. 1992. 1991 a 'record year' for leatherback productivity on St. Croix, U.S. Virgin Islands. Marine Turtle Newsletter 57:15-17.
- ECKERT, K.L., ECKERT, S.A., ADAM, T.W., AND TUCKER, A.D. 1989. Interesting migrations by leatherback sea turtles (*Dermochelys coriacea*) in the West Indies. Herpetologica 45(2):190-194.
- HENDRICKSON, J.R. 1962. The programme for conservation of the giant leathery turtle, 1961. Malayan Nature Journal 16:64-69.
- HENDRICKSON, J.R., AND ALFRED, E.R. 1961. Nesting populations of sea turtles on the east coast of Malaya. Bull. Raffles Mus. 26:190-196.
- HUGHES, G.R. 1996. Nesting of the leatherback turtle (*Dermochelys coriacea*) in Tongaland, KwaZulu-Natal, South Africa, 1963-1995. Chelonian Conservation and Biology 2(2):153-158.
- JABATAN PERIKANAN TERENGGANU. 1989. Kajian risikan kesan pukut penyu ke atas penyu di negeri Terengganu. Kertas Bil. 3/89, Mesyuarat Majlis Penasihat Santuari Penyu, 20 Feb. 1989, Kerajaan Negeri Terengganu.
- JABATAN PERIKANAN TERENGGANU. 1991. Program pengeraman telur penyu belimbing dalam kotak stirobusa tahun 1991. Kertas Bil. 21/91, Mesyuarat Majlis Penasihat Santuari Penyu, 10 Dis. 1991, Kerajaan Negeri Terengganu.
- JABATAN PERIKANAN TERENGGANU. 1992. Program penetasan telur penyu belimbing di dalam kotak stirobusa tahun 1992. Kertas Bil. 21/92, Mesyuarat Majlis Penasihat Santuari Penyu, 3 Dis. 1992, Kerajaan Negeri Terengganu.
- JABATAN PERIKANAN TERENGGANU. 1993. Laporan program penetasan penyu Terengganu tahun 1993. Kertas Bil. 9/93, Mesyuarat Majlis Penasihat Santuari Penyu, 21 Dis. 1993, Kerajaan Negeri Terengganu.
- JABATAN PERIKANAN TERENGGANU. 1994. Laporan program santuari penyu Jabatan Perikanan Terengganu tahun 1994. Kertas Bil. 9/94, Mesyuarat Majlis Penasihat Santuari Penyu, 27 Dis. 1994, Kerajaan Negeri Terengganu.
- LAW, A.T., AND RAHIMI, Y. 1986. Hydrocarbon distribution in the South China Sea. In: Mohsin, A.K.M., Ibrahim, M., and Ambak, M.A. (Eds.). Expedisi Matahari '85: A Study on the Offshore Waters of the Malaysian EEZ. Universiti Pertanian Malaysia, pp. 93-100.
- LEONG, T.S., AND SIOW, K.T. 1980. Sea turtles in the east coast of Peninsular Malaysia and their economic importance. In: Chua, T.E., and Charles, J.K. (Eds.). Coastal Resources of East Coast Peninsular Malaysia. Universiti Sains Malaysia, pp. 319-346.
- LIEW, H.C., AND CHAN, E.H. 1994. Tar ball pollution along the beaches of Terengganu. Final Report submitted to ESSO Production Malaysia Inc., Agreement PCP-321 (Tar Ball Survey). Fisheries and Marine Science Centre, Universiti Pertanian Malaysia, Malaysia, 53 pp.
- MINISTRY OF AGRICULTURE MALAYSIA. 1978. Annual Fisheries Statistics, 1977. Fisheries Division, Ministry of Agriculture Malaysia, Kuala Lumpur, 154 pp.
- MORTIMER, J.A. 1989. Threats to the survival of Terengganu's sea turtles and a review of management options. Report submitted to the Turtle Sanctuary Advisory Council of Terengganu. Produced under WWF Malaysia Project 3868.
- MROSOVSKY, N. 1983. Conserving Sea Turtles. British Herpetological Society, London, 176 pp.
- NATIONAL RESEARCH COUNCIL. 1990. Decline of the Sea Turtles: Causes and Prevention. Washington, DC: National Academy Press, 259 pp.
- PRITCHARD, P.C.H. 1973. International migrations of South American sea turtles (Cheloniidae and Dermochelyidae). Anim. Behav. 21:18-27.
- SIOW, K.T., AND MOLL, E.O. 1982. Status and conservation of estuarine and sea turtles in West Malaysian waters. In: Bjorndal, K.A. (Ed.). Biology and Conservation of Sea Turtles. Smithsonian Institution Press, Washington, DC, pp. 339-348.
- SITI, K.D., AND DE SILVA, M.W.R.N. 1985. Survey of turtle nesting sites in the Chukai-Rantau Abang coastline in Terengganu. Report submitted to ESSO Production Malaysia Inc., Universiti Pertanian Malaysia.
- SUAREZ, M., AND STARBIRD, C. 1995. A traditional fishery of leatherback turtles in Maluku, Indonesia. Marine Turtle Newsletter 68:15-18.
- SUAREZ, A., AND STARBIRD, C.H. 1996. Subsistence hunting of leatherback turtles, *Dermochelys coriacea*, in the Kai Islands, Indonesia. Chelonian Conservation and Biology 2(2):190-195.
- WETHERALL, J.A., BALAZS, G.H., TOKUNGA, R.A., AND YONG, M.Y.Y. 1993. Bycatch of marine turtles in North Pacific high-seas driftnet fisheries and impacts on the stocks. In: Ito, J., et al. (Eds.). INPFC Symposium on Biology, Distribution and Stock Assessment of Species Caught in the High Seas Driftnet Fisheries in the North Pacific Ocean. Bulletin Int. North Pac. Fish. Comm. 53(3):519-538.
- WYATT-SMITH, J. 1960. The conservation of the leathery turtle *Dermochelys coriacea*. Malayan Nature Journal 14:194-199.
- YATSU, A., HIRAMATSU, K., AND HAYASE, S. 1991. Outline of the Japanese squid driftnet fishery with notes on the bycatch. INPFC Symposium, 4-6 Nov. 1991, Tokyo.