Marine turtle status and conservation in the Indian Ocean

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Abstract

This paper reviews the status and distribution of sea turtles in the Indian Ocean and Southeast Asia, with a brief account of populations and stocks. There is a summary of threats, legal instruments and conservation approaches, principally in south and Southeast Asia. The paper also provides a series of annexes on fishing effort primarily in south Asia, as an indicator of fishing effort in the region. Lack of complete data sets for the region is identified as a major lacuna that has to be addressed to enable informed management decisions.

INTRODUCTION

Six species of marine turtle are found in the Indian Ocean: the green turtle (*Chelonia mydas*), the hawksbill (*Eretmochelys imbricata*), the loggerhead (*Caretta caretta*), the olive ridley (*Lepidochelys olivacea*), the leatherback (*Dermochelys coriacea*) and the flatback (*Natator depressus*). The olive ridley, green turtle and loggerhead are listed as endangered in the IUCN Red List of Threatened Species, while the hawksbill and the leatherback are listed as critically endangered at a global level, and the flatback is listed as data deficient. Marine turtle populations in the Indian Ocean have been depleted through long-term exploitation of eggs and adults, incidental capture (fisheries bycatch) and many other sources of mortality.

There are few reliable assessments of population status and trends. Over the last 30 years, various groups of researchers, government officials and non-governmental organizations have been involved in monitoring turtle populations in the region, but the reliability of many of these estimates is questionable (Shanker and Pilcher, 2003). For example, when over 20 publications on *arribadas* (the "arrivals") in Orissa were reviewed, the numbers quoted by different authors and different agencies did not match even when the data was ostensibly from the same source (Shanker, Pandav and Choudhury, 2004). Similarly, in Malaysia, although data sets have been collected over many years, for many of the older records, reconciliation of the (supposedly) linked data sheets was rarely possible (N. Pilcher, pers. obs.). In Viet Nam, nesting data sets can be correlated with the hatching data sets in less than 30 percent of cases (N. Pilcher, pers. obs.). Furthermore, genetic studies in the region are recent and far from complete, thus making the identification of stocks difficult.

Most governments in the region today have laws concerning turtles, but enforcement has generally been weak (Shanker and Pilcher, 2003). Fishery-related issues have become an area of concern, and of conflict, within the region. In a recent case, when the United States

[1] Principal sources: Shanker and Pilcher (2003); Limpus *et al.* (unpublished)

government imposed regulations on the import of shrimp, calling for the use of Turtle Excluder Devices (TEDs), the governments of India, Malaysia, Pakistan and Thailand opposed the move through the World Trade Organization, leading to the "shrimp–turtle" dispute (Oravetz, 2000; Bache and Frazier, in press). Although Asian governments such as that of India may have shared a concern for sea turtle conservation (as reflected by the inclusion of sea turtles in Schedule 1 of Wild Life Protection Act, 1972, and many government-sponsored conservation programmes in Orissa), they opposed the United States position to protect their political agendas and since then have mostly failed to require or enforce the use of TEDs in their trawler fleets (Shanker and Pilcher, 2003).

Information of sea turtles is constrained primarily by the lack of complete data sets for the region, and the first lacuna that has to be addressed in the formulation of fishery policy in the context of sea turtle conservation is the collection and compilation of reliable, up-to-date data sets that will enable informed management decisions.

CURRENT STATUS OF MARINE TURTLES IN THE INDIAN OCEAN

Most populations in the Indian Ocean have declined in recent years, some to the brink of extinction, although there are a few cases in which protection over the last 30 years has restored turtle populations. The occurrence of sea turtles is summarized country by country in Appendix 1. It is important to note that many sources are not recent, and even with recent accounts, many are rough estimates and the numbers need to be treated with caution. Major nesting populations are as follows:

Leatherbacks

The only major leatherback nesting sites in the Indian Ocean region are on Bird's Head Peninsula, West Papua, Indonesia, where around 5 000 nests are deposited each year (Halim, Silalahi and Sugarjito, 2001; Putrawidjaja, 2000) and Great Nicobar Island, with about 2 000 clutches per year (Andrews and Shanker, 2002). Nesting also occurs at a few other sites in the Andaman and Nicobar Islands (Andrews, Krishnan and Biswas, 2001) and Godavaya, Sri Lanka with around 300 clutches per year (Ekanayake *et al.*, 2002). A small leatherback population (about 100 females/year) also nests in Natal, South Africa (Hughes, 1996).

Green turtles

This is the most widely distributed species, with regionally important populations occurring in Indonesia (10 000–20 000 clutches per year; Halim, Silalahi and Sugarjito, 2001), Malaysia (Sabah and Sarawak Turtle Islands combined: up to 10 000 nests per year), Peninsular Malaysia (2 000–3 000 nests/ year; Chan, 2001; Nasir, Karim and Ramli, 1999) and the Tawi-Tawi Turtle Islands, Philippines (10 000–20 000 nests/year; Trono, 1991). Myanmar has a reported 500 nests per year (Thorbjarnarson, Platt and Khaing, 2000) while in Thailand 200–300 clutches are deposited yearly in the Gulf of Thailand, and possibly a similar number on the Andaman sea coast (Chantrapornsyl, 1993). Green turtles also nest in Pakistan (around 1 000 nests a year; Asrar, 1999), Gujarat, India (Sunderraj, Joshua and Serebiah, 2001), Lakshadweep (fewer than 1 000 nests a year; Tripathy, Choudhury and Shanker, 2002) and the Andaman and Nicobar Islands (more than 1 000 nests a year; Andrews, Krishnan and Biswas, 2001), Sri Lanka (Kapurusinghe, in press) and the Maldives

(Frazier, Salas and Hassan Didi, 2000). In Viet Nam, Con Dao has an average of 230 females per year (1995 to 2001) (Nguyen Thi Dao, 1999; WWF/Con Dao unpublished data) and the total Viet Nam nesting population(s) is likely to be around 250 females per year (Hamann *et al.*, 2002). There are extensive green turtle populations in Madagascar and in the oceanic islands including Seychelles, Mauritius and other small islands, perhaps numbering 5 000 nesting females (Frazier, 1975; Frazier, 1980). Large nesting grounds are also located at Ras Al Hadd (Oman) (7 000 females a year) and Makulla (Yemen) (10 000 females a year), and several small nesting grounds are found in the region (Ross and Barwani, 1982).

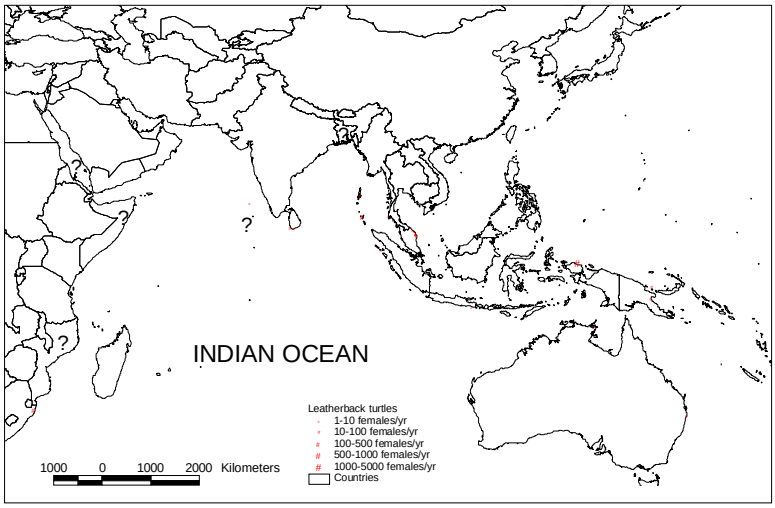


Figure 1. Distribution of leatherback turtle (*Dermochelys coriacea*) nesting beaches. Source: Limpus *et al.*, unpubl

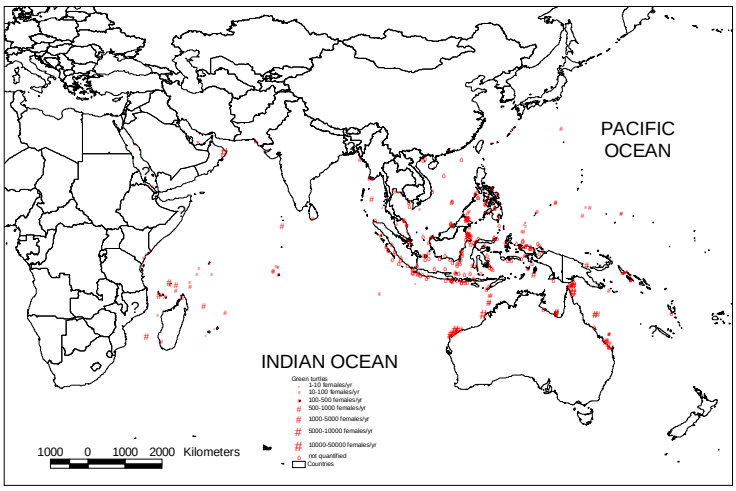


Figure 2. Distribution of green turtle (*Chelonia mydas*) nesting beaches. Source: Limpus *et al.*, unpubl.

Hawksbills

In Malaysia, 400–600 hawksbill nests are deposited each year in the Sabah Turtle Islands (Pilcher and Lamri, 1999), and 200–300 nests are produced every year in Melaka (Peninsula Malaysia). Nesting in Indonesia is higher, with a total of 1 000–2 000 nests per year (Chan, 2001; Nasir, Karim and Ramli, 1999). In the Indian subcontinent, hawksbill nesting is restricted to Lakshadweep (Tripathy, Choudhury and Shanker, 2002) and the Andaman and Nicobar Islands (Andrews, Krishnan and Biswas, 2001). Seychelles has the largest population of nesting hawksbills in the western Indian Ocean with about 1 000–2 000 nesting females annually (Mortimer, 1984). The Chagos Archipelago has about 300–700 nesting females (Mortimer and Broderick, 1999), while 600–800 nest annually in the Sultanate of Oman (Salm, Jensen and Papastavrou, 1993), 100–500 in Saudi Arabia, the former People's Democratic Republic of Yemen and Sudan and up to 1 000 in Iran (Ross and Barwani, 1982).

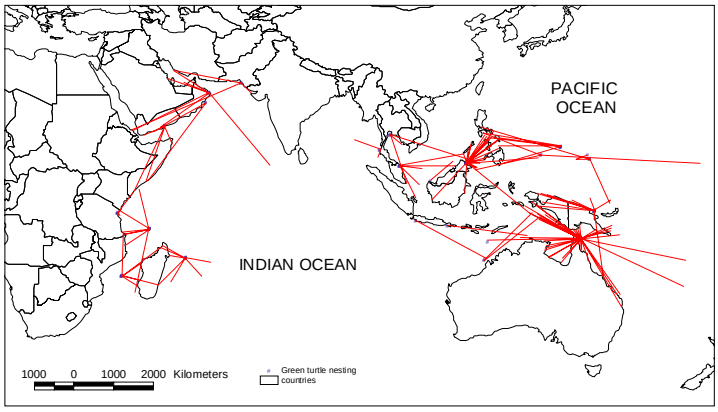


Figure 3. Breeding migrations of green turtle (*Chelonia mydas*). Source: Limpus *et al.*, unpubl.

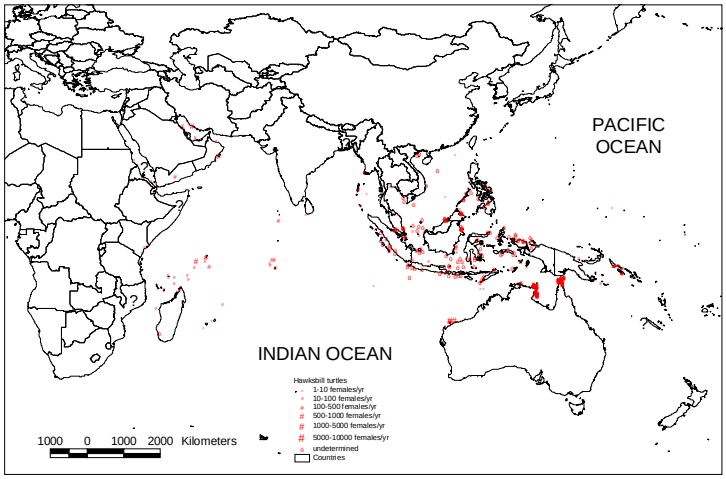


Figure 4. Distribution of hawksbill turtle (*Eretmochelys imbricata*) breeding. Source: Limpus *et al.*, unpubl.

Olive ridleys

Olive ridleys nest in Pakistan (Asrar, 1999), the east and west coasts of mainland India (Kar and Bhaskar, 1982) and Sri Lanka (Kapurusinghe, in press), Bangladesh (Islam, 2002), Myanmar (Thorbjarnarson, Platt and Khaing, 2000) and Andaman and Nicobar Islands (Andrews, Krishnan and Biswas, 2001), and small populations are found in Viet Nam (Hamann *et al.*, 2002), Malaysia and Australia. Important sporadic nesting occurs in Tamil Nadu, with around 4 000 nests a year (Bhupathy and Saravanan, 2002), Andhra Pradesh, with up to 10 000 nests a year (Tripathy, Shanker and Choudhury, 2003) and Andaman and Nicobar Islands with over 1 000 nests a year (Andrews, Krishnan and Biswas, 2001). The single most important breeding area is Orissa on the east coast of India, which has three mass nesting beaches (Gahirmatha, Devi River mouth and Rushikulya) where more than 100 000 turtles nest during *arribadas* at Gahirmatha and tens of thousands nest at the other sites during single mass nesting events over the course of five to seven days (Shanker, Pandav and Choudhury, 2004). This species is mostly absent in Southeast Asia. Myanmar and Brunei record activity exceeding 300 nests a year and Indonesia, Malaysia and Thailand have fewer than 50 nests a year (Chan, 2001; Nasir, Karim and Ramli, 1999). It is difficult to estimate the population size in Viet Nam, but it is likely to be tens of nests per year. In the western Indian Ocean, olive ridleys nest on the east coast of Africa, particularly Mozambique (Frazier, 1980) and in Oman (Ross and Barwani, 1982).

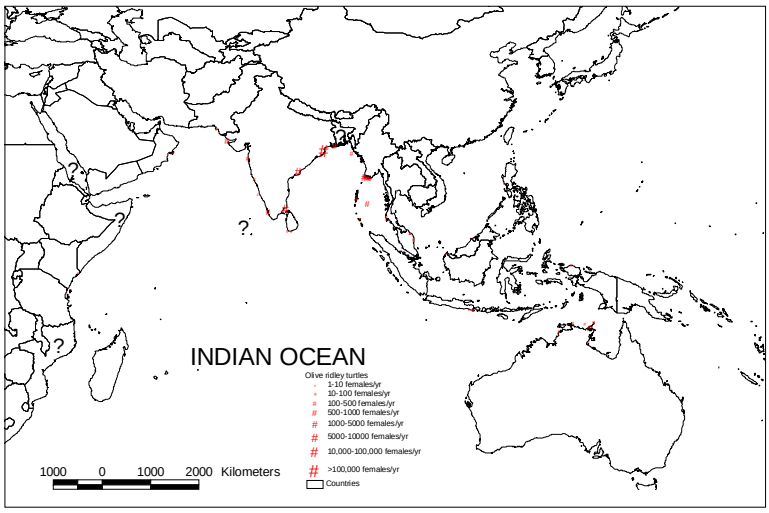


Figure 5. Distribution of olive ridley (*Lepidochelys olivacea*) nesting beaches. Source: Limpus *et al.*, unpubl.

Loggerheads

The only reported loggerhead nesting site in south and Southeast Asia is in Myanmar, with about 60 to 100 nests per year (Thorbjarnarson, Platt and Khaing, 2000). However, the data may not be reliable and most of the turtles are likely to be misidentified olive ridleys. The largest nesting population in the Indian Ocean occurs in Oman (Masirah) with 30 000 nests a year, believed to be the largest aggregation of this species in the world (Ross and Barwani, 1982). Smaller nesting aggregations with 100 to 1 000 nesting females annually occur in Tongaland (South Africa), Mozambique, Madagascar, the Arabian Sea coast (Oman)

and the Halaniyat Islands (Oman) (Ross, 1982). A small population of loggerheads also nests in Sri Lanka.

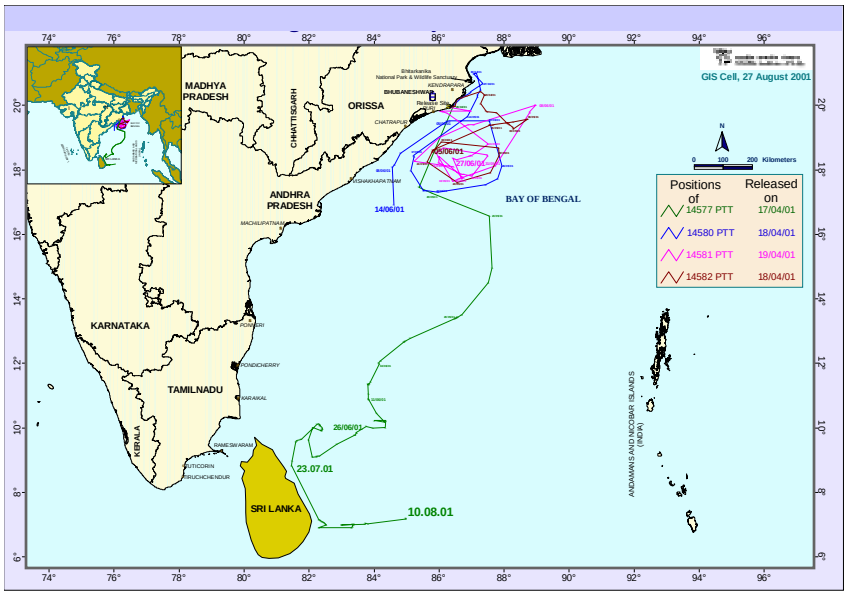


Figure 6. Satellite tracking of olive ridley turtles on the Indian coast. Source: Shanker *et al.*, unpubl. data

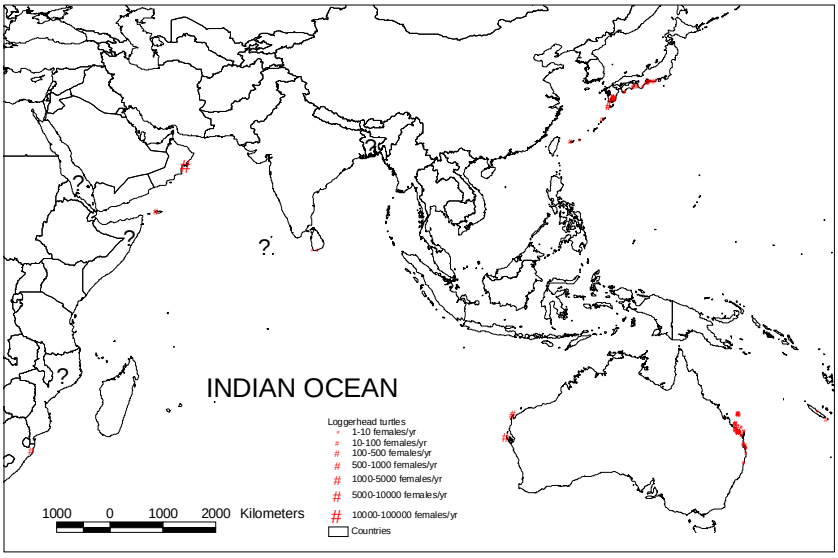


Figure 7. Distribution of loggerhead (*Caretta caretta*) nesting beaches

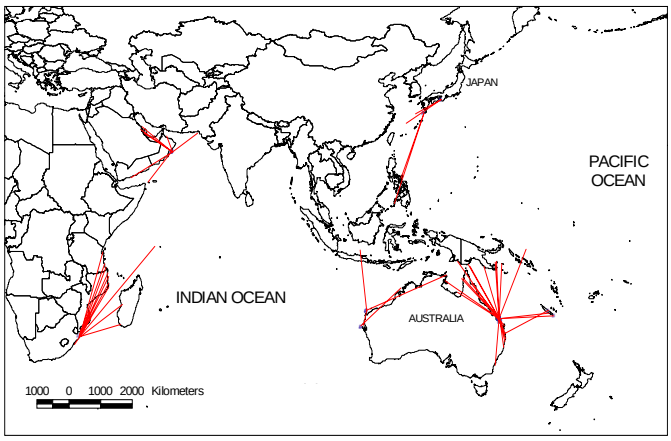


Figure 8. Breeding migration of loggerhead turtle (*Caretta caretta*)

GENETIC STOCKS IN THE REGION

Olive ridleys

Olive ridleys clearly have the most remarkable stocks in the Indian Ocean, distinct from Pacific and Atlantic stocks. Bowen *et al.* (1998) and Shanker *et al.* (2004) suggest an Indian West Pacific origin for this species. Shanker *et al.* (2004) further suggest that the clade that currently dominates the population on the east coast of India may have served as an evolutionary source for olive ridleys in the Pacific and Atlantic. Remarkably, this population is even distinct from the adjacent Sri Lankan population (Shanker *et al.*, 2004), which differs in haplotype frequencies from Indian West Pacific stocks (Malaysia, Australia), but perhaps not significantly (Bowen *et al.*, 1998). Based on geographical separation and available genetic data, one may classify olive ridleys into the following stocks: (1) East African, (2) western Indian, including Pakistan, west coast of India, Lakshadweep islands (this is based on geographical proximity as well as nesting seasonality, which differs from the population on the east coast of India), (3) eastern Indian, (4) Sri Lankan and (5) southeast Asian, including Andaman and Nicobar Islands, Southeast Asia and Australia.

Leatherbacks

Leatherbacks in South Africa had haplotypes found from the Atlantic to the Indian Pacific, while those in Malaysia also shared haplotypes with the eastern Pacific (Dutton *et al.*, 1999). It is not apparent that there are genetically unique stocks of leatherback turtles in the Indian Ocean. Currently, work is in progress to characterize populations in the Andaman and Nicobar Islands (K. Shanker *et al.*, in prep.). Based on geographical separation, these can be classified into stocks in (1) South Africa, (2) Sri Lanka, (3) Andaman and Nicobar Islands, and (4) West Papua.

Loggerheads

Loggerheads were assayed using restriction site analysis of mitochondrial DNA, which revealed unique haplotypes in Oman and South Africa (Bowen *et al.*, 1994). However, sequencing analysis needs to be carried out to elucidate their relationship to each other and to

populations in the other oceanic basins. Based on geographical separation, these can be classified into stocks from (1) Oman, (2) South Africa, (3) Sri Lanka, and possibly (4) Myanmar.

Green turtles

Green turtles have been most extensively studied across the globe. Studies clearly reveal an Atlantic–Mediterranean and Indian–Pacific divide in the species (Bowen and Karl, 1997). Within the Indian–Pacific group, several stocks have been identified in the Australian region (Norman, Moritz and Limpus, 1994). Further studies are required to characterize populations in the Indian Ocean.

Hawksbills

Hawksbills have been found to have multiple stocks in Australian waters (Broderick *et al.*, 1994). Mortimer and Broderick (1999) suggest that nesting hawksbills in the Chagos represent a distinct stock that is most closely related to Seychelles turtles. Resident foraging populations in the two sites appear indistinguishable. Clearly, for hawksbills and green turtles, more comprehensive sampling and genetic analysis is needed to elucidate stocks. However, geographically, they can be divided into (1) northwestern Indian Ocean, (2) Seychelles and western Indian Ocean islands, (3) Sri Lanka, Maldives, Lakshadweep, (4) Andaman and Nicobar Islands, and (5) Southeast Asia and northwestern Australia.

POPULATION TRENDS

Green turtles

Green turtle populations have, for the most part, decreased throughout their range in the region. Turtles have been taken for their meat and have become bycatch in the ever-increasing fisheries. Coupled with this, the thorough and systematic exploitation of eggs in many parts of Southeast Asia results in few hatchlings reaching the sea, such as occurs in many parts of Indonesia (Pilcher, 1999), Thailand, and formerly in Malaysia and Myanmar. It is important to note that with long-term conservation efforts, some populations are starting to stage a comeback (see below).

Hawksbills

These populations have also declined at nearly every rookery in the region, as exemplified by the population at Suka Made, Indonesia (Limpus *et al*., unpubl.), for which data from recent years indicate a near-collapse of the nesting population. However, there is evidence that some populations may be stable at present, such as those in Malaysia (Chan and Liew, 1999; Pilcher and Lamri, 1999), or increasing, such as on Cousin, Seychelles.

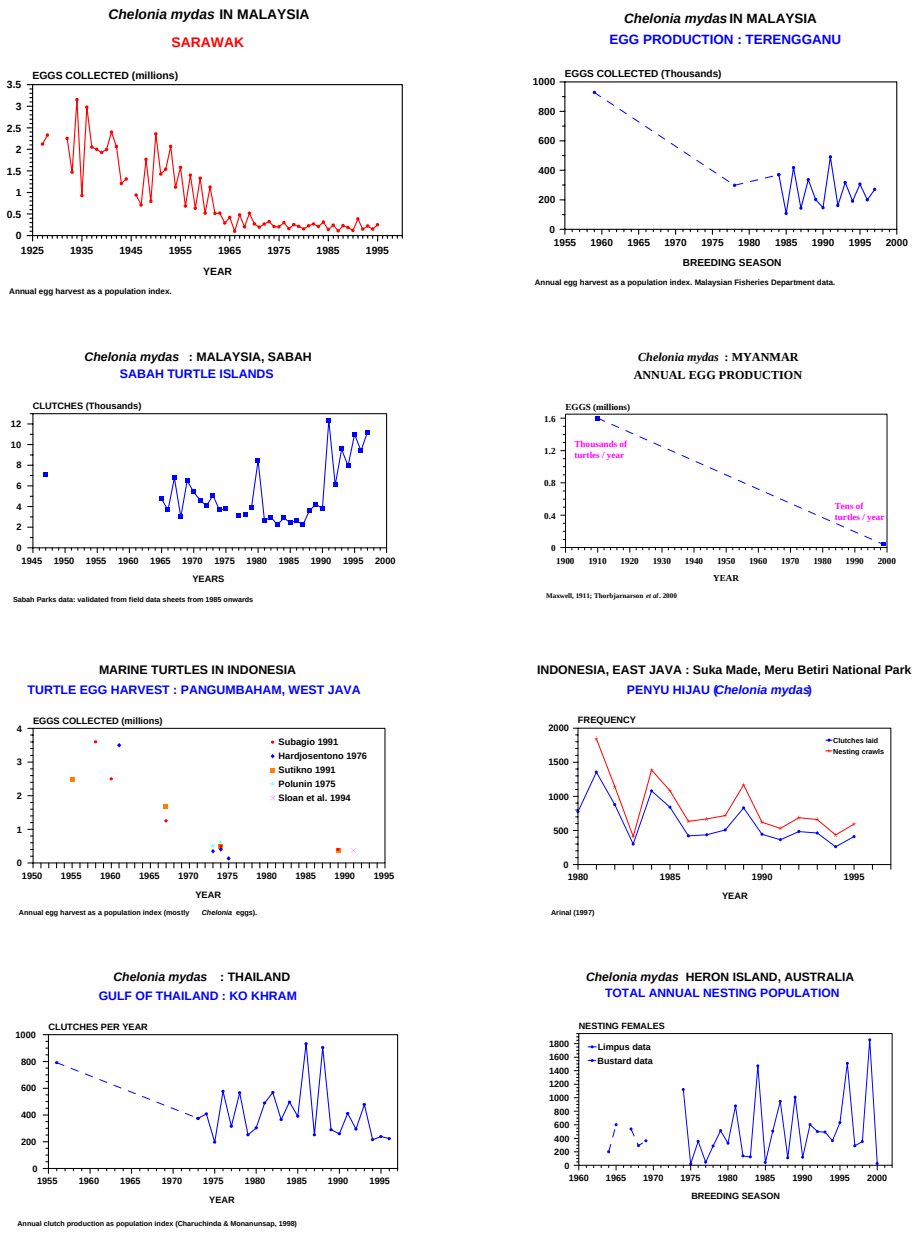


Figure 9. Green turtle population trends. Source: Limpus *et al.*, unpubl

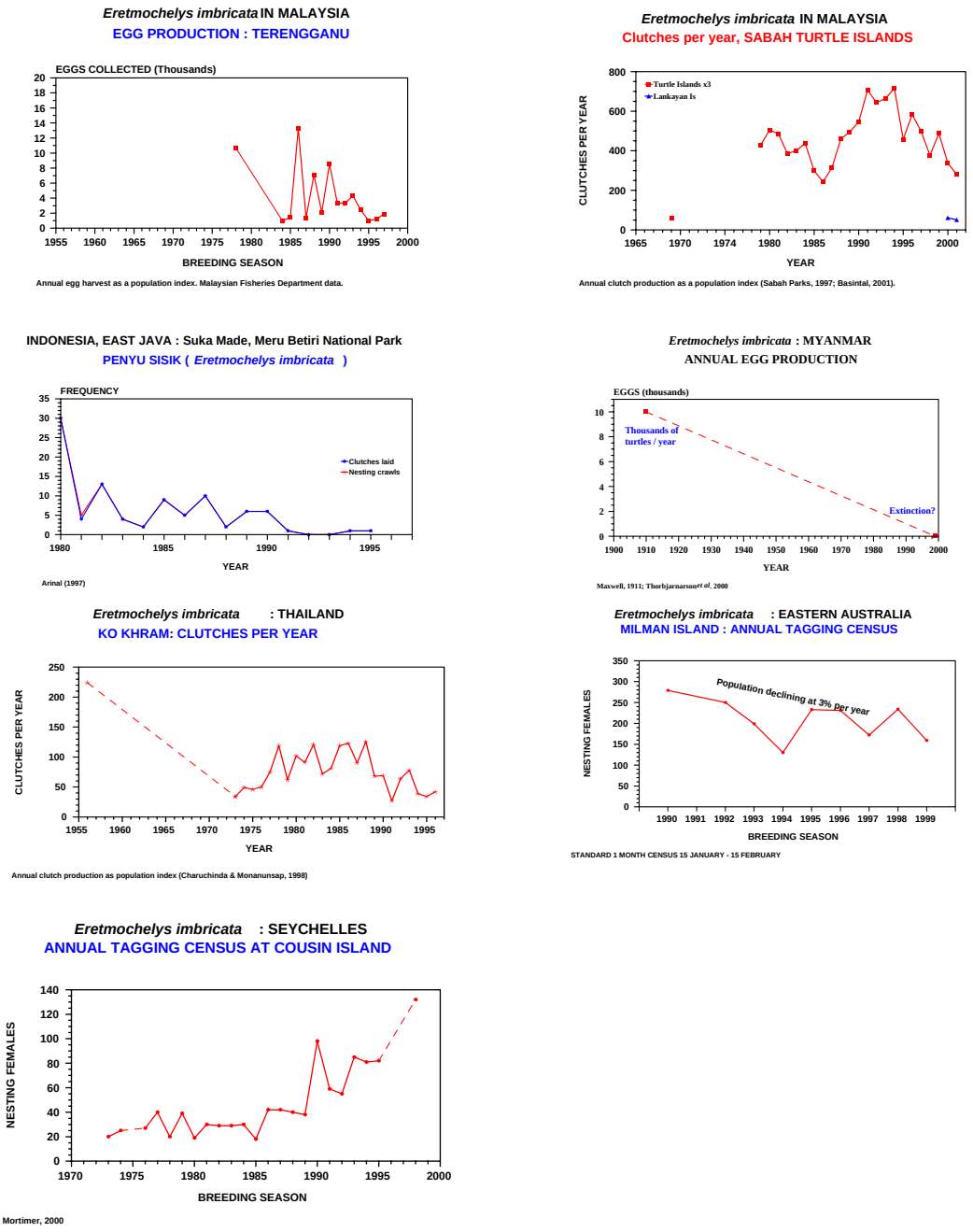
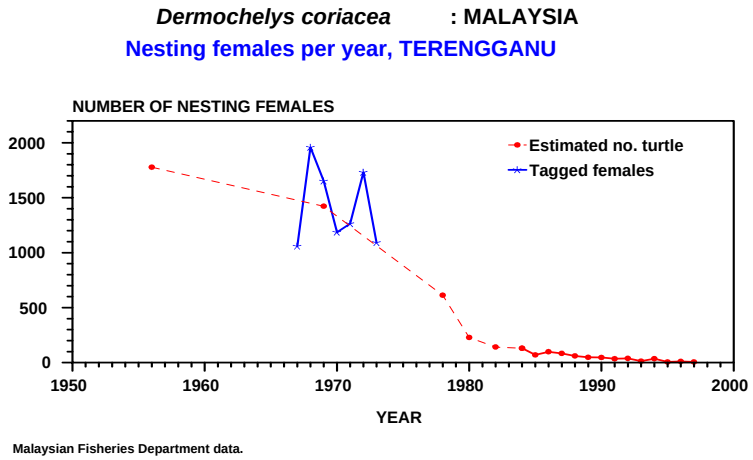
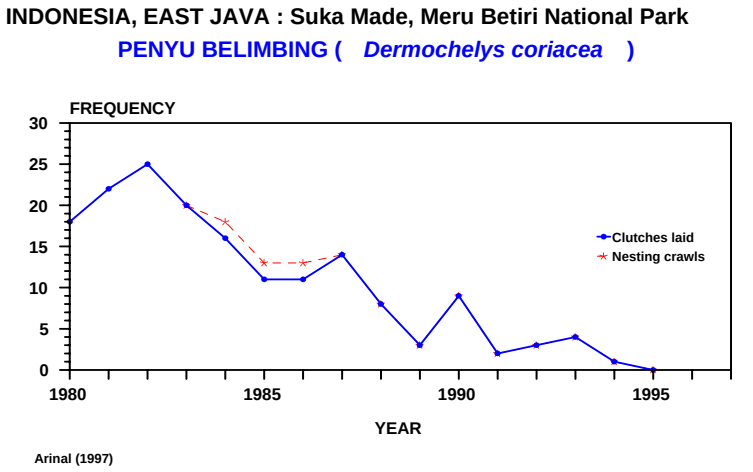


Figure 10. Hawksbill population trends. Source: Limpus *et al.*, unpubl

Leatherbacks

The leatherback turtle and its eggs have been overexploited and lost to fisheries as bycatch, with many populations on the brink of extinction, most notably at Terengganu in Malaysia, where nesting declined from 10 000 nests a year in the 1950s to less than 20 nests a year in recent years (Chan, 2001).





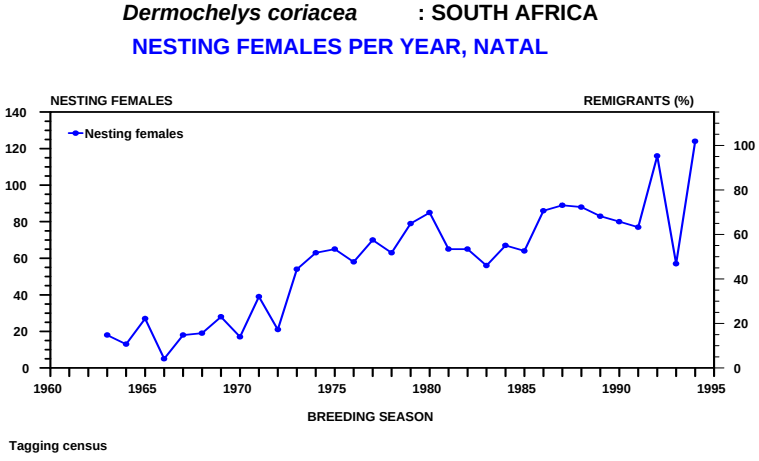


Figure 11. Leatherback population trends. Source: Limpus *et al.*, unpubl.

Olive ridleys

Olive ridleys appear to have declined in Bangladesh (Islam, 2002), Myanmar (Thorbjarnarson, Platt and Khaing, 2000) and Sri Lanka. At Hawkes Bay (Pakistan), there has been a dramatic decline despite a hatchery programme (Asrar, 1999). In some areas, declines may have been arrested by local conservation programmes such as the one in Madras, India, where eggs have been collected by conservation volunteers and incubated in hatcheries since 1974 (Shanker, 2003). In Orissa, the fishery-related mortality has resulted in over 100 000 dead turtles since 1994, which may have caused a severe decline in the population (Shanker, Pandav and Choudhury, 2004). Over 50 000 turtles may have been taken each year in the 1970s (Biswas, 1982; Das, 1985), but later implementation of wildlife laws drastically reduced this take (Dash and Kar, 1990). Numbers of turtles appeared to rise in the 1980s following the ban on commercial trade, but may now be declining as a result of an increase in fisheries-related mortality (Shanker, Pandav and Choudhury, 2004). Although most estimates of nesting females are unreliable, the failure of mass nesting events in three of the last five years and a consistent decrease in the size of breeding adults (both males and females) between 1996 and 2002 suggests a potential or imminent decline (Shanker, Pandav and Choudhury, 2004).

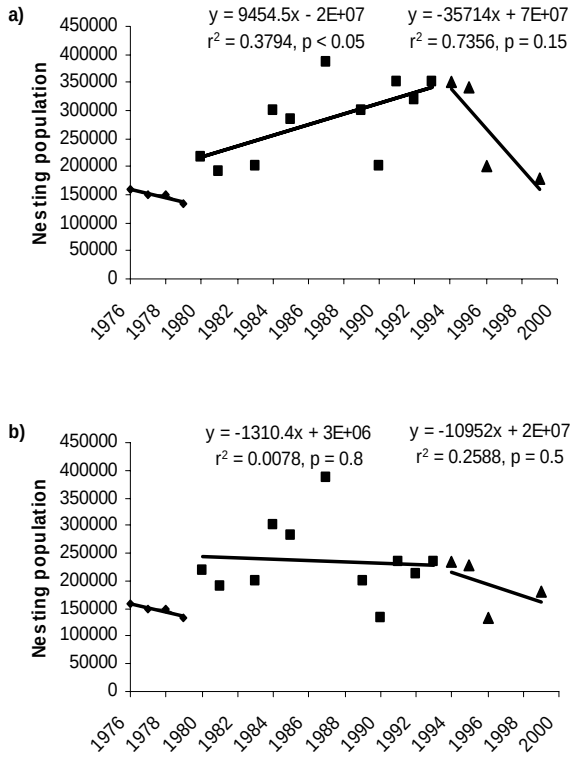
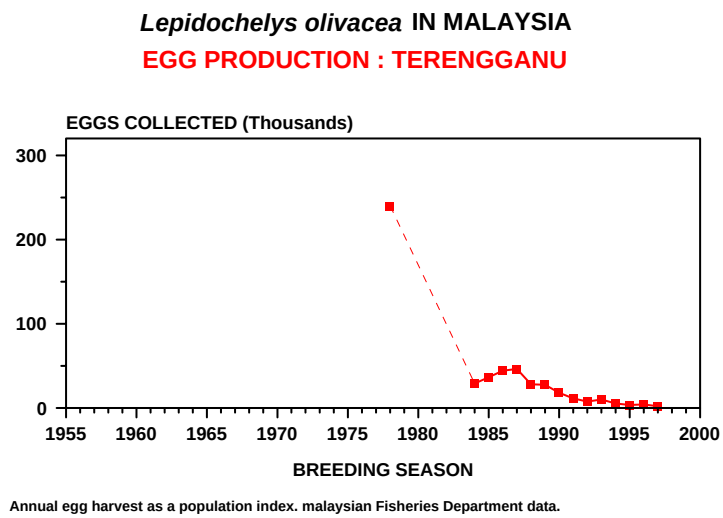
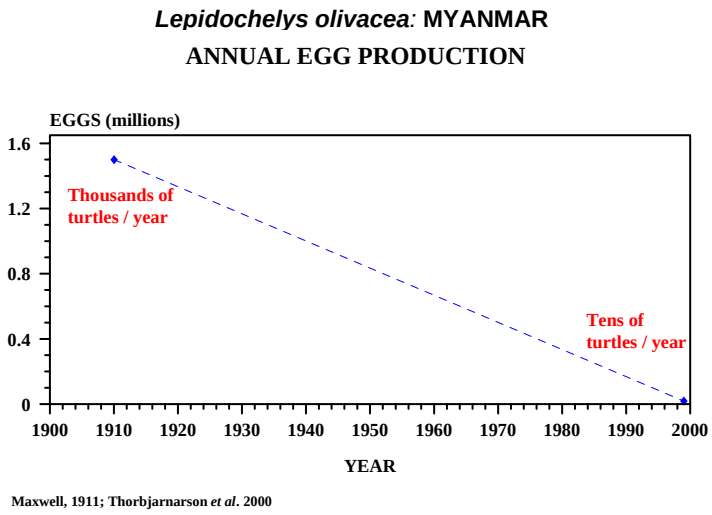


Figure 12. Olive ridley nesting trends in Gahirmatha over 25 years: (a) consensus data, (b) adjusted data for 1989–1998. Source: Shanker, Pandav and Choudhury, 2004





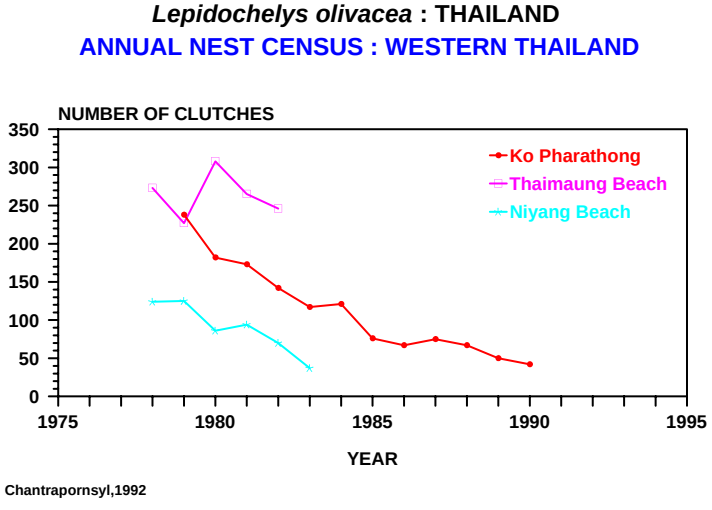
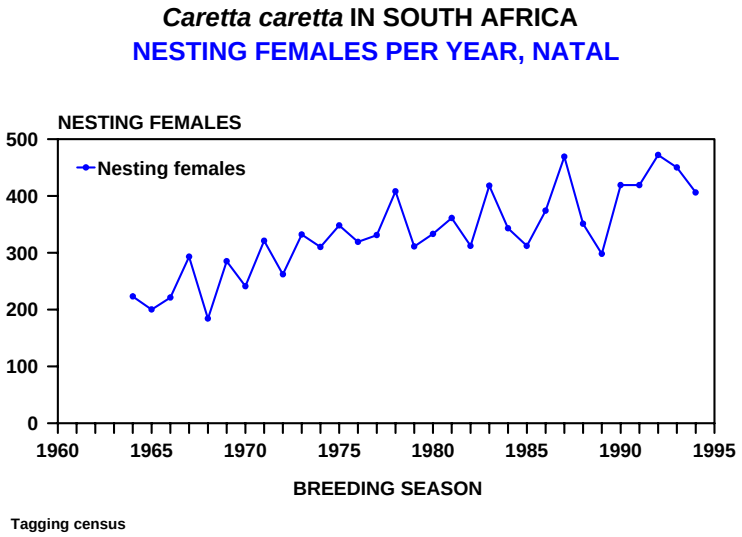


Figure 13. Olive ridley population trends in Malaysia, Myanmar and Thailand

Loggerheads

Loggerheads have declined in Australia, but they have increased in South Africa. However, little is known about trends in the most important rookeries in the western Indian Ocean, i.e. those in Oman.



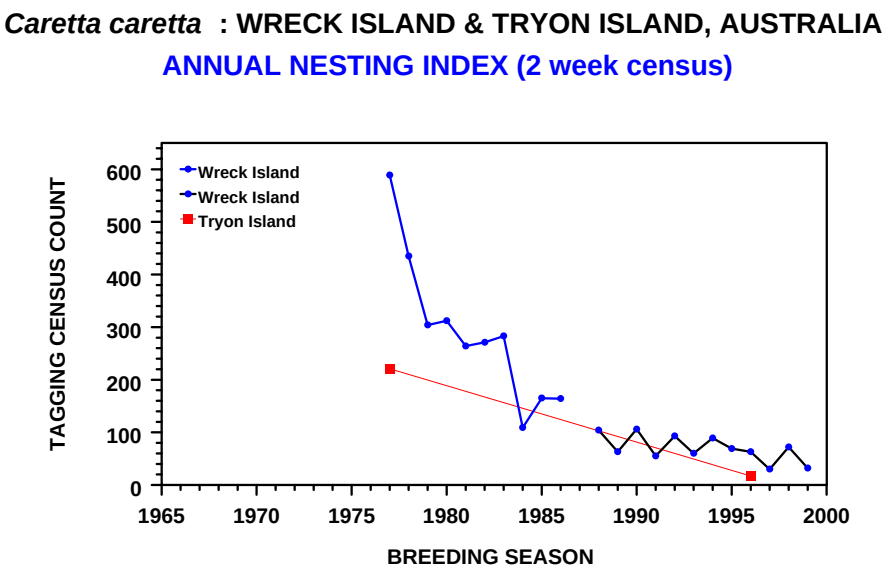


Figure 14. Loggerhead population trends. Source: Limpus *et al.*, unpubl.

POLICIES AND LEGISLATION IN SOUTH AND SOUTHEAST ASIA PRIOR TO 1982

A major obstacle in the legislative processes throughout the region prior to 1982, and in several cases still today, has been the improper listing or complete omission of marine turtles from wildlife ordinances and other legislative instruments. In many cases marine turtles were considered under fisheries regulations, in which the basic premise was exploitation rather than conservation. Only in the last decade have major advances been made towards rectifying these deficiencies, and marine turtles are now, for the most part, listed by name and often as populations. The following is an outline of the major legislation regarding marine turtle conservation in the region prior to 1982 in key southeast Asian countries (Pilcher, unpubl):

Cambodia: No ordinances regarding marine turtles.

Indonesia: Turtles protected under Act No. 4-1982 (Basic Provision for the Management of Living Resources), but not specifically mentioned. *Caretta caretta* and *Lepidochelys olivacea* protected under SK Mentan No. 716/Kpts/Um/10/1980. *Dermochelys coriacea* protected under SK Mentan No. 327/Kpts/Um/5/1978 and SK Menhut No. 301/Kpts-II/1991. Acceded to the Convention on International Trade in Endangered Species (CITES) in 1978.

Malaysia: Fisheries Act 1963, Fisheries Rule (1978-Kelantan), Fisheries Rule (1978-Pahang); Turtle Enactment (1951-Terengganu), Turtle Enactment (1972-Kedah); Turtles' Rule (1975-Kedah); Fisheries Rules (1976-Negri Sembilan); Fauna Conservation Ordinance (1983-Sabah); Turtle Trust Ordinance (1957-Sarawak). Acceded to CITES in 1977.

Philippines: Executive Order 542 (1979) on the establishment of the Task Force Pawikan, which enforces MAO No. 33 and No. 8, regarding marine turtle sanctuaries and the harvesting and exploitation of eggs in the Turtle Islands and Tawi-Tawi; Ministry of Natural Resources Administrative Order 12 (1979) on regulations for the conservation of marine turtles in the Philippines. Ratified CITES in 1981.

Thailand: The Ministry of Agriculture and Cooperatives Enactment (1947) listed marine turtles as protected, whereby the killing of turtles and collecting their eggs was prohibited; The Fisheries Act (1972): Commercial fishing within 3 km of the coastline was prohibited; The Ministry of Commerce Enactment (1979) prohibiting the export of marine turtle;

Viet Nam: Ordinance on the Conservation and Management of Marine Resources (1989).

Major New Policy Developments

Cambodia: Ratified CITES in 1997, and since then has used the CITES list as the list for endangered species within Cambodia under responsibility of the Ministry of Agriculture, Forestry and Fisheries and the Under-Secretary of State in the Ministry of Agriculture, Forestry and Fisheries. A draft of a new Fisheries Law to protect and conserve endangered species such as sea turtles is currently under development.

Indonesia: Act No. 9-1985 (Fishery) and Act No. 5-1990 (Conservation of Ecosystems). All turtle species protected by Peraturan Pemerintah Republik Indonesia No. 7 & 8 (1999) concerning the Protection of Plant and Animal Species (all forms of turtle trade are prohibited) and the Conservation of Natural Resources and their Ecosystems.

Malaysia: Wildlife Protection Act (1990-Federal); Fisheries Regulations (1990-Prohibition of method of fishing, Federal); Wildlife Protection Ordinance (1999, Article 26(3)-Federal); Fisheries Regulations (1991-Prohibited Areas, Rantau Abang); Fisheries Rules (1984-Turtles and turtle eggs, Johor); Fisheries Rules (1989-Turtles and turtle eggs, Malacca); Wildlife Protection Ordinance (1990-Sarawak); Amendments to the Turtle Enactment 1951 (1987, 1989-Sabah). Signed the Association of South East Asian Nations (ASEAN) Sea Turtle Memorandum of Understanding (MoU) in 1997.

Philippines: Presidential Proclamation 171 (1999) on Establishment of Turtle Islands Wildlife Sanctuary under the National Integrated Protected Area System; Republic Act 9147 (Wildlife Act of 2001), an act providing for the conservation and protection of wildlife resources and their habitats; Signed the Bonn Convention (CMS) in 1994. Signed the MoU on Conservation and Management of Sea Turtles in the Indian Ocean and Southeast Asia (IOSEA) in 2001.

Thailand: The Conservation and Protection of Living Resources Enactment, Act No. 19 (1992), whereby collecting marine turtles, their products and their carcasses is prohibited; Wild Animal Reservation and Protection Act, 1992. The use of Turtle Excluder Devices (TEDs) in shrimp trawl fisheries has been enforced since 1997. Ratified CITES in 1983. Signed IOSEA.

Viet Nam: Acceded to CITES in 1994. Signed the IOSEA MoU on Marine Turtle Conservation in 2001.

Upadhyay and Upadhyay (2002) have reviewed national and international legislation in India with reference to marine turtles and coastal and marine environments, and evaluated the efficacy and potential of these laws.

Table 1. Year of accession or ratification by countries in south and Southeast Asia of the Convention on International Trade in Endangered Species (CITES), the Convention on the Conservation of Migratory Species of Wild Animals (CMS) and the Memorandum of Understanding on Conservation and Management of Sea Turtles in the Indian Ocean and Southeast Asia (IOSEA)

Country	CITES	CMS	IOSEA	National laws
Pakistan	1976	1987		Yes
India	1975	1983		Yes
Bangladesh	1982			
Sri Lanka	1979	1990	2001	Yes
Myanmar			2002	
Thailand	1983			Yes
Malaysia	1977			Yes
Cambodia	1997		2002	
Viet Nam	1994		2001	Yes
Philippines	1981	1994	2001	Yes
Indonesia	1978			Yes

THREATS TO SEA TURTLES

Human activities that directly or indirectly threaten marine turtles include the exploitation of eggs and turtles, fishery-related mortality, inappropriate management practices, destruction or modification of habitats, pollution, mariculture and tourism. In many cases, it has been the combination of modern fisheries (mechanization and fishing gear) and traditional practices (turtle exploitation) that has resulted in drastic declines in recent years. Mechanized trawlers, together with gillnets used by non-mechanized/traditional fishers are major threats in many areas, because many turtles are taken as bycatch.

Direct take

Marine turtle populations have long been exploited throughout the Indian Ocean and southeast Asian region (for a review, see Frazier, 1980). Each year over 5 000, and possibly as many as 10 000 green turtles are killed on the Indonesian island of Bali for religious and cultural reasons (Halim, Silalahi and Sugarjito, 2001). In Bali and surrounding waters the green turtle is almost extinct, and most of the turtles landed at Benoa now come from further afield. Recent scientific efforts have determined that some of these turtles may also originate from Australia, the Philippines and Malaysia (see Lindsay and Watson, 1995). About 1 000 green turtles are caught annually at Masirah, Oman, mostly from feeding grounds (Ross and Barwani, 1982). However, there is less consumption of turtle meat in the Near East than in some other regions because of religious reasons. Sea turtles have also been exploited for meat on the east coast of Africa, Madagascar, Seychelles and other oceanic islands (Frazier, 1980). In Mozambique, marine turtles are killed accidentally and intentionally by fishing activities (Magane, Sousa and Pacule, 1998), and fishermen in Madagascar take turtles for meat (Rakotonirina and Cooke, 1994).

In south Asia, the take of nesting turtles is mostly opportunistic and occurs at a few sites along both coasts of India, and parts of Sri Lanka and Bangladesh. In the Indian subcontinent, meat is not generally consumed by Muslims and Hindus because of their

religious beliefs, but by Christians and ethnic tribes. One of the only turtle fisheries in the region was in the Gulf of Mannar (both in India and Sri Lanka), where the focus was green turtles, but many ridleys were also taken. Several thousand green turtles were killed annually in the Gulf of Mannar for trade in Sri Lanka and India, and while this has declined since the implementation of wildlife laws or depletion of stocks or reduction of demand in both countries, many turtles are still caught opportunistically (Hewavisenthi, 1990; Bhupathy and Saravanan, 2002) and intentionally (Kapurusinghe and Cooray, 2002). The biggest ridley fishery was in Orissa and West Bengal in the 1970s when tens of thousands of ridleys were shipped to markets in West Bengal each year (Das, 1985). This population is now also subject to high incidental mortality – 10 000 to 20 000 turtles have been washed ashore each year since the late 1990s. The meat and eggs of ridleys are also consumed in the Andaman and Nicobar Islands and southeast Asian countries where they occur, such as the Philippines and Thailand. The consumption of meat (and, to an extent, eggs) has declined in recent years, either because of the decline of nesting populations, and/or because of the implementation of wildlife laws in many countries.

Hawksbill shell is used widely in the manufacture of trinkets and jewellery. The meat is generally not eaten – often it is poisonous to humans, so the animals are killed simply for their keratinous scutes, and the tortoiseshell industry has been responsible for the massive declines in the wild populations over the past four or five decades simply for the animal's shell. Despite CITES regulations, the trade in tortoiseshell continues in Viet Nam (Duc and Broad, 1995; Pham Thuoc *et al.*, 2002), Sri Lanka (Richardson, 1997), Indonesia and many other countries.

Incidental catch in fisheries

Incidental catch in fisheries is a major cause of mortality in the Indian Ocean and has been reported from the Near East (Ross, 1982), Pakistan (Asrar, 1999), both coasts of India (Rajagopalan *et al.*, 1996; Pandav, 2000) and other regions. Many reports indicate that the increase in fishing effort may be causing significant incidental mortality of sea turtles, and in other instances, are definitely a cause for concern in the future. Nearshore trawl and gillnet fisheries are already known to cause mortality in areas from which there is data (such as India and Sri Lanka). Campbell (2003) provides an overview of the longline fishery in the Indian Ocean, which has increased from 80 000 to 140 000 tonnes in the eastern Indian Ocean, and from 100 000 to 150 000 tonnes in the western Indian Ocean, between 1990 and 2000. The largest fleets are those of Japan and Taiwan, Province of China, in both regions, and also Indonesia in the eastern Indian Ocean. Although data on turtle catch in the longline fishery is sparse, this is clearly a cause for concern for the future.

South Asia. Gillnet and trawl fisheries are a major problem in south Asia. Incidental catch in fisheries has been reported from Pakistan (Stevens, unpubl.). In India, it has been reported from Gujarat (Sunderraj *et al*., 2002), Maharashtra (Giri and Chaturvedi, 2003), Karnataka (Sharath, 2002), Kerala (Dileepkumar and Jayakumar, 2002), Tamil Nadu (Bhupathy and Saravanan, 2002), Andhra Pradesh (Tripathy, Shanker and Choudhury, 2003), West Bengal (Roychoudhury, 2001) and the Andaman and Nicobar Islands (Andrews, Krishnan and Biswas, 2001). In the Lakshadweep Archipelago, turtles are killed for the oil used to treat wooden boats, for bait, and for making stuffed curios (Tripathy, Choudhury and Shanker, 2002; Tripathy *et al.*, in review). Sea turtles reported from Maldives were either entangled in discarded fishing gear or caught incidentally in oceanic driftnets or longlines. Incidental catch has also been reported from Sri Lanka (Kapurusinghe and Cooray, 2002). In some parts of

Maharastra, most of Goa and Kerala (where populations are Christian), and parts of Tamil Nadu, Andhra Pradesh and West Bengal, and also Sri Lanka, incidentally captured turtles (and nesting turtles) may be consumed as meat.

One of the most dramatic instances of the impact of fishery-related mortality on sea turtles is in Orissa, India where the incidental mortality in trawl nets has increased from a few hundred each year in the 1980s to around 15 000 each year since 1999 (Pandav, 2000; Shanker, Pandav and Choudhury, 2004). More than 100 000 dead turtles have been counted on the Orissa coast in the last decade (Shanker, Pandav and Choudhury, 2004). Recently, gillnets have also been identified as causing significant mortality in Orissa (Wright and Mohanty, 2002) and along the rest of the Indian coast (Rajagopalan *et al.*, 1996). Fishery-related factors may have contributed significantly to the failure of mass nesting in 1997, 1998 and 2002.

A detailed account is provided for south Asia, for which the data are available (Appendix 2). Data are particularly scarce for the western Indian Ocean region. However, the data for south Asia may serve as an indicator of trends in fishing, and impacts on sea turtle populations.

Western Indian Ocean. There are a number of important nesting and feeding sites in the northwestern Indian Ocean and on the east coast of Africa. Little information is available for most of these sites, either with regard to nesting and feeding populations or with regard to threats, but recent reports (Mortimer, 2002) indicate fisheries-related threats exist in most countries. Ross and Barwani (1982) provide a review of turtles in the Arabian area, while Frazier (1980) provides reviews of populations and threats in the western Indian Ocean. A more recent review for the western Indian Ocean region is provided in Mortimer (2002). (See Appendix 3 for a list of relevant reports and literature on the western Indian Ocean region.)

Hare (1991) estimated a total catch of 586 turtles in the demersal fishery in Oman, but indicated that this may be lower than the true value. Magane, Sousa and Pacule (1998) reported that the beach seine fishery was taking some 20 turtles per month in Mozambique, but a more recent study of bycatch estimated that between six and eight, or perhaps as many as 12, turtles are caught by "semi-industrial" trawlers per month, yielding an annual estimate of 2 000–5 000 turtles captured annually just on the Sofala Bank, Mozambique (Gove, Pacule and Gonçalves, n.d.). It has been reported that every turtle captured in both artisanal and commercial shrimp fisheries in the United Republic of Tanzania is killed (Haule, Kalikela and Mahundu, 1998). Although relatively few trawlers have been licensed to work in Kenya, there have been significant numbers of strandings in Ungwana and Malindi Bays for years, and it is estimated that at least 100–500 marine turtles are caught annually in this fishery (Wamukoya, Mbendo and Eria, 1998). Studies from Eritrea indicate that significant numbers of marine turtles are caught incidentally in shrimp trawls (Gebremariam *et al.*, 1998). No records of captures in shrimp trawls were available from Madagascar, but this is probably because there was no effort to document incidental capture of marine turtles (Randriamiarana, Rakotonirina and Maharavo, 1998).

Southeast Asia. The waters of Southeast Asia include the Andaman Sea, the Gulf of Thailand, Gulf of Tonkin, South China Sea, Celebes Sea, Java Sea, Banda Sea, Timor Sea, Arafura Sea (much of which is taken together as the Sunda Sea) and the Gulf of Carpentaria. One common problem is the lack of systematic, long-term data. Both direct take and incidental mortality have been threats in Southeast Asia. The dramatic decline to near

extinction of the Terengganu leatherback population (Chan, 2001) is perhaps only an indicator of the impact of incidental mortality in the region. Shrimp trawling, nearshore driftnet fishing and offshore fishing fleets may all pose a serious threat to sea turtles in the Philippines (Trono, 1991), Malaysia (Chan, 2001), Indonesia (Halim, Silalahi and Sugarjito, 2001), Thailand (Chantrapornsyl, 2002) and Viet Nam (Hamann *et al.*, 2002). In Cambodia little is known, but marine turtle populations are said to be decreasing, and fishing activities seem to be related to the decline (Try, 1999); little seems to be known from Viet Nam (Vinh and Thuoc, 1999). There is at least one record of an estimated 300 turtles being drowned in just one 2 000 m shark gillnet over a two-week period in Northern Australia, 85 percent of which were *L. olivacea* (Guinea and Chatto, 1992; Limpus, 1994). It has also been suggested that plastics may be a major source of pollution and mortality in this region (Limpus, 1994). In the mid-1990s, scattered accounts from Northern Australia began to document stranded turtle carcasses, entangled in marine debris, including net webbing (Chatto, Guinea and Conway, 1995).

The tale of the Turtle Excluder Device. At the centre of international dialogue, and viewed as a crucial factor in turtle conservation, are Turtle Excluder Devices (TEDs), which minimize mortality from accidental or incidental capture of turtles in trawl fisheries. The reason this has become an issue stems from a decision taken by the United States Government that required most countries exporting shrimp to the United States to use TEDs on their trawlers. Many developing countries in Asia took exception to this, citing illegal implementation of World Trade Organization (WTO) trade restrictions. While the United States recently won its appeal against claimant nations, and is free to implement restrictions while working in close collaboration with exporter states, it is not clear if this will be an effective mechanism to enforce the use of TEDs (see Bache, 2001; Bolton, 2001; Bache and Frazier, in press). In India, there has been a growing awareness of the need to use TEDs, but little progress has been made in Orissa, the state with the highest incidental mortality of turtles in trawlers, because of conflicts between trawler owners and conservationists (Choudhury, 2003; Shanker and Mohanty, 1999; Shanker and Pilcher, 2003). An indigenous TED has been developed by the Central Institute of Fisheries Technology (Dawson and Boopendranath, 2003) and is in use in Andhra Pradesh, the state south of Orissa (Sankar and Raju, 2003).

Other Threats

Egg collection. The collection of eggs in Southeast Asia is widespread, and one of the main threats to turtle survival in the region. In the early 1970s, less than 10 percent of eggs was retained for incubation in hatcheries in peninsular Malaysia and Sarawak (Siow and Moll, 1982). In Sabah, from 1965 to 1978, over 6 000 000 eggs were collected, of which slightly over 2 700 000 were transplanted to hatcheries. Around 66 percent of these hatched (Siow and Moll, 1982). Depredation of nests by feral animals is also widespread in many south Asian areas (Dattatri and Samarajeeva, unpubl.; Sunderraj, Joshua and Serebiah, 2001; Bhupathy and Saravanan, 2002; Islam, 2002; Tripathy, Shanker and Choudhury, 2003).

Poor management practices. Despite a meteoric increase in scientific knowledge on marine turtles, little of this knowledge is yet incorporated into conservation projects in Asia. Unshaded beach hatcheries that produce 100 percent female hatchlings (Tiwol and Cabanban, 2000), retention of hatchlings for several days in hatcheries for the sake of tourism in Thailand (Chantrapornsyl, 2002) and Sri Lanka (Hewavisenthi, 1993) and other poor management practices also pose a threat to sea turtle populations.

Lack of basic research. Research has been relatively advanced in India, Malaysia and Thailand, while the remainder of Asian nations simply lack the funding and other resources to carry out scientific research. Many countries have surveys and monitoring programmes, but these are often not standardized to provide accurate population trends.

Development. Habitat loss and beachfront lighting as a result of development are threats throughout the region, particularly south Asia (Bhupathy and Saravanan, 2002; Islam, 2002; Kapurusinghe, in press; Pandav, 2000; Sunderraj, Joshua and Serebiah, 2001; Tripathy, Choudhury and Shanker, 2002; Tripathy, Shanker and Choudhury, 2003). For example, the planned Dharma port facility within kilometres of Gahirmatha nesting beach (Sekhsaria, 2004a) and the planned offshore oil exploration and extraction activities on the Orissa coast (Sekhsaria, 2004b) are sure to have a serious impact on the large numbers of olive ridleys that nest in Orissa. Similarly, major threats to marine turtles on the coast of Gujarat are petrochemical industries, sand mining, and harbour activities (Sunderraj, Joshua and Serebiah, 2001).

CONSERVATION STRATEGIES: MULTILATERAL AGREEMENTS

The list below is not globally exhaustive, but covers the primary international resolutions, conventions and legal instruments applicable in particular to the Asian region. Further details on the contents, objectives and limitations of each agreement can be obtained from the original documents, lodged with the Department of Fisheries of Malaysia (Secretariat for the ASEAN MoU), the CMS Secretariat at the offices of the United Nations Environment Programme (UNEP) in Bonn, Germany (Interim Secretariat for the IOSEA MoU), and the World Wildlife Fund for Nature (WWF) Philippines of Sabah Parks Malaysia (for the Turtle Islands Heritage Protected Area [TIHPA] Agreement).

- **ASEAN Memorandum of Understanding** – The ASEAN MoU was signed by the Governments of Negara Brunei Darussalam, the Republic of Indonesia, the Lao People's Democratic Republic, Malaysia, the Union of Myanmar, the Republic of the Philippines, the Republic of Singapore, the Kingdom of Thailand, and the Socialist Republic of Viet Nam. It recognizes the significance of sea turtle populations and their habitats in ASEAN waters, and also that sea turtles are migratory species and that the waters of ASEAN countries form a contiguous area of waters without any interval. Noting this, and recognizing that effective conservation efforts cannot be independently realized at a national level and that multilateral efforts are necessary to ensure the long-term survival of sea turtles in the ASEAN region, these countries resolved to promote the protection, conservation, replenishing and recovery of sea turtles and of the habitats based on the best available scientific evidence, taking into account the environmental, socio-economic and cultural characteristics of the Parties. This appears to have been a political move, and has stagnated.

- **TIHPA Malaysia–Philippines** – The Philippine–Sabah Turtle Islands harbour one of the world's major nesting grounds for green turtles (*Chelonia mydas*). The Philippine–Sabah Turtle Islands group is located in the Sulu Sea, at the southwestern tip of the Philippines, about 1 000 km southwest of Manila and some 40 km north of Sandakan, Sabah, Malaysia. These nine islands (six in the Philippines and three in Malaysia) lie adjacent to the international treaty limits that separate the two countries. In a historic bilateral agreement, the Governments of the Philippines and Malaysia established the Turtle

Islands Heritage Protected Area (TIHPA), the first and only trans-frontier protected area for marine turtles in the world. Management of the TIHPA is shared by both countries, making possible the conservation of habitats and sea turtles over a large area, independent of their territorial boundaries. This is an unprecedented initiative by both implementing agencies of the TIHPA – the Pawikan Conservation Project under the Protected Areas and Wildlife Bureau of the Philippines Department of Environment and Natural Resources, and Sabah Parks of Malaysia. The following priority activities were identified to achieve the goal of the TIHPA: management-oriented research, the establishment of a centralized database and information network, appropriate information awareness programmes, a marine turtle resource management and protection programme, and an appropriate ecotourism programme (for details, see Frazier, 2002, pp. 157–162).

- **IOSEA Memorandum of Understanding** – The Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and Southeast Asia took effect on 1 September 2001, following the conclusion, in Manila in June 2001, of a comprehensive Conservation and Management Plan. The Memorandum has now been signed by the following states: Australia, Comoros, Islamic Republic of Iran, Kenya, Mauritius, Myanmar, Philippines, Sri Lanka, the United Republic of Tanzania, the United Kingdom, the United States of America, and Viet Nam. (Text and discussion in Frazier, 2002, pp. 193–198.)

CONCLUSIONS AND RECOMMENDATIONS

Despite many positive steps taken in the region, marine turtle populations continue to decline. This is partially because of the lack of integration of local stakeholders, but mostly a result of the continued exploitation of nearly all eggs, directed take of turtles in some areas, the lack of use of TEDs by trawling fleets and a disregard for existing scientific, technical and indigenous knowledge. There is a need for legislative instruments that demand the use of TEDs, and adequate enforcement to ensure compliance. For this, it is necessary to educate (and win the support of) fishing communities regarding the benefits of TEDs, which include increased longevity of fishery stocks, a decrease in unwanted bycatch, and general marine conservation. In India, the parallel cases of Orissa and Andhra Pradesh demonstrate how a TED programme should not (and should) be implemented. In Orissa, the polarization between the fishing community and conservationists has prevented the introduction of TEDs, while in Andhra Pradesh, TEDs were introduced by the state Fisheries Department with appropriate demonstration and training programmes (see Shanker and Pilcher, 2003).

To date, little use of existing information has been made by governments and conservationists, while at every level there is a need to incorporate existing scientific, technical and traditional knowledge into management plans. Any potential national management plan has to have the acceptance of the general public. Much of the current legal infrastructure in most Asian countries was arrived at without the participation of the general public, and this translates into problematic compliance and nearly impossible enforcement. A case in point was the signing of the IOSEA MoU in July 2001 by Viet Nam. While the objectives behind signing the MoU were entirely honourable, it is doubtful that people living in Ninh Thuan, Khanh Hoa and Phu Quy, for example, were involved in the decision, or are even aware that the country has an international commitment to preserve marine turtle populations. This is similarly applicable to all signatory states.

While each government has its own way of developing and implementing legislation, experience has shown that at least some measure of public acceptance is a prerequisite for long-term conservation efforts to be effective. This acceptance can be gained through discussions at public fora, through meetings at the provincial level and down to the community level, raising awareness of the need to preserve marine turtles, of the benefits that this will bring, and of ways in which conservation efforts will impact people's lives and livelihoods. This calls for greater dialogue between the stakeholders and transparency and participation in the decision-making process.

It is time for the people of the region to understand that turtles are an important component of marine ecosystems, that they offer benefits far beyond the tangible, and that their conservation is a public process, not one driven by a handful of dedicated individuals. For this there is a need for a widespread awareness campaign, coupled with programmes that (1) assess the socio-economic status of those affected by changed management strategies and, if necessary, provide alternative livelihoods, and (2) are supported by contemporary knowledge, sound research and monitoring techniques.

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APPENDIX 1

COUNTRY-BY-COUNTRY SUMMARY OF SEA TURTLE OCCURRENCE AND THREATS IN THE INDIAN OCEAN

Country	Logger -head	Leather back	Hawks -bill	Green	Olive ridley	Reference
Red Sea						Ross & Barwani, 1982; Frazier, 1980
Egypt	X	X	P	P	X	Frazier & Salas, 1984
Ethiopia	X	X	P	P	X	Ross & Barwani, 1982; Frazier, 1980
Sudan	X	X	P	?	P?	Ross & Barwani, 1982; Frazier, 1980
Saudi Arabia	?	?	?	P	X	Ross & Barwani, 1982; Frazier, 1980
Jordan	?	?	?	?	X	Ross & Barwani, 1982; Frazier, 1980
Eritrea					X	Ross & Barwani, 1982; Frazier, 1980
Djibouti	?	?	P?	?	X	Ross & Barwani, 1982; Frazier, 1980
Former PDR Yemen	X	P	N	FN	X	Ross & Barwani, 1982; Frazier, 1980
Former Yemen Arab Rep.	?	?	?	N	P?	Walczak, 1979
Persian Gulf and adjacent waters						
Saudi Arabia	?	?	?	FN	X	Ross & Barwani, 1982; Frazier, 1980
Qatar	?	X	P	FN	X	Ross & Barwani, 1982; Frazier, 1980
Bahrain	X	X	X	F	X	Ross & Barwani, 1982; Frazier, 1980
United Arab Emirates	?	?	?	F?	X	Ross & Barwani, 1982; Frazier, 1980
Kuwait	X	X	X	X	X	Ross & Barwani, 1982; Frazier, 1980
Oman	N	P	N	FN	N	Ross & Barwani, 1982; Frazier, 1980
Islamic Rep. Iran	?	P	N	N	P	Kami, 1997; Mobaraki, 2004
Pakistan	?	P	?	FN	N	Kabraji & Firdous, 1984; Asrar, 1999; Firdous, 1989; Groombridge, Kabraji & Rao, 1988
Western Indian Ocean						
Somalia	X	X	?	P	P?	Frazier, 1980
Kenya	P	P	N	N	N	Okemwa, 2003

United Rep. Tanzania	P	P	N	FN	N	Frazier, 1980
Mozambique	N	N	FN	FN	N	Frazier, 1980
Madagascar	N	P	FN	FN	N	Frazier, 1980
Comoros	X	X	N	N	X	Frazier, 1980
South Africa	N	N	P	P	N	Hughes, 1982
Seychelles	X	X	FN	FN	X	Frazier, 1980
Mauritius	X	X	N	N	X	Frazier, 1980
Maldives	X	P	FN	FN	N	Frazier, 1980
Reunion (France)	X	X	N	N	X	Frazier, 1980
Chagos (UK)	X	X	FN	FN	X	Frazier, 1980
Mainland India	X	X	X	N	N	Kar & Bhaskar, 1982; Shanker & Choudhury, in press
Lakshadweep, India	X	X	FN	FN	N	Kar & Bhaskar, 1982; Shanker & Choudhury, in press
Eastern Indian Ocean						
Sri Lanka	FN	N	FN	FN	FN	Hewavisenthi, 1990; Kapurusinghe, in press
Mainland India	X	X	X	X	N	Kar & Bhaskar, 1982; Shanker & Choudhury, in press
Andaman–Nicobar, India	X	N	FN	FN	N	Kar & Bhaskar, 1982; Shanker & Choudhury, in press
Bangladesh	X	X	X	N	N	Rashid and Islam, in press
Myanmar	N	X	X	N	N	Thorbjarnarson, Platt & Khaing, 2000
Thailand	X	?	?	FN	N	Chantrapornsyl, 1993
Malaysia	X	n	N	FN	N	Chan, 2001
Brunei Darussalam	?	?	?	?	N	Pilcher, pers. comm.
Cambodia	?	?	?	?	?	
Viet Nam	?	?	?	N	N	Hamann *et al*., 2002
Australasia						
Western Australia	N	N	N	N	N	
Indonesia	N	N	N	N	N	Putrawidjaja, 2000; Halim, Silalahi & Sugarjito, 2001
Philippines			N	N	N	Trono, 1991
Papua New Guinea	X	N	N	N	N	

Key: F – Feeding, N – Nesting, P – Present, X – Not present, ? – Unknown.

APPENDIX 2

FISHERIES AND SEA TURTLE MORTALITY IN SOUTH ASIA

BANGLADESH

Bangladesh has a coastline of 710 km, with sandy beaches for nesting, and several offshore islands with suitable feeding and nesting habitats for sea turtles. There is some threat of incidental turtle mortality from trawl fishing vessels, driftnets, gillnets and mesh nets. The turtles either die of suffocation or the fishermen kill them to free their nets. The superstitious fishing community considers the sighting of a turtle or a turtle getting entangled in the fishing net as a bad omen. A Marine Fisheries Research Institute study reported that the number of turtle deaths in trawl fishing was not significant. However, these results may have been biased because of the United States ban on the import of shrimps from Bangladesh unless fishing vessels used TEDs (Alam, F., pers. comm. 1996, cited in Rashid and Islam, in press).

St. Martin's Island is a major sea turtle nesting ground in Bangladesh (Islam, 2002). The main fishing season here extends from September to April and the main fishing gears are: drifting gillnets (*Duba Jal*), fixed gillnet (*Shil Jal*), gillnet (*Rocket Jal*) and seine net (*Tana Jal*). Of these, the fixed gillnet is used in the rock beds while the seine net is used along the coast for catching smaller fish species. Some fishing methods appear to exert severe impact on other aquatic resources. The seine net has been observed to damage the algal beds on the sandy shore. Juvenile sea turtles, young jellyfish, cuttlefish, squid, octopus and other forms of marine life are also caught in this net. Driftnets are usually used in offshore fishing boats. The width of driftnets ranged from 15 to 60 m in different areas of Bangladesh. On St. Martin's Island, fishermen only use driftnets that are 15–20 m in width and 100–150 m in length. Driftnets are operated from top to bottom in the sea and can trap turtles and other underwater animals during fishing. The size of the hole in the driftnets used on St. Martin's island is usually about 13–15.5 cm (5–6 inches). According to the fishermen many sea turtles are trapped in this sort of net. Threats are serious during inshore fishing. If a sea turtle gets entangled, fishermen kill it or cut its flippers to save their nets. The situation has improved, at least on St. Martin's Island, as a result of the course held on sea turtle conservation awareness over the last several years. Rocket nets are smaller, about 5 m wide and about 150 m long. They have a very small hole and have no effect on sea turtles and other non-fished marine resources. They are operated in near-shore areas from small boats. Fixed gillnets are set under water but remain in touch with the bottom of the sea. The usual length is 80–100 m on St. Martin's Island. The upper portion remains open and floats with signals and tags are used to indicate the presence of the nets. They are set at 16–20 m depth along the major southeastern to western shallows of the main sea turtle nesting ground on St. Martin's Island (see Islam, 2002 for details).

During the 1996–98 survey, 27 turtles of both sexes and subadults were found dead on the beach of St. Martin's Island. About 19 of these individuals were suspected to have died as a result of fishing operations. More than 51 dead olive ridleys were washed ashore during the 2000/2001 season (Islam, 2002). However, the major threat to marine turtles in Bangladesh is exploitation of eggs.

INDIA

Mainland India has a coastline of 6 500 km, with a total population of more than 200 million people. In addition, the Andaman and Nicobar Archipelago consists of over 345 islands, islets and rocky outcrops, with land area extending up to 8 249 km^2 and a coastline 1 962 km long. There are nine coastal states, numerous small Union Territories and two groups of offshore islands, including the Andaman and Nicobar Islands in the Bay of Bengal and the Lakshadweep Islands in the Arabian Sea. There are a large number of major and minor fishing harbours in most states in India (Table 1) (summarized in Marine Fisheries Information Service Technical and Extension Series No. 153). There has been a significant increase in fishing effort (Tables 2–6), resulting in an increase in fish production and exports over the years (Table 7). This has led to significant turtle mortality along the entire coast (Table 8) (Rajagopalan, Vijayakumaran and Vivekanandan, in press). However, they clearly underestimate the trawling-related mortality for Orissa, where other sources (Pandav and Choudhury, 1999; Pandav, 2000; Wright and Mohanty, in press) have documented the stranding of over 100 000 olive ridley turtles since the mid-1990s. Their estimates for strandings in other states may also be underestimates (see Rajagopalan, Vijayakumaran and Vivekanandan, in press for sampling methodology) as the data for Andhra Pradesh and West Bengal indicate. For states with significant sea turtle mortality, there is a brief account below of fishing effort, major concerns and sea turtle mortality, based largely on surveys carried out by various agencies under the Government of India/United Nations Development Programme (UNDP) national sea turtle project (Sharma, in press).

Gujarat

One of the chief factors responsible for sea turtle mortality is incidental catch in fishing gear. In 1977, there were 477 fishing centres including fishing villages along the Gujarat coast. This increased to 854 in 1992 with an annual growth rate of 5.3 percent. The number of active fishers also increased from 45 570 in 1977 to 139 608 in 1992 with an annual growth rate of 14 percent. The 1995 records of the State Fisheries Department showed a total of 12 648 mechanized and 8 370 non-mechanized vessels operating along the coast of Gujarat (Anonymous, 1995). The increase in fisher population and vessels indicates an intensification of fishing activities, which is likely to be detrimental to turtles. Barring a few nesting beaches along the south Gujarat coast, which face problems caused by human habitation and coastal plantation, there are no other developmental activities, such as the building of coastal resorts and highways, and beach armouring, along the coast. Pair trawling of the coast of Gujarat between December 1983 and March 1984 was reported to have caught 70 *C. mydas* (Siraimeetan, 1988). During the Government of India/UNDP survey in 2000–01, 37 dead turtles were counted on the coast (Sunderraj *et al*., 2002).

Tamil Nadu

Bhupathy and Saravanan (2002) documented 462 dead turtles (377 olive ridleys, 74 green turtles, 4 loggerheads, 5 hawksbills, 2 leatherbacks) along the Tamil Nadu coast during the Government of India/UNDP survey. Gillnets are widely used for marine fishing along the Tamil Nadu coast. A total of 245 dead turtles were observed along the Nagapattinam coast; of the 94 fresh carcasses, 66 (70 percent) had visible injuries. The head or one of the flippers was missing in eight cases. When turtles get entangled in nets, the fishermen chop off the flippers or club the head to remove the animals from the net without major damage to the net

or fisherman. This is particularly common along the Nagapattinam coast. This is in contrast to what happens on the Tuticorin–Kanniyakumari coast, where live turtles are collected and consumed or sold. The number of registered fishing vessels is low compared with actual numbers that are seen on the shore near fishing villages. For instance, according to the Fisheries Department, there were 1 278 fishing vessels registered in the Nagapattinam district. However, interviews and counting in 11 villages revealed that there were at least 2 110 vessels. Incidental catch of turtles in fishing gear has been reported as a major cause of turtle mortality along the Indian coast, including the coast of Tamil Nadu (Rajagopalan *et al.*, 1996).

Andhra Pradesh

Andhra Pradesh has nine coastal districts with 453 fishing villages and 280 landing centres along the coast. By 1998, the fishers population was 0.87 million, with 8 642 mechanized boats, 3 269 motorized craft (boats fitted with outboard motors for gillnet operations) and 54 000 non-mechanized boats (traditional craft) in coastal Andhra Pradesh (Anonymous, 1999). Of the total marine fish catch, 32 percent comes from trawl nets, 24 percent from non-mechanized drift gillnets, 14 percent from bottom-set gillnets, 13 percent from shore seines and the rest from boat seines, driftnets, hooks and lines and other gear (Alagaraja *et al.*, 1987). In all, 806 dead olive ridley turtles and two dead green turtles were counted along the Andhra Pradesh coast between December and April, 2001 (Tripathy, Shanker and Choudhury, 2003).

West Bengal

West Bengal has 200 km of coastline. The coastline of the Bay of Bengal extends from the Indo-Bangladesh border – situated in the deltaic region of the Sundarban in the east – up to the border with Orissa in the west. India and Bangladesh are divided by the river Hariabhanga in the extreme east of West Bengal. Major trawling takes place near different islands of Digha, Shankarpur, Sundarban and Junput. During monthly inspections of about 40 km of beach in Medinipore and 8 km of beach of sea-facing islands in the Sunderbans during 2000/01 and 2001/02, 862 carcasses of olive ridleys (58 percent female) and 1 hawksbill were counted (Roy Choudhury, 2001).

Orissa

Orissa has a long coastline, yet the marine fishing activities here are dominated by migrating fishers from West Bengal (between the Bengal–Orissa border and Dhamra) and Andhra Pradesh (from Puri to the Orissa–Andhra Pradesh border). There are 329 marine fishing villages in Orissa comprising 20 815 households and a population of 126 000. However, only about 40 percent of this population is engaged in fishing. The district where local communities are most heavily engaged in fishing is Balasore – 241 villages and 58 percent fisher families – which also has 23 of the 62 fish landing centres in the state. Puri has the least number of fishing villages (24) while Cuttack has the smallest number (95) of fisher families (Puri has 15 percent and Ganjam 18 percent). Balasore also leads (48 percent) in the number of mechanized boats in the state, followed by Cuttack (36 percent). Cuttack is ahead (29 percent) in terms of the number of traditional craft used, followed by Ganjam (26 percent), Puri (25 percent) and Balasore (20 percent). Of the traditional non-mechanized boats, catamarans constitute 51 percent while dingis make up 32 percent of the total. Over 100 000 dead turtles have been counted on the coast of Orissa, primarily a result of fishery-related mortality. Much of this is believed to have been

caused by trawlers (Pandav and Choudhury, 1999; Pandav, 2000), but recent reports of gillnets with hundreds of dead, entangled turtles (Wright and Mohanty, 2002) indicate that they may also be a major cause of mortality. For a review of population trends and threats, see Shanker, Pandav and Choudhury (2004).

Lakshadweep

Marine fishing is the basic economic activity on these islands, with an estimated 6 000 fishermen and about 850 tuna fishing craft (Anonymous, 2001). The fishing season in Lakshadweep extends from October to April. However, during the monsoon, fishing is undertaken in near-shore waters, mostly in the surrounding lagoons. The gillnet, shore seine, anchor net and dragnet are commonly used for lagoon fishing but the largest catch comes from pole and line, which is used for tuna fishing in the deep sea (Table 1). The current annual fish landing is an estimated 10 000 tonnes (Anonymous, 2001), which consists mostly of tuna and other commercially viable finfish, not including turtles, which are illegally fished in the lagoons. The incidental fishing-related mortality of turtles in Lakshadweep is negligible, as fishing methods are very different from those used on the mainland coast. The only method used for tuna fishing is pole and line, which poses no threat to the turtles. During the Government of India/UNDP survey (2000–01) three dead hawksbills were encountered on the beach. Although the cause of their mortality could not be clearly ascertained, they are presumed to have died by drowning in gillnet fishing operations. The increase in the level of gillnet fishing in the lagoons is a cause for concern for the future (Tripathy, Choudhury and Shanker, 2002).

Andaman and Nicobar Islands

Bhaskar (1994) estimated the annual rate of juvenile and subadult turtles caught in shark nets just around Middle Andamans as 1 500 turtles. Recent socio-economic studies, shark fishing assessment and interviews with fishermen in the Andaman Islands indicate that 2 000–3 000 turtles of all size classes are caught annually in nets all around the Andaman Islands (Andrews, Krishnan and Biswas, 2001). The most frequent turtle entanglements were in shark nets, mostly set in passages between islands very close to turtle feeding and nesting habitats. However, a ban on shark fishing has been imposed and it is hoped this will reduce the annual rate of entanglement. Turtles entangled in old, discarded nets that drift for months in the sea have been observed in the Andamans and Great Nicobar Island (Daniels and David, 1996).

PAKISTAN

Pakistan has a coastline of 1 120 km. The western region, the Makran coast, extends from the Hub River to the Iranian border and is about 770 km long. The southeastern region, the Sindh coast, extends from southwest of Karachi to the Indian border and is about 350 km long. Most of the continental shelf of the Makran coast is rocky. It falls sharply to a great depth. The Sindh coast is characterized by a network of creeks with an area of 7 680 km^2. The bottom is sandy or muddy and is good for trawling and gillnet operations.

In terms of foreign exchange earnings, Pakistan's most important fishery is the shrimp fishery. Commercial shrimp trawling began in 1958 on the recommendation of FAO (cited in Stevens, unpubl.). The shrimp trawl net used in Pakistan was designed in 1958 when shrimping was introduced for the first time in the country, and no change to the design of the

net has been made since (Moazzam, 1998). Wooden trawlers about 15 m in length are used for shrimp fishing; no mechanical devices are used on these shrimp trawlers and the deployment and retrieval of nets is manual (Stevens, unpubl.). The crew consists of eight to 16 fishermen and the duration of the trawl operation is between 30 minutes and one hour, depending on the catch rate. In addition to the target species (shrimp), a variety of fish and invertebrates are caught as bycatch. The trawler fleet had increased to 1 070 trawlers in 1985. In 1998, the total number of mechanized fishing boats was 3 380, comprising 1 562 trawlers and 1 810 gillnetters. In addition, there were 8 194 mechanized cum sail-driven boats with outboard motors. The number of trawlers decreased from 1 926 in 1993 to 1 562 in 1998, while the number of gillnetters increased from 1 154 to 1 810 during the same period. The number of mechanized cum sail-driven boats increased from 6 524 to 8 194, while the number of sail-driven boats increased from 16 105 to 19 830 over this period. The population of marine fishermen increased marginally, with Sindh having three times as many fishers as Balochistan (*Handbook of Fisheries Statistics of Pakistan*, Marine Fisheries Department).

The Marine Fisheries Department started a programme to analyse shrimp bycatch, which indicated a preponderance of juveniles of food fishes, small fishes and invertebrates. The study indicated that adult and juvenile turtles were not represented in the bycatch. A survey was conducted by the Marine Fisheries Department in 1997 in which 146 fishermen were interviewed to find out the frequency of turtle entrapment in shrimp trawl nets. The interviewees said that turtles were rarely caught in shrimp trawl nets, and that in almost all cases where turtles were accidentally caught, they were released immediately (Qureshi, in press).

The Sindh Wildlife Department has been monitoring green turtles and olive ridleys for over two decades at Hawkes Bay and Sandspit (Karachi coast), which is a 20 km beach (Kabraji and Firdous, 1984; Asrar, 1999). Asrar (1999) reports a dramatic decline in olive ridley nesting at this site between 1980 and 1997, from 50 to 100 nests/season to fewer than 10 nests/season in the last five years of monitoring. Though carcasses have been recorded on the coast, no quantitative data is available on mortality (Stevens, unpubl.). The decline is likely to be a result of fishery-related mortality, as in the adjacent state of Gujarat, in India (Sunderraj *et al.*, 2002).

SRI LANKA

The island has a 1 585 km coastline and its national waters cover an area of approximately 488 675 km^2 under the United Nations Convention on the Law of the Sea. Sri Lanka is remarkable in that it has feeding and nesting grounds for five species of sea turtle. Sri Lanka has a total of about 3 000 fishing vessels; there may be 1 800 multiday fishing boats that fish in Sri Lanka's exclusive economic zone (EEZ). Previous data and reports on the extent of the turtle catch in Sri Lanka are confusing because they are contradictory (see Hewavisenthi, 1990 for a review). Hoffman (cited in Frazier, 1980) estimated the annual bycatch of turtles in Jaffna in the mid-1970s to be around 1 500, and a total of 3 000–5 000 turtles island wide. Dattatri and Samarajeewa (unpubl.) found olive ridley turtle carapaces in almost every fishing community along the southern, southwestern, western and northeastern coasts. The fishermen who were interviewed throughout the island during a study confirmed that turtles were often caught and drowned in their nets. Indeed, the fishermen all believed that the mortality caused by their nets was the major cause for the decline in turtle populations around the island (Kapurusinghe, in press).

During the turtle conservation project (TCP) surveys, many fishermen stated that they often killed entangled turtles and sold their flesh or carapaces to obtain “compensation” to repair the damage caused by the turtles to their nets (Kapurusinghe, in press). The latest TCP bycatch survey shows 5 241 turtle entanglements between Kalpitiya and Kirinda during the period of November 1999 and June 2000 (Table 9) (Kapurusinghe and Cooray, 2002). Of these, 1 626 were olive ridley turtles, 1 310 were loggerheads, 908 were green turtles, 431 were leatherbacks and the remaining 148 were unidentified species. Of the 5 241 turtles entangled, 1 063 were found dead, killed or sold. The remaining 4 178 were released by the fishermen.

Major threats in Sri Lanka include the illegal exploitation of hawksbill turtles for tortoiseshell, collection of eggs for consumption and tourist hatcheries, depredation of eggs by feral predators and development-related threats (Kapurusinghe, in press).

Table 1. Fish landing centres in different states in India

State	**Length of coast (km)**	**Number of landing centres**
Andhra Pradesh	974	379
Goa	104	87
Gujarat	1 600	854
Karnataka	300	28
Kerala	590	226
Maharashtra	720	184
Orissa	480	63
Tamil Nadu	1 000	362
West Bengal	160	47
Andaman–Nicobar	2 000	57
Pondicherry	45	28
Lakshadweep	130	11
Daman and Diu	27	7

Table 2. Mechanized vessels (trawlers), non-mechanized vessels (traditional craft) and motorized vessels (traditional craft and wooden gillnetters fitted with outboard and inboard motors) in 1980, 1990 and 1994

State	Mechanized			Non-mechanized			Motorized			Total		
	1980	1990	1994	1980	1990	1994	1980	1990	1994	1980	1990	1994
West Bengal	1 054	1 880	1 880	4 061	4 361	4 091	0	270	270	5 115	6 511	6 241
Orissa	469	1 796	1 665	9 728	13 791	7 796	0	529	2 453	10 197	16 116	11 914
Andhra Pradesh	580	4 082	8 911	36 013	50 333	54 000	0	1 688	3 269	36 593	56 103	66 180
Tamil Nadu	2 627	4 500	8 230	43 343	39 969	26 737	0	3 298	5 340	45 970	47 767	40 307
Pondicherry	176	561	553	1 750	5 293	5 900	0	332	365	1 926	6 186	6 818
									12			
Kerala	3 038	5 026	4 206	26 271	27 104	27 873	0	7 934	913	29 309	40 064	44 992
Karnataka	2 004	3 730	3 655	6 942	11 860	11 952	0	190	1 189	8 946	15 780	16 796
Goa	908	736	850	2 513	2 445	1 100	0	675	900	3 421	3 856	2 850
Maharashtra	4 718	6 451	7 930	7 928	17 441	9 888	0	286	4 701	12 646	24 178	22 519
Gujarat	3 413	5 215	8 365	4 120	7 795	8 370	0	1 154	4 283	7 533	14 164	21 018
Andaman and Nicobar	10	184	230	na	964	1 180	0	124	160	10	1 272	1 570
Lakshadweep	213	410	443	na	740	780	0	225	298	213	1 375	1 521
	19	**34**	**46**	**142**	**182**	**159**			**36**	**161**	**233**	**242**
Total	**210**	**571**	**918**	**669**	**096**	**667**	**0**	**16 705**	**141**	**879**	**372**	**726**

Source: Rajagopalan *et al*., 1996

Table 3. Changes in fishing statistics in India over different periods

Period	1961–62[a]	1973–77[a]	1980[a]	1999[b]
Fishing villages	1 797	1 913	2 408	3 651
Fishermen population	959 937	1 435 158	2 096 314	5 000 000
Active fishermen	229 345	322 532	474 731	1 000 000
Traditional boats	90 424	106 480	140 833	150 000*
Mechanized boats	0	8 086	19 013	47 000

Source: [a] James, 1989; [b] Devaraj and Vivekanandan, 1999; * does not include 36 500 motorized boats.

Table 4. Increase in number of fishing craft and gear from 1980 to 1998

	1980	1998
Fishing craft		
a) Mechanized		
Trawlers	6 288	30 979
Gill-netters	2 362	9 968
Doll-netters	241	5 538
Purse seiners	221	1 006
Others	177	1 579
Total	**9 289**	**49 070**
b) Traditional		
Plank-built boats	37 904	39 951 (43)*
Dug-out canoes	21 684	17 297 (38)*
Catamarans	73 431	58 921 (29)*
Others	1 722	11 349 (89)*
Total	**134 741**	**127 518 (40)***
Fishing gear		
Trawl nets	14 165	151 466
Purse seines	238	1 216
Drift/set gillnets	216 037	1 534 555
Boat seines	29 976	8 166
Fixed bag nets	48 817	77 582
Hooks and lines	56 676	89 261
Rampans	187	257
Shore seines	18 841	4 481
Traps	98 825	4 068
Scoop nets	6 080	3 719
Others	95 804	86 527
Total	**585 646**	**1 961 298**

*Percentage of motorized vessels given in parentheses.

Source: Central Marine Fisheries Research Institute (CMFRI) census 1980 (Anon., 1981) and rapid census 1998

Table 5. Number of boats and gear per km of coastline in different maritime states as per 1998 rapid survey

State	Mechanized boats	Traditional craft	Gillnets
West Bengal	26.68	24.45	47.89
Orissa	4.17	16.40	42.77
Andhra Pradesh	2.18	29.09	63.61
Tamil Nadu	7.37	37.29	145.06
Pondicherry	10.27	60.76	214.07
Kerala	8.62	43.02	72.11
Karnataka	10.81	26.93	38.94
Goa	9.39	12.86	19.98
Maharashtra	18.66	8.96	231.23
Gujarat	6.36	3.88	628.90
All India	**6.1**	**15.86**	**183.28**

Source**:** Rajagopalan, Vijayakumaran and Vivekanandan, in press

Table 6. Operational details of gillnets at selected landing centres along the Indian coast

Landing centre	Operating distance from shore (km)	Length of craft (m)	Maximum length of net (m)	Height of net (m)	Mesh size (mm)
Veraval (Gujarat)	20–45	7–13	2 310	7	65–215
Ratnagiri (Maharashtra)	15–30	5–9	1 000	9–11	50–130
Mangalore (Karnataka)	10	10	700	7	65–135
Calicut (Kerala)	5–10	9	600	10	100–150
Cochin (Kerala)	20–50	7–9	1 000	4–8	70–130
Chennai (Tamil Nadu)	8–20	10	700	4–7	10–150
Kakinada (AP)	2–10	5–10	1 600	4–8	18–100
Visakhapatnam (AP)	2–8	5–10	660	3–6	15–90

Source**:** adapted from Vivekanandan, 2002 (cited in Rajagopalan, Vijayakumaran and Vivekanandan, in press)

Table 7. Fish production and exports for selected years, 1950–2000

Year	Marine ($t \times 10^5$)	Total ($t \times 10^5$)	Exports ($t \times 10^3$)	Value ($Rs \times 10^7$)
1950/51	5.34	7.52	19.7	2.46
1960/61	8.8	11.6	15.7	3.92
1970/71	10.86	17.56	35.9	35.07
1980/81	15.55	24.42	75.6	234.84
1981/82	14.45	24.44	70.1	286.01
1982/83	14.27	23.67	78.2	361.36
1983/84	15.19	25.06	92.7	373.02
1984/85	16.18	28.01	86.2	384.29
1985/86	17.16	28.76	83.7	398
1986/87	17.13	29.42	85.8	460.67
1987/88	16.58	29.59	97.2	531.2
1988/89	18.17	31.52	99.8	597.85
1989/90	22.75	36.77	110.2	635
1990/91	23	38.36	139.4	893.37
1991/92	24.47	41.57	171.8	1 375.89
1992/93	25.76	43.65	208.6	1 767.43
1993/94	26.49	46.44	244	2 503.62
1994/95	26.92	47.86	305.1	3 553.08
1995/96	28.25	49.5	296.3	3 501.11
1996/97	28.57	51.4	378.2	4 121.36
1997/98	29.5	53.88	383.8	4 697.48
1998/99	26.96	52.62	302.9	4 626.87
1999/00	28.34	56.05	340	5 095.73

NOTE: t – tonnes; Rs. – rupees.

Source: Department of Animal Husbandry and Dairying, Ministry of Agriculture, India (cited in Rajagopalan, Vijayakumaran and Vivekanandan, in press)

Table 8. Sea turtle mortality in 1997, 1998 and 1999, excluding that along the Gahirmatha coast

	Landed/trapped			Stranded			Total		
State	**1997**	**1998**	**1999**	**1997**	**1998**	**1999**	**1997**	**1998**	**1999**
West Bengal	0	28	0	96	97	60	96	125	60
Orissa	199	305	130	129	201	378	328	506	508
Andhra Pradesh	175	159	114	209	276	587	384	435	701
Tamil Nadu	1 518	900	69	538	457	510	2 056	1 357	579
Kerala	270	182	69	4	0	0	274	182	69
Karnataka	0	0	0	10	0	0	10	0	0
Goa	24	0	0	0	0	10	24	-	10
Maharashtra	0	0	0	18	0	0	18	0	0
Gujarat	0	0	0	0	0	0	0	0	0
Total	**2 186**	**1 574**	**382**	**1 004**	**1 031**	**1 545**	**3 190**	**2 605**	**1 927**

Source: cited in Rajagopalan, Vijayakumaran and Vivekanandan, in press

Table 9. Results of turtle conservation project bycatch survey (key: no. – number of fishermen interviewed; Cm – green (*Chelonia mydas*), Lo – olive ridley (*Lepidochelys olivacea*), Cc – loggerhead (*Caretta caretta*), Dc – leatherback (*Dermochelys coriacea*), Ei – hawksbill (*Eretmochelys imbricata*), Uk – unknown)

Survey site	**No.**	***Cm***	***Cc***	***Lo***	***Dc***	***Ei***	**Uk**	**Total**
Beruwala	699	13	28	36	36	7		120
Chilaw	591	1	25		1	2		29
Colombo	881	43	25	29	9	29	7	142
Dondra	481	4	8	9	6	24		51
Galle	1 421	473	678	597	40	263	4	2 055
Hambantota	1 395	2	1		2		3	8
Kandakkuliya	608			107				107
Kirinda	655	117	160	236	32	82	2	629
Kottegoda	1 176	15	51	2	115	23	7	213
Mirissa	922	75	146	55	106	51	68	501
Morogalla	885	1		6		2		9
Negombo	1 429	43	115	483	1	4	8	654
Panadura	350	5	4	1	14	3		27
Tangalle	1 030	10	6	11	24	137	4	192
Wadduwa	229	2	2	4	1	7		16
Weligama	1 008	104	61	50	44	184	45	488
Total	13 760	908	1 310	1 626	431	818	148	5 241

Source: Kapurusinghe and Cooray, 2002

APPENDIX 3

RELEVANT LITERATURE FOR THE WESTERN INDIAN OCEAN REGION

(extracted from Mortimer, 2002)

Regional

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