The hawksbill turtle (*Eretmochelys imbricata*): conservation research

H. Robert Bustard

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The hawksbill is one of the smaller sea turtles with adults weighing around 45-70kg and a curved carapace length of c60-110cm. It is the most tropical of sea turtles. The specific name, *imbricata*, refers to the overlapping carapace scutes, though these are not usually seen in very young or elderly animals.

The hawksbill is frequently closely associated with coral reefs where its favourite food is sponges. Hawksbills, however, are omnivorous, eating a wide range of small invertebrates; their hooked jaws (Fig. 1) are well adapted to winkling prey out of small crevices. In some areas a significant part of the diet may be sea grasses (*Zostera* spp.) (Bjorndal & Bolten 2010). It is thought in some regions that they may consume on average 440kg of sponges a year (Bjornal & Bolten, ibid). Hawksbills are clearly unaffected by the sponges´ tiny glass-like needles. Most interestingly, some of their diet, including certain sponges, is toxic. The hawksbills absorb the toxins without adverse effects but it makes their meat potentially poisonous to humans. In certain areas – presumably where toxic prey is widely eaten by the turtles – human fatalities have been recorded and in these areas people avoid eating this species (Bustard 1972).

On land, hawksbills move with the normal quadrupedal gait like the other smaller species but unlike green and leatherback sea turtles which use laborious forward pushes with all four limbs acting together. The hawksbill´s progress is fast due to fewer rest periods, allowing rapid movement up and down the beach and this, combined with rapid nesting, means that it will often have returned to the water before it is discovered by a predator. However, this does not prevent its eggs being taken for food.

Current estimates of the population of hawksbill turtles worldwide (all such estimates are based on breeding females) are 20,000-23,000. This compares with figures of 800,000 for the Pacific or olive ridley, 85,000-90,000 for the green turtle, 60,000 for the loggerhead and 34,000-36,000 for the leathery turtle – these five comprising the most widespread species. The figure for the very local Kemp's ridley is 7,000-9,000 and for the Australian endemic flatback turtle 20,000-21,000 (Anon 2013).

Fig. 1. The hawksbill turtle showing its powerful beak. Photo by Sumer Verma.

These figures, it should be stressed, are merely published estimates, some of which are questionable but are quoted here to put the status of the hawksbill into context.

The US Fish and Wildlife Service (Anon, ibid.) have provided data for nesting populations on a worldwide basis with much of the data based on Mortimer and Donnelly (2008). This is summarised below. The above qualifications also apply.

The Atlantic populations

Thirty-two rookery sites are recorded, nine of which have a minimum of more than 100 hawksbills nesting annually. These larger sites are in the Bahamas, Barbados, Cuba (Doce Leguas Cays), Jamaica, Porto Rico (two grouped sites), Panama (two important sites) and Brazil. Interestingly, and most encouragingly, six of these populations appear to be increasing. There are inadequate data for the Bahamas, Cuba and Jamaica. The total population size for the Atlantic is given as 3,600-6,000 nesting females.

The Indian Ocean

There are 64 sites, 12 of which have over 100 nesting turtles annually. These are Madagascar, the Seychelles (both inner and outer island groups), Iran, Oman, Sudan, United Arab Emirates, Yemen, Western Australia, the British Indian Ocean Territory (BIOC – the Chagos Islands), Malaysia and the Maldives.

In none of these sites has an increase in the nesting population been reported; three are stable and three are said to be decreasing. The population in Oman is reported as stable with an estimated population of 600-800. It should be pointed out that Oman under Sultan Qaboos has enjoyed excellent wildlife conservation over many decades.

The BIOC has interesting possibilities with no resident human population on the islands apart from the military base on Diego Garcia. The UK government has made this archipelago into a huge nature reserve which should provide an excellent area for hawksbills if this remote area is properly policed. The 1999 nesting female population of BIOC is given as between 300-700 (Mortimer & Day 1999). The population in Western Australia, quoted as about 2,000 – which in my view is an underestimation (see below) – is noteworthy as being by far the largest of any of the Indian Ocean populations. Furthermore, it enjoys a very high conservation status, the state of Western Australia having an excellent long-term record in this respect. In eight of these sites there is insufficient information to form an opinion. The total for the Indian Ocean populations is given as between 8,000-10,000.

The Pacific populations

There are 88 rookery sites in the Pacific, of which only nine have more than 100 nesting females each year. Two of these are in Australia: one in Torres Strait/northern Great Barrier Reef (Figs 2 & 3) and the other in north-eastern Arnhem Land at the tip of Australia's Northern Territory. Both have several thousand nesting females (see below). The others are Papua New Guinea, the Philippines, Fiji, the Solomon Islands, Vanuatu and Salvador. The four largest populations are the two areas in Australia, Indonesia (median estimate 1,700) and Papua New Guinea (median estimate 750). In none of these sites has a population increase been reported. In Sabah (East Malaysia) the population is said to be stable at 90-150 and in three there are insufficient data to provide an estimate. There are reported to have been large exports of tortoiseshell from Indonesia. Furthermore, the conservation prognosis for Indonesia and Papua New Guinea may not be good whereas in Australia it is excellent. The total population for the Pacific Ocean is given as between 10,000-13,000. I estimate the Australian populations alone will total over 10,000.

The above summary of nesting areas shows the hawksbill is still very widely distributed. However, detailed examination shows that in 35 of these 184 sites – many entire countries – numbers are very small, i.e. below 50 nesting females per year. Of those areas, where some data are available, numbers are decreasing in 136, stable in three and increasing in only eight, the latter all in the Atlantic.

The small numbers of nesting females in many areas is of great concern because sea turtle population ecology is based on maximum reproduction.

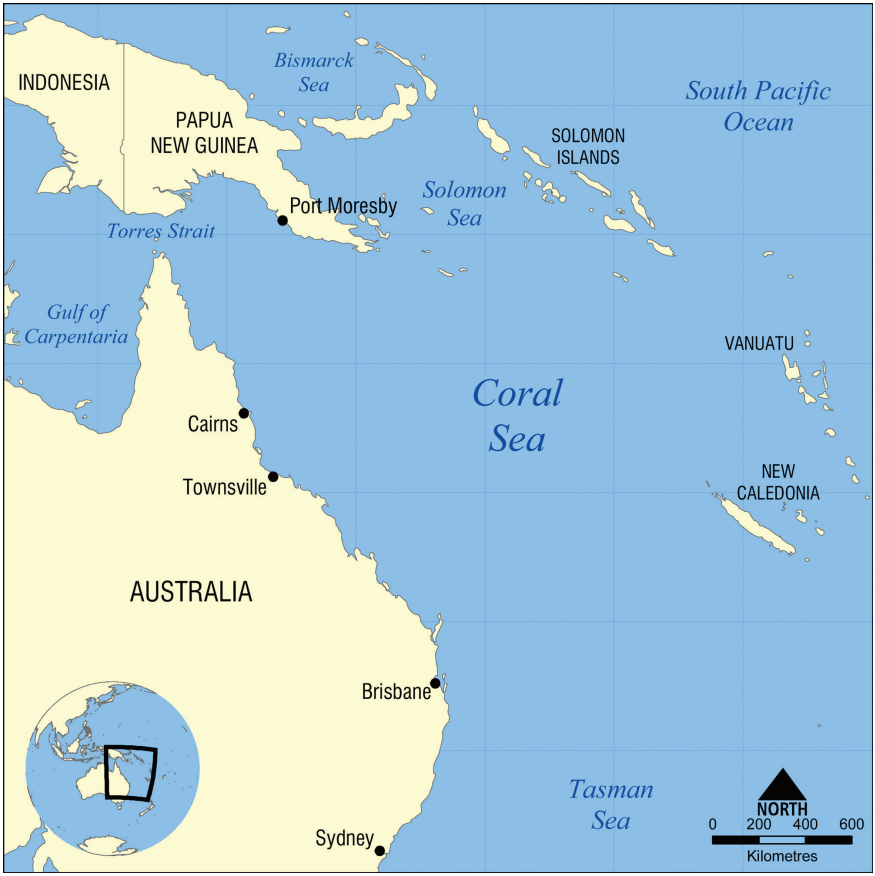

Fig. 2. Map showing eastern Australia with the Coral Sea and Torres Strait.

High-density nesting on key rookeries combined with very large egg production reduces the overall percentage consumption of incubating eggs by nest predators on vulnerable nesting beaches. There is also beach predation of hatchlings by birds and crabs but this is usually much less important. Whatever the level of land predation on the nocturnally emerging hatchlings, the level is very considerably higher once the hatchlings reach the water, especially if they have to cross a shallow reef platform (Hendrickson 1958). Percentage survival during this hazardous period depends on the overall numbers making the journey (Bustard 1972a; 1976). Hence, enormous rookeries are crucial to achieving high levels of hatchling survival, a factor that has often been overlooked. It is necessary to flood the sea surrounding the breeding beaches with baby turtles because few may survive to reach deep water until the predators have taken their fill (Bustard 1979).

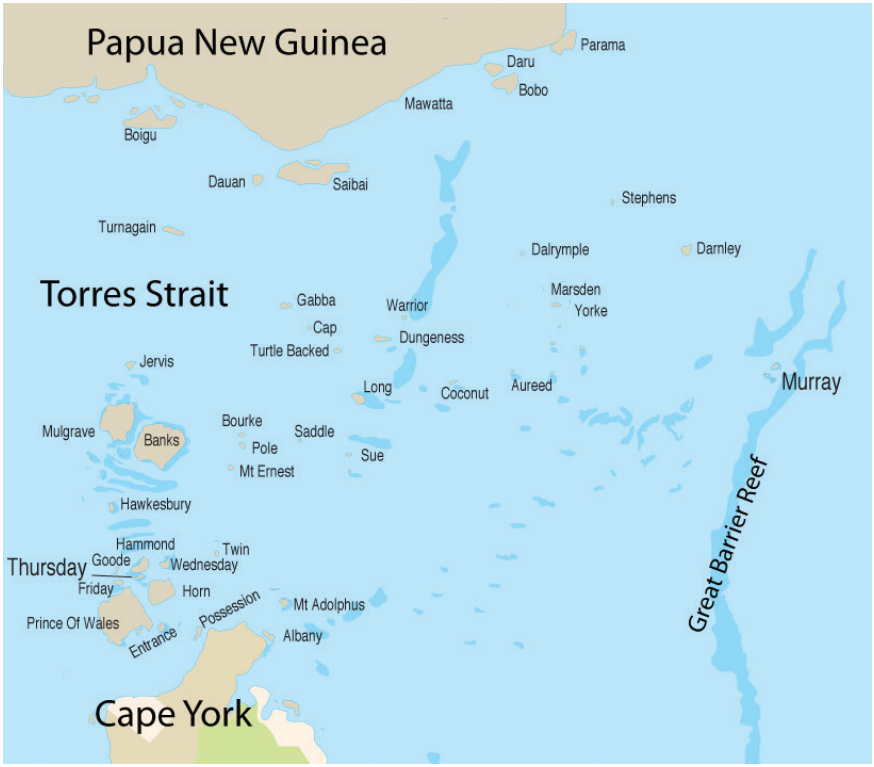

Fig. 3. Map showing the many islands of Torres Strait, both volcanic and coral cays. Long Island is in the centre.

This phenomenon may explain why Archie Carr's attempts to recreate rookeries in the Caribbean failed – the numbers released at any one site may have been insufficient to allow for an adequate number of post-predation survivors. On this basis it may be vital to maintain the current levels of some of the major rookeries rather than making efforts to re-establish those on the point of extinction.

My research on hawksbills indicated that micro-geographical studies can prove especially rewarding (Bustard 1979a). In Torres Strait there are hawksbill populations readily distinguishable on carapace colouration and shell thickness, yet they nest on islands only a few kilometres apart. For instance, in Torres Strait the distance between Long Island and Pole Island (Fig. 3) is only c20km, between Long Island and Cap Island c26km and between Cap Island and Bourke Island c85km, yet the population nesting on each of these islands is distinguishable at a glance. This was a fascinating discovery I made in the early1970s as it showed that populations feeding communally return

to their nascent island to breed and thus remain distinct. Sea turtles are now known to use the Earth's magnetic field in their long-distance migrations.

In the early 1960s very little was known about hawksbills in Australia (Bustard 1969c; 1971). In an outstanding ecological paper, Hendrickson (1958) suggested that the green turtle reached maturity at an age of between five and eight years. We now know that sea turtles are extremely slow maturing, which makes them very vulnerable to any harvesting of adult members of the population. Hence, free range management of populations is normally essential to take forward conservation necessitating sound government backup regulations – often of several countries working together – if it is to succeed. And, of course, regulations must be both drawn up and enforced, as is the case in Australia. Such an ideal situation is extremely difficult to achieve in practice.

The Australian populations

We now know that hawksbills in north-eastern Australia take between 31 and 39 years to reach sexual maturity and this figure, where reliable estimates are available, is not markedly different elsewhere. Absolute age has not been directly measured in wild animals. It is known that females grow faster than males at around 0.5cm per year; maximum growth recorded is 2.2cm per year when at 60cm carapace length. The sex ratio is biased 70:30 in favour of females. This means that the turtles must be able to survive over this extended timescale before any reproduction can occur, making larger individuals particularly vulnerable to human exploitation. The population ecology of all species of sea turtles results in the species being well equipped to cope with very substantial losses at early stages in the life history, but they are not able to cope with continuous losses of breeding adults. This latter has been responsible for the drastic falls in the size of sea turtle populations in modern times.

Australia supports the largest populations anywhere in the world. The eastern Australian populations re-nest only on a mean of a five yearly cycle (range two to nine years) with fewer than 20% returning after less than three years. Clutch sizes average 120–140 eggs with a mean of 2.4 clutches laid in the nesting year (range one to six) and nesting at two-weekly intervals. The nesting females of this population have curved carapace lengths (CCL) of 63-95cm and weigh between 32 and 72kg. Nest predation on mainland beaches is very high – feral pigs, dogs and monitor lizards (*Varanus indicus*) destroy approximately 90% of the nests. However, it is virtually zero on coral cays unless the eggs are harvested by native Australians, and small islands are the favoured rookery sites (Bustard 1976).

The population of the north of the Great Barrier Reef/Torres Strait is independent of the stock which breeds on the north-west shelf of Western Australia.

Fig. 4. Map showing the central coastline of western Australia to highlight the Dampier Archipelago with Rosemary Island at the top of circled area.

Turning to the western Australian rookeries, the Dampier Archipelago (Fig. 4) in the Pilbara is home to one of the world's largest remaining hawksbill populations: Rosemary Island (Fig. 5) has in the order of 1,000 nesting females annually making it probably the largest hawksbill rookery in the world. In Western Australia nesting takes place between October and January (mid-spring to summer). Adult females are much larger (mean CCL 111.5cm) than those in eastern Australia. The re-nesting cycles are also shorter – mean 3.7 years. These data would suggest a nesting population for Rosemary Island alone of the order of 4000 nesting females (1000×3.7) which is twice the number proposed for the whole of Western Australia (Anon 2013). Hawksbills have other rookery areas in Western Australia but the size of the populations is as yet unknown. There are two further factors

Fig. 5. Rosemary Island, Western Australia, one of the world's two largest hawksbill rookeries.

which make Western Australia by far the world's most important hawksbill populations in conservation terms. Firstly, unlike the situation in Queensland and in many populations elsewhere in the world where the turtles migrate between different jurisdictions, I am advised by the Western Australian government that:

'Based upon satellite tracks or flipper tag returns to date there is no evidence that Pilbara hawksbills migrate outside W.A. boundaries.' (Tony Tucker pers. comm.).

And secondly that:

'The nesting abundance of Rosemary Island hawksbills appears to be stable based on Western Australia Department of Parks and Wildlife (DPAW) data from 2003-2012. Varanus Island hawksbill abundance appears to be stable based on DPAW data from 1989 to 2007.' (Tony Tucker, pers. comm.).

This situation appears to differentiate the western Australian populations from those of Queensland set out below. The Dampier Archipelago, Thevenard Island and Barrow Island of Western Australia are nature reserves and together with the Montebello Conservation Park provide protected nesting habitat for a significant part of the state's hawksbills. Importantly, the foraging areas in Western Australia are being managed as protected habitats for them. To put the huge areas involved into perspective the state of Western Australia alone has a coastline of 13,500km.

We now know that there are at least 72 rookeries within the northern Great Barrier Reef/Torres Strait region of Queensland. The largest is Long Island, with between 500-1000 nesting females per year, followed by Hawkesbury Island and Dayman Island, each having more than 500 (Limpus 2009). In the early 1970s I recorded 76 nesting hawksbills on Long Island in one 24-hour period in July (mid-winter) making this clearly a most important rookery. On the 14-day re-nesting cycle this could imply a rule of thumb figure of the order of 1000 nesting females (14x76=1064) using this rookery

in a single year, assuming 76 to be an average daily figure over that 14 day cycle. Interestingly, recent research indicates that this is the current order of magnitude for Long Island. However, with my data being well outside the widely believed main nesting season of January to February, combined with the fact of year-round nesting in this location, the total figure then might have been even more.

As well as the three most important Queensland rookeries, the following nesting sites provide many more annual nesting females:

13 islands with between 100 and 500, 28 islands with between 10 and 100 and 27 islands with between one and ten (Limpus, ibid.).

It is obvious that the first two groups of islands above account for some thousands of additional annual nesting hawksbills, so I conclude that the Queensland population may be considerably larger than Western Australia's which itself remains to be fully enumerated.

Many Queensland rookeries are within national parks. However, all the rookeries in Torres Strait and along Western Cape York Peninsula are in Aboriginal or Torres Strait Islander land including the three largest island populations referred to above. I do not see this as a key conservation problem since utilisation of wildlife by these indigenous peoples has decreased markedly and will continue to do so as hunting becomes less and less important to their way of life.

Milman Island, situated off the Cape York Peninsula, has been used as a reference point for Queensland populations, having been monitored annually for one month from mid-January to mid-February in 1990 and the 1992-1999 breeding seasons (Limpus, ibid). After this there was a gap of four years until it was again monitored in 2015. On the basis of these data some Queensland researchers have said that the population is declining by 3 to 4% annually. Looking at the published data for the years 1990-1999 I would not be confident in making such a prediction. Unfortunately, I was advised that the data for the years subsequent to 1999 will not be made available to researchers until published (Limpus, pers. comm.). The data for 2015, which is available, does indicate a fall in numbers. However, since numbers of nesting hawksbills can vary greatly between years, data from one year does not provide a sound basis for deciding the population trend. I also question whether it is sound science to infer an overall trend for the whole northern Great Barrier Reef/Torres Strait region based on data from a single island.

The Arnhem Land subpopulation is reported to have more than 2,500 females nesting annually (Limpus, ibid.).

Hawksbills show a strong tendency to return to nest at the rookery of their birth but between nesting seasons they are highly migratory. The Great Barrier Reef World Heritage area and associated Great Barrier Reef Marine Park together with Queensland State marine parks provide the largest

protected marine area in the world. However, this is still not large enough to adequately protect this species. The Queensland population regularly visits the Solomon Islands, south-east Indonesia and southern Papua New Guinea. We believe that substantial losses of adults occur when they undertake these migrations, and that the population may not be able to withstand these losses on a continuing basis. Furthermore, the Arnhem Land population contributes to the huge harvest in Indonesia.

The Japanese bekko (tortoiseshell) trade

Tortoiseshell has been greatly prized since ancient times. When Julius Caesar defeated Cleopatra in Egypt he considered the warehouses of Alexandria, brimming with tortoiseshell, to be the chief spoil of his Egyptian triumph. This trade has increased enormously over time, putting great pressure on hawksbills. In Australia, the 'Malay' trade was monitored in the late 1880s to 1890s when in excess of one ton of tortoiseshell was exported annually from Arnhem Land – equivalent to an annual harvest of over 1,000 adult hawksbill turtles. In Torres Strait over the same period a similar quantity was exported, so a total of 2,000 adult turtles was taken each year from these two areas in Australia.

Clearly there must have been huge hawksbill populations in these areas to support this trade for almost a century. Incidentally, there is no evidence of such harvests having occurred in Western Australia.

Looking specifically at the Japanese demand for tortoiseshell which has accounted for 90% of world demand, many millions of hawksbills have been killed in the last hundred years. In 1977, when CITES was established, more than 45 countries were involved in exporting and importing raw tortoiseshell. Despite CITES prohibition this trade remained high as a result of Japanese demand. Based on the trade from the 1950s to 1992, when legal Japanese imports ceased, Japan imported the quite remarkable total of the shells of 1,374,242 hawksbill turtles and 575,000 stuffed juveniles. Numerous irregularities in bekko imports occurred in the final year of Japan's trade under its CITES reservation (which permitted it to continue to trade in tortoiseshell for 16 years after the ban was implemented). After Japan officially banned all imports in 1993, annual Japanese domestic sales from stockpiled supplies remained high. Between July 1995 and July 1998 the stockpile was reduced from 202.73 to 188.4 tonnes (equal to a fall in the shell from 94,000 to 71,360 hawksbills (TRAFFIC East Asia-Japan 2000). Information on subsequent sales and use is not available, but supplies would now be exhausted if utilisation had continued at 28 tonnes (the shell of 28,000 hawksbills) a year after July 1998. However, the bekko industry remained intact in 2000 and Japanese consumer demand continued high with the valuable raw shell from abdominal plates ranging in price from US$942-1470 per kg at that time (see above reference).

Twenty-first century global trade

According to TRAFFIC (2004 & 2006) significant domestic trade in tortoiseshell remains a major problem in many countries and despite prohibitions on international trade this remains a pervasive threat in the Americas, Asia and parts of Africa. We also consider it to be a serious threat to the large hawksbill populations of Torres Strait/northern Great Barrier Reef and Arnhem Land when they leave Australian waters migrating to feeding grounds elsewhere. Over time the Queensland population may not be able to withstand this level of illegal trade. Some Japanese dealers have continued to import shell illegally as evidenced by numerous large shipments intercepted en route to Japan since the ban took effect. Furthermore, an ongoing underground trade from south-east Asia to Japan continues unabated. More than a decade after the Japanese prohibition on bekko came into effect, the Japanese Bekko Association was reported to be interested in the illegal acquisition of Indonesia's large stockpiles of bekko. Indonesia's trade in tortoiseshell was substantial and Indonesian stockpiles remain to be seized by the authorities. Surveys in Vietnam in 2002 revealed an active international trade in tortoiseshell that had increased since 1999. Shell was being purchased in bulk for export to Hong Kong, Japan, etc. There continues to be an extensive underground trade in tortoiseshell which the law enforcement authorities are inadequate to deal with.

Against this backdrop I am unable to agree with Mrosovsky's (2000) monograph entitled 'Sustainable use of Hawksbill Turtles' advocating sustained use. In taking this approach Mrosovsky is recommending utilisation as he did in the case of the huge olive ridley rookery in eastern India which we have studied for 40 years. My views then – which agreed with those of the Government of India – were that such a scheme would not be workable under Indian conditions (Bustard 2014). In my view, legalising any harvest of hawksbill turtles would seriously undermine current attempts to stop international trade in tortoiseshell because it would not be possible in practice to distinguish between legal and illegal shell, as with the legal Hong Kong trade in ivory which is providing cover for a continuing large illegal trade. Similarly, any illegal trade in tortoiseshell would play into the hands of the main tortoiseshell market – Japan – which is why Japan went to great lengths, fortunately unsuccessfully, to reopen the Cuban trade. During 1991-2006 the Japanese government spent the equivalent of US$6 million on research on hawksbill resources (i.e. where they could get them from) and US$1.1 million on projects to resume international trade including trade with Cuba. It was also reported that the Ministry of Economy, Trade and Industry in Japan would support the bekko industry for another five years.

It is my belief that extensive illegal trade of tortoiseshell to Japan is continuing on a substantial scale. I also believe that this could be contributing to the possible reduction in the Australian north-eastern Great Barrier Reef/Torres Strait population. The likely scale of the killing of North Queensland tagged hawksbills when they migrate up into Papua New Guinea, the Solomon Islands and Vanuatu for nesting would suggest a substantial harvest exceeding the local demand for scutes. This strongly suggests there is a trade up into Asia. Two summers ago Australian Fisheries arrested a Vietnamese fishing vessel off the Arnhem Land coast which was fishing exclusively for hawksbills for making stuffed turtles and for giant clams (Limpus, pers. comm.).

Conservation of all hawksbill turtle populations in the many jurisdictions where they still occur worldwide should be actively encouraged. However, the huge populations occurring in Australia will be invaluable to the long-term survival of the species, as will the substantial populations elsewhere. Australia provides an outstanding habitat as it is a stable democracy; the hawksbills occur in three separate jurisdictions – the states of Queensland, the Northern Territory and Western Australia – each state being huge on a world scale. All three states are under the overall umbrella of the Australian government. A major contribution of this paper is to highlight the size and conservation status of the Australian populations which is not widely appreciated. Data on the size of two of the three populations are presented here for the first time.

Conservation status

There is a need to look at the conservation requirements of not only this species, but also the other four species which occur circum-globally, on a geographical basis so as to highlight areas where they may be critically endangered but could recover under first class management. This should not detract from making every effort to maintain the large populations elsewhere. This would enable the conservation status to be shown on a geographical basis. Some countries do not accept the IUCN status of 'critically endangered' for the hawksbill turtle. For instance, Australia only lists hawksbills as vulnerable, which is eminently sensible for their populations.

Conclusion

Hawksbill turtles suffer from the problems common to all sea turtles, which include alienation of nesting habitat and bycatch in fishing nets; but they also have the additional problem of the continuing substantial demand for tortoiseshell. Unless this problem can be successfully addressed the future of the hawksbill turtle will be bleak throughout most of its range.

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