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Australian Tropical Reptile Species: Ecological Status, Public Valuation, Attitudes to their Conservation and Commercial Use

Abstract

Five species of reptiles present in tropical Australia are considered in this study. These are the hawksbill turtle (*Eretmochelys imbricata)*; the northern long-necked turtle (*Chelodina rugosa)*; the taipan snake (*Oxyuranus scutellatus)*; the freshwater crocodile *(Crocodylus johnstoni)*; and the saltwater crocodile *(Crocodylus porosus).* Background information is provided on the ecological status of each of these species and after outlining their human use (including commercial use) and management in Australia, an experimental survey method is introduced and results from its application are reported and analysed. The survey method involves two serial surveys of a sample of 204 Brisbane (Australia) residents. The first survey is based on the initial knowledge of the respondents of the reptile species and for the subsequent survey the knowledge available to participants about these species is experimentally increased. These surveys provide information on the amount of knowledge possessed by this sample of the public about the relevant reptile species, the respondents' attitudes to these species (including their attitudes to commercial use), respondents' support for the survival of these reptiles and for their conservation. Furthermore, data is gathered from the surveys on the comparative amount respondents' state they would be prepared to contribute to support the conservation of each of these focal reptile species. Respondents are asked to assume that they are given $1,000 and that this can only be allocated to the conservation of these reptiles. Later, however, they are also given the option to donate this money to any charity concerned with human welfare. The contingent valuation data for each of the reptile species are used to isolate factors that influence the comparative allocation of conservation funds to each of the relevant reptile species. Factors considered include the extent of the respondents' knowledge of the species, the stated degree to which respondents' reported that they liked or disliked the species, and ethical views of the respondents. Implications of the findings for the theory of economic valuation of wildlife species and for of the focal reptile species in Australia are discussed in concluding this chapter.

Australian Tropical Reptile Species: Ecological Status, Public Valuation, Attitudes to their Conservation and Commercial Use

1. Introduction

A large portion of Australia (approximately 40% of it) is located in the tropical zone, above the Tropic of Capricorn. This study focuses on five species of reptiles that occur in the Australian Tropics. The two species of crocodile considered, the saltwater crocodile (*Crocodylus porosus*) and the Australian freshwater crocodile (*Crocodylus johnstoni*), occur in Australia mainly in the tropics. The two species of taipan snakes are discussed of which one (*Oxyuranus scutellatus*) occurs mainly in the Australian tropics. Two species of turtles are assessed; the northern long-necked turtle (*Chelodina rugosa*) and the marine hawksbill turtle (*Eretmochelys imbricata*). The former occurs only in the Australian tropics and the latter occurs mainly in tropical waters but is sometimes found in subtropical waters.

After considering the ecological status of these species in Australia, we outline the use made of them in Australia by indigenous Australians, their potential uses and their commercial uses, giving particular attention to the saltwater crocodile. The saltwater crocodile is one of the least liked of the Australian reptiles but is commercially very valuable. It obtains the greatest commercial use of the reptile species considered here.

We then draw upon the results of a survey of a sample of 204 Brisbane (Australia) residents. This provides information about the sampled public's awareness of each of the focal reptile species and the extent to which they state that they like or dislike each of these species. From the latter, a 'likeability' index is calculated for each of the species based on the attitudes of the whole sample of respondents.

It is hypothesised that likeability is a major factor influencing the attitudes of the public to the survival of individual species, their support for the commercial harvesting of species and for their comparative willingness to allocate funds for the conservation of different species. This is tested using the likeability index for each of those reptile species and the results from the sample.

Note that the sample of reptile species was selected on the premise that they would reveal significant differences in awareness of them by the public and also in their likeability. As will be found later, this condition is satisfied.

Now let us consider the ecological status in Australia of the five focal reptile species. Strictly, this should be six species because there are two species of Taipan snake present in Australia, the western taipan and the coastal taipan. The western taipan only occurs below the tropics. However, both species were mentioned, and referred to commonly in the survey as 'taipan snake'.

2. Ecological Status in Australia of the Focal Reptile Species

2.1. Saltwater Crocodile

2.1.1. Description

The saltwater crocodile (*Crocodylus porosus*) (Figure 1), along with the Indian gharial, is the world's largest crocodilian species and reptile (Grenard, 1991; Ross, 1998). Generally, adults are 5 metres long and around 400 to 500 kg in weight, but adult males can reach sizes of up to 6 or 7 metres and weigh more than 1,000 kg (Ross, 1998). It is a large-headed crocodilian species with a shorter and broader snout than the Australian freshwater crocodile, and has a heavy set of jaws capable of crushing the bones of mammals as large as a buffalo (Ross, 1998; Cronin, 2001; EPA, 2002). Juveniles are normally pale tan in colour while mature adults are generally grey, brown to almost black, with creamy yellow bellies (Ross, 1998; Cronin, 2001). It has a fierce disposition and is known to injure or kill humans (Webb and Manolis, 1993, p. 250; Britton, 2002a).

Figure 1: A saltwater crocodile in northern Queensland

2.1.2. Distribution and Habitat

Saltwater crocodiles are the most widely distributed of the crocodilians, ranging from southern India, Southeast Asia to Papua New Guinea and Australia (Ross, 1998). In Australia, they are distributed in the coastal regions of northern Australia, from Broome in Western Australia through the Northern Territory to Gladstone in Queensland (see Figure 2).

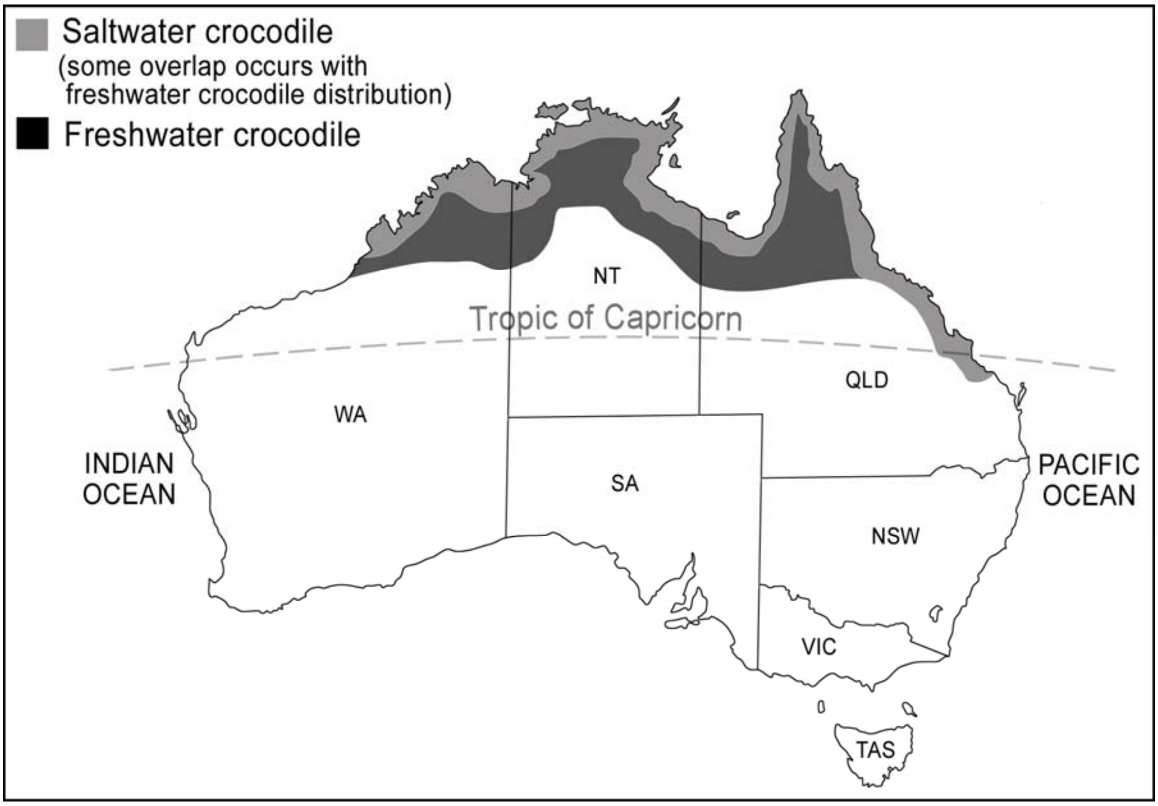

Figure 2: Distribution of the saltwater and freshwater crocodiles in Australia (based on Cronin, 2001)

The saltwater crocodile lives in coastal brackish water habitats and tidal sections of rivers (Ross, 1998). It is also found in freshwater sections of rivers and in freshwater swamps (Ross, 1998). It is known to frequent inland lakes, and can be encountered at sea, usually around the coasts (Webb et al., 1987; Messel and Vorlicek, 1989; Webb and Manolis, 1993).

2.1.3. Life History and Ecology

The saltwater crocodile breeds during the wet season (from November to March) (Cronin, 2001; EPA, 2002). Breeding and recruitment is established in the freshwater areas of rivers and freshwater swamps. Females become mature at lengths of 2.2 to 2.5 metres (about 12 years of age) and lay 40 to 60 eggs in mound nests about 45 centimetres high to prevent losses of eggs from flooding during rainfall (Webb et al., 1987; Cronin, 2001; Britton, 2002a). Incubation lasts around 90 days (Ross, 1998). The sex of the hatchling is determined by the incubation temperature in its nest, a phenomenon known as temperature-dependent sex determination (TSD) (Britton, 2002a). Low and high temperatures produce females while temperatures between 31 and 33°C produce males (EPA, 2002). This feature is much researched because it is of value for captive breeding programs to ensure the desired sex ratio (Britton, 2002a). TSD is also manipulated to produce males for farming purposes because male saltwater crocodiles have faster growth rates than the females (Britton, 2002a).

The saltwater crocodile is reported to be territorial. The growing male encounters competition from larger individuals for area, and is sometimes forced to move to marginal habitats like higher salinity rivers (Ross, 1998; Webb, 2002). This competition results in high mortality among intermediate-sized crocodiles (Ross, 1998; Webb, 2002). The survival of juveniles is sometimes threatened by large individuals who will kill and eat them (Britton, 2002a; Webb, 2002). Intraspecific competitive behaviour appears to be one of the main factors limiting the population size of this species in many areas (Britton, 2002a).

The diet of young saltwater crocodiles consist of small animals such as crabs, prawns, fish, frogs and insects. Larger crocodiles take bigger prey such as rodents, birds, pigs, wallabies that come close to the water's edge and even other crocodiles (Cronin, 2001; EPA, 2002).

2.1.4. Abundance, Survival Status, Threats and Conservation Overview

In Australia, intensive commercial harvesting for saltwater crocodile skins occurred in 1945 when the population of saltwater crocodiles in the Northern Territory numbered around 100,000 individuals (Webb et al., 1984; Webb et al., 1987; Webb et al., 2000). Protection was accorded to the crocodile in Australia beginning in the late 1960s (Western Australia in 1969, the Northern Territory in 1971 and Queensland in 1974) (Letts, 1987) when, after thirty years of unregulated hunting, the saltwater crocodile population became severely depleted (Webb et al., 2000). In the Northern Territory, for example, adult crocodiles were rare and the total population, consisting mostly of young juveniles, was thought to be no more than 5,000 individuals (Messel, 1977; Webb, 1997). Over the next thirty years, the population level of saltwater crocodiles rebounded to pre-exploitation levels (Webb et al., 1986; Webb et al., 1994) and this crocodile now occupies its complete historical range (Webb, 2002). Their estimated population size in Western Australia, Northern Territory and Queensland is now considered to be at least 100,000 to 150,000 adults (Britton, 2002a). It is considered to be at low risk or of least concern according to the IUCN Red List (IUCN, 2003). Highly threatened in many parts of the world, it is nonetheless considered unlikely to become extinct because its population is numerous and secure in Australia and Papua New Guinea (Ross, 1998). Other threats include predation of eggs by pigs and goannas and the destruction of nests from seasonal flooding (EPA, 2002). The saltwater crocodile is a CITES-listed species, and comes under Appendix II for controlled trade in Australia, Papua New Guinea and Indonesia and under Appendix I prohibiting trade in all other countries (Ross, 1998). This reflects the success of crocodile management strategies in Australia in ensuring effective conservation and subsequently successful sustainable farming and wild harvesting programs (Ross, 1998; Webb, 2000a).

2.1.5. Possible Implications of Territoriality and Intraspecific Competition for Sustainable Harvest levels of Wild Crocodiles

The chief form of competition the saltwater crocodile faces in its habitat in several areas in Australia is intraspecific competition (i.e., competition within species). Interspecific competition on the other hand is low or negligible for the saltwater crocodile because the species is located at the top of the food chain in its ecosystem (EPA, 2003b) and has little extra-species competitors or predators (if predation of eggs is excluded). Interspecific competition occurs with its sympatric species, the freshwater crocodile, where as Webb et al. (1983) point out saltwater crocodile competitively exclude or prey upon freshwater crocodiles at overlapping habitat areas. Therefore, a significant ecological relationship exists between sustainable use or harvesting and intraspecific competition of saltwater crocodiles.

The territorial behaviour saltwater crocodiles exhibit is a form of intraspecific competition (Webb and Manolis, 1989; Begon et al., 1996, p. 253). In the tidal waterways of northern Australia, the saltwater crocodile occupies year-round territories where breeding and nesting occur (Lang, 1987). Territories are established and maintained by dominant males, from which other males are excluded but females are tolerated (Lang, 1987). A male's territory may encompass the nesting sites of several females (Lang, 1987). Females are also territorial with nesting sites. The energy spent defending and maintaining territories results in gains in terms of increased survival or productivity of the territorial animal (Bolen and Robinson, 2003). Given that suitable area is a limiting factor, it is a zero-sum game: the animal that has failed to secure a territory for itself loses out in terms of access to resources such as food, favourable habitat and potential mates. These individuals frequently do not reproduce and suffer higher mortality rates than the owners of territories (*cf.* Jenkins et al., 1963; Begon et al., 1996, p. 253). These difficulties have been observed among the smaller, subadult saltwater crocodiles that have been disadvantaged by larger adults. Territory formation

thereby restricts breeding, setting a limit on the sizes of breeding populations (Bolen and Robinson, 2003). The rate at which the population expands is thus regulated.
Evidence of intraspecific competition in saltwater crocodiles exists. In a study of saltwater crocodile population sizes in the Blyth-Cadell River system in the Northern Territory during the years of protection between 1974 and 1990, Webb and Manolis (1992) found that while overall crocodile population size showed an increasing trend, there was also a negative correlation between the numbers of juveniles (2, 3 and 4 year olds) with increasing density of larger crocodiles (6 years old and above). The decreasing abundance of smaller crocodiles is thought to be evidence of direct predation on juveniles by larger crocodiles and/ or the exclusion of juveniles by larger crocodiles (Webb et al., 1996).

However, currently ongoing studies of Queensland saltwater crocodile populations seem to show that saltwater crocodile territories in the wild overlap to quite a degree, suggesting that the high competitive exclusion usually assumed may have been overestimated (Mark Read, personal communication, 22nd July 2004). Possibly competitive territoriality varies from place to place depending on biological and natural conditions. There are comparatively greater saltwater crocodile densities in the Northern Territory than in Queensland, and abundant suitable landscape features in the Northern Territory (e.g. long meandering river systems that provide good habitat for the crocodiles) compared to the Queensland east coast (where development may have also had some effect). Environmental factors control saltwater crocodile populations more in Queensland than in the Northern Territory where intraspecific competition is possibly more controlling, according to preliminary findings by Mark Read (personal communication, 22nd July 2004). This may explain the possibly stronger territoriality of saltwater crocodiles in the Northern Territory than in Queensland.

At first blush, the idea of harvesting adult crocodiles possesses intuitive appeal because it can be envisaged that through population regulation other competing adults or subadults will rapidly take the place of the removed (or dead) territory holder (*cf.* Begon et al., 1996, p. 253). However, the wisdom in harvesting territory-holding saltwater crocodiles is unclear. Lang (1987) for instance contends that although some territory holders or large adult animals that are not breeding may appear to be “surplus” animals, the removal of the larger animals with high reproductive potential can destabilise long-standing social relations in a population and decrease in the long-term the population’s overall reproductive success (Lang, 1987). Studies of other territorial animals inform that enough males should be left in the adult age or size class that are developing territoriality so that the annual supply of physically and socially mature males is not undermined (see Wilson and Franklin, 1985; Franklin and Fritz, 1991, p. 329).

It is thus hypothesised, based on the theory of compensatory mechanism (Errington, 1946, 1967), that the harvesting of the non-breeding segment of the population (particularly the subadult males) that would perish in any case through competition would be favourable and ensure minimal net loss to the population. Despite the evidence presented by Webb et al. (1996) from their Blyth-Cadell River system studies of decreasing abundance of smaller crocodiles, they point out that recruitment into the older age classes is continuing and expect harvesting to be sustainable. This would suggest that in areas like the Northern Territory where wild populations are closer to carrying capacity and contain more larger-sized animals, the populations could sustain a substantial harvesting rate without significant decline in population size. Population growth rates may increase because of higher per capita resource availability, increased juvenile or subadult survivorship and increased fecundity (Thorbjarnarson, 1991, p. 231).

The situation may be different in Queensland where the environmental factor is the limiting factor in many areas, holding population densities and size classes at lower levels and rendering sustainable harvesting not very feasible. The effects of harvesting are being investigated in the trial harvests conducted in the Northern Territory (Webb et al., 1996). Similarly, the harvesting of eggs that would otherwise be destroyed by flooding appears to leave recruitment unaffected; the number of non-hatchlings counted in the Adelaide River has steadily increased even with the harvesting of 22,823 eggs over a period of twelve years (Webb et al., 1996).

Consider the possible relevance of standard theories of the population dynamics of wild vertebrates to the net recruitment and level of harvestable biomass of saltwater crocodiles. This relationship is commonly assumed to be of a symmetric inverted U-shape, usually quadratic, as a function of the population of the species. If this is so, the maximum sustainable yield (MSY) or maximum sustainable harvest of the species occurs at half the population level that corresponds to the carrying capacity of its environment (Caughley and Sinclair, 1994).

However, when considerable intraspecific competition occurs (as it does for some population of crocodiles), the net recruitment curve or curve of net change in biomass of a species as a function of population density is likely to be skewed or asymmetric as illustrated in Figure 3 (*cf.* Begon et al., 1996, p. 221). This implies that MSY corresponds to a population closer to carrying capacity than in the symmetric case. It also indicates that because of intraspecific competition, the species can withstand a high level of harvesting pressure when its population level is near carrying capacity without greatly reducing its sustainable level of population. Basically this is because harvesting pressure reduces intraspecific competition.

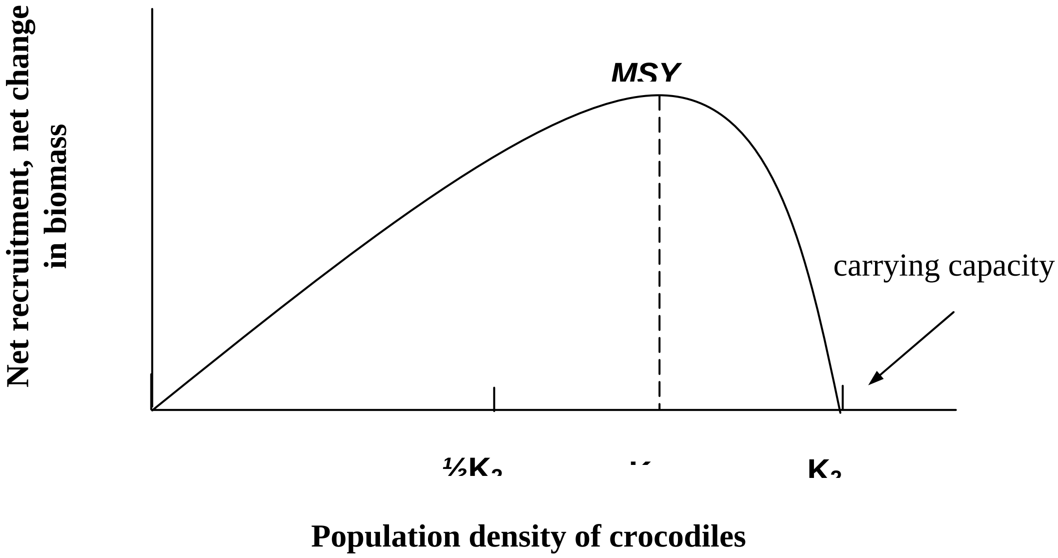

Figure 3: As a result of intraspecific competition, the net recruitment or net change in biomass of populations of saltwater crocodiles may be a skewed or asymmetric curve like the above one (adapted from Begon et al., 1996)

It should, nevertheless be borne in mind that the situation illustrated in Figure 3 is based on highly simplified theory. It does not, for example, take into account the age classes harvested of the population. The above discussion of saltwater crocodiles indicates that this can be a relevant consideration when assessing the sustainability of net recruitment or harvest. Furthermore, in one environment intraspecific competition may be an important influence on the population levels of a species, such as the saltwater crocodile, but not in others. As suggested above, intraspecific competition of saltwater crocodiles may be a much more important factor influencing their population levels in the Northern Territory than in Queensland, Australia.

2.2. Freshwater Crocodiles

2.2.1. Description

The freshwater crocodile (*Crocodylus johnstoni*) is a small- to medium-sized freshwater crocodile unique to Australia (Ross, 1998). It is similar to other Asian freshwater crocodilian species but is morphologically distinct because of its long, unusually narrow and tapering snout (Ross, 1998; Cronin, 2001; Britton, 2002b). Adult males can grow to sizes of up to 2.5 to 3 metres and can have bodyweights of 70 to 80 kg (Webb and Manolis, 1993; Ross, 1998; Britton, 2002b). Their powerful jaws can crush turtle shells, and have very sharp teeth that intermesh when the jaws are closed (Cronin, 2001). The freshwater crocodile has grey to olive brown body colour, with darker bands forming across the back and sides (Cronin, 2001; Britton, 2002b). Though it occasionally bites swimmers during the courtship season, this species is generally considered harmless to man (Webb and Manolis, 1993).

2.2.2. Distribution and Habitat

The freshwater crocodile is restricted to the tropics of Western Australia, Northern Territory and Queensland (see Figure 2) (Ross, 1998). It inhabits various permanent freshwater areas such as floodplain lakes, billabongs and swamps, including less saline upstream areas of river systems and creeks (Ross, 1998). The freshwater crocodile is generally not found near the coast, where prohibitive high salinity and competition with the more dominant saltwater crocodile renders this habitat far less favourable (Britton, 2002b). However, they may be found in some tidal estuaries where the saltwater crocodile is absent (Cronin, 2001).

2.2.3. Life History and Ecology

Freshwater crocodiles breed during the dry season (from August to September) (Cronin, 2001; EPA, 2002). The female freshwater crocodile lays its eggs in moist holes dug into sand bars that become exposed in the dry season (Ross, 1998, Cronin, 2001). Clutch size averages 13 eggs, but range from 4 to 20 (Britton, 2002b). The incubation period is usually 75 to 85 days (Webb et al., 1983). Temperature-dependent sex determination is also evident in the freshwater crocodile (Britton, 2002, p.2). Feral pigs and goannas are major predators of eggs (Britton, 2002b). Often only 1% of hatchlings survive to reach maturity, and in some years predation pressures are so great that it is unlikely that any contribution is made to the adult population pool (Britton, 2002b).

The freshwater crocodile eats fish; the shape of its snout itself suggests primary adaptation to a piscivorous diet (Britton, 2002b). They feed on a variety of other prey too, such as invertebrates and small, young vertebrates, lizards, turtles, bats and birds (Britton, 2002b; EPA, 2002). Larger individuals may even take small terrestrial species that come close to the waters edge (Britton, 2002b).

2.2.4. Abundance, Survival Status, Threats and Conservation Overview

Freshwater crocodiles have survived long-term traditional hunting by Australian Aborigines for food. At the end of the 1950s as saltwater crocodile populations declined, commercial hide-hunters targeted freshwater crocodiles, causing widespread reduction of their populations (Britton, 2002b). The freshwater crocodile has since been accorded protection (Western Australia in 1962 and the Northern Territory in 1964) (Letts, 1987). Populations are said to have recently recovered to a significant extent (Britton, 2002b). The wild population size of the Australian freshwater crocodile is estimated at between 50,000 to 100,000 (Britton, 2002b). According to Britton (2002b), the IUCN Red List ranks this species as at ‘low risk’ and of ‘least concern’. Threats to the species still exist in the form of habitat destruction, and possibly some mortality caused by an invasive species, the cane toad (*Bufo marinus*) (Britton, 2002b). Under CITES, it is included in Appendix II, which allows legal but controlled trade (CITES, 2003). There are now small-scale farming and ranching programs for the freshwater crocodile in Australia, and monitoring and management studies that have been in place since the 1970s continue (Britton, 2002b).

2.3. Taipan Snakes

2.3.1. Description

Australia’s two species of taipan snakes, the coastal taipan (*Oxyuranus scutellatus*) and the western taipan (*Oxyuranus microlepidotus*), are among the continent’s largest snakes and probably the most dangerous venomous snakes in the world (Shine and Covacevich, 1983; Cogger, 2000). Mature adults of both species measure on average 2 metres in length (Cogger, 2000). The coastal taipan is uniform light to dark brown above, paling on the sides to creamy-brown while the western taipan is rich brown or olive-brown above and scales with dark brown or black anterior edges sometimes forming obscure cross-bands (Cogger, 2000).

2.3.2. Distribution and Habitat

The coastal taipan is found in the Kimberley Division of Western Australia, the northern part of the Northern Territory and along the coasts of eastern Queensland (see Figure 4) (Cogger, 2000). It is also found in the extreme north-eastern corner of New South Wales (Cogger, 2000). The habitats of the coastal taipan are tropical wet and dry sclerophyll forests, open savannah woodlands and cultivated areas such as sugarcane fields (Cogger, 2000; Queensland Museum, 2003a). The western taipan on the other hand is distributed further inland, in western and south-western Queensland, north-eastern South Australia and western New South Wales (Cogger, 2000). Its habitats are in arid to semi-arid drainage regions of inland river systems, in sparsely-vegetated sites, on flood plains with deep cracking soils, on lateritic gibber plains and on sand dunes and rocky outcrops (Cogger, 2000; Cronin, 2001). It occurs only below the Tropic of Capricorn.

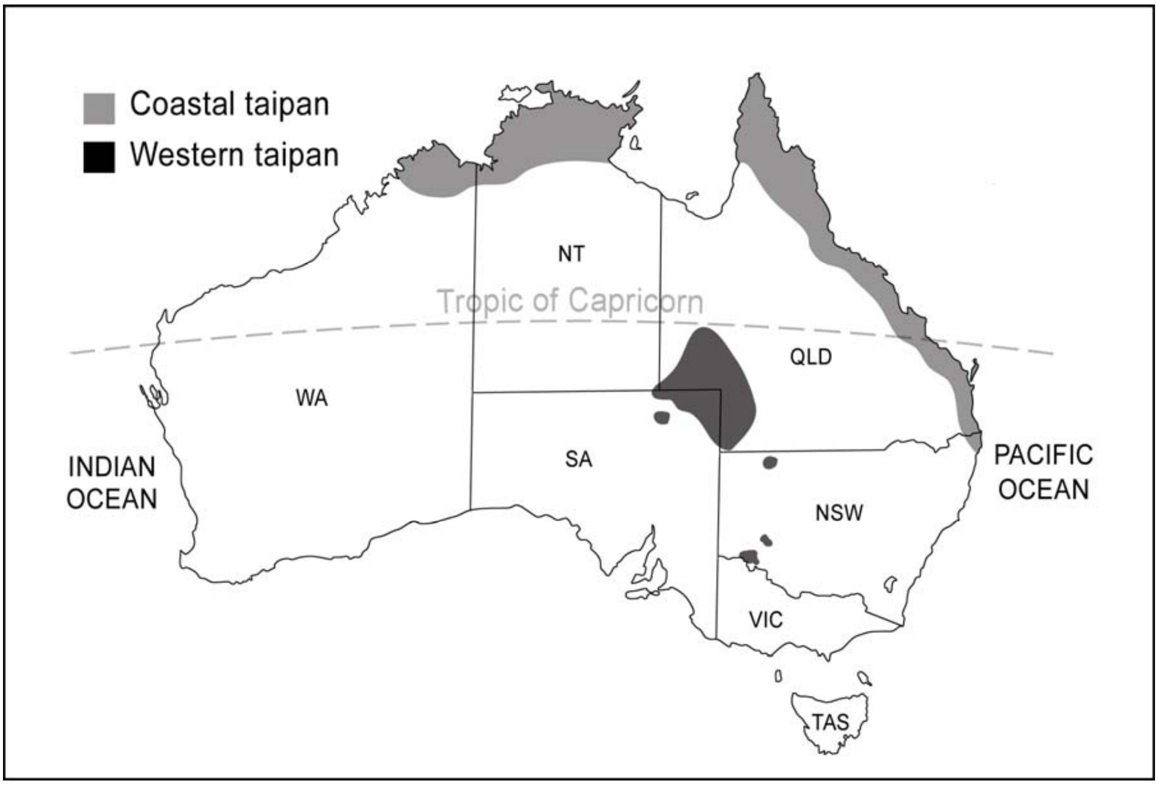

Figure 4: Distribution of taipan snakes in Australia (based on Queensland Museum, 2003a, 2003b; Cogger, 2000)

2.3.3. Life History and Ecology

Taipan snakes are mostly diurnal, though the coastal taipan is sometimes nocturnal (Cogger, 2000). Egg-layers, the coastal taipan and western taipan breed between July and December and have recorded clutches of about 3 to 20 eggs (Cogger, 2000) and 12 to 20 eggs respectively (Cogger, 2000; Cronin, 2001). Taipans are unique among Australian elapid snakes because they specialise in mammalian prey. They feed on rats (*Rattus* spp.), house mice (*Mus musculus*), bandicoots (*Isoodon macrourus, Perameles nasuta*) and quolls (*Dasyurus hallucatus*). The coastal taipan is also known to consume some birds (Shine and Covacevich, 1983; Shine, 1991). The coastal taipan has a notable method of killing its prey: it bites and then usually releases the victim immediately, knowing the prey will not go far before dying (Shine and Covacevich, 1983; Gow, 1989). This is an energy-saving response.

2.3.4. Abundance, Survival Status, Threats and Conservation Overview

There have been records of elapid snake deaths and the decrease in populations in Australia since the introduction of an exotic and toxic species, the cane toad (*Bufo marinus*) (Shine and Covacevich, 1983). Consumption of these toads kill snakes that eat them. This is especially so in places where the toads have invaded, like the cane-growing areas of Queensland (Shine and Covacevich, 1983). The numbers of taipan snakes however have shown no apparent decline over the same period (Shine and Covacevich, 1983). It is presumed that the widespread establishment of sugarcane farms provided habitat for and increased the densities of rats, which in turn allowed the taipan snake to thrive whilst other elapid species that are dependent on uncleared forested areas were disadvantaged (Shine and Covacevich, 1983). The taipan snake populations, though sparsely distributed, are presently considered secure (Cronin, 2001).

2.4. Northern Long-necked Turtle

2.4.1. Description

The northern long-necked turtle (*Chelodina rugosa*) is a tropical freshwater turtle (see Figure 5) distinguished by its flattened head and very long neck that when extended together exceed the length of its shell (Cronin, 2001). It has nostrils at the tip of its snout, enabling it to breathe while submerged (Cronin, 2001). Its shell is broadly oval and is wider towards the rear (Cogger, 2000; Cronin, 2001). It is usually dark brown to black in colour above with darker flecks and blotches; its ventral area is whitish (Cogger, 2000; Cronin, 2001). Adults weight up to 4 kg and their shell length measures about 40 centimetres long (Cogger, 2000; Cronin, 2001; Kennett, 2004).

Figure 5: The northern long-necked turtle

2.4.2. Distribution and Habitat

The northern long-necked turtle probably occurs in all rivers running to the sea, from the Kimberly district in Western Australia, across the coastal regions of the northern Territory to Cape York in Queensland (see Figure 6) (Cann, 1998; Cogger, 2000). Apart from large slow-flowing rivers, the habitats of the northern long-necked turtle include freshwater lagoons and lakes, billabongs and swamps (Cann, 1998; Cronin, 2001).

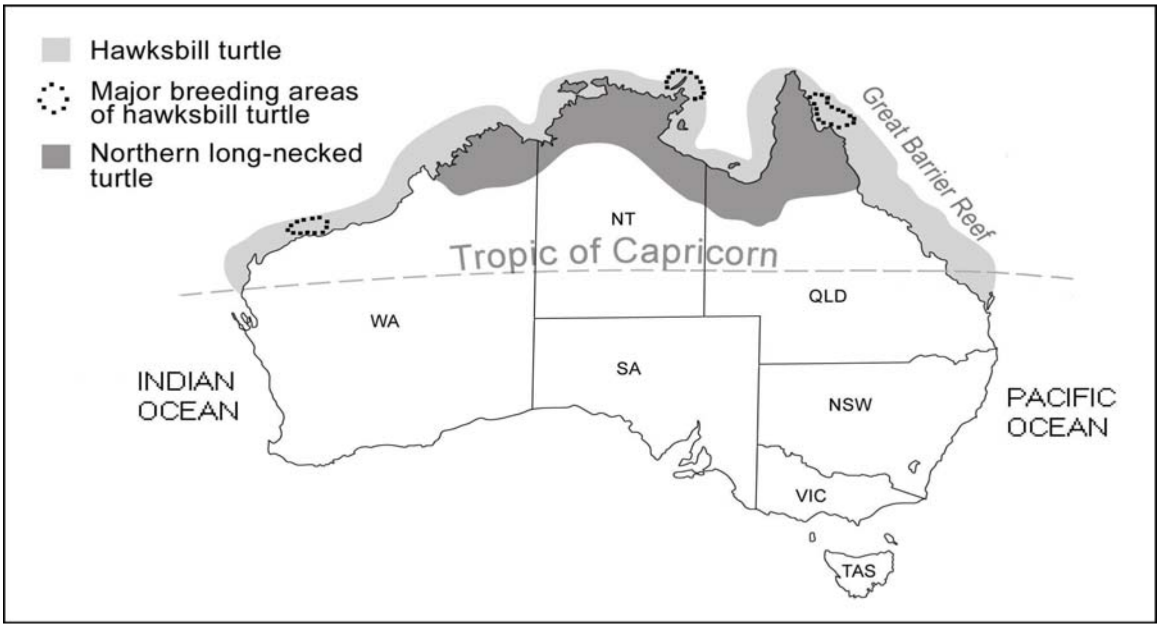

Figure 6: Distribution of the hawksbill and northern long-necked turtles in Australia (based on Cann, 1998; Cogger, 2000; Cronin, 2001; DEH, 2004a)

2.4.3. *Life History and Ecology*

Among Australia's freshwater turtles, the northern long-necked turtle is unique in that it nests and lays its eggs under water (Reader's Digest, 1997; Kennett, 1999). Nesting occurs in the wild during the dry season, from March to September (Cann, 1980; Kennett et al., 1993; Cronin, 2001). The female produces on average two clutches a season (sometimes up to four clutches per season) of 12 to 20 eggs (Cann, 1998; Cronin, 2001).

Unlike all known reptiles, the eggs are laid in moist soil rather than on dry land, in holes dug in banks by the water's edge where they incubate under the sun's heat (Cann, 1998). The eggs hatch at the beginning of the next wet season, from December to January (Cronin, 2001).

The northern long-necked turtle survives drought periods by aestivating, the summer equivalent of hibernating (Kennett, 2004). They do this by burying themselves in drying mud and do not emerge until the return of the wet season (Kennett, 2004).

The turtle is a very efficient carnivorous predator (Cann, 1998). With its long neck it strikes and captures its prey swiftly (Kennett, 2004). They feed primarily on fish, crustaceans, tadpoles, frogs and aquatic insects but even eat snakes (Cann, 1998; Cronin, 2001).

2.4.4. *Abundance, Survival Status, Threats and Conservation Overview*

The populations of the northern long-necked turtle are considered secure (Cronin, 2001). The turtle is a traditional food and its flavoursome meat is a significant protein source of the Australian Aborigines (Kennett, 2004; Fordham, undated). They have been consumed by the Aboriginal people for tens of thousands of years and is considered to represent one of the "world's longest-running and ecologically sustainable wildlife harvests" (Kennett, 2004).

2.5. *Hawksbill Turtles*

2.5.1. *Description*

The hawksbill turtle (*Eretmochelys imbricata*) is a medium-sized marine turtle that is distinctive for its sharp beak-like upper jaw and beautiful shell that is highly sought after for ornamental trade (see Figure 7) (Cronin, 2001; NMFS, 2001). The shell is olive-green or dark brown in colour with streaks and marbles of amber, yellow or reddish-brown (Kemf et al., 2000; Cronin, 2001). The shell is narrowly heart-shaped and serrated at the rear, with 4 overlapping plates on each side (Cronin, 2001). Its ventral area is cream (Cronin, 2001). It grows to about almost 90 centimetres in length and weighs 60 to 80 kg on average (NMFS, 2001; WWF, 2004).

Figure 7: A hawksbill turtle in a pen at Crocodylus Park near Darwin, Northern Territory

2.5.2. Distribution and Habitat

The hawksbill turtle occurs in tropical and subtropical seas and nests in more than 60 countries (WWF, 2002; NMFS, 2001). In Australia, its distribution is along the tropical and warm temperate coastal waters and islands of Western Australia, the northern Territory and Queensland, even extending as far south as northern New South Wales (see Figure 6) (Cronin, 2001; DEH, 2004a). Their common habitats are tidal and sub-tidal coral and rocky reefs (DEH, 2004a). In Australia, hawksbills feed in rocky areas and on coral reefs (GBRMPA, 1996). Their main feeding area extends along the east coast of Australia, including the Great Barrier Reef (GBRMPA, 1996). There are three main breeding areas in Australia: the northern Great Barrier Reef and the Torres Straits region (internationally significant area for hawksbill turtle nesting), the archipelagos of the Northern Territory and Western Australia (GBRMPA, 1996; DEH, 2004a).

2.5.3. Life History and Ecology

The female hawksbill turtle breeds in 2 to 5 year cycles and produces 3 to 5 nests at about bi-weekly intervals in a single breeding season (WWF, 2002). The female comes ashore at night and usually lays clutches of 50 to 130 eggs, in nest chambers dug into the sand of the beaches beyond the high tide line (Cronin, 2001; Lutz and Musick, 1997, p. 65). Eggs hatch 52 to 57 days later, the male-female proportion of hatchlings determined by incubation temperature (Cronin, 2001). Hatchlings emerge and they dash to the water under cover of darkness (Cronin, 2001). Small turtles spend their first years of life carried by the currents of the open ocean, then move to near-shore waters, reef habitats and areas with hard, sandy bottoms (WWF, 2002). In the wild, they reach maturity late at between 20 to 50 years of age (WWF, 2002). A major part of the hawksbill turtle's diet is made up of sea sponges, although they also eat seagrasses, algae, sea cucumber, shellfish, some crustaceans and molluscs (GBRMPA, 1996; Cronin, 2001; WWF, 2002).

2.5.4. Abundance, Survival Status, Threats and Conservation Overview

The hawksbill turtle global population is believed to have declined by 80% over the past few decades (Red List Standards & Petitions Subcommittee, 1996). Intense national and international trade in hawksbill shell has led to widespread concerns that the species is seriously overexploited (Meylan, 1998; Bjorndal, 1999; WWF, 2002). Other threats worldwide include hunting for meat and eggs, loss of nesting beaches and feeding areas, fisheries by-catch, and marine pollution and debris (Cronin, 2001; WWF, 2002). Threats within Australia include death by ingestion of synthetic materials, drowning in shark control nets and fishing gear, and fox and goanna (*Varanus* lizard) predation of eggs along Queensland coast (GBRMPA, 1996). The hawksbill turtle is listed in IUCN's Red List (2003) as critically endangered. It has been listed in Appendix I under CITES since 1977, prohibiting its commercial international trade (WWF, 2002; CITES, 2003). Under Australia's *Environment Protection and Biodiversity Conservation Act 1999*, it is protected and listed as vulnerable (DEH, 2003). Various other State-level conservation legislations provide the hawksbill turtle protection and have spurred successful conservation effort (DEH, 2003). For example, some of the hawksbill turtle's major breeding and feeding sites in Australia are protected in the Great Barrier Reef Marine Park (DEH, 2003).

However, given the current level of protection in Australia, the hawksbill turtle seems secure in Australia (Grahame Webb, August 2004, personal communication), although there may be some threats to those turtles that migrate out of Australian waters, for example, to Indonesia. Furthermore, considerable doubt has been raised by Mrosovsky (2003) about the adequacy of the IUCN Red List classification of the hawksbill turtle. It is listed as critically endangered but "is not expected to become extinct in the foreseeable future" (see Mrosovsky, 2003, p.

31). Only the IUCN critically endangered status of the hawksbill was conveyed to participants in our survey. So they would have perceived the hawksbill turtle as being at high risk of extinction in the wild in the near future. This should be borne in mind later when interpreting survey results.

3. Human Use in Australia, Including Commercial Use, of the Reptile Species Under Consideration

All of the reptile species considered here have human use, some of them having considerably more human use value than others. In the past, this was a serious threat to the populations of some when combined with open-access to harvesting them. The high commercial use values of the saltwater crocodile, the freshwater crocodile and the hawksbill turtle resulted in serious declines in their populations and a prospect of the species becoming extinct. The northern long-necked turtle has had modest commercial demand quite recently in the domestic pet market. The taipan snake, besides being used to obtain snake bite antidote, has the lowest commercial value of the reptilians in this study but may have considerable potential commercial value due to the other properties of its highly poisonous venom. In this section, we review the various consumptive and non-consumptive human uses of these reptile species, historic and current, and discuss prospects for sustainable use into the future.

3.1. Saltwater and Freshwater Crocodiles

3.1.1. Historic and Current Uses

Australia's Aborigines have utilised crocodiles for 20,000 to 40,000 years (McBryde, 1979; Flood, 1983). Their eggs and meat are eaten by many Aboriginal people. The crocodile has also been used for ceremonial purposes by certain Aboriginal tribes to whom it is culturally significant and a sacred symbol (Lanhupuy, 1987). For the most part, their use of the crocodiles in Australia has been essentially cultural and subsistence-based.

It was not until around the middle of the twentieth century that commercial consumptive use of Australia's crocodiles took off and resulted in widespread hunting (*cf.* Webb et al. 1987; PWC, 1999) fuelled by high American and European demand for leather products (Thorbjarnarson, 1999, p. 465). The saltwater crocodile's skin is considered to be the most valuable of crocodilian skins and highly sought after because it produces the highest quality leather (Peucker 1997; Department of Primary Industries and Fisheries, 2004). It is used to produce various fashion apparel and accessories like shoes, bags, wallets, watchstraps, belts and luggage bags (Ashley and David, 1987; Brazaitis, 1987). Export market demand for freshwater crocodile skin on the other hand is low because of their comparatively lower quality and value (PWC, 1999; Warfield et al., 2000).

The saltwater crocodile is consequently the main crocodilian species farmed in Australia and the main variety whose skin is commercially exported (Warfield et al., 2000) although a small, negligible amount of freshwater crocodile skin is also exported (Love and Langenkamp, 2003, p. 123). With 11,849 saltwater crocodile skins exported in 2001 (accounting for about 43% of total saltwater crocodile skin trade), Australia is one of the leading exporters of saltwater crocodile skin in the world (Caldwell, 2003). The major markets for skins are France, Italy, Japan and Singapore (Department of Primary Industries and Fisheries, 2004). Australian crocodile farms also produce and sell trophy skins, and jewellery made out of crocodile feet and teeth (Darwin Crocodile Farm, 2003).

Another consumptive use of the crocodile is the commercial consumption of its meat. The saltwater crocodile meat is regarded as a tasty white meat with a delicate flavour, and has nutritional values that compare favourably with traditional meats (Mitchell et al., 1995; Castaldo, 2001; Department of Primary Industries and Fisheries, 2004). The supply of crocodile meat is dictated by the demand for skins (Peucker, 1998; Department of Primary Industries and Fisheries, 2004). In 2000, Australia produced 66,480 kg of crocodile meat (Department of Primary Industries and Fisheries, 2004). Crocodile meat consumption is mainly in the domestic Australian market, through restaurants, specialty meat outlets and some large foodchain stores (Peucker, 1998). The retail price of the meat is between $15 and $40 per kg (in Australian dollars[*] as of 2001 and 2002) (see Bodger and Goulding, 2003, p. 5). It is therefore relatively expensive compared, for example, with chicken. Export demand for Australian crocodile flesh has been growing over the last few years, with major markets in the United Kingdom, Denmark, Japan, Korea, China and New Zealand (Peucker, 1998; Department of Primary Industries and Fisheries, 2004). It has also been an alternative choice of meat during meat-related disease outbreaks like the avian influenza in parts of Asia (Castaldo, 2004).

[*] All values in this chapter are in Australian dollars unless otherwise stated.

While consumptive use of the saltwater crocodile is still the primary form of human use, non-consumptive use is also popular. Non-consumptive use includes wild viewings and captive displays in zoo. Wild and captive crocodilians have become primary tourist attractions in places like Queensland, the Northern Territory and Western Australia, generating wealth and employment (Webb et al., 2000, p. 223). A privately owned company called Adelaide River Queen Cruises in the Northern Territory is well known for their 'Famous Jumping Crocodiles': tourists are taken on boat cruises on the Adelaide River to view crocodiles making spectacular leaps out of the water when receiving feed (see Figure 8) (Adelaide River Queen Cruises, 2004). Several other tour companies also operate similar cruises on the Adelaide River. At Crocodylus Park near Darwin, captive displays of crocodiles in various habitats and museum displays of crocodile history are available for tourists (WMI, 2004). In Queensland, the Australia Zoo, which features shows of daring human-crocodile interaction, recently won the Australian Tourism Award 2003/2004 for best major tourist attraction (Queensland Tourism Industry Council, 2004; Australia Zoo, undated). Many Australian crocodile farms also cater for tourists.

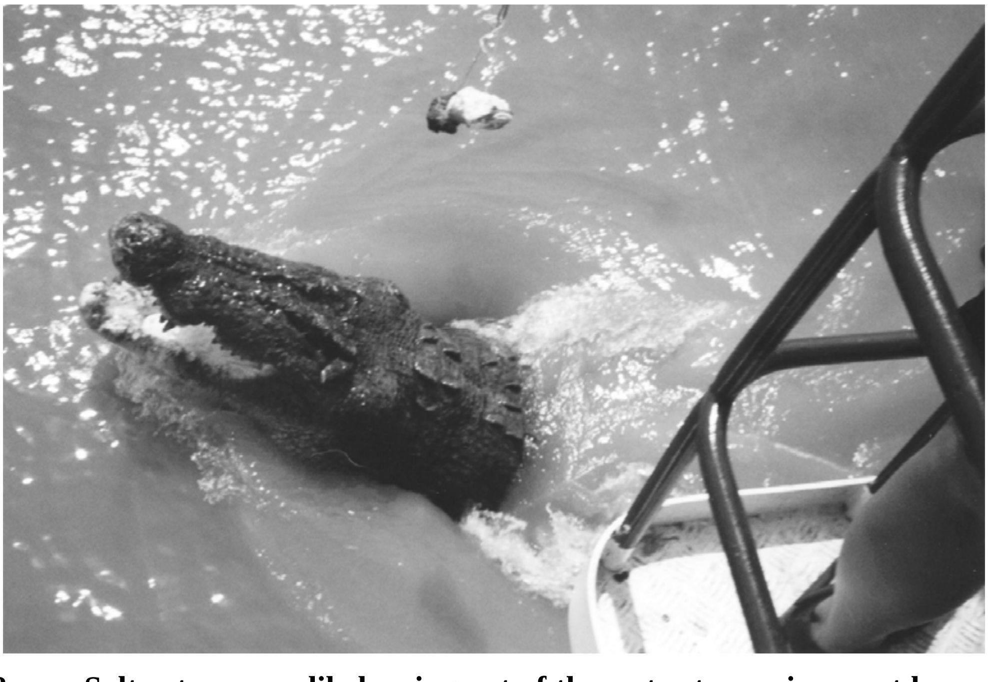

Figure 8: Saltwater crocodile leaping out of the water to receive meat lowered from a deck of a tourist cruise boat on the Adelaide River, Northern Territory, Australia

Annual earnings from the sales of meat and skins in Australia has been estimated to be $5 million ($4 million for skins and $1 million for meat) (Stubbs, 1998), while revenue from crocodile cruises for tourists in the Northern Territory amounted to at least $2 million annually in the late 1990s (Australian Senate, 1998).

3.1.2. Management Practices

Crocodile management in Australia currently involves crocodile farming and ranching programs, wild egg and animal harvest programs and research and monitoring programs (Webb, 2000a; Webb et al., 2000). In the Northern Territory, where the largest crocodile enterprises are, private entities manage farming and ranching programs whereas relevant government departments maintain a regulatory role that includes the setting of quotas and provision of permits, monitoring, analysis or results and egg harvest reporting (PWC, 1999; PWC, undated; Webb et al., 2000, p. 224).

Crocodile farming in Australia first began in Queensland in 1969 with the dual aim of conserving the saltwater crocodile and providing employment for the local community (Department of Primary Industries and Fisheries, 2004). However, it was not until the 1980s that viable commercial farming commenced following growing international market demand for crocodile leather goods and apparel, population recovery and CITES endorsement of the Australian proposal to move the Australian population of the saltwater crocodile from Appendix I to Appendix II (Webb et al. 1984; Stubbs, 1998; Stirrat et al., 2001; PWC, undated).

In strict terms, crocodile farming is the husbandry or closed-cycle captive breeding of adult animals taken from the wild which then lay eggs that form the farm’s stock (Thorbjarnarson, 1999; EPA, 2003a; see also CITES, undated). The hatchlings that are raised in captivity are killed for meat and skins in 3 to 4 years or are retained for breeding in 10 years (Webb et al., 1996). Some of the advantages of closed-cycle farming are that the production of eggs and hatchlings is more reliable and predictable than in the wild; the eggs can be obtained on the day of laying thereby reducing mortality; and commercial gains are totally detached from the status of wild populations (Webb et al., 1996).

Alternatively, crocodile ranching is an open-cycle procedure that involves the removal of eggs or hatchlings from the wild and their incubation and rearing in farms (EPA, 2003a; CITES, undated). Crocodile ranching is commercially advantageous because it has lower infrastructure costs than crocodile farming because breeding pens do not have to be constructed and breeding stocks do not have to be maintained (Magnusson, 1984; Porosus Pty. Ltd., 2003) and the 'costs of obtaining eggs and/ or juveniles are generally less than those of producing them through captive breeding' (Webb et al., 1996). Ranching also allows the removal of eggs or hatchlings that would otherwise have very low chances of survival in the wild due to mortality (Porosus Pty. Ltd., 2003). Mean egg survivorship is estimated to be about 25% of eggs laid (Webb et al., 1984) and 54% of hatchlings survive to one year in the wild (Webb et al., 1987). Once taken from the wild and ranched, hatch rates rise to about 70-80% and rates are of similar magnitude for subsequent survival (Porosus Pty. Ltd., 2003). However, commercial viability ranching enterprises are dependent on the conservation status of the wild population and thus resources may need to be expended to ensure that key habitats and populations are monitored and protected (Webb et al., 1996).

Crocodile farms (see Figure 9) usually run farming and ranching operations in combination. This is practiced in the Northern Territory and Western Australia, where the law permits farming and ranching. In Queensland, however, ranching is prohibited (DEH, 2004b); crocodiles are protected wildlife in Queensland and capturing wild crocodiles is illegal unless a license has been granted under Queensland's *Nature Conservation Act 1992* (DEH, 2004b). In 1998, there were 20 crocodile farms in Australia with a combined stock level of 60,000 crocodiles (Stubbs, 1998). Current estimates are that there are about 12 to 14 crocodile farms (Warfield et al., 2000; MacNamara et al., 2003), six each in the Northern Territory and Queensland and two in Western Australia (Love and Langenkamp, 2003, p. 123).

Figure 9: Juvenile saltwater crocodiles in a pen on a crocodile farm in northern Queensland

The main use of the wild egg harvesting is to provide stock for ranching. Harvesting requires a permit and harvesters are to report details of all stocks removed from the wild (PWC, 1999). The total number of eggs collected annually in the Northern Territory has increased broadly from 2,320 eggs in 1984 to 17,536 eggs in 2002, with a maximum of 29,044 gathered in 1995/1996 (PWC, 1999; PWC, undated; Williams et al., 2001, p. 75). The number of eggs collected depends on the timing and extent of rainfall because nest flooding greatly influences egg survival and availability (PWC, 1999).

Management programs in the Northern Territory also include annual quotas for the harvesting of hatchlings, juveniles and adults to stock farming operations with breeding animals. Only 67 juveniles and adult crocodiles were removed from the wild over the past two decades to 1999 for farming purposes (PWC, 1999). Problem crocodiles removed from native habitats in areas of recreational use because of public safety concerns have often been used to supplement breeding stocks on farms (PWC, 1999). Since 1997 in the Northern Territory, a few adult crocodiles have been harvested from the wild for direct skin and meat production. The number of such crocodiles harvested increased from 17 individuals in 1997 to 138 individuals in 2002 (PWC, undated).

Overall, harvests of crocodile eggs and crocodiles have been sustained at a conservative level (below maximum sustainable yield), allowing populations of crocodiles to increase and stabilise over the years (Webb et al., 2000, Webb, 2000a; Webb, 2000b). Sustainable harvesting of crocodiles and their eggs for ranching provides landowners and people living in remote and rural communities (particularly indigenous communities) with an opportunity to benefit economically from this wildlife with minimal capital investment (PWC, undated; Ross, 1995), and can consequently (in particular circumstances) induce the conservation of crocodiles and their habitat (Thorbjarnarson, 1991, p. 221). Interestingly, it has been argued that ranching and harvesting in the wild can be more effective as a means for conservation than closed-cycle farming, because the latter is not naturally linked with the maintenance of wild populations and their habitat, and does not provide the economic incentives for conservation in the wild that forms the basis of sustainable-use programs (Thorbjarnarson, 1999).

Overall, saltwater crocodile research and management strategies in Australia continue to promote sustainable use and conservation of crocodilians. Current approaches have been billed as involving a “sound model of pragmatic, effective conservation” (Webb et al. 2000, p. 224).

3.3. Hawksbill Turtle

3.3.1. Historic and Current Uses

People of different cultures have hunted and used hawksbill turtles for many centuries (Parsons, 1972; Groombridge and Luxmoore, 1989; Meylan, 1999; Kemf et al., 2000).

Hawksbill turtle exploitation has chiefly been for its highly valued ornate shell, referred to also as *carey* or *bekko* (in Japanese), and there has never been significant international trade in other hawksbill turtle products (although other uses such as for leather and oils for cosmetics exist) (TRAFFIC, undated; Ottenwalder, 1996; NMFS, 2001). The hawksbill turtle shell has been used to make household items like combs, brushes and spectacle frames and expensive ornamental products like rings and necklaces and works of art such as exquisite carvings in Japan (TRAFFIC, undated). The need for turtle shell products declined worldwide with the advent of plastics, but it has retained a niche at the high end of the luxury market (Groombridge and Luxmoore, 1989).

Over the past few decades, the greatest market for hawksbill turtle shells has been from Japan, where the commercial production and consumption of *bekko* products is a multi-million dollar industry and involves an ancient and culturally significant tradition (Meylan and Donnelly, 1999; Kaneko and Yamaoka, 1999; TRAFFIC, undated). Between 1970 and 1992, Japan imported about 754 tonnes of hawksbill shell, representing approximately 712,000 hawksbills turtles (Meylan, 1998). Since the CITES’s trade ban, the *bekko* industry in Japan has continued to operate on existing stockpiles (CITES, undated). Because it is a luxury item in Japan, hawksbill shell prices rise with increasing rarity, motivating illegal harvesting and trade in places like Vietnam and Indonesia (Bjorndal, 1999; van Dijk and Shepherd, 2004).

The hawksbill turtle has also long been a supplemental source of food protein for some people. Hawksbill turtle meat and egg harvesting have been carried out at the subsistence level by fishing and coastal communities in the Caribbean and is sometimes used for medicinal purposes (CITES, undated). In some indigenous communities, for example, in the Torres Straits off the north of Australia, hawksbill turtle meat is considered to be poisonous and is rarely eaten but the eggs are considered highly palatable (Hobson, 1988; Limpus and Parmeter, 1988).

3.3.2. Management Practices

It has been suggested that the introduction of hawksbill turtle farming and ranching to satisfy the demand of a well-regulated market, such as in Japan, can alleviate or eliminate illegal harvest pressures on wild populations (Anonymous, 1995a; Anonymous, 1995b; Ross, 1995; Ross, undated). To date, hawksbill turtle farming and ranching activities have been experimental and a response to Cuba's recent efforts to re-open trade in hawksbill turtle shells (Gray, 1998; Grahame Webb, personal communication, 25th June 2004). In Australia, Crocodylus Park near Darwin is trying to rear hawksbill turtles in captivity and establish a closed cycle. Some critics have argued that there could be drawbacks to hawksbill turtle farming and ranching: increased availability of products on the legal international market might stimulate demand, which existing farms will be unable to satisfy, thereby increasing pressure on wild populations and trade through illegal channels (Tisdell, 1986; Ross, undated). Ross (undated) says that although objective evidence on the reality of such a scenario is contradictory, it merits objective testing.

3.4. Northern Long-necked Turtle

3.4.1. Historic and Current Uses and Management Practices

The northern long-necked turtle has been traditionally harvested by the indigenous people of Australia, particularly the Aboriginal people of the Northern Territory, as a source of food over a long period in history with little or no negative impact on the overall survival of the species (Kennett, 2004). Evidence of the sustainability of northern long-necked turtle use is manifest in its relatively secure and abundant populations throughout its Australian range of distribution.

Traditional knowledge of northern long-necked turtle harvesting coupled with scientific research and support may help in meeting the dual aim of sustaining the survival of the species while providing economic benefit to Aboriginal people. Support agencies like the Bawinanga Aboriginal Corporation in Maningrida, Northern Territory enable the Aboriginal people to employ their wealth of knowledge of wildlife, such as that about the northern long-necked turtle, to achieve these aims. Currently, the Bawinanga Aboriginal Corporation in collaboration with the University of Canberra and Charles Darwin University in Darwin is trying to promote increased economic self-sufficiency of Aboriginal people by developing a sustainable indigenous enterprise involved in harvesting northern long-necked turtles and incubating their eggs for hatchlings to be reared and sold in the pet trade (Applied Ecology Research Group, 2003). The possibility of the commercial use of such turtles for meat is also being trialled.

3.5. Taipan Snake

3.5.1. Current Uses

Taipan snake venom is used to produce antivenom to treat snakebites. But snake venoms, due to their chemical properties, are known to promise a range of other medical benefits too, such as treatment for cancer, stroke, heart ailments, Parkinson’s disease and Alzheimer’s disease (Ferrer, 2001). The highly poisonous venom of the taipan snakes is no exception. Taipan snake venom is being studied for medical applications in screening for lupus, an autoimmune disorder (ABC Radio National, 1995; Marsh, 2001; Moore et al., 2003).

4. Public Attitudes to Conservation and Commercial Use towards Focal Reptile Species and their Comparative Willingness to Allocate Funds for Species Conservation

4.1. Survey Methodology

Having outlined the ecological status of the focal reptilians in Australia, let us now consider attitudes of the Australian public to them. Attitudes to their survival, for their commercial use, and willingness to support their conservation financially are amongst the issues considered.

Two questionnaire-based surveys provided the data for this study. The surveys were conducted from July to September 2002. These surveys were designed to elicit information about the following: (i) the Brisbane public’s knowledge and attitude towards (‘likeability’of) tropical Australian reptile species, (ii) their degree of support for the survival of these species and willingness to pay for the conservation of these species, and (iii) their attitude towards the commercial use of the reptilians.

A survey sample of 204 responding participants was drawn from various suburbs of Brisbane with differing socio-economic characteristics. This was achieved mostly by means of letterbox-dropped circulars distributed in the Brisbane area. The circular was an invitation to participate in the series of surveys on the conservation and use of Australia's tropical resources, to be conducted at the University of Queensland. In the circular, it was mentioned that participants would be offered $20, a public lecture, refreshments and a chance to win $200. The real nature and objectives of the experimental survey were withheld from the participants to avoid bias.

Responding participants were selected on a first-come-first-served basis according to the age distribution of Brisbane city so that the sample would be reasonably representative of Brisbane residents. The participants were divided into groups of five consisting of 40 individuals each to attend survey sessions of about two hours with a 15-minute tea break. Four groups were asked to attend sessions held at the University of Queensland— two during the working week and two during the weekend. The remaining group was requested to attend a Sunday session at a church hall. The survey sessions were arranged as such to accommodate the participation of employed persons and provide flexibility of attendance for others.

In the survey sessions, participants filled out a structured questionnaire (Survey I) to gather participant's background information, and their initial knowledge, attitude and support for the conservation of 24 Australian wildlife species made up of mammals, birds and the 5 reptilians addressed in this study. In the survey, the participants were also asked to allocate among the reptilians a hypothetical sum of $1,000 to fund conservation work for the species.

After completing the above task, the participants were given a tea break. A public lecture followed, presented by Dr. Steven Van Dyck, the then-Curator of Mammals and Birds at the Queensland Museum. This lecture dealt mostly with birds and mammal species. The participants were then given coloured photo brochures containing descriptions of all the species concerned including the reptilians, their geographical range, current status and other pertinent information. In the brochures, approximately the same amount of factual background information was provided on each species and normative statements were avoided. The participants were asked to take the brochure home and read it before completing and returning (in postage pre-paid envelope) the second questionnaire, Survey II, which contained several overlapping questions with Survey I. This overlap of questions was planned to provide us information on changes in the respondents' knowledge of the various species, and alterations in their attitudes and support for the conservation of species.

4.2. Aims

Tisdell and Wilson (2004) hypothesised that important factors in influencing individuals' willingness to contribute to schemes to conserve particular wildlife species might be: (i) judgement of respondents about the effectiveness of the scheme; (ii) perceived degree of threat to the survival of the species; (iii) the likeability of the species; (iv) ethical considerations; and (v) degree of knowledge of the species, which can affect (ii), (iii) and possibly (i). Here we use results from the surveys to consider the relationships between the respondents' stated likeability of each of the focal reptile species and their support for survival of each of the reptile species and for commercial use of these. Also, the hypothetical allocation of funds for conserving each of these species is considered in a similar manner.

To reduce the influence of the knowledge factor, we concentrate on the results from Survey II for analytical purposes. In that survey, respondents had reasonably balanced information about the nature and status of the various reptile species. In Australia, none of the reptile species considered is threatened by imminent extinction. However, the hawksbill turtle is listed in the IUCN Red List (2001) as critically endangered and respondents were made aware of this status and this would have been an influence on their response in Survey II. Therefore, we assume that the major influences on the dependent variables to be investigated in relation to results from Survey II are likeability, threat to survival of species and ethical considerations.

The importance of likeability as a factor to strongly influencing support for conservation of wildlife species is suggested by the analysis of Metrick and Weitzman (1996, 1998) of the public funding of conservation of endangered species in the USA. They suggest that 'charismatic megafauna' effects dominate allocations of public funds for the conservation of such species (Metrick and Weitzman, 1998, p. 33), or that 'visceral' characteristics are the main determinant rather than scientific characteristics such as 'degree of endangerment' and 'taxonomic uniqueness' (Metrick and Weitzman, 1996, p. 1). We consider that 'likeability' ratings capture the visceral or charismatic aspects of wildlife species.

Note that our study differs from that of Metrick and Weitzman (1996, 1998) because it is based upon stated preferences of individual respondents rather than the revealed public spending decisions. It is possible that the latter are to some extent 'corrupted' by political processes and may not be an entirely accurate reflection of the preferences of individuals for conserving species. Given this background, we shall investigate to what extent likeability of the various species is important for support for the survival and funding of conservation of reptile species in our selected group.

4.3. Results

4.3.1. Knowledge of Species and their Likeability Ratings

Respondents were asked to state in Survey I whether they knew the species or not. Less than half the respondents said they knew the hawksbill turtle while at least 95% said they knew the crocodiles (see Table 1). Species dangerous to man were better known than the turtles, which posed no danger to man.

Table 1:

The percentage of respondents who said they knew the reptile species in Survey I

	Hawksbill turtle	Northern long-necked turtle	Taipan snake	Freshwater crocodile	Saltwater crocodile
Percentage of respondents who said they knew the species	42	65	82	95	96

Respondents were asked in the surveys to indicate how much they knew about each species and the extent to which they liked the species according to the rating possibilities shown in the first row of Tables 2 and 3 respectively. We assigned the weights shown in the second row of these tables to these ratings.

Table 2:

Knowledge rating

Rating	Very good	Good	Poor	Non-existent
Knowledge weights	3	2	1	0

Table 3:

Likeability rating

Rating	Strongly like	Like	Uncertain	Dislike	Strongly dislike
Likeability weights	2	1	0	-1	-2

The knowledge and likeability weights shown in Table 2 and 3 respectively were used to calculate a knowledge index and a likeability index for each of the species. Each of these is a simple average of the weights determined for each of the respondents. The results are shown in Table 4.

Table 4:

Knowledge and likeability indices (Survey I and Survey II) for the focal species

	Hawksbill turtle	**Northern long-necked turtle**	**Taipan snake**	**Freshwater crocodile**	**Saltwater crocodile**
Survey I					
Knowledge index	0.55	0.81	1.22	1.51	1.66
Likeability index	1	1.07	-0.31	0.4	0.3
Survey II					
Knowledge index	1.49	1.51	1.51	1.69	1.77
Likeability index	1.21	1.08	-0.15	0.32	0.18

We note from Table 4 that the knowledge indices of the species in Survey I is consistent with the data in Table 1 and that the least liked species are those most dangerous to man whereas the turtles (not dangerous to man) are the most liked. The ordering of likeability of the species is broadly similar in Survey I and Survey II but some differences are apparent. The differences are due to extra information being provided to survey participants about the individual species. As a result of this, knowledge about all the species increased (compare rows 1 and 3 in Table 4) and become more even or balanced; knowledge of the more poorly known species increased relatively more than for the best known species. As a result, the hawksbill turtle displaced the northern long-necked turtle as the most liked species, but the latter remained a highly liked species. The taipan snake remained the least liked species but it improved its likeability rating in Survey II, possibly because respondents became aware of its possible use value in medicine. The saltwater crocodile and the freshwater crocodile displayed some likeability reduction, but the freshwater crocodile continued to be the least disliked of the two. Both had low likeability indices, but not negative ones.

In order to reduce the possible influence of uneven knowledge of wildlife species on the responses of survey participants, we shall concentrate on analysis using responses given in Survey II. Linear regression analysis will be used to consider whether attitude to the survival of species is associated with its likeability, whether support for commercial harvesting of species is associated with its likeability, and whether individuals are more likely to want to allocate more funds to the conservation of a species if they like it more than others.

4.3.2. Likeability and Support for Survival of Species

Comparing likeability to the percentage of respondents who said they are in favour of a species' survival, a pattern of relationships as shown in Figure 10 emerges. The species are identified as follows: Northern long-necked turtle (Lt), hawksbill turtle (Ht), freshwater crocodile (Fc), saltwater crocodile (Sc) and taipan snake (Ts).

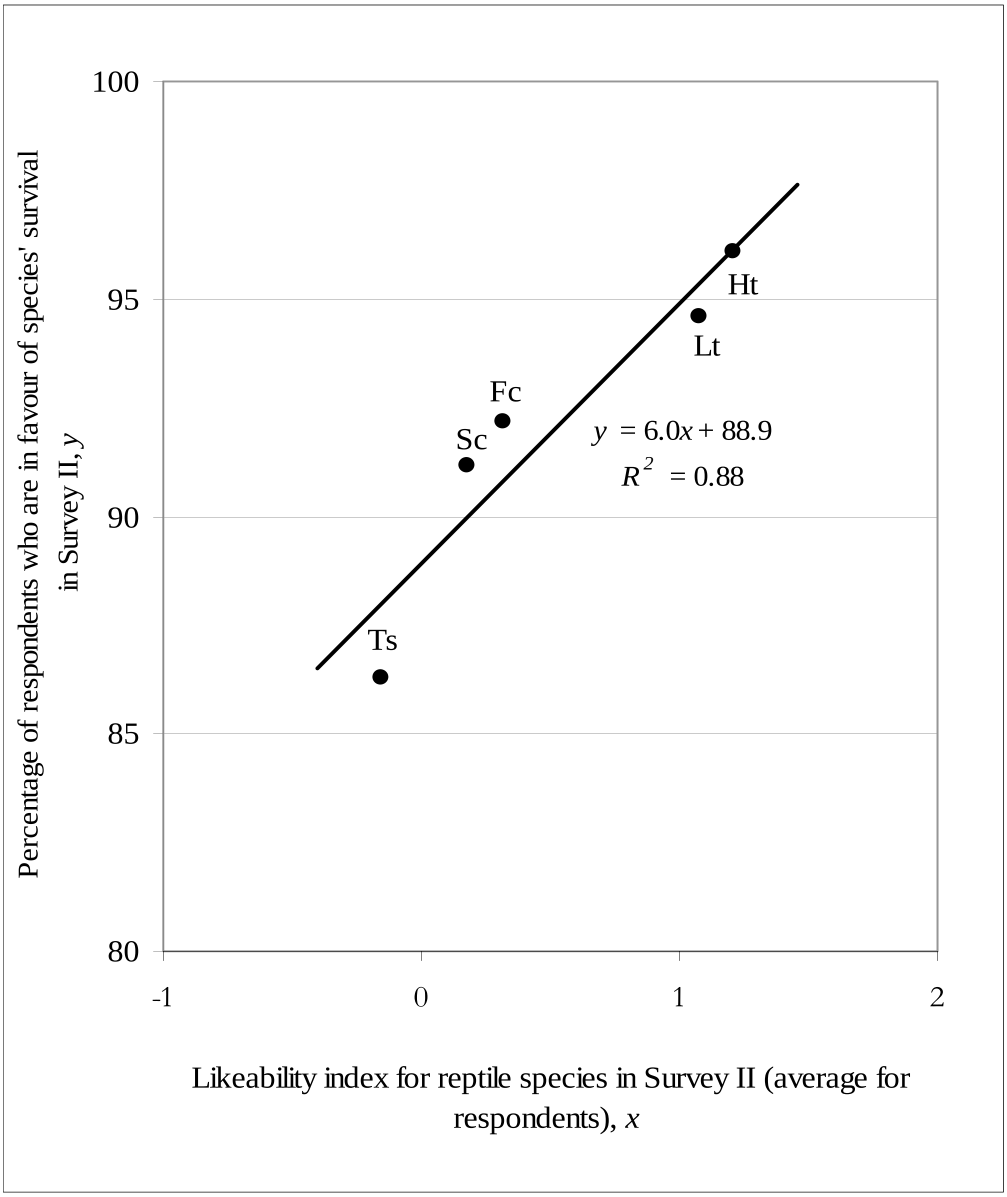

Figure 10: Likeability versus percentage of respondents in favour of survival of the reptile species in Survey II

From the relationship known in Figure 10, it can be seen that there is a positive relationship between the stated likeability of a wildlife species and the percentage of respondents in favour of its survival. The linear regression line when fitted by ordinary least squares is

$$y = 88.9 - 6.0x \qquad (1)$$

It is a relatively good fit ($R^2 = 0.88$) and using the t-test the slope factor is significant at 95% confidence interval ($P = 0.02$).

It should be noted that most individuals supported the survival of all the reptile species in the set, even the most disliked species. For example, more than 85 percent of respondents favoured the survival of taipan snakes. The reason frequently given was that all species have a right to exist.

4.3.3. Likeability and Attitude towards Sustainable Commercial Harvesting of Species

We assessed the relationship between the likeability of reptile species and the percentage of respondents supporting their sustainable commercial harvesting. It was thought likely that a negative relationship would exist.

The scatter of observations is shown in Figure 11. This confirms that a negative relationship does exist. Fitting a linear regression line by ordinary least squares, the line

$$y = 49.9 - 16.8x \qquad (2)$$

provides the best fit. However, the fit is not close ($R^2 = 0.49$) and the slope is statistically significant only at 80% confidence interval ($P = 0.19$).

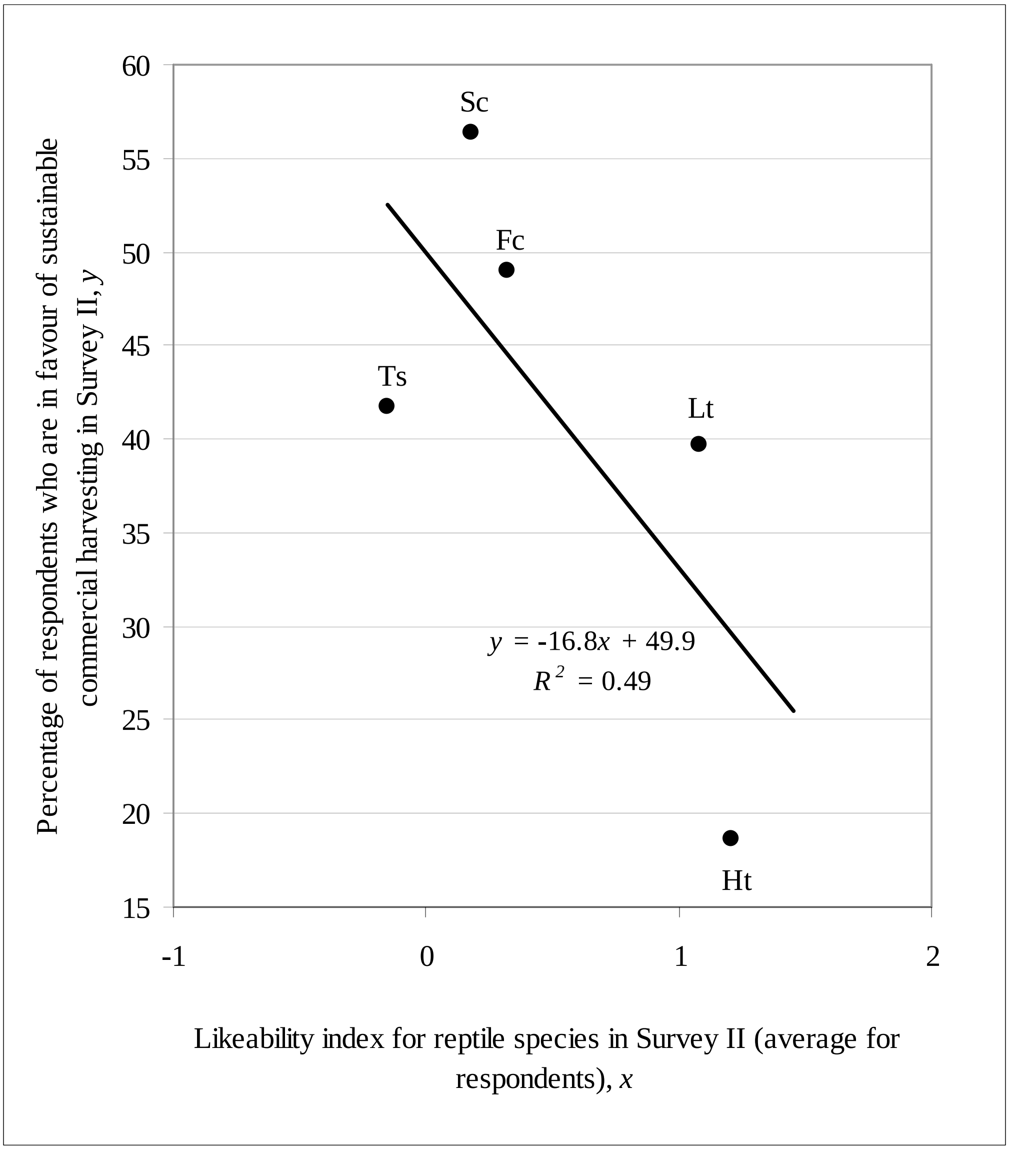

Figure 11: Likeability versus percentage of respondents in favour of commercial harvesting of the reptile species in Survey II

4.3.4. Comparative Willingness to Respondents to Allocate Funds for the Conservation of the Reptile Species

Respondents were asked to complete the following exercise:

"Suppose that you are given Aus $1,000, but you can only use it to donate funds to support the conservation of the reptiles in Australia listed below. Suppose that a reliable organisation were to carry out the conservation work and your money would supplement other funds for this purpose. What percentage of your $1,000 would you contribute for the conservation of each of the reptiles listed below? Your total should add up to 100%."

Reptiles	(%)
Saltwater crocodiles	
Freshwater crocodiles	
Hawksbill sea turtles (a marine species with a beautiful shell)	
Northern long-necked turtle (freshwater) turtle	
Taipan snakes (also known as Fierce snakes)	
	100

The scatter of average allocations that emerged is shown in Figure 12 for Survey II and is plotted against the likeability index for each species. A positive association exists between the percentage of funds allocated for the conservation of each of the species and their likeability. However, the hawksbill turtle is an outlier. This seems to reflect its reported critically endangered status. The association between the likeability index and funds allocated for conservation of the other four species is quite close.

Fitting a linear regression to all the observations by ordinary least squares, the following is the result:

$$y = 8.3 + 22.3x \qquad (3)$$

$$(R^2 = 0.65)$$

The slope value is significant at 80% confidence interval ($P = 0.097$).

This linear relationship is not very close. This is mainly because of the high allocation of funds for conservation of hawksbill turtle. This is probably a result of its being reported

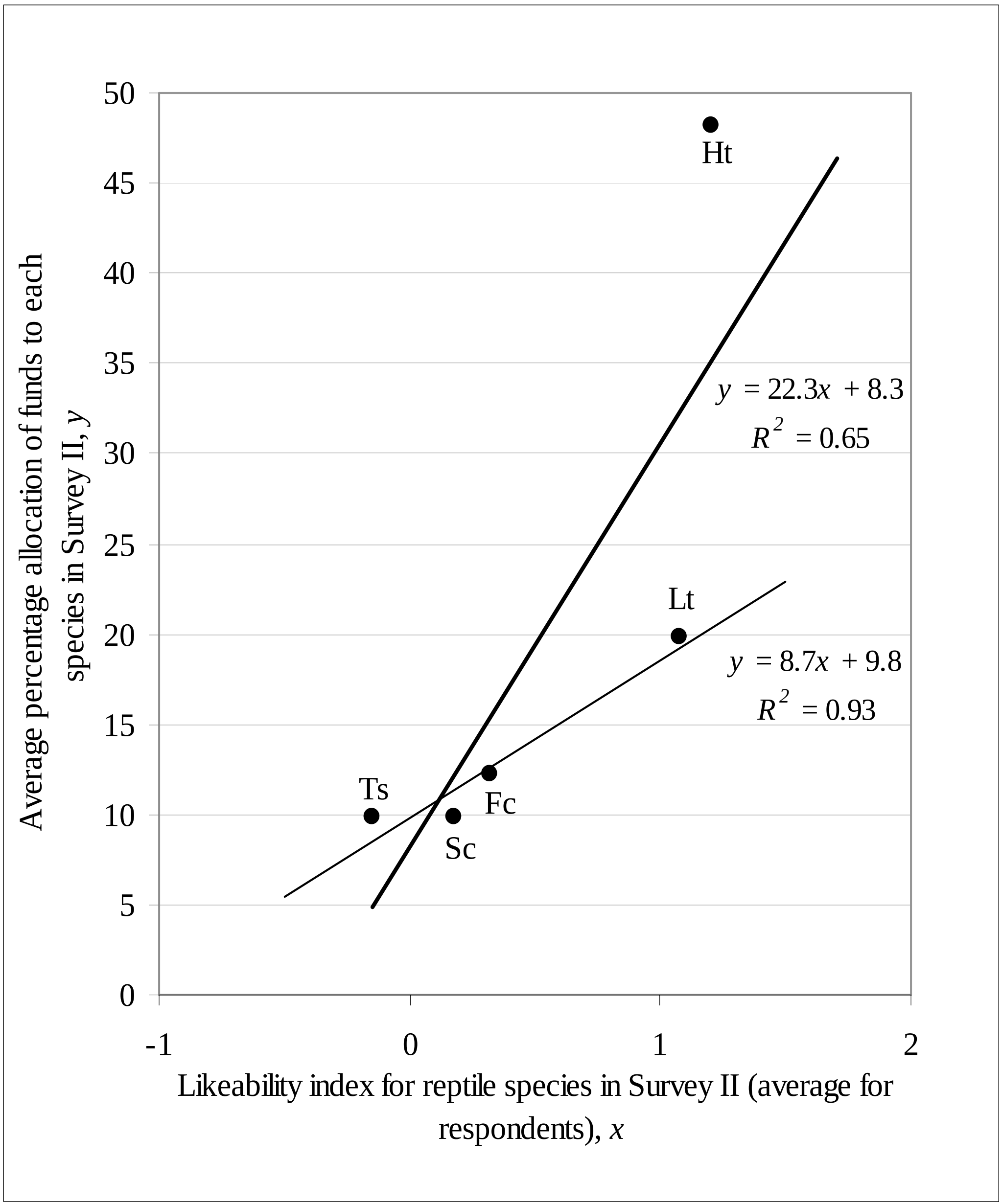

Figure 12: Likeability versus average percentage allocation of funds for the conservation of the reptile species in Survey II

to be critically endangered. The observation for Ht, therefore, is influenced by a combination of its likeability and its reported high level of endangerment.

None of the other species are endangered in Australia. Likeability is the major influence on allocation of funds for their conservation. Fitting a linear regression to the four observations for these other species yields the regression line

$$y = 9.8 + 8.7x \quad (4)$$

$(R^2 = 0.93)$

The relationship is close and is statistically significant at the 95% level. It suggests that if likeability is the only influence on the relative allocation of funds for conserving species, the hawksbill turtle would be allocated 20.3% of available funds for its conservation. However, in fact 48.2% of funds are allocated for its conservation. Thus more than half the allocation of funds for conservation of the hawksbill turtle (28%) may be accounted for by its IUCN critically endangered status, which suggested to respondents that it is in imminent danger of extinction.

Respondents were also asked their reasons for choosing the reptile (the hawksbill turtle in this case) for the largest allocations of funds for their conservation. The reasons respondents provided include:

‘they are harmless and beautiful’ and ‘they are gentle creatures’
‘this appears to be the only one of the reptiles that is endangered’ and ‘more danger facing the animal’

The reasons offered boil down essentially to the following factors: likeability (attractiveness of species, benign nature of species) and perceived endangerment of species. To a lesser extent, some respondents also said that ecological and tourism values of the species were important as an influence. Respondents who decided to give equal allocations for all species justified their decision by giving the following reasons: ‘do not have enough knowledge about species’, ‘all species have intrinsic values’ or ‘the right to exist’ and the desire to protect ‘the balance of nature’.

The results tend to support the view of Metrick and Weitzman (1996, 1998) that visceral factors play an important role in support for conservation of wildlife species. However, the degree of endangerment also seems to be important as illustrated by the case of the hawksbill turtle. Furthermore, even species that are not very much liked (taipan snakes and crocodiles in this case) were allocated at least 10 percent of funds available for allocation to conservation of reptiles in the selected set. This seems to reflect the importance of moral or ethical sentiments e.g. all species have a right to exist, mentioned by several respondents. The importance of such sentiments may have grown in recent times. We can conclude that although likeability of species is very important, it is far from being the sole arbiter of human support for conservation of wildlife species.

It is also interesting to find from our research that human interests (humanitarianism) do not completely displace support for wildlife conservation when the option exists for reducing support for conservation of wildlife to benefit humans in need.

4.3.5. Allocation of funds from a $1,000 Fund to Different Causes (Conservation of Reptiles versus Funds for Charity)

The following proposition was presented to participants in Survey I and Survey II:

Suppose you have a choice of donating your Aus $1,000 to support conservation of the above reptiles or donating it or a part of it to support a charity of your choice to help people in need (e.g. Lifeline, Smith Family, Salvation Army, St Vincent de Paul). What percentage would you allocate to each of the following:

Support for conservation of the above reptile species …..%

Support for charity to help people in need …..%

The average response in Survey I and Survey II is shown in Figure 13. In Survey I, on average, respondents allocated 53.4% of the fund to charity and 46.6% to the conservation of the focal reptile species. The difference is significant at 95% confidence interval. In Survey II, having learnt more about the species, allocation of funds were on average 50.1% to charity and 49.9% to reptile conservation. The t-test performed on the results from Survey II showed no significant difference between both averages at 95% confidence interval.

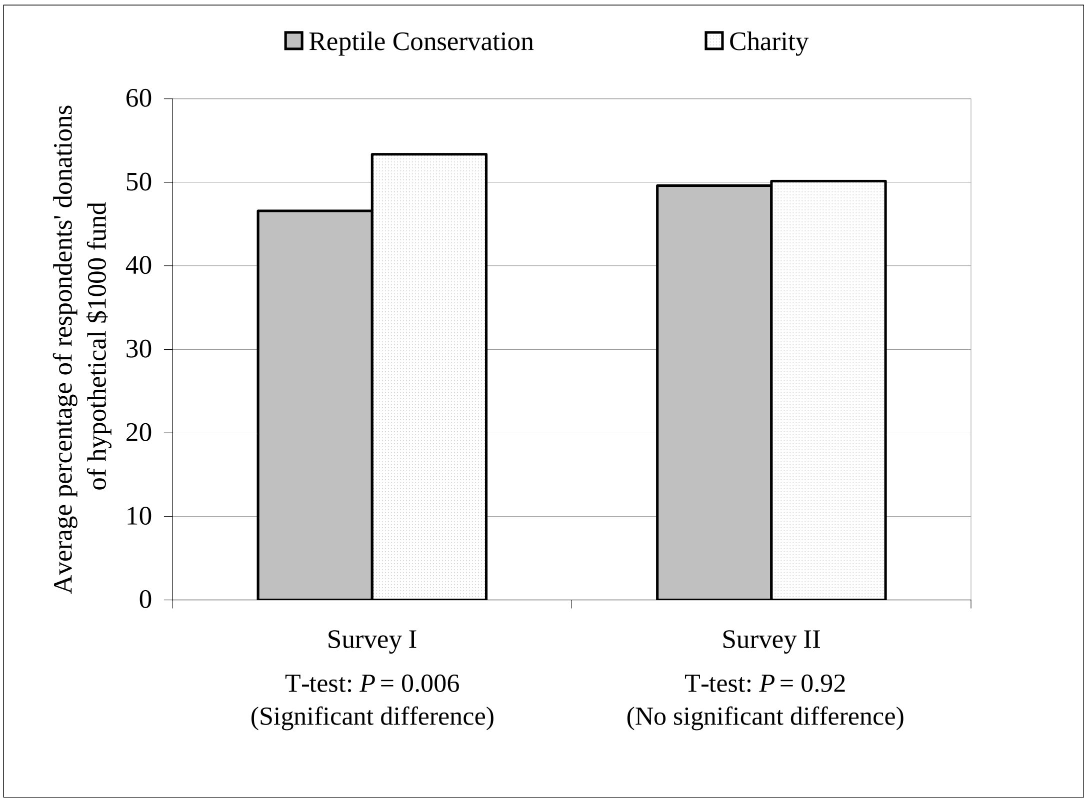

Figure 13: Respondents' allocation of hypothetical $1,000 fund between charity and the conservation of the focal reptile species

Thus the allocation of funds for conserving reptiles (a group with which most humans have limited empathy) managed to retain a considerable proportion of funds for their conservation even when respondents had an opportunity to allocate these funds instead for human charitable help.

Reasons given in favour of a positive allocation of funds to the conservation of reptiles in the set included the following:

'Reptiles are endangered due to human mismanagement' and 'humans are plundering wildlife, we need to protect wildlife'
'Some reptiles are endangered, humans are not'
'Both causes are of equal concern to me' and 'both equally need help'
'A lot of financial support is available to charities'

Although most respondents remained supportive in providing fund for conserving reptiles, when the above trade-off was possible some were not supportive. Their comments included the following:

'Human life is more important' and 'people in need come before animals'
'I suppose I value people more than animals'
'Problems of people seem more pressing' and 'I see the suffering of people more and thus understand this more'

Although views of participants varied on average, it is clear that considerable support exists for conserving reptiles, despite some species not being liked very much.

5. Concluding Comments

The ecological status of several species of reptiles present in tropical Australia has been reviewed. The coverage includes two species of turtles (a marine one and a freshwater one), two crocodilian species and taipan snakes. None of these are considered to be endangered in Australia. However, the anomaly exists that the hawksbill turtle is considered by the IUCN to be critically endangered globally. This is not because it lacks protection in Australia but possibly because it is migratory and faces lack of effective protection outside Australia. The IUCN classification was reported to participants in the survey. Therefore, the hawksbill would have been regarded by them as in imminent danger of extinction, even though this seems not to be the case in reality.

Of the reptile species considered, the saltwater crocodile has the greatest commercial value in Australia. It has consumptive economic use values (for leather and meat) and non-consumptive use value (e.g. for tourism). It is both farmed and ranched. The hawksbill turtle has significant commercial potential as a farmed animal and Crocodylus Park near Darwin is experimenting with the possibility of closed-cycle farming of it. Limited commercial use of the northern long-necked turtle has developed in the Northern Territory (mainly sales of animals for the pet trade) based on ranching by the Aboriginal people of Maningrida. No significant commercial use of taipan snakes has occurred but their venom has potential applications in medicine.

Based on a sample of 204 members of the Australian public living in Brisbane (located below the Australian tropics), it was found that their stated knowledge of the focal reptile species varied greatly. They are much more aware of reptile species dangerous to man rather than benign species, in this case the turtle species.

Associations between the stated likeability of each of the reptile species and respondents' attitudes to their survival, commercial use and respondents' willingness to allocate funds for their conservation were considered. While there is a negative relationship between support for commercial use of a species and their likeability, the relationship is a weak one. On the other hand, the probability of respondents favouring the survival of species rises with the likeability of a species, and the relationship is relatively close and significant. This is also mirrored in respondents' proposed allocation of funding for the conservation of the various reptile species (allocations are higher for species that are more liked) but the result is confounded by the endangered status of the hawksbill turtle.

Those results are consistent with the findings of Metrick and Weitzman (1996, 1998) in a different context. However, the results suggest that likeability is not the only factor that influences the proposed financial support of humans for conserving wildlife. For example, the degree of perceived endangerment plays a role, as for instance illustrated above by support for conservation of the hawksbill turtle. Furthermore, moral sentiment is also important (*cf.* Kotchen and Reiling, 2000). For example, more than 85 percent of the sampled public supported the survival of the taipan snakes, even though they were the most disliked species. Respondents as a whole allocated some funds to conserve all the focal reptile species. Several respondents stated that even the most disliked species have a right to exist.

In addition, it was found that humanitarian considerations by the sampled public did not completely override support for conservation of reptiles. When respondents were given a chance to allocate funds to a charity helping people in need rather than having the funds used to conserve the focal reptiles, they opted to allocate about half of the funds, on average, for the conservation of the reptiles. The desire to help humans in need did not extinguish funding support for conserving reptiles. Non-anthropocentric values in modern societies are stronger than is often recognised.

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References

ABC Radio National. (1995). The Health Report: Medical benefits of snake venom. Radio National Transcripts. Australian Broadcasting Corporation. Available from: www.abc.net.au/rn/talks/8.30/helthrpt/hstories/hr140804.htm

Adelaide River Queen Cruises. (2004). The Famous Jumping Crocodiles. Available from: www.jumpingcrocodilecruises.com.au

Anonymous. (1995a). Legal briefs. Marine Turtle Newsletter, 69, 25-28. Available from: www.seaturtle.org/mtn/archives/mtn69/mtn69p25b.shtml

Anonymous. (1995b). Sea turtle ranching guidelines. Marine Turtle Newsletter, 69, 2-3. Available from: www.seaturtle.org/mtn/archives/mtn69/mtn69p2.shtml

Applied Ecology Research Group. (2003). Research flier: Aboriginal harvest of long-necked turtles. Canberra: University of Canberra. Available from: www.maningrida.com/mac/wwwmedia/newsletter.pdf

Ashley, D. and David, D.N. (1987). Marketing crocodilian skins. In G.J.W. Webb, S.C. Manolis and P.J. Whitehead (Eds.), Wildlife Management: Crocodile and Alligators (pp. 397-403). Chipping Norton, Australia: Surrey Beatty and Sons in association with the Conservation Commission of the Northern Territory.

Australian Senate. (1998). Report of the Rural and Regional Affairs and Transport References Committee: Commercial utilisation of Australian native wildlife. Canberra: Parliament of Australia. Available from: www.aph.gov.au/senate/committee/rrat_ctte/wild/report/contents.htm

Australia Zoo. (Undated). The Crocodile Hunter. Available from: www.crocodilehunter.com/australia_zoo/welcome/index.html

Begon, M., Harper, J.L. and Townsend, C.R. (1996). Ecology: Individuals, Populations and Communities (3rd Edition). Osney Mead, England: Blackwell Science.

Bjorndal, K.A. (1999). Conservation of Hawksbill sea turtles: Perceptions and realities. Chelonian Conservation and Biology, 3, 174-176. Available from: www.turtles.org/bjorndal.htm

Bodger, J. and Goulding, B. (2003). Distribution of Meat Products from Prospective Australian Animal Industries: Crocodiles, Emus, Game birds, Rabbits, Hares and Snails. ACT, Australia: RIRDC (The Australian Government Rural Industries Research and Development Corporation). Available from: www.rirdc.gov.au/reports/NAP/03-023sum.html

Bolen, E.G. and Robinson, W.L. (2003). Wildlife Ecology and Management (5th Edition). Upper Saddle River, New Jersey: Prentice Hall.

Brazaitis, P. (1987). The identification of crocodilian skins and products. In G.J.W. Webb, S.C. Manolis, P.J. Whitehead (Eds.), Wildlife Management: Crocodile and Alligators (pp. 373-386). Chipping Norton, Australia: Surrey Beatty and Sons in association with the Conservation Commission of the Northern Territory.

Britton, A. (2002a). Crocodilian species list: Crocodylus porosus (Schneider, 1801). Available from: www.flmnh.ufl.edu/natsci/herpetology/brittoncrocs/csp_cpor.htm

Britton, A. (2002b). Crocodilian species list: Crocodylus johnstoni (Krefft, 1873). Available from: www.flmnh.ufl.edu/natsci/herpetology/brittoncrocs/csp_cjoh.htm

Caldwell, J. (2003). World Trade in Crocodilian Skins, 1999-2001. Cambridge, UK: UNEP World Conservation Monitoring Centre.

Cann, J. (1980). Notes on the reproduction of the northern long-necked tortoise (Chelodina rugosa). Northern Territory Naturalist, 1, 4-5.

Cann, J. (1998). Australian Freshwater Turtles. Singapore: Beaumont Publishing.

Castaldo, D. (2001). Ostrich: The other red meat? MEATNEWS, 3 (39), article no. 38. Available from: www.meatnews.com/index.cfm?fuseaction=issue&issNum=107&Status=Archive

Castaldo, D. (2004). Thailand going organic. MEATNEWS, 6 (12), article no. 37. Available from: www.meatnews.com/index.cfm?fuseaction=issue&issNum=235&Status=Archive

Caughley, G. and Sinclair, A.R.E. (1994). Wildlife Ecology and Management. Boston: Blackwell Scientific Publications.

Choquenot, D. (1996). The ecological basis of wildlife harvesting. In M. Bomford and J. Caughley (Eds.), Sustainable Use of Wildlife by Aboriginal Peoples and Torres Strait Islanders (pp. 48-59). Canberra: Australian Government Publishing Service.

CITES. (Undated). CITES glossary. Available from: www.cites.org/eng/resources/glossary.shtml

CITES. (2003). Appendices I, II and III. Available from: www.cites.org/eng/append/index.shtml

Cogger, H.G. (2000). Reptiles and Amphibians of Australia. Sydney: Reed New Holland.

Cronin, L. (2001). Australian Reptiles and Amphibians. Annandale, NSW: Envirobook.

Darwin Crocodile Farm. (2003). Products: Others. Available from: www.crocfarm.com.au/other.asp

DEH (Australian Government Department of Environment and Heritage). (2003). Recovery Plan for Marine Turtles in Australia. Available from: www.deh.gov.au/coasts/species/turtles/recovery/index.html

DEH (Australian Government Department of Environment and Heritage). (2004a). Marine Turtles in Australia: Hawksbill Turtle (Eretmochelys imbricata). Available from: www.deh.gov.au/coasts/species/turtles/hawksbill.html

DEH (Australian Government's Department of the Environment and Heritage). (2004b). Approved farming operations for crocodiles in Queensland. Available from: www.deh.gov.au/biodiversity/trade-use/sources/captive/crocodile-farms.html

Department of Primary Industries and Fisheries (Government of Queensland). (2004). Crocodile farming: A general overview. Available from: www.dpi.qld.gov.au/crocodiles/12600.html

EPA (Queensland Environmental Protection Agency). (2002). Wildlife information: Crocodiles in Queensland. Brisbane, Queensland: Environmental Protection Agency.

EPA (Queensland Government Environmental Protection Agency). (2003a). Code of Practice – Crocodile Farming. Brisbane, Queensland: Environmental Protection Agency. Available from: www.epa.qld.gov.au/publications?id=65

EPA (Queensland Government Environmental Protection Agency). (2003b). Crocodiles. Available from: www.epa.qld.gov.au/nature_conservation/wildlife/living_with_wildlife/crocodiles

Errington, P.L. (1946). Predation and vertebrate population. Quarterly Review of Biology, 21, 144-177, 221-245.

Errington, P.L. (1967). Of Predation and Life. Ames, Iowa: Iowa University Press.

Ferrer, E. (2001). Snake venom: The pain and potential of poison. The Monitor, Newsletter of the Hoosier Herpetological Society, 12 (2). Available from: coloherp.org/cb-news/Vol-28/cbn-0103/Venom.html

Flood, J. (1983). Archeology of the Dreamtime. Sydney: Collins.

Fordham, D. (Undated). Aboriginal harvest of the northern long-necked turtle (Chelodina rugosa) – modelling population dynamics in support of a sustainable industry. PhD Thesis Proposal, University of Canberra. Available from: www.wildlife.ntu.edu.au/postgrad/downloads/Damien%20Fordham%20WebPage.pdf

Franklin, W.L. and Fritz, M.A. (1991). Sustained harvesting of the Patagonia guanaco: Is it possible or too late? In J.G. Robinson and K.H. Redford (Eds.), Neotropical Wildlife Use and Conservation (pp. 317-336). Chicago; London: University of Chicago Press.

GBRMPA (Great Barrier Reef Marine Park Authority). (1996). Hawksbill turtles– Eretmochelys imbricata. Available from: www.gbrmpa.gov.au/corp_site/key_issues/conservation/threatened_species/turtles/hawksbill_turtles.html

Gow, G. (1989). Graeme Gow's Complete Guide to Australian Snakes. London: Angus and Robertson Publishers.

Gray, J. (Ed.). (1997). Proposals for Amendment of Appendices I and II: Hawksbill Turtle Eretmochelys imbricata. Report of the Tenth Meeting of the Conference of the Parties to CITES. TRAFFIC Bulletin, 17. Available from: www.traffic.org/factfile/cop10/cop10_37.html

Grenard, S. (1991). Handbook of Alligators and Crocodiles. Malabar, Florida: Krieger Publishing Company.

IUCN. (2003). 2003 IUCN Red List of Threatened Species. Available from: www.redlist.org

Groombridge, B. and Luxmoore, R. (1989). The Green Turtle and Hawksbill (Reptilia: Cheloniidae): World Status, Exploitation and Trade. Lausanne, Switzerland: CITES Secretariat.

Hobson, I. (1988). Traditional knowledge within the communities. In F. Gray and L. Zann (Eds.), Traditional Knowledge of the Marine Environment in northern Australia : Proceedings of a Workshop held in Townsville, Australia, 29 and 30 July 1985 (pp. 42-53). Townsville, Queensland: The Great Barrier Reef Marine Park Authority. Available from: www.gbrmpa.gov.au/corp_site/info_services/publications/workshop_series/ws008

Jenkins, D., Watson, A. and Miller, G.R. (1963). Population studies on red grouse, Lagopus lagopus scoticus (Lath.) in north-east Scotland. Journal of Animal Ecology, 32, 317-376.

Kaneko, Y. and Yamaoka, H. (1999). Traditional use and conservation of Hawksbill turtles: From a Japanese industry's perspective. Report of the Proceedings of the 2nd Symposium on Sustainable Use of Wildlife Resources, Chengdu, China, 22-26 November, 1999. Lausanne, Switzerland: IMWC (World Conservation Trust). Available from: www.iwmc.org/sustain/2ndSymposium/aquatic/aquatic-22-1.htm

Kemf, E., Groombridge, B., Abreu, A. and Wilson, A. (2000). Marine Turtles in the Wild: A WWF Species Status Report. Gland, Switzerland: WWF (World Wildlife Fund for Nature). Available from: www.wwf.be/online_publications/species/wanted_alive_turtles.pdf

Kennett, R. (1999). Reproduction of two species of freshwater turtle, Chelodina rugosa and Elseya dentata, from the wet-dry tropics of northern Australia. Journal of Zoology, 247, 457-473.

Kennett, R. (2004). Turning turtle. Nature Australia Magazine, 27, 46-51.

Kennett, R., Georges, A. and Palmer-Allen, M. (1993). Early developmental arrest during immersion of eggs of a tropical freshwater turtle, Chelodina rugosa (Testudinata: Chelidae), from Northern Australia. Australian Journal of Zoology, 41, 37-45.

Kotchen, M.J. and Reiling, S.D. (2000). Environmental attitudes, motivation, and contingent valuation of non-use values: A case study involving endangered species. Ecological Economics, 32, 93-107.

Lang, J.W. (1987). Crocodilian behaviour: Implications for management. In G.J.W. Webb, S.C. Manolis and P.J. Whitehead (Eds.), Wildlife Management: Crocodiles and Alligators (pp. 273-294). Chipping Norton, Australia: Surrey Beatty and Sons in association with the Conservation Commission of the Northern Territory.

Lanhupuy, W. (1987). Australian Aboriginal attitudes to crocodile management. In G.J.W. Webb, S.C. Manolis and P.J. Whitehead (Eds.), Wildlife Management: Crocodile and Alligators (pp. 145-147). Chipping Norton, Australia: Surrey Beatty and Sons in association with the Conservation Commission of the Northern Territory.

Letts, G.A. (1987). The management of crocodilians in Australia— introductory comments. In G.J.W. Webb, S.C. Manolis and P.J. Whitehead (Eds.), Wildlife Management: Crocodile and Alligators (pp. 103-105). Chipping Norton, Australia: Surrey Beatty and Sons in association with the Conservation Commission of the Northern Territory.

Limpus, C.J. and Parmeter, C.J. (1988). The sea turtle resources of the Torres Strait region. In F. Gray and L. Zann (Eds.), Traditional Knowledge of the Marine Environment in northern Australia: Proceedings of a Workshop held in Townsville, Australia, 29 and 30 July 1985 (pp. 149-163). Townsville, Queensland: The Great Barrier Reef Marine Park Authority. Available from: www.gbrmpa.gov.au/corp_site/info_services/publications/workshop_series/ws008

Love, G. and Langenkamp, D. (2003). Australian Aquaculture: Industry Profile for Selected Species. Canberra: ABARE (Australian Bureau of Agricultural and Resource Economics).

Lutz, P.L. and Musick, J.A. (1997). The Biology of Sea Turtles. Boca Raton, Florida: CRC Press.

MacNamara, K., Nicholas, P., Murphy, D., Riedel, E., Goulding, B., Horsburgh, C., Whiting, T. and Warfield, B. (2003). Markets for Skins and Leather from the Goat, Emu, Ostrich, Crocodile & Camel Industries. ACT, Australia: RIRDC (The Australian Government Rural Industries Research and Development Corporation). Available from: www.rirdc.gov.au/reports/NAP/02-142.pdf

Magnusson, W.E. (1984). Economics, developing countries and the captive propagation of crocodilians. Wildlife Society Bulletin, 12, 194-197.

Marsh, N.A. (2001). Diagnostic uses of snake venom. Haemostasis, 31, 211-217.

McBryde, I. (1979). Archeology. In D. Barwich, M. Mace and T. Stannage (Eds.), Handbook for Aboriginal and Islander History. Canberra: Aboriginal History Publishers.

Messel, H. (1977). Chapter 13— The crocodile programme in Northern Australia: Population surveys and numbers. In H. Messel, and S. Butler (Eds.), Australian Animals and their Environment (pp. 207-236). Sydney, Australia: Shakespeare Head Press.

Messel, H. and Vorlicek, G.C. (1989). Ecology of Crocodylus porosus in northern Australia. In IUCN, Crocodiles: Their Ecology, Management and Conservation. A Special Publication of the IUCN/SSC Crocodile Specialist Group (pp. 164-183). Gland, Switzerland: IUCN.

Messel, H., Vorlicek, G.C., Wells, A.G., Green, W.J., Curtis, H.S., Roff, C.R.R., Weaver, C.M. and Johnson, A. (1981). Surveys of Tidal Waterways on Cape York Peninsula, Queensland, Australia, and their Crocodile Populations. Monograph 16. Oxford, England; Sydney, Australia: Pergamon Press Ltd.

Metrick, A. and Weitzman, M.L. (1996). Patterns of behaviour in endangered species preservation. Land Economics, 72, 1-16.

Metrick, A. and Weitzman, M.L. (1998). Conflicts and choices in biodiversity preservation. Journal of Economic Perspectives, 12, 21-34.

Meylan, A. (1998). Hawksbill turtles still endangered. Nature, 391, 117-117.

Meylan, A.B. (1999). Status of the hawksbill turtle (Eretmochelys imbricata) in the Caribbean region. Chelonian Conservation and Biology, 3, 177-184.

Meylan, A.B. and Donnelly, M. (1999). Status justification for listing the hawksbill turtle (Eretmochelys imbricata) as Critically Endangered on the 1996 IUCN Red List of Threatened Animals. Chelonian Conservation and Biology, 3, 200–224.

Mitchell, G.E., Reed, A.W. and Houlihan, D.B. (1995). Composition of crocodile meat (Crocodylus porosus and Crocodylus johnstoni). Food Australia, 47, 221-221.

Moore, G.W., Smith, M.P. and Savidge, G.F. (2003). The Ecarin time is an improved confirmatory test for the Taipan snake venom time in warfarinized patients with lupus anticoagulants. Blood Coagulation & Fibrinolysis, 14, 307-312.

Mrosovsky, N. 2003. Predicting extinction: Fundamental flaws in IUCN's Red List system, exemplified by the case of sea turtles. Available from: members.seaturtle.org/mrosovsky

NMFS (National Marine Fisheries Service). (2001). Hawksbill Sea Turtle. Available from: www.nmfs.noaa.gov/prot_res/species/turtles/hawksbill.html

Ottenwalder, J. A. (1996). The current status of sea turtles in Haiti. In R. Powell and R.W. Henderson (Eds.), Contributions to West Indian Herpetology, 12, 381-393.

Parsons, J.J. (1972). The hawksbill turtle and the tortoiseshell trade. In Etudes de Géographie Tropicale Offertes à Pierre Gourou (pp. 45-60). Mouton, Paris: La Haye.

Peucker, S. (1998). The crocodile industry. In K. Hyde (Ed.), The New Rural Industries: A Handbook for Farmers and Investors. ACT, Australia: RIRDC (The Australian Government Rural Industries Research and Development Corporation). Available from: www.rirdc.gov.au/pub/handbook/croco.html

Porosus Pty. Ltd. (2003). Australia’s crocs: Farming in Australia. Available from: www.crocfarm.com.au/farming_in_australia.asp

PWC (Parks and Wildlife Commission of the Northern Territory). (1999). A Management Program for Crocodylus porosus and Crocodylus johnstoni in the Northern Territory of Australia. Darwin, Northern Territory: Northern Territory Parks and Wildlife Commission. Available from: www.deh.gov.au/biodiversity/trade-use/sources/management-plans/approved/crocodile-nt/

PWC (Parks and Wildlife Commission of the Northern Territory). (Undated). A Draft Management Plan for Crocodylus porosus in the Northern Territory. Darwin, Northern Territory: Northern Territory Parks and Wildlife Commission. Available from: www.deh.gov.au/biodiversity/trade-use/sources/management-plans/draft/croc

Queensland Museum. (2003a). Queensland Museum Explorer: Coastal Taipan (Oxyuranus scutellatus). Available from: www.qmuseum.qld.gov.au/features/snakes/snakedetail.asp?TaxName=Oxyuranus+scutellatus

Queensland Museum (2003b). Queensland Museum Explorer: Western Taipan (Oxyuranus microlepidotus). Available from: www.qmuseum.qld.gov.au/features/snakes/snakedetail.asp?TaxName=Oxyuranus+microlepidotus

Queensland Tourism Industry Council. (2004). 16 February 2004 - Queenland A Big Winner at the Australian Tourism Awards. Available from: www.qtic.com.au/ATAstory.htm

Reader's Digest. (1997). Encyclopedia of Australian Wildlife. Sydney: Reader's Digest .

Red List Standards & Petitions Subcommittee. (1996). Eretmochelys imbricata. In: IUCN, 2003 IUCN Red List of Threatened Species. Available from: www.redlist.org

Ross, J.P. (Undated). Ranching and captive breeding. Special programmes: Hawksbill turtle in CITES. Available from: www.cites.org/eng/prog/HBT/intro.shtml

Ross, J.P. (1995). C.I.T.E.S. Approves Marine Turtle Ranching Guidelines. Marine Turtle Newsletter, 69, 1-2. Available from: www.seaturtle.org/mtn/archives/mtn69/mtn69p1.shtml

Ross, J.P. (1995). La Importancia del Uso Sustentable para la Conservación de los Cocodrilos. In A. Larrieta and L.M. Verdade (Eds.), La Conservación y el Manejo de Caimanes y Cocodrilos de América Latina. Vol. 1 (pp. 19-32). Santo Tome, Argentina: Fundación Banco Bica.

Ross, J.P. (Ed.). (1998). Crocodiles. Status Survey and Conservation Action Plan (2nd Edition) [Online]. IUCN/SSC Crocodile Specialist Group. Gland, Switzerland; Cambridge, UK: IUCN. Available from: www.flmnh.ufl.edu/natsci/herpetology/act-plan/plan1998a.htm

Shine, R. and Covacevich, J. (1983). Ecology of highly venomous snakes: the Australian genus Oxyuranus (Elapidae). Journal of Herpetology, 17, 60-69.

Shine, R. (1991). Australian Snakes: A Natural History. New South Wales, Australia: Reed.

Stirrat, S.C., Lawson, D., Freeland, W.J. and Morton, R. (2001). Monitoring Crocodylus porosus populations in the Northern Territory of Australia: A retrospective power analysis. Australian Wildlife Research, 28, 547-554.

Stubbs, A. (1998). Information Systems for New Animal Industries. RIRDC (Rural Industries Research and Development Corporation) – Publication No. 98/139. Canberra: RIRDC. Available from: www.rirdc.gov.au/fullreports/nap.html

Thorbjarnarson, J.B. (1991). An analysis of the spectacled caiman (Caiman crocodilus) harvest program in Venezuela. In J.G. Robinson and K.H. Redford (Eds.), Neotropical Wildlife Use and Conservation (pp. 217-235). Chicago; London: University of Chicago Press.

Thorbjarnarson, J. (1999). Crocodile tears and skins: International trade, economic constraints, and limits to the sustainable use of crocodilians. Conservation Biology, 13, 465-470.

Tisdell, C. (1986). Conflicts about living marine resources in Southeast Asian and Australian waters: Turtles and dugong as cases. Marine Resource Economics, 3, 89-109.

Tisdell, C.A. and Wilson, C. (2004). Information and wildlife valuation: Experiments and policy. A paper prepared for WEAI 79th Annual Conference, Vancouver, 28th June to 3rd July, 2004.

TRAFFIC. (Undated). Status of trade in hawksbill turtles. Available from: www.cites.org/eng/prog/HBT/bg/trade_status.shtml

van Dijk, P.P. and Shepherd, C.R. (2004). Shelled Out? A Snapshot of Bekko Trade in Selected Locations in South-east Asia. Selangor, Malaysia: TRAFFIC Southeast Asia. Available from: www.traffic.org/news/press-releases/bekko_trade_report.pdf

Warfield, B., Twyford-Jones, P. and MacNamara, K. (2000). Identification of market opportunities for skins and leather products of newly emerging animal industries – crocodile. Crocodile Capers, 7. Available from: www.dpi.qld.gov.au/croc/11813.html

Webb, G.J.W. (1997). Crocodiles. Australian Biologist, 1, 31-39.

Webb, G.J.W. (2000a). Crocodiles and sustainable use in the Northern Territory. Lausanne, Switzerland: IWMC World Conservation Trust. Available from: www.iwmc.org/reptiles/010322.htm

Webb, G.J.W. (2000b). Sustainable use of large reptiles – an introduction to issues. In Proceedings of the 15th Working Meeting of the IUCN-SSC Crocodile Specialist Group, Varadero, Cuba, 15-20 January, 2000 (pp. 413-430). Gland, Switzerland: IUCN.

Webb, G.J.W. (2002). Conservation and sustainable use of wildlife— an evolving concept. Pacific Conservation Biology, 8, 12-26.

Webb, G.J.W., Bayliss, P.G. and Manolis, S.C. (1986). Population research on crocodiles in the Northern Territory, 1984-1996. In Crocodiles. Proceedings of the 8th Working Meeting of the IUCN-SSC Crocodile Specialist Group, Quito, Ecuador (pp. 22-59). Gland, Switzerland: IUCN.

Webb, G.J.W., Britton, A.R.C., Manolis, S.C., Ottley, B. and Stirrat, S. (2000). The recovery of Crocodylus porosus in the Northern Territory of Australia: 1971-1998. In The Proceedings of the 15th Meeting of the IUCN-SSC Crocodile Specialist Group, Varadero, Cuba, 15-20 January, 2000 (pp. 195-234). Gland, Switzerland: IUCN.

Webb, G.J.W. and Manolis, S.C. (1989). Crocodiles of Australia. Frenchs Forest, New South Wales: Reed Books.

Webb, G.J.W. and Manolis, S.C. (1992). Monitoring saltwater crocodiles (Crocodylus porosus) in the Northern Territory of Australia. In D.R. McCullough and R.H. Barrett (Eds.), Wildlife 2001: Populations (pp. 404-418). Essex, England: Elsevier Science Publishers.

Webb, G.J.W. and Manolis, S.C. (1993). Conserving Australia's crocodiles through commercial incentives. In D. Lunney and D. Ayers (Eds.), Herpetology in Australia: A Diverse Discipline (pp. 250-256). Sydney: Surrey Beatty and Sons.

Webb, G.J.W., Manolis, S.C. and Buckworth, R. (1983). Crocodylus johnstoni in the McKinlay river area, N.T. I. Variation in the diet, and a new method of assessing the relative importance of prey. Australian Journal of Zoology, 30, 877-899.

Webb, G.J.W., Manolis, S.C. and Ottley, B. (1994). Crocodile management and research in the Northern Territory: 1992-1994. In Crocodiles. Proceedings of the 12th Working Meeting of the Crocodile Specialist Group (pp. 167-180). Gland, Switzerland: IUCN.

Webb, G.J.W., Manolis, S.C. and Sack, G.C. (1983). Crocodylus johnstoni and C. porosus coexisting in a tidal river. Australian Wildlife Research, 10, 639-650.

Webb, G.J.W., Manolis, S.C., Whitehead, P.J. and Letts, G.A. (1984). A proposal for the transfer of the Australian population of Crocodylus porosus Schneider (1801), from Appendix I to Appendix II of CITES. Conservation Commission of the Northern Territory, Tech. Report No. 21.

Webb, G.J.W., Missi, C. and Cleary, M. (1996). Sustainable use of crocodiles by Aboriginal people in the Northern Territory. In M. Bomford and J. Caughley (Eds.), Sustainable Use of Wildlife by Aboriginal Peoples and Torres Strait Islanders (pp. 176-185). Canberra: Australian Government Publishing Service.

Webb, G.J.W., Whitehead P.J. and Manolis, C.S. (1987). Crocodile management in the Northern Territory of Australia. In G.J.W. Webb, S.C. Manolis and P.J. Whitehead (Eds.), Wildlife Management: Crocodile and Alligators (pp. 107-124). Chipping Norton, Australia: Surrey Beatty and Sons in association with the Conservation Commission of the Northern Territory.

Williams, J., Read, C., Norton, A., Dovers, S., Burgman, M., Proctor, W. and Anderson, H. (2001). Biodiversity: Australia State of the Environment Report 2001 (Theme Report). Canberra, ACT: CSIRO Publishing on behalf of the Department of the Department of Environment and Heritage.

Wilson, P. and Franklin, W.L. (1985). Male group dynamics and inter-male aggression of guanacos in southern Chile. Zoological Tierpsychology, 69, 305-528.

WMI (Wildlife Management International). (2004). Crocodylus Park: Wildlife Research and Education Centre. Available from: wmi.com.au/crocpark/

WWF (World Wildlife Fund). (2002). Hawksbill Turtles. Species Programme May 2002. UK: WWF International Species Programme.

WWF (World Wildlife Fund). (2004). Marine Turtles: Hawksbill. Available from: www.worldwildlife.org/turtles/species/ht.cfm

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