# CROCODILES

Proceedings of the 17th Working Meeting of the Crocodile Specialist Group of the Species Survival Commission of IUCN - The World Conservation Union convened at Darwin, Northern Territory of Australia, 24-29 May 2004

(Unreviewed)

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#### The Crocodile Specialist Group

The Crocodile Specialist Group (CSG) is a worldwide network of biologists, wildlife managers, Government officials, independent researchers, non-government organization representatives, farmers, traders, tanners, manufacturers and private companies actively involved in the conservation of crocodilians (crocodiles, alligators, caimans and gharials). The group operates under the auspices of the Species Survival Commission (SSC) of IUCN. The CSG provides a network of experts to assess conservation priorities, develop plans for research and conservation, conduct surveys, estimate populations, provide technical information and training, and to draft conservation programs and policy. CSG also assists monitoring of international trade and identifying products. Working meetings of the group are held every two years.

#### Foreword

For the people who work on crocodilians around the world, the biennial meetings of the CSG have long been recognised as something special. They provide an opportunity for like-minded people to get together, to share information and experiences, and to discuss how the field crocodilian conservation and management has evolved since their last meeting. Regardless of advances in communication, it seems that nothing beats face-to-face contact with colleagues, and the ability to establish and re-establish personal relationships.

Despite the successes we have achieved with crocodilian conservation in many countries, there remains some serious problems with crocodilian conservation. Some species exist as minor remnants of their former abundance, still fighting for survival in countries where human survival is the national priority. Reviewing these critical conservation problems and formulate actions to help overcome them, is the core business of the CSG Working Meetings.

The 17th CSG meeting, held in Darwin, Northern Territory of Australia, continued a fine tradition of "good" CSG meetings. The Steering Committee meeting, which is open to all members, addressed a daunting array of different problems. One of the outcomes was that I would replace Professor Harry Messel as CSG Chairman, when he stands down in November. The meeting itself reviewed the linkages between the CSG and various international organizations and instruments, provided case history reports on conservation in many nations, and provided an opportunity for members to be updated on current research initiatives.

For the Tomistoma Task Force, formed at the 16th CSG meeting in Gainseville, USA (2002), it provided the first opportunity for TTF members to meet, discuss progress, and raise more funds for Tomistoma surveys in Kalimantan later in 2004. Other working groups met to discuss the conservation and management of Siamese Crocodiles in Cambodia, the Philippine Crocodile, the Chinese Alligator, human-crocodile conflicts, veterinary aspects, trade, etc. We had a lively evening social program to complement each day's deliberations, which finished with a field trip to the McKinlay River, where an Australian Freshwater Crocodile population has been studied for over 25 years.

The CSG could not operate without the shared commitment of its members to improving crocodilian conservation. Their willingness to donate time, effort and funds to help achieve the IUCN's goals with crocodilians, is the glue that binds members together. Continuing this commitment and activity is the challenge to be faced as the new Chairman, and I am looking forward to it.

Grahame J.W. Webb Chairman-elect

#### Summary of the Meeting

Between 24 and 29 May 2004, 232 members and supporters of the Crocodile Specialist Group, from 34 countries, convened in Darwin, Northern Territory, Australia for a very successful 17th Working Meeting. Wildlife Management International Pty. Limited hosted the meeting, which was held at the MGM Grand Hotel, in Darwin.

The organising committee [Grahame Webb, Charlie Manolis, Tom Dacey Nancy Pedersen, Larry Bannister and Mike Letnic] were ably assisted by WMI staff and a band of volunteers. A large number of donors and sponsors made the meeting possible, and we are particularly grateful to the Northern Territory Government, the Rural Industries Research and Development Corporation and the Key Centre for Tropical Wildlife Management (Charles Darwin University) for their financial support. Internationaler Reptillederverband e.V. and Reptilartenschutz e.V. (Offenbach, Germany) provided financial assistance for some participants to get to the meeting.

The first day of the meeting was devoted to the CSG Steering Committee, which handled a daunting schedule of international crocodile issues. A highlight was the election of Professor Grahame Webb as CSG Chairman-elect, to take over the leadership when Professor Harry Messel steps down in November 2004.

The working meeting was opened by Professor Harry Messel and the Chairman of the Species Survival Commission, Dr. David Brackett. The official opening and welcome to the Northern Territory was carried out by Dr. Chris Burns, Minister for Infrastructure, Planning and Environment, at Parliament House. This occasion was also used by the SSC Chairman to present Professor Messel the IUCN's highest award for conservation - the Sir Peter Scott Medal.

Major workshops were held concurrently with the meeting, and dealt with skin quality, human crocodile conflicts, sustainability of trade, CSG core business, and conservation of Tomistoma, Siamese Crocodiles and Philippine Crocodiles.

A session on the "Conservation, Management and Sustainable Use of Crocodiles in Australia" reviewed each of the State and Territory programs and discussed the unique role of Aboriginal people in management. Two sessions dealt with the foundations of crocodilian conservation, and provided reviews of many issues intimately linked to crocodilian conservation today (IUCN, CITES, Compliance with CITES, Article IV of CITES, Precautionary Principle, IUCN Red List, wildlife management practices and principles; and, adaptive management in Louisiana, bio-economic modelling, harvesting adults and parallels between the management of crocodiles and kangaroos in Australia).

A session was devoted to actions being taken with some of the most endangered species: Chinese Alligators, Siamese Crocodiles, Tomistoma and Muggers in Iran. This was followed by a series of sessions on management case histories from Cambodia, Sri Lanka, the Philippines, Sarawak, Congo/Gabon, Bolivia, Sabah, Venezuela, Argentina, Bangladesh and South America generally. A session on local people in crocodilian conservation examined the challenges of education generally, particularly on the internet, and examined case histories from Cambodia, Bolivia and the Philippines. A session on trade issues included some advances in crocodile farming technology.

More than 40 posters were presented, and in a break from tradition, most of the poster authors were given the opportunity to address the plenary for 5 minutes about their work. This was very successful in terms of linking the audience to particular issues and subjects before they got to the posters. The subjects addressed in the posters were highly diverse, ranging from strictly pure to applied science.

The final day was devoted to miscellaneous papers and reports which again covered a diverse range of subjects: effects of heavy metals and other pollutants; diving behaviour, crocodilian red blood cell physiology, the case for an anatomical treatise on crocodilians, genetics, radio-tracking, satellite tracking, survey biases, biomechanics, integumentary sense organs, *Caiman yacare* life history, American Crocodiles in Florida, reproduction of Gharials, artificial foods, population modelling, immune responses, etc.

"Nocturnal" activities included an "ice breaker" hosted by the National Aquarium in Baltimore, and a BBQ at the Darwin Trailer Boat Club. Even an atypical thunderstorm as participants made their way to the boat club could not dampen people's spirits. A high point of the social agenda was the closing banquet, served outdoors at Crocodylus Park. Participants revelled in the "down-under' hospitality, meal and drinks, together with Latin music.

The Castillo prize for crocodilian conservation, a hand-made Mexican silver pitcher, was presented to Jenny Daltry in recognition of the exciting research she has been undertaking in Cambodia and southeast Asia. A raffle was

organised for crocodile skin wallets and opals, and together with additional items sold at the meeting, resulted in around \$U\$3000 being raised for the Tomistoma Task Force.

The field trip began early the next morning, with participants departing by bus and 4-wheel drive to the McKinlay River, about 120 km east of Darwin. The McKinlay River population of Australian Freshwater Crocodiles has been under study for over 25 years. Most people were able to go out in the boats and help catch freshies, and assist with processing and measurement. Of the 17 crocodiles caught, most were marked, some as long ago as 1980. Cane toads have just arrived in the McKinlay River, and significant increases in mortality rates are expected over the next few years.

The meeting could not been as great a success without the contribution of many people and organisations: crocodile farms (Janamba, Koorana, Lagoon, QDPI) provided crocodile meat; Lenah Game and Gourmet provided kangaroo fillets; local industry (Newfishing Australia, Taroona, Marine Harvest) provided seafood; Parks and Wildlife Service Rangers assisted in the field trip; Kerry Sharpe (media liaison) organised the media; and, volunteers manned the registration desk and assisted in so many ways (Lesley Sullivan, Peter Sullivan, Peta Jones, Harvey Ottway, Erin O'Brien, Pushpa Palianappan). Akira Matsuda set up a secure server for registrations. Adam Britton ensured that presentations were loaded and ready to go as scheduled.

A special thank-you must go to the chief organiser, Tom Dacey, for his considerable efforts in the months leading up to, and at the meeting.

The CSG Working Meetings, held each two years, are the primary international meeting dedicated to crocodilian conservation. They have become the major forum for discussion of conservation problems, new findings and new directions. Each meeting has its special highlights, and participants at the 17th CSG Meeting seemed unanimous in their view that it had been one of the "best" meetings.

## Hosts, Sponsors and Donors

#### **Host Organisation**

• Wildlife Management International

#### 17th CSG Meeting Organising Committee

- Tom Dacey, Clifton Beach, Queensland
- Grahame Webb, Wildlife Management International
- Charlie Manolis, Wildlife Management International
- Larry Bannister, Department of the Chief Minister
- Nancy Pedersen, Department of Business, Industry and Resource Development
- Mike Letnic, Parks and Wildlife Service of the Northern Territory

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- Northern Territory Department of Business, Industry and Resource Development
- Northern Territory Department of Infrastructure, Planning and Environment
- Rural Industries Research and Development Corporation
- Key Centre for Tropical Wildlife Management, Charles Darwin University

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- John Hannon, Lagoon Crocodile Farm, Darwin, Northern Territory
- Stuart Barker, Janamba Croc Farm, Middle Point, Northern Territory
- Queensland Department of Primary Industry, Townsville, Queensland
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Chairman-elect Prof. Grahame Webb with Chairman Prof. Harry Messel (Photo: Charlie Manolis).



Craig Franklin, Boyd Simpson, Adam Britton and Akira Matsuda at the BBQ night (Photo: Charlie Manolis).



Alvaro Velasco with his first McKinlay River freshie. Included in the background are Chris Hagen, Jayantha Jayewardene, Mick Pitman, Hildegarde Huchzermeyer and Ashgar Mobaraki (Photo: Alvaro Velasco).



Colin Stevenson (right) and Michael Comerford (left) help Adam Britton process a freshie. (Photo: John Breuggen).



'Croc' women and Allan Woodward at work catching a McKinlay River freshie (from left, Allan Woodward, Libby Bernadin, Heather Thompson and Susan Woodward) (Photo: Phil Wilkinson).



The McKinlay River population of freshwater crocodiles has been studied by WMI for over 26 years. The field trip gave participants an opportunity to see the study-site and participate in the capture of a number of freshies. The impact of cane toads on this population is currently under investigation (Photo: Grahame Webb).

# The History of Crocodile Conservation in Australia

## **Goff Letts**

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For millions of years Australian crocodiles (now represented by *Crocodylus porosus* and *C. johnstoni*) managed their own affairs quite successfully as predators and reproducers at the top of our aquatic food chain. The arrival of Aboriginal people, up to 40,000 years ago, made an impact, though it was not critical. Eggs and meat became part of the diet of coastal people. At the same time these majestic reptiles were embraced into Aboriginal culture in story, ceremony and art.

Early European explorers encountered crocodiles. In 1818, Phillip Parker King misnamed the Alligator Rivers during his maritime survey of the northern coastline. In 1855, A.C. Gregory, the first to cross Australia from west to east, lost horses to crocodile attacks near the mouth of the Fitzmaurice River, an event vividly recorded by the party's artist, Baines. In 1894 Knut Dahl, accompanying Aborigines on the lower Daly River, gave us a sketch of numbers, size and distribution of crocodiles there, and of their cultural significance.

For the next half-century, crocodiles continued to do their own thing within their natural range. The north coast was sparsely populated by settlers who embarked on sporadic hunting forays to counter livestock predation or to harvest a few skins. Webb *et al.* (1984) estimated the Australian population of *C. porosus* in 1945 to be in the order of 200,000.

This peaceful existence was interrupted dramatically from 1945 onwards when world demand for skins attracted professional and amateur shooters to the hunt. Webb *et al.* (1984) estimated that in the order of 300,000 *C. porosus* were harvested from the wild between 1945 and 1972. There was minimal industry regulation. Licences were issued, skins were given a cursory inspection and exports were cleared through customs.

*Crocodylus johnstoni* entered the market later in about 1958. In readily accessible habitat, they were easy targets. Their over-exploitation gave rise to concern among northern wildlife management authorities.

They were given legal protection in Western Australia in 1962 and in the Northern Territory in 1964, following passage of the Northern Territory's first Wildlife Conservation and Control legislation. Some poaching and leakage through Queensland continued.

As the wild harvest of *C. porosus* went on apace, numbers and size dropped. Concern rose within the Commonwealth and States Conservation Ministers' Council (CONCOM) leading to protection action at State level, first in Western Australia (1969), then in the Northern Territory (1971). The Commonwealth Government, exercising its constitutional powers, embargoed exports in 1972, and Queensland adopted protection in 1974.

The next 15 years were critical in the story of crocodile conservation and management in Australia. In 1971 Professor Messel and Sydney University had initiated the North Australia research program. His landmark surveys of *C. porosus* populations in northern estuaries and rivers continued to 1984. Research into the biology of both species stepped up in the Northern Territory, Queensland and NSW. It became the basis for management plans in force today.

In 1975 the Australian National Parks and Wildlife Service commissioned Grahame Webb to prepare a report on the status, conservation and management of world crocodilians. His recommendations in the Australian section were to prove prophetic.

At the same time, international decisions were impacting on the Australian scene. IUCN identified the endangerment of all crocodilians throughout their range. The advent of CITES in 1973 saw our *C. porosus* first listed on Appendix II, then transferred to Appendix I in 1979. (The contiguous Papua New Guinea population remained on Appendix II).

That coincided with a rise in interest in farming crocodiles in Australia, to take advantage of leather and tourism markets and as part of conservation programs. Edwards River Aboriginal project, based on captive breeding, got under way. But for others, the Appendix-I listing would prove difficult. Tensions between interested parties, at home and abroad, followed.

"Problem" crocodiles, increasing in numbers and size, were appearing in Darwin Harbour. Between 1979 and 1981, six attacks (4 fatal) were recorded in Territory coastal areas. Between 1980 and 1982, 179 crocodiles were taken from Darwin Harbour. Public apprehension was growing and crocodiles were becoming politically difficult at the local level.

Based on his surveys Harry Messel was unhappy about future prospects for "salties". He pointed to losses caused by fishing nets and other limiting factors. His advice to the CITES Secretariat - no change!

Grahame Webb's research team was painting a more optimistic picture. CONCOM agreed that *C. porosus*' conservation interests would be best served by an appendix change. CITES ranching resolution opened the door; internationally the role of sustainable utilisation in conservation was being realized.

It was a bumpy road. Supporting the change at CSG meetings at Victoria Falls and St. Lucia in 1982, I found myself in splendid isolation. A follow-up application by Australia at CITES (Gabarone, 1983) was withdrawn in the face of general opposition (with some evidence of self-interest). I learnt about international conservation politics.

1984 saw the breakthrough. A comprehensive proposal for an CITES appendix change for the NT population of *C. porosus*, drafted by Webb *et al.* (1984), was endorsed in a meeting of minds at the CSG meeting in Caracas, Venezuela and subsequently by IUCN. The CITES meeting in Buenos Aires in 1985 approved Australia's application for an Appendix-II downlisting (ranching).

By that time 5 farms were operating in Australia - 3 in the NT, 2 in Queensland. About 4500 *C. porosus* and 7000 *C. johnstoni* were being held on these establishments under approved plans of management. In January 1985 a very successful international crocodile conference was held in Darwin. Substantial progress was made in public education ("Living With Crocodiles"), feral buffalo elimination, net fishing reduction, expansion of protected areas, and Aboriginal consultation (60% of *C. porosus* habitat is on Aboriginal-owned land). By 1986, Professor Messel acknowledged that "recovery is under way" (Messel *et al.* 1986).

Since then there have been regularly refinement to management plans, Australian crocodiles continue to survive and grow in the wild, the industry has come through ups and downs, and research continues to break new ground. The CSG maintains a watching brief. Most of the tensions have eased.

To see the above events in context, it is necessary to understand something of the intricacies of Australia's federal system. Under our Constitution, land, rivers, coastal fringes and wildlife management are largely the responsibility of State and Territory Governments. The Commonwealth Government is directly responsible for matters of common national interest. For example, through Customs it regulates export activities. It also plays a role in co-ordinating common State interests.

Under the Constitution, the Commonwealth is responsible for "external affairs". The High Court has interpreted this to give the Commonwealth jurisdiction over matters which are the subject of international treaties like CITES and the RAMSAR wetlands Conventions. In exercising this power the Commonwealth enacted the Wildlife Protection (Regulation of Exports and Imports) Act, 1982 (since amended to the Environment Protection and Biodiversity Conservation Act, 1999), becoming the Scientific and Management Authority for Australia. The Act embraces the CITES Appendices.

The States have day-to-day responsibility for wildlife management and research. Policies and programs are coordinated through a ministerial council that includes representation from New Zealand and Papua New Guinea, backed by regular meetings of departmental heads and technical working groups.

Today the management of crocodiles in Australia is the product of sound biological research, robust debate, private enterprise and government support, leavened by goodwill and co-operation, in all of which the CSG has plated a significant role.

#### Literature

Messel, H., Vorlicek, G.C., Wells, A.G., Green, W.J., Onley, I.C., and King, F.W. (1986). Surveys of tidal river systems in the Northern Territory of Australia and their crocodile population. Monograph 19. Macarthur Press.

Parliamentary Education Office, Canberra (1991). The Australian Constitution.

Webb, G.J.W., Manolis S.C., Whitehead, P.J. and Letts, G.A. (1984). A proposal for the transfer of the Australia population of *Crocodylus porosus* (Schneider 1801) from Appendix I to Appendix II of C.I.T.E.S. Technical Report No. 21. CCNT: Darwin.

# **Crocodile Management in the Northern Territory of Australia**

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#### Abstract

Two species of crocodile, the estuarine crocodile (*Crocodylus porosus*) and the Australian freshwater crocodile (*C. johnstoni*) occur in the Northern Territory. Since crocodiles were declared a protected species in 1971 their populations have increased dramatically. In 1972 the *C. porosus* population was estimated to be 3000 individuals. Today there are more than 70,000 non-hatchling estuarine crocodiles in the Northern Territory.

Crocodiles are iconic species that attract considerable publicity and a wide range of community views regarding their abundance and cultural and economic importance. Crocodile management in the Northern Territory is directed towards the conservation of crocodiles, their sustainable use and ensuring that crocodiles do not threaten human safety and enjoyment of the environment. In this paper I discuss the conservation and management of crocodiles in the Northern Territory.

#### Introduction

Two species of crocodile, the estuarine crocodile (*Crocodylus porosus*) and the Australian freshwater crocodile (*C. johnstoni*) occur in the Northern Territory. Since crocodiles were declared a protected species in 1971 their populations have increased dramatically. In 1972, the *C. porosus* population was estimated to be 3000 individuals. Today there are more than 70,000 non-hatchling estuarine crocodiles in the Northern Territory. There are no reliable estimates of the population size of *C. johnstoni*, however they are regarded as being abundant.

In the Northern Territory crocodiles are iconic species that attract considerable publicity and a wide range of community views and opinions regarding their abundance, distribution and cultural and economic importance. Community views towards crocodiles range from them being regarded as totems of spiritual significance by some Aboriginal communities to being regarded as objects of revile and as dangerous pests among some other sectors of the community. Crocodiles are also an important natural resource for many community sectors including Aboriginal communities, the tourist industry and the wildlife harvesting industry.

The opportunities for development provided by an abundant crocodile population in the Northern Territory are considerable. Crocodiles are a major attraction for tourists visiting the Top End of the Northern Territory and many tourists have an expectation that they will see a large crocodile during their visit to the Northern Territory. The abundant crocodile population also supports the crocodile farming industry and provides people living in remote and rural communities with the opportunity to harvest wild crocodiles and their eggs. Wild harvesting of crocodiles and their eggs offers rural and remote communities, particularly indigenous communities, with opportunities for economic development without substantial capital investment.

Because of crocodiles' economic significance, danger to people and property and the potential for conflict between different user groups, crocodile management in the Northern Territory is a complex task. In this paper I provide an overview of crocodile management in the Northern Territory. The paper will concentrate mainly with the management of *C. porosus* because this is the main species of management concern.

#### Distribution of Crocodiles within the Northern Territory

*Crocodylus porosus* occurs in tidal and freshwaters in northern Australia ranging from Gladstone to Port Hedland (Fig. 1). In the Northern Territory, *C. porosus* occur in high densities in the tidal portions of some mangrove-lined rivers. They are also common in freshwater floodplain habitats and may occur in any freshwater habitat within their range. Detailed descriptions of *C. porosus* habitats within the Northern Territory are available in Messel *et al.* (1979-1987), Magnusson (1980), Magnusson *et al.* (1978), Magnusson and Taylor (1980) and Webb *et al.* (1977, 1983).



Figure 1. Distribution of *Crocodylus porosus* in Australia (after Cogger 1993).



Figure 2. Distribution of *Crocodylus johnstoni* in Australia (after Cogger 1993).

*Crocodylus johnstoni* are found only in northern Australia; in Western Australia, the Northern Territory and Queensland (Fig. 2). *Crocodylus johnstoni* occur primarily in freshwater habitats although they may also occur in the saline, upper tidal reaches of river systems.

#### The Conservation Status of Saltwater Crocodiles in the Northern Territory

The Northern Territory population of *C. porosus* is the largest in Australia. Trends in total population size have been monitored by spotlight counts in a number of tidal rivers since the 1970s (Messel and Vorliceck 1986; Stirrat *et al.* 2001). In 1994 the *C. porosus* population was estimated to be between 70,000 and 75,000 non-hatchling individuals (non-hatchlings are greater than 60 cm total length) (Webb *et al.* 1994). Of this number between 20-40% are likely to occur in fresh water (Webb *et al.* 1984).

There are few known threats to the conservation status of crocodiles in the Northern Territory. The habitats of crocodiles are, in general, not threatened by development and crocodiles appear to be little affected by the invasion of freshwater wetlands by introduced plants such as Mimosa (*Mimosa pigra*). Since the 1970s the disturbance of floodplain habitats by feral buffalo and cattle has been reduced greatly following eradication campaigns. Cane toads are potentially a threatening process to freshwater crocodiles but are not considered to be a threat to saltwater crocodiles (van Dam *et al.* 2002).

Entanglement in fishing nets is known to be a cause of mortality for crocodiles in the Northern Territory. Losses of *C. porosus* due to accidental capture and drowning in barramundi fishing nets was assessed in the early 1980s (Webb *et al.* 1984). Firm data on the level of mortality and the effect of that mortality on crocodile populations are not available for the Northern Territory (Webb *et al.* 1987). Commercial fishing has been banned within a number of river systems that are important habitats for *C. porosus*, such as the Mary, Adelaide, Roper and Alligator Rivers. Fishermen are not permitted to utilise wild crocodiles that drown in their nets.

#### **Population Dynamics**

Since they were declared a protected species in 1971, *C. porosus* populations throughout the Northern Territory have undergone a dramatic recovery. The population increased at a rate of around 4-5% per year during the 1980s and early 1990s (Webb *et al.* 1998). Recent surveys suggest that in most areas the rate of increase of the crocodile population is slowing or approaching an asymptote.

The population of *C. porosus* on the Blyth River near Maningrida has been the most intensively studied crocodile population in the Northern Territory and its population density and dynamics are typical of those seen in rivers throughout the Territory. The population on the Blyth River increased dramatically following protection in 1971 and has been relatively stable since the late 1980s (Fig. 3). An examination of the age structure of the population indicates that since protection, the proportion of individuals, greater than 2.1 m in length, has increased and continues to increase with time (Fig. 4). Similar trends in crocodile populations have been observed throughout areas subject to both the harvesting of crocodile eggs and adult crocodiles. The results of crocodile surveys conducted throughout the Northern Territory since the harvesting of eggs began in 1983, provides no evidence for changes in the size or structure of crocodile populations that can be attributed to egg harvesting or the harvesting of adult crocodiles.



Figure 3. Long-term monitoring data for *Crocodylus porosus* in the Blyth River showing the density of non-hatchling crocodiles from the time of protection in 1971 until 2003.



Figure 4. Long-term monitoring data for *Crocodylus porosus* in the Blyth River showing the size structure of the population expressed as a percentage of the population in 4 size classes.

Studies of survivorship indicate that there is a high mortality rate of crocodiles from egg to maturity. Webb and Manolis (1993) predicted rates of survival for several size classes of *C. porosus* in the wild: at least 25% of eggs usually hatch; 54% of hatchlings survive to one year; 30% of one-year-old crocodiles survive to two years; 60% of two-year-olds survive to three years of age; 56% of three-year-olds survive to four years of age; 56% of four-year-olds survive to five years of age. It follows that about 18 crocodiles would survive to five years from 1000 eggs laid. The actual rates of survival between age five and maturity have never been estimated; however, Webb and Manolis (1993) estimate that less than 1% of these individuals survive to breed. The survival rate of mature animals is unknown.

The gradual decrease in rate of population increase over time, changes in the age structure of populations and studies of the mortality of crocodiles at each stage of their life cycle suggest that the survival of hatchling, juvenile and adult crocodiles is most dependent upon the density of larger crocodiles. It is likely that larger crocodiles prey upon and/ or competitively exclude smaller crocodiles (Webb and Manolis 1993). Although most crocodile populations in the Northern Territory appear to display classic density-dependent population dynamics similar to that observed on the Blyth River, some like the Mary River show very different dynamics.

Figure 5 shows the population dynamics of *C. porosus* in the tidal part of the Mary River. This population, like those elsewhere, underwent a dramatic increase in numbers following protection in 1971. However, the Mary River population is exceptionally dense when compared to other populations that have been surveyed in tidal rivers and also has an atypical population structure. Population structure data for the Mary River indicate that, unlike most other rivers, the population is dominated by individuals greater than 2.5 m in length (Fig. 6). There is no immediately apparent reason to explain why the Mary River population is so different to those in other tidal rivers. It may be that the Mary River is located on a particularly rich floodplain area that can support a large number of crocodiles without invoking intra-specific competition between individuals.



Figure 5. Long-term monitoring data for *Crocodylus porosus* in the Mary River showing the density of non-hatchling crocodiles from the time of protection in 1971 until 2003.

There is a general consensus that the population and range of *C. porosus* in freshwater habitats is increasing, however, little is known of the population size or population structure of *C. porosus* in freshwater habitats. There has been a considerable body of literature describing the breeding habits of *C. porosus* in freshwater areas (see Webb *et al.* 1977; Magnusson 1980). The paucity of information on the ecology of *C. porosus* in freshwater areas is due largely to the difficulties associated with conducting studies in these habitats. These include poor visibility owing to emergent and overhanging vegetation and limited access to freshwater habitats.



Figure 6. Long-term monitoring data for *Crocodylus porosus* on the tidal section of the Mary River showing the size structure of the population expressed as a percentage of the population in 4 size classes.

#### **Brief History of Management**

Crocodile meat and eggs are thought to have been used as a food source by Aboriginal people for as long as Australia has been settled. The importance of crocodiles in Aboriginal culture is reflected in a complex system of totems and ceremonies that is still evident in northern Australia today (Lanhupuy 1987).

In the Northern Territory, commercial hunting of *C. porosus* began in 1945 and continued until 1971 when the species was declared protected due to the marked decline of the population. The decline of the *C. porosus* population between 1945 and 1971 is evident from the reduction of skins produced during this period. Between 1945 and 1971 the total number of *C. porosus* skins from the Northern Territory entering trade is estimated to have been 113,000, with 87,000 between 1945 and 1958 and only 26,000 between 1959 and 1971 (Webb *et al.* 1984).

After protection in 1971, the Northern Territory population of *C. porosus* increased from approximately 3000 nonhatchlings (individuals >0.6 m total length) in 1971 to between 30,000 and 40,000 individuals in 1984 (Webb *et al.* 1984). On 1 July 1975, *C. porosus* was listed on CITES Appendix II. On 28 June 1979, all populations of *C. porosus* except for the population in Papua New Guinea were moved to Appendix I. Following the recovery of the *C. porosus* population, the Australian and Indonesian populations were transferred from Appendix I to Appendix II in 1985. The transferring of populations to Appendix II allowed the re-establishment of an export orientated crocodile industry. In the Northern Territory, this industry began operating in 1980 as crocodile farming whereby farm-stock was derived from wild harvests of crocodile eggs and from captive breeding programs. The first crocodile farm in the Northern Territory was established in 1980.

The ranching industry has been managed closely to ensure that it does not have any detrimental effects on crocodile populations. The current egg harvest quota is 25,000 eggs. Since 1996 limited harvesting of adults and hatchlings from the wild has also occurred. The sustainability of crocodile harvesting in the Northern Territory is evidenced by the continued increase of the *C. porosus* population.

The current management program for *C. porosus* is directed at the long-term sustainable utilisation and conservation of crocodiles and their habitats throughout the Northern Territory. The rationale underlying the program is that abundant populations of crocodiles should be maintained for their ecological and economic value while at the same time ensuring that crocodiles do not threaten human safety and the enjoyment of the environment.

The Territory Parks and Wildlife Conservation Act 2000 provides for traditional harvest (otherwise than for the purpose of sale) of crocodiles and their eggs for food gathering, ceremonial and religious purposes by Aboriginal people. The extent of traditional harvests of crocodiles is difficult to quantify and varies greatly from area to area and year to year. The number of eggs and non-hatchling crocodiles harvested in the last several years is estimated to be around 2000 individuals.

#### Use of and Trade of Crocodile Products

The commercial harvesting of crocodile eggs started in the early 1980s. Records kept by the Parks and Wildlife Service of the Northern Territory show that the total number of eggs collected has increased from 135 in 1984 to a maximum of 29,044 in 1995/96 (Table 1). The number of eggs collected each year depends to a large extent on the timing and extent of rainfall, which can cause the flooding of nests and therefore influence egg survival.

Season	Total Eggs
1979/80	135
1980/81	2758
1981/82	327
1982/83	298
1983/84	2320
1984/85	3518
1985/86	3737
1986/87	4401
1987/88	5300
1988/89	6497
1989/90	12,010
1990/91	9212
1991/92	15,298
1992/93	12,379
1993/94	17,322
1994/95	19,033
1995/96	29,044
1996/97	21,979
1997/98	10,812
1998/99	13,976
1999/00	11,987
2000/01	15,478
2001/02	17,536

Table 1. Numbers of *C. porosus* eggs harvested from the wild since 1979/1980.

Adult and juvenile crocodiles have been removed from the wild over the past two decades to stock crocodile farms with breeding animals. Since 1997 adult crocodiles have been harvested from the wild under permit for direct skin and meat production. Data held by the Parks and Wildlife Service of the Northern Territory show that the numbers harvested have increased from 17 individuals in 1997 to 158 individuals in 2001 (Table 2).

There are currently six crocodile farms in the Northern Territory. Details of commercial crocodile farm production in the Northern Territory are given in Table 3.

#### **Crocodiles and Tourism**

Tourism is one of the major industries in the Top End of the Northern Territory and saltwater crocodiles are currently the Territory's principal marketing icon. Most tourists visiting the Top End have an expectation that they will encounter a crocodile during their time there. The demand to see crocodiles is reflected by a vast array of tours and facilities

Year	Wild Harvest	Problem Crocodiles
1996	0	135
1997	17	128
1998	10	112
1999	91	139
2000	92	181
2001	158	252
2002	138	150

Table 2. The number of *Crocodylus porosus* harvested from the wild and the number of problem crocodiles removed by PWSNT staff each year between 1996 and 2002.

Table 3. Numbers of skins produced and quantity of meat produced (kg) by Northern Territory crocodile farms since 1987.

Year	No. of Farms	Skins	Meat (kg)
1987	4	251	2072
1988	4	962	3171
1989	4	1402	2675
1990	4	1954	4939
1991	6	2381	No data
1992	6	3277	4017
1993	6	4796	13,850
1994	7	3595	17,401
1995	8	6917	26,626
1996	8	6410	35,411
1997	8	8448	34,621
1998	8	8456	44,115
1999	8	8466	45,651
2000	8	7643	41,502
2001	6	6351	28,634
2002	6	3938	14,794

that allow people to encounter crocodiles. These range from tours of crocodile farms, to tours of waterways that allow people to see crocodiles in their natural habitats. Because of this demand, the management of crocodiles in the Northern Territory recognizes the value of crocodiles to tourism. This is evidenced in the current management program by the creation of areas where the harvesting of adult crocodiles is restricted due to their high usage by tourists. Areas where crocodile harvesting is currently restricted are parts of the Adelaide River, Mary River and Daly River catchments. By restricting harvesting it is expected that crocodiles will be more abundant and less wary than would be the case if there was harvesting.

#### **Human-Crocodile Conflicts**

*Crocodylus porosus* is a species that is potentially dangerous to humans and unfortunately there have been numerous records of fatal attacks by crocodiles on humans in the Northern Territory. Since 1971 there have been 10 fatal attacks and at least 33 non-fatal attacks by crocodiles. In most instances where attacks have occurred the victims have been in the water at the time of the attack, though in some cases the victims were located on the waters edge. Saltwater crocodiles are also known to attack livestock and although these losses have never been quantified, they are at times said to be substantial.

To reduce the likelihood of human crocodile/conflicts the Parks and Wildlife Service operates a program to remove problem crocodiles and also issues permits to private individuals allowing them to remove problem crocodiles. *Crocodylus porosus* are not relocated because of their homing instincts (Walsh and Whitehead 1993). The majority of animals captured under the Parks and Wildlife Service's problem crocodile program are distributed to farms and some enter trade directly as skins. These animals may be used for breeding stock or processed for skins and meat along with captive-bred and ranched animals.

In some areas such as Darwin Harbour, Gove Harbour, the Katherine River and swimming areas in National Parks, all crocodiles are considered problem crocodiles and there are permanent removal programs. Data on the Darwin Harbour problem crocodile program are presented in Table 4. In Darwin Harbour there are 19 permanent crocodile traps. These traps capture over 100 crocodiles per year. The sex ratio of the captured crocodiles is biased towards males and is dominated by individuals between 2 and 3 m in length (Fig. 6).

Year	Male	Female	Total
2001	82	33	115
2002	89	41	130
2003	130	57	187
2004 (Jan-Apr)	73	14	87

Table 4. Problem *C. porosus* removed from Darwin Harbour between January 2001 and April 2004.



Figure 6. Size distribution of *Crocodylus porosus* removed from Darwin Harbour in 2002.

In other areas, crocodiles that pose a threat to human safety or that have made repeated attacks on stock are considered to be problem crocodiles and are removed by Parks and Wildlife staff or private contractors. The Parks and Wildlife Service conducts regular public awareness campaigns aimed at reducing the occurrence of harmful interactions between people and crocodiles.

#### Conclusion

Crocodiles are a prominent and economically important component of the Northern Territory's fauna. Managing crocodiles is a complex task that requires finding a balance between competing economic uses, conservation requirements and reducing the dangers posed by crocodiles to people. To reflect these competing uses the management of crocodiles is becoming increasingly regionalised to reflect the different social and economic pressures on crocodile populations in different parts of the Northern Territory.

#### Literature

- Cogger, H. (1992). Reptiles and Amphibians of Australia. Reed Books: Sydney.
- Lanhupuy, W. (1987). Australian aboriginal attitudes to crocodile management. Pp. 145-147 *in* Wildlife Management: Crocodiles and Alligators, ed. by G.J.W. Webb, S.C. Manolis and P.J. Whitehead. Surrey Beatty and Sons: Sydney.
- Magnusson, W.E. (1980). Habitat required for nesting by *Crocodylus porosus* (Reptilia: Crocodilidae) in northern Australia. Aust. Wildl. Res. 7: 149-156.
- Magnusson, W.E., Grigg, G.C. and Taylor, J.A. (1978). An aerial survey of potential nesting areas of the saltwater crocodile, *Crocodylus porosus* Schneider, on the north coast of Arnhem Land, northern Australia. Aust. Wildl. Res. 5: 401-415.
- Magnusson, W.E. and Taylor, J.A. (1980) A description of developmental stages in *Crocodylus porosus*, for use in ageing eggs in the field. Aust. Wildl. Res. 7: 479-486.
- Messel, H., Green, W.J., Wells, A.G., Vorlicek, G.C., Onley, I.C., Johnson, A., Gans, C., Elliott, M., Brennan, K.G., Burbidge, A.A., Curtis, H.S., Fuller, P.J., Roff, C.R., Weaver, C.M. and King, W.F. (1979-87). Surveys of the tidal river systems in the Northern Territory of Australia and their crocodile populations, Series of 20 monographs. Pergamon Press: Sydney.
- Messel, H. and Vorlicek, G.C. (1986). Population dynamics and status of *Crocodylus porosus* in the tidal waterways of northern Australia. Aust. Wildl. Res. 13: 71-111.
- 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. Wildlife Research 28: 547-554.
- Van Dam, R.A., Walden, D.J. and Begg, G.W. (2002). A preliminary risk assessment of cane toads in Kakadu National Park. Scientist Report 164, Supervising Scientist, Darwin, NT.
- Walsh, B. and Whitehead, P.J. (1993). Problem crocodiles, *Crocodylus porosus*, at Nhulunbuy, Northern Territory: an assessment of relocation as a management strategy. Wildlife Research 20: 127-135.
- Webb, G.J.W., Messel, H. and Magnusson, W.E. (1977). The nesting biology of *Crocodylus porosus* in Arnhem Land, northern Australia. Copeia 1977: 238-249.
- Webb, G.J.W., Sack, G.C., Buckworth, R., and Manolis, S.C. (1983) An examination of *Crocodylus porosus* nests in two northern Australian freshwater swamps, with analysis of embryo mortality. Aust. Wildl. Res. 10: 571-605.
- 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 C.I.T.E.S. Conservation Commission of the Northern Territory, Tech. Report No. 21.
- Webb, G.J.W., Whitehead, P.J. and Manolis, S.C. (1987). The management of crocodiles in the Northern Territory of Australia. Pp. 107-124 *in* Wildlife Management: Crocodiles and Alligators, ed. by G.J.W. Webb, S.C. Manolis and P.J. Whitehead. Surrey Beatty and Sons: Chipping Norton.
- Webb, G.J.W. and Manolis, S.C. (1993) Conserving Australia's crocodiles through commercial incentives, Pp. 250-256 *in* Herpetology in Australia, ed. by D. Lunney and D. Ayers. Surrey Beatty and Sons: Chipping Norton.
- Webb, G.J.W., Manolis, S.C. and Ottley, B. (1994). Crocodile management and research in the Northern Territory: 1992-94. Pp. 167-180 in Crocodiles. Proceedings of the 12th Working Meeting of the IUCN-SSC Crocodile Specialist Group. Pattaya, Thailand, 2-6 May 1994. IUCN: Gland, Switzerland.
- Webb, G.J.W., Manolis, S.C. and Ottley, B. (1998). Recovery of saltwater crocodiles (*Crocodylus porosus*) in the Northern Territory: 1971-1998. Report prepared for the Parks and Wildlife Commission of the Northern Territory.

# **Crocodiles in Queensland - An Overview**

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## Abstract

Crocodiles are large, semi-aquatic oviparous reptiles. Two species occur in Queensland (Cogger 1992): the estuarine crocodile (*Crocodylus porosus*) and the smaller freshwater crocodile (*C. johnstoni*). As the names imply, the preferred general habitats utilised by these two crocodiles are separate, but in ecological terms they regularly occur in sympatry. In Queensland, *C. porosus* can be found in marine, estuarine and freshwater habitats from Gladstone to the Queensland-Northern Territory border (Taplin 1987; Read *et al.* 2004), including some of the islands and reefs of the Northern Great Barrier Reef (Limpus 1980; Miller and Bell 1997). In contrast, the freshwater crocodile (*C. johnstoni*) can be found in many freshwater habitats west of the Great Dividing Range (Taplin 1987; Tucker 1997) and in the upper reaches of the Herbert River (QPWS, unpubl. data) and Lakefield National Park on the east coast of Queensland (Taplin 1987; Read and Miller 1998) as well as in isolated introduced populations in some rivers along the eastern coast (QPWS, unpubl. data). *C. johnstoni* can also be found in estuarine and brackish waters in Queensland (Read 1998).

#### Distribution of crocodiles and description of crocodile habitat within Queensland

The estuarine or saltwater crocodile is broadly distributed around the coastline of Queensland and is recorded over 12.5° of latitude. Estuarine crocodiles are regularly sighted in the Fitzroy River at Rockhampton (23.5°S, 150.6°E), with infrequent sightings as far south as Elliott Heads (24.9°S, 152.5°E) near Bundaberg. The most southern breeding population is located in the Fitzroy River at Rockhampton (Taplin 1987).

The freshwater crocodile is also broadly distributed over 12.5° of latitude, with animals recorded from Cape York Peninsula to the Fitzroy River in the south (Read 1999b). The main population is distributed on the western side of the Great Dividing Range, or in Lakefield National Park on the eastern coast.

Following extensive vessel-based and aerial surveillance of *C. porosus* populations and habitat in Queensland, Taplin (1987) defined eight crocodile biogeographic regions based largely on major drainage divides, changes in physiography, land use and human population density (Fig. 1). These biogeographic regions differ considerably in available habitat and population abundance of *C. porosus*, thus providing a general structure by which to describe the estuarine crocodile population in Queensland. Detailed descriptions of these crocodile biogeographical regions can be found in Taplin (1987).

The eight biogeographical regions as defined by Taplin (1987) are:

- 1. Southern Gulf Plains
- 2. Northern Gulf Plains
- 3. North-west Cape York Peninsula
- 4. North-east Cape York Peninsula
- 5. Princess Charlotte Bay
- 6. Eastern Coastal Plains, sub-divided into:
  - (a) Cape Melville to Cooktown
  - (b) Cooktown to Ayr
  - $(c) \quad \text{Ayr to Gladstone} \\$
- 7. Burdekin River Catchment
- 8. Fitzroy River Catchment





#### 1. Southern Gulf Plains

The Southern Gulf Plains are comprised of extensive flat plains and large meandering rivers. The region is dominated by enormous expanses of saltpan and saline meadows of marine couch grass (*Sporobolus virginicus*) and floodplain lagoons are widespread. Winter is characterised by low rainfall, low temperatures and extensive periods of strong winds (>20 kts), with intermittent but extensive flooding in summer.

There is a considerable amount of good crocodile habitat within this region, but nesting habitat is poor overall (Magnusson *et al.* 1980; Taplin 1987) and the number of successful nests produced each year is limited (Read 1998a, 1999a; Read *et al.* 2004). Taplin (unpubl. data) located nests on the Norman and Bynoe Rivers in saltmeadows that formed a narrow fringe between mangroves and saltpan; in dense stands of pure rubber vine *Cryptostegia grandiflora*, an introduced tangling vine which infests many stranded beach ridges in the Gulf; and in bare mud under the mangrove fringe. Taplin reported these nests produced low numbers of hatchlings, but the impact of the apparently unfavourable locations on the survival of eggs or subsequent fitness of hatchlings is unknown. Crèches of hatchlings have been recorded in Walkers Creek, Jenny Lind Creek, Wills Creek and the Gilbert River (Read 1998a, 1999a).

*C. johnstoni* occurs throughout the Southern Gulf Plains region and are usually encountered in the middle to upper reaches of these waterways. Individuals are occasionally captured in estuarine sections less than 5 km from the river mouth (Read 1998a, 1999a). Limited research has been done on the population of *C. johnstoni* in these areas, so there is no information on current distribution and abundance or population status for this species.

The relative densities of non-hatchling *C. porosus* in waterways in the Southern Gulf Plains is low to very low, with the majority of waterways sustaining <0.5 non-hatchlings km<sup>-1</sup>. Spotlight surveys conducted in five waterways in 1999 indicated a mean relative density of  $0.8 \pm 0.5$  (mean  $\pm$  standard deviation) non-hatchlings km<sup>-1</sup> (Read 2001). Several small creeks in the middle reaches of the Norman River, Walkers Creek, Jenny Lind Creek and Wills Creek, all sustain higher numbers of non-hatchlings, with relative densities between 1.5 and 2.5 non-hatchlings km<sup>-1</sup>. Netting for commercially important finfish species occurs in most waterways of the Southern Gulf Plains, with regular unofficial reports of *C. porosus* drowning in nets (Taplin 1987). Previously it was assumed that only the larger size classes of crocodile were drowned in nets, but recent data indicates that animals as small as 0.9 m TL become tangled and drown (QPWS, unpubl. data). The cumulative impact of *C. porosus* drowning in nets remains unquantified.

#### 2. Northern Gulf Plains

The Northern Gulf Plains have a flat topography like the Southern Gulf Plains, but higher annual rainfall, hotter

summers and milder winters (Parkinson 1986). Extensive areas of the region are flood-prone. Grasses such as black speargrass (*Heteropogon contortus*) and marine couch (*Sporobolus virginicus*) grow on eroding banks or behind the mangrove fringe on low-energy banks (Taplin, unpubl. data). The dune swale swamps of the extensive beach ridge have yet to be assessed.

*C. johnstoni* occurs throughout the Northern Gulf Plains region and are usually encountered in the middle to upper reaches of these waterways. Individuals are occasionally captured in estuarine sections less than 5 km from the river mouth (Read 1998a, 1999a). Limited research has been done on the population of *C. johnstoni* in these areas, so there is no current information on distribution and abundance or population status for this species.

As with the Southern Gulf Plains, waterways in the Northern Gulf Plains do not support good crocodile nesting habitat, with low numbers of hatchlings recorded in all waterways during surveys (Read 1998a, 1999a). The relative abundance of non-hatchling *C. porosus* in waterways in the Northern Gulf Plains is usually higher than for waterways of the Southern Gulf Plains, with spotlight surveys recording <1.0 non-hatchlings km<sup>-1</sup>. Spotlight surveys conducted in three waterways in 1999 indicated a mean relative density of  $0.8 \pm 0.3$  non-hatchlings km<sup>-1</sup> (Read 2001). Netting for commercially important finfish species also occurs in most waterways of the Northern Gulf Plains, with intermittent unofficial reports of *C. porosus* drowning in nets.

#### 3. North-west Cape York Peninsula

The North-west Cape York Peninsula region has a unique combination of high temperature and rainfall, extensive deep-water estuaries and permanent freshwater swamps. Small areas of freshwater swampland are scattered throughout the North-west Cape York Peninsula, from the Archer River north to the Jardine River. Heathlands and shallow, sandy estuaries occur over much of the area.

The region is dominated by two large, complex bay systems: Albatross Bay and Port Musgrave. Both systems are associated with deep-water estuaries and freshwater swamps in the middle to upper reaches of the waterways, which provide prime crocodile nesting habitat (Magnusson *et al.* 1980; Messel *et al.* 1981). The waterways of the Port Musgrave system are fringed in the middle third by areas of dense estuarine rainforest and the mangrove palm *Nypa fruticans*. Small freshwater creeks flow into the estuaries in this area (Read, pers. obs.). Along the coastline north of Port Musgrave is a series of regularly spaced rivers and creeks, interspersed with freshwater swamps and dense stands of Melaleuca (Read and Miller 1997).

*C. johnstoni* occurs throughout the North-west Cape York Peninsula region and are only encountered in the middle to upper reaches of these waterways. Limited research has been done on the population of *C. johnstoni* in these areas, so there is no information on the current distribution and abundance or population status for this species in this region.

Waterways of the North-west Cape York Peninsula region contain the highest relative density of *C. porosus* in Queensland (Messel *et al.* 1981; Miller 1994; Read *et al.* 2004). Spotlight surveys conducted in Tentpole Creek, a tributary of the Wenlock River, have recorded non-hatchling densities as high as  $10.5 \text{ km}^{-1}$  (Read and Miller 1997) with a non-hatchling density averaged across all waterways surveyed in 2000 calculated at  $2.2 \pm 1.3 \text{ km}^{-1}$  (Read *et al.* 2004). Waterways of Port Musgrave also support successful nesting by *C. porosus*, especially the Wenlock River and Tentpole Creek (Messel *et al.* 1981; Taplin 1987; Miller 1994; Read *et al.* 2004).

The principal impact on crocodiles in this area of the North-west Cape York Peninsula region comes from the presence of the town of Weipa, the largest settlement on Cape York Peninsula (population ~2500) and site of the world's largest bauxite mine. There is an intense seasonal tourist influx into this region, with many visitors travelling to experience the remote and relatively undisturbed habitats of this region. Netting for commercially important finfish species also occurs in many waterways of the North-west Cape York Peninsula region, with intermittent unofficial reports of *C. porosus* drowning in nets.

#### 4. North-eastern Cape York Peninsula

The North-eastern Cape York Peninsula region has a rainfall and temperature regime comparable to the Northwestern Cape York Peninsula region. Many of the coastal streams run fresh for much of the year. However, the region is dominated by inaccessible dune lake systems of low fertility and has only a narrow coastal plain for the most part. This region is dominated by three large estuarine systems of Newcastle Bay, Temple Bay and Lloyd Bay, and the three major waterways of the Olive River, Pascoe River and the Stewart River. Spotlight surveys conducted in ten waterways of the North-eastern Cape York Peninsula region in 2000 indicated a mean relative density of 0.6  $\pm$  0.3 non-hatchlings km<sup>-1</sup> (Read 2001).

*C. johnstoni* occurs throughout the North-east Cape York Peninsula region and are only encountered in the middle to upper reaches of these waterways. Limited research has been done on the population of *C. johnstoni* in these areas, so there is no current information on distribution and abundance or population status for this species in this region.

#### 5. Princess Charlotte Bay

The Princess Charlotte Bay region has four substantial estuarine systems and large numbers of inland lakes and lagoons. It has more in common with the Northern Gulf Plains around the Nassau and Mitchell Rivers than with other parts of the eastern Cape York Peninsula. It lies at the same latitude, has a similar climate, and consists of a broad, flat, depositional plain with large, meandering rivers. It supports areas of sedges, fringing forest and broadleaf grasses.

Two of the four river systems of Princess Charlotte Bay (the North Kennedy and Bizant Rivers) are contained wholly or largely within the boundaries of Lakefield National Park. The Normanby River forms the eastern boundary of the park for some 80 km of its length. Lakefield National Park is a very popular recreational fishing area, receiving more than 7000 visitors a year. The park plays a very important role in *C. porosus* conservation on the east coast of Queensland, as it provides an area of good crocodile habitat contained within protected area estate.

During the dry season the reduction in water flow within the major river systems forms a series of linked waterholes in the middle to upper reaches of the park, which often support both species of crocodile. There is a significant difference in the relative density of *C. porosus* in non-tidal waterholes versus tidal waterways (ANOVA:  $F_{1,8}$ = 5.59; p<0.005), with the relative density of non-hatchling *C. porosus* in the waterholes recorded at 3.5 ± 0.4 compared to 1.3 ± 0.9 in the tidal waterways (QPWS, unpubl. data).

*C. johnstoni* occurs throughout Lakefield National Park and are usually encountered in the middle to upper reaches of these waterways, with individuals occasionally captured in the tidal reaches of the estuaries. Information on the current distribution and abundance of this species in Lakefield National Park has been collected during surveys for *C. porosus* and indicate that this species can be found throughout the park (Read and Miller 1998; Miller and Coleman 1999; Miller and Beloff 1999; Read 2001).

#### 6. Eastern Coastal Plains

The Eastern Coastal Plains region is divided into three sub-regions extending from Cape Melville to Cooktown (6a); Cooktown to Ayr (6b); and Ayr to Gladstone (6c). The Cape Melville to Cooktown sub-region is considered separately from the other sub-regions that constitute the populated east coast of Queensland.

*C. johnstoni* has been recorded in numerous small populations throughout the Eastern Coastal Plains, but are only considered to represent natural populations for those that occur in the upper Herbert and the upper Burdekin Rivers. The populations that occur around Townsville, Giru, and Rockhampton and further south are considered introduced. In all these areas the species occurs in low density only (QPWS, unpubl. data).

#### Cape Melville to Cooktown (sub-region 6a)

This region has much in common with North-eastern Cape York Peninsula, having a narrow coastal plain backed by a sedimentary plateau, high rainfall, many small freshwater streams, and large areas of silica sand dunes with extensive but infertile lakes and swamps. Human density in this sub-region is very low, encompassing the townships of Cooktown and Hopevale, seasonal travellers and a sand mining operation near Cape Flattery.

Ground surveys of 20 lakes in the Cape Flattery dunefields during September 1985 and 1986 revealed only very low densities of *C. porosus* (Taplin, unpubl. data). Twenty-one crocodiles were sighted, including 12 hatchlings. Local residents and observations from helicopter pilots indicate that crocodiles move in and out of the lakes from

coastal streams. There are no current data on the distribution and abundance of C. porosus in this sub-region.

#### Cooktown to Ayr (sub-region 6b)

This sub-region takes in a coastal fringe, typically less than 40 km wide, in which mangroves, freshwater swamps, agriculture, urban development, humans and crocodiles are concentrated. It is distinct from all other regions of Queensland and virtually all other parts of the range of *C. porosus* in Australia.

The area between the townships of Cooktown and Tully in sub-region 6b encompasses some 325 km of coastline. During the past 50 years this area has undergone tremendous urban, rural residential and agricultural development. The major waterways between Cooktown and Tully were surveyed for estuarine crocodiles between 1996 and 1998 (Kofron and Smith 2001). Three hundred and forty-six kilometres of waterway were surveyed, sighting 146 crocodiles at non-hatchling relative densities ranging from 0.11 to 1.00 km<sup>-1</sup>, with a mean of 0.34 non-hatchlings km<sup>-1</sup> (Kofron and Smith 2001). Spotlight surveys conducted in twelve waterways in 2000 indicated a mean relative density of  $0.6 \pm 0.6$  non-hatchlings km<sup>-1</sup> (Read *et al.* 2004).

Human activities such as urban, rural residential and agricultural development, clearing of riparian vegetation, commercial gill netting in estuaries and removal of crocodiles appear to be keeping crocodile numbers low in this area.

#### Ayr to Gladstone (sub-region 6c)

This region is similar to sub-region 6b and consists of a coastal fringe, typically less than 40 km wide, in which mangroves, freshwater swamps, agriculture, urban development, people and crocodiles are concentrated. Waterways in this sub-region support low to very low numbers of crocodiles, with the notable exception of the Proserpine River, which supports a comparatively healthy *C. porosus* population. Spotlight surveys conducted in this system have recorded relative densities as high as 3.2 non-hatchlings km<sup>-1</sup>. Several successful nests are usually recorded in this system every year and the population is dominated by juvenile crocodiles (QPWS, unpubl. data).

#### 7 and 8. Burdekin and Fitzroy River Catchments

Neither catchment area provides important resources for crocodiles, and populations are scarce and recruitment is minimal. Due to sub-optimal ambient temperature conditions, these regions have always represented marginal habitat for *C. porosus* (Taplin 1987).

#### Burdekin River Catchment

The Burdekin River catchment has a favourable climate in its downstream reaches but the prime wetlands are now largely developed for sugarcane, rice and small crops as part of the Burdekin Delta Irrigation Scheme. Crocodiles are reported only occasionally in the area, with the majority of reports from the Haughton River area (Read 2002). Upstream of the delta, the river runs through a series of narrow, rocky, gorges with long, shallow, sandy or rocky stretches providing limited deep-water refuges. The upstream reaches pass through an arid, rain-shadow region inland of the coastal ranges and experience cold, dry winters comparable with those on the Fitzroy River System.

A comprehensive spotlight and aerial survey was conducted in fourteen waterways of the Burdekin catchment in 2002. A total of 199 km of waterway were covered, and only 12 non-hatchling *C. porosus* were sighted for a mean relative density of  $0.06 \pm 0.01$  non-hatchlings km<sup>-1</sup> (Read 2002).

#### Fitzroy River Catchment

The Fitzroy River catchment lies at the southernmost boundary of the breeding distribution of *C. porosus* in eastern Australia (Taplin 1987). Due to sub-optimal ambient temperature conditions, this region has always represented marginal habitat for *C. porosus* (Taplin 1987), and it is questionable whether this sub-region ever had the capacity to maintain a large crocodile population without a continuing influx of migrants from more productive coastal systems to the north, most which are now affected by agriculture.

Intensive vessel-based surveys conducted in 1998 and 1999 found there were few *C. porosus* in the Fitzroy River, with the numbers of crocodiles highest in the freshwater reaches some 60 km upstream from the mouth of the river. Fifteen *C. porosus* were sighted in 1998, and eight in 1999 (Read 1999b, 2001). Only two of these crocodiles were sighted in the tidal section of the Fitzroy River below the barrage, a concrete weir installed to control water flow and upstream tidal influx, with the remaining sighted in the non-tidal freshwater sections of the river above the barrage. The presence of seven hatchling *C. porosus* sighted in the upper reaches of the Fitzroy River in 1997 suggests that limited recruitment is occurring there (Read 1999b).

#### Population size and trends over time since protection

Information on the current distribution and abundance of *C. porosus* in Queensland comes from data collected during statewide spotlight surveys conducted between 1994 and 2000 (Read *et al.* 2004). A total of 6444 *C. porosus* (4303 non-hatchlings and 2141 hatchlings) were recorded during 196 vessel-based surveys of 103 waterways covering 4174.3 km.

The distribution and abundance of the *C. porosus* population in northern Queensland is spatially variable, with the highest relative density of crocodiles recorded from waterways of the North-west Cape York Peninsula region. Hatchling numbers follow this same trend, with the highest numbers of hatchlings recorded from waterways of the North-west Cape York Peninsula region, followed by Lakefield National Park and selected waterways of the East Coast Plains (Read *et al.* 2004). The structure of the population, as determined by spotlight surveys, was biased towards immature crocodiles with 91% of all animals sighted less than 2.0 m in total length.

The *C. porosus* population in northern Queensland appears to be undergoing a limited recovery, with marginal increases in the mean relative abundance of non-hatchlings across the state (Table 1). There were no discernible

Region	1979-1988	1989-1994	1995-1999
1 Southern Gulf Plains	Mean: 0.19	Mean: 0.4	Mean: 0.81
	Std: 0.12	Std: 0.3	Std: 0.72
	R: 0.09-0.33	R: 0.14-0.86	R: 0.13-2.4
	N= 7	N= 9	N= 23
2. Northern Gulf Plains	Mean: 0.66	Mean: 1.0	Mean: 0.98
	Std: 0.37	Std: 0.3	Std: 0.41
	R: 0.19-1.13	R: 0.75-1.5	R: 0.5-1.5
	N=9	N= 4	N= 8
3. North-west Cape York	Mean: 1.6	Mean: 2.5	Mean: 2.4
Peninsula	Std: 0.881	Std: 3.0	Std: 2.7
	R: 0.41-3.21	R: 0.14-10.5	R: 0.14-10.7
	N=9	N=23	N=33
4. North-east Cape York	Mean: 0.51	Mean: 1.2	Mean: 0.7
Peninsula	Std: -	Std: 0.6	Std: 0.47
	R: -	R: 0.5-2.07	R: 0.4-1.07
	N= 1	N= 5	N= 2
5. Lakefield National Park	Mean: 0.87	Mean: 0.7	Mean: 1.4
	Std: 0.39	Std: 0.4	Std: 1.6
	R: 0.47-1.11	R: 0.12-1.2	R: 0.06-7.5
	N= 3	N= 5	N= 20
6. East Coast Plains	Mean: 0.37	Mean: 0.4	Mean: 0.51
	Std: 0.66	Std: 0.4	Std: 0.9
	R: 0.00-2.67	R: 0.00-2.0	R: 0.00-3.9
	N=22	N= 36	N= 49
7. Burdekin River Catchment	Mean: 0.29	Mean: 0.0	Mean: 0.0
	Std: -	Std: -	Std: -
	R: -	R: -	R: -
	N= 1	N= 1	N= 1
8. Fitzroy River Catchment	Mean: -	Mean: -	Mean: 0.1
	Std: -	Std: -	Std: 0.02
	R: -	R: -	R: 0.09-0.12
	N= -	N= -	N= 2

Table 1. Summary information on changes in mean relative abundance of estuarine crocodiles in defined habitat regions in Queensland.

trends in the data describing changes to the *C. porosus* population structure over the duration of the survey period for six of the eight biogeographic regions. There were considerable fluctuations in the proportion of the population represented by crocodiles in the 2-4 ft, 4-6 ft and >6ft+EO size class, with a significant increase through time in the number of crocodiles in the larger size classes for three of the biogeographical regions (Table 2).

Crocodile	codile Size Class							
biogeographic	2-	2-4ft 4-6 ft				>6ft+EO		
region	F	Р	F	р	F	р		
SGP	0.12	0.76	22.6	0.04	1.19	0.34		
NGP	0.002	0.97	0.85	0.52	0.06	0.84		
NWCYP	1.7	0.25	1.10	0.34	26.3	0.004		
NECYP	0.02	0.91	19.10	0.05	0.79	0.47		
LNP	1.46	0.35	1.42	0.36	1.01	0.42		
ECP	2.22	0.20	0.08	0.79	1.55	0.27		

Table 2. Details of regression analysis describing changes in population structure for three size classes of *Crocodylus porosus* in Queensland during the period January 1994 to December 2000 (from Read *et al.* 2004).

#### A chronology of crocodile research and management in Queensland

Intensive commercial utilisation of crocodiles in Queensland commenced in 1945/46 following the influx of soldiers returning from the Second World War (Taplin 1987). In Queensland, the majority of these crocodile hunters were land-based, with the first vessel-based hunting expeditions commencing in the early to mid-1950s. Over the years of hunting, thousands of skins of both species were exported from Queensland (Roff 1966), with the result that the numbers of wild *C. porosus*, and to a lesser extent, *C. johnstoni*, were reduced dramatically (Taplin 1987). Efforts to conserve wild populations of crocodiles in Queensland began indirectly in 1972 with a Commonwealth Government embargo on the export of crocodile products (Taplin 1987). Effective protection of both species began in 1974 with the declaration of the Queensland Fauna Conservation Act.

Initial research into the distribution and abundance of crocodiles in Queensland focussed on *C. johnstoni*, with the first surveys starting in the Gulf of Carpentaria in 1972. A more comprehensive survey to determine the distribution and abundance of this species covering northern Queensland was initiated in 1976, and one of the first detailed demographic studies was started the same year in the Lynd River and continued for many years (Tucker *et al.* 1994). This study site was revisited in 1992, and numerous publications on the ecology and demographics of this species were produced (see Tucker 1997).

The first research on *C. porosus* commenced in 1979 when the first broad-scale, vessel-based survey of selected waterways in the Gulf of Carpentaria and Cape York Peninsula were completed (Messel *et al.* 1981). Messel and his team collected information on the physical and habitat characteristics of these waterways, as well as determining the distribution and abundance of crocodiles. This research trip provided the initial database that identified the Wenlock River-Tentpole Creek system as an area of prime habitat for *C. porosus* in Queensland (Messel *et al.* 1981).

Laurie Taplin was appointed as a crocodile biologist in 1984 and began conducting a series of vessel-based surveys throughout the Gulf of Carpentaria and Cape York Peninsula. During his tenure with the Service, Taplin produced a series of publications and internal reports on the status of *C. porosus* and *C. johnstoni* in Queensland (Taplin 1987, 1990; Taplin *et al.* 1988; Taplin and Krieger 1989).

Taplin's research showed that the abundance of *C. porosus* in Queensland was spatially variable, with low numbers of crocodiles in most waterways apart from those in the Port Musgrave area north of Weipa. Research indicated that one of the limiting factors controlling population growth of *C. porosus* in Queensland was the availability of suitable nesting habitat. Magnusson *et al.* (1980) conducted an aerial survey in February 1979 from the tip of Cape York Peninsula to the mouth of the Norman River at Karumba, assessing the habitat for suitability of nesting for crocodiles. They concluded that the amount of suitable nesting habitat decreased from north to south, principally because the broad alluvial plains of the Gulf of Carpentaria are often subjected to extensive flooding. They found that the best nesting habitat for crocodiles was located around the Wenlock River and Tentpole Creek area near Port Musgrave.

Through another series of aerial surveys, Taplin showed that annual low-density nesting occurred in the Lockhart River basin and the Escape River system (Taplin *et al.* 1988; Taplin and Krieger 1989). Taplin *et al.* (1988) concluded that no major nesting areas comparable to the swamplands of Port Musgrave existed in Queensland.

In an effort to alleviate public concern about the numbers of crocodiles on the east coast of Queensland and the threat of crocodile attack, the East Coast Crocodile Management Program (ECCMP) was introduced in late 1987. Under this plan, areas within the state were allocated to one of three 'zones', where in zone 'A' all crocodiles were removed, in zone 'B' all crocodiles which exceeded a minimum length of 1.2 m total length were removed and zone 'C', where crocodiles were removed only by staff from the former Queensland National Parks and Wildlife Service (QNPWS). This management program was continued until the early 1990s.

A revision of the status of *C. porosus* in Queensland was published in 1993 (Miller 1994). And the management of crocodiles was redefined in a management programme entitled Conservation and management of *Crocodylus porosus* in Queensland 1995 to 1997 (QDEH 1995) which defined a 'problem' crocodile, allowed for the removal of up to 50 'problem' crocodiles from the wild to protect people, prevented ranching and promoted farming, following the IUCN/CITES definitions. Under this program problem crocodiles were removed on a case-by-case basis.

In May 1998, the Minister for the Environment modified the management of crocodiles on the East coast by declaring a three-year Trial Intense Management Area for Crocodiles (TIMAC). This management area extended from Wonga Beach (south of the Daintree River) to the northern point of the Trinity Inlet near Cairns, and within this zone all crocodiles were to be removed. The plan also called for the removal of all crocodiles from the areas of the Russell, Mulgrave, North Johnstone and South Johnstone rivers west of the Bruce Highway. TIMAC had three primary goals:

- 1. To increase protection of Cairns' popular swimming beaches;
- 2. To promote safe practices in crocodile habitat; and,
- 3. To improve crocodile conservation and management.

These goals were achieved by:

- 1. Removing crocodiles from designated areas in the Cairns and Port Douglas Shires;
- 2. Surveys and monitoring;
- 3. Public education; and,
- 4. Relevant research.

In addition, staff responsible for servicing the TIMAC program were responsible for managing problem crocodiles outside the TIMAC zone. The number of crocodiles removed from within and outside the TIMAC zone between May 1998 and June 2001 is shown in Tables 3 and 4.

Year	Number rem	Sex ratio			Yearly total	Size range (m)	
	Estuarine	М	F	U			
1998	12	1	4	4	5	13	0.3 - 3.1
1999	7	0	6	0	1	7	1.1 - 3.5
2000	13	0	11	2	0	13	1.3 - 3.7
2001	13	0	8	4	1	13	0.2 - 3.6
Total	45	1	29	10	7	46	

Table 3. Crocodiles removed from the TIMAC zone, May 1998 to 30 June 2001.

To augment the TIMAC program, the Queensland Parks and Wildlife Service (QPWS) also implemented a system to work cooperatively with local councils by signing memoranda of understanding with councils. Although not legally binding, these MOUs provided a framework for the formation of a cooperative partnership and a better working relationship. Under these agreements QPWS still had legislative responsibility to manage crocodiles, but the local councils were involved in the decision-making process and the release of joint media statements about crocodiles.

In May 2001 the TIMAC program was continued as the Intensive Management Area for Crocodiles (IMAC) program. This management program and the MOU's with council continue to date.

Year	Number rem	S	ex ratio		Yearly total	Size range (m)	
	Estuarine Freshwater			F	U		
1998	5	0	4	1	0	5	2.8 - 4.5
1999	14	1	8	6	1	15	1.3 – 3.7
2000	10	0	6	4	0	10	1.1 – 3.8
2001	3	1	3	0	1	4	0.3 – 4.2
Total	32	2	21	11	2	34	

Table 4. Crocodiles removed from areas outside the TIMAC zone, May 1998 to 30 June 2001.

#### Philosophies underlying management

The two primary philosophies underlying the management of *C. porosus* in Queensland are to ensure that viable populations are maintained across their natural range while providing for public safety and ecologically sustainable use.

#### Objectives

The specific objectives of the management program are:

- 1. To maintain wild populations of *C. porosus* across its range in Queensland, at least at current population levels consistent with the Queensland Government's obligations concerning public safety;
- 2. To permit and control legitimate commercial enterprises that use crocodiles;
- 3. To increase public awareness and safety in crocodile habitat; and,
- 4. To educate the public to appreciate the ecological significance of crocodiles and the need for crocodile conservation.

#### Strategies

The strategies developed to attain these objectives are:

#### Objective 1

- Monitor crocodile populations and assess the impact of control measures and economic use;
- Undertake research to support the management program, including research into genetic structure, population dynamics and conservation requirements;
- Ensure that sufficient wetland habitats remain to maintain populations of *C. porosus* within and outside protected areas;
- Identify and establish key areas for crocodile conservation; and,
- Ensure that any commercial use of wild crocodiles is sustainable and provides a conservation benefit for crocodiles.

#### Objective 2

- Regulate the use of estuarine crocodiles by the crocodile farming industry;
- To develop and permit and monitor a trial harvest of crocodile eggs on Aboriginal lands in western Cape York Peninsula; and,
- Always provide for a conservation benefit in specified areas to ensure that conservation of the species and its habitat is not compromised by the management procedures.

#### Objective 3

- Develop strategies for the management of crocodiles in populated areas, particularly along the east coast between Gladstone and Cooktown;
- Provide for a crocodile removal zone in the Cairns and Port Douglas areas (IMAC Intensive Management Area for crocodiles);
- Investigate whether crocodile removal zones, such as IMAC, are an effective and efficient strategy for preventing crocodile attack;

- Monitor visitor/crocodile interactions in protected areas;
- Promote the need for appropriate and responsible behaviour in crocodile habitat; and,
- Increase public awareness and educate the public that crocodiles may be encountered in most coastal waterways (both saltwater and freshwater) in tropical Queensland and emphasising that "crocodile free" areas do not exist.

#### Objective 4

• Conduct a community education program with the aim of changing community attitudes towards crocodiles, including the use of videos, television and radio broadcasts, brochures, displays, signs, and education kits for schools.

The QPWS continues to intensively manage crocodiles in the IMAC zone (between Cairns and the Daintree River) and problem crocodiles located outside that area are managed on a case-by-case basis. All crocodile sightings are investigated and crocodile are classified as a 'problem' crocodile based on standard protocols (www.epa.qld.gov.au). Between 15 and 25 crocodiles are removed annually, with the majority of these animals captured north of Townsville.

QPWS has a specialised unit, the Crocodile Management Unit, to investigate and manage crocodile-related incidences, but an additional 60 staff have received training in crocodile handling and assessment and share this response. QPWS has memoranda of understanding for crocodile management with eight local councils in Northern Queensland, creating a reciprocal working relationship between the two groups that is beneficial for crocodile management and responses. QPWS has also signed a MOU for crocodile management and research with Australia Zoo, whereby QPWS can call on the services and equipment of Australia Zoo to manage crocodile responses in remote or logistically challenging areas. This service has now been utilised three times.

The QPWS implemented the 'Croc-Wise' program in October 2001 to raise public awareness about crocodiles and to better inform people about appropriate human behaviours in crocodile country. The aim of this program was to provide better information to people to minimise the risks posed by crocodiles. The messages of the Croc-Wise campaign have been delivered at agricultural and local shows, boating and camping shows, public and community seminars and through radio, print and TV media.

#### Use of and trade in crocodile products

There are six functional crocodile farms in Queensland: the Edward River Crocodile Farm (Pormpuraaw); Hartleys Creek Crocodile Farm (Hartleys Creek, north of Cairns); Melaleuca Crocodile Farm (Mareeba); Cairns Crocodile Farm (Cairns); Johnstone River Crocodile Farm (Innisfail) and Koorana Crocodile Farm (Rockhampton). Edward River Crocodile Farm is primarily a breeder farm and hatchery, with post-hatchlings entering the grow-out phase at Cairns Crocodile Farm. The remaining farms maintain breeding populations and grow-out and process their own stock.

Currently in Queensland, it is closed system of farming with no take from wild populations, except for the occasional crocodile designated by QPWS to be a problem crocodile and sold through a rotating purchase system.

The QPWS is also committed to investigate the sustainable utilisation of wild crocodiles. Given that *C. porosus* is listed as 'vulnerable' under state conservation legislation, there is a need to ensure any harvesting will not be detrimental to the wild population. QPWS is working cooperatively with external proponents to establish research programs to determine the impact of egg harvesting on wild *C. porosus* populations. No harvest of wild live crocodiles is planned.

#### **Crocodile farming**

Guidelines for crocodile farming are contained in the QPWS document Code of Practice - Crocodile Farming. It includes recommendations for the humane use of crocodiles, human safety and sound husbandry. The Code of Practice of the Australasian Regional Association of Zoological Parks and Aquaria Queensland - minimum standards for exhibiting wildlife in Queensland outlines the minimum standards for exhibiting wildlife (including crocodiles) in Queensland. Copies of these documents can be seen at www.epa.qld.gov.au. The Guide for the Crocodile Industry, published by and available from the Division of Workplace Health and Safety, contains the requirements under the Workplace Health and Safety Act 1995 as well as good industry practices.

#### Regulatory control of farms and zoos

Applications for licences to farm or exhibit crocodiles under provisions of the Nature Conservation Act 1992 will be considered for approved farms or zoos. Such licences are valid for a maximum period of three years.

The holder of a Wildlife Farming Licence or Commercial Wildlife Licence for Dead Protected Wildlife is required by regulation to keep records in the required format and to submit Returns of Operations (eg Wildlife Farming Licence - monthly Returns; Commercial Wildlife Licence - annual Returns). A licensee is required by regulation to enter in the Record Book details of wildlife breeding, acquisitions, disposals, deaths and escapes. Record Books and Returns remain the property of the State.

QPWS and the Department of Environment and Heritage (formerly Environment Australia) have implemented a tagging and marking system for identifying skins, skin products and other parts, products and derivatives of crocodiles. These items may be destined for overseas export, either as commercial shipments or as personal effects carried by tourists. Products derived from crocodiles include whole skins, other skin products (including taxidermied and stuffed whole skins, wallets, handbags, and belts), meat (including offal) and low unit-value items (including teeth, claws, skin remnants and skulls).

#### Human-crocodile conflicts

Since 1985 there have been 13 reported crocodile attacks in Queensland, with four fatalities. These attacks have all occurred in northern Queensland, with the most southern attack occurring at Babinda (17.35°S, 145.96°E) in September 1999. The spatial distribution of these attacks is shown in Figure 2.



Figure 2. Map of Queensland showing the distribution of crocodile attacks since 1985.

The statistics on these crocodile attacks are:

- 11 (85%) of the attacks occurred in the water;
- 6 (46%) of the attacks occurred while victims were swimming at night; and,
- 7 (54%) of the victims had been consuming alcohol before the attack occurred.

To minimise the potential for a negative interaction between a crocodile and a human, QPWS intensively manages crocodiles around urban areas and promotes appropriate humans behaviours as part of the 'Croc-Wise' campaign. QPWS is also using proactive media to target and highlight dangerous human behaviours in crocodile country, such as dumping fish frames and wastes around public facilities like boatramps. Under Queensland legislation, it is an offence to feed dangerous wildlife such as crocodiles. Significant fines can be imposed on people who break this law.

#### Ongoing management research and monitoring program

QPWS has initiated a management-orientated research and monitoring program to gain better information about crocodile populations and patterns of spatial utilisation.

To obtain better information about the status of the wild population, vessel-based surveys have been conducted in Lakefield National Park and waterways of the North-West Cape York Peninsula region, and surveys are planned for the North-east Cape York Peninsula, Southern and Northern Gulf Plains regions to determine the current distribution and abundance of *C. porosus* in Queensland and to examine in trends in the population. These surveys will also provide information on the size class distribution and help to identify threatening processes acting on the population.

Intensive research projects to determine how crocodiles use space through time have recently been designed and implemented across northern Queensland. These projects are using radio and satellite telemetry to look at the movement patterns of immature and mature *C. porosus* in tidal and non-tidal waterways. A total of six *C. porosus* have been fitted with satellite transmitters and an additional eleven animals have been fitted with radio transmitters. A further research project is planned for 2004-2005 to attach additional satellite and radio transmitters to crocodiles on Lakefield National Park and around Weipa. The aim of this research is to determine movements and habitat requirements for these crocodiles and to see how crocodiles near urban areas interact with people and man-made structures. Part of this research will also involve translocating crocodiles fitted with satellite transmitters to determine whether these animals display homing behaviour, thus determining whether translocation is an appropriate management option in Queensland.

This work has been substantially supported and resourced through a partnership agreement with Australia Zoo and a bequest by the late Charles Tanner.

#### Summary

#### 1. Crocodile habitat

Both species of crocodile are distributed over 12.5° of latitude, from the tip of Cape York Peninsula to Rockhampton, with irregular sightings of *C. porosus* as far south as Elliott Heads. Crocodile habitat is markedly different around the state, such that the area has been divided into different crocodile biogeographic zones. The distribution and abundance of estuarine crocodiles reflects these differences, with the highest numbers recorded in waterways of the North-west Cape York Peninsula region north of Weipa. Crocodile habitat along the populated east coast of Queensland has undergone extensive modification to support intensive agriculture, grazing and urban development, and the numbers of crocodiles in these waterways is low to very low.

#### 2. Crocodile populations

The population of *C. porosus* in Queensland has undergone a limited recovery, with the relative density of nonhatchlings increasing in most crocodile biogeographic zones. The population, as surveyed using standard spotlight techniques, is biased towards immature crocodiles with >90% of all animals sighted less than 2.0 m long. There were no discernible trends in the data describing changes to the *C. porosus* population structure over the duration of the survey period for six of the eight biogeographical regions.

#### 3. Management of crocodiles

The two primary philosophies underlying the management of *C. porosus* in Queensland are to ensure that viable populations are maintained across their natural range while providing for public safety and ecologically sustainable use.

#### 4. Managing human: crocodile interactions

There have been thirteen crocodile attacks in Queensland since 1985, with four fatalities. Analysis of these attacks indicates that a high proportion occurred while the victims were engaged in an activity that placed them directly in crocodile habitat. The QPWS aims to minimise the risks posed by crocodiles by the targeted removal of animals from urban areas and around high use public facilities like boatramps, and by raising public awareness of the dangers posed by crocodiles and promoting appropriate human behaviours in crocodile habitat. People are reminded that they are responsible for their own safety in crocodile habitat.

#### 5. Crocodile research and monitoring

Crocodile research in Queensland is focused on determining the current distribution and abundance of *C. porosus* and to determine how adult crocodiles use space through time in remote areas and urban areas using telemetry.

#### Literature

- Bayliss, P. (1987). Survey methods and monitoring within crocodile management programs. Pp. 157-175 in Wildlife Management: Crocodiles and Alligators, ed. by G.J.W. Webb, S.C. Manolis and P.J. Whitehead. Surrey Beatty and Sons: Chipping Norton.
- Choquenot, D. and Webb, G.J.W. (1987). A photographic technique for estimating the size of crocodiles seen in spotlight surveys and for quantifying observer bias. Pp. 217-224 in Wildlife Management: Crocodiles and Alligators, ed. by G.J.W. Webb, S.C. Manolis and P.J. Whitehead. Surrey Beatty and Sons: Chipping Norton.
- Cogger, H.G. (1992). Reptiles and Amphibians of Australia. 5th Edition. Reed Books: Chatswood, Australia. 775 pp.
- Limpus, C.J. (1980). Observations of *Crocodylus porosus* in the northern Great Barrier Reef. Herpetofauna 12(10): 34.
- Magnusson, W.E., Grigg, G.C. and Taylor, J.A. (1980). An aerial survey of potential nesting areas of *Crocodylus porosus* on the west coast of Cape York Peninsula. Australian Wildlife Research 7: 465-478.
- 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. South Western Cape York Peninsula (Nassau, Staaten and Gilbert River systems and Duck Creek system) and Northern Cape York Peninsula (Port Musgrave: Wenlock and Ducie River systems, Palm, Dulcie and Namaleta Creeks, Escape River). Pergamon Press: Rushcutters Bay, Australia. 115 pp.
- Miller, J.D. (1994). Crocodiles in Queensland: A brief review. *In* Crocodiles. Proceedings of the 2nd Regional (Eastern Asia, Oceania, Australasia) Meeting of the Crocodile Specialist Group. IUCN: Gland, Switzerland.
- Miller, J.D. and Bell, I.P. (1997). Crocodiles in the Great Barrier Reef World Heritage area. Pp. 248-255 in State of the Great Barrier Reef World Heritage Area Workshop. Proceedings of a technical workshop held in Townsville, Queensland, Australia, 27-29 November 1995, ed. by D. Wachenfeld, J. Oliver, and K. Davis. Great Barrier Reef Marine Park Authority: Townsville, Australia. 561 pp.
- Miller, J.D. and Coleman, I.W. (1999). Report on the distribution and abundance of the estuarine crocodile (*Crocodylus porosus* Schneider, 1801) and the freshwater crocodile (*Crocodylus johnstoni* Krefft, 1873) in Queensland. Lakefield survey September 1998. Internal Report to the Conservation Strategy Branch, Queensland Department of Environment. 20 pp.

- Miller, J.D. and Beloff, P. (1999). Report on the distribution and abundance of the estuarine crocodile (*Crocodylus porosus* Schneider) in Queensland. Lakefield survey September 1999. Internal Report to the Conservation Strategy Branch, Queensland Department of Environment. 20 pp.
- Parkinson, G. (1986). Atlas of Australian Resources, Third Series, Vol. 4. Climate. Division of National Mapping: Canberra.
- QDEH (1995). Conservation and management of *Crocodylus porosus* in Queensland 1995-1997. Department of Environment and Heritage. 48 pp.
- Read, M.A. (1998a). Report on the Distribution and abundance of the estuarine crocodile (*Crocodylus porosus* Schneider) in Queensland. 1. Southern Gulf of Carpentaria. Research conducted July 1997. Internal Report to the Conservation Strategy Branch, Queensland Department of Environment. 19 pp.
- Read, M.A. (1999a). Report on the Distribution and abundance of the estuarine crocodile (*Crocodylus porosus* Schneider) in Queensland. 4. Southern Gulf of Carpentaria. Research conducted July to September 1998. Internal Report to the Queensland Parks and Wildlife Service, Queensland Environmental Protection Agency. 23 pp.
- Read, M.A. (2001). Report on the Distribution and abundance of the Estuarine crocodile (*Crocodylus porosus* Schneider) in Queensland. Internal Report to the Queensland Parks and Wildlife Service, Queensland Environmental Protection Agency. 57 pp.
- Read, M.A. (2002). Risk Assessment: Crocodiles in the Burdekin Shire. Internal Report to the Queensland Parks and Wildlife Service, Queensland Environmental Protection Agency. 57 pp.
- Read, M.A. and Miller, J.D. (1996). Status of the Estuarine crocodile (*Crocodylus porosus*) in Queensland. Internal report to the Queensland Department of Environment's "State of the Environment Report".
- Read, M.A. and Miller, J.D. (1997). Summary Report on the Distribution and Abundance of Estuarine Crocodiles (*Crocodylus porosus* Schneider) in Queensland. Research conducted May 1996 to June 1997. Internal Report to the Conservation Strategy Branch, Queensland Department of Environment. 23 pp.
- Read, M.A. and Miller, J.D. (1998). Report on the Distribution and abundance of the estuarine crocodile (*Crocodylus porosus* Schneider) in Queensland. 2. Lakefield National Park. Research conducted September 1997. Internal Report to the Conservation Strategy Branch, Queensland Department of Environment. 20 pp.
- Read, M.A., Miller, J.D., Bell, I.P. and Felton, A. (2004). The current distribution and abundance of the estuarine crocodile, *Crocodylus porosus*, in Queensland. Wildlife Research (accepted for publication).
- Roff, C. (1966). Crocodiles in Queensland. Division of Plant Industry Advisory Leaflet No. 883. 9 pp.
- Taplin, L.E. (1987). The Management of Crocodiles in Queensland, Australia. Pp. 129-140 in Wildlife Management: Crocodiles and Alligators, ed. by G.J.W. Webb, S.C. Manolis and P.J. Whitehead. Surrey Beatty and Sons: Chipping Norton.
- Taplin, L.E. (1990). The population status and management of estuarine crocodiles in Queensland present situation and future prospects. Pp. 253-307 in Crocodiles. Proceedings of the 9th Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.
- Taplin, L.E., Bayliss, P. and Krieger, G. (1988). Summary Report. Crocodile Distribution and Abundance Cape York Peninsula. Report on a helicopter survey of eastern, northern, and north-western Cape York, May 1988. Internal Report to Queensland National Parks and Wildlife Service. 24 pp.
- Taplin, L.E. and Krieger, G. (1989). Distribution of crocodiles and crocodile nesting habitat on the Lockhart and Escape River systems - Cape York Peninsula. Internal Report to Division of Conservation, Parks and Wildlife, Department of Environment and Conservation. 25 pp.

- Tucker, A.D. (1997). Ecology and demography of freshwater crocodiles (*Crocodylus johnstoni*) in the Lynd River of North Queensland. PhD Thesis, The University of Queensland, Brisbane, Queensland. 232 pp.
- Tucker, A.D., McCallum, H.I., Limpus, C.J. and McDonald, K.R. (1994). Crocodylus johnstoni in the Lynd River, Queensland: continuation of a long-term field study. In Proceedings of the 2nd Regional Meeting of the IUCN-SSC Crocodile Specialist Group. Darwin, March 1993. IUCN: Gland, Switzerland.
- Webb, G.J.W., Whitehead, P.J. and Manolis, S.C. (1987). Crocodile management in the Northern Territory of Australia.Pp. 107-124 *in* Wildlife Management: Crocodiles and Alligators, ed. by G.J.W. Webb, S.C. Manolis and P.J. Whitehead. Surrey Beatty and Sons: Chipping Norton.

# **Crocodile Management in Western Australia**

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#### Abstract

In Western Australia, crocodiles were hunted extensively for skins between 1930 and 1970, with *C. porosus* almost hunted to extinction. Both species are at the western limits of their range in Australia and a combination of factors including lower rainfall, limited riparian vegetation and degradation remaining vegetation as a consequence of cattle grazing have had an impact on the rate of recovery of both species since legal protection was put in place. *Crocodylus porosus* populations have yet to reach pre-hunting levels, but are showing signs of a steady rate of increase (1-2.5%) in monitored areas. There are two licensed crocodile farms in Western Australia, with no intention by the Government to issue any further licences in the immediate future. Crocodile farming is managed under an approved management plan. Increasing tourism in northern Australia, particularly by crocodile-naïve tourists appears to be resulting in an increase in conflicts, some fatal. High visitor use areas are designated as crocodile control zones and any crocodiles found in these areas that pose a threat are relocated to crocodile farms or culled. Better public education will be required to ensure that crocodiles can continue to increase to pre-hunting levels while reducing the risk of conflict with the human population.

#### Introduction

Two species of crocodile, the saltwater crocodile *Crocodylus porosus* and the freshwater or Johnstone's crocodile *C. johnstoni*, occur in the Kimberley and Pilbara regions of Western Australia. The majority of the populations of both species occur in the Kimberley region. *Crocodylus porosus* occupy marine, estuarine and freshwater habitats below waterfalls. *Crocodylus johnstoni* is occasionally found in low numbers in estuarine habitat, but more common in freshwater habitats, particularly those above waterfalls where they do not have to compete with *C. porosus*.

#### Distribution

The distribution of crocodiles in Western Australia is provided in detail by Burbidge (1987), Grigg and Gans (1993), Cooper-Preston and Jenkins (1993) and Molnar (1993). *C. porosus* are found in most of the major river systems of the Kimberley including the Ord, Patrick, Forrest, Durack, King, Pentacost, Prince Regent, Lawley, Mitchell, Hunter, Roe and Glenelg Rivers and Parrys Creek. The largest populations occur in the rivers draining into the Cambridge Gulf, the Prince Regent and the Roe River systems of the east and northwest Kimberley. Much lower densities occur in the rivers draining into King Sound and Stokes Bay in the west Kimberley. Lone male crocodiles have also been recorded as resident in isolated rivers in the Pilbara region including the Sherlock River. Vagrant crocodiles have been recorded in marine habitat at Derby, Broome (Cable Beach and Willies Creek) and as far south as Carnarvon on the mid-west coast.

Nesting habitat for *C. porosus* is limited and only the Ord, King and Roe River systems support suitable vegetation for nesting to significant levels. A few nests have been recorded in other river systems such as the Drysdale and Prince Regent Rivers and Admiralty Gulf Creek. *C. porosus* occur in four of the ten conservation reserves >2000 ha in area in the Kimberley that have rivers running through them.

*C. johnstoni* occupies the same river systems as *C. porosus* in the Kimberley region, with most animals occurring above waterfalls that exclude the larger species. *C. johnstoni* is also common in the Fitzroy River system. This species has also established large populations with the creation of two dams that impound sections of the Ord River to form Lakes Kununurra and Argyle. *C. johnstoni* breeds in all of the river systems where it occurs. Freshwater crocodiles occur in all ten of the conservation reserves >2000 ha in area in the Kimberley that have rivers running through them.

#### Habitat

Burbidge (1987) noted that the areas of the Kimberley inhabited by *C. porosus* differ markedly from most of the Northern Territory. The Kimberley coastline and hinterland are chiefly composed of steep, rugged, ancient, deeply faulted sandstones. Access up many rivers is blocked to crocodiles by waterfalls and their associated gorges. There are few areas of floodplain and very few freshwater swamps and hence breeding habitat is scarce. It would appear, therefore, that the carrying capacity of the Kimberley river systems and the Kimberley as a whole is much less than that of the Northern Territory.

River systems in the Pilbara region further to the south, flow through less steeply dissected landscapes and include areas of flood plain. However, the significantly lower annual rainfall and the resultant differences in fringing vegetation mean that most rivers in the Pilbara cannot support viable crocodile populations.

#### **Population Size and Trends Since Protection**

*C. porosus* was extensively hunted for the skin trade in the 1950s and 1960s, and while the pre-harvest population size is unknown, the species apparently suffered a decline in numbers throughout its range in Western Australia. It is considered that the total population of *C. porosus* in Western Australia is now only in the order of a few thousand non-hatchlings. Nesting habitat is limited, with very few nests located during the surveys conducted to date. Nevertheless, from anecdotal information and limited surveys, the *C. porosus* appears to be recovering from past hunting, and still occupies its historical range.

The number of *C. porosus* killed for trade prior to the species being protected in Western Australia is unknown. However, Webb *et al.* (1984) estimated that a total of between 270,000 and 330,000 *C. porosus* were killed in Australia from 1945 to 1972, with the upper estimate comprising 271,500 skins exported, 13,500 (5%) assumed killed and not retrieved, and 45,000 juveniles killed for the curio trade. Webb *et al.* (1984) estimated that 10% of the skin harvest was from Western Australia, and it therefore seems likely that some 25,000 *C. porosus* were harvested in Western Australia from 1946 until 1970. Webb *et al.* (1987) considered that the earlier estimate of the number of juveniles killed for the curio trade was probably an overestimate.

There are no published estimates of the numbers of *C. johnstoni* killed in Western Australia for the skin trade prior to the species being protected (Burbidge 1987). While the intensity of legal hunting of *C. johnstoni* in Western Australia was always low, there was significant poaching in accessible habitat during the 1960s and early 1970s (Bustard 1970; Burbidge 1987).

The first documented report on the status of *C. porosus* populations in Western Australia was that of Bustard (1970), who in 1969 conducted limited boat spotlight surveys in several areas. Bustard concluded that *C. porosus* "has been hunted to the verge of extinction" and recommended that the species be protected for ten years.

The first systematic surveys of *C. porosus* populations in Western Australia were conducted in 1977 (Messel *et al.* 1977) and 1978 (Burbidge and Messel 1979). These boat spotlight surveys covered the estuarine portions of major river systems across most of the range of *C. porosus* in Western Australia. The combined results yielded the estimates of the non-hatchling populations in the surveyed portions of each river system given in Table 1. Extrapolating from the survey results to correct for unsurveyed areas, Burbidge and Messel (1979) estimated that there were about 2000 non-hatchling *C. porosus* in the whole of Western Australia at that time.

In 1986, most of the areas surveyed in 1977 and 1978 were resurveyed, as well as some additional areas (Messel *et al.* 1987), resulting in a Kimberley-wide population estimate of 2500 non-hatchling *C. porosus*. The 1986 survey revealed a significant increase in the proportion of large crocodiles in the population, and showed that the largest populations were in the Cambridge Gulf, and the Prince Regent and Roe River systems.

Since 1986, no further large-scale population surveys covering most of the range of *C. porosus* in the Kimberley have been conducted. However, the *C. porosus* population in King Sound and Stokes Bay was surveyed for the first time in 1989, resulting in an estimated population of the order of 25 (G Webb Pty Ltd 1989a). The low density of *C. porosus* in the King Sound area reflects a generally poor environment at the extremity of the main part of the range of *C. porosus*.

Associated with the Western Australian Government's 1988 decision to permit crocodile farming, the West Arm

River	Population Estimate
Ord	235-306 (a)
Lawley	44-57
Mitchell	60-78
Hunter	51-67
Roe	177-230
Prince Regent	190-246
Glenelg	200-259
Total (all surveyed rivers)	957-1243

Table 1. Non-hatchling *C. porosus* population estimates from 1977-1978 boat spotlight surveys (after Messel *et al.* 1977; Burbidge and Messel 1979). (a) = estimate was subsequently revised to 245-297 by Messel *et al.* (1987).

river systems in Cambridge Gulf that had been surveyed in 1986 were resurveyed in 1989, 1990, and 1992-2003 inclusive (G Webb Pty Ltd 1989b, 1990, 1992; Wildlife Management International 1994b, 1995-2003). In 1992 the Ord River, which had been partly surveyed in 1978 and 1986, was fully surveyed for the first time (G Webb Pty Ltd 1992). As a result of the 1989-1993 surveys, Wildlife Management International (WMI), which has been contracted by the Department of Conservation and Land Management (CALM) to conduct the crocodile surveys, developed helicopter-monitoring zones for the East Arm (Ord River) and West Arm areas of the Cambridge Gulf. After trial development and proofing, population estimates from 1994-on have been based on the results of the helicopter surveys of monitoring areas. The Ord River has been surveyed annually during the period 1993-2003 (Wildlife Management International 1994a, 1994b, 1995-2003).

The results of crocodile population monitoring surveys (helicopter count indices and spotlight data) in the Cambridge Gulf river systems are summarised on Figure 1. The results from the 2003 survey show that the 2003 population estimate for the West Arm of Cambridge Gulf is almost 50% greater than the estimate for 1989. In the East Arm the 2003 population is slightly more than 50% above the original (1992) estimate (Fig. 2).



Figure 1. Numbers of non-hatchling *C. porosus* sighted during helicopter surveys of the West Arm monitoring zone, 1986-2003. Lines indicate linear regression relationships (1986-1998; r<sup>2</sup>= 0.45, p= 0.03; 1998-2003, r<sup>2</sup>= 0.66, p= 0.048).



Figure 2. Helicopter index for *C. porosus* in the Ord River monitoring zone, 1978-2003. Line indicates significant second-order polynomial regression (r<sup>2</sup>= 0.54, p= 0.02) with all years (1998 excluded due to high temperatures during the survey period]. Values for 1978-1990 were derived from spotlight count data.

The Cambridge Gulf river systems have been the principal source of *C. porosus* for crocodile farms in Western Australia. The combined population estimates for the two survey areas give a total population in 2003 of 885, which is a 53% increase on the first combined estimate available (577 in 1992).

Prior to 1989, there had only been very limited surveys of the *C. johnstoni* population in Western Australia. As a consequence of the 1988 decision by the Western Australian Government to allow crocodile farming, there has been a considerable increase in knowledge about the Western Australian *C. johnstoni* population. The earlier construction of two dams on the Ord River impounded Lake Kununurra (in 1963) and the very large Lake Argyle (in 1972). In 1989, boat spotlight surveys yielded non-hatchling population estimate of 25,000 in Lake Argyle and 7500 in Lake Kununurra (G Webb Pty Ltd 1989d).



Figure 3. Numbers of *C. johnstoni* sighted in Lake Argyle, Lake Kununurra and Ord River, 1992-2003. Line indicates the non-significant linear regression relationship  $(r^2 = 0.04, p = 0.54)$ .

Also in 1989, boat spotlight and helicopter surveys yielded a population estimate of 13,000 non-hatchling *C. johnstoni* along 172 km of the Fitzroy River and in some of its tributaries and Seventeen Mile or Camballin Dam (G Webb Pty Ltd 1989a). Boat spotlight surveys in 1992 and 1993 yielded estimates of 2100 and 2900 *C. johnstoni* respectively in the Ord River downstream of the Diversion Dam which forms Lake Kununurra, all within 90 km of the dam (G Webb Pty Ltd 1992; Wildlife Management International 1994a). During 1994 a comparison of boat spotlight and helicopter counts was undertaken by WMI in order to provide helicopter count indices for future population monitoring. Helicopter counts were repeated in 1995-2003, giving the monitoring results displayed on Figure 3. There has not been a more recent survey of the total Western Australian *C. johnstoni* population since that conducted in 1989 (G Webb Pty Ltd 1989d), nevertheless the species is clearly common in suitable habitat and would have a total population in the order of an integer x 10<sup>4</sup>, if not higher.

#### Management of Crocodiles 1958-2004

Crocodiles were not afforded legal protection in Western Australia until it became apparent that unregulated harvesting and illegal poaching were having a severe impact on their populations. *C. johnstoni* was the first species to receive protection in June 1958, but *C. porosus* was not fully protected until April 1970.

Active management in the form of surveys of wild crocodile populations did not commence until 1969 (see above). In 1988 the Western Australian Government authorised the establishment of the first commercial crocodile farms. Since that time three farms have been established; one at Wyndham (in 1989), one at Broome (in 1991) and the other at Fremantle (in 1990). The Wyndham and Fremantle operations were owned and operated by the same company. The Fremantle operation closed in 1998 when the land was sold for development and all stock was either slaughtered for the trade or relocated to the Wyndham facility. Since 1991 there have been no further applications for crocodile farming in Western Australia.

All commercial crocodile farming in Western Australia has been managed under the provisions of approved management plans (eg Anon 1993; CALM 1993). A new 10-year management plan is currently before the Commonwealth Department of the Environment and Heritage for consideration.

#### **Philosophies Underlying Management**

Crocodile management in Western Australia is based around three goals that are applied to both species of crocodile.

Those goals are:

- maintain viable populations of *C. porosus* and *C. johnstoni* over their natural range in Western Australia in an ecologically sustainable manner;
- provide for public safety by maintaining public awareness and providing a mechanism for removing "problem" crocodiles; and,
- where possible, to manage crocodile species as a renewable natural resource providing the conservation of the species is not compromised.

#### Use of and Trade in Crocodile Products

Crocodile products produced by the commercial crocodile farms include skins for both the domestic and international market and meat for the domestic market. There is a minor market for byproducts such as feet, teeth, skulls and leather products manufactured from smaller pieces of the hide that are usually sold through secondary curio outlets. Currently there is very little market demand for products from *C. johnstoni* and as a consequence the current stocks of this species held by both the crocodile farms are low.

#### Sustainable Use and Tourism

The concept of sustainable use of crocodiles and crocodile products is supported by one of the three goas of the Western Australian crocodile management plan (see above). Achieving sustainable use of crocodiles can only be achieved by management of the commercial harvest of crocodiles through a best practice harvest quota system, effective licence and tag procedures, and monitoring and maximizing compliance with relevant legislation. It also

requires that CALM and industry members improve their understanding of the impacts that commercial harvest and unrelated industries (such as cattle grazing and irrigation horticulture) have on crocodiles, their habitat and ecosystems. Given the small current population of *C. porosus* and the poor market demand for *C. johnstoni* products at present care needs to be taken to ensure that market forces do not take precedence over conservation imperatives.

There is no regulated tourism based around crocodiles in Western Australia. There are however, a number of boatbased tourism businesses operating in waters inhabited by crocodiles. CALM has in the past received a small number of applications to allow for the capture and holding of *C. johnstoni* for short periods to facilitate close observation of crocodiles by tourists. CALM has not approved any of these applications because of the risks of injury during capture to the crocodiles, the greater risk of injury to the person catching the crocodiles and the risk of injury to tour patrons in the event of an animal escaping within the tour vessel. Repeated capture or attempts at capture is also likely to lead to avoidance behaviour by crocodiles, which could detract from non-invasive tourism opportunities.

Fishing charter boats also operate in parts of the Ord River and Lakes Kununurra and Argyle targeting a range of freshwater fish species. Several of these operators take the opportunity to draw charter patrons' attention to the presence of crocodiles and a small number have engaged in feeding larger crocodiles to habituate the animals to the close approach of boats. While such behaviour is likely to lead to successful tourism interactions it is also likely to reduce any natural fear that crocodiles have of humans and fishers. In a worst-case scenario this is likely to lead to large crocodiles approaching small boats and threatening the safety of boat-owners and fishers. CALM has made a point of taking this issue up with individual charter operators and seeking their co-operation in ending the feeding of crocodiles. CALM has a "no feeding" policy with regard to wildlife, in particular where such activities are likely to place members of the public at risk of injury or death.

#### **Human-Crocodile Conflicts**

Most people consider human-crocodile conflicts to involve situations whereby people are actually bitten or killed by crocodiles. However, with ever-increasing recreational activities in habitat occupied by crocodiles and an increasing resident human population and a rapidly increasing but seasonal tourist population (see Table 2) combined with a slowly increasing crocodile population the potential for a range of conflicts will arise.

Year	Number of Data Collection Sites	Total Number of Visits (millions)
1996/97	137	6.4
1997/98	144	8.1
1998/99	149	8.7
1999/00	158	8.9
2000/01	158	9.7
2001/02	185	9.8
2002/03	190	10.2

Table 2	Total	visits	to	lands	and	waters	managed	by	the	Department	of
Conservation and Land Management (Anon 2003).											

Localized surveys of visitors entering conservation estates in the east Kimberley show important trends in demographics of those visitors. Typically more than 90% originate from outside of Western Australia, with more than 75% of those coming from other parts of Australia with a bias towards those coming from the southern States of Australia. More than 70% are over 40 years of age and more than 90% of the tourists are visiting those sites for the first time. Visitor trends and demographics such as these while encouraging from the point of view of increasing the public exposure to the wonders of the State, but they also clearly indicate that the majority of people entering into areas occupied by crocodiles are unlikely to have had any prior experience in how to ensure their own safety in the presence of crocodiles. This means that the CALM has an increasing requirement to ensure adequate signage at sites inhabited by crocodiles and visited by tourists as well as an over-arching role in community education about the need to conserve crocodiles while ensuring the safety of the public.

CALM has identified Crocodile Control Zones for *C. porosus* around selected centres of human population or activity. Within these areas effective control of *C. porosus* is possible, taking into account the availability of staff and resources and the potential for reinvasion. The aim is to remove all *C. porosus* entering these areas, regardless of size. Whenever practical crocodiles removed from these zones will be caught alive and relocated to crocodile farms (because of their homing tendencies, it is generally impractical to relocate these animals in the wild). However, because of the unacceptable risk to public safety in Crocodile Control Zones, CALM officers may destroy any *C. porosus* within these zones whenever it is deemed necessary. Persons other than CALM officers may be authorised in writing to remove *C. porosus* form these zones. Within these criteria, particular emphasis will be given to problem crocodiles at Wyndham, Derby, Broome, Aboriginal settlements and popular recreational areas along the Ord and Fitzroy Rivers. It is important that the public recognize that a Crocodile Control Zone does not guarantee and area is "crocodile-free" and therefore absolutely safe.

The documented cases of attacks on humans by crocodiles in Western Australia since the Second World War are shown in Table 3. It is likely that there were more cases than this, particularly in the period pre-1980 but these were not reported or recorded in medium that readily allows them to be collated. Most of the early records listed in Table 3 come from print media articles, while all of the later ones come from direct investigations by local police and/or CALM staff.

Date	Location	Species	Outcome
Jun 1947	Wyndham Harbour	C. porosus	British merchant seaman - suspected taken by crocodile. Confirmed that crocodile ate him but did not necessarily kill him.
Nov 1980	Gulf at Wyndham	C. porosus	Paul Flanagan - killed while having a midnight swim.
Nov 1982	Mitchell R., Kimberleys	Unknown	Robyn Collyer - survived after trying to handle a crocodile.
28 Nov 1986	Parry Creek, Wyndham	C. porosus	Stephen Forrest - attacked, required stitches in arm.
1 Apr 1987	King Cascades, Derby	C. porosus	Ginger Meadows 24 - fatal.
26 Apr 1987	Geike Gorge National Park	C. johnstoni	Mark Weir - severe lacerations to feet, stitches required.
17 May 1990	Oombulgurri Community	C. porosus	Molly Gore - survived, caught trying to fish, deep lacerations to chest and abdomen.
10 Mar 1991	Chamberlin Gorge	Unknown	All survived after a crocodile tipped their canoe and they had to swim to the bank of the gorge.
12 Apr 2003	Ord River, Kununurra, just below the Diversion Dam	C. porosus	Drunk man swimming in known crocodile habitat. Was warned off by local police, but re-entered the water shortly after and was bitten on the right lower leg by 2.4 m crocodile

Table 3. History of documented crocodile attacks in Western Australia, 1947-2003.

As recreational pursuits in and around waterbodies increase, so to does people's desire to involve their domestic pets in those activities. Unfortunately, dogs are a very attractive food source to crocodiles (Table 4).

#### **Ongoing and Management and Research**

CALM is committed to the sustainable management of crocodile populations in Western Australia in accordance with the aims set out in the approved management plan. A new management plan for the period 2004-2013 has been through the public comment process and final amendments are being made prior to submission to the Commonwealth Minister for the Environment.

Table 4. Crocodile attacks on domestic dogs in Western Australia.

Date	Location	Species	Outcome
6 February 1984	Boat ramp - Wyndham	C. porosus	Two dogs found dead - only one confirmed killed by crocodile
31 March 1987	Wyndham	C. porosus	Three dogs taken in last three months
6 April 1987	Crossing Falls, Lake Kununurra	C. johnstoni	Small dog attacked - survived.
15 June 1987	Wyndham	C. porosus	Dog found dead - presumed crocodile attack
1 July 1989	Boat ramp - Wyndham	Unknown	Dog found dead, crocodile attack witnessed

Other than the annual surveys of the populations in specific monitoring zones there has been very little research conducted on either species. In 1975 tissue samples from both species of crocodile were collected from the east Kimberley area as part of a survey to determine the bioaccumulation of DDT in the ecosystem. DDT had been used fairly widely in the irrigation area to control pests of cotton and horticulture crops. In 2003 the opportunity arose to resample both species of crocodile in Lake Kununura, the lower Ord River and the Ord River irrigation area to determine whether the levels of DDT residues had decreased in the intervening 28 years. The samples are currently being analysed in Japan and the results should make for interesting reading given the role of crocodiles as top-order predators. It will also be interesting to learn what impact pesticide residues might have on the reproductive function in crocodiles given the known impact of by-products of DDT on crocodilian reproductive endocrinology.

A PhD student has also just completed (and submitted) his thesis on the population ecology of *C. porosus* in the Kimberley of Western Australia. Several manuscripts have been prepared as a result and some of these have been accepted for publication while others are currently under review.

#### **Ongoing Monitoring Programs**

Crocodile populations have been monitored annually since 1990 in Western Australia using a combination of spotlight boat surveys and helicopter surveys. Recent published studies examining crocodile survey data from the Northern Territory (eg Stirrat *et al.* 2001; Harvey and Hill 2003) indicate that there may be good reasons to modify survey techniques in the future to provide more accurate population estimates, but also to provide some economies to offset the steadily increasing costs of surveys. The applicability of some of these new techniques may be limited or will require modification given the very different nature of crocodile habitat in Western Australia.

Be that as it may, CALM is committed to continued monitoring of the crocodile populations in accordance with the undertakings set out in the new draft management plan.

#### The 'Big Picture'

In Western Australia the commercial crocodile industry is small in terms of the number of licensed operators. Accordingly there has been a limited harvest from the wild and it is expected that as captive husbandry in the farms improves the need to source animals direct from the wild will further decrease. Recovery of both species of crocodiles has occurred, with rates of increase influenced by the availability of suitable nesting habitat and competing land uses (eg pastoralism) that can lead to degradation of scarce of nesting resources for *C. porosus*.

An in creasing seasonal tourist population visiting areas inhabited by crocodiles places increasing responsibilities on CALM to ensure adequate levels of public education and awareness of the risks of living with crocodiles. This requirement must also take into account the fact that most visitors are crocodile naive and a significant proportion come from overseas and for whom English may not be their first language. The continued development and diversification of the tourism industry and the types of products they wish to offer customers along with new industries based around greater water use (eg aquaculture, intensive irrigation) will also have the potential to impact on crocodile conservation and management. CALM will need to be actively involved in providing comment on any such proposals to ensure that their impacts are minimal and that public safety is not jeopardized. As with most conservation agencies around the world the capacity of the Department to continue to achieve these goals will be influenced by resources.

#### Literature

- Anon. (1993). Conservation and Management of Crocodiles. Department of Conservation and Land Management Policy Statement No. 24, June 1993.
- Anon. (2003). Annual Report 2002-2003. Department of Conservation and Land Management.
- Burbidge, A.A. (1987). Crocodile Management in Western Australia. Pp. 125-127 *in* Wildlife Management: Crocodiles and Alligators, ed. by G.J.W. Webb, S.C. Manolis and P.J. Whitehead. Surrey Beatty and Sons: Sydney.
- Burbidge, A.A. and Messel, H. (1979). The Status of the Saltwater Crocodile in the Glenelg, Prince Regent and Ord River Systems, Kimberley, Western Australia. Dept. Fish. Wildl. West. Aust. Rep. No. 34. Dept. Fish. Wildl.: Perth.
- Bustard, H.R. (1970). Report on the Current Status of Crocodiles in Western Australia. Dept. Fish. Fauna West. Aust. Rep. No. 6. Dept. Fish. Fauna: Perth.
- CALM (1993). Management Program for the Saltwater Crocodile *Crocodylus porosus* and the Freshwater Crocodile *Crocodylus johnstoni* in Western Australia (Unpublished).
- Cooper-Preston, H. and Jenkins, R.W.G. (1993). Natural history of the Crocodylia. Pp. 337-343 *in* Fauna of Australia. Vol 2A Amphibia and Reptilia, ed. by C.J. Glasby, G.J.B. Ross and and P.L. Beesley. AGPS: Canberra.
- Grigg, G. and Gans, C. (1993). Morphology and physiology of the Crocodylia. Pp. 326-336 *in* Fauna of Australia. Vol. 2A Amphibia and Reptilia, ed. by C.J. Glasby, G.J.B. Ross and P.L. Beesley. AGPS: Canberra.
- G. Webb Pty Ltd (1989a). The results of Saltwater Crocodile (*Crocodylus porosus*) and Freshwater Crocodile (*C. johnstoni*) surveys in King Sound, Stokes Bay and the Fitzroy River, Western Australia in November 1989. Report to WA Dept. Conservation and Land Management.
- G. Webb Pty Ltd (1989b). The results of Saltwater Crocodile (*Crocodylus porosus*) surveys in the West Arm river systems of Cambridge Gulf, Western Australia in October 1989. Report to WA Dept. Conservation and Land Management.
- G. Webb Pty Ltd (1989d). The results of Freshwater Crocodile (*Crocodylus johnstoni*) and Saltwater Crocodile (*C. porosus*) surveys in Lake Kununura and Lake Argyle, Western Australia in February-March 1989. Report to WA Dept. Conservation and Land Management.
- G. Webb Pty Ltd (1990). The results of Saltwater Crocodile (*Crocodylus porosus*) surveys in the West Arm river systems of Cambridge Gulf, Western Australia in September 1990. Report to WA Dept. Conservation and Land Management.
- G. Webb Pty Ltd (1992). Results of spotlight and helicopter surveys of crocodiles in Cambridge Gulf, Lake Argyle and Lake Kununurra (1992). Report to WA Dept. Conservation and Land Management.
- Harvey, K.R. and Hill, G.J.E. (2003). Mapping the nesting habitats of saltwater crocodiles (*Crocodylus porosus*) in Melacca Swamp and the Adelaide River wetlands, Northern Territory: an approach using remote sensing and GIS. Wildlife Research 30: 365-75.
- Messel, H., Burbidge, A.A., Wells, A.G. and Green, W.G. (1977). The Status of the Saltwater Crocodile in Some River Systems of the North-west Kimberley, Western Australia. Dept. Fish. Wildl. West. Aust. Rep. No. 24. Dept. Fish. Wildl.: Perth.
- Messel, H., Burbidge, A.A., Vorlicek, G.C., Wells, A.G., Green, W.J., Onley, I.C. and Fuller, P.J. (1987). Surveys of Tidal River Systems in the Northern Territory and Their Crocodile Populations. Monograph 20. Tidal Waterways of the Kimberley Surveyed during 1977, 1978 and 1986. Pergamon Press: Sydney.

- Molnar, R. (1993). Biogeography and phylogeny of the Crocodylia. Pp. 344-348 *in* Fauna of Australia. Vol 2A Amphibia and Reptilia, ed. by C.J. Glasby, G.J.B. Ross and P.L. Beesley. AGPS: Canberra.
- Stirrat, S.C., Lawson, D., Freeland, W.J. and Morton, R.A. (2001). Monitoring *Crocodylus porosus* populations in the Northern Territory of Australia: a retrospective power analysis. Wildlife Research 28; 547-54.
- Webb, G.J.W., Beal, A.M., Manolis, S.C. and Dempsey, K.E. (1987). The effects of incubation temperature on sex determination and embyonic development rate in *Crocodylus johnstoni* and *C. porosus*. Pp. 507-31 *in* Wildlife Management: Crocodiles and Alligators, ed. by G.J.W. Webb, S.C. Manolis and P.J. Whitehead. Surrey Beatty and Sons: Sydney.
- Webb, G., Manolis, S., Whitehead, P. and Letts, G. (1984). A Proposal for the Transfer of the Australian Population of *Crocodylus porosus* Schneider (1801), from Appendix I to Appendix II of C.I.T.E.S. Tech. Rep. No. 21. Conserv. Comm. N.T.: Darwin.
- Wildlife Management International (1994a) Results of spotlight and helicopter surveys of crocodiles in Cambridge Gulf, Lake Argyle and Lake Kununurra, 1993. Report to WA Dept. Conservation and Land Management.
- Wildlife Management International (1994b) Results of spotlight and helicopter surveys of crocodiles in Cambridge Gulf, Lake Argyle and Lake Kununurra, 1994. Report to WA Dept. Conservation and Land Management.
- Wildlife Management International (1995) Results of spotlight and helicopter surveys of crocodiles in Cambridge Gulf, Lake Argyle and Lake Kununurra, 1995. Report to WA Dept. Conservation and Land Management.
- Wildlife Management International (1996) Results of spotlight and helicopter surveys of crocodiles in Cambridge Gulf, Lake Argyle and Lake Kununurra, 1996. Report to WA Dept. Conservation and Land Management.
- Wildlife Management International (1997) Results of spotlight and helicopter surveys of crocodiles in Cambridge Gulf, Lake Argyle and Lake Kununurra, 1997. Report to WA Dept. Conservation and Land Management.
- Wildlife Management International (1998) Results of spotlight and helicopter surveys of crocodiles in Cambridge Gulf, Lake Argyle and Lake Kununurra, 1998. Report to WA Dept. Conservation and Land Management.
- Wildlife Management International (1999) Results of spotlight and helicopter surveys of crocodiles in Cambridge Gulf, Lake Argyle and Lake Kununurra, 1999. Report to WA Dept. Conservation and Land Management.
- Wildlife Management International (2000) Results of spotlight and helicopter surveys of crocodiles in Cambridge Gulf, Lake Argyle and Lake Kununurra, 2000. Report to WA Dept. Conservation and Land Management.
- Wildlife Management International (2001) Results of spotlight and helicopter surveys of crocodiles in Cambridge Gulf, Lake Argyle and Lake Kununurra, 2001. Report to WA Dept. Conservation and Land Management.
- Wildlife Management International (2002) Results of spotlight and helicopter surveys of crocodiles in Cambridge Gulf, Lake Argyle and Lake Kununurra, 2002. Report to WA Dept. Conservation and Land Management.
- Wildlife Management International (2003) Results of spotlight and helicopter surveys of crocodiles in Cambridge Gulf, Lake Argyle and Lake Kununurra, 2003. Report to WA Dept. Conservation and Land Management.

# **Crocodile Management in Australia - The Federal Government's Involvement**

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#### Abstract

The State and Territory Governments of Australia have primary responsibility for wildlife conservation and management. The Federal Government regulates the import and export of wildlife including administering the provisions of CITES, and manages wildlife on Federal land. The Department of the Environment and Heritage (DEH) is the Australian Government Department responsible for regulating the import and export of wildlife. Kakadu National Park is jointly managed by DEH and the traditional landowners. This paper summarises the Australian Government's involvement in crocodile management in Australia, explains how DEH fulfils its role as the CITES Management and Scientific Authorities, gives details of the legislative requirements that allow exports and discusses how crocodiles are managed in Kakadu.

#### Background

Australia has a federal system of government. Under the Australian Constitution, the States and Territories have primary responsibility for wildlife conservation and management. The Australian (or Federal) Government has responsibility for regulating exports and imports, managing wildlife on Federal land and negotiating and abiding by international treaty obligations.

Australian crocodiles were listed on Appendix II of CITES in 1975. At the second Conference of the Parties (COP2; San José, 1979), the world population of *C. porosus* was transferred from Appendix II to Appendix I with the exception of the population of *C. porosus* within Papua New Guinea, which was retained on Appendix II.

At COP5 (Buenos Aires, 1985), the Australian population of *C. porosus* was transferred from Appendix I to a restricted Appendix II listing. The restriction limited the wild harvest to ranched specimens. At COP9 (Fort Lauderdale, 1994) the Appendix II listing was changed to a non-restricted listing.

#### **Federal Regulation of Trade**

The Australian Department of the Environment and Heritage is responsible for regulating trade in native and CITES listed species. CITES became enforceable under Australian law on 27 October 1976. Initially, CITES was enforced under the Customs (Endangered Species) Regulations. From 1984, the Wildlife Protection (Regulation of Exports and Imports) Act 1982 governed wildlife trade. Under amendments effective from 11 January 2002, Australia's responsibilities under CITES is now provided by Part 13A of the Environment Protection and Biodiversity Conservation Act 1999 (the EPBC Act).

CITES requires that countries divide the responsibility of administering CITES provisions into separate Management and Scientific Authorities.

#### **CITES Scientific Authority**

The role of the CITES Scientific Authority is undertaken by the Sustainable Wildlife Industries Section (SWI) in DEH. This section is responsible for making non-detriment findings, and does so by assessing the sustainability of the management arrangements of the State or Territory from which the crocodiles are sourced.

Western Australia and the Northern Territory prepare management plans which are submitted to SWI for approval under the EPBC Act as Approved Wildlife Trade Management Plans. SWI works with the States and Territories to ensure that the plans meet the requirements of the EPBC Act and CITES. The Australian Minister for the Environment and Heritage (or delegate in DEH) is responsible for approving the plans. (A more detailed description of the EPBC

Act's requirements for an approved wildlife trade management plan is included in Legislative Framework below).

A management plan is approved for a maximum period of five years. Crocodile management plans require the State agencies to provide annual reports to SWI. An approval can be revoked or conditions added to ensure that the harvest remains sustainable. In approving a plan, the Minister may add conditions to that approval.

Queensland does not allow the wild harvest of crocodiles, except those removed for public safety. Crocodiles held in Queensland crocodile farms are either captive-bred or sourced from the Northern Territory or Western Australia. The Queensland licensing regime has been assessed and approved as a captive breeding program to permit export of crocodiles that have been captive-bred in Queensland.

#### **CITES Management Authority**

The role of the CITES Management Authority is undertaken by the International Wildlife Trade Section in DEH. This section provides tags to the States/Territories, issues permits and reports to the CITES Secretariat.

#### Animal Welfare

The Australian Government is committed to animal welfare and, as the Australian crocodile industry continues to grow, the Government is working towards the development and implementation of a nationally consistent set of minimum standards for the humane treatment of wild taken and farmed crocodiles. The key focus of the draft Code of Practice for the Humane Treatment of Wild and Captive Australian Crocodiles is to ensure the humane treatment of a protected native species which is harvested on a sustainable basis. The scope of the Code is limited to the taking of crocodiles from the wild and the farming of crocodiles. It does not cover the public display of crocodiles in zoos and animal parks, which have different requirements. The minimum standards recommended in the draft Code draws on current knowledge of crocodile welfare issues and best practice in humane handling techniques.

The draft Code was published on the DEH website in January 2004 for a further round of public consultation. DEH is currently considering all comments received and is keen to finalise the Code.

Crocodile trade management plans will be approved subject to adherence to the draft Code. State and Territory Governments are responsible for the enforcement of the Code as a normal component of their wildlife management, compliance and enforcement functions.

#### Legislative Framework

International movement of wildlife and wildlife products is regulated under Part 13A of the EPBC Act. Specifically, the Act regulates the:

- export and import of CITES specimens;
- export of Australian native species other than those identified as exempt; and,
- import of live plants and animals that, if established in Australia, could adversely affect native species or their habitats.

Objects of the wildlife trade provisions of the EPBC Act are to:

- comply with CITES and the Biodiversity Convention obligations;
- protect wildlife that may be adversely affected by trade;
- promote the conservation of biodiversity in Australia and other countries;
- ensure that commercial utilisation of native wildlife is managed in an ecologically sustainable way;
- promote the humane treatment of wildlife;
- ensure the ethical conduct during research associated with the utilisation of wildlife; and,
- ensure the precautionary principle is taken into account.

#### Permits

The EPBC Act sets out the criteria that must be met before an export permit may be issued. Criteria for commercial export include that the specimens come from a program or plan that is approved under the EPBC Act. In the case of

*C. porosus* and *C. johnstoni*, this is either an Approved Captive Breeding Program or an Approved Wildlife Trade Management Plan.

The commercial export of live *C. porosus* and *C. johnstoni* is prohibited. The EPBC Act prohibits the live export of native birds, reptiles, mammals and amphibians except for specific non-commercial purposes that are outlined in the EPBC Act. These include research, education (enrolled students) and exhibition (zoos).

#### Captive Breeding Program

A captive breeding program can be approved if the Minister (or delegate) is satisfied that:

- if an animal reproduces sexually, its parents transferred gametes in a controlled environment;
- if an animal reproduces asexually, its parents were in a controlled environment when it began to be developed;
- breeding stock must be:
  - established in a way that is not detrimental to survival of the species in the wild;
  - maintained without introduction from wild except to ensure ongoing genetic viability and to dispose of animals confiscated, seized, rescued or removed from the wild for public health and safety; and,
- the animal has produced offspring to at least the second generation, or is managed in a way that has been demonstrated to be capable of reproducing second generation offspring.

#### Approved Wildlife Trade Management Plan

The Minister (or delegate) must not approve a plan unless satisfied that:

- the plan is consistent with the objects of the EPBC Act;
- there has been an assessment of the environmental impact of the activities of the plan;
- the plan includes management controls to ensure that the impacts of the activities are ecologically sustainable;
- activities undertaken under the plan will not be detrimental to survival or conservation status of the taxon or any relevant ecosystem; and,
- in the case of plans that cover mammals, reptiles, birds or amphibians that animal welfare requirements are met.

In approving a management plan the Minister (or delegate) must have regard to whether the legislation relating to the taxon is in force in the relevant State or Territory and whether it applies throughout the State or Territory and is effective.

Prior to approving a wildlife trade management plan, a notice setting out the proposal (plus a copy of the relevant State or Territory management plan) is placed on the Internet for a minimum period of 20 business days and inviting written comment. The Minister must consider any comments received when making a decision. In addition, the Minister must consult the relevant agency of each State or Territory affected by the declaration of a wildlife trade management plan.

#### Miscellaneous

The EPBC Act provides additional protection for specific species that are listed on lists maintained under the EPBC Act (that is, threatened, marine and migratory species). *Crocodylus porosus* and *C. johnstoni* are not listed as threatened, but *C. porosus* is a listed migratory species and both are listed as marine species. These listings require additional protection in or on a Federal area.

# **Crocodile Management - Kakadu National Park**

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#### Abstract

Kakadu National Park is jointly managed by DEH and the traditional landowners. This paper discusses how crocodiles are managed in Kakadu.

#### Preface

The term 'crocodile' is used herein to refer to the species *Crocodylus porosus*, the salt-water or estuarine crocodile. The species *Crocodylus johnstoni* will be referred to in full as "freshwater crocodile".

#### Background

Crocodiles are of high conservation, cultural and tourism significance. As with other areas in Australia's Top End both species of crocodile were commercially hunted to a situation of serious decline, with their populations critically endangered, in the late 1960s and early 1970s. Since protection crocodiles have made a remarkable population recovery to levels not seen since pre-hunting times. Parks Australia, the Commonwealth (Australian Government) management agency responsible for managing Kakadu (in a joint management partnership with Kakadu's Aboriginal traditional owners, has a responsibility to manage this natural heritage population whilst minimizing the obvious risks they pose, particularly saltwater crocodiles, to humans (Kakadu residents and visitors). The main management issue predominantly lies not with crocodiles but with managing and educating people about the risks whether living in or visiting Kakadu, where large and healthy populations of crocodiles exist in varying densities throughout Kakadu's waterways. This paper provides information about current crocodile management practice in a world heritage listed (natural and cultural heritage) landscape.

#### Introduction

Kakadu is about 19,804 square kilometres in area. About 50% of Kakadu is Aboriginal land leased back to the Commonwealth to be managed as a national park. Today, about 1600 people live in Kakadu. About 1164 (214 indigenous) live in the township of Jabiru, which is situated roughly in the centre of Kakadu. 207 indigenous and 188 non-indigenous residents reside outside Jabiru in Kakadu, at Aboriginal community outstations and park ranger stations. About 170,00 to 180,000 people visit the park each year.

Many residents and visitors carry out activities near or in water bodies in which crocodiles occur. Aboriginal people continue their traditional hunting and gathering of food in these areas. Other residents and visitors carry out activities including camping, fishing, boating and, in some locations, swimming. Estuarine crocodiles present a risk to people carrying out these activities. The level of risk varies depending on physical features of the area, the time of year, the size and behavior of crocodiles in the area, the type of people that use the area and the activities they carry out.

Some activities dangerously attract the interest of crocodiles. Such activities include: cleaning fish; leaving offal or food scraps near the water's edge; camping close to the water's edge; fishing while standing in the water; getting captured fish by hand from the water; holding fish in the water for some time before releasing them; going very close to crocodiles in boats; feeding crocodiles; annoying crocodiles; boating in unsafe or small craft; adults or children wading and splashing at the water's edge; and, swimming in areas where crocodiles may be.

There have been numerous adverse interactions between crocodiles and people since the park was declared, ranging from crocodiles entering campgrounds to scavenge food waste, to fatal attacks on people. Over the years, Parks Australia developed and adopted a range of strategies to reduce the risk of crocodile attacks on people in Kakadu, and to respond to any attacks.

#### Legal and management framework for managing crocodiles in Kakadu

Kakadu National Park is a Commonwealth reserve under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

Approximately half of Kakadu is Aboriginal land under the Aboriginal Land Rights (Northern Territory) Act 1976 (Land Rights Act) and is owned by Aboriginal Land Trusts on behalf of the traditional Aboriginal owners. The Land Trusts have leased the land to the Director of National Parks. Most of the remaining land in Kakadu is under claim under the Land Rights Act.

The Director of National Parks and the Kakadu Board of Management manage the park, in accordance with the EPBC Act and the management plan for the Park. Day to day management is carried out by Parks Australia (staff within the Department of the Environment and Heritage).

Section 354(1) of the EPBC Act prohibits killing, injuring, taking, trading, keeping or moving a member of a native species except in accordance with a management plan. Each management plan for Kakadu since 1986 has specified that park staff may capture and relocate or destroy problem crocodiles.

The EPBC Act, the Land Rights Act and the lease agreements protect the rights of indigenous people to continue their traditional use of areas and resources in the park for hunting, food gathering, ceremonial and religious purposes. This means that indigenous people have rights under contemporary legislation as well as under traditional Aboriginal law to continue to take crocodiles and their eggs in Kakadu for food and other traditional purposes.

Kakadu has been listed on the World Heritage List for both its natural and cultural values. Australia has obligations under the World Heritage Convention, codified in the EPBC Act, to protect, conserve and present the attributes of the park that are of World Heritage significance. The World Heritage values include animal species of conservation significance, including crocodiles.

Crocodiles are listed as endangered on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). This listing placed restrictions on international trade in crocodiles and crocodile products. Consequently, Part 13A of the EPBC Act regulates imports and exports of crocodiles and crocodile products to and from Australia. Within Australia, crocodiles they are protected and managed under Commonwealth, State and Territory legislation. In Commonwealth areas, including Kakadu, crocodiles have strong legislative protection through being listed as migratory and marine species under Part 13 of the EPBC Act. This strictly limits the circumstances under which crocodiles or their eggs may be taken. In the rest of the Northern Territory, the Territory Parks and Wildlife Conservation Act 2000 provides for the protection of crocodiles and regulates the harvesting of crocodiles and eggs.

#### Historical background

Archeological evidence suggests man has occupied Kakadu continuously for up to 60,000 years or more while the climatic history of the Top End indicates Kakadu may have been unavailable to saltwater crocodiles periodically and in fact may have been solely the domain of freshwater crocodiles for much of these 60,000 years.

In more recent times the Top End rivers were visited by early explorers and occupied by following settlers. They noted the region was "infested" with crocodiles with these impressions recorded permanently in local place names: the Alligator Creeks, Alligator Head, Alligator Billabong and Crocodile Island, etc.

Since contact times (pre-1945) crocodiles have been exposed to commercial harvesting for their hides. Other reasons for killing crocodiles (by poison baiting, hooking and nest destruction) involved cattlemen reducing stock predation. Despite this type of hunting pressure crocodile numbers remained high until after World War II. Then, the adoption of spotlight shooting for commercial hunting of crocodiles, coupled with a good return for hides and a surplus of adventurous hunters, brought a rapid decline in crocodile numbers (D. Lindner, pers. com). Due to the decimation of crocodile populations both species were given protection in the late 1960s and early 1970s. Since then there has been a rapid increase in the observable population of crocodiles (Palmer 1992). This is particularly evident on the tidal and inland waterways (eg Alligator and Wildman Rivers, Yellow waters - late dry season) of Kakadu.

Kakadu's crocodile population grew rapidly in the 1980s then leveled out in the 1990s, however the number of

estuarine crocodiles found in upstream areas is still increasing each year. Parks Australia staff estimate that, as at 2004, there are about 5000 to 6000 (very approximate estimation only) estuarine crocodiles in Kakadu, which roughly represents 10% of the Top End's crocodile population.

#### Managing and maintaining Kakadu's resident crocodile population in or near to its natural state

Both species of Australian crocodile, the estuarine crocodile (*Crocodylus porosus*) and the freshwater crocodile (*Crocodylus johnstoni*) live in Kakadu National Park.

Aboriginal people in the Kakadu region refer to the saltwater crocodile as Ginga and the freshwater crocodile as Gumugen, The estuarine crocodile is most common in tidal wetlands and freshwater bodies associated with subcoastal plains. Both species occur in the upper freshwater regions of tidal rivers, creeks and billabongs. Estuarine crocodiles are dangerous to humans. Freshwater crocodiles, although generally harmless to humans, can be dangerous, particularly if they are annoyed or interfered with.

Before non-Aboriginal people arrived in this area, Aboriginal people and crocodiles preyed on each other. People understood the risks. For Aboriginal people, swimming or deep wading in waters down stream from the waterfalls of the escarpment crocodiles attacks presented a degree of risk, which to an experienced person varied from negligible to extremely high. At the high risk end of the scale even camps were made well away from waters edge to avoid crocodile attacks. For crocodiles, Aboriginal people were nest robbers, and a cunning predator using decoys, with the victim crocodile ambushed by gangs of people armed with spears.

Man could hunt crocodiles occupying small water holes or floodplain wallows and burrows with relative impunity and this effectively confined crocodiles in their wetland distribution. Neither man nor adult crocodiles had other predators to consider (other than their own species) unless they entered a deep-water environment.

This relationship may offer an explanation why crocodiles often appear wary of humans by instinct, in contrast to their behaviour to other large animals (eg dingoes, pig, buffalo and horses) where they don't appear to sense threat and are often attracted to these animals, particularly dogs on Aboriginal outstations situated near billabongs.

Today, Aboriginal people still live in Kakadu and still eat crocodile meat and eggs, but they take far fewer crocodiles and eggs than they did before non-Aboriginal people arrived. There are fewer Aboriginal people living in Kakadu than there were in the past, they live in fewer locations and, in most situations, are not living immediately in or adjacent to the wetland and estuarine areas that historically provided most of these peoples rich food resources. Aboriginal people are no longer solely reliant on these areas and resources for hunting and gathering for food.

#### "Boss crocodiles"

Very large crocodiles (5 m long and larger) exist throughout the tidal and inland waterways of the park. Some of these individual identity animals have co-existed with Aboriginal residents prior to declaration of Kakadu in 1979; as a result Aboriginal people afford them protection. The smaller peer crocodiles (up to 2.5 m) in a large crocodile's territorial home range were commonly hunted and are still intermittently hunted today.

As an example one large crocodile, known locally as Roughnut, is about 5 m long. Roughnut resides at a very well used floodplain and billabong area known as Gindjela. Aboriginal people have seen Roughnut in this area since 1975. At Gindjela Aboriginal people utilize the resources such as magpie geese, file snakes, feral pig, water pythons, saratoga, barramundi, catfish, freshwater turtles, and aquatic plants. Roughnut and Aboriginal people in this area have experienced a dramatic change where crocodiles numbers in this waterhole were very low. In recent times the numbers of smaller peer group crocodiles has become very high, particularly at the end of the dry season where receding water has forced about 100 crocodiles to live in the 3 km stretch of billabong (2003).

Roughnut's territory includes a couple of 4 m plus crocodiles. This is followed by number of crocodiles about the 3 m size class. The most abundant size range in this group of 100 crocodiles is the 1 to 2.5 m size class. Typically, as with other 'boss crocodile' situations the majority of these crocodiles (about 60% of the population) occupy about 25% of the space available, at one end of the billabong system. Roughnut and the remaining 40% of the population occupy the other 75% percent of the billabong. The crocodiles "accommodated" by Roughnut are usually animals up to 2.7 m in length and are fairly evenly dispersed throughout the billabong. The remaining 60% of Roughnut's peer group exist in the shallow end, which is about 2 m deep in the middle sections. These crocodiles co-exist, albeit the