

Crocodile Specialist Group Steering Committee Meeting
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Australia and Oceania

Three species of crocodylian are endemic to the Australia & Oceania region; *Crocodylus porosus*, *C. novaeguineae*/*C. halli* (Papua New Guinea only) and *C. johnstoni* (Australia only).

Australia

In late 2021, the Department of Agriculture, Water and the Environment (DAWE) initiated a process to review the *Code of Practice on the Humane Treatment of Wild and Farmed Australian crocodiles* (the code) in conjunction with the relevant state and territory governments (Western Australia, Northern Territory, Queensland). The code sets out the framework and standards for the humane capture, restraining and housing of both wild and farmed crocodiles in Australia. The code was endorsed by the Natural Resource Management Ministerial Council (NRMMC) and came into effect on 21 May 2009. While the intention was for the code to be reviewed after 10 years, this has not occurred and given recent advances in science, technology, and husbandry practices, it was broadly accepted by the relevant state and territory governments and industry stakeholders that a review should be carried.

Northern Territory

The *C. porosus* population in the Northern Territory has been increasing since intensive unregulated hunting (1945-1971) and is now estimated at around 102,000 non-hatchlings, with 42% of crocodiles estimated at >2.1m TL (Fukuda *et al.* 2021). Monitoring of the population has occurred consistently since 1975, with only minor gaps in the record (Fukuda *et al.* 2021). Despite COVID restricting survey coverage in recent years (2020-2021), results have been consistent with recent trends, showing either stable (believed to have reached an asymptote) or increases in both numbers and in biomass (more larger crocodiles observed) (Clancy and Fukuda 2021).

The number of problem *C. porosus* removed for public safety and to protect stock in pastoral areas has been increasing over the last two decades, in line with the increasing crocodile population. In 2019-2020, a total of 249 problem *C. porosus* (72% males) were removed from the wild with the majority (96%) from Darwin Harbour. Drier than average wet seasons in recent years have likely influenced lower capture numbers in those years (eg 2018-2019 and 2019-2020; Clancy and Fukuda 2021).

In the Northern Territory, there is an annual ceiling of 90,000 viable *C. porosus* eggs and 1200 non-hatchling crocodiles that can be collected from the wild under permit. These eggs and crocodiles are used to supply crocodile farms. In 2019-2020, only 41,462 viable eggs were collected and 78 non-hatchlings (+249 problem crocodiles) removed. Ten crocodile farms are currently operating in the Northern Territory, with the economic value of the industry estimated at around \$25.4 million over the last five years (Clancy and Fukuda 2021).

Recent research involving *C. porosus* in the Northern Territory includes modelling to examine the impact of the harvest of eggs and adults since protection and to predict future scenarios (Fukuda *et*

al. 2021), landscape genetics approaches to quantify dispersal patterns and demonstrated environmental influences on emigration, movement, and settlement (Fukuda *et al.* 2022), use of eDNA to detect estuarine crocodiles (Rose *et al.* 2020), examination of spatial events implicated in the homing ability of large translocated males and genetic structure across the NT coast (Fukuda *et al.* 2019), and exploration of dietary changes that may have accompanied population recovery by comparing the isotopes in bones (Campbell *et al.* 2022).

Queensland

Unlike in the Northern Territory, *C. porosus* monitoring in Queensland has been sporadic and inconsistent over time, with comprehensive state-wide monitoring only occurring in the late 1980s, late 1990s/early 2000s, and again in 2016-2019. A summary report of the 2016-2019 survey results and historical analyses (1985-2019) was released in mid-2021 by the Department of Environment and Science. The results revealed a current population of 20-30,000 non-hatchlings at an average density of 1 crocodile/km, which has increased since the 1980s. However, recovery has been relatively slow and highly variable across the state at around 2% on average each year (Taplin *et al.* 2020). While numbers in some rivers appear to have stabilised as early as the 1980s (eg Wenlock River, north-western Cape York), in other rivers (eg Norman River, Gulf of Carpentaria) numbers continue to increase (Taplin *et al.* 2020). Saltwater crocodiles occupy a diverse range of habitat types in Queensland (13 defined crocodile bioregions), most of which are considered marginal or sub-optimal for crocodiles (Taplin 1987; Taplin *et al.* 2020). The population is also largely riverine with the majority (>90%) found below 20 m elevation (Taplin *et al.* 2020). Population monitoring of the Australian Freshwater crocodile (*Crocodylus johnstoni*) does not currently occur in Queensland.

Because of increasing crocodile and human populations, especially along the populated east coast between Cooktown and Ayr, there has been increasing human-crocodile conflict in Queensland over the last two decades (Brien *et al.* 2017). Since 1975, there have been 47 crocodile attacks (16 fatal, as of May 2022) on humans, with a record 5 in 2021 (1 fatal). However, while non-fatal attacks have been increasing, fatalities (0.3 per year) have not. In response to the increasing conflict, the department, under the Queensland Crocodile Management Plan (QCMP), has removed a record number of problem crocodiles (total >450, mostly >2 m TL) over the last decade largely from the populated east coast (Cooktown-Ayr). While the average size of crocodile has been increasing throughout the state, it has decreased along the populated east coast and this is believed to be a consequence of the removal program (Taplin *et al.* 2020). Australian Freshwater crocodiles pose little threat to humans, with attacks being rare.

The commercial utilisation of *C. porosus* in Queensland has historically been restricted to captive-bred animals, problem crocodiles received through the management program, and eggs and stock imported from the Northern Territory. It only became lawful to harvest wild *C. porosus* eggs in Queensland in 2018 under the *Nature Conservation (Estuarine Crocodile) Conservation Plan 2018*, with only one group currently permitted to collect in the Pormpuraaw region.

Recent research involving saltwater crocodiles in Queensland includes ongoing tracking in the Wenlock River to describe movement patterns, social interactions, and nesting behaviour using acoustic telemetry (Baker *et al.* 2019, 2022), utility of digital surveillance, sonar and associated algorithms to detect and alert to the presence of saltwater crocodiles (Brien *et al.* 2021), use of drone technology to detect (CrocSpotter-Little Ripper) and capture crocodiles (Brien *et al.* 2020), aversive conditioning as a non-lethal management tool for estuarine crocodiles (Booth *et al.* 2020), modelling to examine the impact of the removal of adults on the populated east coast as part of the management program since protection and to predict future scenarios, and use of eDNA to detect

crocodiles in the wild. There is no research involving *Crocodylus johnstoni* currently occurring in Queensland.

Western Australia

Regular monitoring of the saltwater crocodile population in the Cambridge Gulf region (Ord River, West Arm) previously occurred via aerial survey between 1992 and 2012, with spotlight surveys occurring sporadically. Currently, monitoring is restricted to an annual spotlight survey of the King River, which has been surveyed consistently since 1989 (1989-1990, 1992-2015, 2017-2021; Corey *et al.* 2020). The most recent survey results indicate relatively high rates of increase in *C. porosus* populations in West Arm (4.1% per year in 2008), the tidal Ord River (6.9% per year in 2008), the non-tidal Ord River (4.7% per year in 2019) and King River (3.3% per year in 2020) (Webb *et al.* 2010; Corey *et al.* 2020), with no sign yet of stabilising. Cattle grazing is a potential threat to some nesting habitats, and some illegal harvesting of eggs is known to have occurred in 2009-2010.

The increasing *C. porosus* population has led to increasing conflict that prompted authorities to implement a public safety program, like the “Be Crocwise” program in the Northern Territory and Queensland. Legal harvesting of juveniles, sub-adults, adults and eggs was undertaken in West Arm between 1989 and 1994 to provide stock for crocodile farms. However, only one farm is currently in operation, in Broome, and it is based solely on captive breeding.

In 2019, Barrow and Hartford described a new biopsy method for the collection of DNA samples from free ranging *C. porosus* that does not require capture or handling. The method employs a modified standard biopsy needle mounted on the end of a harpoon pole that is plunged into the neck or tail of the crocodile. In the study, a total of 69 free ranging crocodiles (size range 0.9-4.4 m TL) from two remote rivers of Western Australia were successfully sampled using the method, with a 95% success rate. This method has since been adopted by researchers in the Northern Territory and Queensland.

Recent research involving *C. johnstoni* includes population genetic analyses from the Ord River, Fitzroy River, and Lennard River basins using single-nucleotide polymorphisms (SNPs) (Cao *et al.* 2020). The population structure found here indicates that delimitation of management units should be based on river basins with the proximity of adjacent river basins taken into consideration when gene flow exists. With the continued spread of cane toads across Western Australia, studies are also focussed on the impact on the Freshwater crocodile population. Clarke *et al.* (2020) described encounters between freshwater crocodiles and invasive cane toads in Lake Argyle, and found that most predation attempts did not result in toad consumption. Instead, often only a limb was removed from the toad that facilitated taste aversion learning in the crocodile. In another study, Aiyer *et al.* (2022) demonstrated that freshwater crocodiles rapidly avoid consuming toads, and shift almost exclusively to aquatic foraging.

Papua New Guinea

The latest report published by the Conservation and Environment Protection Authority (CEPA) indicated a fluctuating but stable *C. porosus* population within the area surveyed in 2020. Degradation of habitat by introduced fish species and burning during dry years continues to affect nesting habitats, although nest monitoring indicates positive trends for both *C. porosus* and the New Guinea Freshwater crocodile (*C. novaeguineae*). Due to financial constraints, CEPA has not been able to conduct any biennial nest counts survey for *C. novaeguineae* or *C. porosus* since March 2020. In 2020 and 2021, the annual wild saltwater crocodile egg harvest in the Middle Sepik River, organized by Mainland Holdings and in collaboration with the Sepik Wetlands Management

Initiative, managed to harvest a combined 16,523 wild saltwater crocodile eggs despite COVID-19 restrictions.

The latest CEPA report also notes a sharp decline in the quantity of wild crocodile skins exported from PNG and a continuous drop in the number of licensed buyers and exporters from all coastal regions in PNG. This situation is due to a combination of low prices paid for wild skins, the ever-stricter grading standards imposed by the buyers/tanneries and, importantly the very high costs for domestic and international freight. This downward trend has further accelerated after the start of the COVID-19 pandemic and it is now believed that Mainland Holdings remains the only active buyer and exporter of wild crocodile skins in PNG. There is concern that the ever-stricter grading standards for skins, resulting in lower prices, will most likely discourage rural communities from continuing to support the crocodile conservation programs.

The drafting of a Bill to amend the *Crocodile Trade (Protection) Act 1974* was announced by the Managing Director for Conservation and Environment Protection Authority on 21 June 2021. This process will involve a review of the current legislation and a series of consultations to assess the needs and priorities of Papua New Guinea's crocodile skin trade. Since the last update of the 1974 Act, over 35 years ago, the approach to management and commercial use of crocodiles has changed considerably in Papua New Guinea. The Act was designed to regulate the trade of crocodile skins and protect wild crocodile populations. The structure of the industry has also changed significantly, evolving into a more efficient, quality-controlled system in which the roles and responsibilities of the various participants have become more stringently defined and the cultural and socio-economic profiles of the individuals involved in the different sectors of the industry better understood.

The proposed amendments to the legislation will reflect these industry changes as well as changes to the management and conservation of crocodiles in Papua New Guinea. In summary the proposed changes will: improve licensing arrangements and fee collections for crocodile skins and eggs, provide for regulations of skin processing and exports, update enforcement provisions (such as forms and penalties), and transfer the export permit provisions of the Act under the International Trade (Fauna and Flora) Act. The review of the Crocodile Management Plan will envisage to eliminate wild hunting in the future, and there will also be a review of the existing exemptions on sales, export of crocodile meat and by-products from registered crocodile farms. The amendments will also enable improvements to the quality of information provided by the industry to the CEPA.

Supported by a crocodile expert, the CEPA will consult with provincial government, community leaders, industry and local conservation and NGO groups on the proposed changes before the amended Crocodile Trade (Protection) Act 1974 and Crocodile Trade (Protection) Regulation (1980) and Schedules are submitted to the National Executive Council and Parliament for endorsement. The review of the Act and consultations are being supported by the By-catch and Integrated Ecosystem Management (BIEM) Initiative implemented by the South Pacific Regional Environment Program (SPREP) under the Pacific-European Union Marine Partnership (PEUMP) program funded by the European Union and the Government of Sweden.

Timor-Leste

The wild saltwater crocodile population in Timor-Leste and rate of fatal attacks on people are both increasing (Brackhane *et al.* 2019). From 2007 to 2019, there were 59 fatalities and 21 non-fatal attacks on people (CrocBITE 2019), but many additional attacks are believed to go unreported. In response, the Timor-Leste Government has set up warning signs at known crocodile spots and is regularly visiting affected communities to raise public awareness. Government has also constructed a crocodile enclosure in Hera, near Dili, to enable the housing of problem crocodiles. Community-

based monitoring has been conducted in various communities in Lautem and Viqueque to assess data on crocodile habitat and attacks, integrating the knowledge of local stakeholders (Brackhane *et al.* 2019).

Local authorities recently raised the concern that crocodiles dispersing from Australia could be responsible for the increase in crocodile attacks in Timor. Brackhane *et al.* (2018) provided circumstantial evidence to support this theory, but it remains unproven. DNA sampling of *C. porosus* is planned throughout coastal areas of the country, but COVID-19 restrictions have delayed progress of this study until late-2022-early 2023. This study involves Australian, German and Timorese collaborators, and has been funded through CrocFest.

Brackhane *et al.* (2018) recommended that future research and management should focus on testing the dispersal hypothesis, and on the removal of problem crocodiles from areas where crocodile habitat and human activity frequently overlaps, as well as on developing an ecotourism strategy including “crocodile watching”.

Crocodiles are culturally very important to local people in Timor-Leste, and *C. porosus* is the national animal. A small number of *C. porosus* are held in captivity in the capital, Dili. Recent social research conducted by Brackhane *et al.* (2019) examined cultural beliefs and traditional ecological knowledge underlying human-crocodile interactions and conflict in Timor-Leste. Local beliefs based on Timor-Leste’s creation myth “Lafaek Diak - The Good Crocodile” are anchored in the East Timorese traditional belief system lulik and involve worship of the widely distributed, but dangerous, saltwater crocodile (Brackhane *et al.* 2019). Interviewees knew this species was a risk (respect, fear) and its population was expanding, and had culturally determined beliefs (ceremonies, rituals) that included differentiating between local “ancestor” crocodiles and invasive “troublemakers.” Cost-effective management could integrate stakeholder groups, especially traditional elders and local knowledge holders (Brackhane *et al.* 2019).

In other recent research, Brackhane *et al.* (2018) performed habitat analysis of Timor-Leste based on Geographic Information Systems (GIS) to identify: 1) core habitats (including perennial waterbodies such as lakes, swamps, billabongs and rivers providing possible breeding sites for *C. porosus*); 2) coastal marine habitats, inter alia, *C. porosus* perennial range for hunting; and, 3) seasonal range, namely potential habitat for *C. porosus* during the wet season.

Solomon Islands

With support from the By-catch and Integrated Ecosystem Management (BIEM) Initiative, the Solomon Islands Government is currently developing a national crocodile management plan as initially identified in their National Biodiversity Strategic Action Plan 2016-2020.

The only spotlight surveys of the *C. porosus* population in the Solomon Islands occurred in the 1980s (Messel and King 1990). The results of these surveys revealed low numbers throughout the islands with a total population size estimated at ~720. Since this time, the population has recovered rapidly, leading to increasing conflict including attacks. As noted by Messel and King in 1990, the Solomon Islands is one of the most logistically challenging places to survey crocodiles, due to the many small rivers and creeks spread across the remote island chain.

Therefore, more recent efforts to estimate the population size and the nature and extent of human-crocodile conflict have focussed on interviews with community members throughout the Solomon Islands (Van der Ploeg *et al.* 2019). The results estimated that the crocodile population had increased since the 1980s to between 1400 and 2300 non-hatchlings. A total of 225 crocodile

attacks on people were recorded, 83 of which were fatal (37%), and included 31 children. Attacks have been increasing over the last decade, with an estimated average of 5/year nation-wide (Van der Ploeg *et al.* 2019).

The results of the study by Van der Ploeg *et al.* (2019) reported that communities recognise the risk posed by saltwater crocodiles and take measures to avoid interactions such as supervising children, avoiding fishing alone, and being alert at night and during floods. It was also found that crocodiles were killed by local hunters with traps and spears as a precautionary measure or in retribution for attacks on humans. Cultural restrictions on killing and eating crocodiles remain pervasive throughout the country, and they are widely regarded as taboo (sacred) animals that need to be treated with respect. Crocodile attacks are often attributed to the wrath of ancestors or to sorcery.

The study provided a range of recommendations, including raising public awareness, removing problem crocodiles, legalizing the sale of crocodile products, and developing community-based monitoring. This latest research provides a basis from which to determine population levels against the estimated virgin population and at what point it can sustain any harvest.

Palau

The *C. porosus* population in Palau is considered to be relatively small and stable. Systematic population surveys have not been carried out in recent years, and HCC is uncommon.

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