The genetic structure and connectivity of the estuarine crocodile (*Crocodylus porosus*) in Queensland 2018–2020 report

Summary and key findings

CSIRO DATA 61

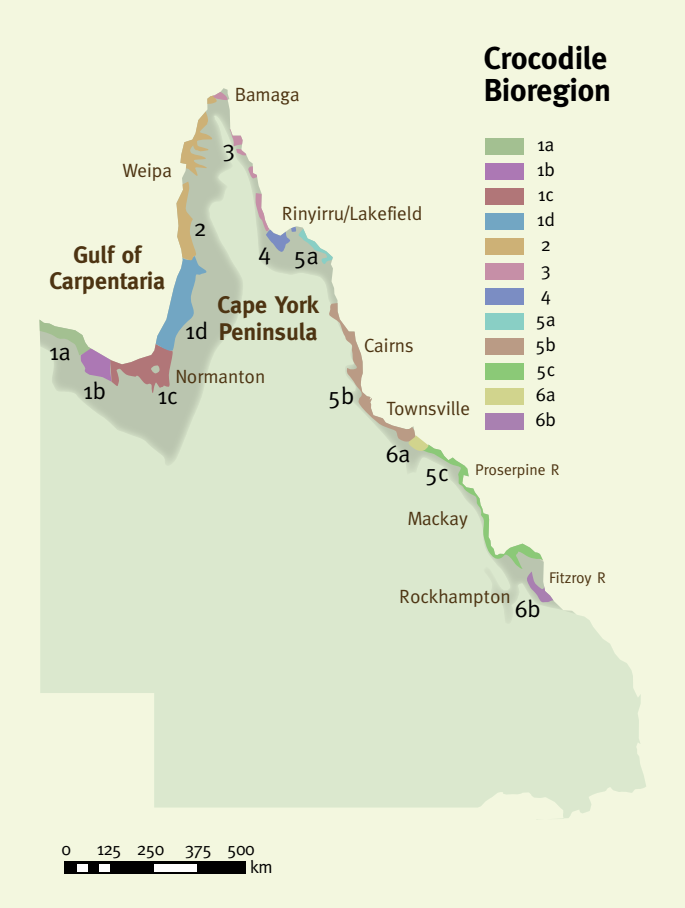
Queensland Government

Introduction

In Queensland, the estuarine crocodile (*Crocodylus porosus*) is distributed throughout coastal areas from Rockhampton on the east coast through to Cape York Peninsula and the Torres Strait and through the Gulf of Carpentaria to the Northern Territory border[1,2]. Most of the crocodile population is found in rivers, with over 90% occurring below 20m elevation[2].

The crocodile population in Queensland has recovered from widescale commercial hunting that occurred until protections were introduced in 1974. The population is still increasing and is estimated at 20,000–30,000 non-hatchlings with 40% found in north-west Cape York at a density of 3 per km[1,2]. The number and density of crocodiles declines southward, falling to 1.2 per km in the southern Gulf of Carpentaria and Cairns regions, down to 0.2 per km in Rockhampton which is the southern-most population anywhere in the world[1,2].

The estuarine crocodile (*Crocodylus porosus*) population in Queensland is distributed across 12 distinct crocodile bioregions, reflecting the highly variable biogeography and climatic conditions that exist across the state[1,2]. Given the long-distance movement capabilities reported for the species[3,4,5] these bioregions will be connected to some extent by migration.



This study describes the genetic structure and connectivity of the Queensland estuarine crocodile population. Understanding where crocodiles in Queensland are from (source), where they go (sink), and how far they travel, will improve understanding of the species. This knowledge will inform more efficient and effective management which will help reduce the threat to public safety.

This project was a joint initiative between the Department of Environment and Science (the department) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO), with support from the Queensland Museum.

> Understanding where crocodiles in Queensland are from (source), where they go (sink), and how far they travel, will inform management to better reduce the threat to public safety.

Figure 1. Estuarine crocodile distribution in Queensland according to the 12 crocodile bioregions and elevation. Crocodile bioregion 1a-d) Gulf Plains: Massacre Inlet—Mitchell-Gilbert drainage 2) North-west Cape York 3) North-east Cape York 4) Princess Charlotte Bay 5a-c) Coastal Plains: Cape Melville—Rockhampton 6a) Burdekin River drainage, 6b) Fitzroy drainage. Coloured area represents <20m elevation where majority (>90%) of crocodile population resides, shaded area represents 20-100m elevation where further ~9% resides.

Summary of key findings

- Based on over two decades of movement studies, it was believed that estuarine crocodiles could move everywhere and anywhere. The results of this genetics study have redefined what is known about estuarine crocodiles in Queensland and the species more generally.
- The estuarine crocodile (*Crocodylus porosus*) population within Queensland can be described broadly as six sub-populations.
- There is evidence of historical and recent movement of crocodiles between adjacent sub-populations with connectivity declining with distance.
- There is greater connectivity along the Western Cape and Gulf compared to the east coast.
- It appears that most crocodiles remain close to their place of birth with 90% of crocodiles dispersing less than 50km, leading to localised populations.
- The Proserpine and Fitzroy River populations show evidence of being isolated and have the most extreme number of related individuals.
- Several crocodiles, or their descendents, were found that had almost certainly been translocated between bioregions through human intervention.
- While Queensland and the Northern Territory have similar levels of genetic differentiation, migration appears to be far greater in the Northern Territory—where 42% of crocodiles were found to be migrants from distant populations[5].
- Knowing where crocodiles come from (source), where they go to (sink), and how far they travel to do it, will help to more efficiently manage crocodiles and protect the people of Queensland now and into the future.

Methods

A total of 1,176 genetic samples were collected from estuarine crocodiles ranging in size from hatchlings through to adults (~5m) between August 1997 and September 2021 across 10 of Queensland's 12 crocodile bioregions.

Samples collected between August 1997 and October 2005 were sourced from the Queensland Museum (n = 482), with the remainder collected by departmental staff between May 2018 and July 2021 (n = 694).

> Almost 1,200 samples were taken from crocodiles of all sizes from across the entire range of the species within Queensland.

Figure 2. A biopsy pole was used to collect genetic material from the base of the tail without the need to capture the crocodile.

Genetic samples were taken from either the raised tail scute of the crocodile after capture, or from the tail of free-swimming crocodiles using a biopsy punch from a boat at night[6].

Genetic analyses involved describing the genetic structure of the population along with recent and historical patterns of connectivity and relatedness.

> Genetic samples were collected from larger animals using a biopsy pole—an innovative and minimally invasive method that avoided the need to capture and handle the crocodile

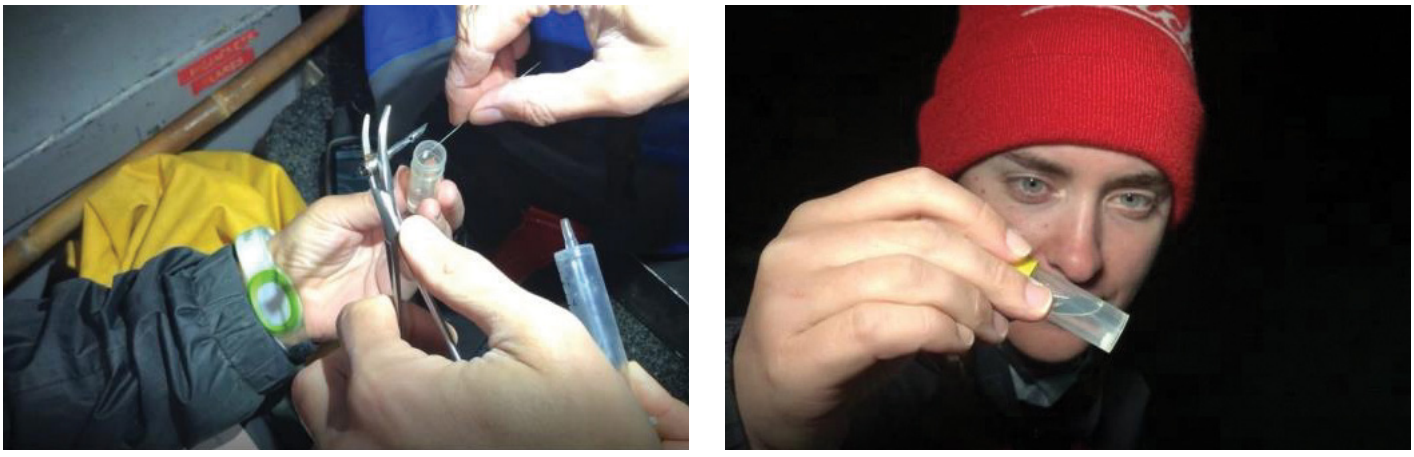


Figure 3. Only a very small piece of tissue was required for a viable genetic sample.

Results

Sub-populations

The analyses showed evidence that the Queensland crocodile population, at the broader scale, consists of six genetic sub-populations. These include: the Gulf Plains, North-west Cape York (including Torres Strait), North-east Cape York and Rinyirru-Lakefield, Northern East Coast (Cooktown-Ayr), Proserpine River on the Central Coast and the Fitzroy River. While the Fitzroy River was grouped with the Northern East Coast population, it can be considered a separate sub-population.

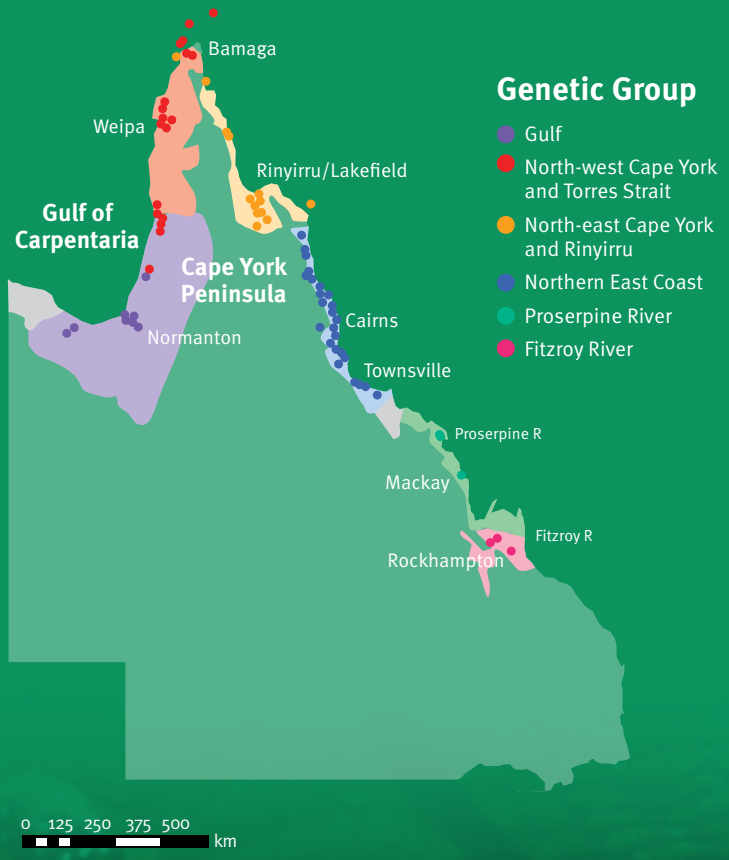


Figure 4. Map of the six genetic sub-populations in Queensland. Genetic groups include 1) Gulf Plains 2) North-west Cape York (including Torres Strait) 3) North-east Cape York and Rinyirru-Lakefield, 4) Northern East Coast (Cooktown-Ayr) 5) Proserpine River on the Central Coast 6) Fitzroy River. Coloured points represent the samples and the genetic group they are associated with.

Gene flow and connectivity

There is evidence of historical and recent movement of crocodiles between geographically close sub-populations with connectivity declining with distance. Gene flow is more restricted from west to east than north to south, and there is greater connectivity and less genetic differentiation along the Western Cape and Gulf compared with the east coast. The tip of Cape York and the Torres Strait does not appear to be a major barrier to dispersal, with crocodiles in the Torres Strait (up to Moa and Badu islands) found to be genetically similar to those in the north-west Cape.

Limited dispersal

It appears that most individuals remain close to their place of birth, leading to localised populations. The findings indicate that 90% of all close relatives are found less than 50km from their birthplace, and most parent-offspring pairs are found within 10km of each other.

Isolation and inbreeding

The Proserpine and Fitzroy River sub-populations show evidence of being isolated, especially the Proserpine. Both populations have the most extreme number of related individuals, suggesting likely inbreeding and very limited immigration from surrounding areas. Climate (e.g. cooler temperatures) and the likely barriers to dispersal created by strong oceanographic forces, such as tides and currents, in and around Proserpine may play a key role in this isolation.

Translocation

There was evidence of several translocated individuals, mostly from remote areas such as the Gulf of Carpentaria and Cape York Peninsula that were found on the east coast. This translocation was likely a consequence of human interventions rather than natural migration. These crocodiles originated from remote areas (e.g. Normanton, Weipa, Lakefield) where problem crocodiles have been regularly removed in the past and many were captured in waterways near farms and zoos on the east coast that receive problem crocodiles.

The lack of any dispersing crocodiles between the remote areas of origin and the east coast, along with the limited dispersal of crocodiles in the Queensland population (90% of close relatives detected within 50km of each other), support the conclusion that the location of these crocodiles was a result of human interventions.

Over a brief period in the 1990s and early 2000s, some problem crocodiles were relocated from the east coast to remote areas, including Princess Charlotte Bay and Northwest Cape York[7]. Some of these individuals (or their descendants) were also identified through the genetic analysis.

Queensland vs Northern Territory

Queensland and the Northern Territory were found to have similar levels of genetic differentiation across a similar geographic scale. However, the degree of dispersal is very different, with 42% of crocodiles in the Northern Territory being migrants from populations most commonly up to 200km away[5]. In contrast, only 10% of the close relatives detected in the analysis of the Queensland population were found at a distance of greater than 50km.

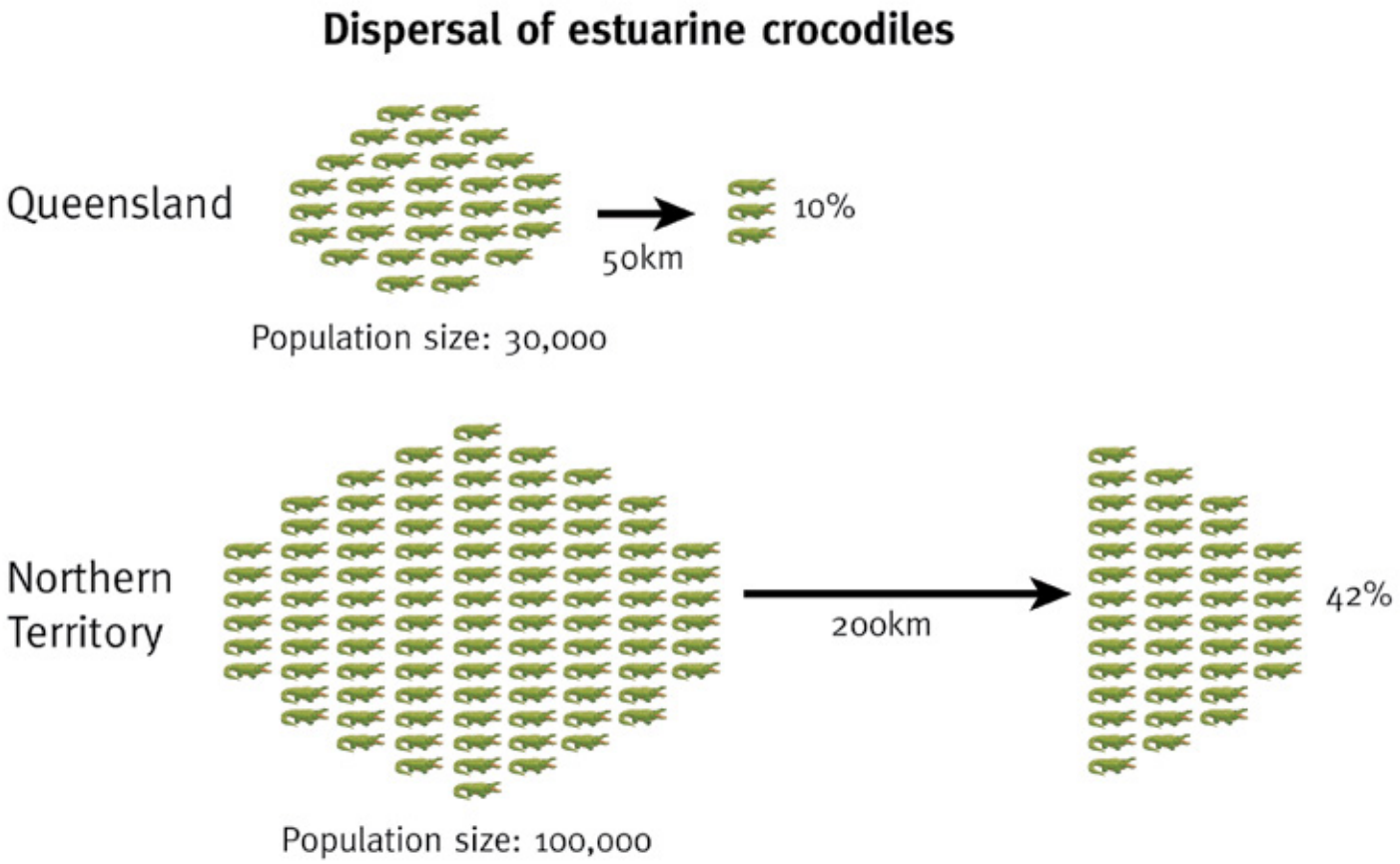


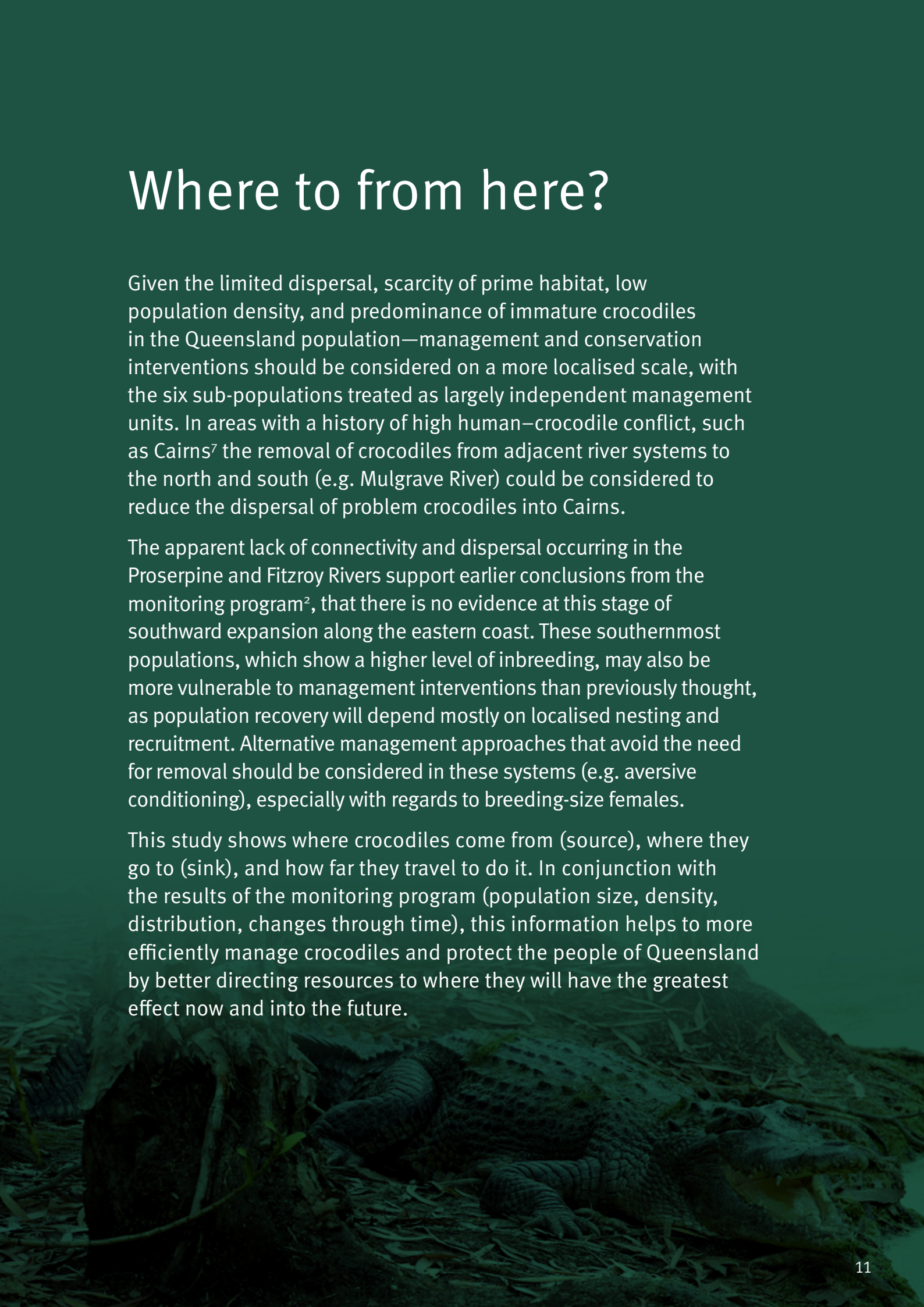
Figure 5. Conceptualization of differences in estuarine crocodile (Crocodylus porosus) dispersal between Queensland and the Northern Territory. Analyses in Queensland refers to kin and Northern Territory estimated migrants.

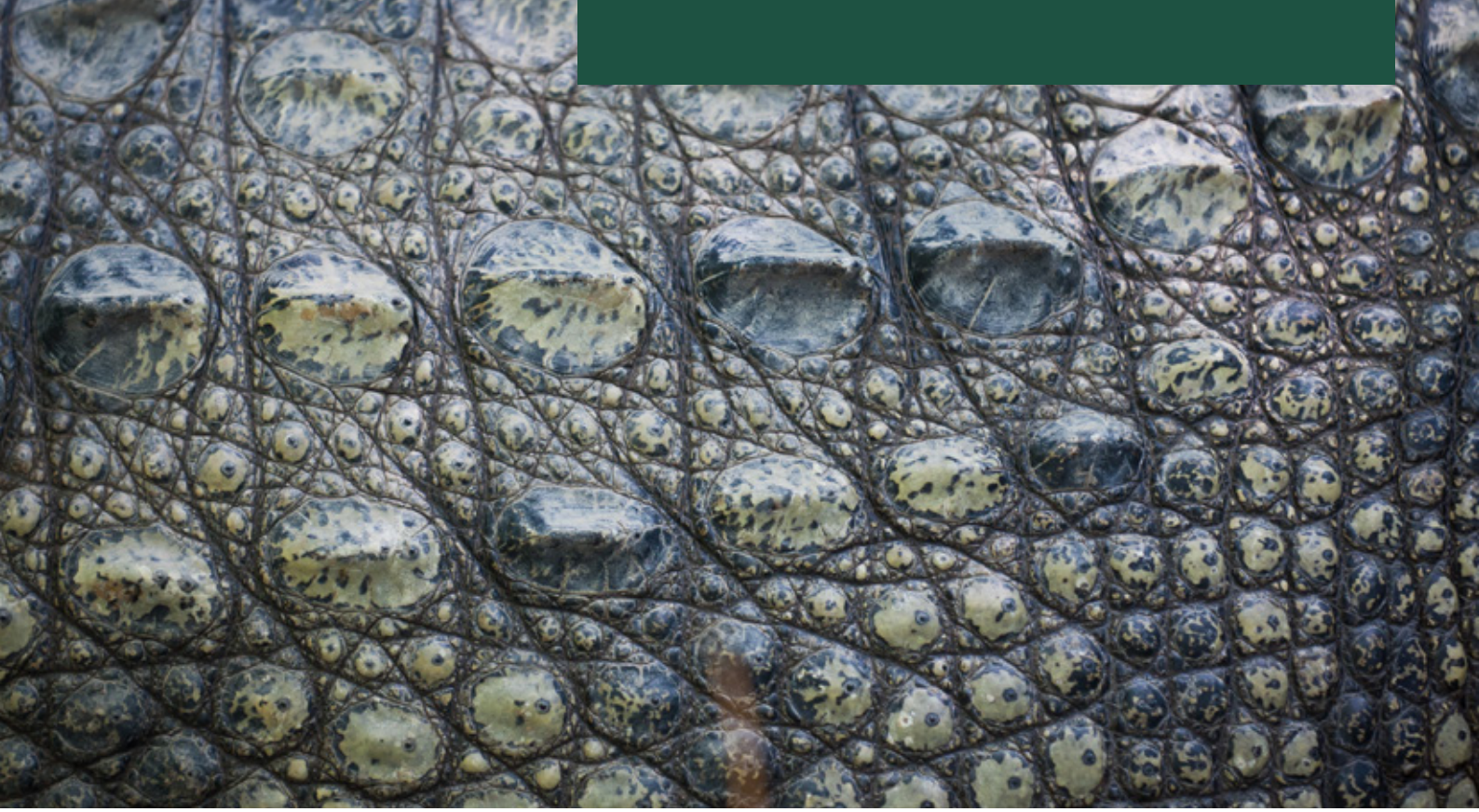
Where to from here?

Given the limited dispersal, scarcity of prime habitat, low population density, and predominance of immature crocodiles in the Queensland population—management and conservation interventions should be considered on a more localised scale, with the six sub-populations treated as largely independent management units. In areas with a history of high human–crocodile conflict, such as Cairns[7] the removal of crocodiles from adjacent river systems to the north and south (e.g. Mulgrave River) could be considered to reduce the dispersal of problem crocodiles into Cairns.

The apparent lack of connectivity and dispersal occurring in the Proserpine and Fitzroy Rivers support earlier conclusions from the monitoring program[2], that there is no evidence at this stage of southward expansion along the eastern coast. These southernmost populations, which show a higher level of inbreeding, may also be more vulnerable to management interventions than previously thought, as population recovery will depend mostly on localised nesting and recruitment. Alternative management approaches that avoid the need for removal should be considered in these systems (e.g. aversive conditioning), especially with regards to breeding-size females.

This study shows where crocodiles come from (source), where they go to (sink), and how far they travel to do it. In conjunction with the results of the monitoring program (population size, density, distribution, changes through time), this information helps to more efficiently manage crocodiles and protect the people of Queensland by better directing resources to where they will have the greatest effect now and into the future.





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