

Crocodiles in the Great Barrier Reef World Heritage Area

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Abstract

The Great Barrier Reef World Heritage Area is not normally considered to be crocodile habitat; however, crocodiles do inhabit the area. A data set for the area has been compiled from several sources, including incidental observations, published records and surveys of islands of the northern Great Barrier Reef. Records indicate that crocodiles occur at low density over a wide area of the Far Northern Section of the Great Barrier Reef. The majority of sightings are of crocodiles basking on remote coral rubble banks, coral cays and continental islands; no nesting has been recorded on any offshore island. The crocodiles sighted on the reef are usually in the 1-2 m size range with only an occasional report of a larger crocodile, usually near shore. Crocodiles found on the reef are considered temporary migrants from the coastal river systems.

Given the biological and habitat requirements of crocodiles, the Great Barrier Reef World Heritage area is an inappropriate geopolitical area in which to focus extensive efforts for the conservation management of crocodiles in eastern Queensland. The primary habitat for crocodiles on eastern Cape York Peninsula occurs below the 250 m contour of the Great Dividing Range north of Cooktown with Lakefield National Park and Jardine River National Park providing critical habitat. The continued survival of crocodiles depends on the conservation management of coastal habitat and the amelioration of threatening processes including the reduction of incidental and intentional mortality.

Introduction

Although the Great Barrier Reef World Heritage Area (GBRWHA) is not normally thought of as being crocodile habitat, the estuarine crocodile, *Crocodylus porosus*, does occur in the area because of its proximity to primary crocodile habitat.

The primary habitat of *C. porosus* in Queensland occurs in the coastal wetlands and rivers of the Gulf of Carpentaria and Cape York Peninsula (Taplin 1987). The myriad of mangrove lined rivers provide complex habitat for crocodiles and their prey; coastal wetlands provide areas for reproduction and suitable habitat for smaller crocodiles. On the eastern coast, populations north of Cairns remain relatively undisturbed by human activity; however, populations south of Cairns have been fragmented by development in the coastal zone through alteration of wetland drainage patterns, agriculture, reclamation, recreational use and by direct management of 'problem crocodiles' (Taplin 1987).

Taplin (1987) provided a detailed analysis of the distribution and factors influencing the survival of estuarine crocodiles in Queensland but he did not consider *C. porosus* in the Great Barrier Reef (GBR) province. This report reviews records of *C. porosus* in the northern portion of the GBRWHA and considers them in the context of pressure, status, response and management within the GBRWHA.

Methods

Records of *C. porosus* occurring in the GBRWHA have been compiled from several sources, including personal observations, published records and unpublished observations made during

surveys of island fauna and flora by Queensland Department of Environment staff. The records are considered to be incomplete because most sightings by fishers and travellers go unreported and because survey coverage of the islands is uneven. However, a sufficient number of records from reliable sources have been accumulated to provide a basis for generalisation. Records of crocodiles at the mouth of coastal rivers and/or adjacent to the mainland coast have been excluded.

Even though crocodiles are easy to recognise, their total length is often over estimated, particularly for larger individuals; among smaller individuals length is usually estimated more accurately (see Choquenot and Webb 1987 for discussion). Calculations based on estimated length have been made using the lowest value in the estimated size range (e.g. for an estimated total length of between 1.5 and 2 m, the value of 1.5 m was used in calculations) to correct for over estimation; where necessary the length estimated by the original observers was converted to metres. Often the only evidence of the presence of crocodiles on an island is a set of tracks (or a slide) in the sand; such evidence is proof of occurrence but is not reliable for estimating size. These are reported as tracks only.

The distance from the location of a crocodile to the nearest island to the west and to the nearest point on the mainland was measured using callipers on Great Barrier Reef Marine Park Authority zoning maps (Cockburn, BRA Q102; Weymouth Bay, BRA Q103; Tijou Reef BRA Q104; Princess Charlotte Bay, BRA Q105). Distances were rounded to the nearest 0.5 km.

All means are reported \pm their standard deviation, range and sample size (n values).

Results

Of the 84 sighting reports of crocodiles (or their tracks) on GBR islands and cays covering the period between December 1976 and May 1995, 55 (65.5%) were of crocodiles, rather than just tracks (34.5%).

Crocodiles (or their tracks) have been recorded on 29 coral cays and continental islands of the Far Northern Section of the Great Barrier Reef Marine Park extending from Frigate Cay (10°47.8'N, 142°58'E) near the northern boundary to Clack Island (14°04'N, 143°02.2'E) in Princess Charlotte Bay (Table 1). The distribution of crocodiles in the GBRWHA probably extends further south than the four degrees of latitude indicated by the available records.

The types of islands on which crocodiles (or their tracks) were found included sand cays (n=18), low wooded islands (n=5) and high continental islands (n=6) (Table 1); the general vegetation of the islands varied from grass and sand (n=12 islands) to forest surrounded by sandy beach (n=6 islands) to fringing mangroves (n=11 islands) (Table 1).

The mean area of islands on which crocodiles (or their tracks) were found was 17.3 ha (\pm 6.48, range=0.5-182.1 ha, n=29). With four exceptions (Sir Charles Hardy Group, 182.1 ha; Gore Island, 68.8 ha; Raine Island, 40.5 ha; Clerke Island, 32.5 ha) the islands used by crocodiles were less than 30 ha in area (Table 1).

Most of the islands on which crocodiles were reported were within sight of another island to the west, the direction toward the mainland. The mean distance from the location of the crocodile to the nearest island to the west was 7.6 km (\pm 6.8, range=0.5-28, n=26), indicating that most crocodiles did not cross vast distances of open water to reach the place where they were recorded.

Table 1. Crocodiles found on islands of the Great Barrier Reef World Heritage Area during the redbill survey of 31 islands, (arranged North to South by Latitude). Type Codes: LW = Low Wooded, VSC = Vegetated Sand Cay, HC = High Continental, (MV) = Minimal Vegetation, (G) = Grassland, (F) = Forested, (G/S) = Grass and Shrub. * = No Data Available. KM to Island = Kilometres to nearest island to the west; KM to Land = Kilometres to nearest point of the mainland to the west

ISLAND	LAT (S)	LONG (E)	GAZETAL NUMBER	DATE	TYPE	AREA	KM to Island	KM to Land	#	NOTES
Frigate Cay	10 47.8	142 58	10-338		VSC (G)	1	28	34	2	Tracks only
Sinclair Island	11 06.6	143 01.1	11-026	28/10/94	VSC (G)	4.1	7	25	1	Track only
Unnamed Reef Cay	11 09.7	143 04.5	11-034	4/12/87	VSC (G)	<2	7	30.5	1	1.5m
Milman Islet	11 10.1	143 00.8	11-035	11/12/76	VSC (F)	22.7	8	24	2	1x2.2 m, 1x1.8 m
Milman Islet	11 10.1	143 00.8	11-035	6/12/78	VSC (F)	22.7	8	24	4	1x2 m, 3 track
Milman Islet	11 10.1	143 00.8	11-035	19/06/91	VSC (F)	22.7	8	24	1	Track only (40 cm width)
Milman Islet	11 10.1	143 00.8	11-035	14/01/94	VSC (F)	22.7	8	24	1	2m
Aplin Islet	11 11.0	143 01.0	11-035	15/02/91	LW (F)	4.9	3	26	1	1.5-2m
Douglas Islet	11 14.1	142 59.7	11-038	8/12/85	VSC (F)	2.8	7.5	20	2	1x1-1.25m, 1x1.5-2m
Cairncross Islets	11 14.5	142 55.6	11-010	21/06/91	VSC (F)	20.2	5.5	13.5	4	3x1 m, 1x1.25 m
Bushy Island	11 14.9	142 52.3	11-009	9/05/95	VSC (F)	10.1	*	8.5	1	1.2m, under 25 reef heron nests
Chomondeley Islet	11 22.6	143 03.5	11-052	13/02/91	VSC (G)	0.5	3.5	21	2	Tracks only, 1 x large, 1 x small
Chomondeley Islet	11 22.6	143 03.5	11-052	5/04/92	VSC (G)	0.5	3.5	21	1	Track only
Jardine Islet	11 22.8	143 01.9	11-053	2/12/89	VSC (G)	5.3	7.5	18	1	Track only
Halfway Islet	11 22.9	142 57.9	11-013	9/12/85	VSC (F)	2.5	*	11	1	1.2m
Wallace Islet	11 27.0	143 02.2	11-055	9/12/85	VSC (G/S)	2.2	3.7	20	2	1x1-1.2m, 1x2-2.5m
Wallace Islet	11 27.0	143 02.2	11-055	30/03/86	VSC (G/S)	2.2	3.7	20	1	2.75m
Wallace Islet	11 27.0	143 02.2	11-055	13/12/88	VSC (G/S)	2.2	3.7	20	2	1x2.5 m, 1x Track (larger)
Wallace Islet	11 27.0	143 02.2	11-055	2/12/89	VSC (G/S)	2.2	3.7	20	1	Track only
Wallace Islet	11 27.0	143 02.2	11-055	22/06/91	VSC (G/S)	2.2	3.7	20	2	Tracks only (1x30 cm and 1x 20 cm width)
Wallace Islet	11 27.0	143 02.2	11-055	6/12/93	VSC (G/S)	2.2	3.7	20	1	Track only
Wallace Islet	11 27.0	143 02.2	11-055	28/10/94	VSC (G/S)	2.2	3.7	20	1	2-2.5m
Wallace Islet	11 27.0	143 02.2	11-055	10/05/95	VSC (G/S)	2.2	3.7	20	1	1.5m
Little Boydong Island	11 28.8	143 02.0	11-061	2/12/87	VSC (G)	2.8	1.5	21	1	Track only
Little Boydong Island	11 28.8	143 02.0	11-061	5/04/92	VSC (G)	2.8	1.5	21	1	Track only
Boydong Island	11 29.2	143 01.6	11-062	12/02/91	LW	10.5	13.7	20	1	1.5-2m
Boydong Island	11 29.2	143 01.6	11-062	10/12/85	LW	10.5	13.7	20	2	1x1.5-1.8m, 1x1-1.2m
Boydong Island	11 29.2	143 01.6	11-062	13/12/88	LW	10.5	13.7	20	1	2.5m
Boydong Island	11 29.2	143 01.6	11-062	10/05/95	LW	10.5	13.7	20	1	1.5m
Boydong Island	11 29.2	143 01.6	11-062	24/08/95	LW	10.5	13.7	20	1	2m

Table 1 cont.

ISLAND	LAT (S)	LONG (E)	GAZETAL NUMBER	DATE	TYPE	AREA	KM to Island	KM to Land	#	NOTES
Hannibal West Island	11 35.5	142 56.0	11-136	11/05/95	LW	0.8	4	9.5	2	1x1.8-2m, 1x1.5-1.8m
Raine Island	11 36	144 1	11-243	3/12/77	VSC (G/S)	40.5	20	96	1	1.35 m
Saunders Islet	11 42.2	143 10.8	11-165	8/06/90	VSC (MV)	8.1	13	24	1	1.5m
Saunders Islet	11 42.2	143 10.8	11-165	12/05/95	VSC (MV)	8.1	13	24	2	1x1 m, 1x1.8 m
Bushy Islets	11 43.7	142 59.0	11-138	11/05/95	VSC (MV)	10.1	3	13	1	2-2.5m
MacArthur Islands	11 43.7	142 59.0	11-138a	18/07/85	LW	12.2	4	15	5	1x1.2 m, 4xTracks
MacArthur Islands	11 43.7	142 59.0	11-138a	9/06/90	LW	12.2	4	15	1	1.5m
Bird Island (North)	11 46.0	143 05.4	11-167	8/12/76	LW	202	11	15	2	1X1.8 m, 1 track
Bird Island (North)	11 46.0	143 05.4	11-167	11/02/91	LW	202	11	15	1	1.25-1.75m
Bird Island (North)	11 46.0	143 05.4	11-167	18/07/85	LW	20.2	11	15	1	1.2m
Bird Island (North)	11 46.0	143 05.4	11-167	11/12/85	LW	20.2	11	15	1	1.2m
Bird Island (North)	11 46.0	143 05.4	11-167	8/06/90	LW	20.2	11	15	1	2m
Bird Island (North)	11 46.0	143 05.4	11-167	11/05/95	LW	20.2	11	15	1	1.8-2m
Magra Islet	11 51.6	143 17.1	11-174	30/11/87	VSC (G/S)	3.6	11.5	0.4	4	Tracks only
Magra Islet	11 51.6	143 17.1	11-174	2/04/89	VSC (G/S)	3.6	11.5	0.4	1	1m
Sir Charles Hardy Group	11 54.3	143 27.8	11-184	12/12/85	HC	182.1	20.5	25	1	1.8m
Sir Charles Hardy Group	11 54.3	143 27.8	11-184	29/11/87	HC	182.1	20.5	25	1	1.5m
Sir Charles Hardy Group	11 54.3	143 27.8	11-184	6/12/87	HC	182.1	20.5	25	2	1x2.4 m, 1x1.8 m
Clerke Island	11 58.5	143 17.2	11-188	25/12/84	HC	32.5	2.5	5	2	1x1.6-1.8m, 1x1-2m
Gore Island	11 59.3	143 15.0	11-194	26/12/84	HC	68.8	1	1.5	1	0.6m
Gore Island	11 59.3	143 15.0	11-194	19/07/85	HC	68.8	1	1.5	1	1.2-1.5m
Orton Island	11 59.8	143 14.4	11-195	25/10/94	HC	8.1	1	1.5	1	2-2.5m
Farmer Island	12 14.6	143 13.5	12-012	10/07/88	VSC (F)	2.4	2	12.5	1	Track only
Farmer Island	12 14.6	143 13.5	12-012	15/06/91	VSC (F)	2.4	2	12.5	1	1-1.2m
Rocky Island	12 53.2	143 32.8	12-125	25/11/87	HC	6	0.5	3	1	1.5m
Wilkie Island	13 46.5	143 38.2	13-091	9/07/92	VSC (MV)	8.1	*	10.5	1	Track only
Clack Is.	14 04	144 15.6	14-017	25/06/88	HC	7	8.5	24	1	2m
Clack Is.	14 04	144 15.6	14-017	12/07/89	HC	7	8.5	24	1	2.5m

On average, the mainland was just over twice the distance away from the location of the crocodile than the nearest island. The mean distance from the location of a crocodile to the nearest point on the mainland to the west was 18.9 km (± 17.3 , range=0.5-96 km, $n=29$), indicating that most crocodiles were located on islands that were close to the mainland. However, crocodiles do occur on cays along the outer reef edge, at least occasionally, as indicated by a 1.5 m *C. porosus* captured at Raine Island (and photographed with the tower in the background) approximately 96 km from the mainland (Limpus 1980). If the distance to Raine Island (96 km) is excluded from the calculation, the mean distance to the mainland changes to 16.2 km (± 9.1 , range=0.4-28 km, $n=28$); the reduction in the standard deviation indicates that the majority of islands on which crocodiles have been found are located close to the mainland.

Crocodiles occur at low numbers on the islands in the GBRWHA (Table 1). Individual crocodiles (or their tracks) were reported on islands 35 times (71% of records). Two crocodiles (or recent signs that could be linked to different individual crocodiles) on the same island were recorded 11 (22%) times and four crocodiles on the same island were reported twice (4%). The greatest number of crocodiles found on any island was five (one sighted, four different tracks) on MacArthur Island.

Crocodiles do not occur on every island in the northern GBRWHA; crocodiles were encountered on about 25% of the islands examined during systematic surveys. For example, during a survey of fauna on 12 GBR cays (nine inner, three outer), Limpus (1980) reported crocodiles (or evidence of crocodiles) from two inner (22%) and one outer (33%) reef islands, including one 1.5 m crocodile captured at Raine Island. During a 1991 survey of flora and fauna on 22 inner GBR islands from Chapman Island north to Johnson island (Miller et al. 1995) crocodiles (or evidence of crocodiles) were found on six (27%) islands (Table 1).

The crocodiles sighted on the reef are usually in the 1-2 m size range with only an occasional report of a larger crocodile (Table 1). The larger animals tend to be located close to the mainland. Based on the minimum size of the 55 crocodiles for which total length was estimated, only one was less than 1 m; among the others 19 (34.5%) were 1-1.5 m, 20 (36.3%) were 1.5-2 m, 11 (20%) were 2-2.5 m and 4 (7.3%) were greater than 2.5 m (Fig. 1). A total of 40 crocodiles (72.7%) were less than 2 m in total length; 15 (27.3%) were longer.

No nesting was recorded on any of the 29 islands for which crocodile records exist.

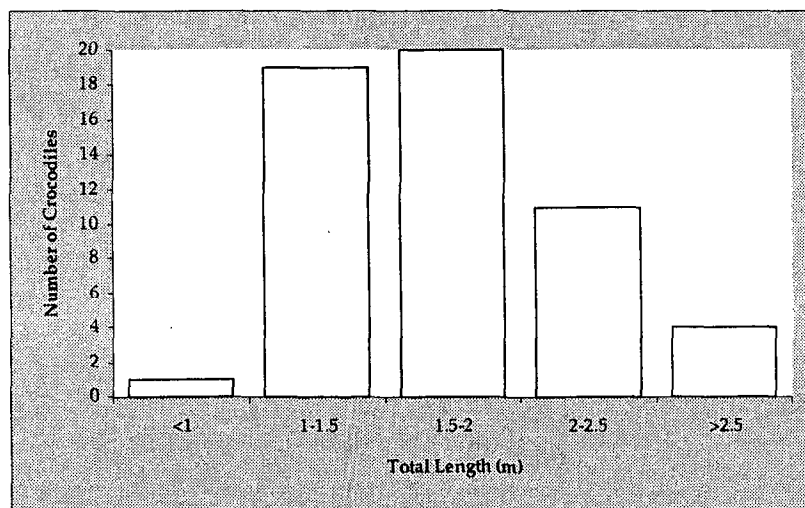


Figure 1. Size classes of crocodiles recorded on Great Barrier Reef islands

Discussion

The natural distribution of estuarine crocodiles along the eastern Queensland coast extends southwards from the tip of Cape York Peninsula to the Tropic of Capricorn, covering approximately 12 degrees of latitude (≈ 1650 km) and is restricted to the rivers and wetlands below the 250 m contour of the Great Dividing Range (Taplin 1987). The eastern flowing rivers are relatively short (usually less than 100 km in length); most rivers that reach the sea have only narrow bands of suitable crocodile habitat (including wetlands) near the mouth.

The northern areas of eastern Queensland support higher densities of crocodiles than southern areas (Taplin 1987). This is a result of both better habitat to support the population(s) and the lower level human interaction with the crocodiles. The mangrove swamps around the Escape and Lockhart Rivers and at Temple Bay provide good crocodile habitat and support seasonal breeding. The rivers in the Princess Charlotte Bay area provide reasonable habitat for larger crocodiles but are subject to flooding which reduces the reproductive success. The coastal area from Cape Melville southward to Cooktown includes very large wetlands which may support large numbers of crocodiles in moderate density; the actual importance of this area to crocodiles on the eastern coast has not been quantified. The coastal area south of Cooktown and extending to Ayr hosts fragmented populations of crocodiles; no large aggregations are known in the area. This coastal area has experienced extensive habitat modification via agriculture, urbanisation and recreation.

The National Parks of eastern Queensland, (e.g. Jardine River NP, Iron Range NP, Cape Melville NP, Lakefield NP and Endeavour River NP, provide critical *C. porosus* habitat at the edge of the GBRWHA. These areas and Aboriginal reserves on the eastern side of Cape York Peninsula contain the majority of the crocodile population of the eastern cape because they provide nesting, developmental and foraging habitat in the context of low human interaction, minimal agricultural and pastoral development, limited access, and restricted fishing (primarily gill netting) in coastal rivers (Taplin 1987).

The majority of records of crocodiles in the GBRWHA come from remote northern islands close to shore; however, it seems likely that crocodiles will, at least occasionally, occur on more southerly islands in the GBRWHA.

Given their biological and habitat requirements (see Webb and Manolis 1989; Webb and Smith 1987), crocodiles found on the reef are considered temporary migrants from the coastal river systems. Limpus (1980) suggested that the crocodiles had '...probably dispersed from populations breeding in the small coastal streams and swamps of eastern Cape York Peninsula'. This outward movement is consistent with data from Darwin Harbour in the Northern Territory from which about 100 crocodiles are removed annually with relatively steady replacement from the rivers that flow into it (Webb and Manolis 1989). Unfortunately, the behavioural and population demographic pressures on crocodiles that result in the outward movement of crocodiles from the coastal rivers and wetlands to the islands of the GBR are unknown (Lang 1987; Webb and Manolis 1989). Whether these individuals ever return to the coastal areas after having spent time on the islands is also unknown.

Female crocodiles reach sexual maturity at a total length of about 2.3 m (approximately 12 years of age); males grow to about 3.3 m in total length before becoming sexually mature (approximately 16 years) (Webb and Manolis 1989). A total of 40 (72.7%) of the crocodiles seen in the GBRWHA were less than two meters in estimated total length and were probably immature individuals. Of the remaining crocodiles, 11 (20%) were in an estimated size class that could include some sexually mature females and four (7.3%) were estimated to be in a size class that could include sexually mature males. Unfortunately, no information on sex or sex

ratio is available for crocodiles in the GBRWHA. However, unless there were strong demographic pressures (e.g. number of individuals, size structure, severe shortage of available space for territories and/or nesting habitat or there was restricted social space in the rivers and wetlands (Lang 1987; Webb and Manolis 1989)), it seems unlikely that reproductively mature crocodiles would venture out to the islands, particularly during the breeding season (October-May). It seems more likely that the larger crocodiles of the GBRWHA are non-breeding animals and/or individuals that may have been displaced from mainland habitats.

Because the GBRWHA does not contain extensive areas of important habitat, does not host large numbers of crocodiles and does not support nesting, it is an inappropriate geopolitical area for the primary conservation management of the estuarine crocodile population along the eastern coast of Cape York Peninsula. The continued survival of crocodiles living along the eastern coast of Cape York Peninsula depends primarily on the conservation management of coastal habitat; in particular, the occurrence of crocodiles on the islands of the GBR depends on the management of eastern Queensland coastal zone habitat.

The state of the crocodiles within the GBRWHA can be summarised in five points:

1. Crocodiles do occur within the GBRWHA;
2. Crocodiles occur in low density on continental islands and coral cays;
3. Crocodiles on the islands are small to medium sized (< 2 m);
4. No current sign or records of breeding have been found;
5. Population is not contained within the GBRWHA.

Because no historical data exist concerning numbers or density of crocodiles within the GBRWHA, population trends cannot be identified. Because the status of crocodiles in the GBRWHA is linked to the status of the population occurring in the rivers and wetlands of eastern Cape York Peninsula, whatever influences the populations and/or their habitat along the eastern side of the cape will also have an impact on the crocodiles using the island and cays.

The population of eastern Cape York Peninsula is under unquantified pressure (probably low but steady) from incidental mortality (resulting from entanglement in discarded nets, ingestion of debris, etc.) and intentional mortality (killing for 'sport' or other reasons) (Taplin 1987). Incidental and intentional mortality add to existing pressure on the population resulting from changes in mainland habitat, albeit low at this time. An increase in the recreational use of islands and cays in the GBRWHA will put more pressure on crocodiles by increasing the number of interactions between crocodiles and people. No one can say what the impact of repeated disturbance of crocodiles at a basking site may have on their behaviour; however, crocodiles do become increasingly wary of interactions with humans (such as close approach and/or capture) with repeated exposure (Lang 1987). The probable future trend of the GBRWHA crocodile population will be a decrease in the number of crocodiles utilising islands and an increase in mortality. However, the rate of change will depend on the type of pressure and its rate of increase.

The management response by conservation agencies that deal strictly with the island and reef ecosystems of the GBR will have little impact on the long term conservation of crocodiles, either in the GBRWHA or along the eastern coast of the cape. This is because the estuarine crocodiles that occur in the GBRWHA are outliers of the main population that inhabits the wetlands of eastern Cape York Peninsula. However, a management response directed at reducing human impact on individual crocodiles that are encountered in the GBRWHA would be beneficial. Public education may have a positive effect by reducing the intentional killing and reducing incidental mortality on immature individuals that may eventually find their way back to the habitats on the mainland coast. The Great Barrier Reef Marine Park Authority could assist the efforts of the Queensland Department of Environment by providing information on

'crocodile-wise' behaviour for reef users and assist the efforts of the Queensland Fisheries Management Authority in promoting better fishing practices which reduce incidental mortality of crocodiles.

Conclusion

A low number of immature crocodiles are infrequently encountered on islands over a wide area of the northern GBRWHA. They utilise a variety of island types (including sand cays, low wooded isles and continental islands) and habitats (including bare sand or grass and mangrove areas). The population in the GBRWHA is marginal to the main population that occurs on the eastern side of Cape York Peninsula. The number of crocodiles within the GBRWHA is considered to be reasonably stable but under threat from continued (and potentially increasing) disturbance by humans. The population is predicted to decline as human use of the northern GBR increases.

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