



Determining the movement patterns of adult estuarine crocodiles using satellite telemetry

The problem

Since the early 1980s, various staff from the Queensland Parks and Wildlife Service (QPWS) have conducted more than 300 vessel-based surveys in Queensland to determine the population status of estuarine crocodiles and to document their distribution and abundance. These surveys have been critical for determining the distribution and abundance patterns of estuarine crocodiles, as well as providing information on the population structure and growth and movement patterns of hatchling and post-hatchling crocodiles in selected waterways.

Unfortunately, there has been limited ability to focus on studying the life history parameters of medium to large estuarine crocodiles. Given the size and potentially aggressive behaviour patterns exhibited by these animals, they present QPWS with an ongoing management problem in northern Queensland. Based on Departmental records, these animals are those most likely to be labelled a “problem” crocodile following some kind of negative (or potentially negative) interaction with a human.

To date we have virtually no information on how this size class of crocodile uses space through time. We have no data on either their short-term or long-term movement patterns, or whether these movement patterns are contained within a discrete geographical area (a ‘home range’). In addition, we have no data on whether these movement patterns vary with the size of the animal, its sex and reproductive status, or with the season. Given that individuals from this size class of estuarine crocodile are most likely to interact with humans, detailed knowledge of their movement patterns is critical for the long-term management of the species in Queensland.

Determining the movement patterns of any cryptic wild animal is always difficult, but when the animal is also shy, semi-aquatic and potentially dangerous to capture, it becomes particularly difficult and challenging. Their behaviour means that movement patterns of estuarine crocodiles could not be studied by direct observation, even if individuals could be recognised. Short distance movement patterns of crocodiles and alligators have been recorded using conventional radio telemetry, but its applicability is limited and there is too much potential for observer intrusion to modify the behaviour patterns of a naturally shy and wary animal. Determining the movement patterns of estuarine crocodiles using conventional radio telemetry would also entail a huge fieldwork component, which can become demanding on staff resources.

Based on these factors, it seems that the most suitable method to determine the movement patterns of medium to large estuarine crocodiles is to use satellite telemetry. Its advantage over conventional telemetry is that locational data continues to be gained remotely, via the satellites, without the observer needing to be nearby. This technique has been used successfully to study the movement patterns of birds, terrestrial mammals such as camels, aquatic mammals such as dugong and elephant seals and several species of marine turtle.

The Tanner bequest

Charles Tanner, a long-term resident of Cooktown with a life-long interest and association with reptiles, passed away in 1993. In his will, Charles Tanner left a bequest to the QPWS with the intention that the bequest be used to conduct research on crocodiles. Given the dearth of information on the movement patterns of wild estuarine crocodiles, and the value of such information for managing large animals in a way that maximises public safety, it was decided that a suitable application of the bequest would be to initiate a project to track the movements of estuarine crocodiles using satellite telemetry.

During the early stages of the project, Professor Gordon Grigg and Dr Craig Franklin from the Department of Zoology and Entomology at The University of Queensland were approached and were asked to join the research team. Both Prof Grigg and Dr Franklin have extensive experience in the field of eco-physiology, and both have an active interest in understanding the movement patterns of large estuarine crocodiles. Both researchers enthusiastically joined the research team and assisted with the initial project and planning proposals.

It was proposed that the bequest funding would be used to initiate the project and to complete the critical phase of the project where transmitter attachment methods were trialled and tested on captive crocodiles. Also, after attachment methods had been developed, two satellite transmitters (each including a VHF radio transmitter) would be purchased and attached to wild estuarine crocodiles in the Endeavour River at Cooktown. These animals will be tracked for a pre-determined period of time, and

then recaptured (hopefully) and the equipment retrieved for redeployment on crocodiles for the main phase of the research project based at Weipa.

The Memorandum of Understanding between the Environmental Protection Agency and Australia Zoo

The Irwin family of Australia Zoo has a long relationship with and interest in crocodiles. This stemmed from when the park was first established in the early 1970s, and continued when Bob and Steve Irwin were catching problem crocodiles under the East Coast Crocodile Management Program in the mid 1980s. The Irwins have a passionate interest in all crocodylians and the conservation of the species around the world.

In December 2002, Steve Irwin and Queensland Environment Minister, the Hon. Dean Wells, signed a memorandum of understanding (MOU) to support crocodile research and management throughout Queensland. This co-operative relationship allows management-related research projects to be conducted and supported by both parties. Studying the movement patterns of estuarine crocodiles was one of the priority research projects identified under this co-operative agreement.

Materials and methods

Two satellite transmitters were ordered from Sirtrack in July 2002 and the units arrived in Australia in late December 2002 (Fig. 1). To maximise the battery life of the transmitter, they turn on for 24 hours and then off for 72 hours. When the transmitter is activated, it transmits a signal every 60 seconds if the aerial is dry. Based on these specifications, it is anticipated that the satellite transmitters will function for a minimum period of ten months. Additionally, both satellite transmitter packages contain a VHF transmitter to allow the animals to be located independently of the satellite transmitter. An animal experimentation ethics application was submitted in September 2002 and approval was given on 6 December 2002.

In early 2003, various different methods for attaching the transmitters were trialed on dummy crocodiles and then on a captive crocodile at the Melaleuca Crocodile Farm, Mareeba. These trials indicated that an attachment method pioneered by a researcher from The University of Queensland (PhD candidate Winston Kay) should be followed in this study. This involves bonding the transmitter to the nuchal shield using two-part epoxy glue and then reinforcing the attachment using wire or bone screws.

Study site 1: The Endeavour River (see Fig 2.)

During the first week of May 2003, two floating crocodile traps were deployed in the Endeavour River at Cooktown with the aim of catching two adult-sized estuarine crocodiles for attachment of the satellite transmitters. The weekend beginning Friday 9 May was selected for the research team to assemble at Cooktown and attach the transmitters. The team consisted of staff from the QPWS Crocodile Management Unit; the Cooktown QPWS sub-district; Prof Grigg and Dr Franklin from The University of Queensland and Toby Millyard from the Australia Zoo.

Two crocodiles were captured in the floating traps on Friday 9 May. The first animal was an adult male and measured 4.35m (14ft 3in) total length (Fig. 3) and the second animal was an adult female and measured 2.65m (8ft 8in) total length (Fig. 4). These animals represented ideal experimental subjects for the trial phase of the project. The male was named "Charles" in memory of the late Charles Tanner, and the female was named "Harriett", in honour of Professor Harry Messel, who initiated the first comprehensive research program on estuarine crocodiles in Australia.

The adult male was extracted from the floating crocodile trap on Saturday 10 May and the adult female on Sunday 11 May. Once extracted, both animals were restrained using top jaw ropes and body weight and their jaws were secured using cord and electrical tape. Once the animal was fully restrained, the nuchal shield area between the shoulders was scrubbed using a chlorhexidine solution, rinsed with fresh water and then rinsed again in 75% ethanol. Once the ethanol had dried, the nuchal shield area was anaesthetised using multiple sub-cutaneous injections of a local anaesthetic (Lignocav™). Post-injection, a series of eight small holes was drilled through the main scales of the nuchal shield to coincide with the four stainless steel attachment points on the satellite transmitter package. Following this procedure, lengths of sterilised plastic-coated braided stainless steel wire (75kg breaking strain) were threaded through the holes and allowed to sit raised in profile (Fig. 5).

Once these wires were threaded through the holes in the nuchal shield, an amount of two-part epoxy glue (Selley's Knead-It Aqua™) was mixed until consistent and then applied to the surface of the nuchal shield. This glue was pressed down using hand pressure to ensure the glue filled all the grooves and holes in the scales. The plastic-coated wires were then pulled tight and embedded in the glue mixture. Further glue was then mixed and applied and the satellite transmitter pressed into the glue mixture. The free ends of the plastic-coated wire were then threaded through the four stainless steel attachment points on the satellite transmitter package, passed across the top of the transmitter and then crimped together using copper crimps. The space between the transmitter and the nuchal shield was then filled in using additional glue (Fig. 6). After the glue had set (approximately 1 hour), the top of the satellite transmitter package and the white glue was sprayed with black epoxy paint (Fig. 7) to minimise the potential for the transmitter package to interfere with the animals' ability to hunt prey or evade predators.

Both animals were released on the same day as they were extracted from the floating trap. The male was released approximately 3km upstream from the original capture location, as there were no suitable release sites downstream. The female was released approximately 200m upstream from her original capture location. Both releases went smoothly.

Study site 2: The Nesbit River (see [Fig 2](#)).

In September 2003, a co-operative research trip, with representatives from Australia Zoo, the Best Picture Show Company, QPWS and Cape York Helicopters was conducted at the Nesbit River, on remote eastern Cape York Peninsula. The aim of this trip was to capture four adult estuarine crocodiles and fit them with satellite transmitters.

Once a base was established at the Nesbit River, the team set up a trap run comprising a mixture of floating traps and mesh bag traps. These traps were positioned to encompass the area from the mouth of the Nesbit River to upstream of the campsite, some 7km inland. The crocodiles were slow to enter the traps, but starting from 14 September the team was catching and processing a large crocodile per day. Initially three satellite transmitters were attached to males measuring 3.15m, 3.93m and 4.26m total length. A fourth animal, measuring a whopping 4.93m, was captured on 21 September. These crocodiles were named Banana, Nesbit, Bob and SuperCroc respectively (see Figures 8 to 11).

The three larger crocodiles were processed and released at the point of capture. For Banana, however, the team was interested in determining whether crocodiles would return to their original capture location if moved and released at another location. This procedure, called "translocation", has been used extensively on problem crocodiles in the Northern Territory; but a high proportion of the translocated crocodiles returned to their original capture location. The movement patterns of translocated crocodiles were unknown in Queensland (where densities of crocodiles is different from that of waterways in the Northern Territory), so Banana was airlifted 52km south and released into the ocean.

Results

Charles: (Figures 12 to 19)

Monthly position locations for Charles can be seen in Figures 12 through to 19. Immediately following his release, the satellite transmitter attached to Charles functioned as expected and provided a series of position locations. The position locations indicated that Charles moved upstream from the release site and remained in that area for at least 24 hours, and then moved downstream to near where he was originally trapped. This pattern was repeated again, with position fixes indicating that Charles moved between the downstream and upstream positions on 22 and 31 May.

For each month Charles has exhibited similar movement patterns, as he appears to move from one end of a defined home range area to the other. His movements are necessarily constrained by the waterway, but the satellite fixes indicate that he also travels into smaller side creeks on a regular basis. The position locations also indicate that Charles often moves from the one end of his home range area to the other within a single 24-hour period (see Fig. 15).

The most recent position locations for Charles (Fig. 19) indicate that he continues to move within a defined home range area, but has also travelled some distance up a small creek to the northwestern side of the map (date 12122003). Using other position locations for the same day, it appears that Charles has moved 6.5km in just over 4hrs.

Harriett: (Figure 20.)

Post-release, the satellite transmitter attached to Harriett functioned as expected and provided a series of position locations immediately after her release. Based on the position locations, Harriett continued to remain in the habitat near her original capture/release location, but was making regular movements of several kilometres between each series of satellite transmissions. Based on the position fixes for 19 May 19, Harriett exhibited she was capable of making daily movements in excess of 6km.

As with Charles, the position locations provided by the satellite transmitter attached to Harriett rapidly defined a home range for this animal. As with Charles, Harriett used the small creeks off the main Endeavour River, and at one stage made a movement towards the Cooktown airstrip, which is shown in the left-hand corner of Fig. 20.

The satellite transmitter attached to Harriett continued to send signals until 11 June, when the satellite transmitter receiving system (ARGOS) failed to receive any signals from the transmitter. No signals were received during the next transmission cycle (15 and 16 June), and at that stage we decided to look for Harriett visually or by using the VHF radio transmitter included in the satellite transmitter package. An attempt was made to track Harriett using a VHF receiver on Monday and Tuesday 23 and 24 June. A weak signal was received from the VHF transmitter once on the Tuesday, but after continuous checking no other signals were detected. The signal was again received on the afternoon of Wednesday 25 June, but the signal ceased when the vessel moved towards the signal. Based on these observations, it appears that Harriett has partially dislodged the satellite transmitter package, causing the satellite transmitter to cease sending signals. This would explain why the satellite transmissions are not being received, but why the VHF signals are being received and then ceasing.

Despite extensive searches and trapping effort, we have been unable to recapture Harriett at this stage. Regular searches have failed to locate the transmitter using the VHF receiver, so it appears the satellite transmitter unit has ceased functioning or is submerged in salt water and the VHF signals cannot be received.

Banana: (Figures 21 and 22)

Following Banana's capture on September 14, we attached a satellite transmitter and he was then airlifted and released on a beach 52km from his original capture location. As indicated by the position fixes, Banana spent the following two weeks moving up and down the coastline, and then travelled north up the coastline and returned to the main pool in the Nesbit River. Not only was this movement completed in only five days, but Banana also made an amazing 3.5km overland crossing to return to the main pool in the Nesbit River. This movement demonstrated that estuarine crocodiles do exhibit a homing instinct, and further research will be required to ascertain whether this is a typical or atypical response.

Since Banana returned to the Nesbit River, he has spent the time moving up and down the waterway, covering a distance of more than 7km. The position location information for December indicates that Banana has also travelled into the ocean and then returned to the Nesbit River again.

Nesbit: (Figure 23.)

Nesbit was captured on September 15, in exactly the same trap that caught Banana. Once he was restrained, we attached a the transmitter to Nesbit and released him back into the river at the same location. Approximately 2.5hrs after his release, the team then witnessed Nesbit (identified by his satellite transmitter) engaged in a battle with another large crocodile in the main pool. This fight lasted for 40 minutes, during which the satellite transmitter on Nesbit took several "hits" from the skull of the second crocodile. The team members were all very anxious that the transmitter might be damaged by these impacts, but a check later that day indicated that the transmitter was functioning as expected and delivering a series of high quality position fixes.

Since the transmitter was attached, Nesbit has made a series of movements upstream and downstream from the main pool area. The satellite transmissions also indicate that Nesbit has made a series of overland movements, with some of these position locations recorded at distances of 2.5km from the main waterway. Nesbit has also made two separate forays into the ocean, but the most recent data indicates he has returned to the main waterway.

Bob: (Figure 24.)

Bob was captured on September 16, in exactly the same trap that caught Banana and then Nesbit. Once restrained, it became apparent by his fresh injuries and by a distinctive scute on his tail that Bob was the crocodile fighting with Nesbit the previous day! As with Nesbit, Bob also received a transmitter and was released back into the river at the same location.

Since the transmitter was attached, Bob has made a series of movements upstream and downstream from the main pool area, and his movements have overlapped those exhibited by both Nesbit and Banana. The satellite transmissions also indicate that Bob has made a series of overland movements, with some of these position locations recorded at distances of 2.5km from the main waterway. Bob has also made a trip out into the ocean, but the most recent data indicates he has returned to the main waterway.

SuperCroc: (Figures 25 and 26)

“SuperCroc” was captured in a floating trap set in the main pool on 21 September. He was restrained, the satellite transmitter was attached and he was released back in the main pool.

Post-capture, SuperCroc spent the next couple of weeks moving up and down the Nesbit River, and his movements overlapped those of Banana, Nesbit and Bob. However, approximately two weeks after the transmitter was attached, SuperCroc departed the Nesbit River and headed south, swimming in the ocean just off the beach. After two days swimming, he entered a small mangrove system 26km south of the mouth of the Nesbit River and has been recorded residing in that system ever since.

Contact details

If you would like to contact the project collaborators to inquire about the project or the crocodiles, their contact details are:

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Figures

Figure 1. A satellite transmitter before attachment to an estuarine crocodile.

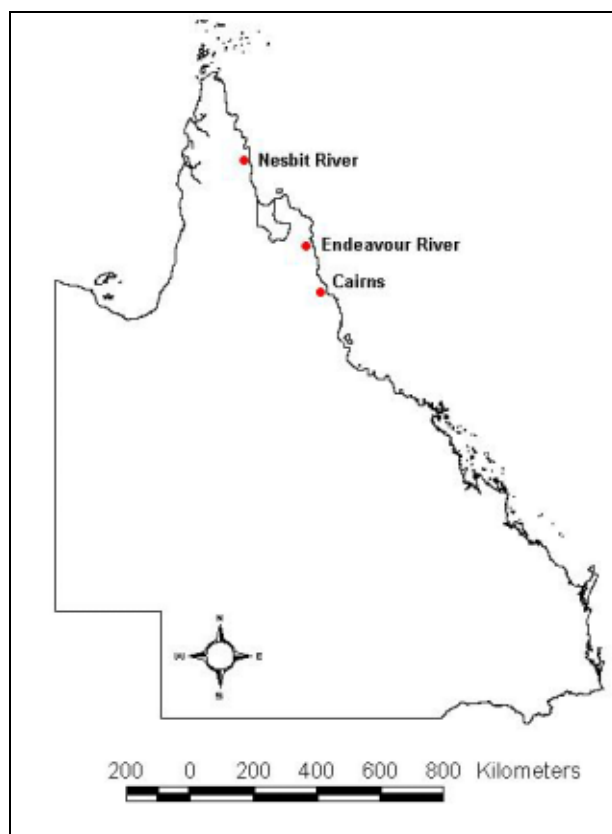


Figure 2. Location of the two study sites in relation to Cairns



Figure 3. "Charles" lying in the trap.



Figure 4. "Harriett" lying in the trap.



Figure 5. Showing the position of the stainless steel braided wires prior to attachment of the satellite transmitter.



Figure 6. The satellite transmitter attached to "Harriett", showing the epoxy glue and wire bonding the unit to the nuchal shield.



Figure 7. “Charles” immediately before his release into the Endeavour River. The satellite transmitter has been painted so it blends into his dorsal colouration.



Figure 8. Steve Irwin (centre) and the team celebrate successful attachment of a satellite transmitter to “Banana”.



Figure 9. “Nesbit” restrained in a ditch where the trap was located.



Figure 10. “Bob” heading back to the water with his new satellite transmitter attached to his nuchal shield.



Figure 11. "SuperCroc" pulling against a bottom-jaw rope immediately before being restrained.

Maps



Figure 12. Position locations for "Charles" in May 2003.



Figure 13. Position locations for "Charles" in June 2003.



Figure 14. Position locations for “Charles” in July 2003.



Figure 15. Position locations for “Charles” in August 2003.



Figure 16. Position locations for "Charles" in September 2003.



Figure 17. Position locations for "Charles" in October 2003.



Figure 18. Position locations for “Charles” in November 2003.

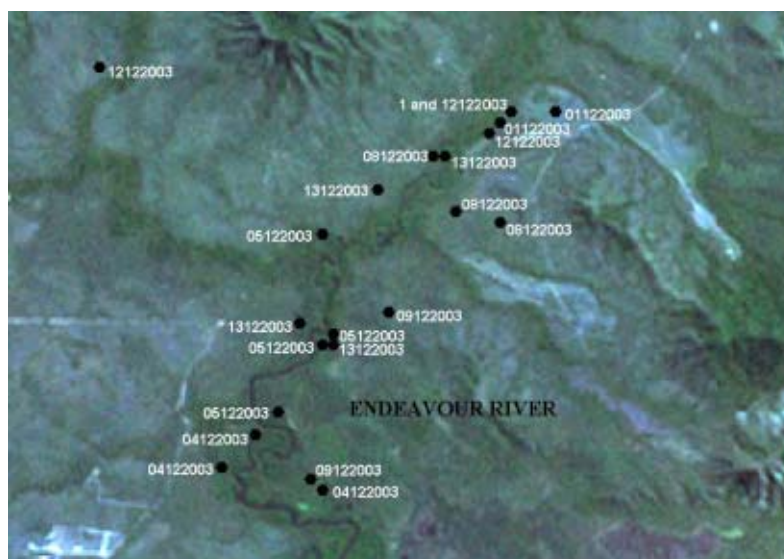


Figure 19. Position locations for “Charles” in December 2003.

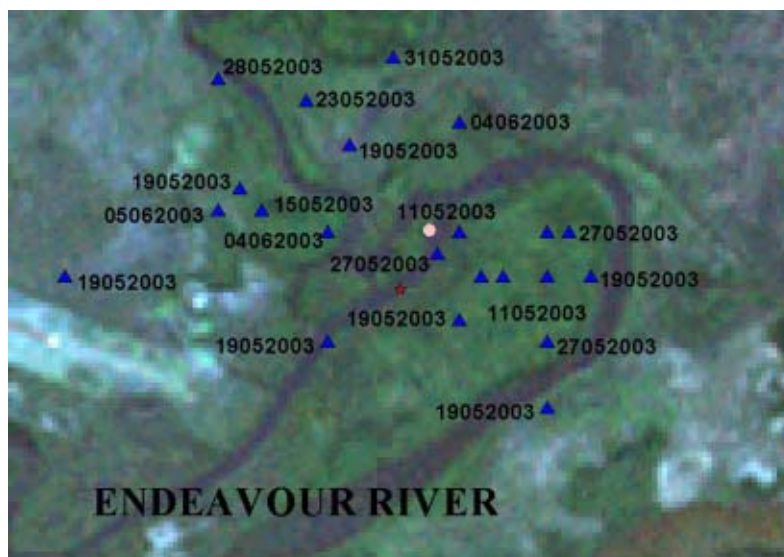


Figure 20. Position locations for “Harriett” in May-June 2003.

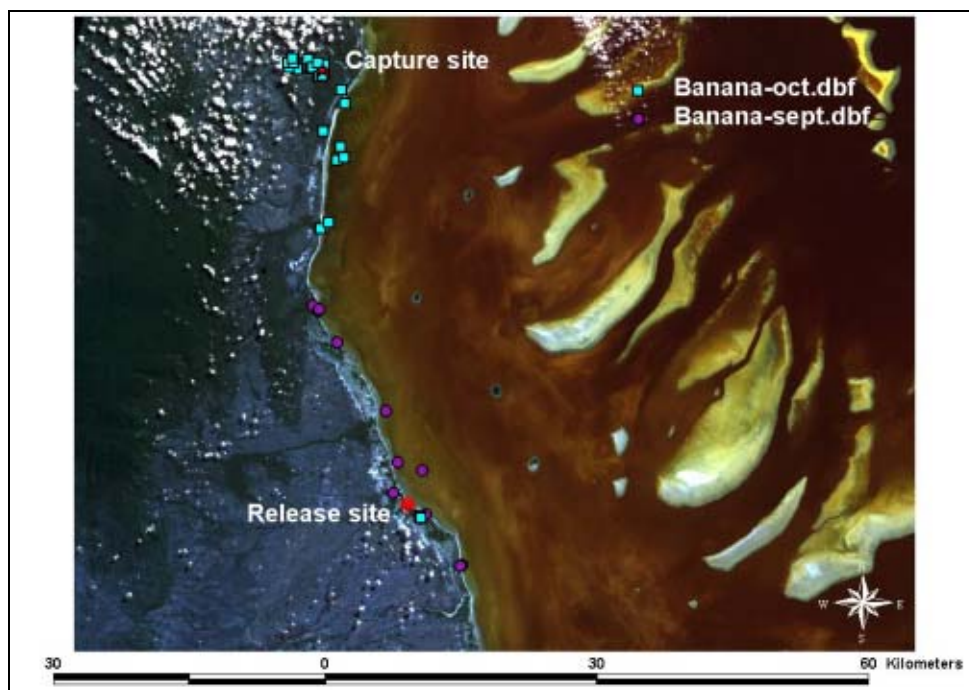


Figure 21. Position locations for “Banana” in September and October 2003.

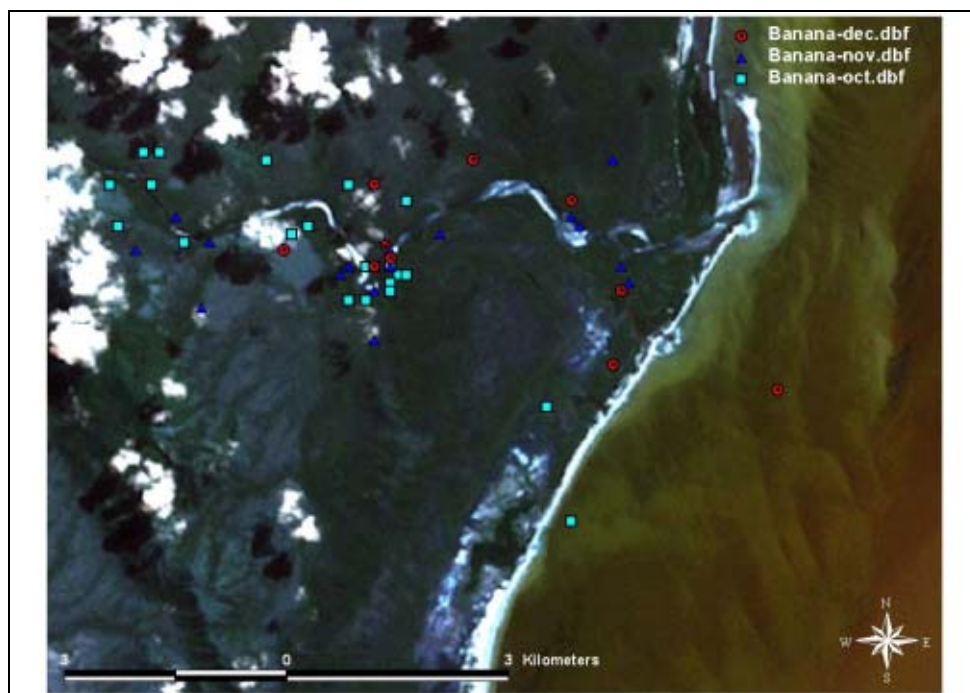


Figure 22. Position locations for "Banana" for October through to December 2003.

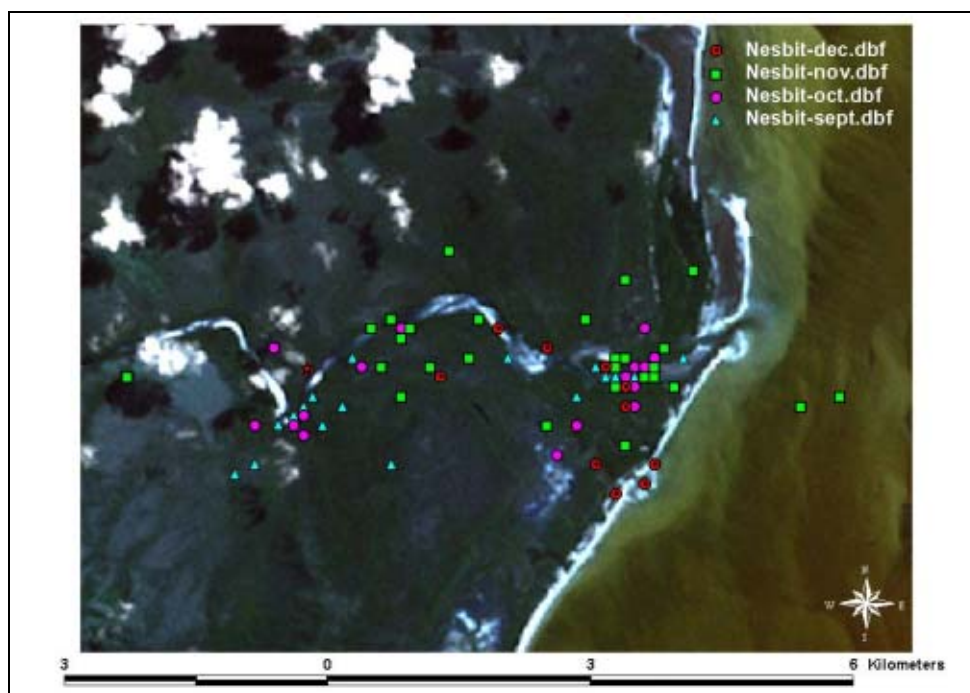


Figure 23. Position locations for "Nesbit" for September through to December 2003.

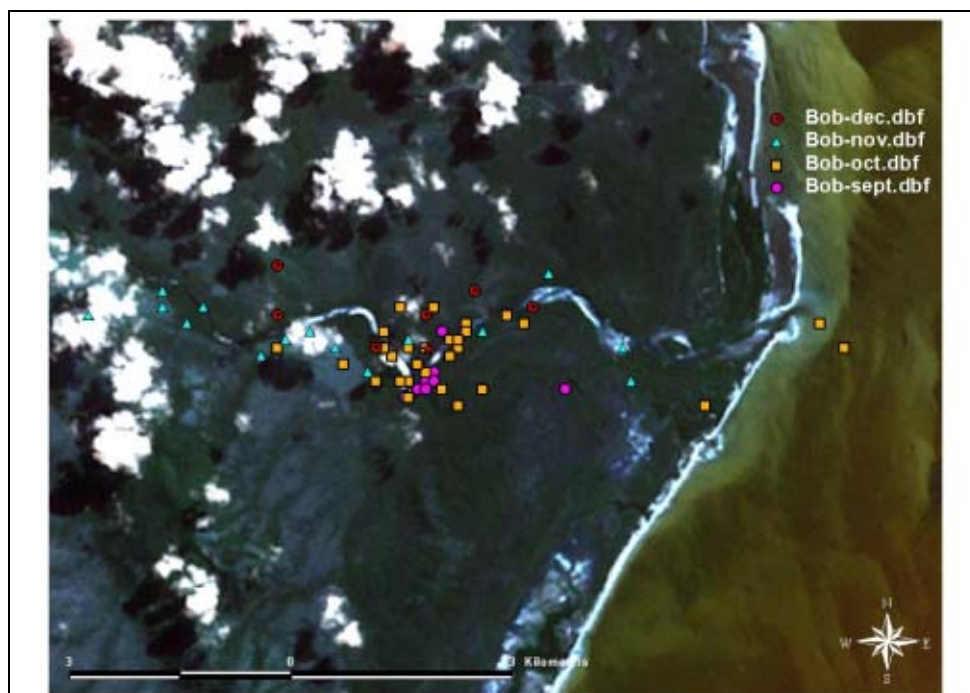


Figure 24. Position locations for “Bob” for September through to December 2003.

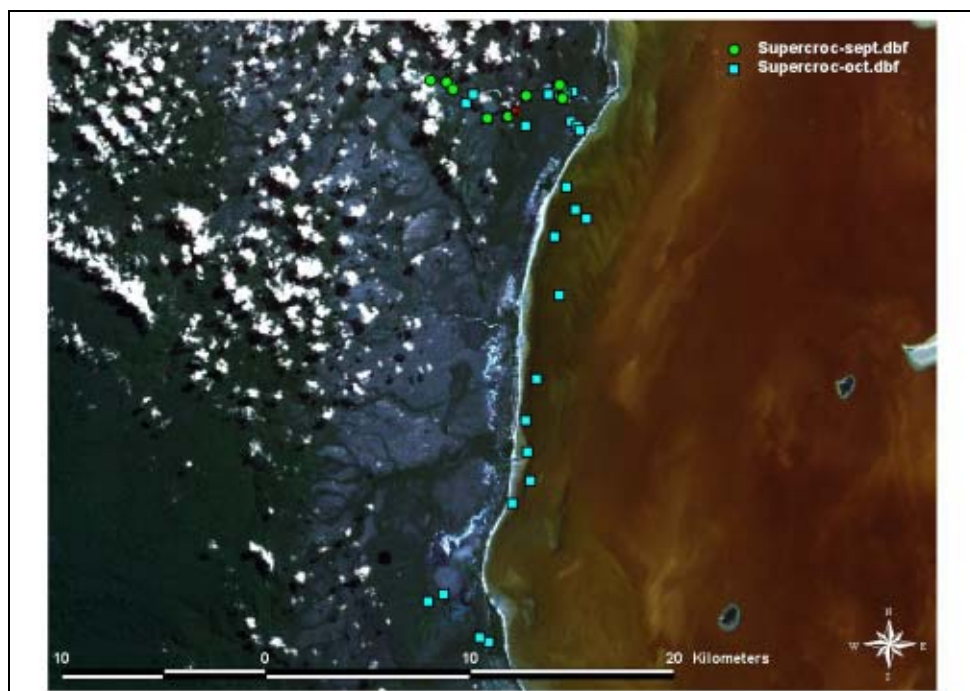


Figure 25. Position locations for ‘SuperCroc’ for September and October 2003.

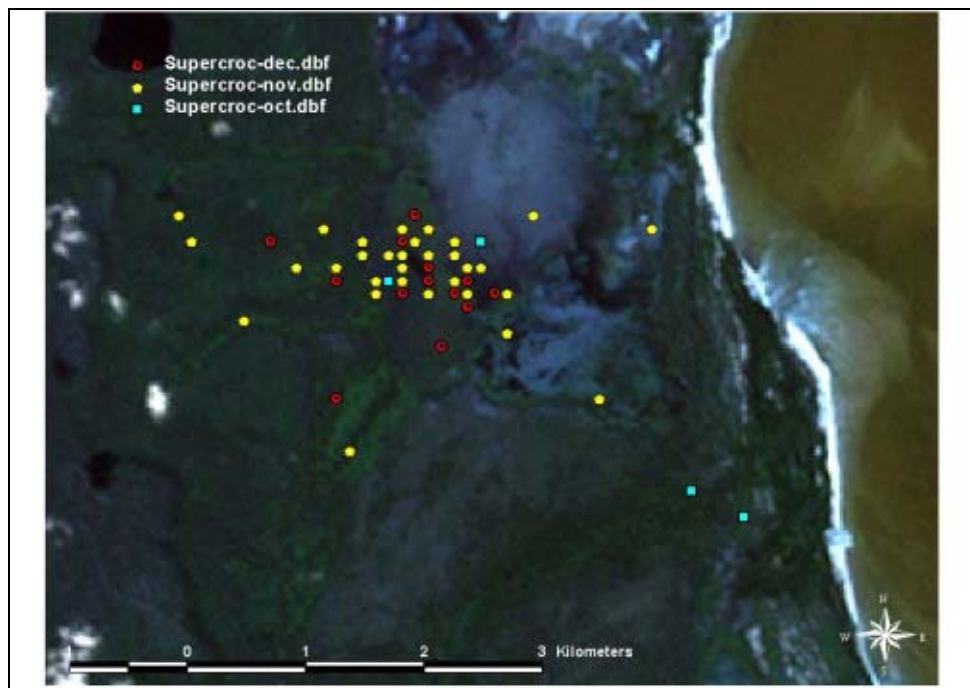


Figure 26. Position locations for 'SuperCroc' for September and October 2003.