INVESTIGATING INTRA-ISLAND TRANSLOCATION AS A CONSERVATION STRATEGY FOR THE TURKS AND CAICOS IGUANA: THE IMPACT OF HOMING AND STRESS

by

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DISSERTATION

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Abstract

Investigating Intra-Island Translocation as a Conservation Strategy for The Turks and Caicos Iguana: The Impact of Homing and Stress

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The University of Texas at Arlington, 2016

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The Turks and Caicos iguana, *Cyclura carinata*, is listed as critically endangered by the International Union for the Conservation of Nature due to introduced mammals and habitat alteration from human development. Inter-island translocations are a key conservation strategy for the species and, while resource intensive, have been successful to date. However suitable islands for translocation (good habitat and free of mammals) are scarce despite a surplus of animals threatened by human development. Intra-island translocation strategies that complement human needs must be found. Big Ambergris Cay (supporting the single largest remaining population of TCI iguanas) presents a unique opportunity to determine the effectiveness of intra-island translocations while also mitigating specific threats facing the significant iguana population there. However, factors affecting the success of translocations include post-translocation stress and homing behavior. This study documented these variables by systematically manipulating the sex, age, and time of year moved for 96 subject animals. Outcome measures include corticosterone concentrations, leukocyte profiles, movement patterns and homing tendencies. Results indicate that there was a significant effect of translocation on baseline corticosterone concentrations. For adults, corticosterone concentrations significantly increased as a result of translocation, nearly doubling over initial levels at the final catch. There were no significant differences in baseline corticosterone values across the movement periods based on gender or season. Capture-stress induced corticosterone and H:L values also increased significantly over time, and there was a significant main effect of gender, with adult females exhibiting higher corticosterone concentrations than adult males and adult males exhibiting higher H:L ratios than adult females. While displaying some evidence of altered HPA axis functioning, subjects of both genders displayed an ability to continue to mount an appropriate stress response. Body condition scores decreased significantly on average across all subjects as a result of translocation. Across all ages, sexes and seasons, subjects traveled further during the translocation period than the baseline period. Adults moved more total distance than juveniles in both the baseline and translocation periods, though the difference between the two age classes was considerably more during the translocation period. During the translocation period, males traveled significantly more total distance than females across both age classes. Adults also moved significantly further per average movement compared to juveniles during the translocation period. Within juveniles, females moved further than males in a single foray between two consecutive locations across both movement periods. During the baseline period, adult and juvenile home ranges were similar in size and very small. Among subjects that did not successfully home after translocation, adults traveled significantly further towards their original capture site than juveniles. There were effects of season on movement patterns during the baseline period only. Across all ages and genders, subjects moved significantly more total distance, covered more area and traveled further per movement during the baseline period of the wet season than the dry season. Adults of both sexes attempted to home, successfully homed, and did so in both the wet and dry seasons. No juveniles homed. Adult males homed faster than females, and the ability to home did significantly impact corticosterone concentrations. With the exception of maximum distance between consecutive points, animals that homed did not significantly differ in total distance moved or minimum convex polygon measures of displacement range. This study represents the first systematic test of homing abilities in a *Cyclura* species, as well as the first *Cyclura* translocation project to utilize juveniles. It is hoped that results of this study add to the allied literature by providing a systematic test of the effects of homing and post-translocation stress on intra-island translocation methods that can be utilized to promote iguana-friendly development throughout the region.

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Dedication

This dissertation is dedicated to those who have influenced and supported me the most. I dedicate this dissertation to my father, Dr. John Wayne Wagener, who first instilled in me a love of science and a life-long dedication to learning. I dedicate this dissertation to my mother, Linda D. Wagener, who always fostered my dreams. I dedicate this dissertation to my brother, Joel Wagener, who is truly the wickedly smart one and has been, and always will be, my rock. I dedicate this dissertation to my husband, Dr. John Wiggans, who believed in my capabilities even when I did not and did not hesitate to put my needs above his own. I could not have finished this document without his unwavering support and belief in me. And last, but certainly not least, I also dedicate this dissertation to my subjects. Through this dissertation project I learned so much more about myself than I ever learned about them, and for that, I am forever grateful.

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Chapter 1

Introduction

Translocation as a Conservation Strategy in *Cyclura*

Translocation, (the deliberate and mediated movement of wild individuals from one part of their range to another (IUCN, 1987), is an important conservation tool increasingly used in reptile conservation programs to augment declining populations, to restore extirpated animal populations, or to mitigate human-wildlife conflict (Burke, 1991; Dickens et al., 2010; Dodd & Siegel, 1991; Fisher and Lindenmayer, 2000; Germano & Bishop, 1998; Reinert, 1991). Despite its wide use as a conservation strategy, the appropriateness of translocations for reptiles in particular has been debated for the past 20 years given poor success rates cited in the literature (Dodd & Siegel, 1991; Fisher & Lindenmayer, 2000; Germano & Bishop, 2008). In a recent review of all reptile translocations reported from 1991-2006 (Germano & Bishop, 2008) projects motivated by human-wildlife conflict made up 16% of those reviewed, and those conducted for that motivation had the highest failure rate of those surveyed. While the underlying causes of translocation failure are often poorly understood due to challenges with follow up measures (Fisher & Lindenmayer, 2000), the most commonly reported causes of failure for amphibians and reptiles were homing, large movements and migration away from the release site (Germano & Bishop, 2008).

West Indian iguanas of the genus *Cyclura* are among the most endangered lizards in the world (Alberts, 2000). Threatened by habitat alteration, human development and introduced mammalian species, reintroduction and translocation strategies are critical to their survival (Alberts, 2000; Alberts, et al., 2004). To date, several translocation programs aimed at increasing the number of viable populations of insular iguanas have been undertaken. Translocated populations exist for the Allen Cays iguana, *C. cychlura inornata* (Knapp, 2001), the Exuma island iguana *C. cychlura figginsi* and the Acklins iguana, *C. reileyi nuchalis* (Knapp and Hudson, pers. obs.), in the Bahamas, the Anegada iguana in the British Virgin Islands (Goodyear & Lazell, 1994), and the Cuban iguana, *C. nubila* in Puerto Rico (Christian, 1986), as well as land iguanas in the Galapagos Islands (Cayot et al., 1994).

West Indian iguanas translocated from wild populations into suitable habitat appear to rapidly resume natural behaviors. Between 1984 and 1986, three male and five female adult Anegada iguanas, including two gravid females, were released on Guana Cay, British Virgin Islands. Observations of subadults in 1987 indicated that at least one gravid female nested successfully. And, by the early 1990s (up to five years later), an estimated twenty adults had established home ranges, excavated burrows, and appeared to be feeding well (Goodyear & Lazell, 1994). In another case, four male and four female Allen Cays iguana were translocated to Alligator Cay in the Exuma Islands, Bahamas between 1998 and 1990. At least one female oviposited during her first and second years on the island, resulting in a minimum of four male and three female descendants. As of 2001, the population numbered between seventy-five and ninety animals (Knapp, 2001). A “few specimens” of the Cuban iguana escaped from a zoo at La Parguera, Puerto Rico, in the mid-1960s, and a colony of at least 157 adults and ten juveniles has since been established on Isla Magueyes (Christain, 1986; Christian & Lawrence, 1991). In 2002 and 2003, more than 200 Turks and Caicos iguanas (*C. carinata*) were translocated from islands where they were threatened to four uninhabited cays within the Turks and Caicos reserve system (Gerber, 2007).

Captive-reared individuals have also been reintroduced through several well-developed captive headstarting and release programs (Bradley & Gerber, 2006; Burton, 1996; Knapp & Hudson, 2004; Wilson et al., 2004). Captive-bred Grand Cayman iguanas (*C. nubila lewisi*) released in the Salina Reserve on Grand Cayman appeared to rapidly adjust to the wild, finding food and retreats, establishing territories and engaging in stereotypical fighting (Burton, 1996). Since 1996, captive-reared Jamaican iguanas (*C. collei)* have been released at nesting sites in Jamaica’s Hellshire Hills. Survival rates based on radiotracking and recapture data have been encouraging, and headstarted animals have integrated into the wild breeding population (Wilson, et al., 2004).

Despite these apparent successes, *Cyclura* translocation programs are not without challenges related to widely moving individuals, homing behavior and acute stress responses (Alberts, 2007; Gerber, 2007; MacDonald et al., 2007; Perez-Buitrago et al., 2008; Wilson, pers. com.). Given that translocation success is often defined as the creation of self-sustaining populations (Dickens et al., 2010), survival and remaining in the target area during the period immediately following the release of animals into a novel environment strongly affects the outcome of translocations. Therefore, important variables that can affect translocation success are homing behavior and post-translocation stress.

Homing Behavior

Definitions of homing vary, and range from the ability of animals to return to their home range after being displaced (Able, 1980) to all actions undertaken to reach a specific site that is already known to the animal (Papi, 1990). Regardless of definition, homing behavior has been reported for many reptile species (e.g. numerous taxa: Gauthrequx, 1980; Rozhok, 2008; Southwood & Avens, 2010; Stamps & Swaisgood, 2007; snakes: Brown et al, 2009; geckos: Lettink, 2007; lizards: Ellis-Quinn & Simon, 1989; 1991; Freake, 1998; 2001; Hein & Whitaker, 1997; Jenssen, 2002; tortoises: Tuberville, et al., 2005). Mechanisms reported are many, including short-distance plotting using familiar, visual, or chemical landmarks as well as orientation over both short and long distances from exogenous compass cues (e.g. celestial, magnetic), to set and maintain a course in a particular direction without the use of landmarks (Able, 1980; Southwood & Avens, 2010). Given the proximate advantages (safe place of rest, specific feeding areas, ease of mate finding), and the reliance on more than one homing mechanism in most species, the bias for the selection of homing behavior must be very strong (Dingle, 1980; Papi, 1990). However, as Able (1980) asserts, even though the orientation and navigation mechanisms of species have evolved in concert with specific life history traits, researchers should be careful not to overgeneralize among species, and considerable divergence in homing behavior of even closely related species should be expected.

Despite the numerous reports of homing behavior in lizards, limited observations of homing and migration behaviors are reported for iguanids. Breeding migrations have been observed in the Green iguana (*Iguana iguana)* in Central America. On the island of Barro Colorado in Lake Gatun, Panama, green iguanas swim considerable distances (1-3 km) to access suitable nest sites on the adjacent island of Slothia. These iguanas show strong nest fidelity between years and return to the same home range along the shoreline of Barro Colorado post-nesting (as reviewed in Southwood & Avens, 2010). The Galapagos land iguana (*Conolophus subcristatus*) covers even greater distances over land during their nesting migrations on the volcanic island of Fernandina, with documented movements of more than 10 km distance between lowland foraging areas and nesting aggregations (as reviewed in Southwood & Avens, 2010). Though only a note, Iverson (1979) did report some evidence of homing behavior in free-ranging Turks and Caicos iguanas.

Field reports from select *Cyclura* release projects indicate that successful settlement near the release site is common for adults and subadults, but may be less likely for younger age classes (Alberts, 2007; Burton, 1996; Gerber, 2004; Knapp, 2000; Wilson et al., 2004). However, within the Mona island iguana *(C. cornuta stejnegeri)*, 25 of 62 headstarted iguanas released 630 m from the rearing facility returned and did not establish territories typical for adult wild iguanas (Perez-Buitrago et al., 2008). In contrast, none of 72 radio-telemetered headstarted Anegada iguanas (*C. pinguis*) released about 5 km from the rearing facility exhibited homing behavior and most established territories near their release site (Bradley & Gerber, 2006). Despite these opposing results, subjects in headstarting cases were subadults maintained in captivity more than one year. In the Jamaican iguana (*C. collei*), individuals are translocated from a zoo many miles away from the release site, however, a handful of individuals have demonstrated erratic and wide-ranging movements directly towards urban areas (Wilson, pers. com.).

Despite these anecdotal observations, no studies have systematically documented homing behavior in *Cyclura*, and the presence of homing behavior may significantly impact translocation efforts (e.g. Brown et al., 2009; Germano & Bishop, 2008; Hein & Whitaker, 1997; Lettink, 2007; Stamps & Swaisgood, 2007; Tuberville, et al., 2005). Recommendations for translocating species that show strong homing and migration tendencies are to release eggs or younger individuals rather than older adults that have had sufficient time to develop strong associations with a home site (Germano & Bishop, 2008). Similarly, Knapp and Hudson (2004) suggest translocating *Cyclura* spp. adults rather than juvenile iguanas to increase the probability for success. However, as Alberts, (2007) and Wilson et al. (2004) assert, juveniles may be the best candidates in terms of social integration into existing populations. Translocations of free-ranging and headstarted *Cyclura* individuals to date have consisted solely of adults and subadults; no juveniles have been utilized.

Stress

Within *Cyclura*, translocation subjects have consisted entirely of adults and subadults since they can reproduce most quickly to create self-sustaining populations, defining criteria of successful translocations. However, it may take a long time to evaluate whether a population is truly viable based solely on reproduction. Therefore, other parameters can be used to assess the ability of released animals to become established in their new location. One important measure is stress. Whether from a headstart facility, inter-island or intra-island, translocation includes such stressors as capture, handling, transport and release into a novel territory (Busch & Hayward, 2009; Dickens et al., 2009; Dickens et al., 2010; MacDonald, et al., 2007; Teizeira, et al., 2007). Further, depending on age class, sex and season (due to changes in reproductive condition and resource availability), the impact of these stressors can vary, be additive, (Cyr & Romero, 2009), and impact both the short and long-term success of a translocation through chronic stress (Germano & Bishop, 2008). Translocation in particular has a high potential for causing chronic stress because the process involves multiple acute stressors initiating multiple, consecutive acute stress responses as well as long-lasting responses (Dickens et al., 2010). And, when a translocation represents conservation intervention employing small numbers of rare animals, the challenge of chronic stress is centrally important (Dickens et al., 2010) due to its particularly deleterious effects.

Transfer of an animal from a known “home” to a novel environment stimulates both the glucocorticoid response as well as the flight or fight response and is a well-known and persistent psychological stressor in many species (see reviews in Teizeira, et al., 2007; Busch & Hayward, 2009; Dickens et al., 2010). Animals typically begin mounting a glucocorticoid (GC) response immediately upon capture and prior to direct human interaction. Following capture, translocation procedures frequently entail some period of captivity, and measurements during captivity and shortly following release indicate that captivity activates both the sympathetic nervous system and GC release. Corticosterone, the GC metabolite in reptiles, has been shown to inhibit normal functions of reproductive hormones, disrupt immune function, inhibit growth, and disrupt normal social and territorial behaviors (e.g. Berger et al., 2005; Crews & Moore, 2005; Moore & Jessop, 2003; Romero, 2004; Romero & Wikelski, 2002; Sapolsky, 2000; Wikelski and Cooke, 2006).

The total period of elevated GCs following an acute stressor such as capture or captivity, is a critically important facet of the stress response because high, stress-induced concentrations of GC can become damaging (Sapolsky et al., 2000). Thus, as argued by Romero (2004) and Dickens et al. (2010), the inability to terminate GC release effectively is a potentially serious endocrinological outcome of translocation given the multiple and additive stressors. Stress may contribute to translocation failure by increasing the animal's vulnerability to chronic stress-related pathology, and such external factors as disease, predation and starvation (Dickens et al., 2010). The age of the animal matters as well—exposure to stressors early in life can induce significant life-long changes in the HPA axis (Romero, 2004). Therefore, as Dickens et al. (2010) argue, perhaps more important than the actual physiological profile as a result of stress, is the prediction that stress system disruption caused by translocation may indicate additional alterations in the physiology and behavior of translocated animals.

For example, stress itself may even impact the movements of animals in general, and movements post-release in particular. Changes in plasma corticosterone levels are associated with migratory behavior of birds, and appear to be involved in mobilization of fuel stores and activity levels of reptiles as well (Southwood & Avens, 2010). Red-eared sliders respond to treatment with corticosterone implants by increasing locomotor activity (Cash & Holberton, 1999), and increases in plasma corticosterone in red-eared sliders under field conditions are associated with emigration from sub-optimal habitats (Cash & Holberton, 2005). Hatchling green sea turtles during the dispersal stage show elevated levels of corticosterone, and corticosterone levels of red-sided garter snakes captured while migrating from dens to summer foraging sites are higher than levels for pre-migratory snakes at the den (Cease et al., 2007). Physiological stress may even increase the likelihood of dispersal (Wingfield & Romenofsky, 1997), and it is theorized by some that homing may actually be a result of stress avoidance behavior, playing an important role in post-release movement away from the release site in an attempt to avoid the stress of the novel environment through actively searching for familiar home range (Dickens et al., 2010; Wingfield & Romenofsky, 1997).

However, as Germano & Bishop (2008) assert, few have looked at the effects of stress in herpetofauna after release into a new environment. Where it has been examined, stress does indeed affect translocated herpetofauna (Burke, 1991; Dickens, et al., 2010; Dodd & Siegel, 1991; Fisher and Lindemayer, 2000; Reinert, 1991) and even short translocation periods can cause significant acute stress responses, which may exist for up to months after release (Alberts, 2007). The only systematic study of translocation stress in *Cyclura* is for the Turks and Caicos iguana, in which individuals translocated from one island to another exhibited severe short-term stress, including elevated corticosterone levels for up to a month post-release and decreased body condition (Gerber, 2007; Gerber et al., 2004). Although released in January following the rainy season when food resources were plentiful, iguanas still experienced a 15% weight loss until 5 months post-release, when they appeared to have settled into more stable home ranges (Alberts, 2007). Known mortality post-translocation has been limited to post-hurricane events (Gerber, pers. com.), however, data are not available to indicate the adrenocortical health of individuals prior to those weather events and to ascertain if animals were experiencing any long-lasting physiological effects from the earlier translocations.

The Turks and Caicos Iguana

The Turks and Caicos iguana is the largest native terrestrial vertebrate and dominant herbivore of the Turks and Caicos Islands (TCI). As adults, iguanas are sexually dimorphic, males are approximately twice the mass of females and they are territorial throughout the year, whereas females are generally only territorial after nesting. Courtship and mating occur in April and May, females lay a clutch of eggs in May or June, and hatching occurs in August or September (Iverson, 1979; MacDonald et al., 2007). Due to increasing human development and the introduction of mammalian predators and competitors, such as dogs and cats, this iguana species now occupies less than 5% of its historic range and at least 15 island populations have been lost in the past 30 years (Gerber & Iverson, 2000). As a result, the Turks and Caicos iguana is categorized as Critically Endangered on the IUCN Red List and is a priority species for the IUCN Iguana Specialist Group (Alberts, 2000).

To counteract threats facing the species, a comprehensive conservation program for the TCI iguana has been developed over the past 15 years. This program includes applied ecological research, public education and awareness, local capacity building, removal of feral mammals, and reintroduction of iguanas to islands using translocation. Since 2002, iguanas have been successfully restored to five small islands (French, Bay, Middle, Six Hills, and Bush Cays) by translocating adult iguanas from two large islands (Little Water and Big Ambergris Cays) with robust iguana populations that are threatened by introduced cats or new development. As of 2007, (Gerber, 2007) translocated iguanas had exhibited high survivorship and successful reproduction every year since being moved, and the population had continued to expand when last monitored in 2012 (Gerber, pers. obs.).

Thus, inter-island translocation appears to be an excellent conservation tool for reestablishing iguanas in the Turks and Caicos, provided the islands to be repopulated have good habitat and are free of feral mammals. However, island to island translocations can be expensive and require substantial manpower and resources. In addition, islands suitable for translocation are usually inferior (e.g., much smaller than source islands with significantly lower plant diversity) and the number of islands available for future translocations in the TCI is rapidly diminishing. Therefore, in addition to inter-island translocations, intra-island translocation strategies that complement iguana-friendly human development plans must be found. In addition to the potential for post-translocation stress, homing is an additional concern in intra-island translocation.

One of the islands used as a source for iguana translocations in the TCI, Big Ambergris Cay, presents a unique opportunity to document post-translocation stress and homing behavior to determine the effectiveness of intra-island translocation for TCI iguanas. Big Ambergris is a privately owned 400 ha island undergoing extensive development and supporting the single largest remaining population of this critically endangered species. Fortunately, the developers have adopted most of the recommendations concerning iguanas set out in the Big Ambergris Environmental Impact Assessment, including small building footprints, use of golf carts and dirt roads, and, most importantly, a restrictive covenance that forbids anyone from bringing cats, dogs or other pets to the island. As a consequence, Big Ambergris is the first island to be developed in the TCI that stands a chance of preserving its iguana population. Nonetheless, the amount of habitat suitable for iguanas on Big Ambergris will decrease by approximately 30% once the island is fully developed (e.g., 450 homes, roads, power plant, airport, marina, etc.) and a significant number of animals will be displaced as development proceeds. Determining the utility of intra-island translocation during the early stages of development will allow an informed conservation strategy to be implemented as development pressures increase.

Study Objectives

The proposed project activities outlined below are part of an established conservation and research program for the Turks and Caicos iguana (now entering its seventeenth year). Activities address specific components of the 2005-2009 Turks and Caicos Iguana Conservation and Management Plan (Gerber & Pagni, 2012) [Obj 3.3.1 (develop and implement a comprehensive monitoring program); Obj 3.3.3 (develop a coordinated translocation strategy); Obj 3.3.4 (undertake basic natural history research pertinent to conservation management) and Obj 3.3.5 (establish guidelines for iguana- and habitat-friendly development practices]. Additionally, activities address the ISG's priority project for "mitigation of the Big Ambergris Cay development" (Gerber and Iverson, 2000). The following project objectives and hypotheses are outlined:

Objective I: Document homing behavior in the Turks and Caicos iguana as it impacts translocation efforts.

Hypothesis 1

H_o: Adult iguanas of both sexes will not exhibit homing behavior.

H_A: Adult iguanas of both sexes will exhibit homing behavior.

Hypothesis 2

H_o: Juvenile iguanas of both sexes will not exhibit homing behavior.

H_A: Juvenile iguanas of both sexes will exhibit homing behavior.

Objective II: Document evidence of post-translocation stress as it impacts translocation efforts

Hypothesis 3

H_o: Adult iguanas of both sexes will not exhibit elevated baseline corticosterone or stress-induced corticosterone concentrations over time.

H_A Adult iguanas of both sexes will exhibit elevated baseline corticosterone or stress-induced corticosterone concentrations over time.

Hypothesis 4

H_o: Juvenile iguanas of both sexes will not exhibit elevated baseline corticosterone or stress-induced corticosterone concentrations over time.

H_A Juvenile iguanas of both sexes will exhibit elevated baseline corticosterone or stress-induced corticosterone concentrations over time.

Hypothesis 5

H_o: Adult iguanas of both sexes will not exhibit differences in baseline corticosterone or stress-induced corticosterone concentrations across seasons.

H_o: Adult iguanas of both sexes will exhibit differences in baseline corticosterone or stress-induced corticosterone concentrations across seasons.

Hypothesis 6

H_o: Juvenile iguanas of both sexes will not exhibit differences in baseline corticosterone or stress-induced corticosterone concentrations across seasons.

H_o: Juvenile iguanas of both sexes will exhibit differences in baseline corticosterone or stress-induced corticosterone concentrations across seasons.

Chapter 2

Methods

Study Design

The study consisted of four six-week study periods: two during the dry/pre-breeding season (February/March) and two during the wet/non-breeding season (October/November) from 2011-2014. These time periods were chosen since they represented a systematic test of the impact of environmental parameters on translocation success but do not disturb animals during the critical breeding and nesting periods. During each study period, 24 specimens served as subjects. Adult animals were defined as those at least 6-7 years of age and greater than 200 mm SVL. Juveniles were defined as two-three year old animals (approximately 100 g). Table 2.1 outlines the study design per season. At each study site, 12 iguanas (three of each age and sex class) were used for the project. Movements of all animals were tracked for at least 14 days prior to translocation to estimate home range and for at least 14 days after translocation to determine homing ability and translocation success. Following the first phase of tracking, study animals from the tents were translocated to the ruins and vice versa.

Table 2.1 Seasonal Study Design

	Male		Female	
Study Site	Adult	Juvenile	Adult	Juvenile
Ruins	3	3	3	3
Tents	3	3	3	3

Note. Entire study period is 4 seasons; n = 96 subjects total

Baseline Data and Marking

During days 1-3 of each study period, subjects were captured with a noose pole, bled for stress analyses (see below), weighed, measured, sexed, assessed for body condition, and individually marked with a unique bead tag sequence attached to the dorsal crest and a PIT tag placed sub-dermally on the proximal dorsal surface of the left rear leg. Finally, subjects were outfitted with externally-attached radio transmitters (Holohil Systems, Ltd. Model BD-2 (1.2-1.4g) following established protocols (Goodman et al., 2009) and adhered with 5200 quick cure marine caulk (3M). All processing occurred at the administration complex, 2.7 km north of the tents study site and 1.9 km north of the ruins study site.

Subjects were transported from the study site in bags, removed from the bags for processing at the complex, and held overnight in bags while the adhesive cured. Subjects were then released at their point of capture within 24 hours. One adult subject dislodged its transmitter following original placement and was held overnight for 48 hours waiting on the transmitter to cure properly prior to release.

Radiotelemetry and Translocations

Following initial processing and release, all subjects were located at least twice daily for 12-14 days (Telenax RX-TLNX tracking receiver and collapsible hand-held yagi antenna) with hours of tracking standardized to ensure an even distribution over the active hours of the subjects. A Trimble GeoExplorer handheld datalogging Global Positioning System (GPS) was used to record iguana locations along with animal ID, date, and time. At the end of the baseline period, radio-tagged iguanas were recaptured, bled, weighed, measured, translocated to the other study site and radio-tracked for 12-14 more days. Following the second tracking period, animals were recaptured, bled, weighed, measured, and released at their final capture location. Data collection was then repeated in the next study period with another set of 24 subjects. Opportunistically, subjects from previous study periods were observed, locations marked and captured for additional measurements and samples. Table 2.2 outlines the project schedule per study period.

Corticoid and Leukocyte Concentrations

During each capture event (3/study period), blood samples were taken within 3 minutes from the caudal vein using standard methods (MacDonald et al., 2007; Romero & Reed, 2005) for a baseline measurement. Subjects were then placed in cloth bags and re-bled at least 30 minutes after the first bleed, representing “restraint or capture stress” (Romero & Wikelski, 2002). Blood was kept on ice and centrifuged within 1.5 hours of collection. Once separated, the plasma was kept frozen and shipped to the San Diego Zoo for analysis. Additionally, a sample of blood was used to create smears in triplicate that were air-dried, stained with Diff Quik stain, and examined by a licensed veterinary technician under a compound microscope. For each blood smear, a full differential was determined by analyzing leukocyte types within the same microscope fields until the cumulative total was at least 100. A heterophil to lymphocyte ratio was then calculated by the principal investigator by calculating the number of heterophils relative to lymphocytes within those counts for each blood smear.

Table 2.2 Project Schedule Per Study Period

Year	Dates	No. Days	Activity
2011	21 Sep – 24 Sep	4	Subjects captured for initial processing
	22 Sep – 9 Oct	17	Subjects radio-tracked for baseline movement patterns
	6 Oct - 9 Oct	4	Subjects captured, processed and translocated
	7 Oct – 27 Oct	21	Subjects radio-tracked for post-translocation movements
	23 Oct – 27 Oct	5	Subjects captured for final processing
2012	15 Sep – 17 Sep	3	Subjects captured for initial processing
	16 Sep – 3 Oct	17	Subjects radio-tracked for baseline movement patterns
	30 Sep – 3 Oct	4	Subjects captured, processed and translocated
	1 Oct – 21 Oct	21	Subjects radio-tracked for post-translocation movements
	16 Oct – 21 Oct	6	Subjects captured for final processing
2013	23 Feb – 28 Feb	6	Subjects captured for initial processing
	24 Feb – 14 Mar	18	Subjects radio-tracked for baseline movement patterns
	9 Mar – 14 Mar	6	Subjects captured, processed and translocated
	10 Mar – 31 Mar	21	Subjects radio-tracked for post-translocation movements
	26 Mar – 31 Mar	5	Subjects captured for final processing
2014	25 Feb – 2 Mar	6	Subjects captured for initial processing
	26 Feb – 16 Mar	19	Subjects radio-tracked for baseline movement patterns
	11 Mar – 16 Mar	6	Subjects captured, processed and translocated
	12 Mar – 3 Apr	23	Subjects radio-tracked for post-translocation movements
	29 Mar – 3 Apr	6	Subjects captured for final processing

Chapter 3

Analyses

Movement Data

Individual baseline and translocation data points were geo-referenced and mapped for each of the 96 subjects. The animal movement analysis extension for ArcView v3.2 software was used to create minimum convex polygon (MCP) ranges for each iguana from all recorded locations during both the baseline and translocation periods. Movements indicating homing behavior were measured in several ways. First, animals were scored as having “homed” if they were located within their baseline MCP range by the end of the study period. Additionally, the following variables were developed: total distance moved (SUM=sum of linear distances between consecutive data points), mean distance/movement (AVG=sum of the distance between consecutive telemetry data points divided by the total number of recorded movements) and range length (MAX=maximum straight line distance between any 2 telemetry points). Note that the MCP ranges for translocated iguanas do not represent a home range, rather the area covered by translocated iguanas while seeking a place to settle (i.e. a dispersal range). Several variables were also created to indicate movement progress for subjects that did not home back to their baseline home range. These variables measured movements towards the subjects’ initial capture site (CTRANS) or the inverse, movements away from the translocation site (TRANSPLUS). These variables were constructed by taking the distances between the subject’s current location and the initial capture site (CTRANS), or the translocation site (TRANSPLUS). A minimum distance between the translocation site and the initial capture site was defined as CTRANSMIN, and a maximum distance from the translocation site was calculated as TRANSPLUSMAX. Average distance from the initial capture location (CTRANSAVG) or translocation site (TRANSPLUSAVG) were also calculated. Given the fluctuating dry and wet climatic seasons in the Turks and Caicos during the study periods, translocation season in this study was defined as wet (years 2011 and 2012) or dry (years 2013 and 2014) and coincide with the non-breeding and pre-breeding seasons respectfully. Movement variables were analyzed three ways, with subjects that homed to their original capture location included and excluded from full analyses, and again with “homed” as an independent variable in an adults-only database. The latter was conducted to ensure that the homing individuals were not affecting the data in a systematic way.

Corticosterone and Leukocyte Analyses

Plasma levels of corticosterone were measured by radioimmunoassay following methods described in MacDonald, et al. (2007) by the San Diego Zoo's Endocrinology Service Lab. As argued by Romero (2004), it is more accurate to report the absolute stress-induced hormone concentrations of the elevated response rather than the change from baseline because baseline and stress-induced GC concentrations interact with different receptors, and reporting a percent change is of little value. Therefore, absolute concentrations were reported. Red blood cell differential counts were determined by a certified veterinary technician from the Lincoln Park Zoo, and heterophil to lymphocyte ratios were calculated by the principal investigator.

Descriptive and Statistical Analyses

For all statistical analyses, dependent morphometric, stress and movement variables were $\log_{10}$ transformed to more closely approximate normal distributions. Following transformations, dependent variables approximated normality (Shapiro-Wilk's, $p > .05$). All reported statistical results for transformed variables represent back transformed values. Descriptive results are reported as mean ± standard errors. Sixteen subjects lost their transmitters, were predated or could not be recaptured and given the lost data, were considered lost to follow up and were excluded from all analyses. Subjects that homed to their original capture site (n=17) were included in all analyses except where noted. The full dataset used for analysis included 80 subjects.

Differences in baseline morphometrics were tested by age class via a one-way ANOVA with dependent variables (DVs) of snout vent length, mass and BCS at catch 1, and a between subjects factor of gender. To examine if there were differences in the time of day subjects were sampled for baseline and capture-stress bleeds, a 3* 2* 2* 2 (capture time*gender*age*season) mixed ANOVA was conducted where gender, age and season were between-subjects factors and bleed time of day was a within subjects factor. To examine if there were systematic differences in the time between baseline and capture-stress bleeds for each catch, a 3*2*2*2 mixed ANOVA (capture time*age*gender*season) was conducted where gender, age and season were between subjects factors and capture time was a within subjects factor.

Differences in baseline plasma CORT and H:L ratios were examined by a one-way ANOVA with age, gender and season between-subjects factors. Differences in BCS, baseline plasma CORT, capture-induced CORT, baseline H:L ratios and capture-induced H:L ratios over time were examined by 3*2*2*2 mixed ANOVAs (capture time*age*gender*season) where gender, age and season were between subjects factors and capture time was a within subjects factor. To account for the variability of individual stress responses, a within-individual response ratio of capture stress CORT/baseline stress CORT and stress response of capture stress CORT – baselines stress CORT were developed and also examined by the same mixed ANOVA. Within subject contrasts were used to determine trend effects. Juvenile data would not meet assumptions of normality and were therefore analyzed with Wilcoxon signed rank tests for the differences in stress variables over time.

Differences in movement variables over time were also analyzed by 3*2*2*2 mixed ANOVAs (movement period*age*gender*season) where gender, age and season were between subjects factors and movement period was a within subjects factor. Data indicating movements towards the initial capture site could not meet assumptions of normality and were therefore tested by Mann-Whitney U tests by gender. Movements away from the translocation site were tested by one-way ANOVAs with between-subjects variables of age, gender and translocation season.

To determine if homing subjects impacted the data in systematic ways, mixed ANOVA analyses were conducted both including and excluding them from the full dataset (n=80). In addition, the subset of adults (n=47) were analyzed with a 3*2*2 mixed ANOVA (movement period*gender*translocation season) where gender and translocation season were between-subjects factors and movement period (or capture time in the case of stress analyses) was a within subjects factor. To determine if there were significant differences in characteristics of homing subjects (n=17), mixed ANOVAs were also conducted on baseline CORT, stress capture CORT and all movement variables.

In all appropriate cases, Mauchly's test of sphericity was used to test for the assumption of sphericity and Levene's test of equality of error variances was used to test the assumption of homogeneity of variance. All results were not significant at $p > .05$.

Chapter 4

Results

Subjects

Baseline morphometrics. Of the 96 individuals used in the study, 48 were adults (n=24 males, n=24 females) and 48 were juveniles (n=24 males, n=24 females). Table 4.1 depicts baseline morphometric variables for subjects included in all analyses. Across both seasons, there was a significant difference in adult snout vent length (SVL) based on gender. Adult SVL at catch 1 differed significantly between males and females, with males exhibiting greater length than females, F (1, 72) = 12.58, p < .001, partial η^2 =.15. Similarly, males were significantly heavier than females, F (1, 45) = 148.28, p <.001, partial η^2 = .77. In addition, males had significantly better BCS scores than females, F (1, 46), p < .001, partial η^2 = .77. There were no significant differences between juvenile subjects SVL based on gender, F (1, 33) = .04, p > .05, partial η^2 = .01. There were also no significant differences between juvenile subjects' baseline mass based on gender, F (1, 33) = .09, p > .05, partial η^2 = 01. Similarly, BCS scores across juveniles were not significantly different, F (1, 33) = 1.06, p > .05, partial η^2 = .03. Subjects for each study year were also distributed across two capture sites. Table 4.2 depicts summary baseline morphometric and stress-related variables for subjects at these two study sites pooled across both seasons. Subjects from the different study sites did not vary widely on these key variables of interest, and were thus pooled in all subsequent analyses.

Table 4.1 Summary Baseline Morphometrics of Subjects Pooled Across Both Seasons

	Adult							
	Male (n=24)				Female (n=23)			
	Mean	SEM	Min	Max	Mean	SEM	Min	Max
SVL (mm)	288.83	2.761	260	314	243.13	2.34	211	263
Mass (g)	1002.3	34.142	655	1340	548.48	18.214	330	760
BCS	41.51	0.7103	37.27	51.84	38.167	1.116	24.48	48.69

	Juvenile							
	Male (n=20)				Female (n=13)			
	Mean	SEM	Min	Max	Mean	SEM	Min	Max
SVL (mm)	137.55	4.422	112	175	137.77	5.487	115	175
Mass (g)	100.65	10.08	45.5	180	93.19	10.51	59	176
BCS	36.447	1.1	26.61	52.48	34.665	1.353	22.02	40.56

Baseline plasma corticosterone and leukocyte analyses. Baseline plasma CORT concentrations and H:L ratios at catch 1 for all subjects across both seasons are depicted in Table 4.3. A one-way ANOVA examining these concentrations by age, gender and season across all subjects indicated that there was a main effect of age, with juvenile baseline plasma CORT concentrations significantly higher than those of adults, F (1, 56) = 7.37, p = .008, partial η^2 = .11 (adult mean = 9.82 ± .57 ng/ml; juvenile mean = 14.10 ± 1.67 ng/ml). For adults, there were no significant differences in these concentrations based on gender or translocation season. There were too few samples to allow for an analysis by gender or translocation season within juveniles. A one-way ANOVA examining baseline H:L ratios by age, sex and season across all subjects indicated that baseline H:L ratios at catch 1 differed significantly based on age and translocation season. Adult ratios were significantly higher than juveniles, F (1, 59) = 9.23, p =.003, partial η^2= .13. There was also a significant main effect of season, and across all ages and genders, with ratios significantly higher in the wet season than the dry season, F (1, 59) = 6.93, p = .01, partial η^2 = .10.

Impact of Sample Collection Times

Given the potential confound of temporal variations in daily and seasonal glucorticioid concentrations, the impact of blood collection time was examined. There was no significant difference in the time of baseline bleeds across the three capture periods, F (2, 134) = .83, p > .05, partial η^2 = .01. There was a main effect of translocation season however, F (1, 67) = 13.27, p < .001, partial η^2 = .17, with the average time of day bled in the dry season significantly later than in the wet season (mean = 13:45 ± :22 compared to 11:58 ± :22).

There were no significant differences in capture-stress bleed time of day across the three capture periods, however there were significant main effects of age and translocation season. Adults on average were bled earlier (mean 13:22 ± :20) than juveniles (mean 14:47 ± :28), F (1, 57) = 10.51, p = .002, partial η^2 = .16. Subjects in the dry season were also bled significantly later on average than those in the wet season (mean dry season = 14:18 ± :19; mean wet season 13:12 ± :21, F (1, 57) = 7.87, p =.007, partial η^2 =.12.

There was a significant difference across time periods in time between baseline and capture-stress bleeds for each catch, F (2, 88) = 3.63, p = .03, partial η^2= .07. Contrasts indicated that subjects were bled significantly later in capture period one (mean 47 ± 2 min) compared to capture period 2 (mean 44 ± 3 min), F (1, 44) = 5.6, p = .02, partial η^2 = .11, and also compared to capture period 3 (mean 43 ± 2 min), F (1, 44) = 4.38, p = .04, η^2 = .09. There was also a significant effect of gender across all subjects, with differences between bleeds being significantly shorter in females than males (F 1, 44) = 5.08, p = .031, partial η^2 = .10 (mean for females = 38 ± 1 min; mean for males = 44 ± 1 min).

Impact of Translocation

Body condition score. Table 4.4 details the summary changes in mass and body condition score for all subjects over the three catches and pooled across both seasons. To examine the effect of age, gender and translocation season on body condition score over time, a mixed ANOVA was conducted on body condition score across the three capture periods. There was homogeneity of variances for body condition scores at capture 1 (p=.21) and capture 3, (p=.10) as assessed by Levene's test for equality of variances, but the assumption of homogeneity was violated at capture 2 (BCS2, p=.04) and capture 3 (BCS3, p = .35). Mauchly's test of sphericity indicated that the assumption of sphericity had also been violated, χ^2 (2) = 10.1, p = .01 and a Greenhouse-Geisser correction was used. There was a significant main effect of capture time, F (1.7, 108) = 6.60, partial η^2 = .09. Contrasts indicated that body condition scores decreased significantly across the three capture periods. Scores at catch 1 (mean = 37.76 ± 1.02) were not statistically different from those at catch 2 (mean =36.90 ± 1.02, p=.24, nor were scores from catch 2 (mean = 36.90 ± 1.02) significantly different from scores of catch 3 (mean =35.89 ±.02), p=.14. Scores from catch 3 however were significantly lower than those at catch 1, F (1, 62) = 11.96, p < .001, partial η^2 = .16. There were no significant effects of age, sex or season on body condition scores on the trend across the capture periods (p>.05). There was a main effect of age however, F (1, 62) = 6.93, p = .01, partial η^2 = .10. Adult body condition scores regardless of gender and translocation season were significantly higher than juvenile scores (mean = 38.19 ± 1.02 for adults and 35.56 ± 1.02 for juveniles, (p = .01).

Table 4.2 Baseline Morphometrics of Subjects by Capture Site Pooled Across Seasons

	Adult									
	Male					Female				
	Mean	SEM	Min	Max	N	Mean	SEM	Min	Max	N
SVL										
Ruins	293.25	3.96	264.00	314.00	12	246	3.51	223	263	11
Tents	283.41	3.43	260.00	302.00	12	240.5	3.08	211	254	12
Mass										
Ruins	1089.58	47.36	820.00	1340.00	12	569.09	24.83	480	760	11
Tents	915.00	35.29	655.00	1120.00	12	529.58	26.26	330	630	12
BCS										
Ruins	43.04	1.13	38.17	51.84	12	38.32	1.57	31.06	48.69	11
Tents	39.99	0.63	37.27	45.36	12	38.02	1.64	24.48	45.41	12
Base CORT										
Ruins	10.97	0.96	5.57	18.00	12	8.64	1.37	3.98	20.31	11
Tents	10.05	1.29	4.70	18.10	12	9.52	1	5.34	17.9	12
Base H:L										
Ruins	0.89	0.31	0.23	4.19	12	0.67	0.10	0.11	1.17	11
Tents	0.72	0.09	0.27	1.14	11	0.42	0.09	0.10	0.85	9

	Juvenile									
	Male					Female				
	Mean	SEM	Min	Max	N	Mean	SEM	Min	Max	N
SVL										
Ruins	141	7.72	116	175	9	143.62	7.12	123	175	8
Tents	134.72	5.17	112	158	11	128.4	7.56	115	158	5
Mass										
Ruins	110	16.68	57	180	9	98.75	12.94	60.5	176	8
Tents	93	12.48	45.5	160	11	84.3	18.99	59	160	5
BCS										
Ruins	37.17	1.01	33.59	43.52	9	32.808	1.88	22.02	39.1	8
Tents	35.85	1.85	28.61	52.48	11	37.63	0.8941	35.93	40.56	5
Base cort										
Ruins	13.42	2.46	7.58	19.42	5	10.5	3.85	4.05	17.4	3
Tents	13.89	3.6	6.27	27.72	6	19.28	2.43	14.45	22.24	3
Base HL										
Ruins	1.07	0.5	0.08	3.89	7	1.071	0.527	0.15	4.11	7
Tents	1.378	0.96	0.07	9	9	1.59	1.15	0.06	6.15	5

Table 4.3 Baseline Plasma Corticosterone and Leukocyte Analyses at Catch One For All Subjects Pooled Across Both Seasons

	Adult									
	Male					Female				
	Mean	SEM	Min	Max	N	Mean	SEM	Min	Max	N
Baseline CORT	10.51	0.79	4.70	18.10	24	9.10	0.82	3.98	20.31	23
Baseline HL	0.94	0.12	0.08	2.33	24	0.77	0.15	0.08	3.13	23
Prop H baseline	36.58	2.66	7.00	56.00	24	28.82	2.86	6.00	52.00	23
Prop L baseline	47.87	3.33	24.00	88.00	24	52.43	3.90	16.00	77.00	23

	Juvenile									
	Male					Female				
	Mean	SEM	Min	Max	N	Mean	SEM	Min	Max	N
Baseline CORT	13.68	2.16	6.27	27.72	11	14.90	2.83	4.05	22.24	6
Baseline HL	0.34	0.05	0.09	0.69	13	0.38	0.09	0.06	0.94	10
Prop H baseline	19.61	2.05	8.00	31.00	13	18.20	3.24	5.00	30.00	10
Prop L baseline	63.07	3.30	45.00	87.00	13	60.90	5.85	32.00	84.00	10

Baseline plasma corticosterone. Baseline plasma CORT and H:L ratios across all subjects and all seasons are presented in Table 4.5. To test the effect of gender and translocation season on these baseline stress levels over time, a mixed ANOVA was conducted on baseline corticosterone concentrations across the three capture periods. Given insufficient samples from juveniles, the between-subjects age factor was dropped from the analysis and only adult subjects were examined (n = 47). There was homogeneity of variances for all three baseline CORT concentrations (baseline CORT 1 p=.56, baseline CORT 2 p=.29 and baseline CORT 3 p = .35) as assessed by Levene's test for equality of variances. However, Mauchly's test of sphericity indicated that the assumption of sphericity had been violated, χ^2 (2) = 15.28, p < .01 and therefore a Greenhouse-Geisser correction was used. There was a significant main effect of capture time, F (2, 30.65) = 26.35, p < .001, partial η^2 = .53. Contrasts indicated that mean baseline CORT increased across captures, with a mean CORT of 9.18 ± 1.07 ng/ml at capture 1 significantly different than capture 2 (mean 11.09 ± 1.07 ng/ml), F(1, 23) = 7.67, p =.01, partial η^2 = .25. Capture 3 was the highest (mean 21.93 ± 1.17), and significantly different than captures 2 and 3, F (1, 23) = 35.05, p < .001, partial η^2 = .60. The main effects of gender and season were not statistically significant (p > .05). Given insufficient blood samples for juveniles, they could not be added to the mixed model and instead were analyzed separately using Wilcoxon signed rank tests. To increase sample sizes, comparisons were made pooling data across both seasons and comparing between values at catch 1 and catch 3 only. There were significant differences in baseline plasma corticosterone concentrations between catch 1 and catch 3 for juveniles, (z = 2.80. p < .01). Examining the differences by gender revealed that differences were significant for male juveniles only, (z = 2.36, p < .05.).

Table 4.4 Mean Changes in Mass and Body Condition Scores for All Subjects Over Three Catches and Pooled Across Seasons

	Adult									
	Male					Female				
	Mean	SEM	Min	Max	N	Mean	SEM	Min	Max	N
Catch 1										
Mass	1002.29	34.14	655.00	1341.00	24	548.47	18.21	330.00	760.00	23
BCS	41.51	0.71	37.27	51.84	24	38.17	38.44	24.48	48.69	23
Catch 2										
Mass	995.00	33.66	770.00	1300.00	21	535.00	25.26	310.00	780.00	19
BCS	40.22	0.76	35.96	50.97	21	37.06	1.38	22.99	47.17	19
Catch 3										
Mass	917.20	32.41	590.00	1220.00	24	516.95	19.77	365.00	680.00	22
BCS	38.09	0.97	28.92	51.19	24	36.13	1.25	27.20	51.73	22

	Juvenile									
	Male					Female				
	Mean	SEM	Min	Max	N	Mean	SEM	Min	Max	N
Catch 1										
Mass	100.65	10.08	45.50	180.00	20	93.19	10.51	59.00	176.00	13
BCS	36.45	1.10	28.61	52.48	20	34.65	1.35	22.02	40.56	13
Catch 2										
Mass	98.02	9.63	51.50	180.00	20	102.46	17.03	54.50	267.00	13
BCS	35.65	0.94	28.13	47.56	20	35.81	1.40	30.90	49.82	13
Catch 3										
Mass	93.47	10.74	47.50	193.00	18	89.83	11.91	59.00	185.00	12
BCS	35.32	1.03	27.61	47.89	18	34.90	0.95	31.11	40.82	12

Table 4.5 Mean Baseline Plasma Corticosterone and H:L Ratios Across All Subjects and Pooled Across Seasons

	Adult									
	Male					Female				
	Mean	SEM	Min	Max	N	Mean	SEM	Min	Max	N
Catch 1										
Baseline CORT	10.51	0.79	4.70	18.10	24	9.10	0.82	3.98	20.31	23
Baseline HL	0.94	0.12	0.08	2.33	24	0.77	0.15	0.08	3.13	23
Prop H baseline	36.58	2.66	7.00	56.00	24	28.82	2.86	6.00	52.00	23
Prop L baseline	47.87	3.33	24.00	88.00	24	52.43	3.90	16.00	77.00	23
Catch 2										
Baseline CORT	12.53	0.97	7.74	23.10	17	10.91	1.13	5.60	21.33	16
Baseline HL	0.65	0.10	0.16	1.84	21	0.55	0.09	0.08	1.74	17
Prop H baseline	30.38	2.45	12.00	59.00	21	26.76	2.45	7.00	47.00	17
Prop L baseline	54.52	2.96	28.00	76.00	21	56.94	3.52	27.00	84.00	17
Catch 3										
Baseline CORT	25.93	4.48	10.82	89.50	19	29.02	6.07	5.28	103.10	19
Baseline HL	1.03	0.17	0.21	2.91	19	0.75	0.15	0.12	2.68	20
Prop H baseline	39.10	3.08	16	67	19	29.25	3.22	10	67	20
Prop L baseline	46.78	3.35	23	76	19	52.25	3.741	25	81	20

	Juvenile									
	Male					Female				
	Mean	SEM	Min	Max	N	Mean	SEM	Min	Max	N
Catch 1										
Baseline CORT	13.68	2.16	6.27	27.72	11	14.90	2.83	4.05	22.24	6
Baseline HL	0.34	0.05	0.09	0.69	13	0.38	0.09	0.06	0.94	10
Prop H baseline	19.61	2.05	8.00	31.00	13	18.20	3.24	5.00	30.00	10
Prop L baseline	63.07	3.30	45.00	87.00	13	60.90	5.85	32.00	84.00	10
Catch 2										
Baseline CORT	22.70	5.53	10.08	51.08	7	13.41	2.14	11.27	15.55	2
Baseline HL	0.21	0.07	0.05	0.53	7	0.53	0.31	0.18	1.15	3
Prop H baseline	11.42	3.10	4.00	23.00	7	22.67	8.29	12.00	39.00	3
Prop L baseline	69.28	6.37	43.00	85.00	7	54.00	10.06	34.00	66.00	3
Catch 3										
Baseline CORT	34.95	4.75	17.60	71.97	10	33.11	3.03	24.63	41.76	5
Baseline HL	0.36	0.07	0.06	0.80	10	0.35	0.17	0.02	1.14	6
Prop H baseline	17.89	2.94	5	36	9	16.83	5.90	2	41	6
Prop L baseline	57.55	4.71	42	84	9	66.66	7.64	36	88	6

Capture stress plasma corticosterone. Summary stress capture corticosterone mean values for adult and juvenile subjects pooled across both seasons are presented in Tables 4.6 and 4.7 respectively.

Table 4.6 Summary Adult Stress Capture Values Pooled Across Seasons

	Adult									
	Male					Female				
	Mean	SEM	Min	Max	N	Mean	SEM	Min	Max	N
Catch 1										
Capture CORT	69.90	5.93	32.00	147.40	24	84.83	4.97	49.02	130.48	23
Stress CORT	59.39	5.64	24.43	138.20	24	75.72	4.77	38.22	119.00	23
Ratio Stress CORT	7.14	0.66	2.84	16.02	24	10.51	1.15	6.12	16.84	23
Capture HL	0.81	0.17	0.23	4.19	23	0.56	0.07	0.10	1.17	20
Prop H capture	32.26	2.37	15.00	67.00	23	26.45	2.68	8.00	45.00	20
Prop L capture	49.82	2.56	16.00	66.00	23	54.60	3.16	36.00	84.00	20
Catch 2										
Capture CORT	61.01	3.33	37.42	93.03	24	86.27	6.72	19.81	134.30	22
Stress CORT	45.69	3.87	27.35	78.92	17	79.62	7.36	12.41	121.60	15
Ratio Stress CORT	4.87	0.36	2.76	7.47	17	9.00	1.13	2.68	21.07	15
Capture HL	0.71	0.12	0.17	2.46	22	0.63	0.09	0.12	1.60	21
Prop H capture	30.36	2.90	12.00	59.00	22	28.76	2.68	9.00	50.00	21
Prop L capture	52.90	3.17	24.00	78.00	22	53.85	3.22	30.00	81.00	21
Catch 3										
Capture CORT	75.53	6.26	41.06	129.60	20	108.52	7.42	53.33	181.80	22
Stress CORT	51.63	6.82	0.60	105.82	17	81.80	5.47	34.21	121.81	19
Ratio Stress CORT	3.71	0.42	1.01	8.11	17	6.12	0.95	1.76	17.52	19
Capture HL	0.92	0.12	0.28	2.88	23	0.59	0.15	0.10	3.72	23
Prop H capture	38.38	2.54	20.00	69.00	24	25.26	2.68	8.00	67.00	23
Prop L capture	47.67	2.50	24.00	71.00	24	56.95	3.36	18.00	80.00	23

To test the effect of gender and translocation season on capture stress concentrations over time, a mixed model ANOVA was conducted on capture-stress corticosterone concentrations across the three capture periods by age, gender and season. As in the baseline CORT analyses, there were insufficient samples from juveniles to allow for their inclusion in the analysis. There was homogeneity of variances for all three stress CORT concentrations (stress CORT 1 p=.54, stress CORT 2 p=.24 and stress CORT 3 p = .80) as assessed by Levene's test for equality of variances. Mauchly's test of sphericity indicated that the assumption of sphericity had not been violated, χ2 (2) = 1.05, p = .59. There was a significant main effect of capture time, F (2, 74) = 5.94, p = .01, partial η^2 = .14. Contrasts indicated that there was no significant difference between CORT concentrations at captures 1 (mean 72.95 ± 1.05 ng/ml) and 2 (mean 67.14 ± 1.86 ng/ml), or between captures 1 and 3 (mean 84.72 ± 1.06 ng/ml). Significant mean differences were found between capture stress CORT concentrations of captures 2 and 3, however, with capture 3 concentrations exhibiting the highest levels, F (1, 37) = 12.73, p = .01, partial η^2 = .26. The effects of gender and season did not significantly differ across capture time (p > .05), Figure 4.1.

Table 4.7 Summary Juvenile Stress Capture Values Pooled Across Seasons

	Juvenile									
	Male					Female				
	Mean	SEM	Min	Max	N	Mean	SEM	Min	Max	N
Catch 1										
Capture CORT	155.73	9.35	114.53	222.48	13	152.95	14.27	106.30	240.47	10
Stress CORT	139.14	12.51	106.76	200.48	8	162.26	21.90	109.96	223.07	5
Ratio Stress CORT	14.70	1.90	9.48	25.39	8	10.90	1.23	6.46	13.82	5
Capture HL	0.73	0.25	0.07	3.89	15	1.29	0.54	0.06	6.15	12
Prop H capture	27.67	4.81	6.00	70.00	15	32.08	6.98	5.00	80.00	12
Prop L capture	57.47	4.70	18.00	85.00	15	50.40	6.82	13.00	83.00	12
Catch 2										
Capture CORT	133.85	17.30	80.30	183.33	6	138.51	14.28	100.25	184.58	6
Stress CORT	113.07	19.17	93.90	132.25	2	129.01	44.31	84.70	173.31	2
Ratio Stress CORT	5.02	1.43	3.59	6.45	2	11.41	4.97	6.45	16.38	2
Capture HL	0.29	0.07	0.08	0.92	10	0.37	0.12	0.07	1.20	10
Prop H capture	15.80	2.34	6.00	34.00	10	18.00	3.31	6.00	42.00	11
Prop L capture	61.00	3.41	37.00	73.00	10	65.60	5.16	35.00	91.00	11
Catch 3										
Capture CORT	133.96	11.51	65.20	191.11	13	165.74	22.73	106.73	267.81	8
Stress CORT	111.86	12.05	55.95	161.21	9	109.45	20.52	68.85	176.24	5
Ratio Stress CORT	4.83	0.75	1.78	10.16	9	4.56	0.84	2.65	6.53	5
Capture HL	0.25	0.03	0.05	0.51	17	0.29	0.12	0.08	1.24	9
Prop H capture	15.00	1.59	4.00	26.00	17	17.50	3.43	6.00	46.00	12
Prop L capture	65.23	2.65	47.00	85.00	17	66.75	4.04	37.00	81.00	12

However, there was a main effect of gender, with female concentrations significantly greater than male concentrations across all ages and seasons, F (1, 37) = 11.58, p = .01, partial η^2 = .24 (female mean 76.38 ± 1.06; male mean 64.57 ± 1.06), Figures 4.2 and 4.3. Analyzing juvenile data via Wilcoxon signed rank tests, differences in capture stress concentrations between captures 1 and 3 were insignificant for both sexes, p > .05. However, as noted in Tables 4.6 and 4.7, capture stress CORT concentrations were greater in juveniles than adults.

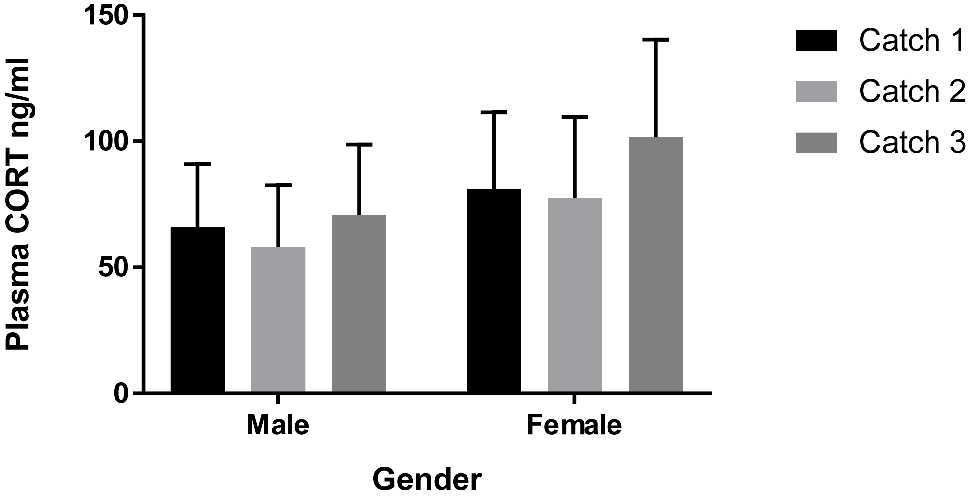

Figure 4.1 Mean capture stress plasma corticosterone for adult males and females over time.

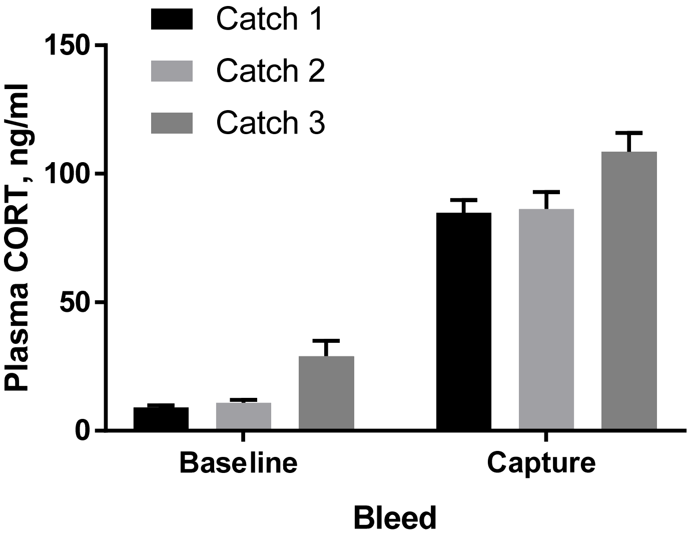

Figure 4.2 Mean baseline and capture stress plasma corticosterone for adult females over time.

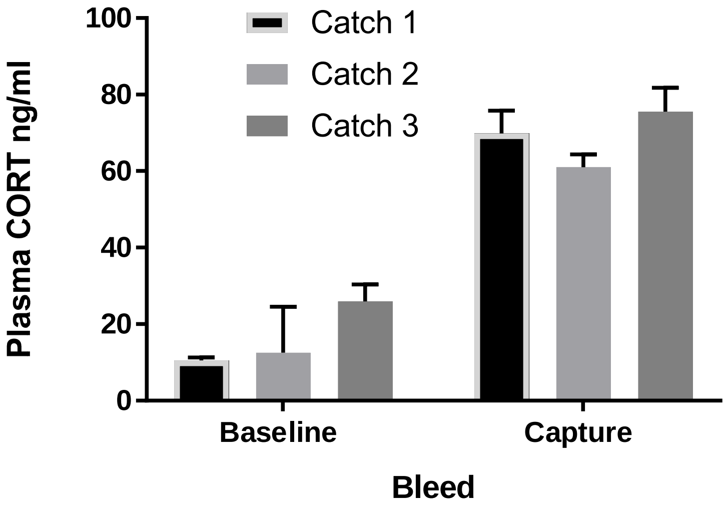

Figure 4.3 Mean baseline and capture stress plasma corticosterone for adult males over time.

Leukocyte analyses. H:L ratios across the baseline and translocation periods are depicted in Table 4.6. Adult baseline ratios did not significantly change over time, or based on gender or season, p > .05. Similarly, there were no significant differences between baseline H: L ratios between movement periods for juveniles, p > .05.

To examine adult capture stress induced H:L ratios over time, time between baseline and stress induced bleeds were added as covariates. Time between bleeds for both catches at baseline (catches 1 and 2) were not significantly correlated with H:L ratios, however the time between samples collected at the final catch was significant, F (1, 32) = 6.87, p = .01, partial η^2 = .17, and was added to the analysis. With this covariate in the model, there was a significant change in stress induced H:L ratios across time, F (2, 64) = 3.51, p = .04, partial η^2 = .10 . There were no significant differences in this trend dependent on gender or translocation seasons. There was however a significant main effect of gender, with male H:L ratios greater than female ratios across all ages and seasons, F (1, 32) = 4.32, p = .05, partial η^2 = .12 (Figure 4.3). For juveniles, there were significant differences in capture stress H:L ratios over movement periods (z = -2.582, p< .01). Further examination indicated that the differences were significant for males only, (z = -2.48, p < .01).

Adult stress response H:L ratios (capture stress H:L ratio/baseline H:L ratio) did not significantly change over time, F (2, 38) =1.45, p > .05, nor were there were significant main effects of gender or translocation season. For juveniles, the stress response H:L ratio did not change significantly over movement period for either gender, p > .05.

CORT stress and stress response ratios. There were no significant differences in adult stress responses over time, F (2, 42) = .24, partial η^2 = .01. There remained however a significant main effect of gender, F (1, 21) = 6.51, partial η^2 = .24. There were however significant decreases in adult stress response ratios over time, F (2, 42) = 9.90, p < .001, η^2 eta = .32, Figure 9. Mauchly's test of sphericity was violated, χ2 (2) = 7.25, p < .05 therefore Greenhouse-Geisser corrections were used. Contrasts indicated that reactivity at catch 1 was significantly greater than at catch 3, F (1, 21) = 19.67, p < .001, partial η^2 = .48, and reactivity at catch 2 was also significantly greater than that at catch 3 (F 1, 21) = 4.91, p = .04, partial η^2 = .19. There was a significant between subjects main effect of gender, with adult females having higher reactivity than males across all seasons F (1, 21) = 14.48, p =.01, partial η^2 = .40 (Figure 4.4). The effect of translocation season approached significance (p=.09) with average response ratios across all subjects greater in the dry season than wet.

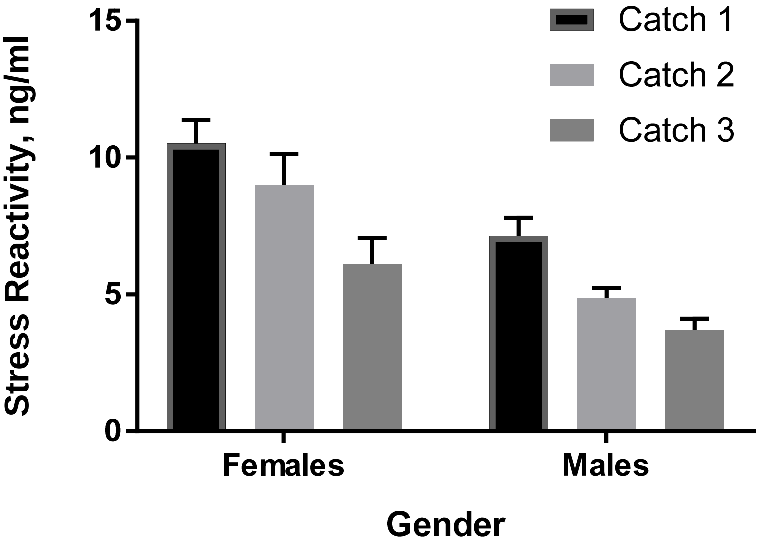

Figure 4.4 Adult mean stress response ratios over time as a function of gender.

Movement

Descriptive analyses. Subjects were tracked an average of 16 days during the baseline study period (14-17 d) and 15 days during the translocation study period (2-21). The average number of locations secured per subject per study period varied slightly, with an average of 27 locations (24-32 points) collected during the baseline period and 21 locations (5-28 points) during the translocation period. These numbers are skewed if a subject was lost to follow up during the translocation period (no subjects were lost to follow up during the baseline study period).

A total of 17 adult subjects homed during the translocation study period (n = 8 females and 9 males), compared to 30 adults who did not home. Note that one adult was lost to follow up and not included in subsequent analyses. No juveniles homed. Subjects homed in both directions (tents to ruins and ruins to tents), though in unequal proportions. The majority of subjects homed from the ruins to the tents (n=11) compared to moving from the tents to the ruins (n=6). Those homing from the ruins to the tents were roughly equally distributed across sexes (n=5 males, n=4 females). Conversely, double the number of males homed from the tents to the ruins (n=4) as females (n=2). Homing was distributed equitably across both seasons, 9 subjects homed during the wet season and 8 animals homed during the dry season.

Subjects varied in the time required to home, averaging 9 days (3-16 d). Females took longer to home, averaging 10.6 days (6-16 d) compared to 6.9 days for males (2-12). It should be noted however that two males took only 2 and 3 days respectively, while the fastest female homed in 6 days. The length of time at home prior to the final catch then also varied across individuals, averaging 8 days across all individuals, 6 days (1-10) for females and 9 days (3-14) for males.

A total of 17 animals (1 adult female, 16 juveniles) were lost to follow up (LTF) either due to inaccessibility, lost transmitters or predation. Of the juveniles, more females were lost to follow up (n=11) than males (n=5), and slightly more were lost in the dry season (n=9) than the wet season (n=7). Snake predation was suspected in several individual cases, however was only confirmed with one male at the tents study site during the dry season (Appendix A).

Tables 4.7 and 4.8 outline the movement outcome for each individual, categorized by season, sex and age. Maps of each individual's movement for both the baseline and translocation periods are included in Appendix A. In general, adults displayed three movement types: remaining at the translocation site, repeated forays from, and returns to, the translocation site (sometimes for significant distances), or repeated, sequential movements in the general direction of home. Most juveniles remained at the translocation site, however nine were considered moving at the end of the study, and two made at least one foray and return to the translocation site. Specific details of these different movement strategies are outlined in the individual subject descriptions in Appendix A.

Total distance moved. The variable of total distance (SUM) was created to equal the sum of distances between all consecutive data points. A SUM variable was computed for each movement period. To test the effect of gender, age and translocation season on total distance moved across baseline and translocation movement periods, a mixed ANOVA was conducted. There was a significant difference in total distance moved across the movement periods for all subjects, F (1, 72) = 247.16, $p < .001$, partial $\eta^2 = .77$. On average, all subjects moved significantly more during the translocation period compared to the baseline period. There were systematic effects of age, gender and season on total distance moved between the two movement periods however. There was a significant interaction of age with movement period, F (1, 72) = 70.57, $p < .001$, partial $\eta = .49$ (Figure 4.5). Comparisons indicated that there was a significant difference between adults and juveniles for both the baseline period, F (1, 72) = 153.76, $p < .001$, partial $\eta^2 = .69$ and the translocation period, F (1, 72) = 5.03, $p = .03$, partial $\eta^2 = .06$. In both cases, adults traveled further between consecutive locations than juveniles, however the difference between the two age classes was considerably greater during the translocation period, with a mean difference of 1323.03 ± 1.07 m in the translocation period compared to 96.12 ± 1.05 m in the baseline period.

Table 4.8 Final Outcome Per Subject in the Wet Season, Classified by Independent Variables Age, Sex, Season as well as Capture Site and Field Season

2011					2012				
ID	Sex	Age	C.Site	Outcome	ID	Sex	Age	C.Site	Outcome
a11	female	adult	tents	remained at trans. site	a25	female	adult	ruins	remained at trans. site
a12	male	adult	tents	homed, ruins to tents	a26	female	adult	ruins	on the move
a13	female	adult	tents	homed, tents to ruins	a27	male	adult	ruins	homed, tents to ruins
a14	male	adult	ruins	on the move	a28	male	adult	ruins	on the move
a15	male	adult	ruins	homed, tents to ruins	a31	male	adult	ruins	on the mov
a16	male	adult	ruins	on the move	a32	male	adult	tents	on the move
a17	female	adult	ruins	homed, tents to ruins	a33	male	adult	tents	on the move
a18	female	adult	ruins	on the move	a34	female	adult	tents	homed, ruins to tents
a21	male	adult	tents	on the move	a35	male	adult	tents	on the move
a22	male	adult	tents	homed, ruins to tents	a36	female	adult	tents	homed, ruins to tents
a23	female	adult	tents	on the move	a37	female	adult	tents	homed, ruins to tents
a24	female	adult	ruins	on the move	a38	female	adult	ruins	on the move
j11	male	juvenile	ruins	remained at trans. site	j22	female	juvenile	ruins	on the move
j12	female	juvenile	ruins	remained at trans. site	j23	male	juvenile	ruins	remained at trans. site
j13	male	juvenile	ruins	remained at trans. site	j24	male	juvenile	tents	remained at trans. site
j14	female	juvenile	tents	remained at trans. site	j25	male	juvenile	ruins	remained at trans. site
j15	male	juvenile	tents	LTF; could not catch	j26	male	juvenile	ruins	on the move
j16	female	juvenile	tents	remained at trans. site	j27	female	juvenile	tents	on the move
j17	female	juvenile	tents	LTF; lost transmitter	j28	female	juvenile	ruins	on the move
j18	male	juvenile	tents	remained at trans. site	j31	female	juvenile	ruins	remained at trans. site
j21	male	juvenile	tents	remained at trans. site	j32	male	juvenile	tents	LTF; lost transmitter
j6	female	juvenile	ruins	LTF; lost transmitter/predation	j33	male	juvenile	tents	on the move
j7	female	juvenile	ruins	LTF; could not catch	j34	female	juvenile	tents	LTF; could not catch
j8	male	juvenile	ruins	remained at trans. site	j35	female	juvenile	tents	LTF; lost transmitter

Table 4.9 Final Outcome Per Subject in the Dry Season, Classified by Independent Variables Sex, Age, Season as well as Capture Site and Field Season

2013					2014				
ID	Sex	Age	C. Site	Outcome	ID	Sex	Age	C. Site	Outcome
a41	female	adult	ruins	on the move	a56	male	adult	ruins	on the move
a42	female	adult	ruins	LTF; lost transmitter	a57	male	adult	ruins	on the move
a43	male	adult	ruins	homed, tents to ruins	a58	female	adult	ruins	remained at trans. site
a44	male	adult	tents	homed, ruins to tents	a6	female	adult	ruins	on the move
a45	female	adult	tents	homed, ruins to tents	a61	female	adult	tents	on the move
a46	male	adult	tents	homed, ruins to tents	a62	male	adult	ruins	on the move
a47	female	adult	tents	on the move	a63	male	adult	tents	on the move
a48	female	adult	tents	on the move	a64	male	adult	tents	homed, ruins to tents
a51	male	adult	tents	on the move	a65	female	adult	tents	homed, ruins to tents
a52	male	adult	ruins	on the move	a66	female	adult	ruins	remained at trans. site
a53	male	adult	ruins	on the move	a67	male	adult	tents	homed, tents to ruins
a54	female	adult	ruins	on the move	a68	female	adult	tents	homed, ruins to tents
j36	male	juvenile	tents	remained at trans. site	j52	male	juvenile	ruins	LTF; confirmed predation
j37	male	juvenile	tents	remained at trans. site	j53	male	juvenile	ruins	LTF; lost transmitter
j38	male	juvenile	tents	remained at trans. site	j54	female	juvenile	tents	LTF; lost transmitter
j41	female	juvenile	ruins	on the move	j55	male	juvenile	ruins	LTF; lost transmitter
j42	female	juvenile	tents	LTF; lost transmitter/predation	j56	female	juvenile	tents	LTF; lost transmitter
j43	female	juvenile	ruins	LTF; lost transmitter/predation	j57	male	juvenile	tents	remained at trans. site
j44	female	juvenile	tents	LTF; lost transmitter/predation	j58	female	juvenile	tents	remained at trans. site
j45	male	juvenile	ruins	on the move	j61	male	juvenile	tents	remained at trans. site
j46	male	juvenile	ruins	on the move	j62	male	juvenile	tents	remained at trans. site
j47	female	juvenile	tents	on the move	j63	female	juvenile	ruins	on the move
j48	female	juvenile	ruins	not translocated	j64	female	juvenile	ruins	remained at trans. site
j51	male	juvenile	ruins	remained at trans. site	j65	female	juvenile	ruins	LTF; lost transmitter

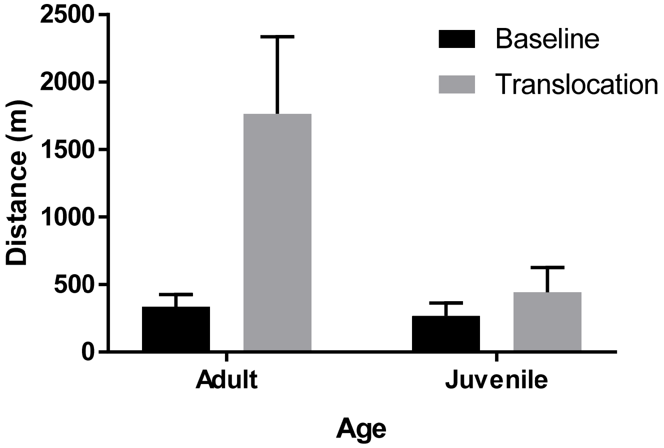

Figure 4.5 Total distance moved by adults and juveniles across movement periods.

There was also a significant interaction of gender with movement period, F (1, 72) = 7, p=.01, ŋ = .09. Comparisons indicated that while there were no significant gender differences during the translocation period, males traveled further mean cumulative distance (mean = 335.74 ± 1.07 m) compared to females (mean = 266.07 ± 1.07 m) during the baseline period, F (1,72) =5.58, p = .02, partial $ŋ^2$ = .07 (Figure 4.6).

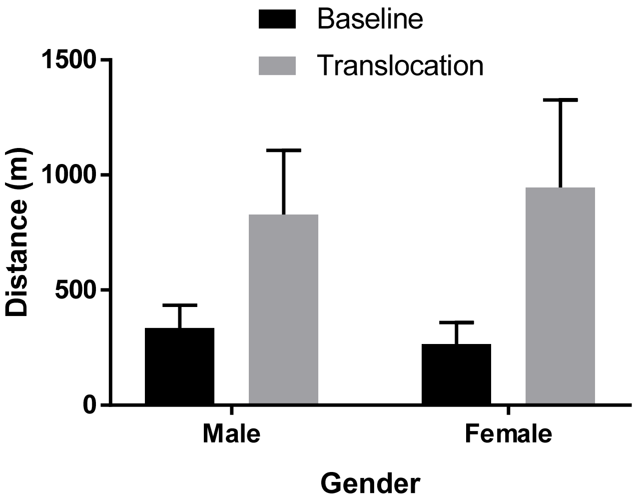

Figure 4.6 Total distance moved by males and females across movement periods.

Translocation season had a significant interaction with movement period on total distance moved as well, F (1, 72) = 5.37, p =.02, partial η^2=.07 (Figure 4.7). Comparisons indicated that across all ages and both genders during the baseline period, subjects traveled further during the wet season than the dry season F (1,72) = 13.76, $p < .001$, partial η^2 = .16 (mean 358.92 ± 1.07 m compared to 248.89 ± 1.07 m).

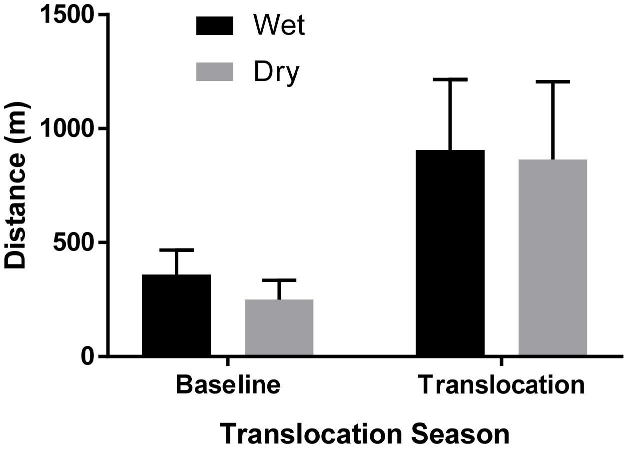

Figure 4.7 Total distance moved by translocation season across movement periods.

Examining the data excluding the homing adults, there remained a significant interaction of age with movement period, F (1, 55) = 52.82, $p < .001$. In both movement periods, adults moved significantly further than juveniles. There also remained a significant interaction of gender with movement period, F (1, 55) = 3.96, p = .05. Comparisons indicated however that without the homers included, the gender effect was only statistically significant during the baseline period, F (1, 55) = 4.62, p = .04. During the baseline period, males moved significantly further than females, mean = 340.41 ± 1.05 m compared to 271.02 ± 1.06 m. The effect of translocation season was not significant during either movement period when excluding the homing subjects, $p > .05$.

Average distance per movement. The variable of mean distance per movement (AVG) was created for each movement period and defined as the cumulative distance moved between locations/number of locations. To test for the effect of gender, age and translocation season on average distance per movement across baseline and translocation periods, a mixed ANOVA was conducted. There was a significant interaction of age with movement periods, F (1, 72) = 71.51, $p < .001$, partial η^2 =

.49. Comparisons indicated that while there were no statistically significant differences between adults and juveniles in the baseline period, adults averaged further per movement than juveniles during the translocation period, F (1, 72) = 119.30, $p < .001$, partial $\eta^2 = .62$. Adults averaged 86.50 ± 1.10 m per movement during the translocation period, while the juveniles averaged 22.49 ± 1.13 m per movement (Figure 4.8).

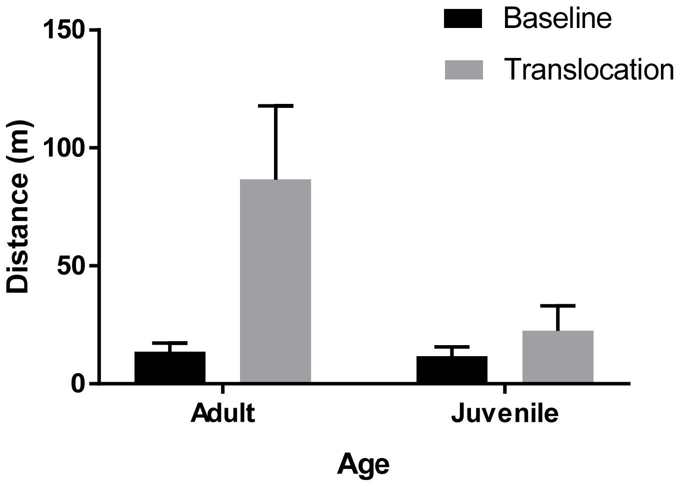

Figure 4.8 Average distance per movement by adults and juveniles across movement periods.

There was also a significant interaction effect of translocation season with movement periods, F (1, 72) = 5.56, p=.02, partial $\eta^2 = .07$. Despite the fact that the average movements were greater during the translocation period compared to the baseline period overall, the average distance per movement was only significantly different during the baseline period, and was greater during the wet season compared to the dry season (14.62 ± 1.10 m compared to 10.76 ± 1.13 m), F (1, 72) = 10.10, p = .01; partial $\eta^2 = .12$. (Figure 4.9).

Examining the data excluding the homing adults indicated that there remained a significant interaction of age across movement periods, F (1, 55) = 59.83, $p < .001$, partial $\eta^2 = .52$. Pairwise comparisons indicated that while there were no statistically significant differences between adults and juveniles in the baseline period, adults averaged further per movement than juveniles during the translocation period, F (1, 55) = 95.21, $p < .001$. There also remained a significant interaction of translocation season with movement periods, F (1, 55) = 4.58, p = .04, partial $\eta^2 = .07$.

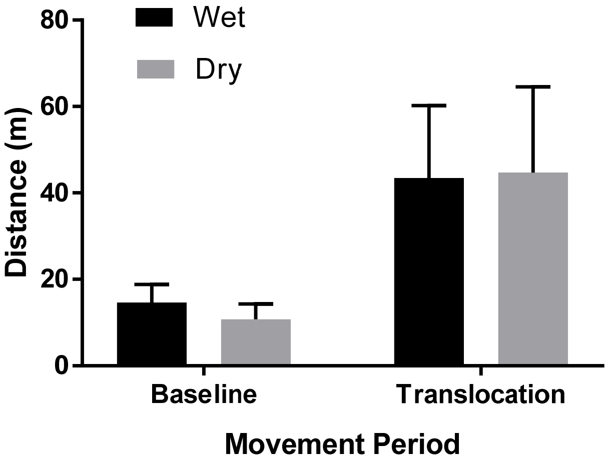

Figure 4.9 Average distance moved per movement by adults and juveniles across movement period.

As in the previous analysis, the average distance per movement was only significant during the baseline period, F (1, 55) = 7.67, p = .01. Subjects moved further per movement during the wet period, with a mean distance moved of 14.59 ± 1.07 m compared to 10.89 ± 1.10 m in the dry season.

Range length. The variable of range length (MAX) was created and defined as the longest distance between two consecutive data points for each movement period. To test the effect of gender, age and translocation season on range length across baseline and translocation movement periods, a mixed ANOVA was conducted. There was homogeneity of variances for both movement periods, baseline MAX F (2, 72) =1.08, p=.39 and translocation MAX F (2, 72) = 1.48, p =.19. There was a significant three-way interaction between movement period, age and gender, F (1, 72) = 4.34, p = .04, partial η^2 = .06. There was not a statistically significant effect of the two-way interaction between age and gender during the baseline period, p> .05, however there was during the translocation period, F (1, 59) = 5.66, p = .02. Comparisons indicated that there was a significant effect of age during this period, with adults of both sexes traveling further distances between consecutive data points than juveniles. The effect of gender however, was only statistically significant in the juvenile age class, with females traveling further than males on average, 110.15 ± 1.06 m compared to 67.61 ± 1.04 m, F (1, 59) = 4.82, p = .03, Figure 4.10.

Examining the data excluding the homing adults indicated that there remained a significant three-way interaction between movement period, age and gender, F (1, 55) = 4.51, p = .04, η^2 = .08. There was not a statistically significant effect of the two-way interaction between age and gender during the baseline period on range length, (p> .05), however there was a significant interaction in the translocation period (F (1, 59) = 5.6, p=.02). Comparisons indicated that there was a significant simple effect of age during this period, with adults exhibiting greater MAX values across both sexes. Adult mean female MAX = 266.07 ± 1.03 m compared to juvenile female MAX = 110.05 ± 1.02 m, F (1, 59) =13.85, p < .001. Similarly, mean adult male MAX = 349.14 m ± 1.01 and juvenile MAX = 67.61 ± 1.05 m, F (1, 59) = 59.03, p < .001. Across ages, the effect of gender was only significant in the juvenile age class (F (1, 59) = 4.82, p = .03). Juvenile females exhibited significantly larger distances between two consecutive locations than juvenile males, with an average of 110.05 1.17 m compared to 67.61 ± 1.16 m.

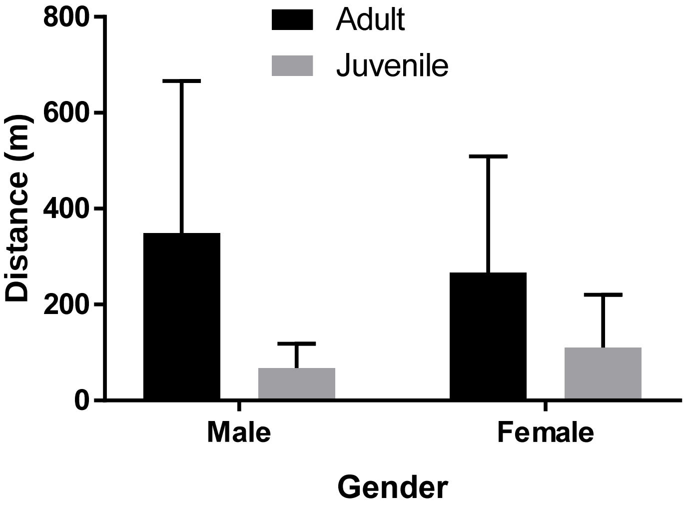

Figure 4.10 Maximum range length distances by age and gender.

Home ranges and minimum convex polygons. Minimum convex polygons (MCP) were developed for each movement period. While the baseline MCP represents a home range area, the translocation MCP represents the area covered while heading towards home, or while traversing back and forth from the translocation site and other locations in search of home. All values are in hectares. To test for the effect of gender, age and translocation season on MCP area across baseline and translocation periods, a mixed ANOVA was conducted. There was a significant trend between the two movement periods, F (1, 72) = 934.19, p < .001, partial η^2 = .63. This trend varied by age however, F (1, 72) = 37.28, p < .001, partial η^2 = .34. Comparisons indicated that this finding was only significant during the translocation period. During the baseline period, adult and juvenile home ranges were similar, and both very small at less than .002 ha. During the translocation period however, both increased significantly, with adult MCP = 6.78 ± 1.16 ha and juvenile MCP = .37 ha, F (1, 72) = 140.34, $p < .001$, partial $\eta^2 = .67$.

There was also a significant interaction of translocation season with movement period. There was a significant effect of season on the baseline period only, with MCP ranges significantly larger in the wet season than the dry season, F (1, 72) = 6.61, p = .01, partial $\eta^2 = .09$. MCP ranges in the wet season = .003 ± .002 ha compared to those in the dry season which were smaller, mean = .001 ± .002 ha.

Excluding the homing animals still resulted in an interaction of age on movement period, F (1, 55) = 24.80, $p < .001$, partial $\eta^2 = .31$. Comparisons again indicated that this effect was only significant in the translocation period, F (1, 55) = 81.21, $p < .001$. Adult subject MCP areas were significantly larger than those of juveniles, with mean adult ranges = 5.09 ± 1.2 ha and juvenile ranges = .37 ha. The effect of translocation season also remained, F (1, 55) = 3.92, p=.05, partial $\eta^2 = .07$. There was a significant effect of season in the baseline period only, with MCP ranges significantly larger in the wet season than the dry season, F (1, 55) = 4.50, p = .04. MCP ranges in the wet season were = .003 [.001, .009] compared to those in the dry season which were smaller, mean = .001 [.001, .003].

Homing intentions. Several variables were created to indicate movement progress for those subjects that did not home back to their initial capture site. These variables measured movements towards the subjects' initial capture site (CTRANS) or the inverse, movements away from the translocation site (TRANSPLUS). Subjects which homed to their initial capture site were not included in these analyses (leaving a total n=80).

Despite numerous transformations, the assumption of homogeneity of variances for data indicating movements towards the initial capture site could not be upheld. Therefore, nonparametric tests were utilized to test for differences in these variables across age, sex and translocation season. A Mann-Whitney U test was used to determine if there were differences in the minimum distance between the translocation site and initial capture site (CTRANSMIN) or average distance per movement (AVG) by the independent variables of age, sex and season. For all variables, distributions were similar based on visual inspection. All tests were conducted by gender.

For CTRANSMIN, median distances were statistically significantly higher in juvenile females (698.5) than in adult females (420), $U = 146$, $z=2.73$, $p < .01$. For CTRANSAVG, median distances were also statistically significantly higher in juvenile females (765.99) than in adult females (696.31), $U = 134$, $z = 2.15$, $p < .05$. For males, CTRANSMIN, median distances were also significantly higher in juveniles (744) than in adults (432), $U = 288$, $z = 4.6$, $p < .01$. For CTRANSAVG, median distances were statistically significantly higher in juveniles (777.16) than in adults (719.86), $U = 246$, $z = 3.2$, $p < .01$.

Analyses were also conducted to examine the effects within translocation season. For females, there were no statistically significant differences across ages for either CTRANSMIN or CTRANSAVG in the wet season. For males CTRANSMIN median distances were significantly higher in juveniles again (749) than adults (429), $U = 84$, $z = 3.30$, $p < .01$. There were no significant differences for the variable CTRANSAVG for males during the wet season.

During the dry season, there were no statistically significant differences across female age classes for either CTRANSMIN or CTRANSAVG. For males, CTRANSMIN median distances were significantly higher in juveniles (702) than adults (456), $U = 61$, $z = 3.12$, $p < .01$. For CTRANSAVG in males during the dry season, median distances were also significantly higher in juveniles (766.60) than adults (662.47), $U = 53$, $z = 2.28$, $p < .01$. Examining gender differences across seasons, there were no significant differences in CTRANSMIN median distances between the wet and dry seasons for adult males or for adult females ($p > .05$). Similarly, there were no significant differences in CTRANSMIN median distances between the wet and dry seasons for juvenile males or juvenile females.

The variable TRANSPLUS MAX was developed to indicate the greatest distance between a given location and the translocation site for each individual. The variable TRANSPLUSAVG was created to indicate the average distance from the translocation site for the translocation period. To test for differences in these variables by age, sex and translocation season, a one-way ANOVA was conducted on each dependent variable. For TRANSPLUSMAX, there was a significant main effect of age, $F(1, 55) = 52.81$, $p < .001$. Pairwise comparisons indicated that adults traveled the furthest distance from the translocation site, with a mean distance of 359.75 ± 1.12 m compared to 109.40 ± 1.12 m for juveniles. There was also a significant main effect of age for TRANSPLUSAVG, F (1, 55) = 28.31, p < .001. Pairwise comparisons indicated that adults were on average further away from the translocation site (adult mean = 142.89 ± 1.12 m; juveniles mean = 58.34 ± 1.12 m). Table 4.9 summarizes movement data for all subjects.

The Impact of Homing

Baseline plasma corticosterone. To further tease out the impact of homing behavior on differences in measures of stress and movement, mixed ANOVAs were conducted on each dependent variable over time by gender, translocation season and the categorical variable of homing ability. These analyses were conducted using only adults (n = 47).

Baseline CORT concentrations increased significantly across the baseline and translocation periods, F (2, 40) = 24.96, p < .001, partial η^2 = .56. Contrasts indicated that concentrations between both initial baseline and catch 2 baseline concentrations differed significantly from those at the final catch, [catch 1 vs catch 3, F (1, 20) = 32.86, p < .001, partial η^2= .62; catch 2 vs. catch 3, F (1, 20) = 21.35, p < .001, partial η^2 = .52]. The trend significantly differed between subjects that homed and those that did not, F (2, 40) = 6.62, p = .003, partial η^2 = .25. Contrasts indicated that baseline CORT concentrations for subjects that homed increased only slightly between catch 2 and the final catch, whereas increases were significant for those that did not home, F (1, 20) = 8.83, p = .01, partial η^2 = .31. There was also a main effect of homing, with subjects that did not home exhibiting higher baseline CORT concentration overall (Figure 4.11).

Capture stress corticosterone. The impact of homing on capture stress corticosterone was also examined. Capture stress CORT concentrations increased significantly across the three catch periods, F (2, 66) = 4.37, p = .01, partial η^2 = .12. Contrasts indicated that across all genders and seasons, concentrations increased significantly from catch 2 to catch 3, F (1, 33) = 9.34, p = .01, partial η^2 = .21, and from catch 1 to catch 3, F (1, 33) = 3.99, p = .05, partial η^2 = .11. There was a significant main effect of gender, with females demonstrating higher concentrations of stress induced CORT than males on average, F (1, 33) = 8.76, p = .01, partial η^2 = .21. Additionally, there was a significant main effect of homing, with animals that homed exhibiting average concentrations lower on average

Table 4.10 Summary of Movement Variables for All Subjects for Both Baseline and Translocation Movement Periods

	Adult								Juvenile							
	Male (n=24)				Female (n=23)				Male (n=20)				Female (n=13)			
	Mean	SEM	Min	Max	Mean	SEM	Min	Max	Mean	SEM	Min	Max	Mean	SEM	Min	Max
MIN																
Base	1.54	0.37	0.00	7.00	0.96	0.13	0.00	2.00	1.25	0.27	0.00	4.00	1.23	0.30	0.00	4.00
Trans	4.42	0.76	0.00	17.00	3.17	0.94	0.00	21.00	0.80	0.22	0.00	2.00	1.00	0.60	0.00	8.00
MAX																
Base	47.29	5.46	17.00	132.00	44.78	5.12	18.00	118.00	41.95	4.90	14.00	84.00	36.15	3.64	20.00	63.00
Trans	415.83	32.12	145.00	773.00	402.83	38.64	46.00	670.00	79.55	18.74	18.00	186.00	130.23	22.46	51.00	305.00
SUM																
Base	418.75	29.55	160.00	753.00	310.52	29.04	109.00	668.00	345.85	43.63	120.00	763.00	303.76	43.06	127.00	663.00
Trans	2052.17	199.65	720.00	4311.00	1879.73	181.59	705.00	4130.00	432.85	58.15	118.00	576.00	567.53	74.24	261.00	1222.00
AVG																
Base	16.53	1.22	6.67	32.74	12.73	1.02	4.54	26.25	14.49	1.72	5.00	31.82	12.78	1.73	5.77	28.83
Trans	106.17	10.62	35.00	226.89	90.44	9.97	24.00	229.44	23.21	3.82	6.94	40.07	27.93	3.92	11.60	58.19
MCP																
Base	0.10	0.02	0.02	0.38	0.08	0.02	0.01	0.35	0.09	0.02	0.01	0.23	0.07	0.01	0.03	0.22
Trans	10.52	1.48	0.83	30.95	9.08	1.33	0.24	20.87	0.60	0.13	0.02	1.21	0.71	0.24	0.13	3.46
CTransMin	304.87	54.21	1.00	711.00	309.21	55.94	0.00	776.00	730.40	11.23	582.00	810.00	675.60	22.88	518.00	757.00
CTransAvg	532.46	50.87	107.63	842.48	550.09	42.68	205.45	806.20	775.73	8.93	679.87	848.27	744.80	16.99	578.60	801.50
TP Max	570.00	52.98	155.00	958.00	542.78	54.00	89.00	885.00	117.65	24.54	19.00	508.00	155.53	27.84	57.00	358.00
TP Avg	343.01	50.26	48.78	765.06	282.80	43.37	49.37	732.28	67.87	12.84	15.71	266.64	79.44	19.69	19.52	290.67

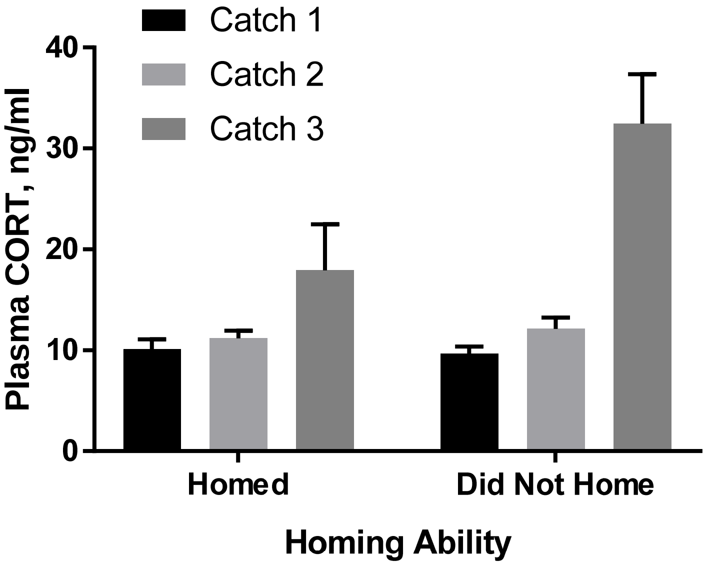

Figure 4.11 Adult mean baseline plasma corticosterone concentration based on homing behavior.

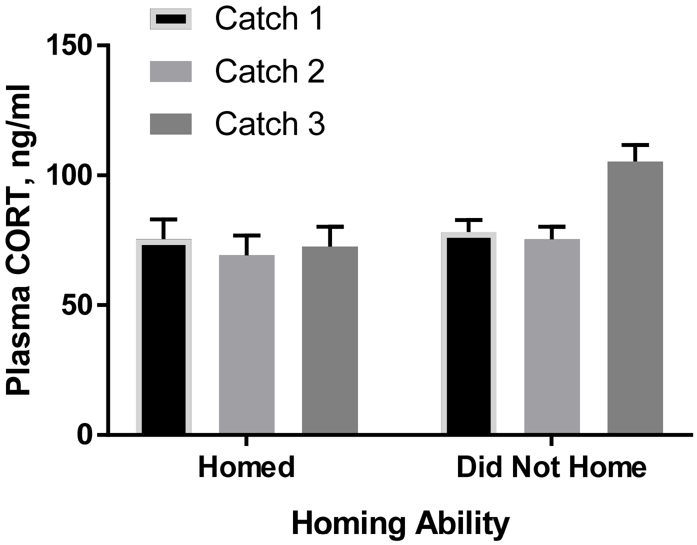

Figure 4.12 Adult mean stress capture plasma corticosterone based on homing behavior.

than animals that did not home, F (1, 33) = 4.17, p = .05, partial η^2 = .12 (Figure 4.12).

Stress response and stress response ratios. To examine the impact of homing on stress response ratios of adult subjects, a mixed ANOVA was conducted with the capture periods as the within variable, and gender, season and the categorical variable of “homed” as between variables. There were not significant differences in stress responses over time, F (2, 42) = .27, p = .76, partial η^2= .01. There was a significant main effect of gender, F (1, 21) = 4.71, p = .04, partial η^2 = .18, with females exhibiting higher stress response concentrations than males. There was a significant difference in stress reactivity over time, F (2, 36) = 9.36, p < .001, partial η^2 = .34 across all subjects, though the trend differs based on whether a subject homed or not. There was a greater decrease in stress reactivity for subjects that homed from catch 2 to catch 3, F (1, 18) = 6.53, p = .02, (Figure 4.13). There was also a significant main effect of the between subjects variable of gender, F (1, 18) = 12.3, p = .01, partial η^2 = .4, with females having significantly larger stress response ratio values than males.

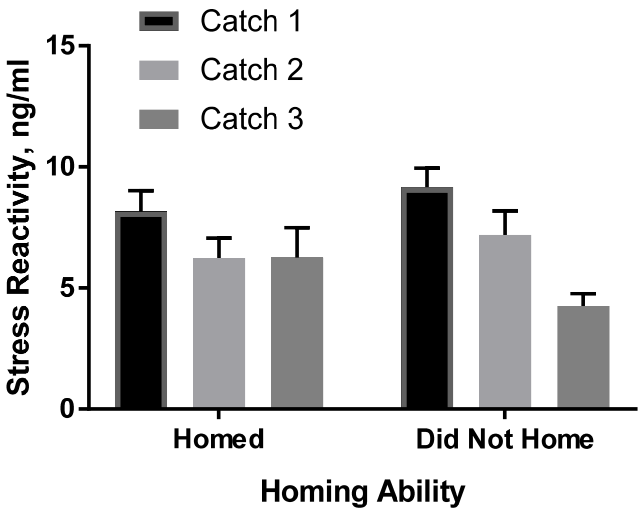

Figure 4.13 Adult mean stress response ratios over time based on homing behavior.

Leukocyte analyses. There were no significant differences in baseline H:L ratios over time, or as a function of gender, homing ability or season over time. There was however a significant main effect of gender, with males having a greater H:L ratio on average than females, F (1, 24) = 4.1, p=.05, partial η^2 = .15. To test for differences in stress induced H:L ratios over time, the covariate of time between the stress-induced and baseline samples was added as a covariate. When that variable was included in the analysis, there was a significant change in the stress induced H:L ratio over time, F (2, 56) = 3.51, p = .04, partial η^2 = .11. There was a significant main effect of gender, F (1, 28) = 7.06, p = .01, partial η^2 = .20, with males showing larger H:L ratios overall. There was a significant interaction effect though of gender and translocation season, F (1, 28) = 5.93, p =.02, partial η^2 = .17, and males had significantly higher H:L ratios in the dry season compared to females. For stress reactivity of the H:L ratio, there were no significant trends over time, or as a function of gender, homing ability or season over time. There was a significant effect of gender and season in stress reactivity of the H:L ratio, F (1, 15) = 4.93, p = .04, partial η^2 = .25. Comparisons demonstrated that female ratios were larger in the wet season, and male ratios were larger in the dry season.

Movement. To examine the impact of homing behavior on differences in measures of movement, a mixed ANOVA was conducted. There was a significant difference in MAX between the two movement periods, F (1, 39) = 339.67, p < .001, partial η^2 = .89, with the MAX movement during the translocation period being significantly greater than that during the baseline period. In addition, there was a difference between individuals that homed and those that did not, F (1, 39) = 4.72, p = .04, partial η^2 =.10, with those that homed demonstrated significantly larger MAX values.

There was also a significant difference in the total distance moved between the two movement periods, F (1, 39) = 288.37, p < .001, η^2 = .81, with baseline mean movements of 327.34 ± 1.06 m compared to translocation mean movements of 1770.10 ±.1.05 m. Adding a covariate of total time monitored to the analysis was not significant, F (1, 38) = .16, p = .69, partial η^2 = .01. There were no significant effects of gender, homing ability or season on total distance moved, though the between subjects main effect of gender was approaching significance (p=.06), with males traveling further than females overall.

There was a significant difference in average distance per movement between the two movement periods, F (1, 38) = 22.68, p < .001, partial η^2 = .37. Adding a covariate of number of movements to the analysis was significant F (1, 38) = 5.97, p = .02, partial η^2 = .14. The between subjects variable of gender approached significance (p = .06), with males traveling further on average per movement than females; however the effect of homing ability was not significant, p > .05.

There was a significant difference between the minimum convex polygons of the baseline and translocation periods across all genders and seasons, F (1, 38) = 166.9, p < .001, partial η^2 = .81, however there were no significant differences based on homing ability. The addition of a time monitored covariate in this analysis was not significant.

Characteristics of Homing Subjects

To test for significant differences among homers based on age, sex and translocation season, a mixed ANOVA was conducted on each dependent variable for those subjects (n = 17 adults; n = 8 females, n = 9 males). Dependent variables for the movement of all individuals that homed were calculated to the first location the individual was found in its original capture home range, rather than to the final catch as was calculated previously. Dependent variables for stress measures remain calculated to the final catch.

For baseline CORT concentrations, there were no significant differences by gender or translocation season at capture 1, capture 2 or the final capture ($p > .05$). For stress capture CORT concentrations, there were no significant effects by gender or translocation season at capture 1 or 2. At the final catch however, the effect of gender was approaching significance, F (1, 12) = 4.27, $p = .06$, partial $\eta^2 = .26$, with adult females that homed back exhibiting higher stress CORT concentrations than males, female mean = 82.79 ± 1.12 compared to male mean = 58.34 ± 1.09 ng/ml.

Analyses were also conducted on movement variables. For MAX to home, there were no significant differences based on gender or translocation season. There were also no significant differences based on gender or translocation season for SUM to home, a variable indicating total distance moved during the homing process. Similarly, there were no significant differences across gender or season for the mean distance moved in the homing period. There were also no significant differences across gender and season for MCP during the homing period. Time to home was also analyzed with a one-way ANOVA. While there were no statistically significant effects, the effect of gender approached significance, F (1, 13) = 2.36, $p = .08$, with males moving faster on average (6.9 days $\pm$ 1.3) than females (10.63 days $\pm$ 1.4).

Chapter 5

Discussion

This study investigated the impact of homing and stress on the translocation success of Turks and Caicos Iguanas. Results indicate that both variables have the potential to disrupt successful translocation attempts for the critically endangered species.

Hypothesis Testing

Results indicate that of 47 adult subjects in the analyses, 17 homed back to their original capture location (36.2%). In addition, adult subjects that moved outside of the translocation site demonstrated an ability to home shorter distances back to where they had been translocated, often time repeatedly venturing outside the translocation site only to return several days later. No juveniles homed, and very few ventured outside of the translocation site (Appendix A). Surprisingly, two juveniles did foray from the translocation site and return after spending several days outside the site. In both cases however, these movements were oriented directly east, rather than north, which would have demonstrated movements towards their original capture site. Given these results, null hypothesis 1 is rejected and null hypothesis 2 cannot be rejected; homing ability in this study differed by age.

Both male and female adult subjects exhibited significant increases in baseline and capture stress-induced plasma CORT over the capture periods. In juveniles, there was a gender difference. Juvenile males exhibited significant increases in baseline CORT over time, though there were no differences in capture-induced CORT over time for either gender of juveniles. Given these results, null hypothesis 3 is rejected; changes in baseline and stress-induced CORT concentrations did change over time for both genders in adults. Null hypothesis 4 cannot be rejected; male juveniles exhibited significant baseline CORT concentration increases over time but there were no significant increases for females, and no significant increases in stress-induced CORT concentrations for either gender. Translocation season did not have a significant effect on baseline or capture-stress induced plasma corticosterone for either gender or age class. Given these results, null hypotheses 5 and 6 cannot be rejected.

Impact of Homing Behavior

Findings regarding homing ability in the current study are similar to those reported for the Mona island iguana (Perez-Buitrago et al., 2008), where one-third of headstarted iguanas returned to the rearing facility and did not establish territories typical for adult wild iguanas, as well as the Jamaican iguana, where a handful of individuals demonstrated erratic and wide-ranging movements directly towards urban areas post-translocation (Wilson, pers. com.). These data are in contrast to the findings with Anegada iguanas however, in which none of the headstarted iguanas exhibited homing behavior and instead established territories near their release site. The ages of subjects and distances translocated differ in these studies, and differ relative to the species' home range. Subjects in headstarting studies were subadults, as compared to adults in the current study, and were held in captivity for several years (i.e. since collected as hatchlings from nesting sites) opposed to overnight in the current study. In the case of Turks and Caicos iguanas, Iverson (1979) opportunistically displaced several adults from .6 to 5.6 km from their home range, none of whom homed successfully, despite demonstrating initial, unsustained movements toward their original capture sites. The current study represented a displacement of approximately .8 km which is within the range of Iverson's work. The number of animals that homed overall is underestimated in the current study as well given that subjects homed in between study years, and many adults lost bead tags and could not be identified without capture (Appendix B). Incorporating the additional seven subjects that homed in between study years (n = 3 males, n = 4 females) increases the total percentage of adults that homed throughout the study to 51% (n = 12 males, n = 12 females).

Adult iguanas of both sexes also demonstrated homing behavior by "homing" back to the translocation site throughout the translocation study period. In these cases, animals would leave the translocation site, only to return from 1-5 days later, with each repeated foray oriented in a slightly different direction or longer distance than the previous one. These movements were nearly always in the general direction of home (as oriented north-south), and most definitely demonstrated an ability to "home back" to the translocation site, even from distances nearly equal to the distance to true home (Appendix A). This behavior may contribute to the finding that while animals that homed and did not both had larger MCPs during the translocation period, and the size of the MCPs did not differ significantly between homing subjects and non-homers. While unanticipated, these forays could have been expected given that traveling long distances for foraging and nesting aggregations has been documented in green iguanas and Galapagos land iguanas (Southwood, 2010).

While their movement was not considered homing behavior, juveniles also moved significantly more during the translocation period compared to the baseline period, though with few exceptions, remained at the translocation site and established home ranges and at least one retreat. Larger movements in only three cases were consistent with the directionality expected in homing animals. The exceptions to this behavior were particularly noteworthy however. Several juveniles traversed east for the entire width of the island. These movements were interesting given the significant distance compared to body size, and that the movements were consistently oriented perpendicular to the north-south orientation of home. This movement pattern was observed across study seasons and across translocation sites. In two cases, juveniles also demonstrated the foray behavior exhibited in adults, and after spending several days directly east of the translocation site, traveled back to the exact retreat used at the translocation site. These age differences in the ability to home are consistent with findings in other species, in that juveniles are not successful regardless of the type of displacement (straight-line vs not) or distance (short vs long), (Ellis-Quin & Simon, 1991; Freake, 1998; Freake, 2001).

Homing literature in other reptile species (Attum, et al., 2013; Holding et al., 2014; Hinderle et al., 2015; Lettink, 2007; Scali et al., 2012; Tuberville et al, 2005) indicated that when homing was successful, duration at the translocation site prior to moving and time to home varied across individuals. Similarly, while some successful homers in the current study left the translocation site within 24 hours, most remained for several days prior to additional “test” forays to and from the translocation site, and others remained for nearly a week prior to successfully homing via a relatively straight-line approach.

In the current study, there were no significant differences in homing abilities between genders, with the exception, while not statistically significant, that males homed more quickly than females. Genders did not significantly differ in homing intention movements either, as described by the variables CTRANS and TRANSP, Table 4.9. Overall movement did vary by gender however. While there were no significant differences in total distance moved between genders in the baseline period, females of both ages moved significantly more during the translocation period. These findings are in contrast to tortoises

(Hinderle et al., 2015) where both genders demonstrated the ability to home, but males exhibited more total movement than females. Interestingly, Scali et al. (2013) demonstrated that both male and female *P. muralis* successfully homed and that a key variable in success in this study was color morph rather than gender.

There were no significant differences between the wet and dry seasons in total distance moved for adults during the translocation period. There was a seasonal effect noted during the baseline season for all subjects however, with all subjects traveling further in the wet season than dry, possibly attributable to the availability of intermittently ripening fruits and plants.

Impact of Post-Translocation Stress

Findings regarding evidence of stress post-translocation is similar to recent findings in varied taxa and translocation methodologies: avian (Jenni et al., 2014; Leche et al., 2016), mammal (Aguilar-Cucurachi, et al., 2010; Bosson et al., 2013; Franceschini et al., 2008) and reptile (Anderson, et al., 2015a; Anderson et al.; 2015b; Holding, et al., 2014). Adult iguanas exhibited significantly elevated baseline and capture-induced plasma corticosterone from baseline to the final catch post-translocation. To account for the wide variation in baseline levels across individuals, two variables were developed to partially control for that variation and to determine if the stress response from baseline to capture was changing over the repeated stressors of monitoring and movement (Stress CORT (capture-induced CORT – baseline CORT) and Ratio Stress CORT (capture-induced CORT/baseline CORT). The findings across the two variables differed, but were most likely attributable to the increases in the baseline values over time. As indicated in Romero (2004), given that baseline and stress-induced GC concentrations interact with different receptors, reporting a percent change in GCs is of little value since the biological effect might be opposite from what is predicted from the percentage changes. However, given that in the current study, repeated samples were possible over time, the changes (or lack thereof) in stress response variables can provide insight into the ongoing effects of the stressors on the subjects. Given that both baseline and stress-induced CORT concentrations increased over time, the subjects were clearly experiencing the repeated captures and translocation as stressful. The lack of a return to initial baseline values for all subjects indicates the animals are experiencing a certain level of disrupted HPA functioning (specifically the negative feedback loop) given the chronic stress. However, the ability for all subjects to continue to mount a stress response (as evidenced by the stress response and stress ratio response variables), indicates that they are experiencing the repeated handlings and translocation as increasingly stressful. This finding is similar to that found in tuatara (Anderson et al., 2015a; 2015b) where there were no suppressive effects of the additive stressors on the acute stress response over time. Interestingly, Gerber et al. (2004; pers. comm.) found that TCI iguanas held longer than in the current study and translocated to different islands demonstrated increases in baseline plasma CORT concentrations that surpassed initial capture-induced stress responses. In the current study, baseline concentrations remained well below those of the capture-induced stress. Given the design of the current study, subjects from previous translocations were only bled again opportunistically and not prior to a year after homing at the earliest. In those cases, subjects had returned to initial baseline levels seen at catch 1, though there is no way to know how long the effects of the chronic stressors remained physiologically prior to that bleed.

There is an alternative hypothesis regarding the elevated baseline CORT changes over time however. For baseline bleeds, all animals were bled within 3 minutes of capture or the sample was not used. However, given the fact that animals were caught three times throughout the study period, the animals became noose-wary and while captures were abandoned if the animal ran repeatedly or appeared overtly impacted, the stress response may have begun well before the animal was in-hand.

The significantly increasing concentrations of plasma CORT over time did not vary dependent on gender, however there was an overall main effect of gender with females exhibiting higher plasma CORT than males, similar to data by MacDonald et al. (2007). Similarly, there was not a significant effect of season on the trend of plasma CORT; however, both genders demonstrated increased mean CORT concentrations across movement periods during the dry season. Interestingly, differences in stress response ratios approached significance indicating that the response was greater in the dry season than wet. While perhaps more subjects are needed to find a significant effect, these findings correlate well with a general finding by Romero (2002) that many reptiles show peak capture-stress responses in the breeding period. Or alternatively, perhaps the abundance of food availability in the wet season reduces the stress response during this season.

Changes in H:L ratios over time in adult subjects were more complex. In several vertebrate species, the number of heterophils (or the neutrophil analogs in mammals) increases in response to stressors while the number of lymphocytes decreases in circulation. The stress-induced redistribution of leukocytes is thought to be beneficial in distributing the cell types where they are most needed (e.g. into the lymph nodes and spleen (lymphocytes), or into the blood stream (heterophils), (Seddon & Klukowski, 2012). However, the time course for the elevation of H:L ratios in reptiles in uncertain, and most likely varies among species (Davis, et al., 2011). For example, Seddon and Klukowski originally interpreted a modest but significant H:L ratio after 1 hour of capture induced stress in skinks to mean the stressor was too short. However, when constrained for 2 hours, there was no longer an effect on the H:L ratio. In contrast, Davis et al. (2012) demonstrated that changes in H:L ratios due to capture method could be identified in as short as a “walk back” for noosed animals in spiny-tailed iguanas, or in 10 minutes in tree lizards (French et al., 2008). In the current study, H:L ratios were determined at both baseline and stress-induced bleeds across captures. There was considerable variation across individuals, with some subjects showing increases between the two bleeds in a single catch, others showing decreases, and others showing no changes. Across all adult subjects however, the baseline H:L ratios did not significantly increase over time, but the capture-stress induced concentrations did show a significant increase over time when the covariate of time between bleeds was added. Opposite to the findings for plasma CORT, there was a main effect of gender, with males showing higher H:L ratios than females. Interestingly, the analysis of time between bleeds did indicate a main effect of gender, and females were bled on average sooner than males for the capture bleed. Without a systematic study examining the time-course of the leukocyte response in this species, it is hard to know if this finding is an artifact of time bled. An alternative explanation is described by Gossling et al. (2015) and Muller et al. (2011), in that perhaps the H:L ratio and plasma CORT respond differently to different stressors. It is feasible that males perceive the repeated captures and translocation as a more extreme stressor than females and that was reflected in the H:L ratio rather than plasma corticosterone. Adult stress response H:L ratios did not significantly change over time, which would not have been expected given the variability in the data and lack of a significant change in the baseline values.

Given the difficulty in bleeding juveniles (particularly during the first field season), fewer data are available for this age class. There was a significant increase in baseline plasma CORT over time, but this finding was only significant for males and is most likely an artifact of the sample size differences across genders as both show general increases over time (Table 7). There were no significant increases in capture-induced CORT over time, though both genders show moderate decreases in the stress response between catch 1 and 2 which may be indicative of acclimation to the handling. While a direct comparison was not made statistically, it is evident in Tables 7 and 8 that juvenile concentrations for both baseline and capture-induced bleeds are much higher than adults. It is not known if these are due to developmental, biologically-relevant or methodological differences. It could be that juvenile CORT values are higher given the tremendous predation pressure that juveniles are under and that the capture and handling was perceived as significantly more stressful in juveniles than adults. Or, they may also be more stressed given their small size and almost constant competition with larger animals. Given that the baseline values are more similar between juveniles and adults, either of these could be plausible rationales for the differences. There were no significant differences between adults and juveniles in time between bleeds for each catch, so it is not expected that time in hand was a factor here.

Leukocyte analyses in juveniles were also complex. There were no significant differences between H:L ratios between movement periods for juveniles, but there were definite trends over time from baseline to final catch (.73 to .25 in males; 1.29 to .29 in females). These trends are both opposite to the slightly increasing trend over time in adults, and juvenile values overall are much lower than those in adults. As described by Gossling et al. (2015) and Muller et al. (2011), it appears as if the H:L ratio and plasma CORT respond differently to different stressors. It could be that the H:L ratio is responding to a different perceived stressor. However, if the environment was perceived as stressful, the H:L ratio should still increase over time since as described in Gossling et al. (2015), the elevation of H:L ratio in response to environmental stress does not decrease over the time duration of the stressor. Instead, another explanation is that the absolute differences could be due to developmental differences. For example, Kakizoe et al. (2007) found that the proportion of heterophils and lymphocytes within differential leukocyte counts significantly changed over increasing age in juvenile loggerhead turtles. Relative cell type counts for adults in the current study are in line with those published for allied iguana species (Davis et al., 2011; Fisse et al., 2004), but juvenile data are not available to the author's knowledge in this species.

There were significant impacts on post-translocation stress measures depending on if a subject successfully homed or not. The trend in baseline CORT for non-homing subjects was significant between catches 2 and 3, while it was not for those animals that homed. As indicated by Dickens et al. (2009; 2010), translocation stress can be additive and result in chronic stress. Given that animals that homed showed decreasing trends in CORT levels at the final catch compared to non-homers, it can be suggested that their corticosterone responses were returning toward initial baseline levels in the absence of the repeated stressor (novel environment, increased movement, etc.). While not statistically significant, non-homers also exhibited nearly double the absolute CORT concentrations at final catch compared to homing animals. These findings together indicate that the homing process is indeed perceived as stressful to the subjects, and while resulting in chronic stress and a disrupted HPA axis response evidenced by the chronically elevated baseline concentrations, the absence of the stressful environment began to return the subjects to normal functioning. The ability to monitor these animals over a longer study period would have been useful in confirming this result.

There was no difference in the capture-induced stress concentrations based on homing ability, though animals that homed did demonstrate somewhat lower mean concentrations overall (66.83 ng/ml for homers compared to 79.77 ng/ml for non-homers). The lack of a significant finding may be due to both the sample size and the differences in time to home. Interestingly, the main effect of gender persisted with females demonstrating significantly greater capture-stress induced CORT concentrations. In the examination within homing individuals, females that homed back also had higher capture-induced CORT concentrations than males that homed. It is unclear if these differences are due the fact that females perceive the homing process to be more stressful, or an artifact of the fact that females took longer to home by 3 days on average than males. Leukocyte analyses did not reveal any differences between homing subjects and those that did not home. It is interesting to note that the only movement variable that differed between homing and non-homing individuals was the variable describing the maximum movement between two consecutive points. Despite these significantly longer movements in homing subjects, the continued movement through novel environments by the non-homers may have been perceived as more stressful as evidenced by the higher baseline CORT concentrations in these subjects.

Study Challenges and Implications

As in any study involving wild animals, there are many uncontrolled factors that may have impacted results in the current study. First, it is important to validate any CORT assay via an ACTH challenge to determine assay sensitivity in general, and potential differences in responsiveness across populations. There are no TCI iguanas in captivity and given the nature of this study and the endangered status of the subjects, an ACTH challenge was not feasible. Despite this, the changes in plasma CORT were wide ranging between bleed type (baseline or stress-induced) and catches as well as across individuals and study sites. For these reasons, the author accepts the sensitivity of the assay used for detecting responses to the stress of translocation and frequent catching and handling over the 6-week study.

The interpretation of leukocyte analyses is complex, particularly when health status is unknown. In the current study, no additional parameters outside of overt physical signs were used to determine whether animals were healthy. No blood parasites were seen on the blood smear slides, but to discern an ongoing inflammatory response, a determination of the absolute total leukocyte count and an assessment of leukocyte morphology should have been conducted. If total leukocyte counts are high, it can suggest a possible infection, or stress-induced immunosuppression if values are low. Timing of the blood sample is also critical to interpretation of reptile leukocyte analyses. It has been suggested that the slowest leukocyte responses to stressors occur in ectotherms, though few studies have been conducted in reptiles (Davis, et al., 2011; Seddon & Klukowski, 2012). These results highlight the importance of determining the time course for leukocyte responses for each study species. In addition, stress may also affect levels of other hormones such as testosterone that may in turn influence leukocytes (Seddon & Klukowski, 2012). Given these challenges in interpretation, pooled levels of GC metabolites may have been preferred to indicate chronic stress and the addition of an analysis of feces or shed skin may have yielded different results than the H:L ratios.

Plasma corticosterone was only sampled two times per catch and thus an integrated corticosterone response curve could not be calculated. The total integrated corticosterone response is a measure of how much corticosterone is secreted during a period of sample collection, so includes both the basal CORT secretion as well as the response to the stressor applied, and is an important variable compared to the max value (Cockrem & Potter, 2009; Cockrem & Silverin 2012; Romero, 2004). In this way, variation both within and across subjects can be better compared and this type of analysis may have added to the interpretation of results in this study.

There could have also been significant differences between the two capture sites (ruins vs. tents) that may have altered results in the current study. Literature reviews have shown that habitat quality or lack of specific habitat characteristics are one of the greatest reasons for translocation failure (Germano et al., 2014). While the relative abundance of both iguanas and plant types was crudely evaluated and deemed equivalent between the two sites, there may have been biologically-relevant differences between them given the differences in the number of successful homers from each site. Similarly, while subjects at both sites were similar in important baseline size morphometrics, there did appear to be more distinction between the two in regards to baseline stress values. These differences may have represented different predation pressures or human exposure (as in French, 2008), which could have influenced both homing pressures and stress responses in these subjects.

Aside from these inherent challenges, the current study has important implications to the conservation management of TCI iguanas and allied species. Since adults of both sexes can home to the original study site and also traveled significantly further than juveniles during the translocation period, it can be surmised that the energetic costs of the translocation to the adults are much higher, and thus may result in both short and long-term implications on the success of the translocation for that age class. In the short term, if the goal of an on-island translocation is to remove animals from a pending construction site, there is a nearly 40% likelihood that adults would return to find their retreats destroyed, or worse yet, killed themselves by the construction. As noted in this study, adults home back in a relatively short timeframe and therefore these consequences for homing animals cannot be avoided. During periods of construction, a significant source of mortality for adult iguanas is due to road mortality and being hit by golf carts or construction vehicles. The wide-ranging movements demonstrated by adults during this period may increase that probability. In addition, given that male iguanas are highly territorial year round, travel in and out of strange male territory results in aggressive interactions along the way, and more than one subject was observed fighting during the translocation period and/or caught with fresh bite wounds at the final catch. Given these implications to adults, juveniles may make better translocation candidates, and thus the current study would concur with Alberts (2007) and Wilson et al (2004) that juveniles may make the best translocation candidate given data that they demonstrate less wide-ranging movements, remain at the translocation site and demonstrate the ability to integrate socially into existing populations. The impacts of stress on juveniles, however, cannot be overlooked. For example, Romero (2004) describes that moderate stressors applied directly to neonates can result in a life-long reduction in glucocorticoid responses to stressors, and stronger stressors may result in life-long hypersecretion of glucocorticoids compared to moderate stressors. Therefore, exposure to stressors early in life can induce significant life-long changes in the HPA axis, and given the pronounced increases in baseline CORT values between the baseline and translocation periods in juveniles, this could be problematic long-term. The ability to continue to monitor the juvenile subjects from this study over time will reveal important data regarding the impact of this study on the subjects' maturing HPA axis systems.

Both adult males and females demonstrated decreased body condition and increased baseline and capture-stress CORT concentrations over the movement periods, indicating that the repeated captures, handling and translocation were perceived as stressful to them. And, the study treatment did indeed create chronic stress as evidenced by the increased baseline plasma CORT concentrations and thus disrupted HPA axis functioning. In the short term, a response to an acute challenge is believed to be adaptive. However, as in the case of these subjects, the negative feedback signal was disrupted and individuals experienced prolonged elevations of glucocorticoids, and over time there can be detrimental physiological and behavioral consequences. The data indicated that while the baseline plasma CORT concentrations increased and remained elevated throughout the study period, they never did reach the level of the initial capture-stress concentrations as in Gerber (2004) or Adams et al. (2011). And, these subjects continued to demonstrate the ability to mount a stress response throughout the duration of the study, indicating that the repeated captures and translocation process was not perceived as so stressful that the HPA axis was downregulated. It should be noted however, that approximately 50% of the adult subjects were “still on the move” when these final blood samples were taken. As indicated by the comparisons of homed vs. not-homed subjects, the baseline plasma CORT concentrations only began to trend downward after animals returned home. Non-homed subjects that continued to experience perceived stressful environments (e.g. novel territory, lack of known resources, fighting with strange conspecifics) may continue to experience chronic stress that may over time result in more significant physiological consequences.

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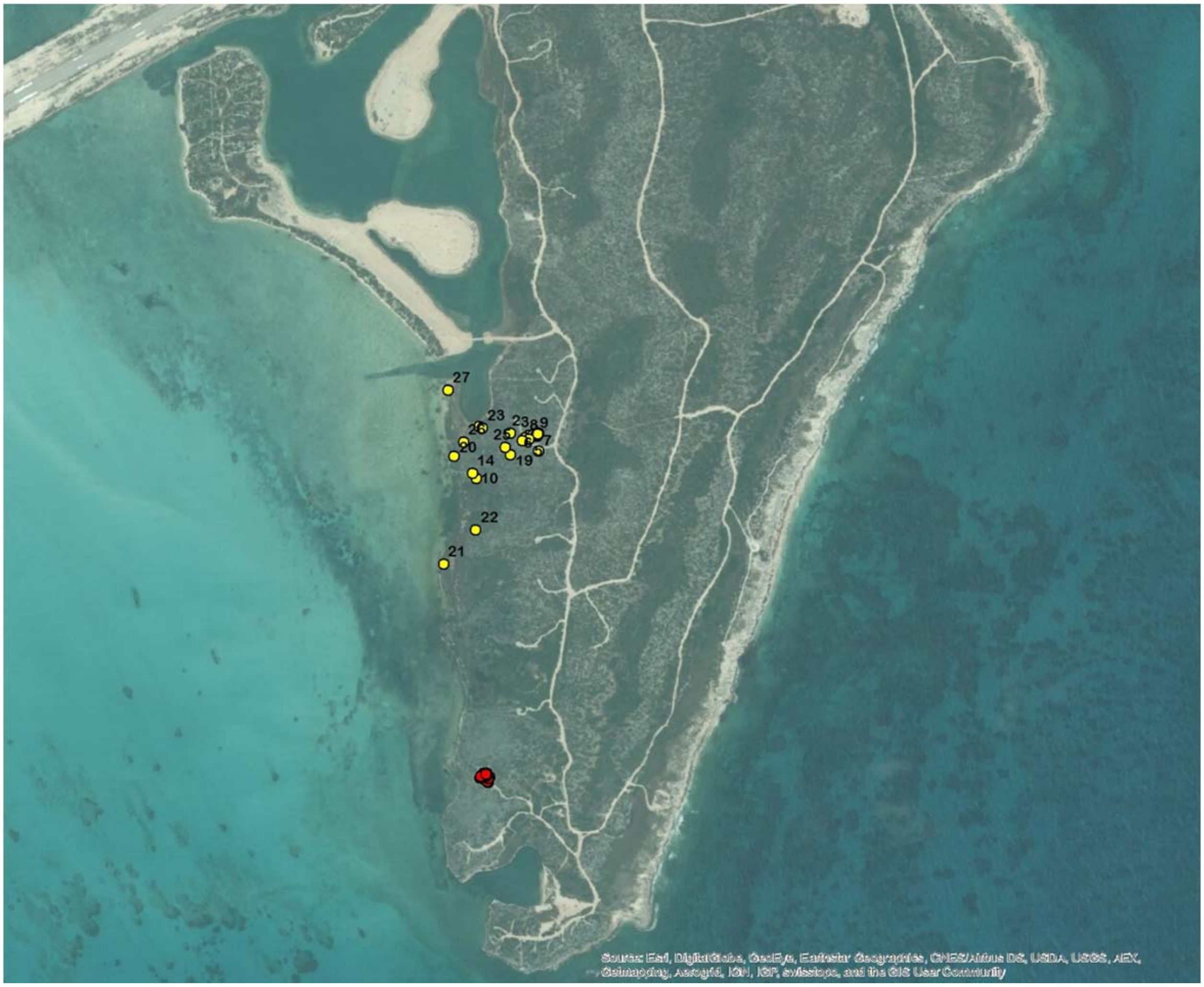
Appendix A

Individual Subject Movements: Baseline (Red) and Translocation (Yellow) Periods



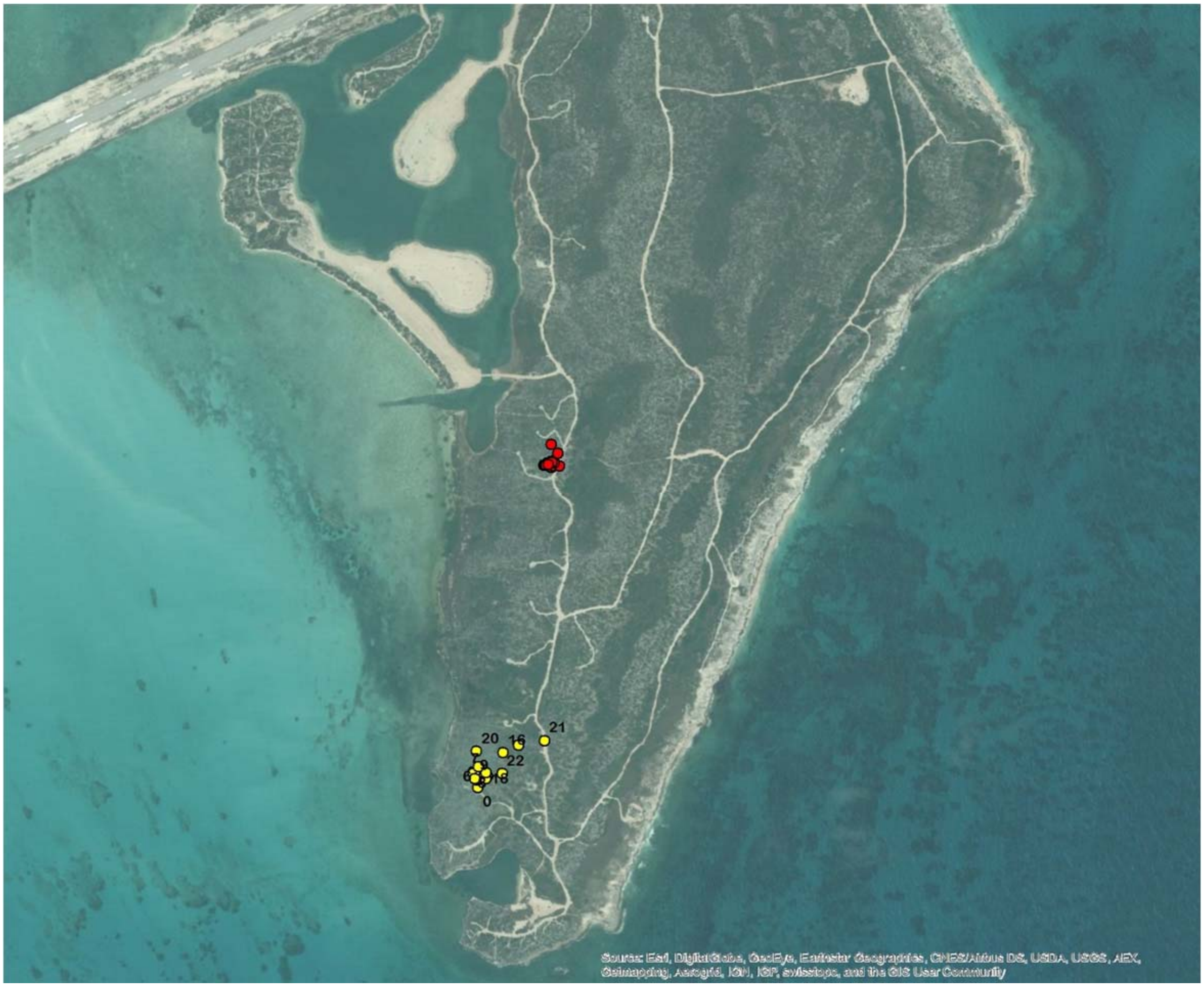
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A11 (female, adult, wet season, 2011) was translocated from the tents to the ruins. She made several forays from the area towards the west coast, and south towards home. She would return to her chosen retreat at the translocation site in between forays. She was ultimately caught in the marshes just west of the ruins study site. She has been observed every study period since her final catch and uses the same retreat she chose in 2011.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A12 (male, adult, wet season, 2011) was translocated from the tents to the ruins. He homed back to the tents in 4 days. A14, a translocated male from the ruins had taken up residence in his old retreat in his absence, and he spent several days upon returning home in altercations with him. A14 eventually left the area and A12 has been observed at the tents study site in all subsequent field seasons.

A13 (female, adult, wet season, 2011) was translocated from the tents to the ruins. She made her way to the mangroves on the west side of the island, and was located approximately 3 m in the air at one point in a tree at that location. She remained there for 2 days, and ultimately homed in 7 days. She was observed in the same retreat area yearly for the next three field seasons.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A14 (male, adult, wet season, 2011) was translocated from the ruins to the tents. He made several forays from the translocation site, but returned to the translocation site throughout the translocation period. He was caught in the tents study area during the final catch. In the 2012 field season however, he was observed one time in the ruins study site within the baseline period home range (Appendix B). He has never been observed since, though many of the study animals have since lost their beads.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A15 (male, adult, wet season, 2011) was translocated from the ruins to the tents. He moved quickly and aggressively towards home, though it appeared as if he was startled at one point by my presence and backtracked a bit. He made it home in 8 days, and was observed in 2012 and 2013 at his original capture site.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

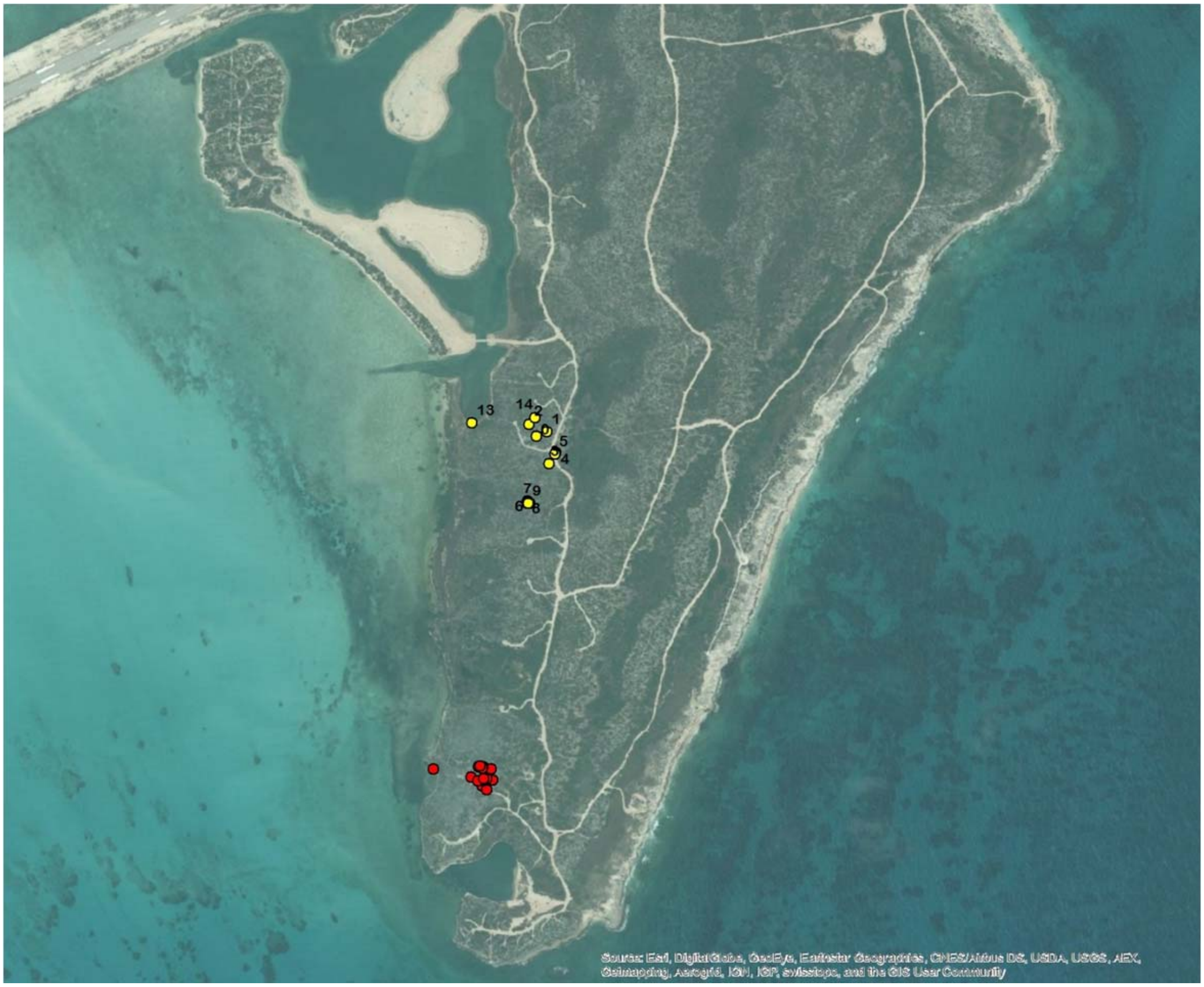
A16 (male, adult, wet season, 2011) was translocated from the ruins to the tents. Following numerous sightings in the translocated area, he moved towards the north and home. He made a long foray mid-way towards home prior to returning to the translocation site. He ventured out a second time, and his final catch was nearly two-thirds of the way towards home, equidistant to his first foray. An adult male without beads that has not been caught to date has been sighted using his retreat, and it is suspected that he has homed and reintegrated into his original retreat area though he has never been recaught.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A17 (female, adult, wet season, 2011) was translocated from the ruins to the tents. She moved directly towards home and reached her original retreat in 13 days. Interestingly, she backtracked once for several days prior to finding home. She had been observed at the same retreat area yearly, minus the 2014 field season.

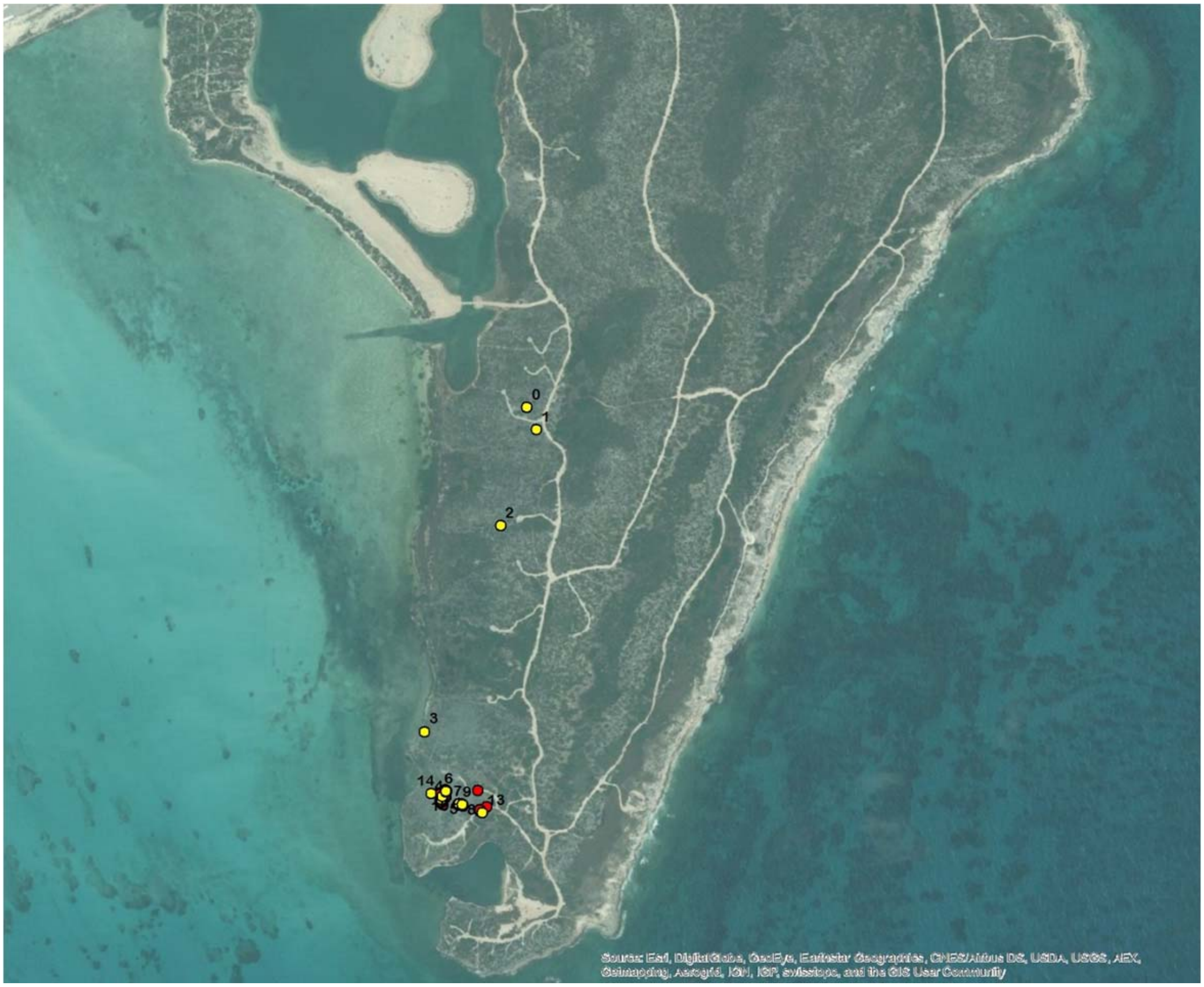
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A18 (female, adult, wet season, 2011) was translocated from the ruins to the tents. She made several forays north and east, and her longest forays left her approximately half way towards home. She was observed home in 2012, after the original study period and has been observed in her original capture area since (Appendix B).



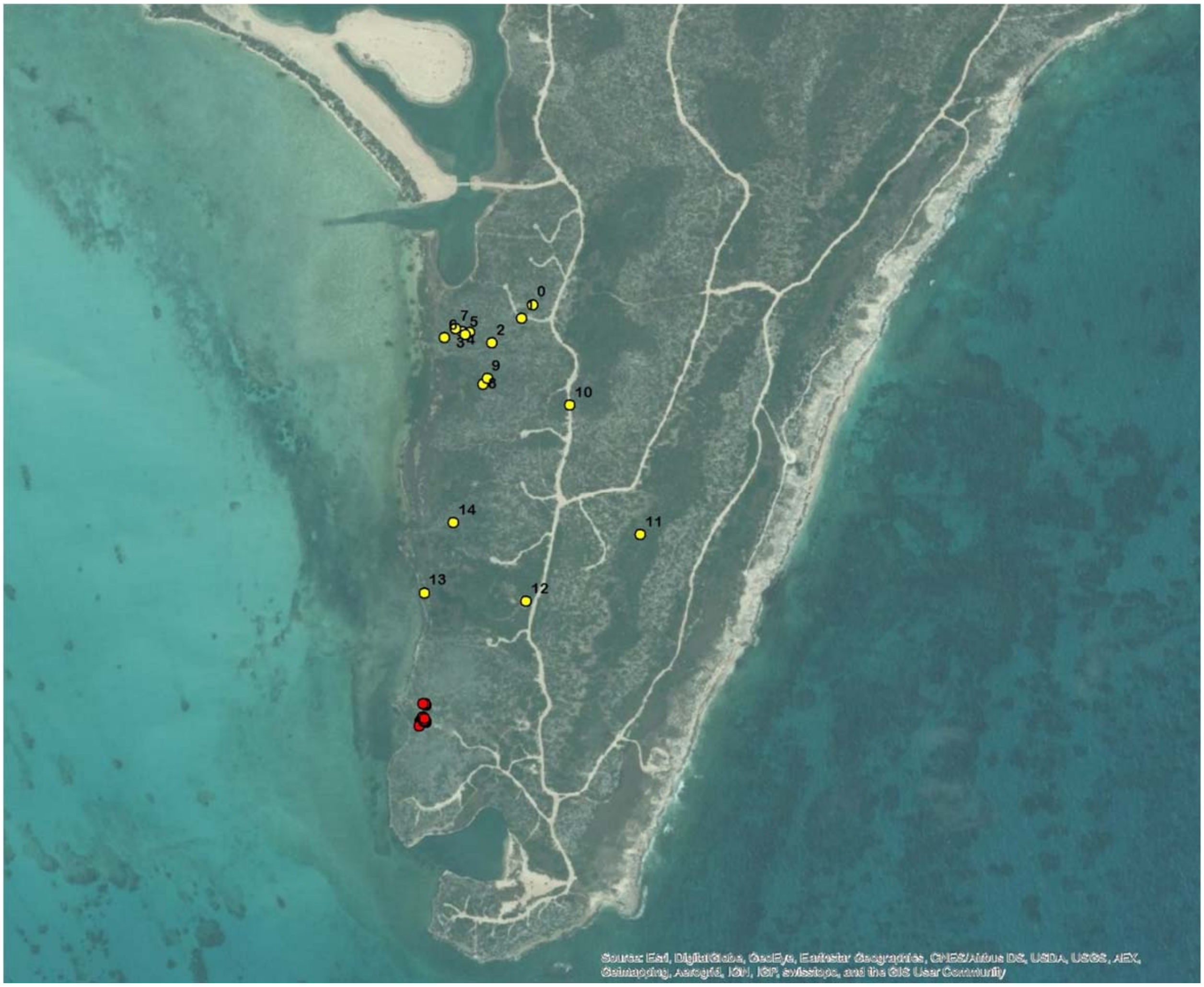
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A21 (male, adult, wet season, 2011) was translocated from the tents to the ruins. He made several short forays south and west from the ruins, but was ultimately caught near from the translocation site.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A22 (male, adult, wet season, 2011) was translocated from the tents to the ruins. His initial movements were in the direction of home, and he made the journey in a record 3 days. He has not been observed in subsequent field seasons, however his retreat area was not in the core study area and it is probable that he lost his beads.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A23 (female, adult, wet season, 2011) was translocated from the tents to the ruins. She moved entirely in the direction of home and was ultimately caught midway between the sites. She was sighted several times along the coast and in trees along the coast. She had homed by the 2012 field season (Appendix B) and was observed again in 2013 but not in 2014.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

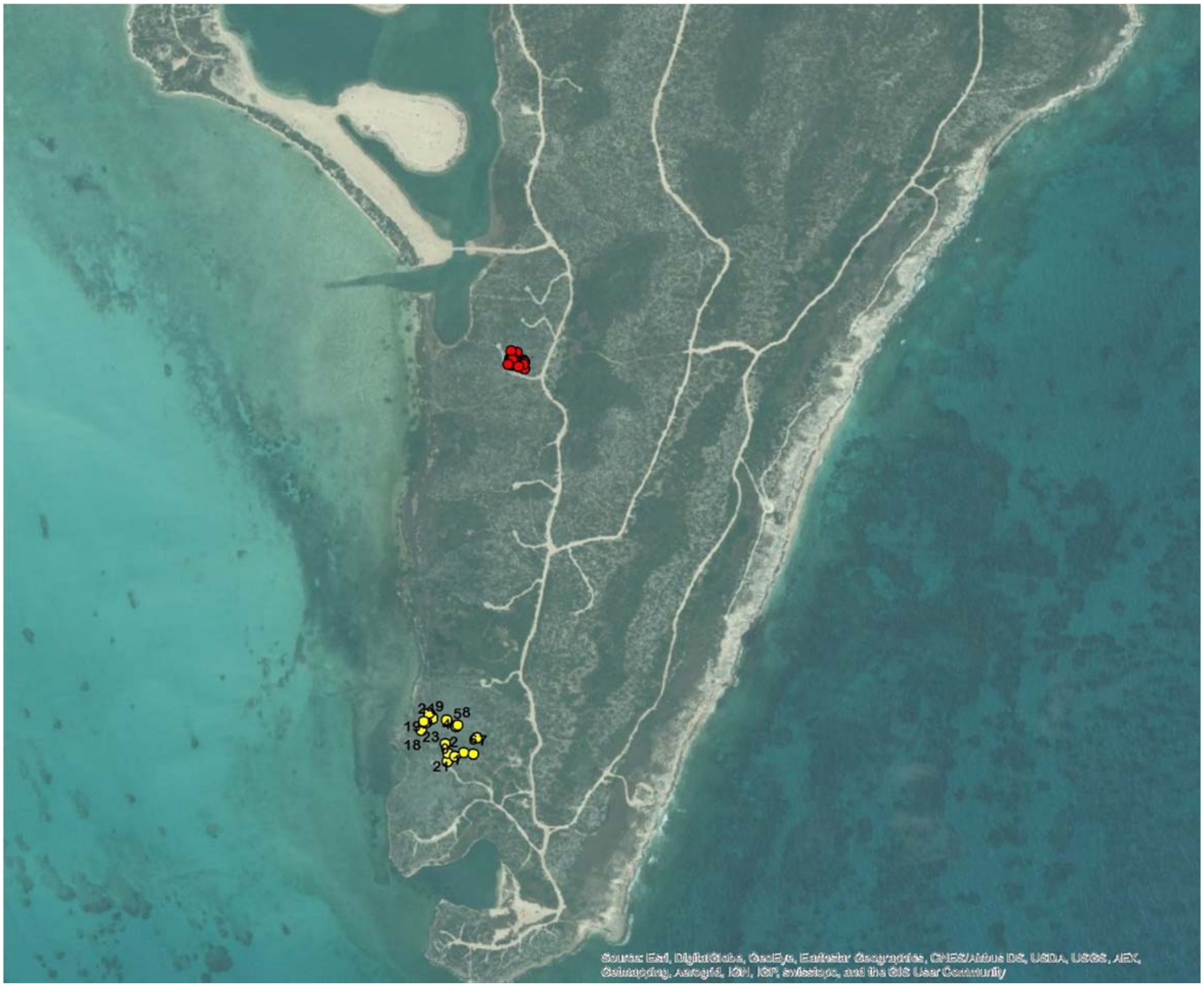
A24 (female, adult, wet season, 2011) was translocated from the ruins to the tents. She spent the majority of the study period in the translocation study site following one significant foray approximately halfway home. She has not been observed since.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J6 (female, juvenile, wet season, 2011) was translocated from the ruins to the tents. Following the original translocation, she was not observed visually and all data points were located at a solution hole. Following 9 days of no additional movement, the subject was assumed to have lost its transmitter or to have been predated. There was no final catch of this subject and it was considered LTF.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J7 (female, juvenile, wet season, 2011) was translocated from the ruins to the tents. J7 was one of the few juveniles moving towards home from the translocation site. Her movements eventually brought her to an area termed the abyss which is inaccessible. Given her location and failed catch attempts, there was no final catch of this subject and she was considered LTF.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J8 (male, juvenile, wet season, 2011) was translocated from the ruins to the tents. He remained at the translocation site, but did make small movements towards the coastline. During his final catch, he was found inside a dead tree branch which was broken to retrieve him. Interestingly, a snake was also found inside the branch.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J11 (male, juvenile, wet season, 2011) was translocated from the ruins to the tents. He remained at the translocation site, in an area right on the shoreline, and chose a large rock slab retreat on the shore's edge. He has been seen during every field season since 2011.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J12 (female, juvenile, wet season, 2011) was translocated from the ruins to the tents. She remained at the translocation site, and has been observed yearly since the original translocation.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

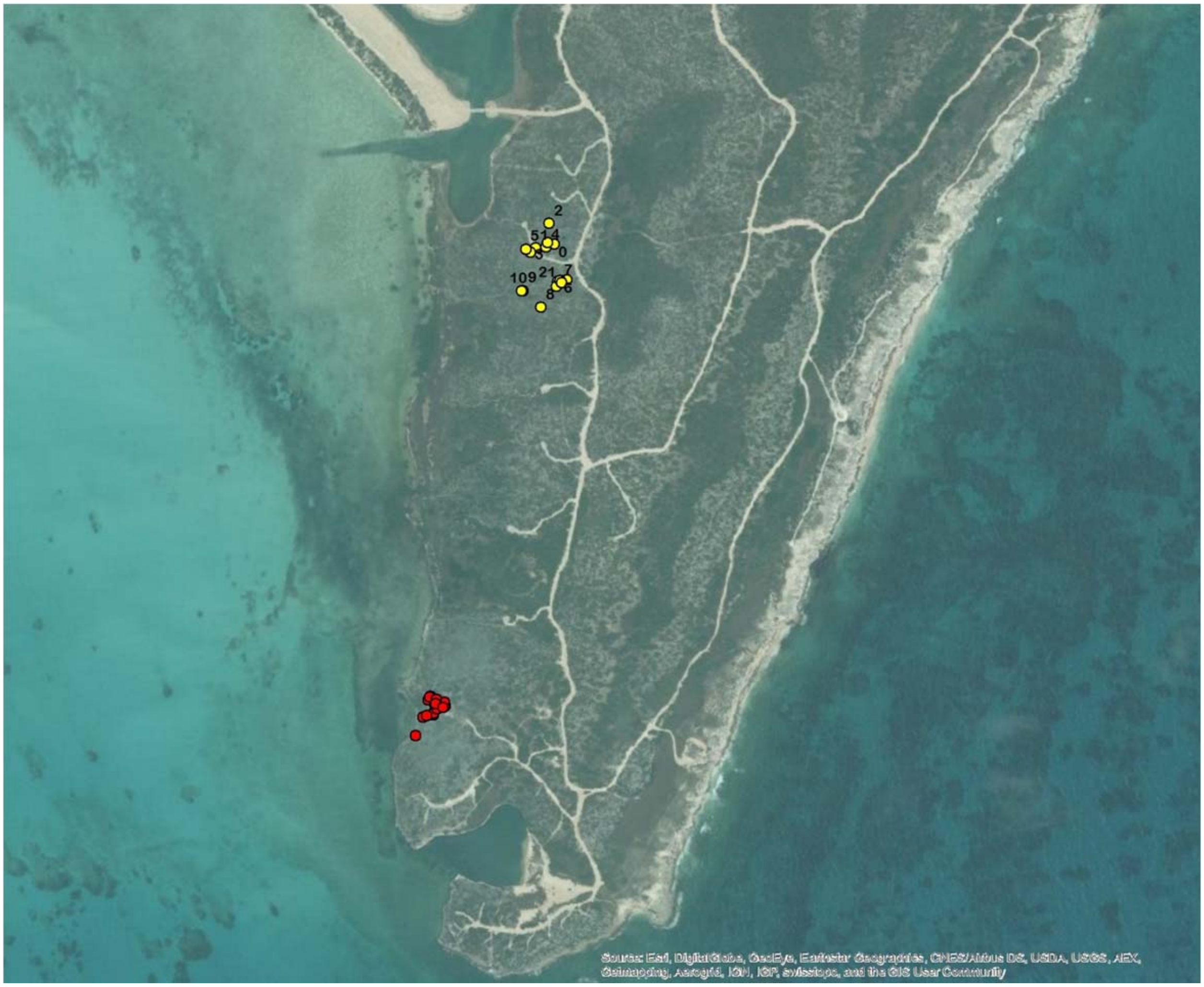
J13 (male, juvenile, wet season, 2011) was translocated from the ruins to the tents. He remained at the translocation site, making a few forays north. He has not been observed since 2011.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J14 (female, juvenile, wet season, 2011) was translocated from the tents to the ruins. She remained at the translocation site, making a few forays across the road from the core area. She was observed again in 2012, but has not been observed in subsequent field seasons.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J15 (male, juvenile, wet season, 2011) was translocated from the tents to the ruins. He left the translocation site and ventured east on top of a rocky ridge. He was sighted on that ridge multiple times, but was inaccessible and was not caught during the final study period. He was considered lost to follow up and has not been observed since 2011.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J16 (female, juvenile, wet season, 2011) was translocated from the tents to the ruins. She remained at the study site, making small forays towards the south.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J17 (female, juvenile, wet season, 2011) was translocated from the tents to the ruins. She lost her transmitter two days following the translocation and was considered lost to follow up.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J18 (male, juvenile, wet season, 2011) was translocated from the tents to the ruins. He remained at the translocation site but has not been seen in subsequent field seasons.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J21 (male, juvenile, wet season, 2011) was translocated from the tents to the ruins. He remained at the translocation site throughout the study period. He has been observed yearly since 2011.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A25 (female, adult, wet season, 2012) was translocated from the ruins to the tents. She remained at the translocation site and did not attempt any forays from the core area. She has been seen yearly at the same location that she adopted post translocation (Appendix B).

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

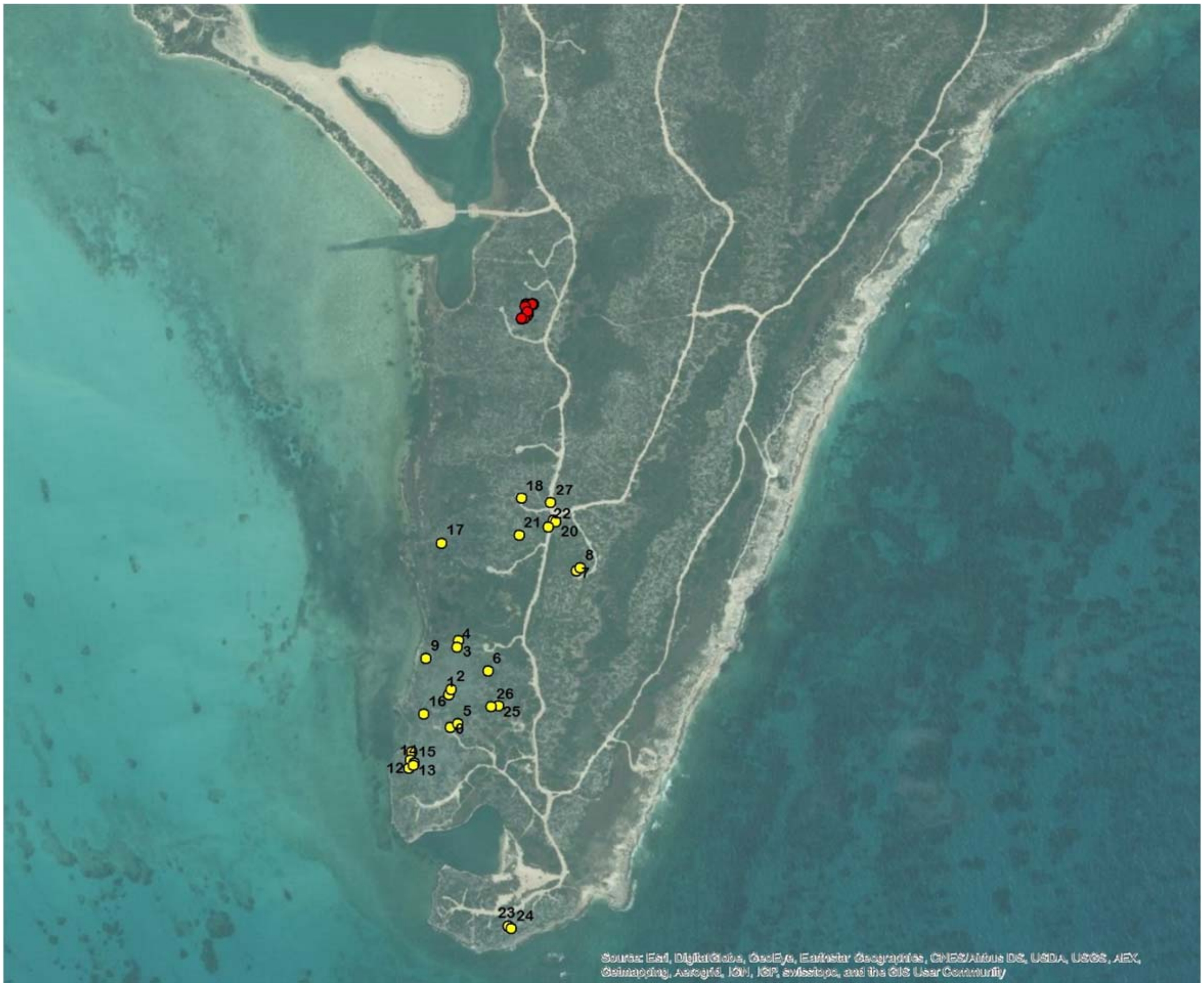
A26 (female, adult, wet season, 2012) was translocated from the ruins to the tents. She traveled throughout the core translocation area and made several forays east across the main dirt road. She lost her beads following the translocation and was re-beaded. She has been seen yearly at the tents study site (Appendix B).

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A27 (male, adult, wet season, 2012) was translocated from the ruins to the tents. He made one significant foray east, returned to the translocation site, and then ultimately homed back to the ruins in 9 days, and has been seen yearly at the ruins since. During his foray, he traveled far to the east and was observed at the ditch on the far side of the island.

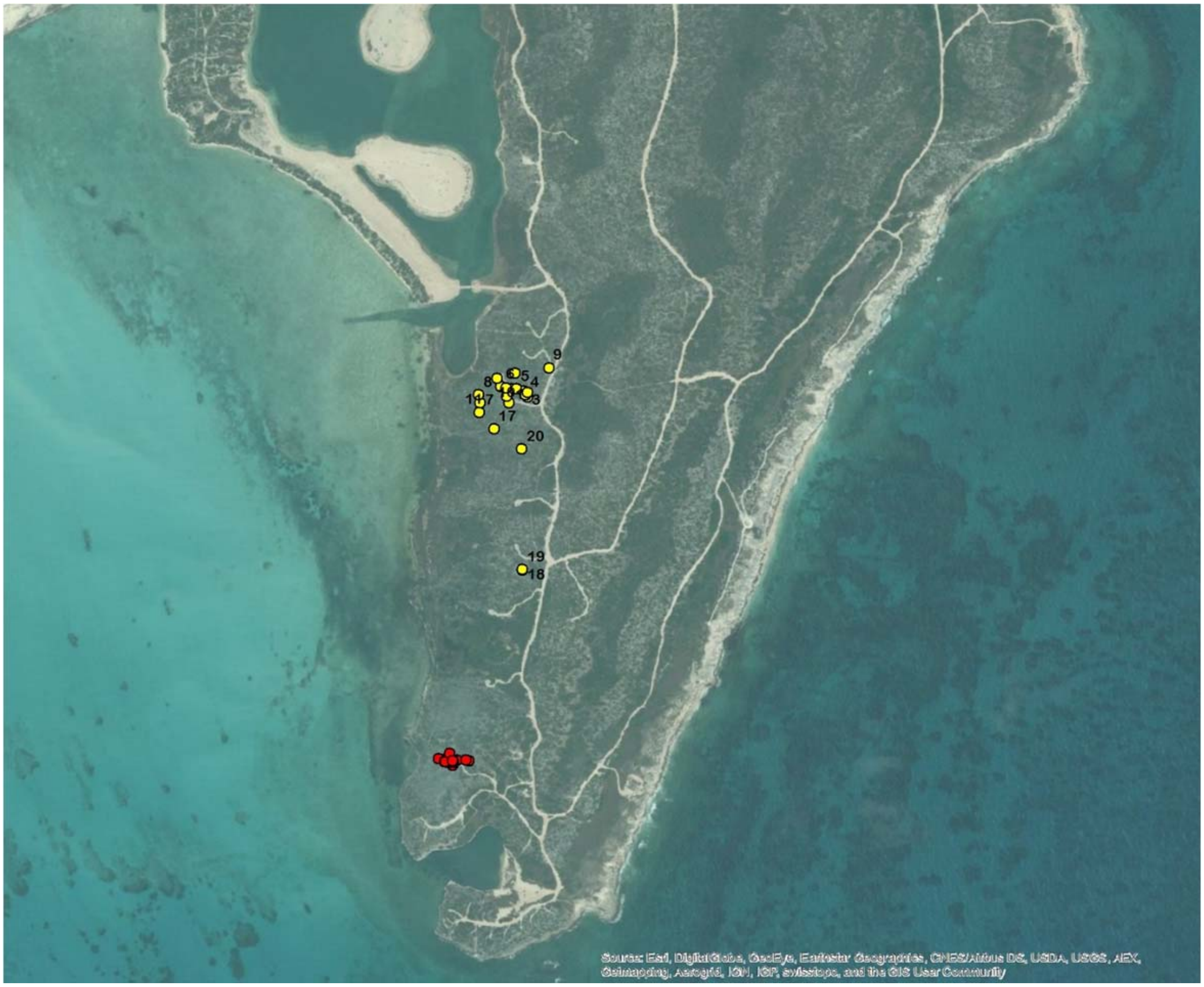
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A28 (male, adult, wet season, 2012) was translocated from the ruins to the tents. He made multiple forays north towards home of varying distances, but never made it further than half way home and was caught on the run. He has not been observed since 2012.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A31 (male, adult, wet season, 2012) was translocated from the ruins to the tents. He made multiple forays from the center of the study site, traveling north, west and south from the translocation point. He was ultimately caught about midway between the study sites. He was observed once in 2014 in his original capture site, but was not observed in 2013 (Appendix B).



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A32 (male, adult, wet season, 2012) was translocated from the tents to the ruins. He made several forays from the translocation site, never making it further than halfway home. He was ultimately caught near the translocation site. He had homed by the 2013 field season, and has been observed in his original capture site since (Appendix B).

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A33 (male, adult, wet season, 2012) was translocated from the tents to the ruins. He made many forays toward home, but made forays more towards the east than south towards the tents. He was ultimately caught on the move and has not been observed since.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A34 (female, adult, wet season, 2012) was translocated from the tents to the ruins. She homed back to the tents in a relatively efficient manner, locating just east of the tents study site prior to navigating to her original retreat. She completed her journey in 6 days, the shortest homing journey for all females.

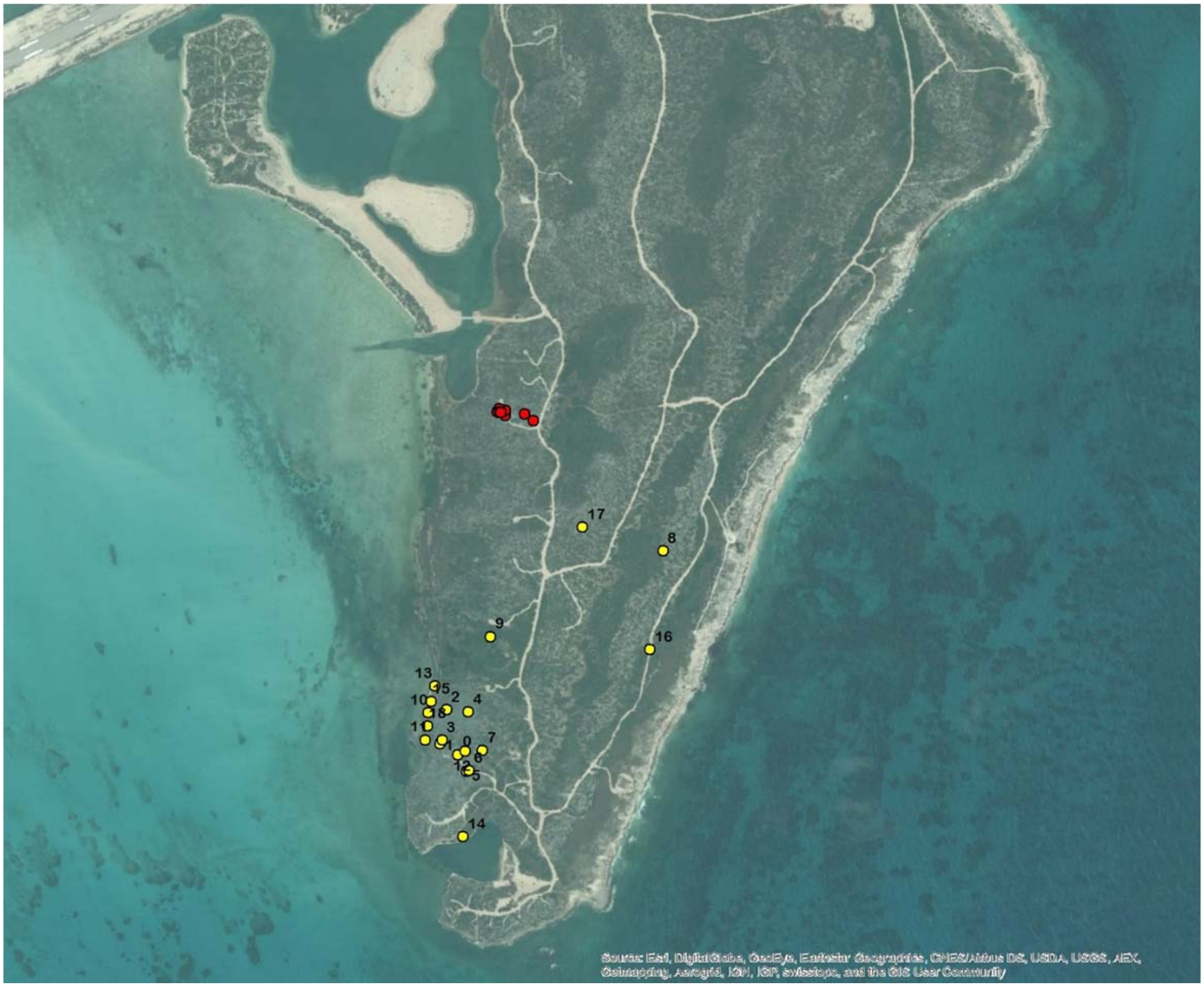
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A35 (male, adult, wet season, 2012) was translocated from the tents to the ruins. He made short movements from the translocation site, but was ultimately caught there.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

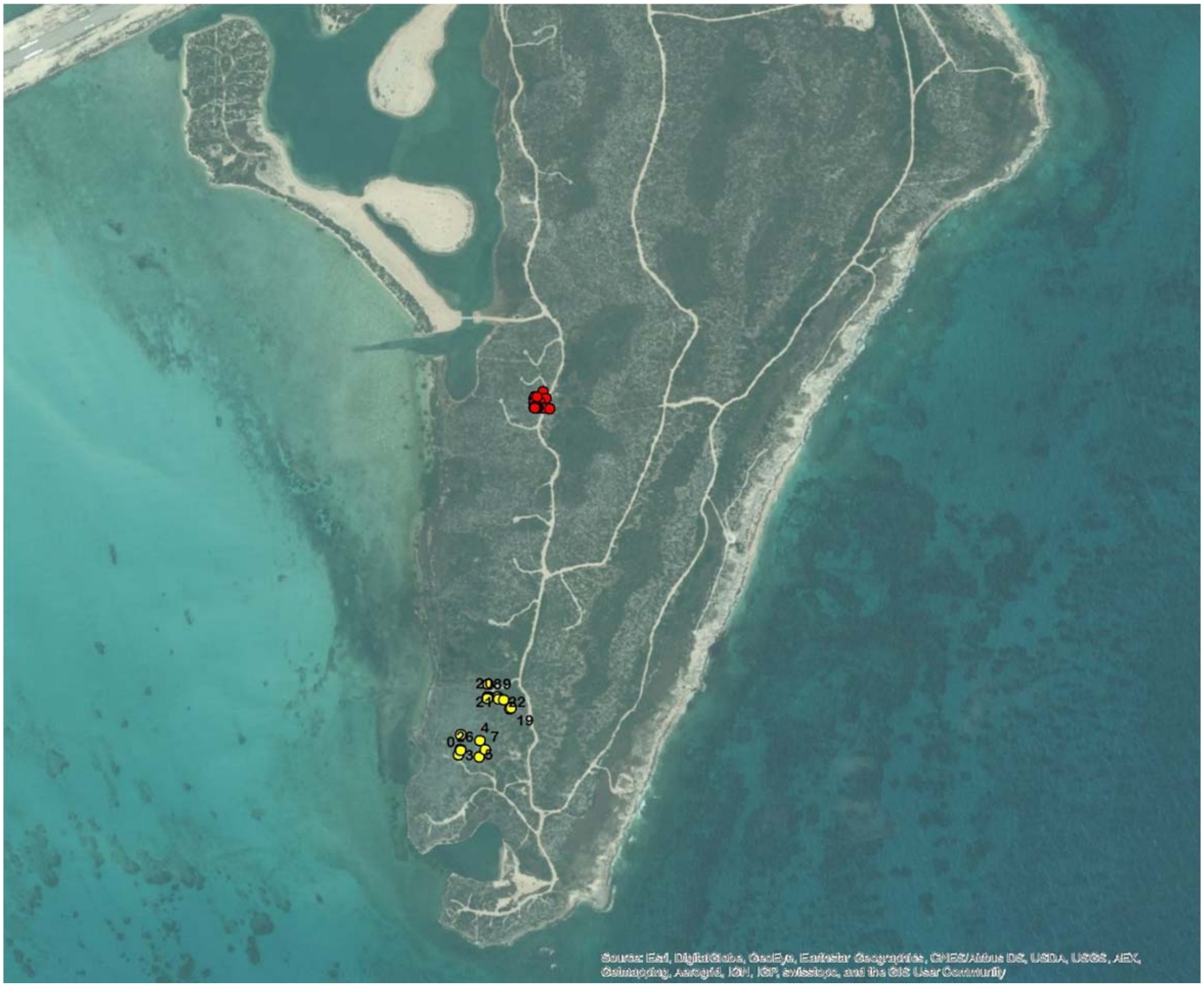
A36 (female, adult, wet season, 2012) was translocated from the tents to the ruins. She homed back from the ruins in 16 days by using the coastline and multiple back and forth forays. She had only one day at home prior to the final catch. She has been observed regularly during each subsequent field season.

A37 (female, adult, wet season, 2012) was translocated form the tents to the ruins. She homed back in 9 days and has been observed regularly in subsequent field seasons.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A38 (female, adult, wet season, 2012) was translocated from the ruins to the tents. She traveled towards the coast and made multiple forays north and east towards the ruins. Ultimately she was caught on the run, north of midway towards her capture site. She has not been observed since.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J22 (female, juvenile, wet season, 2012) was translocated from the ruins to the tents. She moved north initially and then settled in a rocky slope area where she was ultimately caught during the final catch. She was not observed in 2013, but was observed in 2014.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J23 (male, juvenile, wet season, 2012) was translocated from the ruins to the tents. He remained at the translocation site, but has not been observed since the original translocation season.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J24 (male, juvenile, wet season, 2012) was translocated from the tents to the ruins. He remained at the study site throughout, though has not been observed in subsequent study seasons.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J25 (male, juvenile, wet season, 2012) was translocated from the ruins to the tents. He remained at the translocation site, though has not been observed in subsequent study seasons.

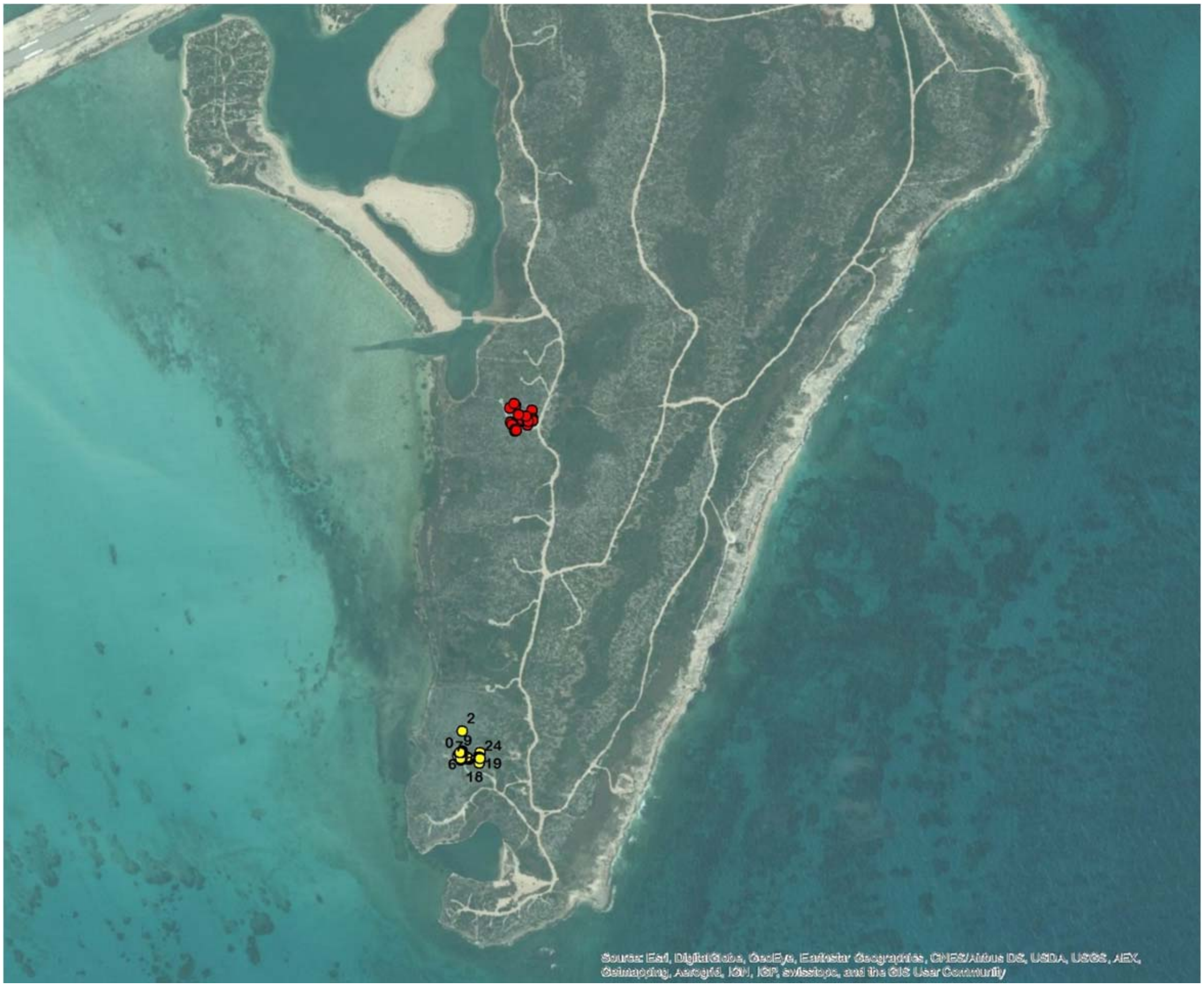
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J26 (male, juvenile, wet season, 2012) was translocated from the ruins to the tents. He moved east over a large ridge, and was caught alongside the uncovered ditch in heavy foliage, significantly north and east of the translocation site.

J27 (female, juvenile, wet season, 2012) was translocated from the tents to the ruins. She moved south in very small forays, but was ultimately caught in the ruins study site. She has not been observed since.

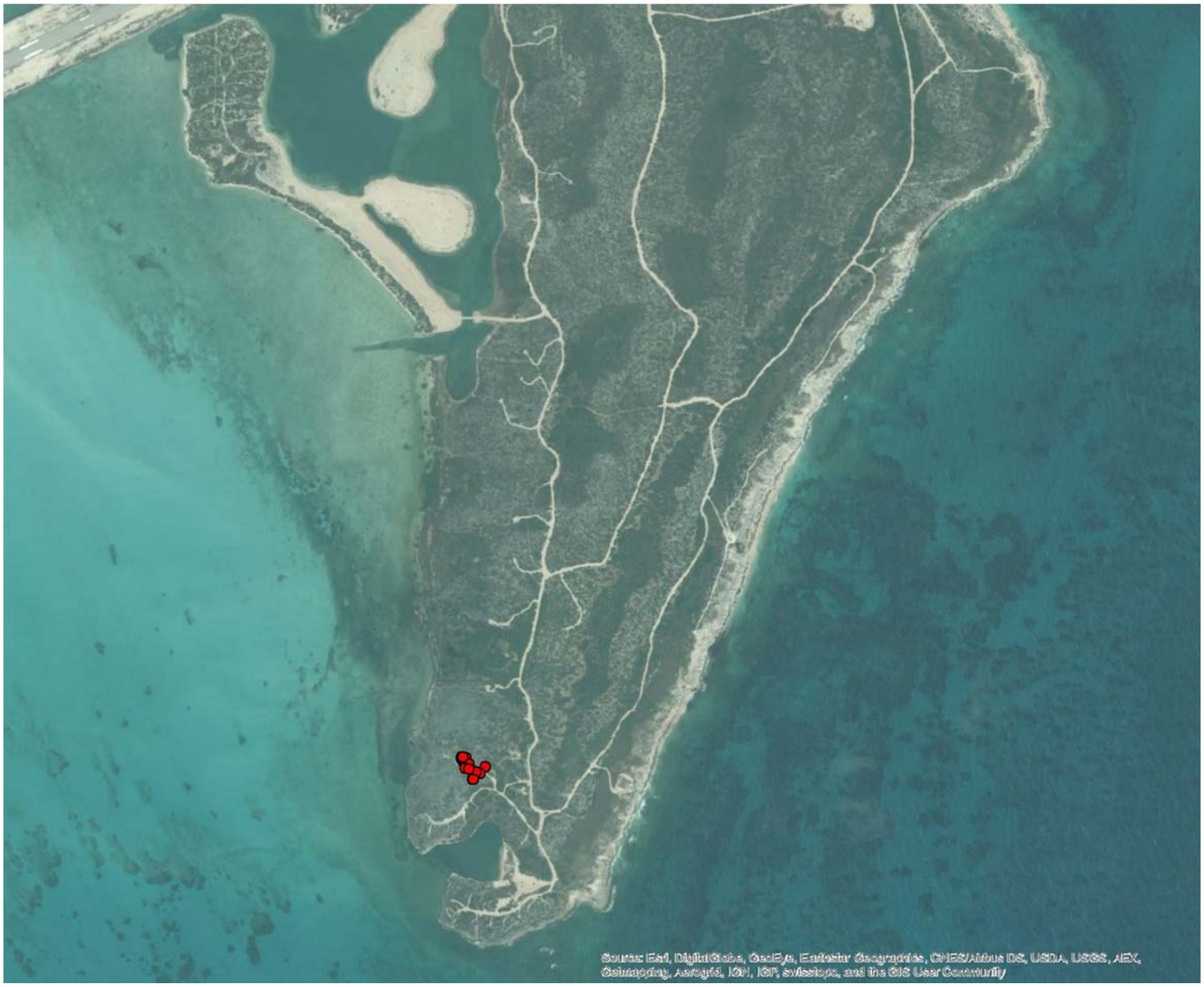
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J28 (female, juvenile, wet season, 2012) was translocated from the ruins to the tents. She settled at the translocation site despite several movements east and west from the translocation point. She has been observed in both 2013 and 2014 study seasons.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J31 (female, juvenile, wet season, 2012) was translocated from the ruins to the tents and remained at the site for the duration of the study.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J32 (male, juvenile, wet season, 2012) was not translocated. He lost his transmitter prior to translocation and was not seen again. The transmitter was recovered, but he is considered lost to follow up.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J33 (male, juvenile, wet season, 2012) was translocated from the tents to the ruins. He made short forays to the south, but was ultimately caught near the translocation site.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J34 (female, juvenile, wet season, 2012) was translocated from the tents to the ruins. She made several forays north and east from the translocation site. Ultimately, she proved elusive, inaccessible and was considered lost to follow up. She was not caught in the final catch.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J35 (female, juvenile, wet season, 2012) was translocated from the tents to the ruins. Seven days following the translocation however, her transmitter was recovered. She was considered lost to follow up and was not caught in the final catch. She was observed in both 2013 and 2014 however in the ruins core study area.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A41 (female, adult, dry season, 2013) was translocated from the ruins to the tents. She made numerous forays to the north and traveled comparatively significant distances by also traveling towards the east. She was ultimately caught on the move, nearing the original capture site. She was observed in 2014 in the same area as her original baseline period the year before.

A42 (female, adult, dry season, 2013) was translocated from the tents to the ruins. She moved very close to home prior to moving backwards towards the translocation site and returning there. She lost her transmitter 15 days post translocation. She is considered lost to follow up for that reason and was never caught in the final catch. In 2014 however, she was observed at home in her original capture area.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

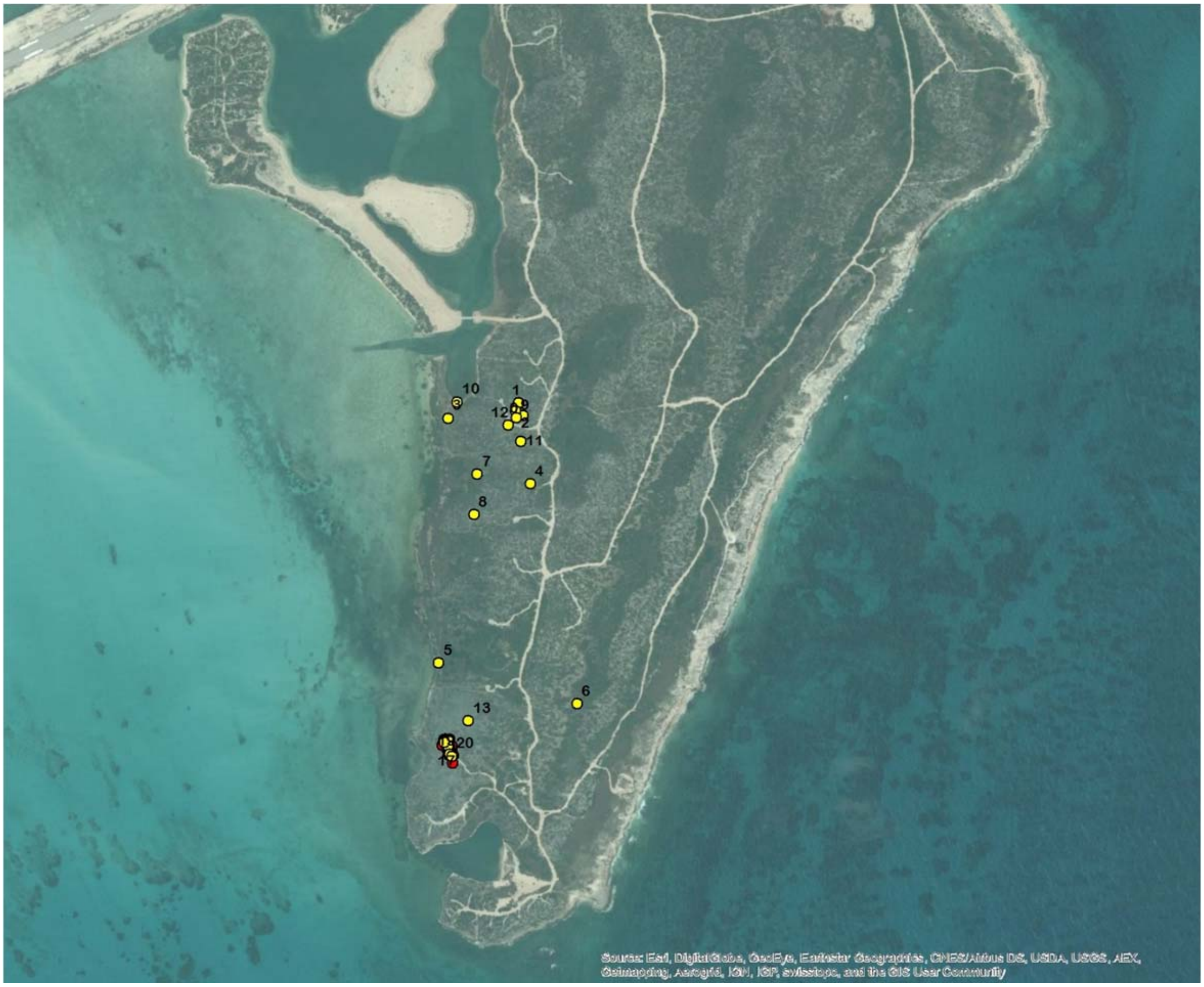
A43 (male, adult, dry season, 2013) was translocated from the ruins to the tents. He homed in 7 days, following a relatively direct route north via the center of the island. He was observed in 2014 in his core home area.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A44 (male, adult, dry season, 2013) was translocated from the tents to the ruins. He homed in a record 2 days. At final catch, he was scanned repeatedly to ensure that he was not a previous subject who had dropped his beads. His movements were direct and aggressive. He was observed again in 2014.

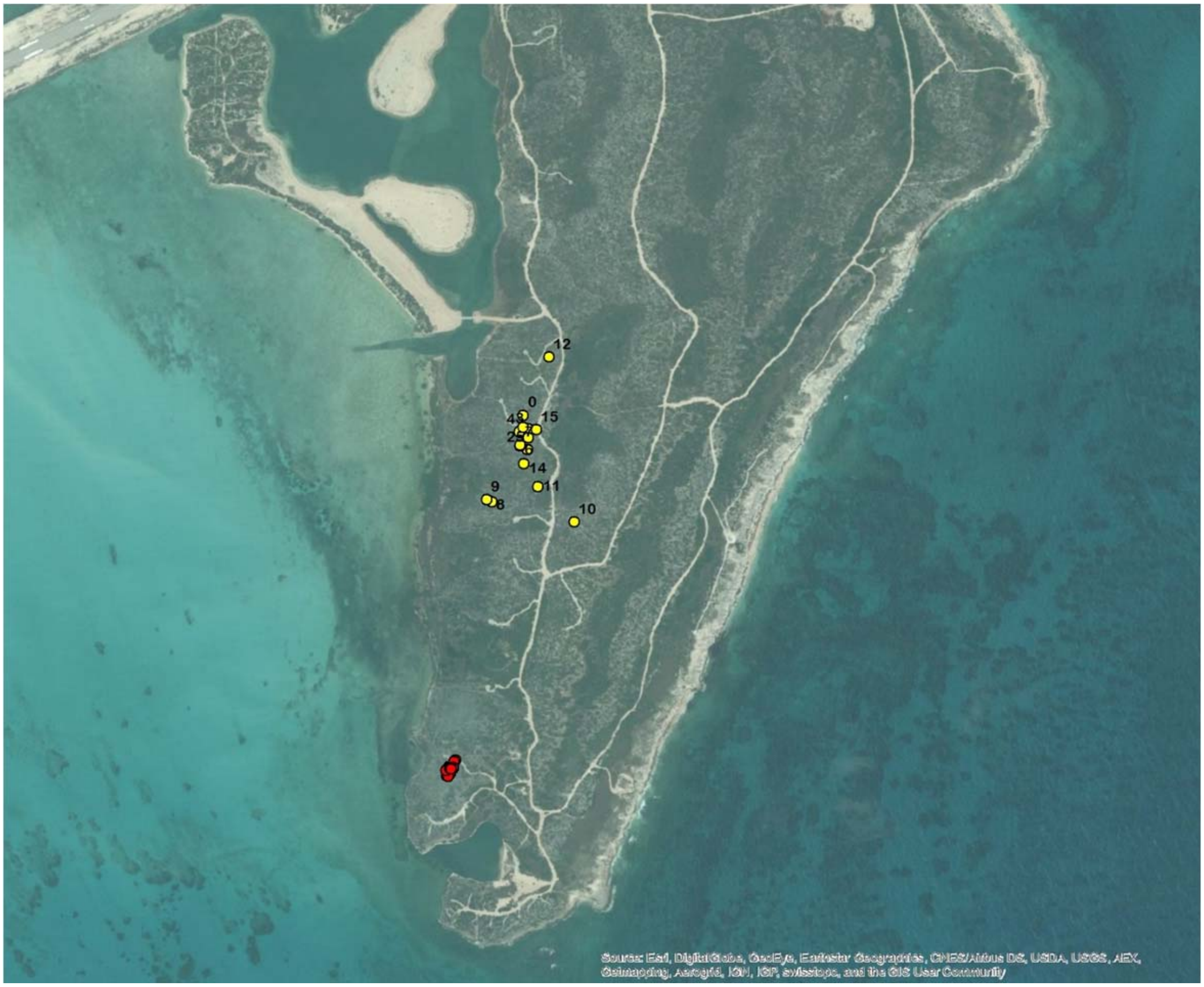
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A45 (female, adult, dry season, 2013) was translocated from the tents to the ruins. She homed in 16 days, following multiple forays from the translocation site. Despite the forays, she did follow a relatively direct route south though. As a result, she had only day at home prior to the final catch. She was observed at home in the 2014 study season.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A46 (male, adult, dry season, 2013) was translocated from the tents to the ruins. He homed in 12 days, after heading towards the west coast on several forays, and a significant foray south towards home. He has been observed remaining at the tents study site in the 2014 field season.

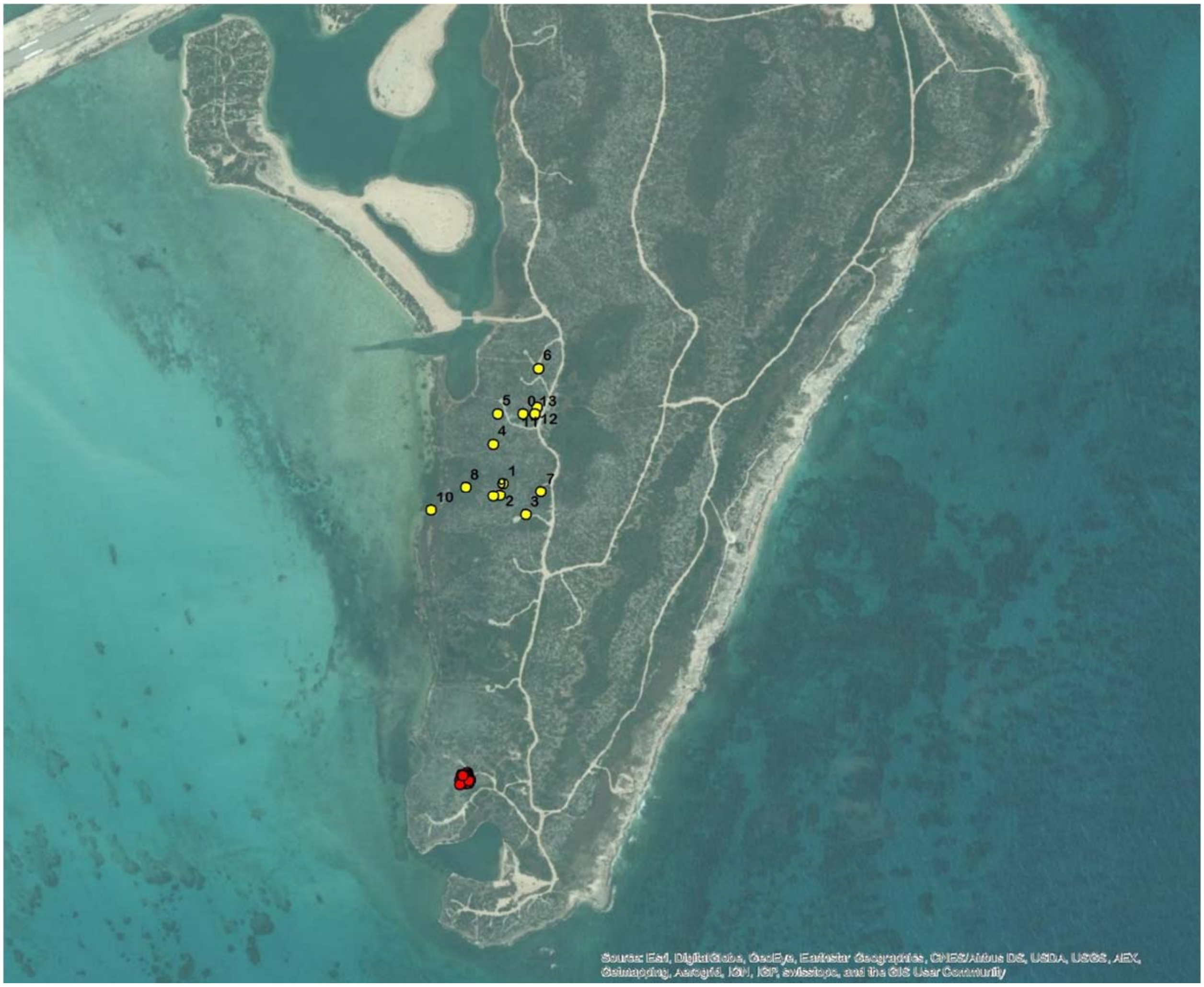


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A47 (female, adult, dry season, 2013) was translocated from the tents to the ruins. She was one of the few animals that headed north of the ruins at one point after heading south in the direction of home. She was ultimately caught on the move not far from the translocation site, and has been observed in the 2014 study season still there.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A48 (female, adult, dry season, 2013) was translocated from the tents to the ruins. During baseline, she made several forays into the nesting area near the study site. During the translocation period after one lengthy foray towards home and back to the translocation site, she stopped moving just north of the abyss, and used a retreat for several days. She was ultimately caught at that location, and has not been observed since.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A51 (male, adult, dry season, 2013) was translocated from the tents to the ruins. He moved north at one point from the ruins, but then began short forays south towards home. He was ultimately caught not far from the translocation site and has not been observed since.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

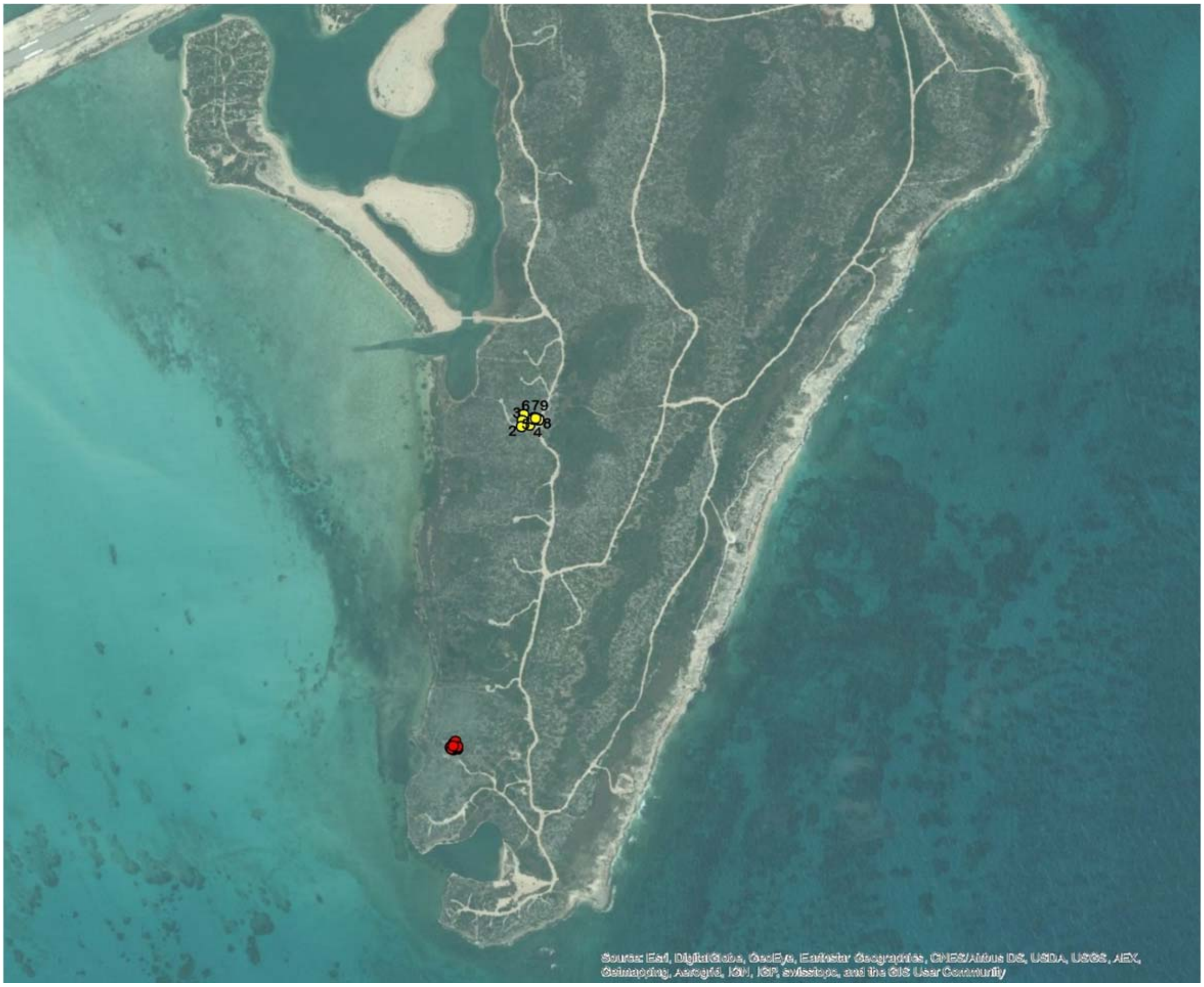
A52 (male, adult, dry season, 2013) was translocated from the ruins to the tents. He moved throughout the tents study site, making one foray north-east of the translocation site. He was ultimately caught just over the ridge north of the tents study area. He was observed in the tents study area in the 2014 study season.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A53 (male, adult, dry season, 2013) was translocated from the ruins to the tents. He moved generally north in the direction of home with several forays but was caught again near the translocation site for the final catch.

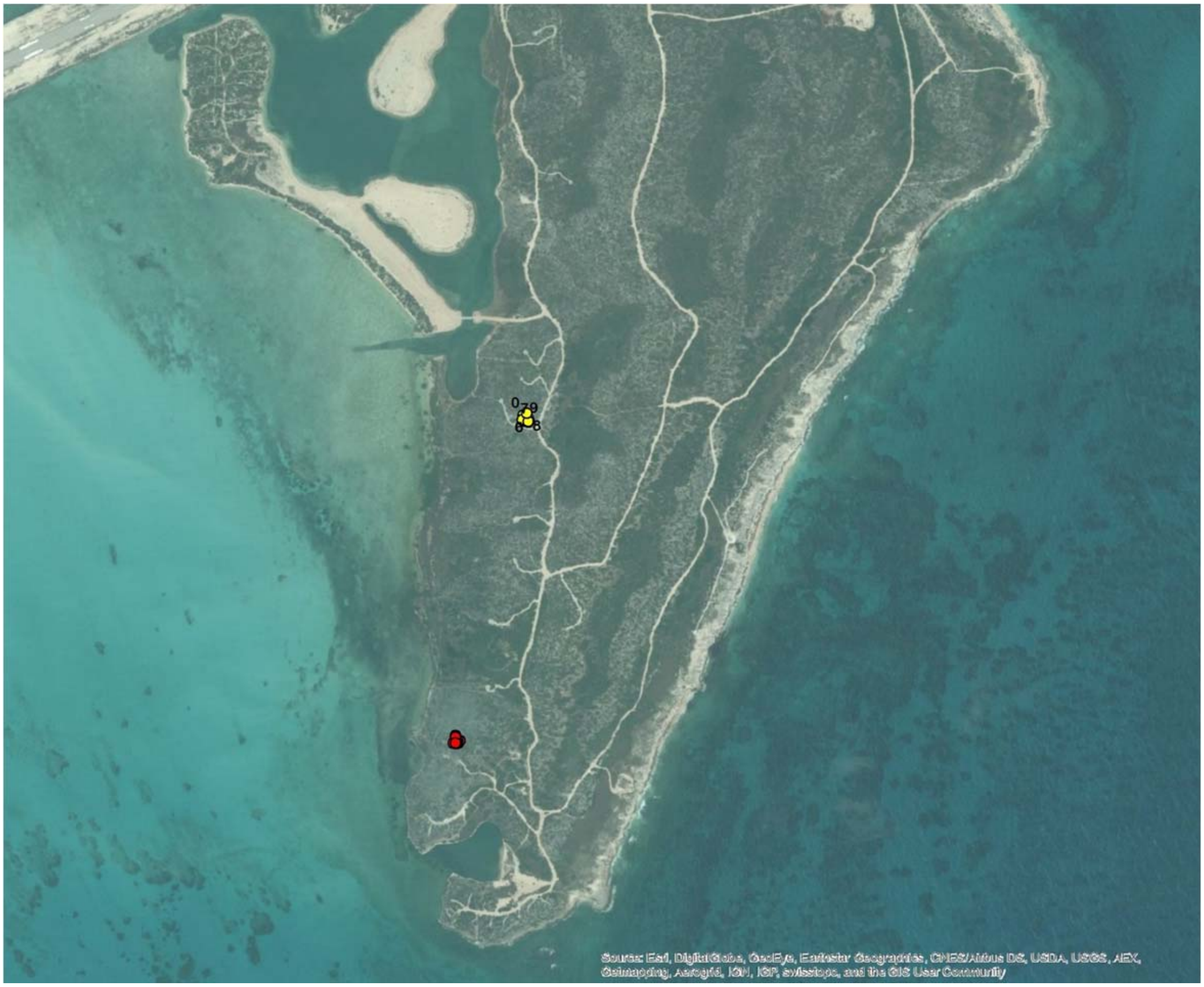
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A54 (female, adult, dry season, 2013) was translocated from the ruins to the tents. She moved north towards the ruins via several forays and was ultimately caught back near the translocation site during the final catch period.



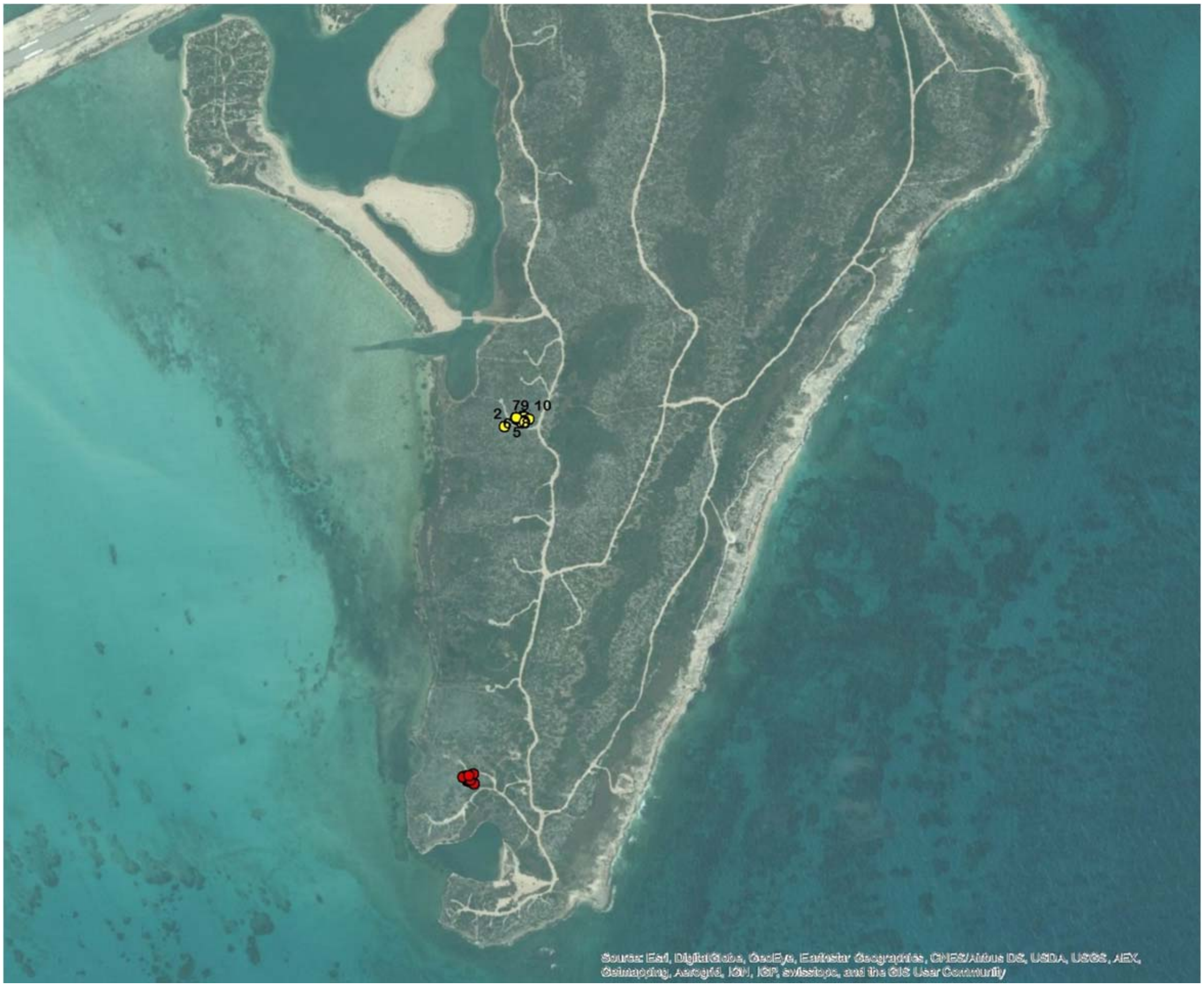
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J36 (male, juvenile, dry season, 2013) was translocated from the tents to the ruins. He remained at the translocation site, and has been observed in the subsequent field season there.

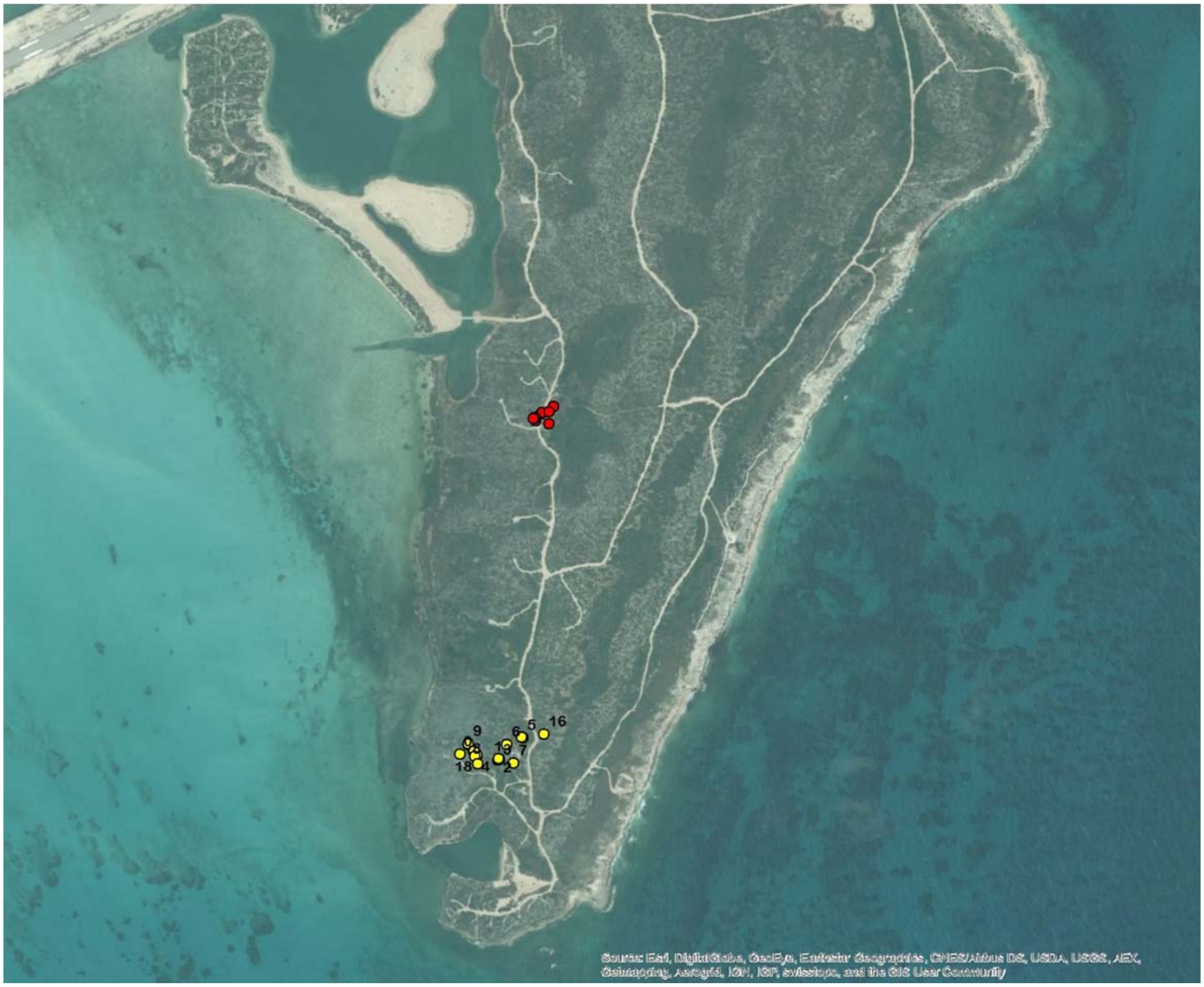


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J37 (male, juvenile, dry season, 2013) was translocated from the tents to the ruins. He remained at the translocation site, and has not been observed in the subsequent field season.

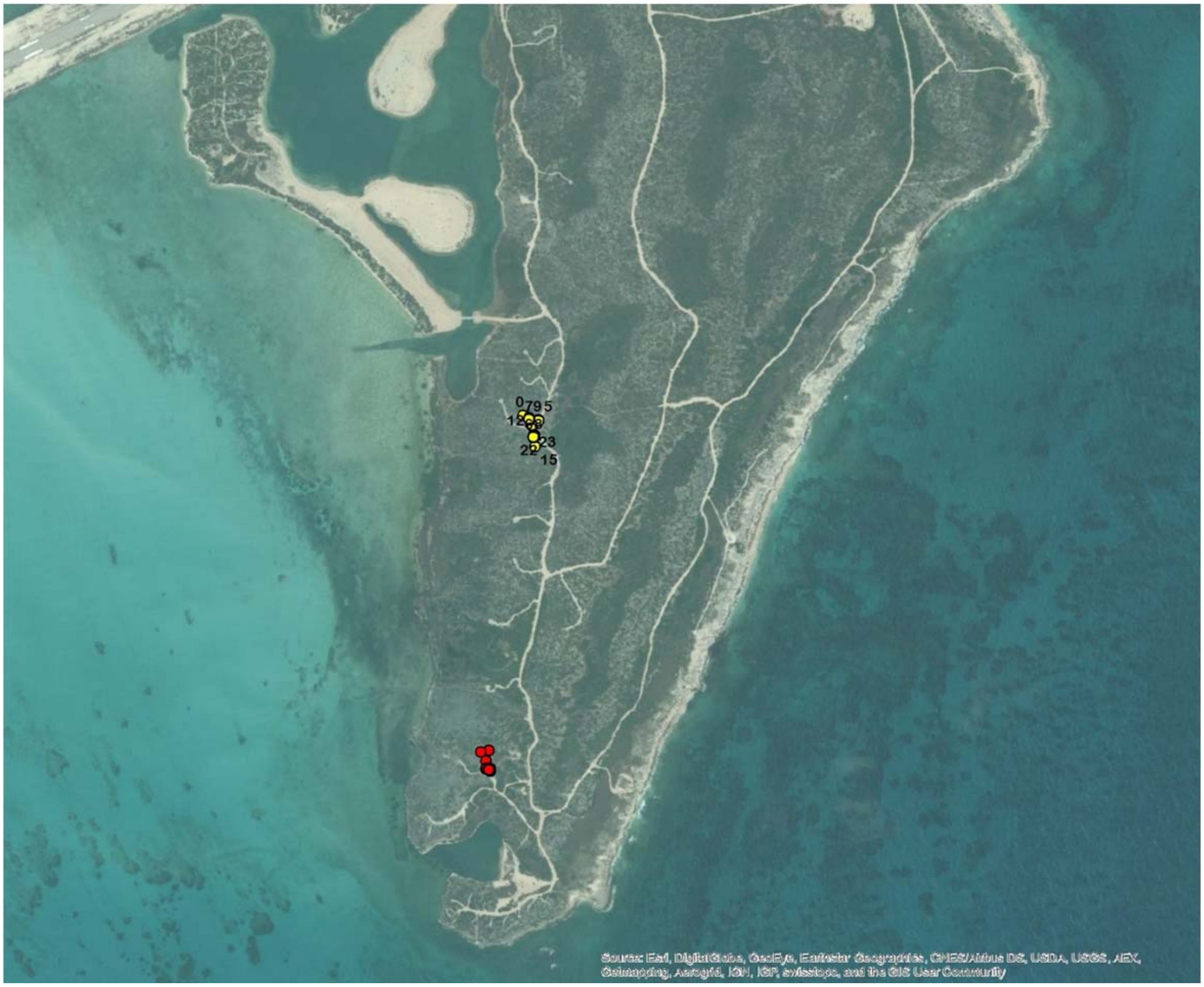


J38 (male, juvenile, dry season, 2013) was translocated from the tents to the ruins. He remained at the translocation site, and has been sighted in the 2014 field season.

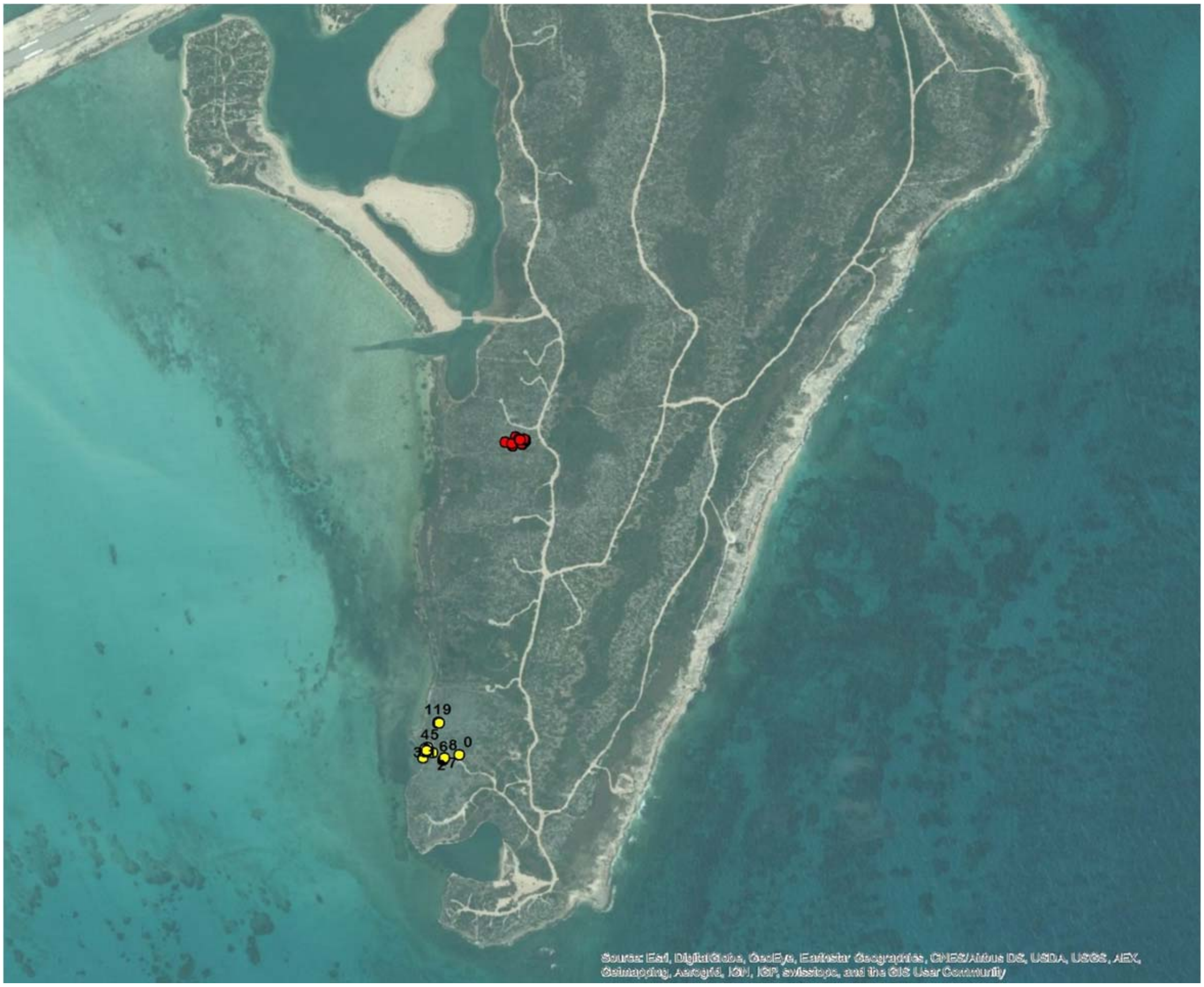


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J41 (female, juvenile, dry season, 2013) was translocated from the ruins to the tents. While she remained in the general area of the tents study site, she moved consistently towards the east. She was ultimately caught on the move for the final catch.



J42 (female, juvenile, dry season, 2013) was translocated from the tents to the ruins. She remained in the translocation area, but by day 7 all locations were in the same general area and predation or a lost transmitter underground were suspected. This animal was never caught, the transmitter was not found and she was considered lost to follow up.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J43 (female, juvenile, dry season, 2013) was translocated from the ruins to the tents. She moved towards the coast, and once there, all subsequent points were from a barely accessible area and an exact location could not be determined. Despite much effort, neither the animal nor the transmitter were ever found and the animal was never caught in the final catch. This animal was considered lost to follow up and predation is suspected.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

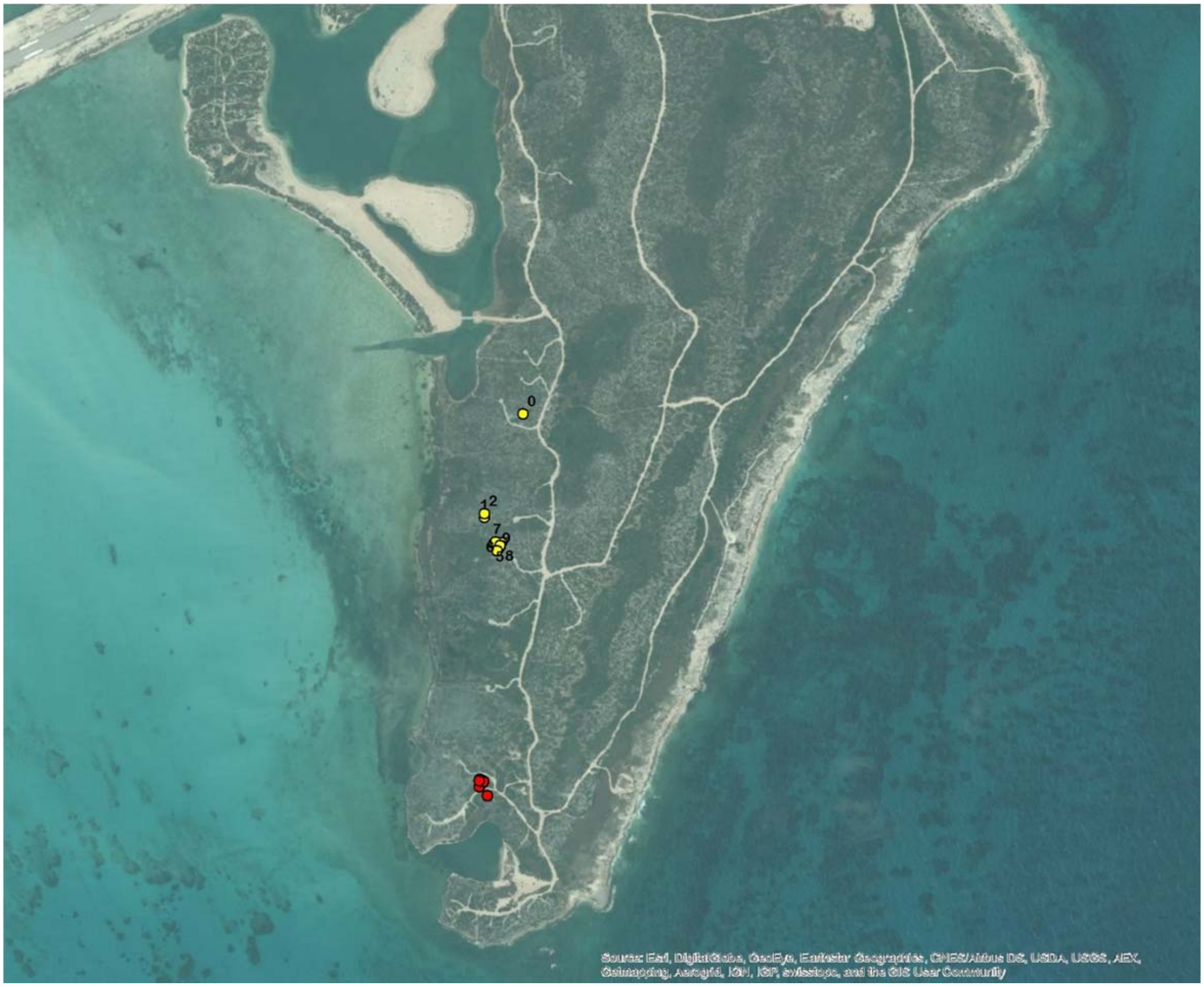
J44 (female, juvenile, dry season, 2013) was translocated from the tents to the ruins. She remained in the translocation area, but midway through data collection, predation was suspected. From that point, all locations were from an underground retreat area and the animal was never caught in the final catch. Either a lost transmitter or predation were suspected and subsequently, the animal was considered lost to follow up.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J45 (male, juvenile, dry season, 2013) was translocated from the ruins to the tents. He remained in the translocation area minus one foray north along the coast but was ultimately caught in the translocation area.

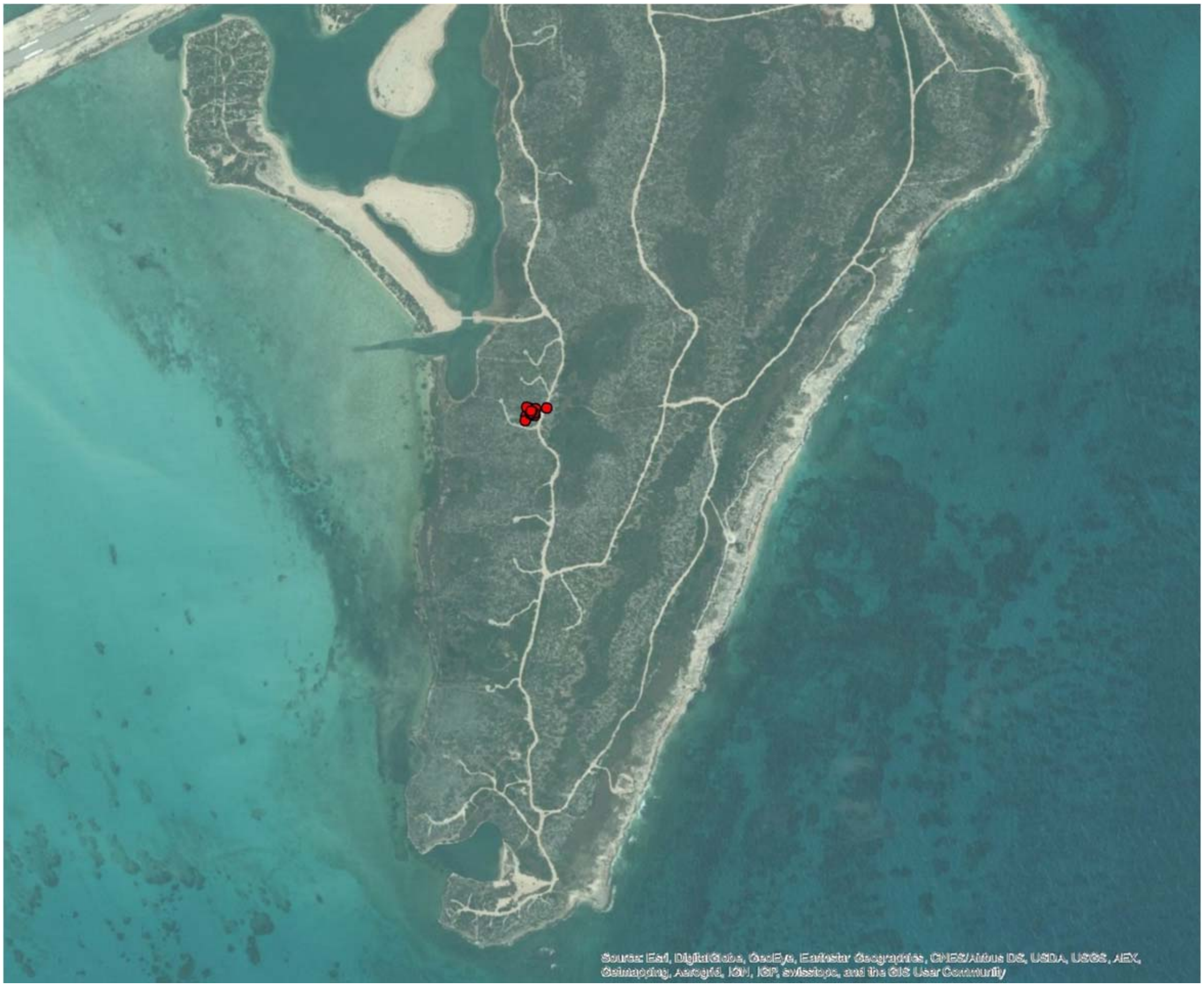
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J46 (male, juvenile, dry season, 2013) was translocated from the ruins to the tents. He moved high up on the cliffs just south of the tent area, and even moved to the other side near the coast. He was ultimately caught near the coast on the south side of the tents.



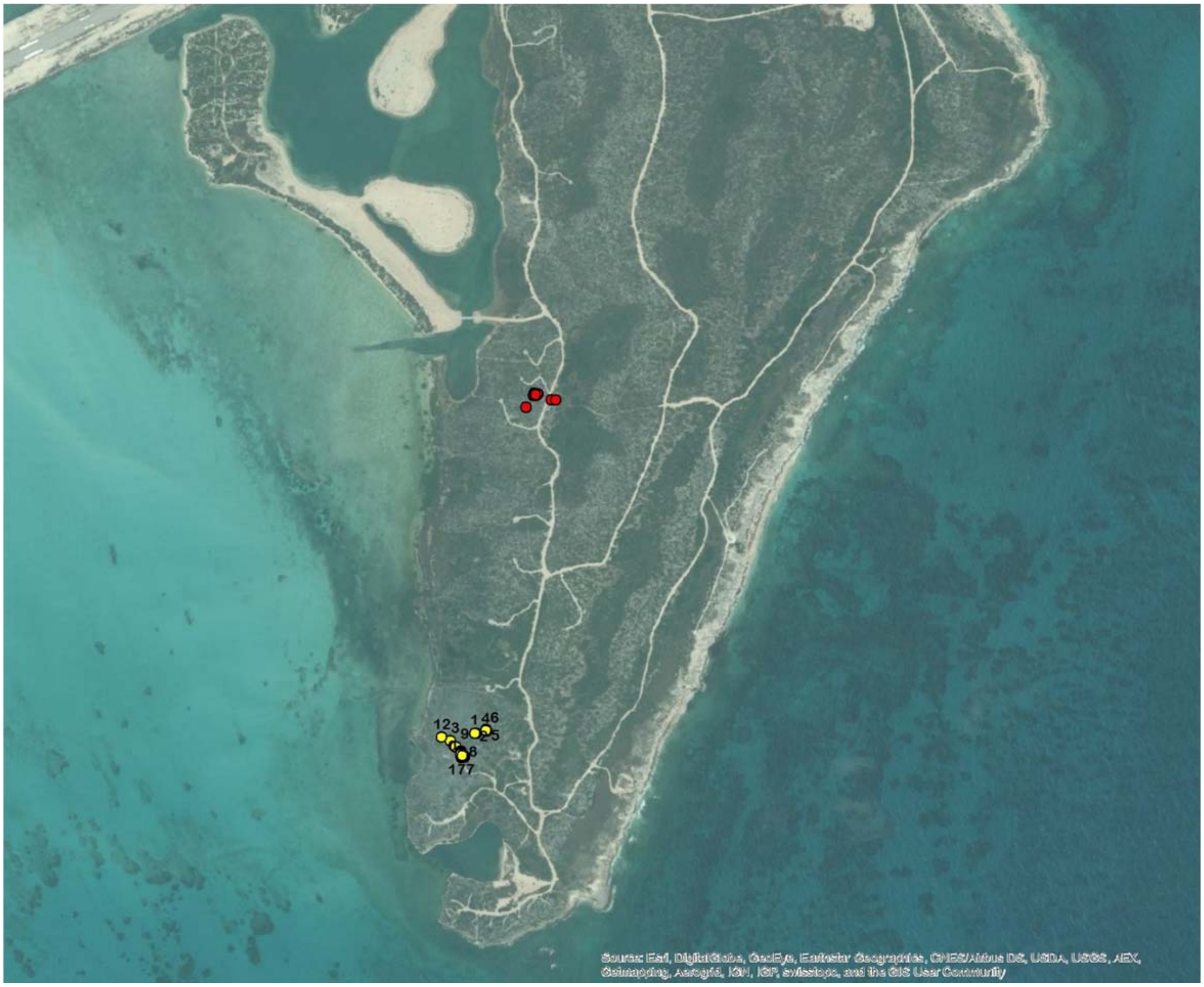
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J47 (female, juvenile, dry season, 2013) was translocated from the tents to the ruins. She left the translocation site almost immediately, and was then always located in a thicket directly south of the translocation site.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J48 (female, juvenile, dry season, 2013) was never caught at catch 2 and thus not translocated. Data collection continued throughout the rest of the study period, and she was serve as an informal control in that regard. She was caught at catch 3 and blood was collected.

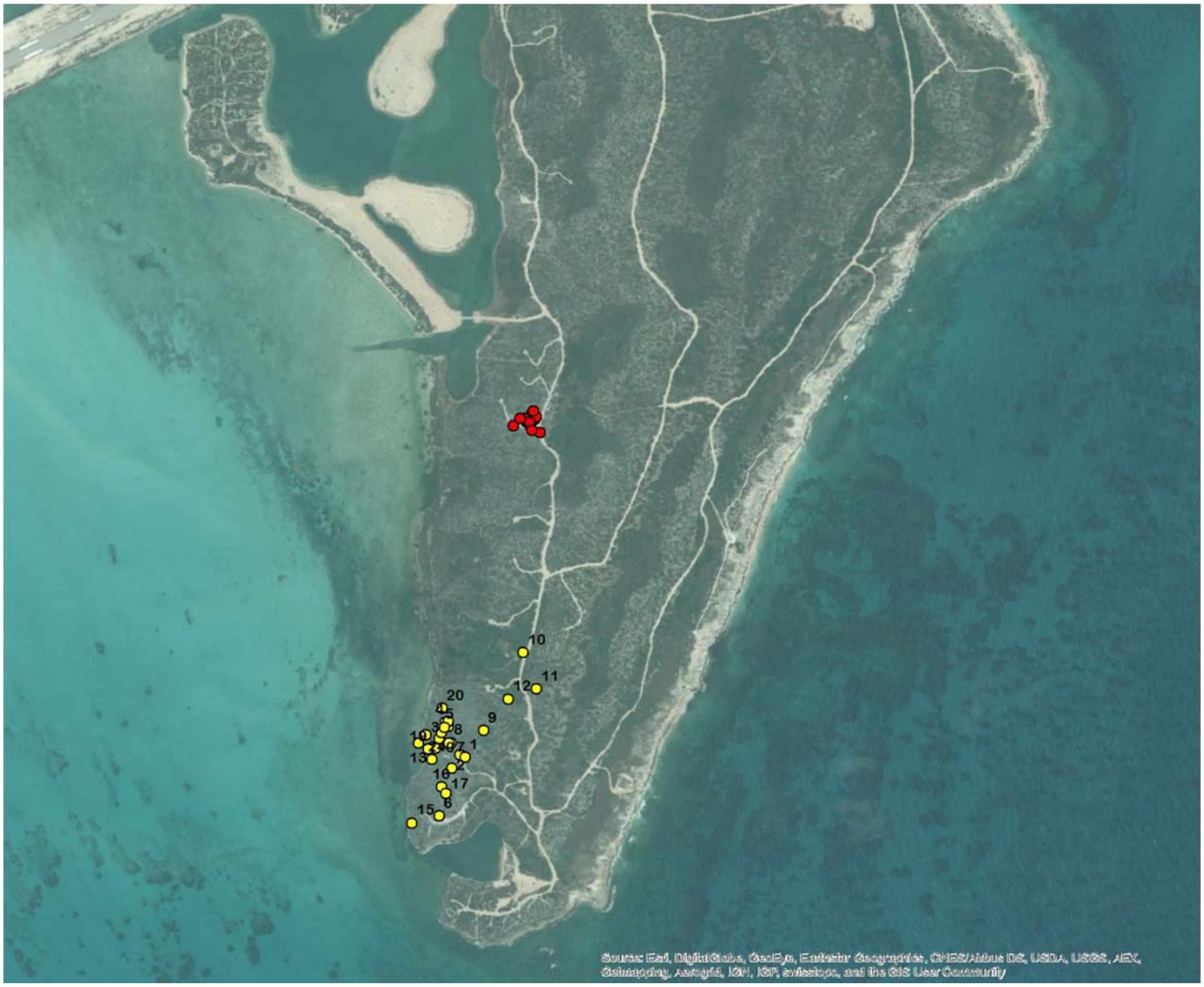


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J51 (male, juvenile, dry season, 2013) was translocated from the ruins to the tents. He remained at the translocation site, and has not been observed in the subsequent field season.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A6 (female, adult, dry season, 2014) was translocated from the ruins to the tents. It should be noted that she also served as a pilot animal and was subjected to baseline monitoring and blood collection in 2010, 4 years previous to the field season. She moved in a general northward direction from the translocation site via several forays, but was ultimately caught on the move.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A56 (male, adult, dry season, 2014) was translocated from the ruins to the tents. He made general movements northward towards home via forays, but was ultimately caught on the move just outside of the translocation area.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

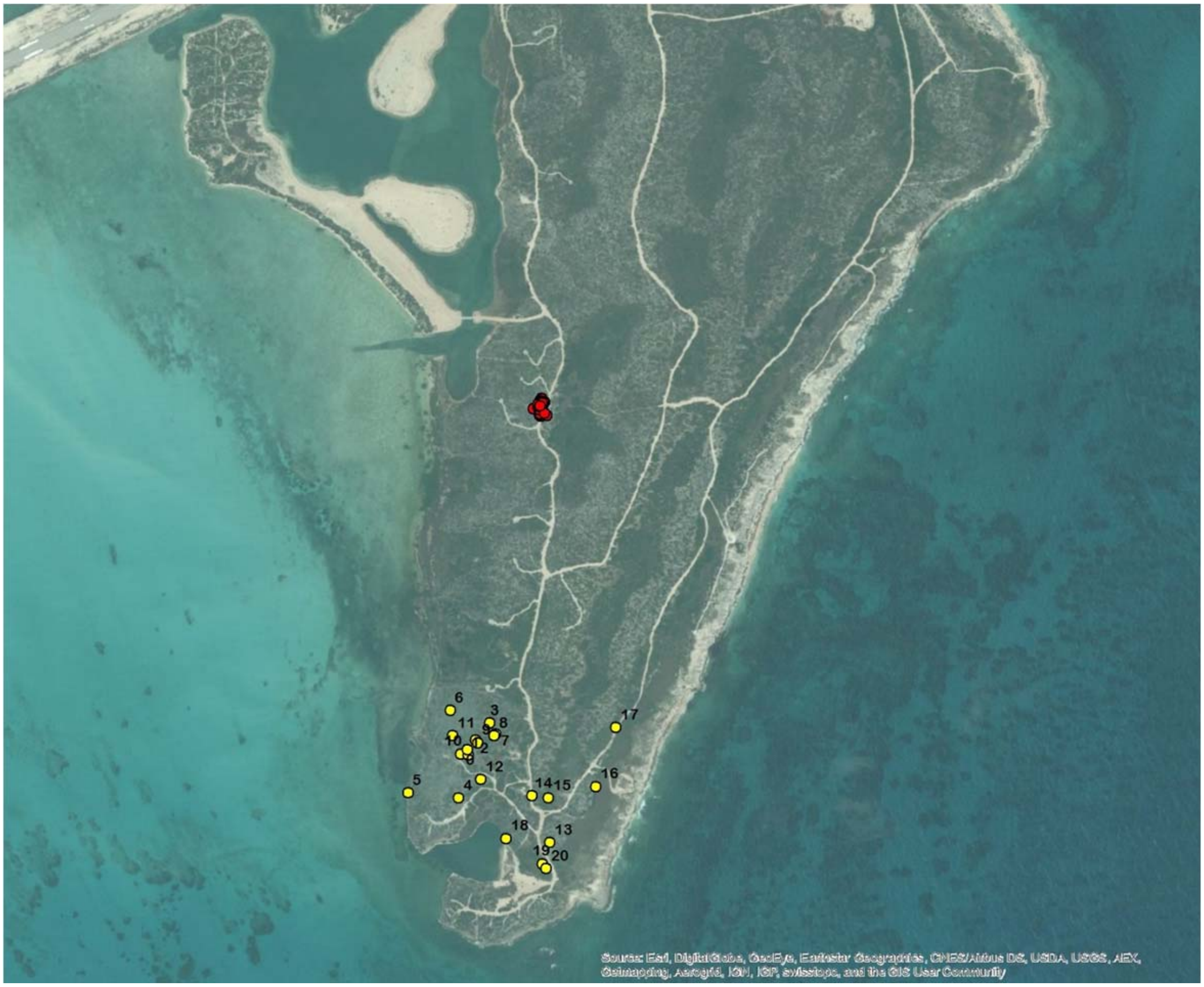
A57 (male, adult, dry season, 2014) was translocated from the ruins to the tents. His movements varied widely, and spanned the width of the island. He was ultimately caught on the move on the far eastern side of the island.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A58 (female, adult, dry season, 2014) was translocated from the ruins to the tents. She remained at the translocation site, though moved high on a ridge and remained there throughout.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A61 (female, adult, dry season, 2014) was translocated from the tents to the ruins. She moved generally south via several forays, but also far to the east and the dunes area. She was ultimately caught on the move midways toward home.



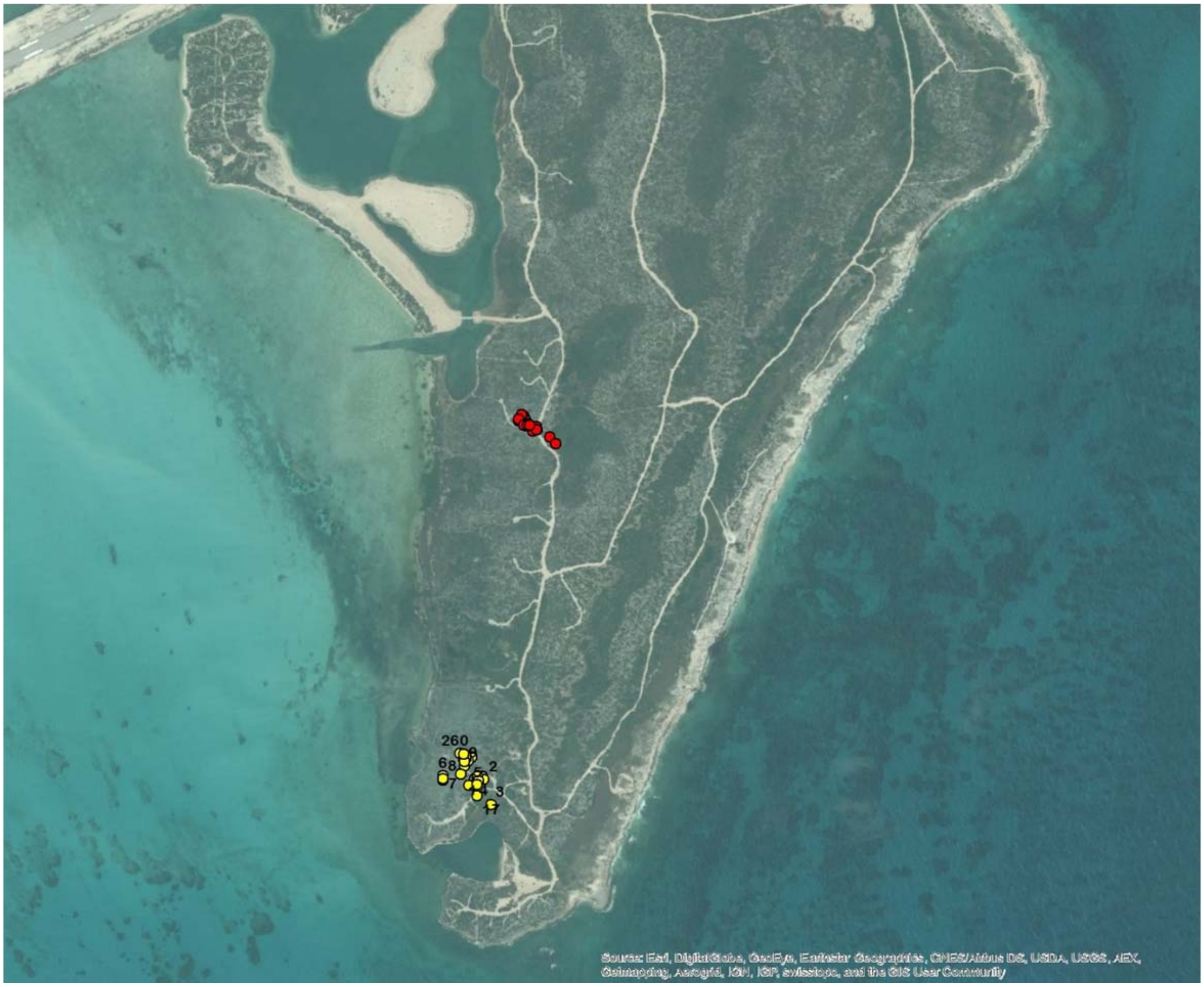
A62 (male, adult, dry season, 2014) was translocated from the ruins to the tents. His movements were generally in the opposite direction of home, moving south of the translocation site. He was ultimately caught south of the translocation area as well.

A63 (male, adult, dry season, 2014) was translocated from the tents to the ruins. He ultimately moved in the general direction of home, though moving north and to the east as well. He was ultimately caught on the move towards home at the far east side of the island, in the open trench area.

A64 (male, adult, dry season, 2014) was translocated from the tents to the ruins. He homed to the tents in 9 days, but traveled further east than any animal to date to do so. He moved east past the trench, and up the dune to the rocks on the easternmost cliff area. From there he proceeded south and eventually home.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A65 (female, adult, dry season, 2014) was translocated from the tents to the ruins. She homed by taking a generally southward direction following one foray north of the translocation site prior to moving south towards home.



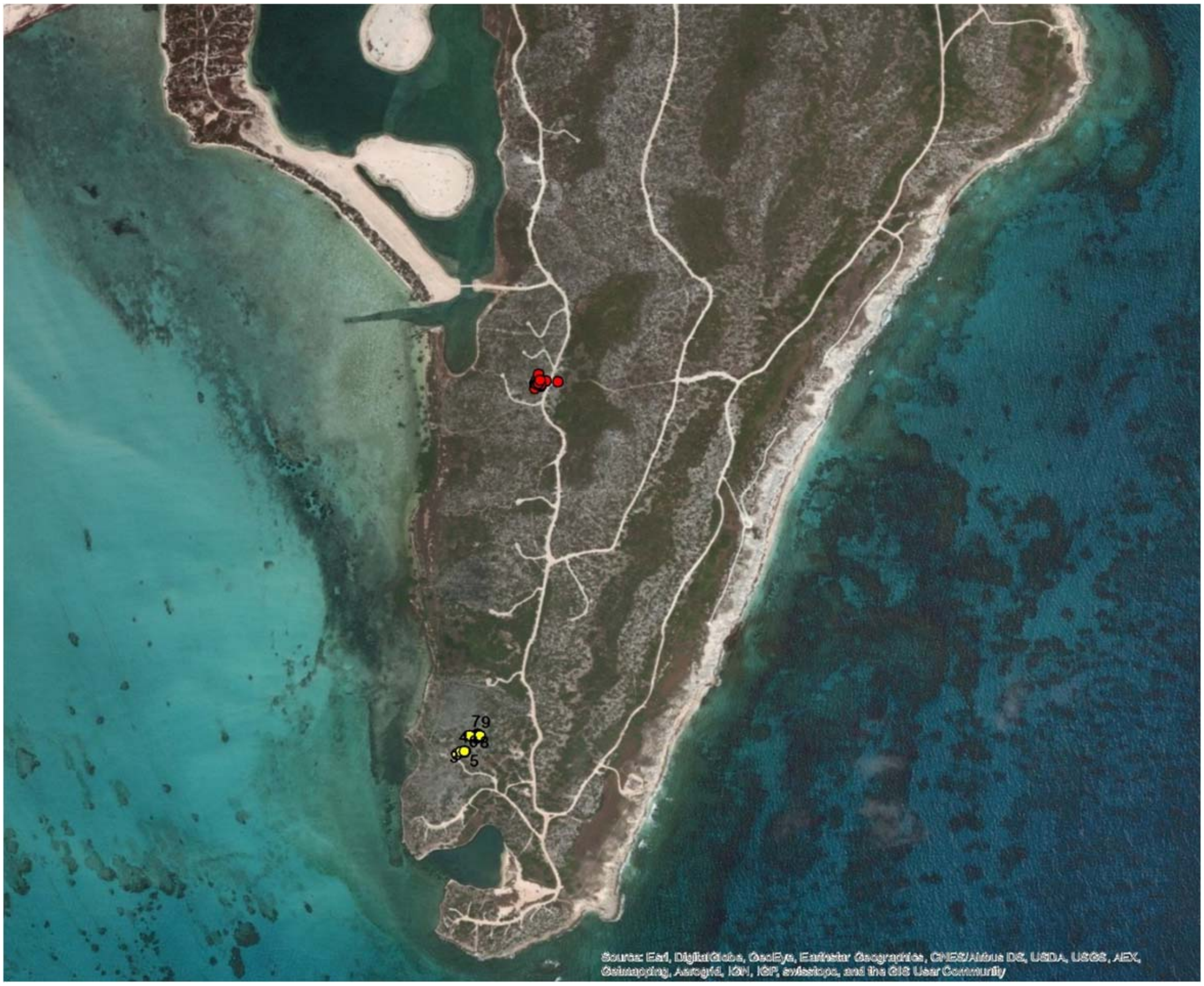
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A66 (female, adult, dry season, 2014) was translocated from the ruins to the tents. She remained at the translocation site throughout, but has not been observed in the subsequent field season.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

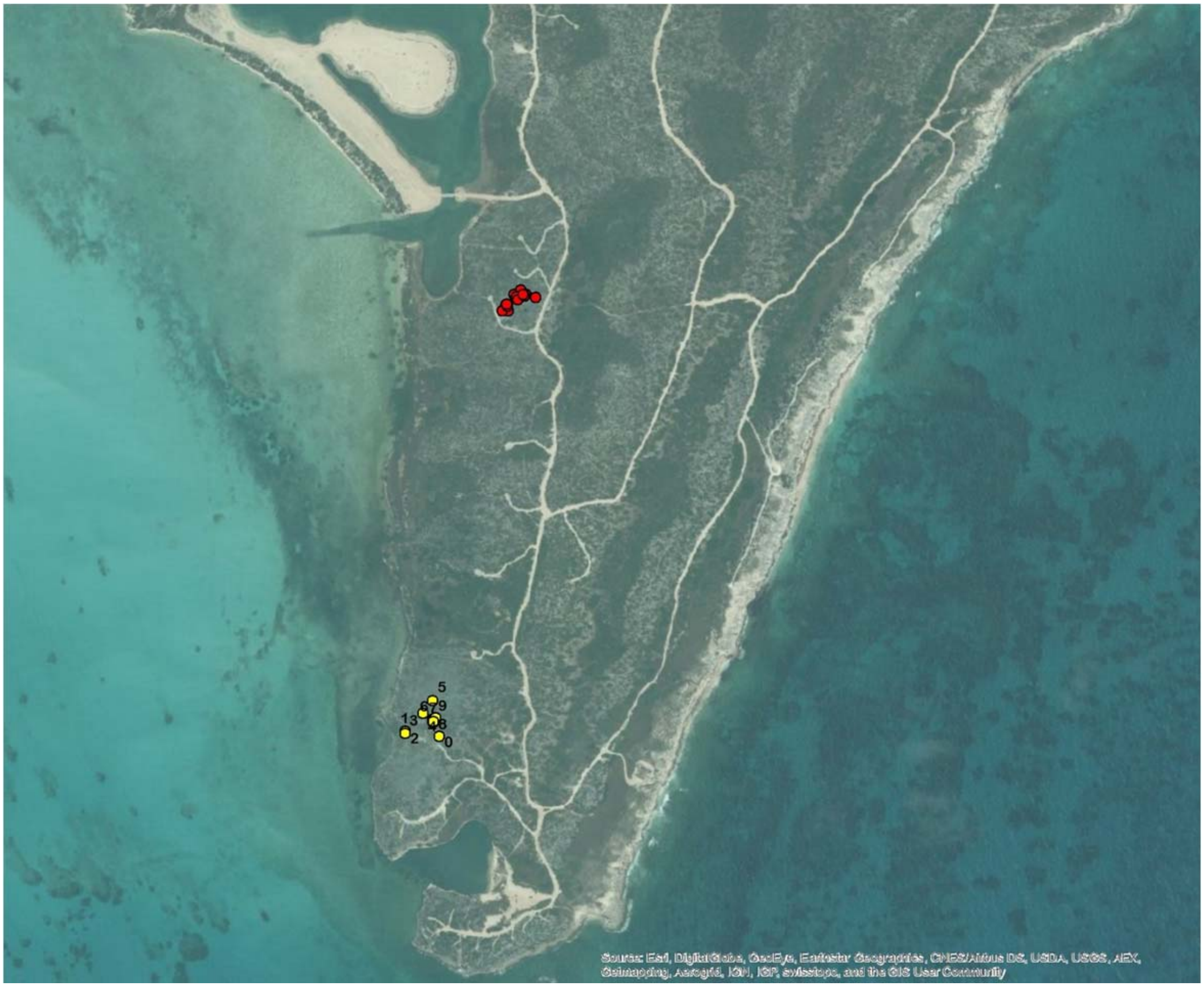
A67 (male, adult, dry season, 2014) was translocated from the tents to the ruins. He homed in 7 days, despite apparently being blind in his right eye. Opportunistically, I was there when he was first returning home and was able to witness his approach in and waited while he headed towards his original retreat area. In his absence, another male had taken residence, and there were aggressive interactions between A67 and the unmarked male upon his return.

A68 (female, adult, dry season, 2014) was translocated from the tents to the ruins. She homed in 8 days, and moved along the coast to do so.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J52 (male, juvenile, dry season, 2014) was translocated from the ruins to the tents. Within 4 days of the translocation, predation was suspected. All telemetry points from that point on were from a large solution hole that would be considered generally inappropriate for a juvenile. On day 17, a snake was found via radio telemetry and visually observed, and then the defecated transmitter was found and retrieved two days later. It was lying on the ground in the middle of the study area.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J53 (male, juvenile, dry season, 2014) was translocated from the ruins to the tents. The last visual on the animal was 5 days post translocation, when a partially eaten tail was observed in a retreat. There were several additional data points, and then movement stopped and all were located at the same retreat. Upon tugging on the antenna, it was discovered that the juvenile had shed the antenna in the retreat. The transmitter was retrieved, and the animal was considered lost to follow up.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

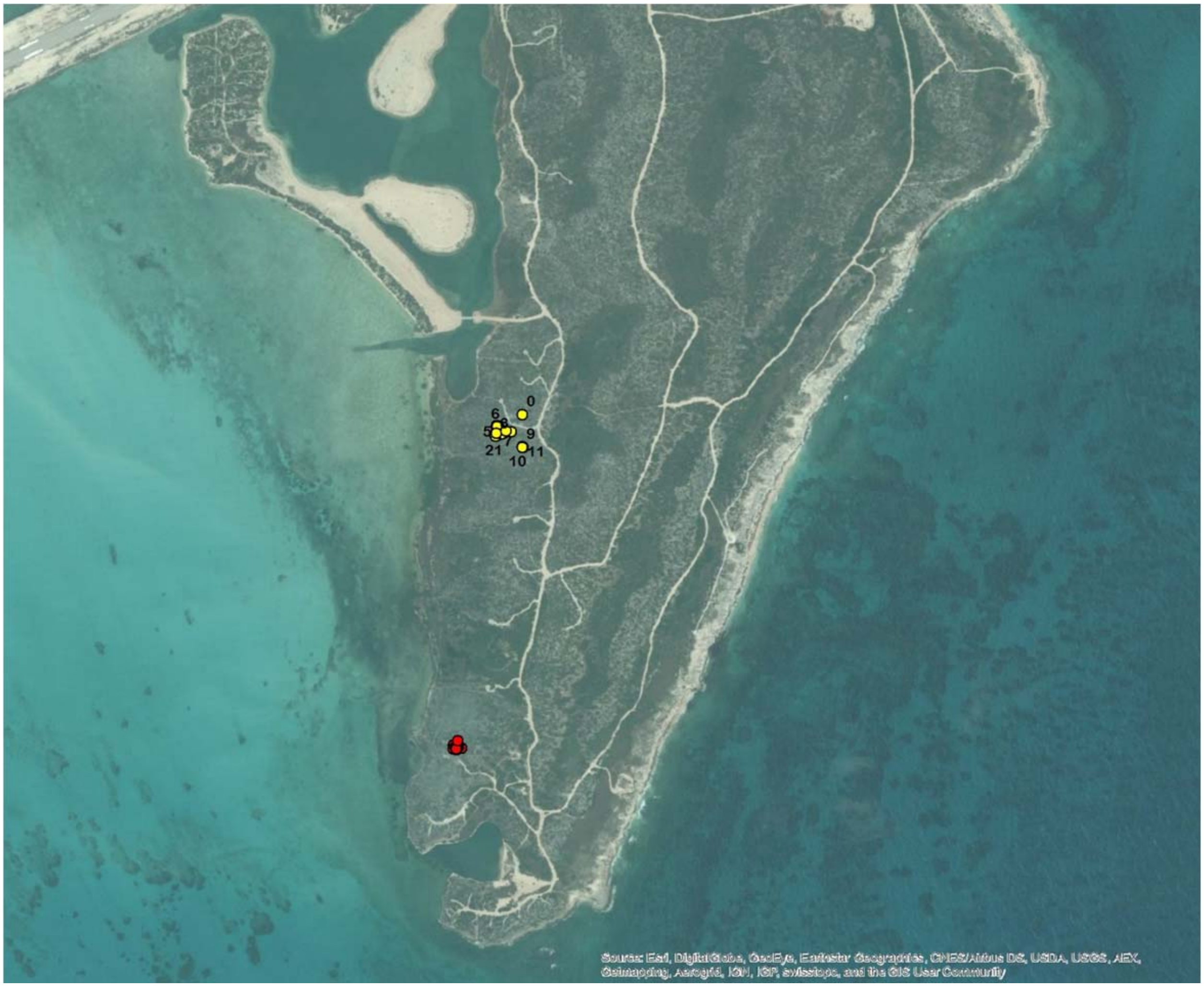
J54 (female, juvenile, dry season, 2014) was translocated from the tents to the ruins. The last known location was the translocation spot, and then the transmitter failed. This was the only failed transmitter in the history of the project. The animal was considered lost to follow up.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J55 (male, juvenile, dry season, 2014) was translocated from the ruins to the tents. He moved far to the east, all the way on the eastern side of the trench and was located there several times. On day 11 however, he lost his transmitter, and it was found lying on a rock. The animal was never captured and was considered lost to follow up.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J56 (female, juvenile, dry season, 2014) was translocated from the tents to the ruins. She remained there throughout, but unfortunately lost her transmitter on day 15. It was recovered, but the animal was considered lost to follow up.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J57 (male, juvenile, dry season, 2014) was translocated from the tents to the ruins. He remained at the translocation site throughout, settling just south of the release site.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

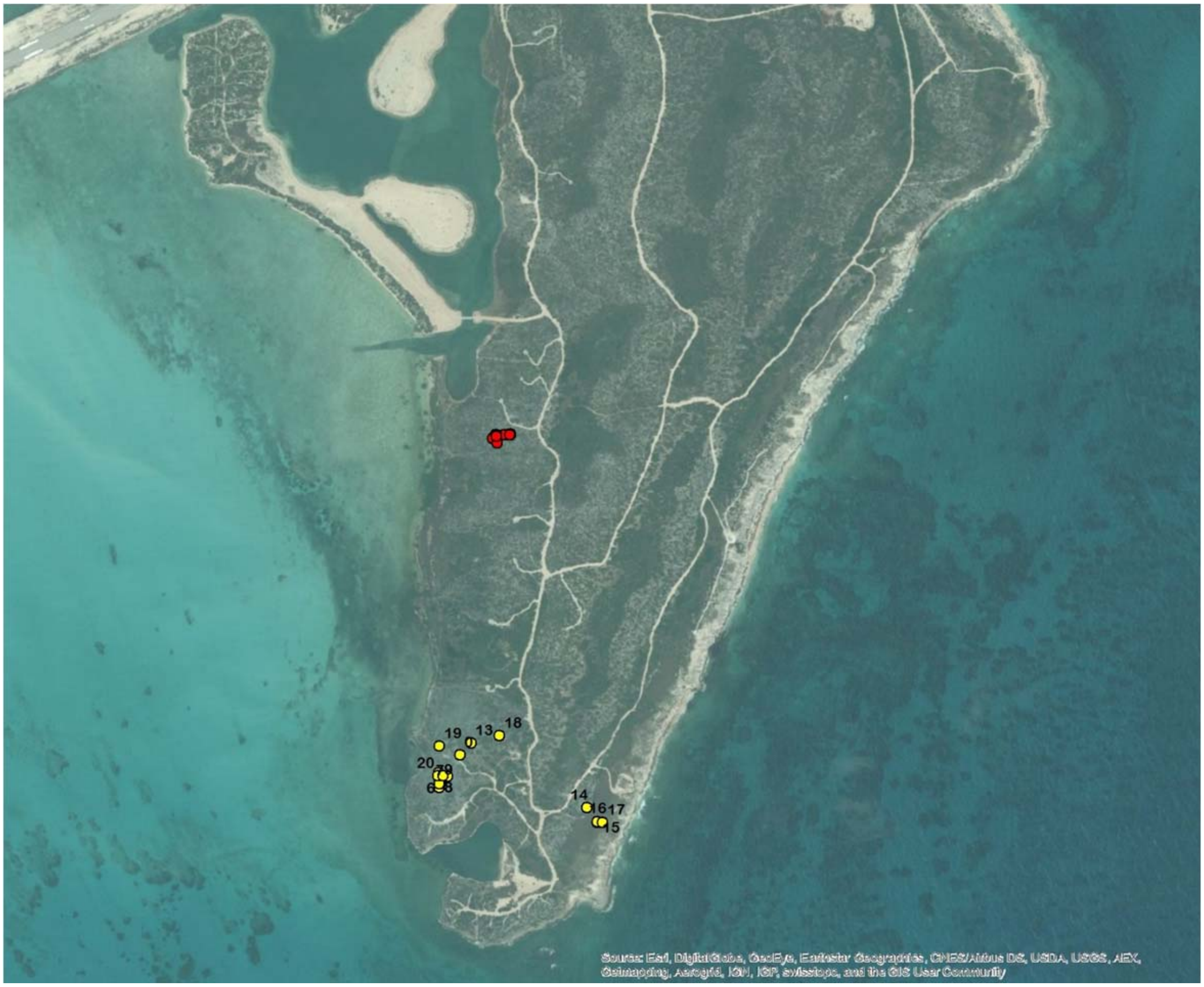
J58 (female, juvenile, dry season, 2014) was translocated from the tents to the ruins. She remained at the translocation site throughout the duration of the study. Midway through the study period, in the midst of recording her location data, a snake moved over the exact location where she was under the rocks. Concerned that perhaps she had been predated, rocks were removed and the retreat area was dug out. She was cold and not moving at first, but upon retrieval, ultimately moved and escaped. She remained in the same retreat area throughout, and dropped her transmitter the day of her final catch. Given that her location was so reliable, the final catch still happened even without her transmitter attached.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J61 (male, juvenile, dry season, 2014) was translocated from the tents to the ruins. He remained at the translocation site throughout.

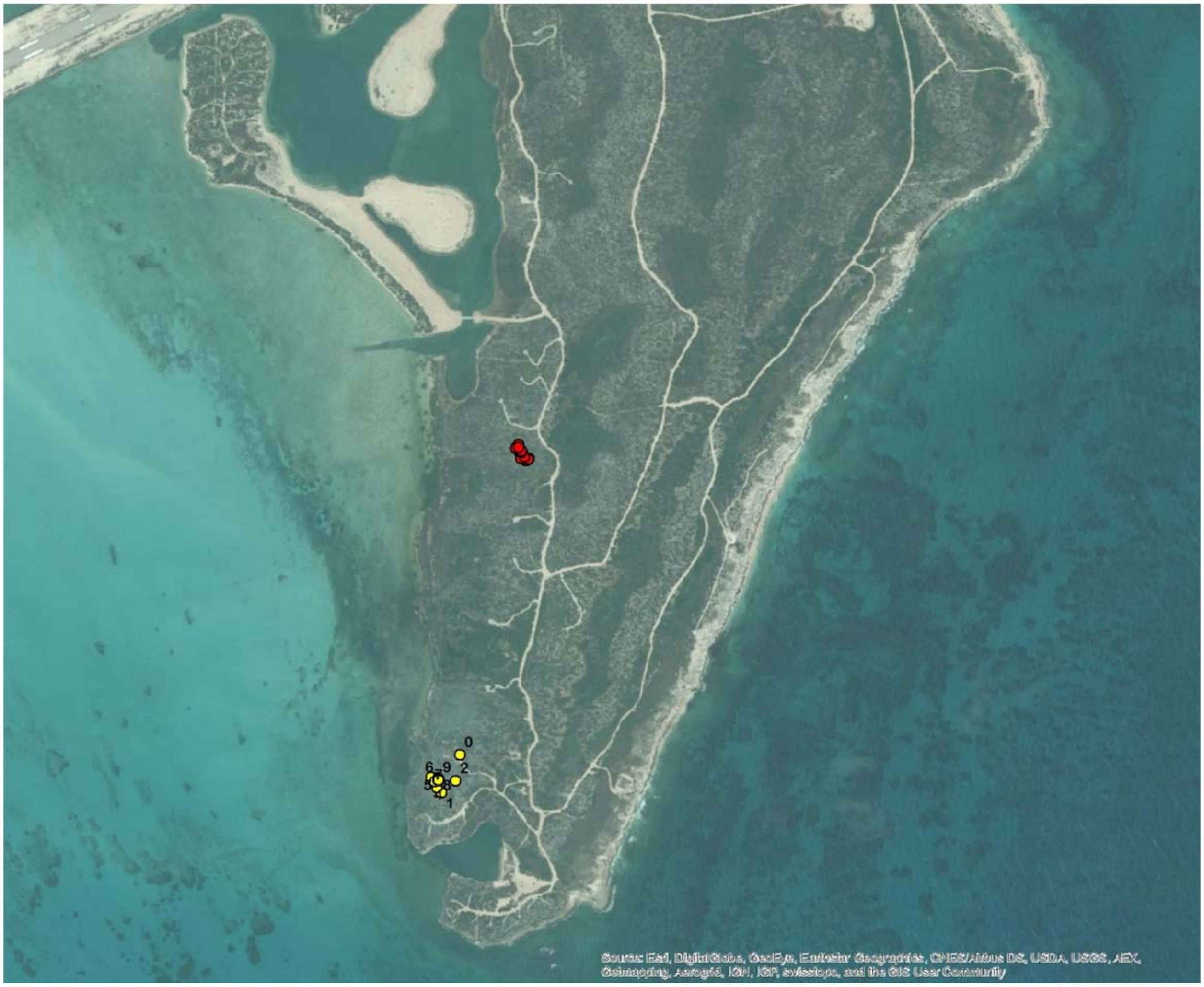
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J62 (male, juvenile, dry season, 2014) was translocated from the tents to the ruins. He remained at the translocation site throughout.



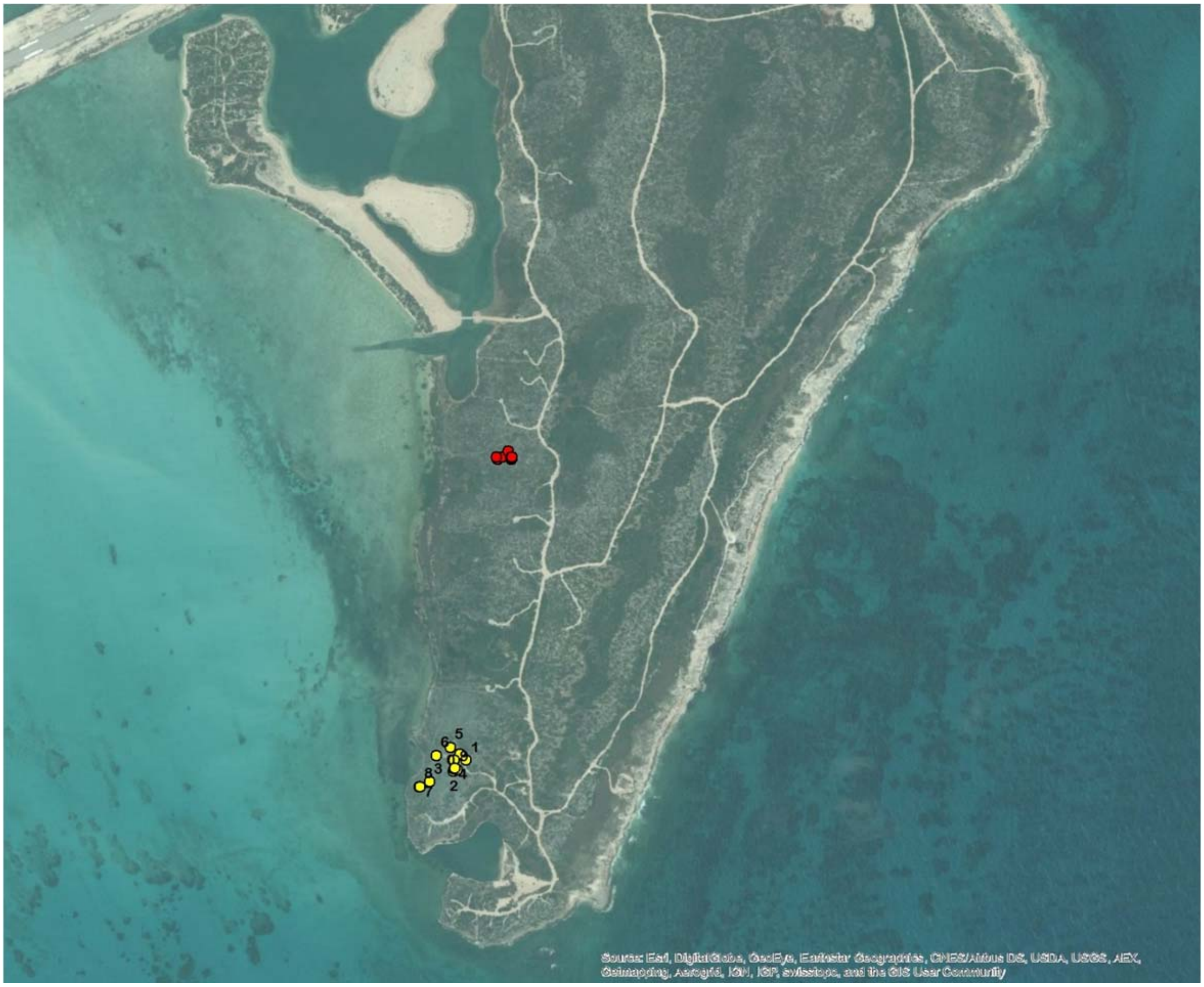
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J63 (female, juvenile, dry season, 2014) was translocated from the ruins to the tents. She traveled far to the east coast away from the translocation site. Interestingly, she also traveled back to the exact retreat she was using earlier in the study period at the translocation site.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J64 (female, juvenile, dry season, 2014) was translocated from the ruins to the tents. She remained at the translocation site throughout.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

J65 (female, juvenile, dry season, 2014) was translocated form the ruins to the tents. She remained in the tents study area, but dropped her transmitter 8 days post translocation. She was never caught and was considered lost to follow up.

Appendix B

Adult Subject Locations After Original Translocation Study Periods

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A14 (male, adult, 2011 study season) was observed once during 2012 back in his original capture area having homed during the preceding year but after the 2011 study season. He has not been observed since, but it is suspected that he may have lost his beads.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A18 (female, adult, 2011 study season) was observed during 2012 back in her original capture area having homed during the preceding year but after the 2011 study season. She was observed in the 2012, 2013 and 2014 study seasons in the same area.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A23 (female, adult, 2011 study season) was observed during 2012 back in her original capture area having homed during the preceding year but after the 2011 study season. She was observed in the 2012 and 2013 study seasons, but not in the 2014 season.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A25 (female, adult, 2012 study season) was observed yearly at the translocation site and has clearly established a new home range there.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A26 (female, adult, 2012 field season) was observed yearly at the translocation site and has also established a new home range there. She remains one of the most visible animals from prior study years.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A31 (male, adult, 2012 field season) was observed once in 2014 back in his original capture site area.

He was not observed in that location in 2013.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A32 (male, adult, 2012 field season) was observed in both 2013 and 2014, having homed during the time period after the 2012 field season.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A41 (female, adult, 2013 field season) was observed during the 2014 field season, having homed during the time period after the 2013 field season.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A42 (female, adult, 2013 field season) was observed in the ruins during the 2014 field season. She had lost her transmitter during the 2013 field season, and was located back at home the following year.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A47 (female, adult, 2013 field season) was observed in the ruins during the 2014 field season. She remained at the translocation site a year after her translocation from the tents.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

A52 (male, adult, 2013 field season) was observed once in the tents during the 2014 field season. He remained at the translocation site a year after his translocation from the ruins.