Tagging and Nesting Research on Hawksbill Turtles (*Eretmochelys imbricata*) at Jumby Bay, Long Island, Antigua, West Indies

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By

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2006 Annual Report:
Jumby Bay Hawksbill Project

TABLE OF CONTENTS

2006 Annual Report:
Jumby Bay Hawksbill Project

TABLE OF CONTENTS
(continued)

LIST OF FIGURES

2006 Annual Report:
Jumby Bay Hawksbill Project

Tagging and Nesting Research on Hawksbill Turtles (*Eretmochelys imbricata*) on Jumby Bay, Long Island, Antigua, West Indies
15 June – 16 November 2006

ABSTRACT

The 2006 season concluded the 20th consecutive year of hawksbill sea turtle (*Eretmochelys imbricata*) nesting research conducted on Long Island, Antigua, West Indies. For 153 consecutive nights, from June 15 to November 15, 2006, hourly beach patrols were performed on foot to identify and tag nesting hawksbills. Data collection protocol remained consistent with that of previous years of study. This season assessed a possible correlation between lunar phase and turtle activity, and also implemented a bi-weekly educational seminar for residents and guests on Long Island.

A total of 62 nesting hawksbills, including 23 neophytes and 39 remigrants, and 224 nests and 286 false crawls were recorded on Pasture Bay Beach and peripheral beaches in 2006. Pasture Bay Beach, the primary study site, had 197 nests and 227 false crawls. Peripheral beaches including Pond Bay Beach, Doniford Beach, Hawksbill Cove Beach, and Carisbrooke Beach supported the remainder of the nesting activity. The nesting season peaked mid-August and continued with significant turtle activity through to the beginning of November. The peak in neophyte and remigrant arrival occurred at the end of June with 11 total females (5 neophytes, 6 remigrants) first encountered at that time.

Most nests deposited on Pasture Bay were located along the northeast end of the beach (stake numbers 19-31). Clutch sizes for excavated nests (those deposited before September 10th) ranged between 81 and 249 eggs with a mean of 149 eggs. Remigrants were found to have larger clutch sizes than neophytes with a mean of 157 eggs compared to the neophyte average of 136. A total of 60% of nests excavated had 80% or higher hatch release with no difference found between the percent hatchling release of remigrants and neophytes. Remigrants averaged 1.4cm larger in curved carapace length and 2.0cm larger in curved carapace width than neophytes. No correlation was found between lunar phase and turtle activity. A total of 54% of remigrants documented in 2006 were observed within 14 days of the dates they were first observed and tagged.

Due to the large number of nests (20) deposited prior to researcher arrival in mid June, an earlier start date (prior to June 14) is recommended for future seasons of research. This season’s data support that an increased focus on beaches peripheral to Pasture Bay Beach is also necessary in the future. The JBHP continues to stress the importance of education and public outreach. With continued support from residents, the EAG, the Jumby Bay Island Company, and WIDECAST, we hope to spread the importance of sea turtle conservation and influence national legislation to better protect all of Antigua and Barbuda’s sea turtle species.

2006 Annual Report:
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I. INTRODUCTION

For over 100 million years, dating prior to the dinosaurs, sea turtles have roamed the oceans. Since their emergence in the Cretaceous period, sea turtles have played integral ecological roles, enlisting them as 'keystone species' (León and Bjorndal 2002, Bjorndal and Bolten 2003, Bjorndal and Jackson 2003, Jackson 2004). Anything that threatens the livelihood of a keystone species has the potential to negatively impact ecosystem functioning. Global studies already show alterations in marine food webs and unhealthy changes in coral reefs with some investigators (Moran et al. 2002) citing declining numbers of sea turtles as contributing factors.

Over-harvesting has been the principle cause of the demise of what used to be one of the most ubiquitous vertebrates on earth. In addition to direct harvest (of all species) for meat, eggs and oil (recently summarized for the Caribbean by Bräutigam and Eckert 2006), hawksbill turtles have historically been traded in large numbers for their beautiful tortoise-shell patterned scutes, used in creating jewelry and trinkets (Milliken and Tokunaga 1987, Meylan and Donnelly 1999). Sea turtles, along with other marine organisms, also fall victim to incidental capture caused by trawl nets, gill nets, and long lines (e.g. NRC 1990, Weber et al. 1995, Lewison et al. 2004, Eckert and Eckert 2005). Finally, habitat destruction takes a toll both on nesting beaches and marine habitats. As a direct result, all six Caribbean sea turtle species are classified as endangered or critically endangered by the World Conservation Union *RedList* (IUCN 2006). Currently, hawksbills are considered critically endangered sea turtles (cf. IUCN), having sustained a more than 80% loss in their numbers on a global scale in less than three generations (Meylan and Donnelly 1999).

The hawksbill sea turtle (*Eretmochelys imbricata*) inhabits tropical waters, foraging amongst most of the world's coral reef habitat for sponges and other invertebrates. Adult hawksbills may grow up to a meter in length, can weigh up to 200 lbs, and are the second smallest genus of sea turtle, after *Lepidochelys* (Gulko and Eckert 2004). During the primary nesting season, from June to November, Nesting females prefer small islands, isolated beach sites, and dense vegetation (Hoyle and Richardson 1993, Witzell 1983).

The Caribbean nation of Antigua and Barbuda is host to four of the region's six species of sea turtle: the leatherback, loggerhead, green, and hawksbill. There is an open season on all species found in Antigua's waters. The Turtle Act, implemented by the Antiguan parliament in 1927 and revised in 1992, offers protection to the nation's sea turtle population, with the exclusion of the loggerhead, from June 1st through September 30th. Only during this time of year is it illegal to take, catch, buy, possess, sell, and even aid in the catching of turtles and their eggs. Anyone found guilty of an offense against the Turtle Act is subject to arrest without a warrant, a maximum fine of five-hundred dollars, seizure of any turtle products or nets, and the forfeiture of such goods if convicted. The only turtle regulation in effect all year round is the stipulation that any turtle taken must be above twenty pounds in weight (Antigua and Barbuda, chapter 449).

These laws are not nearly effective enough to allow the nation's sea turtles to recover to a stable population (Fuller et al. 1992). Research conducted by groups such as the Jumby Bay Hawksbill Project (JBHP) plays an essential role in informing the improvement of protective legislature for sea turtles.

When working with a species as long-lived as sea turtles, the importance of continuous, long-term research investigating such aspects of the life history as nesting ecology and population demographics is immense (Richardson 1999). The JBHP has worked for the past twenty years to better understand the life history of the hawksbill turtle, in hopes that findings will serve as a foundation for wise management and policy making.

An important aspect for all conservation projects is education. The Jumby Bay Hawksbill Project takes pride in performing educational outreach in a variety of forms. Visiting schools, attending summer camps, holding educational seminars, and hosting turtle watches are all essential to educating others of the local hawksbill sea turtle population's critically endangered status and importance of sea turtle conservation. Only through long-term public support will Antigua and Barbuda's hawksbills have a chance at survival and recovery.

II. STUDY SITE

Pasture Bay Beach is an approximately 450m long beach located on the northern side of Long Island, a 120ha privately owned island several kilometers off the northeast coast of Antigua, West Indies (see Appendix I). Long Island functions as the site of the Jumby Bay Resort and at least 30 residential estates.

Located on the windward side of the island, Pasture Bay Beach collects sand through natural processes. For centuries, hawksbill sea turtles have probably been nesting at this site where, historically, thick maritime forest and coastal shrubs covered the beach. Since this species prefers to lay eggs adjacent to or under the shelter of vegetation, such an environment has provided prime nesting ground for hawksbills. Although, over the years much of the natural vegetation has been cleared to support island development, vegetation islands of scaevola and seagrape shrubs have been planted specifically to improve environmental conditions for hawksbill nesting.

Numbered markers placed along the vegetation line at 10-15 meter intervals along Pasture Bay Beach divide the beach into 36 sectors. Characterization of beach into three zones also helps to describe the study area.

The northeast-facing section (stakes 19-31) is relatively narrow, consisting of mixed shrubs and sparse mangrove. There are no man-made structures on this portion of the beach except for a small road that runs parallel with the coastline behind the vegetation layer.

The middle, north-facing section (stakes 8-18) is characterized by wider stretches of beach. Vegetation islands have been planted in recent years to supplement existing nesting habitat since portions of the natural vegetation have been cleared. Behind this section of the beach (stakes 8-14) and separated by a layer of vegetation is a marsh, home to threatened water-fowl species.

The northwest facing section (stakes 7 to -5) encompasses more varied habitat. Between stakes 3-7 the habitat is similar to the northern parts of the beach with a mix of scaevola, seagrape, and palm trees. The shoreline stretching along stakes -1 to 3 has exposed limestone shelves. In addition, along these stakes is a three-foot, man-made wall separating the rocky beach from a private residence. Two other private residences occur between stakes -3 to 0 and stakes -4 to -5 are in front of a lawn separating the beach by a 6 inch concrete wall. Stakes 0 to -5 have primarily open, sandy beaches separated by rows of vegetation adjoining the properties.

Pasture Bay Beach is the primary nesting site and, therefore, the focus of the project. However, nesting activity continued to occur this season on nearby peripheral beaches as in recent years. Other beaches included Pond Bay Beach (lying behind privately owned villas) as well as, Doniford Beach, Carisbrooke Beach, and Hawksbill Cove Beach, all of which are private, man-made beaches set east of Pasture Bay Beach.

III. METHODS

Patrols

Following the same protocol as past years, hourly patrols were performed on foot using flashlights for a total of 153 consecutive nights (June 15th through Nov 15th with the exclusion of Aug 7th) in order to document all turtle activity. The entire 450m length of Pasture Beach was walked every hour from 8 p.m. until first signs of morning light. Final patrols of the beach began at approximately 4:30 a.m. in the beginning of the season and delayed until about 5 a.m. as the season progressed. Patrolling in this manner ensured that every nesting turtle was encountered and identified.

Peripheral beaches to Pasture Beach, such as Doniford and Pond Bay, were patrolled at least once a night**,** just prior to final patrol**,** in order to document any false crawls or potential nests. Frequency of patrols to these beaches was dependent on prior and anticipated activity. Hawksbill Cove was also patrolled occasionally based on activity reported by residents there, but was not monitored on a nightly basis. Carisbrooke was monitored when granted permission by houseguests.

Data Collection

Data collection procedures were performed in a manner consistent with all other years of field research. To ensure a turtle's complete immersion into her nesting trance-like state, data collection procedures began after the first egg was deposited. Any invasive procedures, such as tagging or drilling, were performed only during laying. Occasionally, a turtle was found in a post-laying state and needed to be approached for data collection. In this exception, any unidentified neophyte was quickly given only one tag to ensure her later identification.

Whenever possible, the entire nesting process was allowed to occur naturally. Assistance in the form of redirection or disentanglement was only given in situations where the turtle's safety was endangered. Eggs were left in situ and nests were allowed to emerge naturally.

Tagging

Metal tags (National Band and Tag, size 681, Issued by WIDECAST's Marine Turtle Tagging Centre in Barbados) were used as the primary means of identification of every nesting turtle. Tags were applied to the middle of the scale pad closest to the body on each front flipper. Remigrants received new tags only if previous tags were missing or seemed likely to detach prior to the next predicted encounter. New tags were applied to scale pads where previous tags had been attached or to the next closest pad to the body. Neophytes were given two tags, one applied to the first scale pad of each front flipper.

Drilling

A secondary form of identification involved drilling a unique series of holes through nonvascular areas of keratin on the supracaudal (SC) scutes of each turtle's carapace. In order to avoid drilling into bone, we shined a flashlight beneath the supracaudal scutes, which appear opaque where bone or heavy pigment is present. In a few instances, drilling resulted in bleeding if bone was accidentally hit. These cases were documented and closely monitored to ensure proper healing.

Remigrants had their original drills cleaned or redrilled higher up on the scute to lengthen the life of the mark, and neophytes were given their own unique drill patterns. Carapace growth and wear causes drill patterns to 'migrate' to the distal edge of each SC and become unreadable over time. Protocol dictated that sequences were drilled on average 12-15mm from the posterior marginal edge and will remain readable for a minimum of 4-5 years (Richardson et al. 1999). Since nesting females do not return for a number of years, it was important to drill to the most anterior point the keratin allowed on each SC. As the drill sequence "grows out" with new keratin formation, the same sequence was redrilled into the most anterior position space each SC allowed for.

Morphology

A turtle's size was gauged by the length and width of her carapace. Curved carapace length (CCL) was measured from the nuchal notch to the tip of the most posterior point of the SC scutes. Curved carapace width (CCW) was measured as the maximum curved width from the marginal scutes on one side of the turtle to the other. When time permitted, barnacles were mapped and deformities and injuries were drawn, recorded, and often photographed. Barnacles that interfered with carapace measurements, or elevated keratin such that infection could be introduced, were removed. Any peculiar markings, nicks, or flipper tears were documented.

Behavior

Turtle nesting behavior was similar for all individuals in alternating rear flippers to dig and methods for covering. In many cases, interesting turtle idiosyncrasies were observed during and after laying. Behavioral observations were recorded for both nesting turtles and observed false crawls. A false crawl was classified as any turtle that emerged completely from the water and then returned to sea without successfully nesting. False crawl activity was categorized by its suspected cause as roots, substrate, observer, unknown, or other. In cases when the false crawl was not witnessed, the cause was estimated by analyzing the crawl and the area where the nest attempt was made.

Nest Location

Nests were labeled as inconspicuously as possible with flagging attached above the nest inside vegetation and a small piece of flagging placed inside the egg chamber while the turtle was laying. The flagging noted the date deposited and original tag number of the nesting turtle. Labeled flagging placed inside the nest ensured that a nest was correctly matched to its mother. In areas of high nest density internal flagging was a necessity.

Longitudinal and latitudinal coordinates of nests were recorded using a Global Positioning System (GPS) unit with 30 meter accuracy (these data were collected to assess broad trends in beach use over time, not to locate nests within seasons). Terrestrial markers, which have remained in the same location since the project's inception, separated the beach into 36 segments (stakes -5 to 31). Distances were measured from the nest to the high tide line and to the vegetation edge.

Hand-drawn maps were also used to facilitate nest location. Each nest map included GPS coordinates, stake number, distance to vegetation edge, distance to high tide line, and any other physical indicators like local flora or man-made marks. Nests that were accessible without destroying a lot of vegetation were checked for predation or poaching. Nests deposited in potentially dangerous areas, such as high tide prone habitat were relocated to a manually dug egg chamber in a safer region of the beach.

Egg Counts

Egg counts were performed when a nesting turtle was in a favorable area, either in the open or at the vegetation edge, where researchers were able to position themselves directly behind her without causing her stress. To execute egg counts, latex gloves were worn and eggs were caught as they dropped from the ovipositor. Each egg was registered using a tally meter held in the free hand before allowing the egg to fall into the egg chamber. Precautions, such as digging out the back of the nest in order to comfortably fit a hand underneath the plastron, were taken to avoid contact with the turtle's ovipositor organ while she was laying. Egg count results were compared against shell counts made at excavation in order to assess percent error in shell count estimates.

Nest Excavations

All nests deposited on Pasture and its neighboring beaches up to September 10th (65 days before the end of the nesting survey) were subject to nest excavation. Nests that showed evidence of an emergence were usually excavated within a 48-hour period of the emergence. The typical incubation period for hawksbill sea turtle nests at Jumby Bay is about 60 days, so a minimum period of 65 days was allowed for hatchlings to emerge naturally before attempting excavation. Eggs encountered during excavations were placed into the following categories: egg shells, fresh undeveloped, decomposed undeveloped, fresh embryo, decomposed embryo, live pipped, dead pipped, live hatched, dead hatched, deformed hatched, deformed unhatched, yolkless, and other. A common "other" category was that of "moldy" eggs, in which the contents of an unhatched egg were covered in a black, fuzzy substance that appeared to be a type of mold. Along with categorizing all eggs found, nest depth of the egg chamber was recorded. After excavation, all eggs and egg contents were returned to the egg chamber and reburied to simulate natural conditions. Any live hatchlings encountered during excavation were released to the ocean from as near to the nest site as possible at the earliest opportunity. Hatchlings found during daylight hours were detained in a dark, cool**,** enclosed area and released following first patrol at 8 p.m.

Weather Conditions

Nightly data collection included assessment of weather conditions while each turtle was on the beach as well as for the entire night. Cloud cover was described using four categories: clear (0 to 25% cloud cover), scattered (26 to 50% cloud cover), broken (51 to 75% cloud cover), and overcast (76 to 100% cloud cover). Rain measurements were also taken every night in millimeters using a rain gauge attached to a stationary stake. The rain gauge was located in the open at stake 13.

Lunar Phases

Phases of the moon were researched at the end of the season using the United States Naval Observatory website's moon calendar for 2006 and were then compared to the corresponding night's turtle activity. Moon phase was categorized as follows: new moon (dark moon with no illumination), waxing crescent (the period between new moon and first quarter with illumination increasing nightly), first quarter (one-half the moon is illuminated and increasing), waxing gibbous (the period between first quarter and full moon with illumination increasing nightly), full moon (the entire moon is illuminated), waning gibbous (the period between full moon and last quarter with illumination decreasing nightly), last quarter (one-half the moon is illuminated and decreasing), waning crescent (period between last quarter and new moon with illumination decreasing nightly) (Phases of the Moon).

IV. RESULTS

Recruitment

A total of sixty-two adult, female hawksbill turtles were documented during the 2006 nesting season on Long Island, Antigua (Fig 1). Twenty-three of these turtles were neophytes and the remaining thirty-nine were remigrants. The total includes two remigrants who were only witnessed performing false crawls and were never documented nesting. The cohort for the 2006 season had a very similar composition to that of the 2005 season (23 neophytes and 40 remigrants).

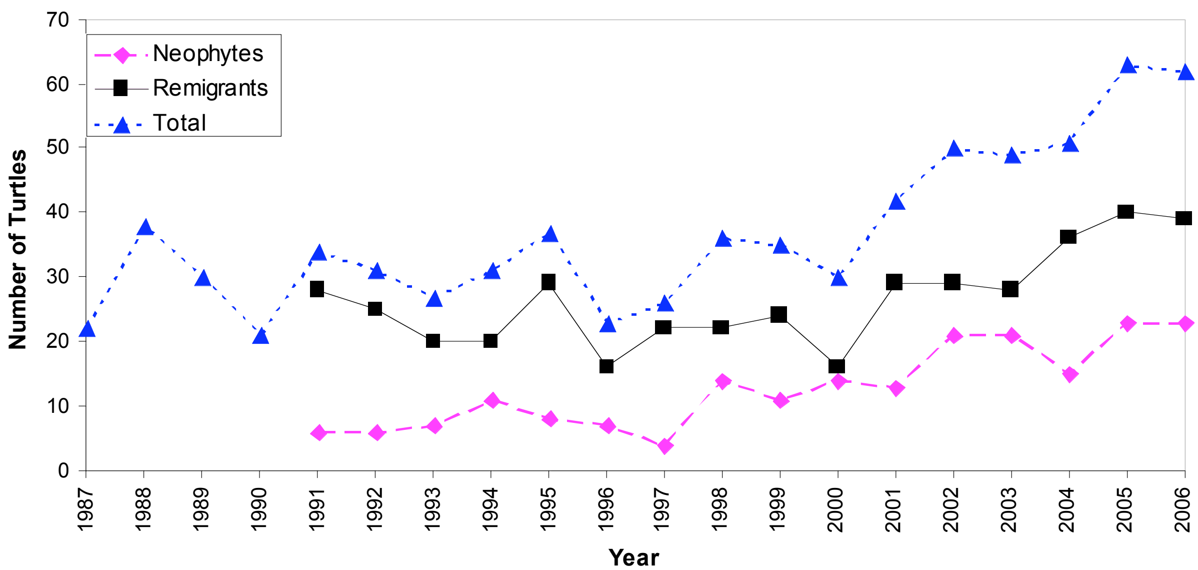

Figure 1. Neophytes, remigrants, and total nesting females documented on Long Island, Antigua, West Indies, during monitoring from 1987 to 2006.

Seasonal Activity Levels

A total of 224 nests and 286 false crawls were documented on Pasture Bay Beach and all other peripheral beaches this season (Fig 2). Pasture Bay Beach alone had 197 nests and 227 false crawls. Pond Bay Beach had 5 nests and 21 false crawls. Doniford Beach had 5 nests and 9 false crawls, Hawksbill Cove Beach had 1 nest and 1 false crawl, and Carisbrooke had 16 nests and 28 false crawls. Of the 153 nights of patrol, there were 15 total nights with no activity on any beach.

Most nesting activity occurred from late June to late August (Fig 2). Nesting activity peaked during the week of August 10th with 17 nests and 22 false crawls for all beaches. The night with the most activity of the season occurred on August 13th with 4 false crawls and 2 nests on Pasture Bay Beach, and 4 false crawls and 1 nest on Pond Bay Beach. Pasture Bay Beach, Doniford Beach, and Carisbrooke Beach experienced some activity through the final four weeks of the season.

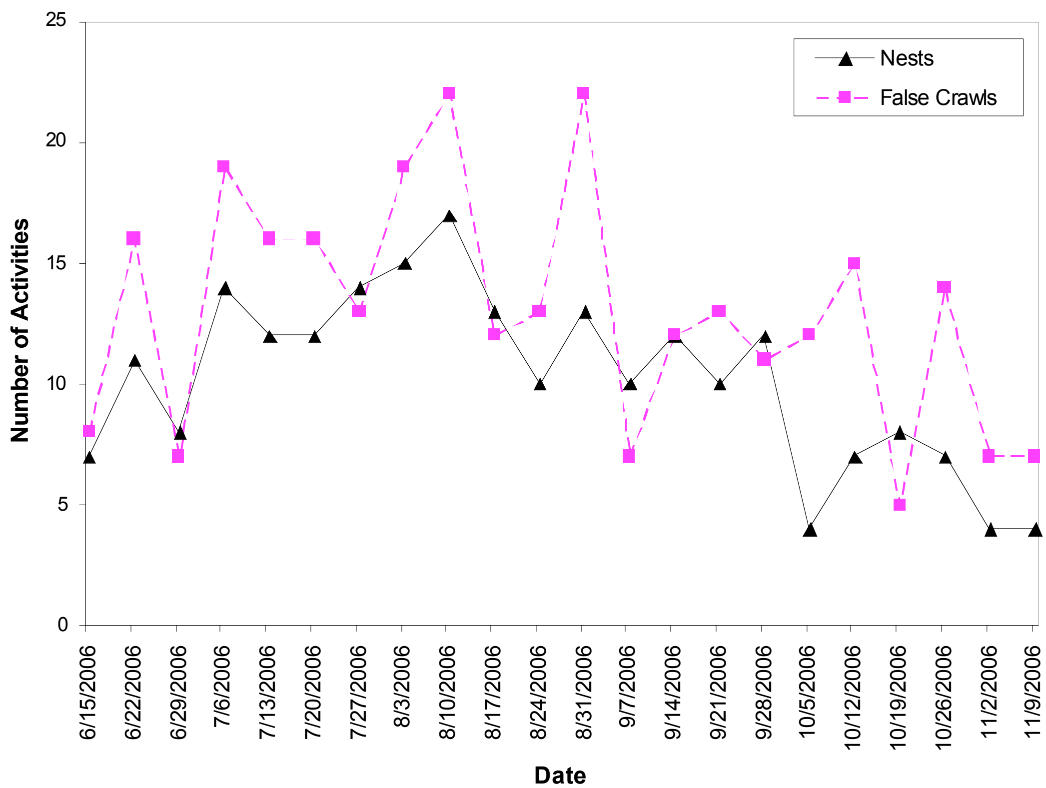

Figure 2. Number of nesting activities recorded on Pasture Bay Beach, Pond Bay Beach, Doniford Beach, Hawksbill Cove, and Carisbrooke Beach on Long Island, Antigua, from June 15 to November 15, 2006. The date signifies the week beginning on that date.

Figure 3 depicts first encounter dates for each turtle (though many of them nested multiple times in 2006). The arrival peak for both neophytes and remigrants occurred within the first four weeks of the season (Fig 3). Both groups showed highest activity during the seven-day period starting June 22[st] and ending June 28[th] with 6 remigrants and 5 neophytes. The final neophytes arrived during the week of September 28[th] and the final remigrants arrived during the week of October 19[th].

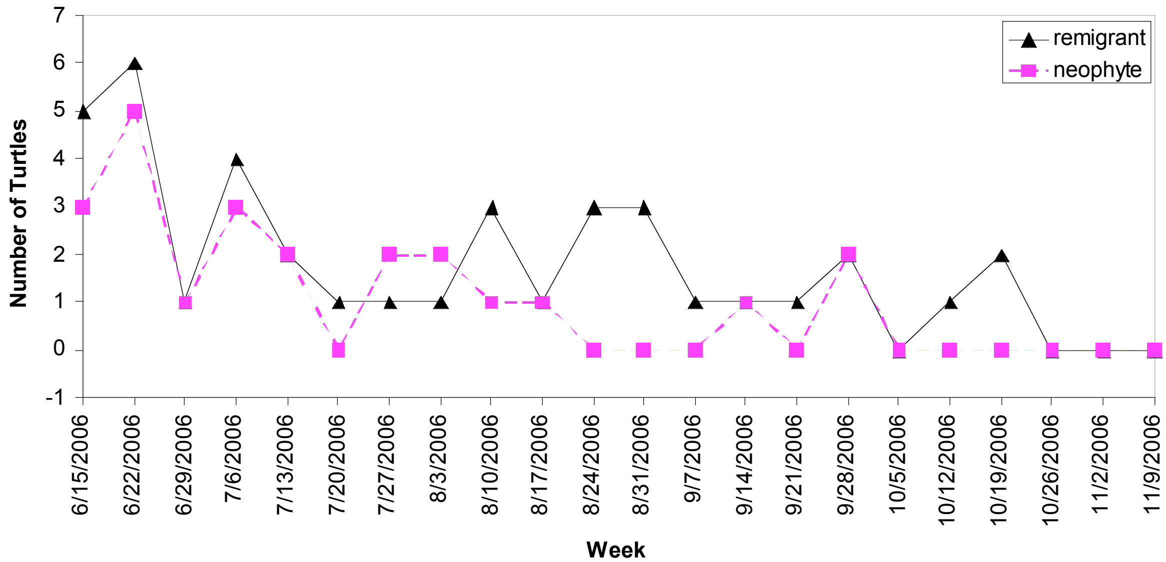

Figure 3. Number of new neophytes and new remigrants encountered per week on Pasture Bay Beach, Pond Bay Beach, Doniford Beach, Hawksbill Cove, and Carisbrooke Beach on Long Island, Antigua, from June 15 to November 15, 2006. The date signifies the week beginning on that date.

Activity by Beach Sector

Certain areas of Pasture Bay Beach were more prone to turtle activity than others (Fig 4). "Hot spots" for nesting represent areas with high vegetation or bushes that come close to the water's edge. There is less nesting in the middle of the beach where vegetation islands are relatively young.

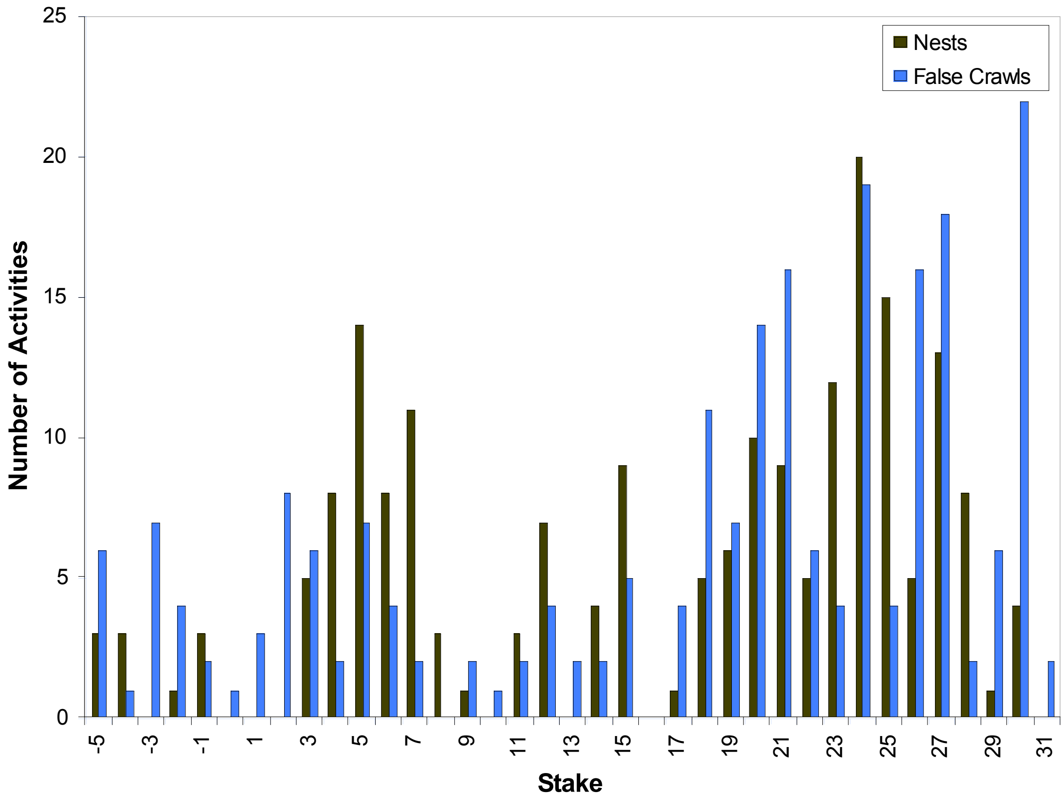

Figure 4. Number of nesting activities according to beach sector on Pasture Bay Beach, Long Island, Antigua, from June 15 to November 15, 2006. Low stake number refers to the lowest number marker of a particular sector on the beach.

The most nests were deposited in the northern part of the beach at stake 24 in the 2006 season (Fig 5). In 2005, nests showed a similar special distribution (low and high stakes most popular, middle stakes less so), but the most nests were located at stake 4.

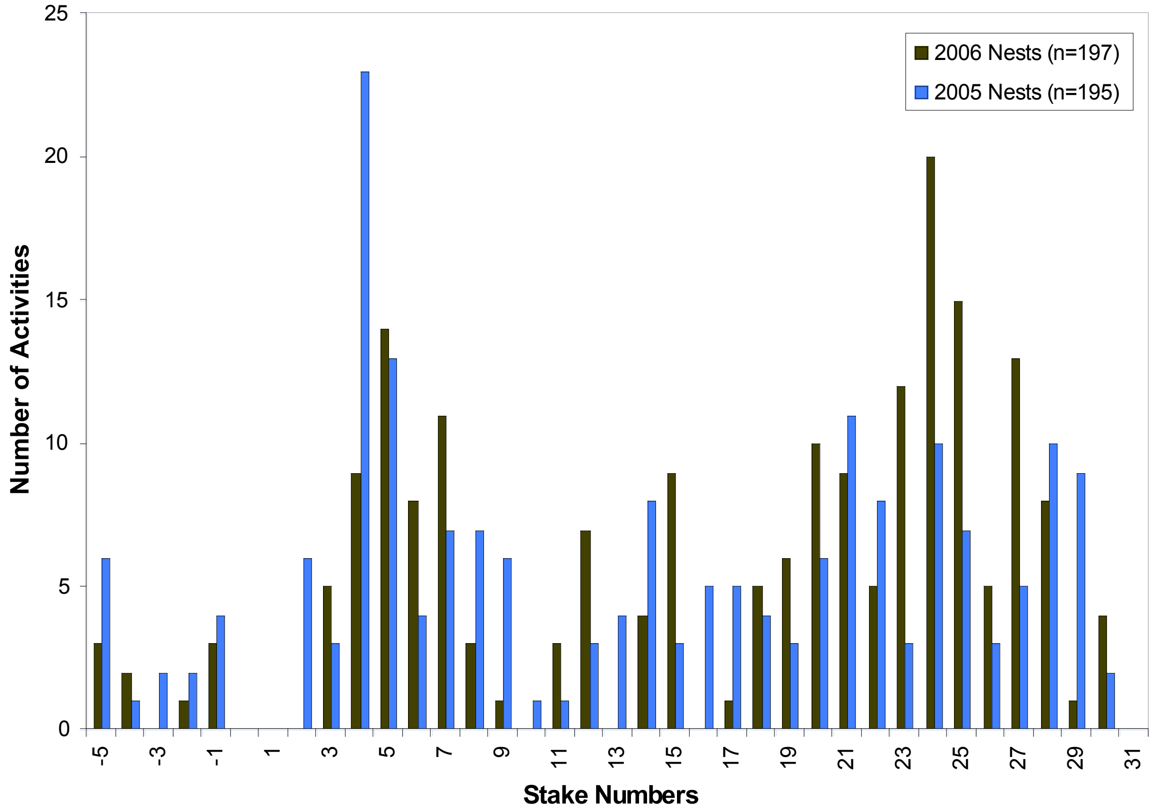

Figure 5. Location of nests deposited in 2005 and 2006 nesting seasons on Pasture Bay Beach, Long Island, Antigua. Low stake number refers to the lowest number marker of a particular sector on the beach.

False Crawls

There were a total of 286 false crawls on Pasture Beach, Doniford, Pond Bay, Carisbrooke, and Hawksbill Cove. In most cases (59%), the cause of false crawls was unknown (Fig 6). Roots and substrate were the largest known cause (34%) while observers were documented to be the cause 2% of the time. Eleven false crawls were classified as caused by "other", including two that were classified as caused by terrain (e.g., the steep slope of the beach) (Fig 6).

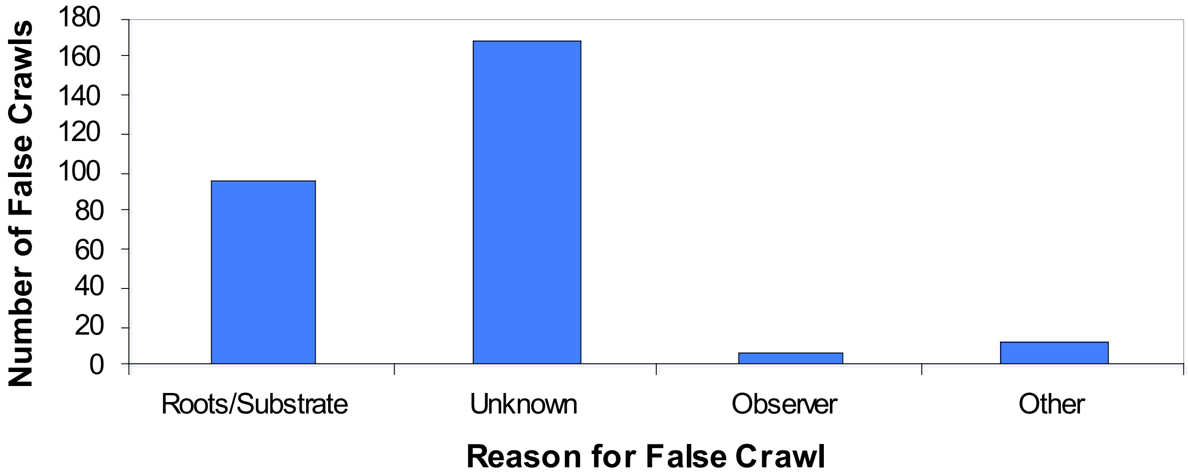

Figure 6. Presumed causation of false crawls on Pasture Bay Beach, Pond Bay Beach, Doniford Beach, Hawksbill Cove, and Carisbrooke Beach on Long Island, Antigua, from June 15 to November 15, 2006.

Remigration Intervals

Remigration intervals (elapsed time since previous nesting seasons) ranged from 2 to 7 years (Fig 7). Remigrants returning in 2 or 3 year intervals comprised 82% of all remigrants. The mean remigration interval in 2006 was 2.9 years.

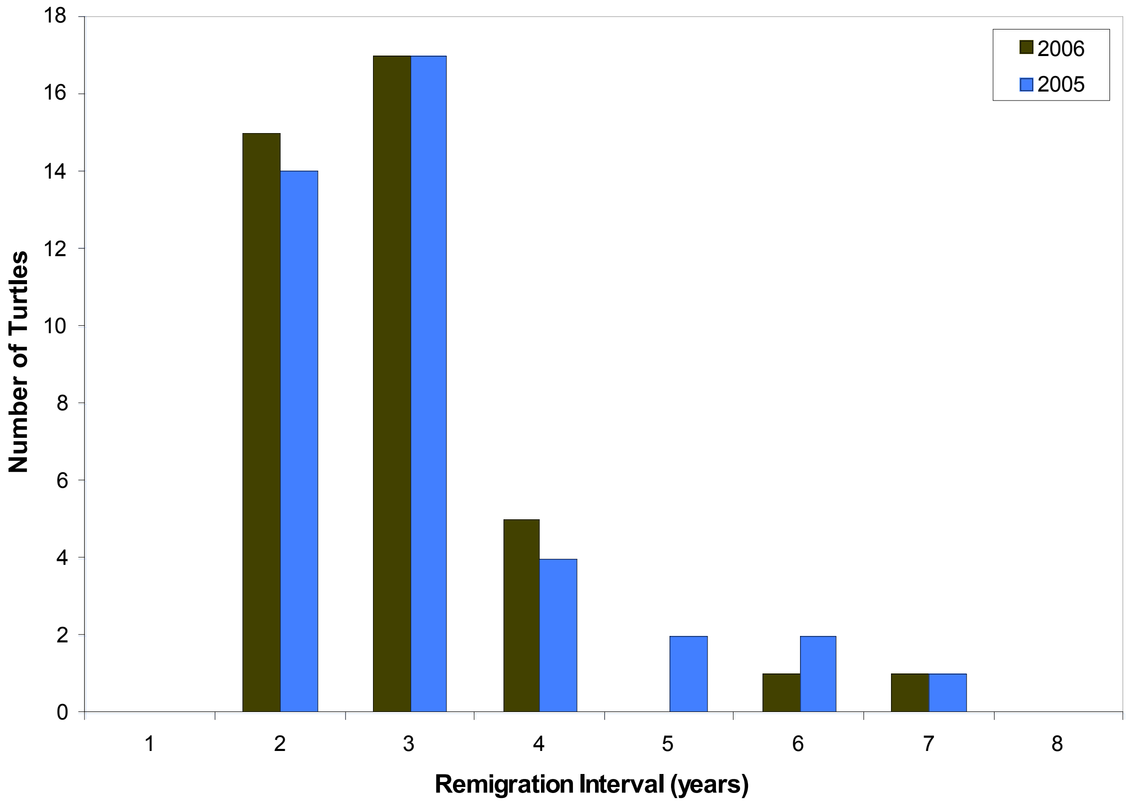

Figure 7. Remigration intervals of hawksbills nesting on Long Island, Antigua, in 2005 and 2006.

Fecundity: Clutch Number

224 nests were deposited on Long Island, Antigua between June 14th and November 16th. Of these 224 nests, 202 were positively matched to the mother. Nests laid on peripheral beaches were often recorded post deposition without encountering the nesting turtle due to less frequent patrolling. Only identified nests were included in assessing clutch number. The number of clutches per individual deposited during the 2006 season ranged from 1-6 (Fig 8). A mean of 3.3 clutches were deposited by the combined cohort. However, when analyzed individually, neophytes deposited a mode of 3 clutches while remigrants deposited a mode of 4 clutches.

In order to maintain consistency with past analysis and reduce bias introduced by early or late-season nesters, we also summarize a truncated data set for turtles with a first visit recorded between July 3rd and September 15th. This decreased the sample size from 23 to 13 neophytes and from 39 to 21 remigrants. As a combined group, the average was 3.2 clutches deposited per individual. When divided, neophytes showed a mode of 4 clutches while the mode for remigrants was 5.

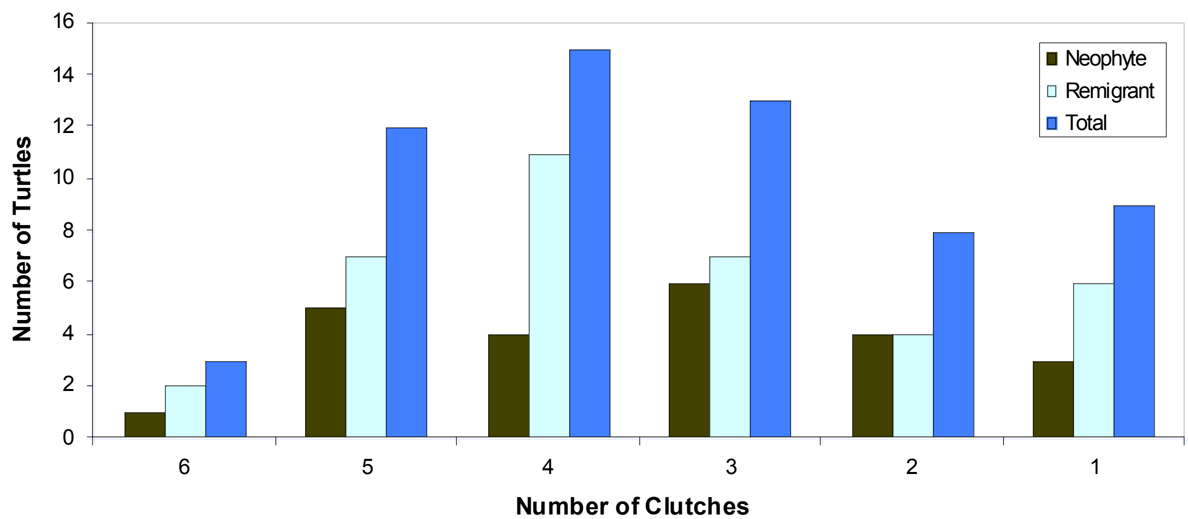

Figure 8. Number of clutches for all turtles recorded from June 15 to November 15, 2006 on Long Island, Antigua.

Fecundity: Clutch Size and Percent Release

Excavation attempts were made for all nests deposited before September 10th. However, in 8 cases, the nests were never located and, therefore, could not be included in clutch analysis. There were also several incidences where an already incubating nest was dug up or disturbed by a nesting female. In these cases, we chose to delay excavation until after the date of the last deposited clutch. Consequently, these nests were also not included in data assessment. This left a sample size of 152 nests (53 neophytes, 70 remigrants, and 29 unknown) for both clutch size and percent release analyses.

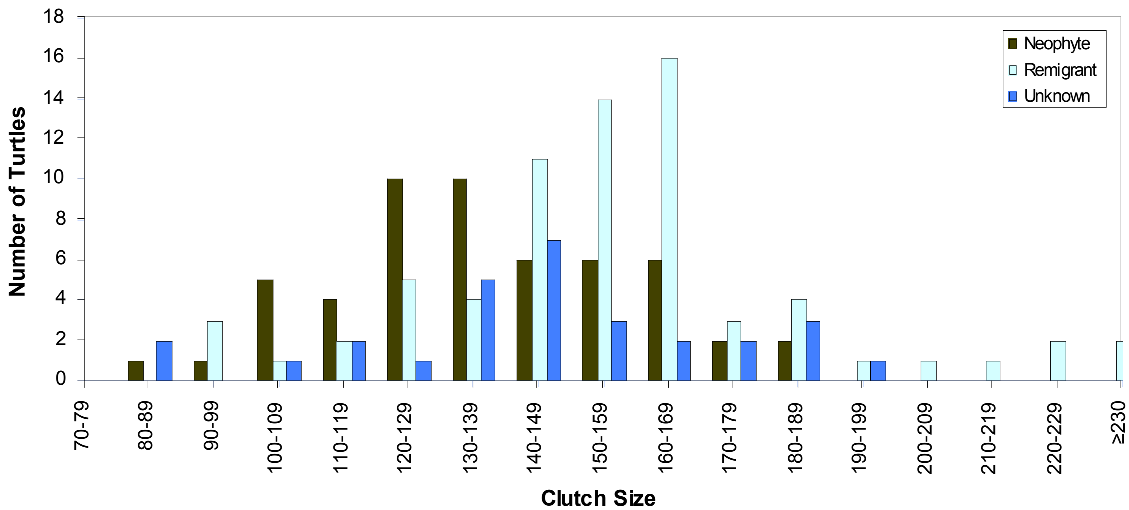

Figure 9. Estimated clutch sizes of nests deposited on Pasture Beach, Pond Bay, Hawksbill Cove, and Carisbrooke during the 2006 season on Long Island, Antigua.

Clutch size ranged from 81 to 249 eggs (Fig 9). As a combined cohort (excluding unknown), the mean clutch size was 149 eggs. When separated, neophytes exhibited an overall smaller clutch size with a mean of 136 eggs compared to 157 eggs for remigrants. Average percent error in clutch size estimates was 5.95% (range: 0-25%), based on 25 known clutch size comparisons.

Percent release ranged from 0% to 100% (Fig 10). Approximately 60% of the total nests had a release success of 80% or higher. Although remigrants generally had larger clutch sizes, they did not exhibit a higher success rate than neophytes. 37.1% of remigrant nests and a comparable 37.7% of neophyte nests had a percent release of 90% or greater. Mean percent release was 70.9% for neophytes and 68.6% for remigrants.

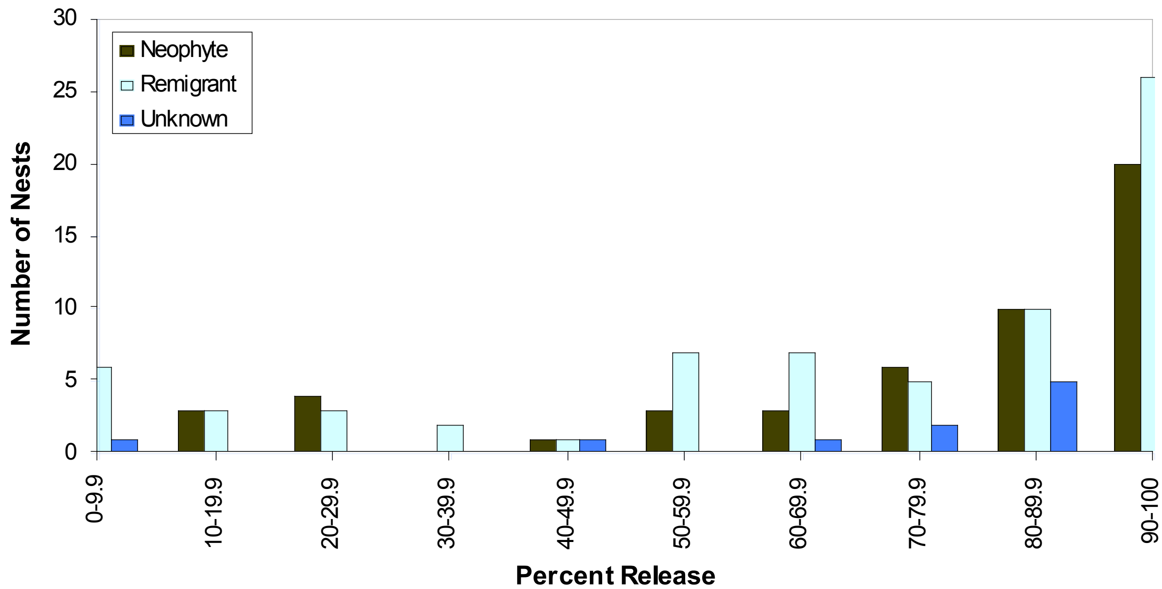

Figure 10. Estimated percentage of hatchlings released from nests documented on Pasture Beach, Pond Bay, Hawksbill Cove, and Carisbrooke during the 2006 season on Long Island, Antigua.

Nesting Female Size

All nesting female sizes were averaged and grouped into 9 curved carapace length (CCL) categories (Figure 11) and 10 curved carapace width (CCW) categories (Figure 12). A total of 36 remigrants and 23 neophytes were measured at least once according to the number of times each nested.

Average size of remigrants was 88.9cm CCL and 79.4cm CCW. Average size of neophytes was 87.5cm CCL and 77.4cm CCW. Total neophytes averaged 1.4cm smaller CCL and 2.0cm CCW than remigrants.

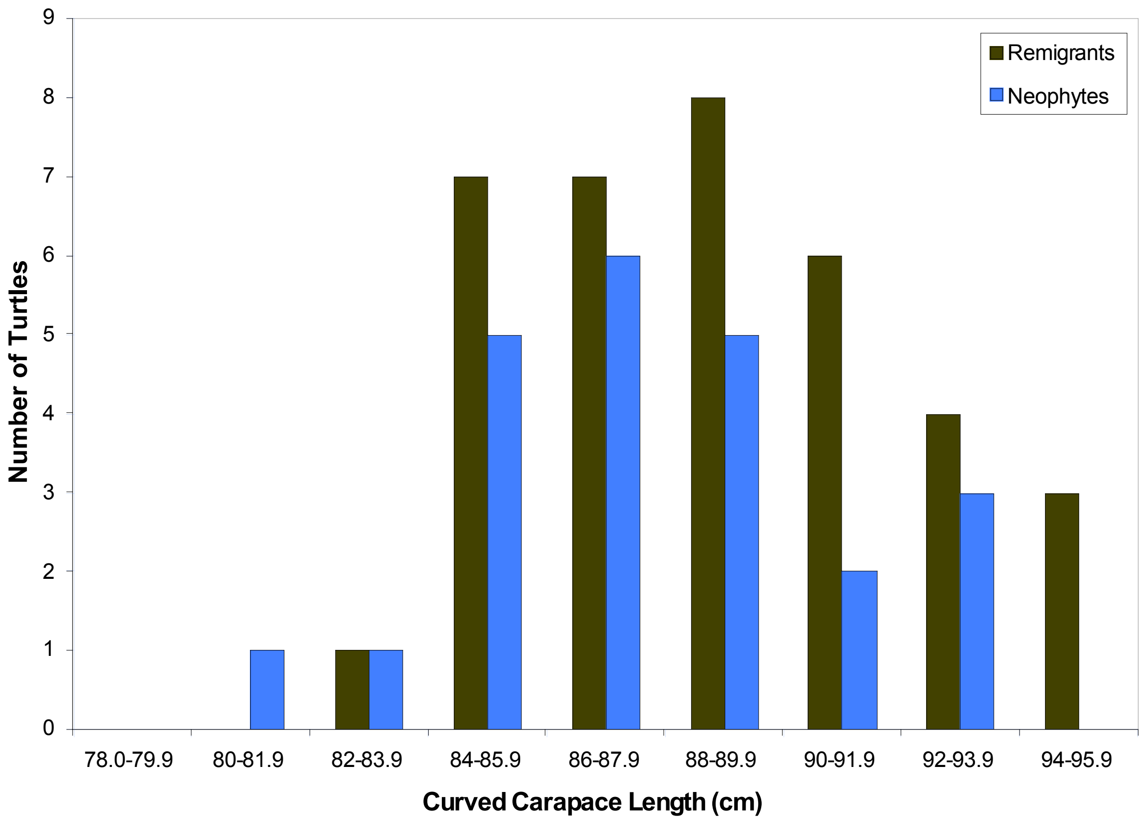

Figure 11. Average curved carapace length of remigrants and neophytes found on Pasture Bay Beach, Long Island, Antigua, from June 15 to November 15, 2006.

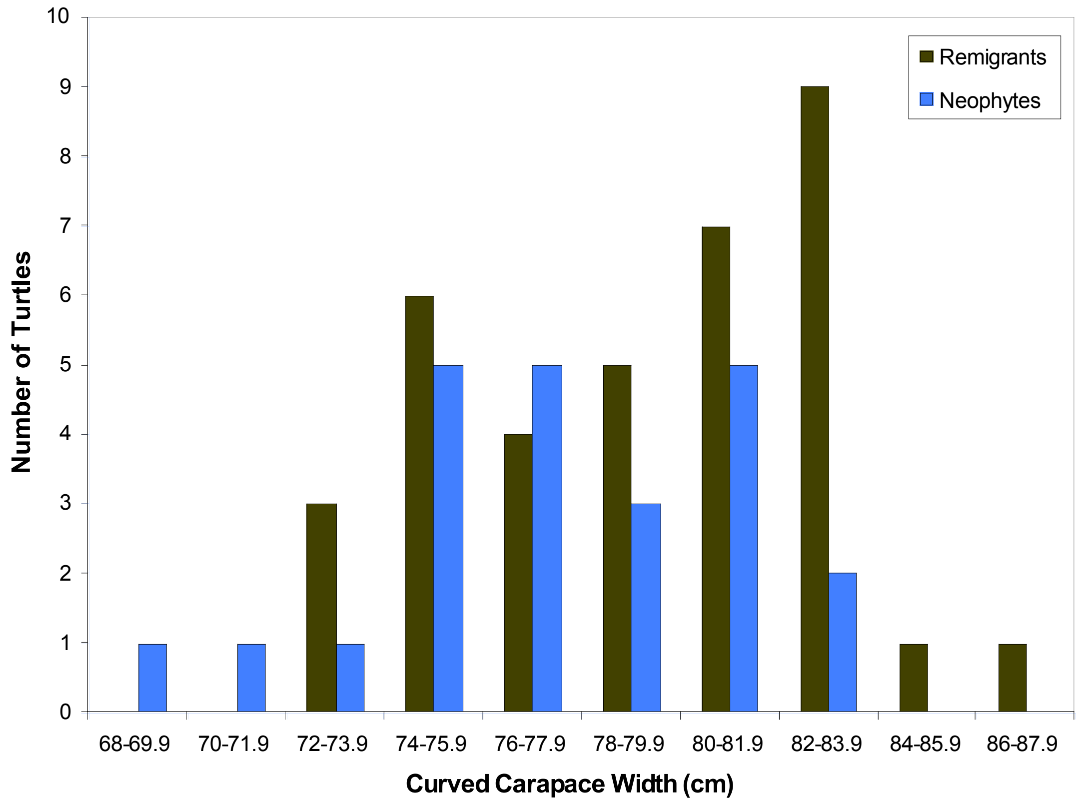

Figure 12. Average curved carapace width of remigrants and neophytes found on Pasture Bay Beach, Long Island, Antigua, from June 15 to November 15, 2006.

Lunar Phase and Turtle Activity

The 2006 season began during the waning gibbous phase of the moon and ended during the waning crescent phase. In order to attempt an accurate assessment of any lunar influence on turtle activity, only complete lunar cycles were utilized in analysis. Therefore, all results are based on data acquired up to November 5th (5 complete lunar cycles), which reduced sample size from 510 to 496 activities. Phase of the moon was also paired with its preceding lunar state for the purposes of analysis. Last (or third) quarter was the only moon phase with a significant difference in turtle activity than any of the other phases of the moon (Fig 13). Although, turtle activity dropped from 132 to 112 activities as the moon enters its waning phase of the lunar cycle, no conclusive results as to the effect of lunar phase on turtle activity can be determined from these data.

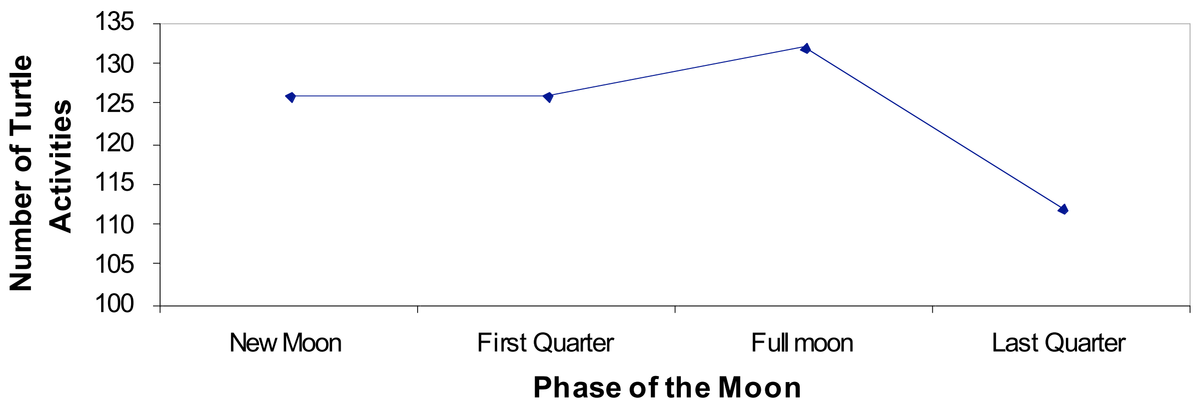

Figure 13. Phase of the moon vs. all turtle activity on Long Island, Antigua from June 15 to November 15, 2006.

V. DISCUSSION AND RECOMMENDATIONS

Season Results

Seasonal Peak

The 2006 nesting season experienced a peak in activity levels, similar to that of the 2005 season, in early to mid august. Last year the seasonal peak was reported as 2 to 4 weeks earlier than in previous seasons. This year's data supports the conclusion drawn by last year's research team that the seasonal peak is being pushed to an earlier point in the season than has been seen in the past. Activity greatly decreased during only the final 2 weeks of the 2006 season, as opposed to the final 6 weeks of the 2005 season. A total of 20 nests were documented as deposited prior to the arrival of this season's research team. This figure concurs with the 26 already deposited nests that researchers encounter in the 2005 season.

The greatest number of both neophytes and remigrants first encountered occurred during the first five weeks of the season. This, coupled with the large number of nests deposited prior to June 14th, leads to the conclusion that some early nesting individuals may not have been documented. To compensate for this possibility, we support Stapleton and Stapleton's 2005 recommendation that data collection begin a few weeks earlier in future seasons. Directors wished to implement that plan in 2006, but scheduling conflicted. This season reinforced the importance of this modification to the quality of the survey, so patrols will start on June 1st in 2007.

Fecundity

Data from the 2006 season suggests that neophytes are equally reproductively significant, if not somewhat more so, than remigrants. Although remigrants had overall larger clutch sizes, neophytes showed reproductive success that rivaled their veteran counterparts. Neophytes deposited an average of 3.3 clutches to remigrants' 3.2 clutches and also had a slightly higher average percent release. These numbers indicate that, as first-time reproducers, neophytes are making a positive contribution towards increasing the Jumby Bay hawksbill population.

In comparison to data from earlier seasons, the average number of clutches (3.3) deposited in 2006 decreased slightly from an average of 4 clutches per individual (Richardson 1999). The recent decrease in number of nests deposited per individual is most likely due to an increase in nests deposited on peripheral beaches. The reduction of nests on Pasture Bay Beach hopefully reflects increased nesting on peripheral beaches and not an actual decrease in fecundity of the Jumby Bay population. However, in order to rule out an overall decrease in fecundity, we need to monitor all peripheral beaches.

Carrying Capacity and Peripheral Beaches

This season there were approximately 8 cases in which a nesting female dug into the egg chamber of a previously deposited nest. This figure is smaller than last season's total of 11 instances, but still remains a saddening problem. Although Pasture Beach is generally a favorable environment for nesting hawksbill females, some sections appear to be preferable to others for nesting hawksbills (Fig 4). These favorable "hot spots" incurred the highest incidence of females excavating existing nests while nesting. Based on annual data confirming the increase in the local nesting hawksbill population (Richardson et al. 2006)**,** and the increase in nest destruction by subsequent nesters, we wonder if Pasture Beach is approaching carrying capacity, or the maximum number of nesting females that the beach can support without significant negative impacts to the population.

The peripheral beaches to Pasture Beach are going to become increasingly important in supporting a growing nesting population. During the final two weeks of the season, open access was granted to the Carisbrooke beach by house guests residing there. We excavated many nests, saw evidence of high turtle activity, and documented several nesting females there in that short period of time. Pond Bay also supported a significant amount of turtle activity until the final quarter of the season when high tides severely eroded the beach and it became unfavorable grounds for nesting. We were grateful for the permission given to monitor some of the beaches peripheral to Pasture Beach. In order to obtain a complete set of data for the 2007 cohort, we believe that permission to patrol all beaches on Jumby Bay at a more frequent rate is necessary.

Shifts in Beach Use

The 2006 cohort made use of nearly all sectors on Pasture Bay Beach, having a greater affinity for higher stakes 24, 27, and 30. Similar to the 2005 nesting season, much of the crawl activity was performed at stake 30 located at the northern end of Pasture Bay Beach. There were 26 documented crawls at this stake successfully depositing only 4 nests (Fig 4). The northern point of the beach including stakes 29-31 had very limited nesting habitat mainly because of diminishing sand exposing rocky substrate just below the surface. Yet, females repeatedly returned to these higher stakes to attempt to nest, presumably because of the relative seclusion and tall vegetation in the area. When the beach endured unusually high tides, the erosion further diminished the available nesting habitat, in part by creating escarpments with two feet drop-offs which made it difficult for females to crawl from the water to the vegetation.

False Crawls

The vast majority of all documented false crawls were attributed to unknown causes. We found that several individuals showed a pattern of false crawling at least once prior to nesting. False crawls for these individuals were often witnessed where no deterrent cause could be determined.

It appeared to us that some turtles simply needed to perform a "dry run" prior to actually nesting. Roots and substrate were implicated as the cause of false crawls the greatest number of times. There are certain areas of Pasture Beach (i.e., stake 0-3 and the area around stakes 19 and 31) that were simply not conducive to nesting in 2006 because of substrate or extremely dense vegetation and an abundance of heavy roots. Females who emerged in these areas were unable to nest. Of the 286 total false crawls for the season, seven were attributed to the presence of observers. This figure reassures us that the presence of researchers is not a significant deterrent to emerging females.

High Tides and Lunar Influence

Starting in mid-September, extremely high tides were observed on Long Island, Antigua. For almost an entire week, the high tide line was above the vegetation edge for the entire length of Pasture Beach causing the beach to narrow significantly for the remainder of the season. The north-east end of the beach, especially, (stakes 19-31) became very narrow and markedly more sloped. Hawksbill Cove and Doniford were both significantly reduced in size. Pond Bay was essentially eroded away completely and all nests deposited there were at one point washed over with water. These circumstances made it increasingly difficult to find evidence of nest emergences and postponed or prohibited excavations in some cases.

This season we were interested in investigating a possible correlation between lunar phase and turtle activity. Lunar phase has been documented as playing a role in restoring loggerhead hatchling's ability to correctly orient towards the sea when artificial light is present (Salmon and Witherington, 1995). Aside from providing background illumination, the lunar cycle influences the ocean's tide, which may also influence turtle nesting activity. A decrease in activity was noticed during periods of extremely low tide when the barrier reef along Pasture Bay Beach was entirely exposed, making it very difficult for turtles to emerge and possibly deterring females completely. In order to investigate this, we compared the total turtle activity seen for all of the different lunar phases. All information for the 2006 lunar calendar and phases was researched post-season (http://aa.usno.navy.mil/data/docs/MoonPhase.html). Our data did not indicate any correlation between lunar phase and turtle activity; however, more detailed and better standardized data may reveal different results. If this idea were to be investigated further, we would recommend that nightly high tide lines be measured from several standard spots along the beach. This would provide a quantitative view of "high" or "low" tides, rather than just using the researcher's perception. It is also possible that there is no actual effect, given that storm swells are a rarity compared to regular high tides on more dynamic beaches.

Vegetation

The main types of vegetation found along the beaches of Long Island, Antigua, were scaevola, seagrape, and a variety of other trees. Classification of the vegetation type was determined by the height and establishment of the vegetation as shrubs, seagrape/mangrove, forest, or vines. There are three recommended actions that need to take place on Pasture Bay Beach in regards to the vegetation.

1. Vegetation planted all over the beach has created more available nesting habitat for the females. However, in recent seasons it has become clear that scaevola, the foundation for vegetation beds on Pasture Beach, has become overgrown in some areas, creating an adverse effect. We recommend the thinning of the nearly impenetrable patch between stakes 18 and 21 (in front of Bananaquit).

2. Due to its eastern exposure, the secluded cove between stakes 29-31 was very susceptible to trash that washed in with the tide. Objects commonly found included: buckets, bottles, light bulbs, and netting. The northern stakes are amongst forested area with the underbrush consisting of broken branches and abandoned termite mounds, all of which accumulate into obstacle courses for nesting turtles. Such areas need to be rid of trash that could harm a turtle, but organic debris should be left in place since it contributes to maritime forest ecology.

3. Natural ocean debris was commonly found tossed or raked on top of areas with high nest density primarily between stakes 4-7 and specifically at stake 28. Because hawksbills are temperature sex determinant organisms (the temperature of the substrate in which the eggs incubate determines the gender of the organism)(Mrosovsky 1992), we were concerned that the discarded debris on the surface of nests could alter the natural gender composition within each nest and additionally induce stress and entanglement as hatchlings emerge. Although nest excavations proved that nests hidden beneath the debris were successful, many questions remain as to how hatchling gender and fitness may be affected. The ocean debris then needs to be limited in quantity if thrown on top of the nest. We believe a thin layer may provide extra cover if beach erosion occurs, but mounds of the debris can be dangerous to the hatchlings.

Hatchling Deformities

In performing nest excavations, we encountered one predominant deformity in unhatched embryos. Embryos suffering from this deformity all had severely disfigured carapaces that appeared indented and compressed. At least 3 nests deposited by XXA-295 contained many unhatched embryos exhibiting this deformity which made up a significant percentage of each clutch. The fact that this deformity was witnessed in great numbers only in nests deposited by XXA-295 leads us to believe that this could be a genetic deformity. The question remains as to who is the contributor of the deformity; the nesting female, XXA-295, or an unidentified male. Previous records would need to be analyzed to determine if XXA-295 has ever deposited nests with this deformity before.

Noteworthy Behavior

Unable to remove themselves from vines or dense scaevola, females would occasionally get caught in vegetation. Researchers would step in and assist the females, such as removing vines twisted around any of their appendages or merely making a path through the vegetation allowing for a less stressful exit to the water. This season there were two turtles, each in completely different circumstances that required researcher assistance unlike the typical assistance described above.

Remigrant, XXA-225, with both left and right rear flipper deformities, probably due to an old injury, had trouble digging a deep enough nest chamber. Since both rear flippers were smaller than the length of a non-deformed sea turtle her size, her nests averaged 32 cm in depth compared to an average of 48 cm in depth for nests deposited by all other turtles. When possible, a researcher helped her dig the egg chamber during laying.

WE-5172 is a remigrant who made us question exactly how a turtle becomes "entranced" to lay her eggs. This female repeatedly dug several holes for an extended period of time. Her final nest attempt encountered extremely rocky substrate and, although she was making no progress, she continued the act of digging. Normally, a nesting female encountering substrate like this while digging would abandon her attempt and either move to another area or return to sea. WE-5172 began exhibiting obvious signs of exhaustion with an increased respiration rate and it became apparent that she needed assistance to be redirected back to the ocean. She was completely non-responsive to several attempts made to direct her to the ocean using flashlight direction and seemed unaware of researcher presence. When eventually brought out of her "trance", she began the act of covering the empty hole beneath her without ever having deposited eggs. This turtle exhibited all signs of being in a laying "trance-like state" without actually laying. This experience leads us to believe that the rhythmic act of digging is the trigger to begin the descent into the trance-like state necessary for egg laying.

While laying and presumably in a trance-like state, 3 females were observed biting on thick branches during laying. The females bit thick, hard wood branches of seagrapes, rather than flexible, scaevola limbs. Whether this was a choice or whether they bit what was available to them is unclear, but the behavior appeared to be an intentional and deliberate action. The exact reason is unknown for this type of behavior, however when the females were observed in the act of biting there was usually some movement around the front part of the body near their heads, possibly causing unintentional stress on the laying females. In all cases, despite the biting behavior, the females completed egg laying.

<u>Proximity of Nests</u>

Many nesting females had affinities for certain areas of the beach. Remigrant, PPN-040 deposited two nests within 5 feet of one another. Neophyte, WE-5139 nested right next to one her own previously deposited nests. Another remigrant, PPN-020, showed an acute nest site preference on Pasture Bay Beach. She deposited a total of 5 nests; 4 of which were located at low stake number 5. Of the 4 nests deposited at low stake 5, 3 nests were deposited within 1 square foot of each other. Although three nests were subsequently deposited in the same area by other turtles, PPN-020's eggs were unharmed. Some of the egg chambers did abut, however.

Remigrational Timing

Of the 39 remigrants observed this season, 21 showed remarkable timing in relation to the month and day when they were originally observed and tagged. 2 remigrants were seen on the same day of the same month as when they were originally tagged on Pasture Bay Beach; 3 remigrants were seen exactly the day after the date they were first observed; 4 remigrants were seen between 3-7 days from the date they were first observed; and 12 remigrants were seen between 8-14 days from the date they were first observed. Therefore, a total of 54% of remigrants documented in 2006 were observed within 14 days of the dates they were first observed and tagged.

Hawksbills on Mainland Antigua

Throughout the season, there were reports of nesting females on mainland, Antigua. Turtles nesting on the mainland drew crowds and, in many cases, observers were reported to take turtle eggs for consumption. The occurrence of mainland nesting has motivated the Environmental Awareness Group (EAG) to initiate the process of acquiring funding for a mainland sea turtle project. The EAG is a locally organized group that aims to bring more attention to environmental conservation. This year, the EAG drafted a proposal for the first mainland sea turtle project with hopes to begin in the 2007 nesting season.

Pasture Bay Beach supports some of the most critical nesting habitats for the endangered hawksbill sea turtle. Over time, though, Long Island's beaches may reach a carrying capacity. Considering the upward trend in the local population of hawksbills, it will be essential to have a functioning mainland sea turtle project to better understand and help conserve shared nesting stocks.

Public Awareness and Education

Jumby Bay Resort Guest Turtle Watches

A total of 342 resort guests alone, as well as homeowners, their families, and friends were brought out to Pasture Beach to partake in turtle watches this season. Turtle watches are a perfect opportunity to spread education to people from areas of the world where they are not exposed to sea turtles. Most guests were first time turtle watchers and were extremely excited about what they were able to witness. Many people told us that their turtle experience was the highlight of their stay in Antigua. Several people told us that they had chosen to stay at Jumby Bay Resort specifically for the opportunity to see a nesting turtle. Some guests expressed such great interest in the turtles that we stayed in contact via email after their departure from the island and updated them on the nests which they had seen deposited. Guest Turtle watches are a fantastic way to get people more interested in sea turtle conservation and pass on education through pictures and stories.

To supplement the turtle watch experience, we implemented a bi-weekly "Turtle Talk" held at the verandah during tea time for anyone interested. This educational session was a power point presentation projected onto a large screen executed by the research team. Despite never having high attendance numbers, we feel that this session was beneficial to the guests. It answered any further questions someone may have after attending a turtle watch and gave guests an understanding of what to expect and witness if they were anticipating a turtle watch. We recommend that this "Turtle Talk" be continued in future seasons.

<u>Environmental Awareness Group</u>

The JBHP devotes a significant amount of energy to public outreach and education. Given the breadth of knowledge from 20 years of research, and the fact that harvesting still occurs with the endangered hawksbill sea turtle, educational efforts are highly emphasized and should not be limited to schools but should be spread across generations of locals. It is especially crucial to educate younger generations about sea turtles so that future generations will be more environmentally conscious and become a positive influence in sea turtle conservation rather than posing a threat to sea turtles.

Beginning in July, we were fortunate enough to have the EAG out every Friday for turtle watch from 7 p.m. to 11 p.m. An EAG volunteer would lead a group of approximately 8 people, consisting of visitors and locals, most of which were children, every Friday. This season we hosted approximately 85 EAG guests on Pasture Beach.

Since there are no other established sea turtle projects in Antigua and Barbuda, EAG turtle watches are the JBHP's primary outreach effort allowing both residents and tourists a chance to witness the phenomenon of a nesting sea turtle. This year, we are excited to support the EAG's first draft proposal for a sea turtle conservation project on mainland, Antigua.

<u>School Visits</u>

In August, prior to schools opening, we attended at least three summer camps to educate children about sea turtles and bring more awareness to the JBHP. Once the academic year commenced, we visited three schools: St. Nicholas Primary School, Christ the King Secondary School, and Claire Hall Secondary School. At St. Nicholas we taught two groups of 40 students ranging from age 4 to age 12. We taught about 50 girls at Christ the King and 35 boys and girls combined at Claire Hall. Our basic presentation used a power-point slide show consisting of pictures and covering topics including sea turtle biology, ecology, threats, and conservation, although alterations were made to accommodate the age group being taught. We also brought hawksbill scutes and turtle bones to add an additional hands-on part to each lecture.

<u>Jumby Bay Staff Night</u>

This season we hosted 4 staff nights for resort staff and their friends and family to come experience a turtle watch. We met many staff members who had worked at the resort for numerous years and had never seen a nesting turtle. Because the resort staff has more frequent interactions with resort guests, they are a great avenue to impart turtle knowledge to guests. We feel that it is important that all resort staff know about the project and experience it themselves so that they may take a sense of pride in it. Resort staff and their families who had previously limited knowledge of the project left each encounter with a turtle absolutely starry-eyed and more aware about sea turtles. It is important to get the local population involved in the conservation of their nation's sea turtles and staff nights were an opportunity to try to do so. We feel that staff nights should be continued and, if possible, held with greater frequency.

Outreach Through Radio

Observer Radio's "Our House" is a great venue for spreading turtle conservation awareness to a large, diverse audience. Unfortunately, we were never able to schedule a successful meeting to appear on the show. However, we feel that appearances on the radio show are important to spreading education and awareness about the state of Antigua's sea turtles and should be continued in the future.

VI. ACKNOWLEDGMENTS

First and foremost, we need to thank Dr. Jim Richardson and soon-to-be Dr. Peri Mason for having faith in us to carry on 20th year of the project's research. We are so grateful for this opportunity and appreciate the constant support along the way. Thank you for such an amazing life experience!!

Thank you to all the homeowners for your continued enthusiasm and financial support for the JB Hawksbill Project. Special thanks to the Franklins, McNeills, Sharps, Fiona McAllister and Sarah Spencer and their families for making us feel welcome and at home on Jumby Bay.

A very large and heartfelt thank you goes out to the entire Jumby Bay Resort staff for going above and beyond the call of duty and making our time on Jumby Bay such a pleasant stay. Thank you to Corina Sealy for acting as our liaison for all educational outreach and Carlos Blanco for all of his assistance. Thank you to our "island moms" Wendy and Hazel for their friendship and hilarious personalities- we always seemed to leave them with our sides hurting from all the laughter! Also, special thank you to Jepson Prince and Rachel Steele for their assistance to the project again this season and for the company on the beach at night!

This year we were privileged to have intern Jane Allen for the entire month of August. Jane provided additional insight to sea turtle ecology and biology and focused her internship on educational outreach. Thank you, Jane for your passion, hard work, and dedication to the project this summer!

We learned a tremendous amount from all the EAG leaders who were extremely welcoming and supporting of us and so deserve many thanks. Donald, Junior, and Andrea were especially wonderful and took the time to show us their work on Green Island. It was an incredible trip and we are extremely grateful for the extra effort that it took to include us in their plans.

Thank you, thank you, thank you to our surrogate mainland family! John and Sarah Fuller, along with son and daughter Fran and Eli, were such wonderful hosts and took amazing care of us during our time in the Caribbean. They offered everything from emotional support to lifts all over the island and were always there whenever we needed them in the slightest.

Thank you to Seth and Carol Stapleton for all of the advice and knowledge of the project they offered upon any request. An extra thank you to Seth for taking over for a week and offering us much needed break. We also appreciate the copy of Dr. Karen Eckert's sea turtle ecology book, which she generously added to our turtle library, and the many benefits that flow to the project from its affiliation with the Wider Caribbean Sea Turtle Conservation Network (WIDECAST).

Last, but certainly not least, we must thank our families and friends for their support and understanding in our five-month absence from their lives. We are very blessed to have families that support our adventurous endeavors and could not have done it without them!

In closing, thank you from the bottom of our hearts once again to everyone. Truly the people, the turtles, our families, and the pure nature of Jumby Bay made this five-month expedition an experience of a lifetime.

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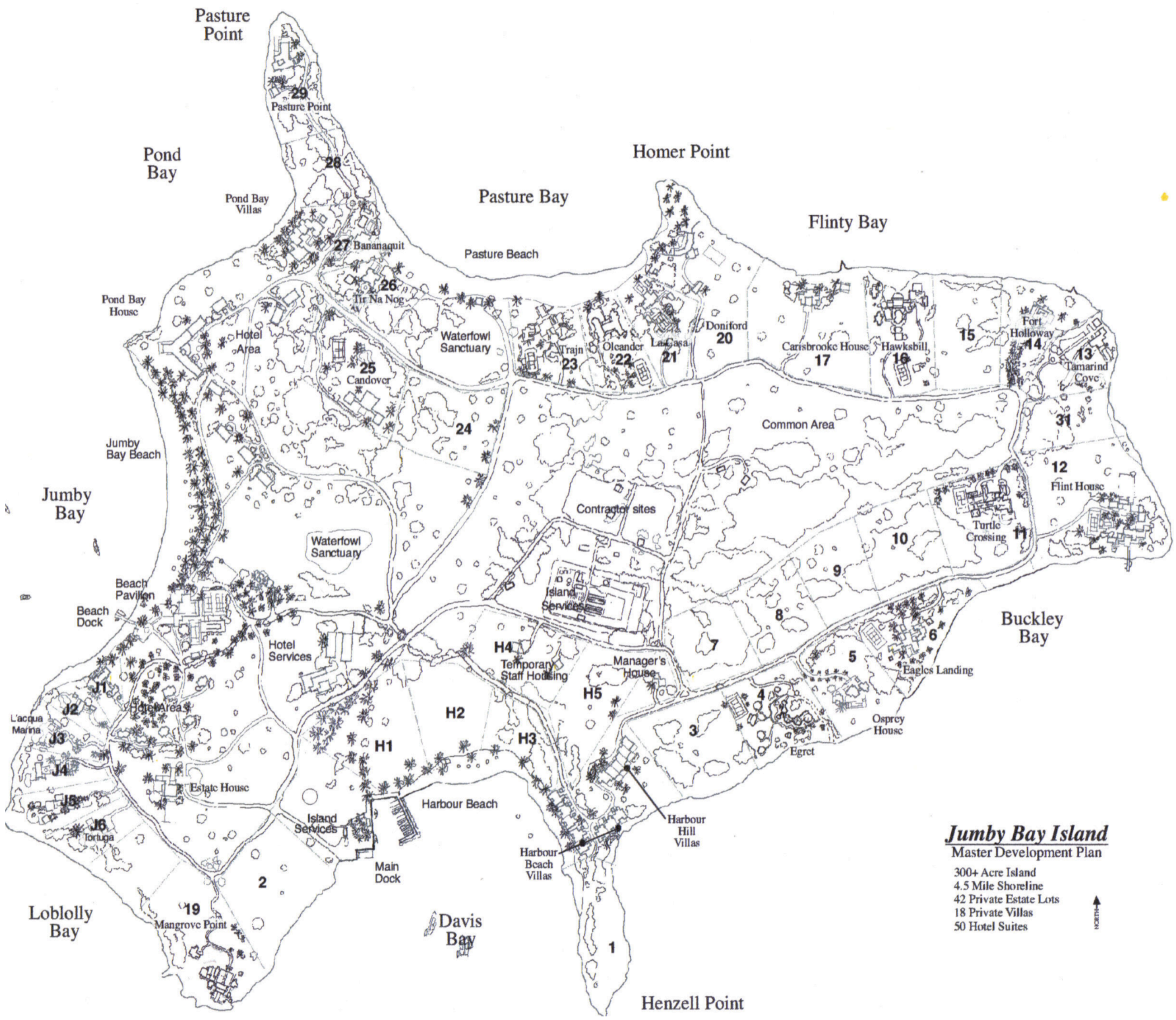
APPENDIX I



Map of Long Island, also known as Jumby Bay Island

APPENDIX II

WIDECAST
Wider Caribbean Sea Turtle Conservation Network

"Working together to build a future where all inhabitants of the Wider Caribbean Region, human and sea turtle alike, can live together in balance."

WIDECAST is a volunteer expert network and Partner Organization to the U.N. Environment Programme's Caribbean Environment Programme. WIDECAST was founded in 1981 in response to a recommendation by the IUCN/CCA *Meeting of Non-Governmental Caribbean Organizations on Living Resources Conservation for Sustainable Development in the Wider Caribbean* (Santo Domingo, Dominican Republic) that a "Wider Caribbean Sea Turtle Recovery Action Plan should be prepared ... consistent with the Action Plan for the Caribbean Environment Programme." Today WIDECAST embraces the largest network of sea turtle research and conservation projects in the world, including the Jumby Bay Hawksbill Project (JBHP) in Antigua, and is a unique model for multilateral marine resource management.

WIDECAST's vision for achieving a regional recovery action plan has focused on bringing the best available science to bear on sea turtle management and conservation, empowering stakeholders to make effective use of that science in the policy-making process, and providing a mechanism and a framework for cooperation within and among nations. By involving stakeholders at all levels and encouraging policy-oriented research, WIDECAST puts science to practical use in conserving biodiversity and advocates for grassroots involvement in decision-making and project implementation.

WIDECAST is all about partnerships - building bridges to the future that facilitate and strengthen conservation action, encourage inclusive management planning, and help to ensure that utilization practices, whether consumptive or non-consumptive, do not undermine sea turtle survival over the long term. Through information exchange and training, WIDECAST promotes strong linkages between science, policy, and public participation in the design and implementation of conservation actions. The network recommends standards for range state adoption, develops pilot projects, provides technical assistance, supports initiatives that build capacity within participating countries and institutions, and promotes coordination among Caribbean countries in the collection, sharing and use of biodiversity data.

With Country Coordinators in more than 40 Caribbean States and territories, the network has been instrumental in facilitating complementary conservation action across range states, strengthening and harmonizing legislation, encouraging community involvement, and raising public awareness of the endangered status of the region's six species of migratory sea turtles. At the center of WIDECAST's activities are its Country Coordinators. They are drawn from professional governmental and non-governmental sectors, must have sea turtle research and/or management experience and responsibility, and participate in the coalition as volunteers.

For more information on the larger context to which data collected by the JBHP contributes, or to contact WIDECAST Country Coordinators in Antigua or elsewhere in the region, please visit us at www.widecast.org.