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

2002 ANNUAL REPORT

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Jumby Bay Island Company, Ltd.

By

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2002 Annual Report:
Jumby Bay Hawksbill Project

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14 June - 16 November 2002

ABSTRACT

For the sixteenth consecutive season, research continued on the reproductive biology and population ecology of the critically endangered hawksbill sea turtle, *Eretmochelys imbricata*, at the Jumby Bay nesting site on Pasture Bay Beach, Long Island, Antigua, West Indies. Allison Parrish and Keri Goodman, 2002 Field Directors, were responsible for conducting the research. Since 1987, consistent hourly patrols (with saturation tagging of all nesting females) have been maintained for 154 consecutive nights during the nesting season, yielding a comprehensive database of information on the Pasture Bay population, as well as on each individual female.

The 2002 patrol season began the evening of June 15th and ended the morning of November 16th, similar to previous years. Nesting activity was highest from August 6 to September 9, approximating a peak in the nesting season. Fifty (50) nesting hawksbills were observed and tagged during the patrol season, the highest number of individuals documented in a single nesting season in the history of the project. A total of 153 nests were deposited during the patrol season, with an estimated average of 146 eggs per clutch. The number of clutches per female ranged 1-6, with an average of 3.7 clutches per turtle. Of the 95 nests analyzed, mean overall hatch success was 72%.

Twenty-nine of the 50 turtles were remigrants, with remigration intervals (elapsed time since previous appearance) ranging 1-7 years and an average remigration interval of 2.5 years. With the addition of the 21 neophytes in 2002, a total of 201 hawksbills have been tagged on Pasture Bay Beach since the project's inception in 1987. A linear regression analysis ($y = -7604.5 + 3.8214x$; $r^2 = 0.781$) of the total number of individuals documented per season over the last seven years (1996-2002) predicts that the annual nesting population has doubled in this time period.

The Jumby Bay Hawksbill Project is a project of the Wider Caribbean Sea Turtle Conservation Network (WIDECAST), a region-wide scientific network and Partner Organization of the UNEP Caribbean Environment Programme. WIDECAST embraces the largest network of sea turtle research and conservation projects in the world, and provides a framework enabling Caribbean nations to collaborate in the collection, sharing and use of research and management information. The Jumby Bay Hawksbill Project has been sponsored since its inception by the homeowners on the island, who have shown deep and abiding concern for these gentle reptiles.

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I. INTRODUCTION

The hawksbill, *Eretmochelys imbricata*, is one of six species of sea turtle that inhabit the Caribbean Sea. The hawksbill is a mid-sized sea turtle with a carapace length of about 3.5 feet. The carapace is brilliantly colored with flames of brown, caramel, and yellow and has been the traditional source of "tortoiseshell" for eyeglasses, jewelry and other forms of art. Over-harvesting of the hawksbill for tortoiseshell in the last century is considered to be the principle reason for their critically endangered status; however, loss of nesting beaches, degradation of foraging grounds, exploitation for domestic and commercial use, and unintentional drowning in commercial fishing nets (bycatch) are also implicated in population declines. For similar reasons (except harvest for tortoiseshell, which is unique to hawksbills), all six species of sea turtle found in the Caribbean are currently listed as endangered or critically endangered throughout their global ranges by the World Conservation Union (IUCN). The hawksbill was first classified as endangered by the IUCN in 1968, and retained that classification until its status was changed to critically endangered in 1996.

Due to the species' precarious survival state and the fact that tortoiseshell (the species' colorful shell plates) were still actively traded on a commercial scale, the nations of the world listed Atlantic populations of the hawksbill sea turtle on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora ("CITES") in 1975 (followed by the listing of Pacific populations on Appendix I in 1977), effectively banning international trade in hawksbill parts or products by nations signatory to the convention. Trade continued, however, because some nations, including Japan (the largest importer of tortoiseshell), took a formal exception to the listing of the species and this enabled them to continue to trade with selected countries. By the end of 1992, responding to two decades of pressure from the global conservation community, Japan had imposed a zero quota on such imports (Meylan and Donnelly, 1999: p.200).

Notwithstanding the ban on international commerce, many Caribbean nations, including Antigua and Barbuda, still allow harvesting of hawksbills for domestic use during part of the year (Fuller et al. 1992). Antigua and Barbuda law currently protects only eggs and smaller turtles, allowing the largest turtles (those with the greatest reproductive potential) to be legally harvested for domestic sale and consumption. Regulations such as these do not reflect the life history of sea turtles. It is commonly accepted that sea turtles do not become sexually active until they are 15 to 40 years of age. Eggs, hatchlings, and juveniles sustain heavy natural mortality rates, while adults have few natural predators apart from man. In the absence of human poaching, adults can be expected to live long and produce thousands of young. Adults represent the age class with the most reproductive potential and should be preferentially protected (Fleming, 2001: p.6). These points have been the basis for WIDECAST recommendations to the Division of Fisheries (Government of Antigua and Barbuda), most recently in September 2002.

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Protecting sea turtles is as complex as the proliferation of threats they face. Sea turtles have a complex life cycle in which they inhabit many different ecosystems, including pelagic waters, coastal waters, reef systems, and terrestrial beaches. Sea turtles are highly migratory over hundreds or even thousands of miles as they grow and reproduce (IUCN, 2002: p.2,12). This means that nations must work together to protect turtles across international waters, in addition to preserving and protecting local beaches and foraging grounds. Clearly there is need for further research and conservation to identify critical habitat, and to affect meaningful harvesting regulations and habitat conservation.

It is the intent of the Jumby Bay Hawksbill Project to continue research into the demographics of this regionally and globally important population of hawksbills. The primary intent of the research is to better understand hawksbill "life history", including adult female recruitment and survivorship, annual and lifetime fecundity per individual adult female (and for the population nesting at Jumby Bay), production of hatchlings, and other reproductive behavioral patterns. This information is not only critical to management decisions in Antigua and Barbuda, but offers a foundation for management and policy decisions made throughout the region. The project is also examining nesting habitat preferences with the intent of applying this understanding to beach restoration initiatives. Public outreach is an equally important component of the Jumby Bay project. Jumby Bay researchers lead educational turtle watches for residents and tourists, as well as visiting Antiguan schools. Only through long-term public support will Antiguan hawksbills have a chance at survival and recovery.

This Annual Report includes a list of recommendations for project improvement and a summary of the information collected during the 2002 field season. We have included some comparisons with statistics for the 1987-1997 field seasons (see Richardson et al., 1999) to place the current information into context.

II. STUDY SITE

Long Island is located 2.5 kilometers off the northern coast of mainland Antigua. This privately owned island is the site of Jumby Bay Resort and approximately twenty private residential estates. Pasture Bay Beach is the main nesting site for hawksbills on the island, and is situated on the north side of Long Island. Pasture Bay is a windward-facing beach that collects sand through natural processes. The historical inaccessibility of the Pasture Bay nesting ground to mainland turtle poachers may account for the survival of this relatively small, remnant population of nesting turtles, while mainland populations have fared worse in recent decades.

Pasture Bay Beach is divided into 30 sectors that are identified by numbered stakes placed along the vegetation line at 10-15 meter intervals. The beach can also be divided into three vegetation zones that differ in nesting habitat quality.

- The northeast-facing section (stakes 22-31) is relatively narrow, with mixed coastal shrubs and sparse mangrove forest. There are no man-made structures in this sector apart from a road built parallel to the coastline and landward of the line of permanent vegetation.

• The middle, north-facing section (stakes 8-21) is characterized by wide and open sand expanses. Much of the native vegetation has been cleared, and the current vegetation line is set 30-40 meters back from the surf. A marsh lies behind the beach in this section, separated from the beach by a thin vegetation line except at the road entrance where there is no segregation between beach and marsh. In a proactive measure to encourage nesting in this zone, several islands of vegetation have been cultivated by island landscapers and turtle project staff. These vegetation islands, measured at the end of the 2002 season, average about one meter high and consist primarily of *Scavola* shrubbery.

• The northwest-facing section (stakes 7-1) is narrow, with prominent limestone shelves exposed at the shoreline. Nesting habitat consists of a steep incline, with patches of vegetation between grassy lawn areas. The sand layer is thin and is succeeded by a rocky, compressed soil substrate. Three homes are located in this section. Beyond stake 1 is an additional section of beach approximately 40 meters long and unsuitable for nesting due to thin substrate. For the 2002 season, this portion of the beach was regularly patrolled to ensure the safety of turtles crawling near construction sites in this area. Pasture Bay beach has been the main focus of the Jumby Bay Hawksbill Project for the last sixteen years. However, recent seasons have experienced noteworthy nesting activity on two other beaches close to Pasture Bay Beach: Pond Bay Beach behind the Pond Bay villas and Brook House Beach, a man-made beach on private property associated with Brook House. We predict that secondary beaches will play an increasingly important role in data collection in the future, as more Pasture Bay turtles select them for nesting and as more “pocket beaches” are constructed in association with new private homes (see Management Recommendations).

III. METHODS

Study Area Coverage

The scientific direction of the project has been to collect the best possible population data on nesting behavior of Caribbean hawksbills, hitherto virtually unknown, including survivorship and recruitment of adults to the nesting colony, reproductive behavior, fecundity, hatching success, recruitment of hatchlings from the Jumby Bay study population, and a range of other reproductive attributes.

To achieve the project’s scientific goals, the beach is patrolled from dusk to dawn for 154 nights during each nesting season (15 June through 15 November). *Every* nesting female is recorded by tag number, and her nesting success is monitored throughout the nesting season. The project represents a survey in excess of 20,000 hours of intensive beach coverage unique among nesting hawksbill studies, and Jumby Bay is known internationally both for the intensity and the longevity of its survey.

During 2002, as in years past, beach coverage began on June 15th and ceased on November 15th. We patrolled the beach hourly, on foot, and typically without lights to ensure that all nesting turtles were observed and identified. Patrol protocols follow standard guidelines, set both by previous project staff and following international norms (cf. Eckert et al., 1999). Previous observations indicate that the hawksbill nesting process usually takes at least one hour to complete; therefore, no portion of the beach is left uncovered (unpatrolled) for more than one hour. Individuals identified as "quick nesters" were noted in the database and the beach was occasionally patrolled at shorter intervals when these individuals were expected. Patrols started at 2000 hours and ended at 0500 hours from June until the end of August. Later in the season, as the nights lengthened, patrols began at 1930 and ended at 0545.

When the season started, Pond Bay and Brook House beaches were checked once on a nightly basis. However, as the busiest part of the season approached, we noticed an elevated level of activity on these beaches. There were also "holes" in our data chart where individual turtles had not been seen on Pasture Bay Beach for an expected nesting visit, indicating that they may have laid their eggs on another (most likely nearby) beach. The frequency of patrols on these beaches was increased when these individuals were expected, to increase our opportunity of identifying each female during each of her nesting visits. Our efforts proved fruitful in some instances and were unsuccessful in others. Data collection on these two peripheral beaches was less efficient than on Pasture Bay Beach because logistically the team cannot fully cover these beaches and still complete hourly patrols of Pasture Bay beach. Creative solutions to dealing with greater dispersal in the distribution of nesting activity will need to be defined in the coming year.

Data Collection

Data collection procedures were followed in accordance with the methodology of previous seasons. Turtles were processed (tagging, measuring, photographs, etc.) only while egg-laying and were not interrupted while approaching, searching, digging, or concealing their nest sites. The Jumby Bay population of turtles is relatively skittish; every effort is therefore taken to ensure that the nesting process remains as natural as possible. Similarly, eggs were left *in situ* wherever possible, and hatchlings were allowed to emerge and disperse to the water in a natural manner and without intervention.

The Master Tag List, a tag history reference tool, aided field data collection. This list contains the status of every tag ever issued to the project. Every nesting turtle observed on Long Island since the project's inception can be cross-referenced by any of the tags she has ever carried and/or by her supracaudal drill pattern (see Drilling). The availability of the Master Tag List ensures that remigrant individuals are not misidentified and that neophytes are recognized as genuine first- time nesters on Pasture Bay Beach. Neophytes are defined as nesting turtles never before seen at Jumby Bay; they are considered new individuals to the nesting population.

For every crawl encountered, an individual crawl sheet was completed (see Appendix). Crawl location was recorded, along with an exact or estimated time when the turtle was on the beach. For nesting turtles, we also noted morphological and behavioral observations, nest location and habitat, and the time and behavior ("action") of the animal when first encountered. A hatchery record sheet was completed for each nest observed on Long Island that had the potential to hatch prior to season's end (see Appendix). Nests were excavated after natural emergence, and contents were categorized according to the guidelines on the back of the hatchery record sheet.
Methods used to collect core data were as follows:

• Morphology: We recorded curved carapace length, also called an "over-the-curve" (o.c.) carapace measurement. Carapace length is defined as the distance from the nuchal notch, along the midline of the carapace, to the posterior tip of the longest supracaudal. When barnacles along the midline affected the accuracy of the measurements, this was noted. Individuals were measured each time they were encountered. For the latter half of the season, a new measuring tape was added to the data collection kit. It was found that a discrepancy of .02 cm existed between the new tape and the older tape used this season and during prior seasons. For consistency of data, all measurements were recorded with the older tape first and then redone using the new tape, if time permitted. We also examined each turtle for diagnostic markings, deformities and injuries; drew a barnacle pattern; and photographed the carapace (posterior, right and left sides).

• Tagging: We attached one Inconel tag (size 681, National Band & Tag Company) through the first, most proximal scale on the trailing edge of each fore flipper of every untagged turtle. Untagged turtles were thoroughly investigated for previous tag scars to assure that the individual was a true (first time) neophyte and not an older turtle returning without her tags. Where two tags were applied on a single animal, the lower tag number was assigned as the turtle's "original tag number" (her permanent research identity) in the Master Tag List. We retagged turtles that had lost one or both of their tags, being careful not to pierce the tender scar tissue from previous tags. In some instances it was necessary to tag in the second most proximal pad; these instances were noted in the Mater Tag List.

We routinely applied tags after the onset of egg-laying, following deposition of approximately 10 or more eggs, to ensure that the turtle was deeply into her nesting trance. In some instances the turtle flinched mildly, and we continued tagging application. In rare instances the turtle flinched so badly on the first application that she shifted from her centered position over the egg chamber. We felt that a second tag application could jeopardize the clutch and, therefore, in these cases we waited to apply the second tag during a subsequent nesting visit (hawksbills typically nest at 14-15 day intervals). Delaying application of a second tag was a personal discretionary decision; there is no project protocol for such cases.

• Drilling: A using a battery powered hand drill, a unique pattern of holes is drilled through the inert posterior marginal edge of the supracaudal scutes of each turtle in the Jumby Bay population. Neophytes are given patterns selected from available patterns noted in the Master Tag List. The drill pattern is used as an additional identification method and can often be read without undue distraction to the turtle. Drill holes "migrate" toward the distal edge of the supracaudals as the result of normal carapace growth and abrasion. A hole placed 12-15 mm or more from the posterior marginal edge of the supracaudals will remain readable for a minimum of 4-5 years (Richardson, Bell and Richardson 1999). When returning turtles (remigrants) exhibited a drill pattern closer than 12-15 mm to the edge, a repeat of the pattern was re-drilled higher on the supracaudals to assure the pattern would be readable for the next nesting season. Sometimes, it was necessary to "clean" holes throughout the season for easier visibility.

• False Crawls: This designation is used for turtles that appear on the beach and then return to the sea without laying eggs. We recorded the exact time of the encounter if the turtle was seen, and an estimated time (i.e., 2200 +/- 30 minutes) if the crawl occurred between patrols. When possible, we recorded the time of emergence and return to the sea when a false crawl was witnessed, along with notable behavioral data. We recorded the crawl location in respect to the two nearest numbered stakes identifying the beach sector (1-31), identifying with arrows the emergence and departure points on a map of Pasture Bay Beach located on the back of each crawl sheet.

False crawl turtles were checked for identification when the consequential disturbance to the turtle was assessed to be negligible. We identified a false crawl turtle by feeling for the diagnostic supracaudal drill pattern during moments when the turtle was inactive. Most false crawl turtles were never witnessed, and, therefore, these events were recorded as # 9999 in place of a tag number on the data sheets.

- Nest Location: Nests were mapped using stake location, distance from high water line (HWL), distance from the nearest vegetation edge (VE), and by triangulation to distinct natural landmarks. Contrary to the experience of previous years, poaching did not occur on Pasture Bay beach during the 2002 season, but efforts to conceal the exact location of the nests were still maintained. In a few instances where the vegetation was thick and flagging could be hidden from view, we used flagging labeled with the deposit date and original tag number as a point for triangulation or placed directly over the nest site. This flagging procedure proved especially valuable in “hot spots” where two or more nests coexisted several inches from each other.

- Egg Counts: Whenever possible, an exact egg count (clutch size) was taken at the time of deposition to measure our accuracy in estimating clutch size “after the fact” when nest contents were analyzed following natural hatching and emergence. Egg counts occurred infrequently due to the fact that the collection of other data (tag numbers, carapace lengths, etc.) took precedence over egg count information.

- Emergence and Excavation: Hawksbill nests typically have a 60-day incubation period between laying and hatchling emergence. Therefore, we monitored nests nightly for several days prior to the expected emergence date. Nests that showed no signs of activity at approximately 67 days were excavated carefully to determine their status. For those nests that successfully emerged, after the emergence we recorded the location, date, estimated time of emergence, and number of hatchlings seen, if any. We assisted disoriented hatchlings (i.e., those attracted to artificial lighting or those trapped in vegetation) to reach the water’s edge.

Excavated nest contents were categorized to estimate a hatching success rate. We opened unhatched eggs to determine the stage of development. Stages were categorized using the criteria outlined on the back of the hatchery data sheet (see Appendix). We described hatchling abnormalities. We noted conditions of the nest cavity such as roots, large rocks, or hard substrate, and recorded nest depth. We released any live hatchlings remaining in the nest, placing them at the vegetation line and allowing them to crawl to the water. When hatchlings were very weak, we set them at the water’s edge. If we found hatchlings not yet ready to leave the nest, they were kept for a day or more before releasing them. We placed these animals in a container with moist sand taken from their nest, draped with a damp cloth. The container was stored in a warm, dark place to simulate the natural nest environment.

- Managed Hatching and Relocated Nests: When a nest was deposited perilously close to the high water mark, we collected the eggs upon deposition and reburied them in a safer area of the beach. We tried to select comparable habitat. For example, if the nest was deposited in open sand, we relocated the clutch to a safer area in open sand. In several instances, nests were relocated because the chamber had not been dug large enough by the adult turtle to hold the entire clutch, and eggs were in danger of being crushed during the tamping (nest-covering) process. We noted that these abnormal behavioral instances were isolated to neophytes. Clutch size was recorded, and the nest depth and shape were recreated according to that of an average chamber (depth = 50cm). If a nest site was determined to be prone to hatchling disorientation due to artificial lighting or another anthropogenic effect, such as close proximity to a road, we constructed a barrier around the nest prior to the time of hatching in order to contain the emerging hatchlings which were then collected, counted and released in a safer area.

IV. RESULTS

Recruitment

Fifty adult hawksbill females were observed on Pasture Bay Beach during the 2002 nesting season, including 29 remigrants (previously tagged turtles) and 21 neophytes (previously untagged turtles) (Fig. 1). Of the neophytes, 20 were fitted with Inconel tags, while one went untagged but was identified as a unique individual by barnacle pattern comparisons. One additional neophyte was observed nesting on June 14th before the official start of the season and was excluded for the season total cohort value. This season experienced the highest seasonal cohort and neophyte values recorded in the history of the project. A linear regression analysis ($y = 3.8214x + 19.286$; $R2 = 0.781$) of total cohort values over the last seven seasons (1996-2002) suggests that the population has doubled in this time period (Fig. 2).

Fig. 1 Total Nesting Females, Remigrants and Neophytes

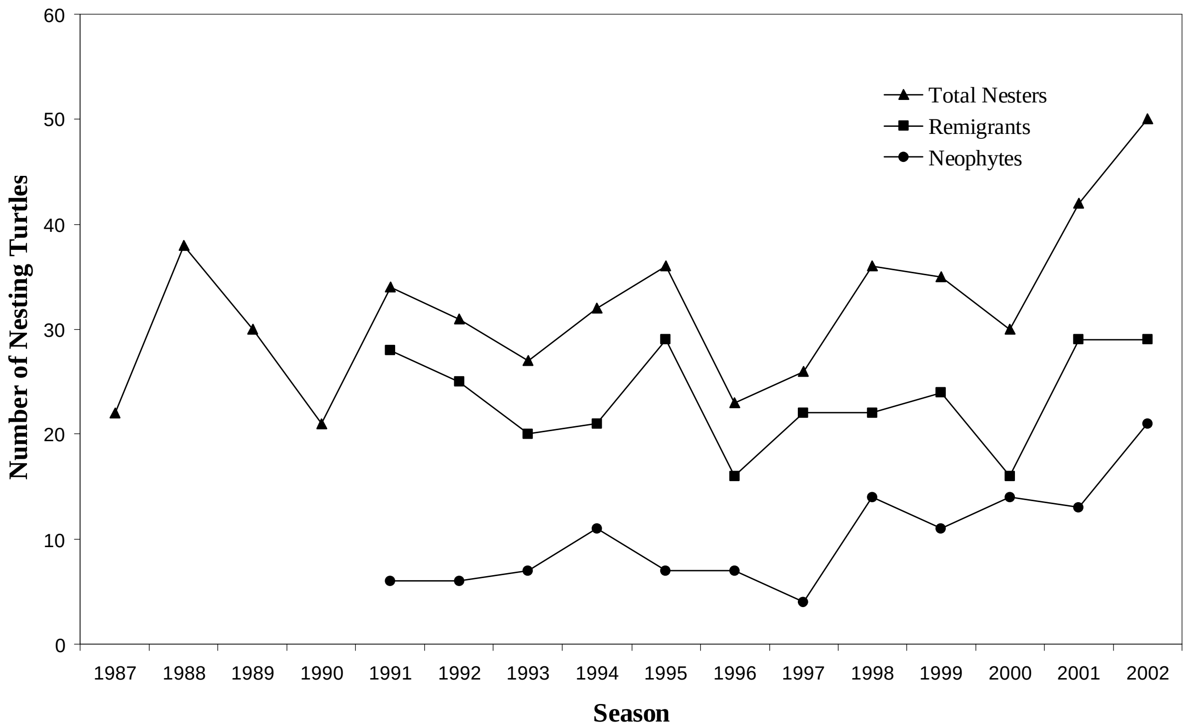
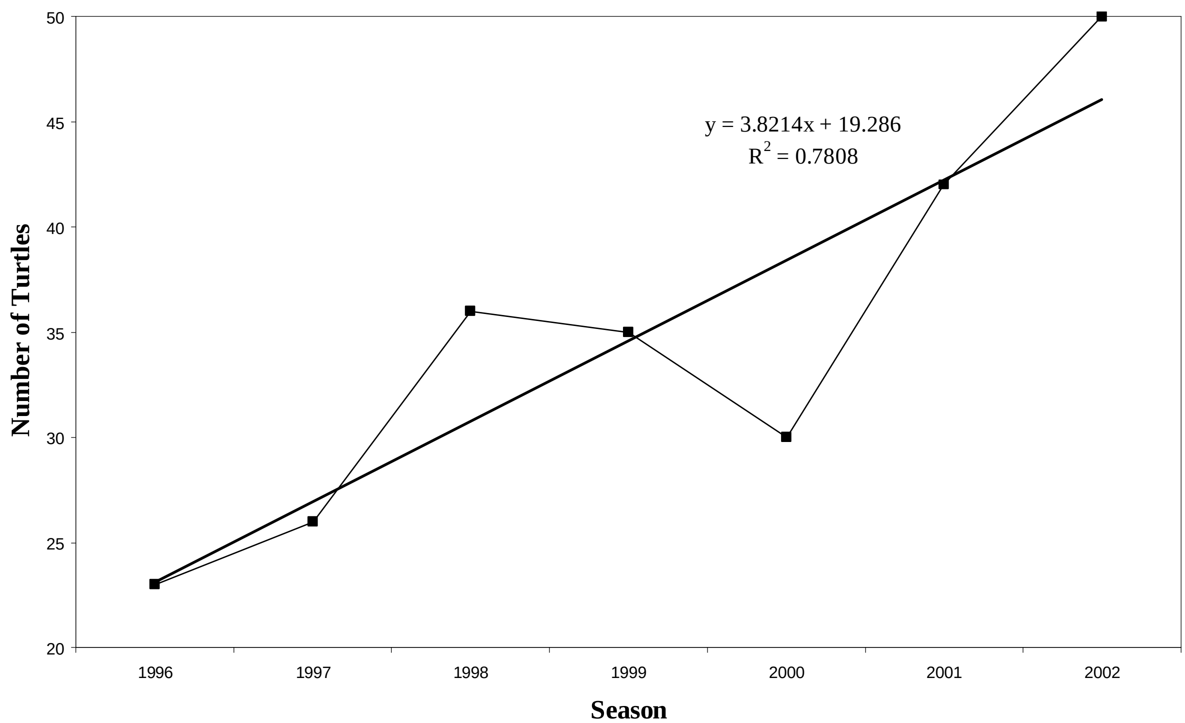


Fig. 2 Linear Regression of Cohort Size from 1996 to 2002



Remigration

Of the 29 remigrants, 3 had a remigration interval of seven years, one had an interval of six years, one had an interval of five years, 7 had an interval of four years, 9 had an interval of three years, 7 had an interval of two years, and one had an interval of one year (Fig. 3). The final record represents the first documented annual nesting turtle in the 16 years of data collected at Jumby Bay. This was her sixth nesting season, during which time she has been seen laying 33 clutches, or approximately 4785 eggs at 145 eggs/clutch! Her 6-season nesting record is as follows:

Year	Clutch number					
	1st	2nd	3rd	4th	5th	6th
2002 season*		6-27/28	7-12/13	7-27/28	8-11/12	8-26/27
2001 season	6-15/16	7-1/2	7-16/17	8-1/2	8-16/17	8-31/9-1
1999 season	6-20/21	7-6/7	7-21/22	8-5/6	8-19/20	9-3/4
1997 season*		6-29/30	7-14/15	7-28/29	8-13/14	8-29/30
1995 season	6-17/18	7-3/4	7-18/19	8-2/3	8-16/17	8-31/9-1
1993 season		7-8/9	7-23/24	8-7/8	8-22/23	9-5/6

* Probably her first seasonal nest was deposited prior to the start of patrol on June 15.

Fecundity - clutch size

Clutch size was estimated at the time of excavation (yolkless eggs were not included). Data from 95 nest excavations were used to estimate clutch size and emergence success. Estimated clutch size ranged from 91 to 257, with an average size of 146 eggs per clutch (Fig. 4). In order to check the accuracy of our estimates, actual egg counts were taken whenever possible at the time of deposition. Of the twelve nests with accurate clutch size determined at the time of deposition, the number of eggs ranged from 98 to 176, with an average of 138 eggs. Our estimated totals deviated by not more than 12 eggs from actual counts.

Fecundity - clutch number

The number of predicted nests per female ranged from 1-6, with a mode of 5 and a mean of 3.8 nests per turtle (Fig. 5). To determine the frequency distribution of the number of clutches per turtle, we restricted our sample to individuals whose documented first visit occurred between July 3rd and September 15th to reduce the chance (error) that individuals chosen for fecundity analysis had nested before our season patrol began or after the patrol ended. The number of documented nests for each turtle was used to determine the mean number of clutches observed for the 2002 season. Additionally, a predicted number of nests per turtle was derived by assuming that blanks in the crawl chart between two observed visits indicated that the turtle had nested on another island or on one of the two other beaches (Pond Bay Beach and Brooke House Beach) located on Long Island (Fig. 5).

Fig. 3 Frequency Distribution of Remigration Intervals for 2002 Jumby Bay Season

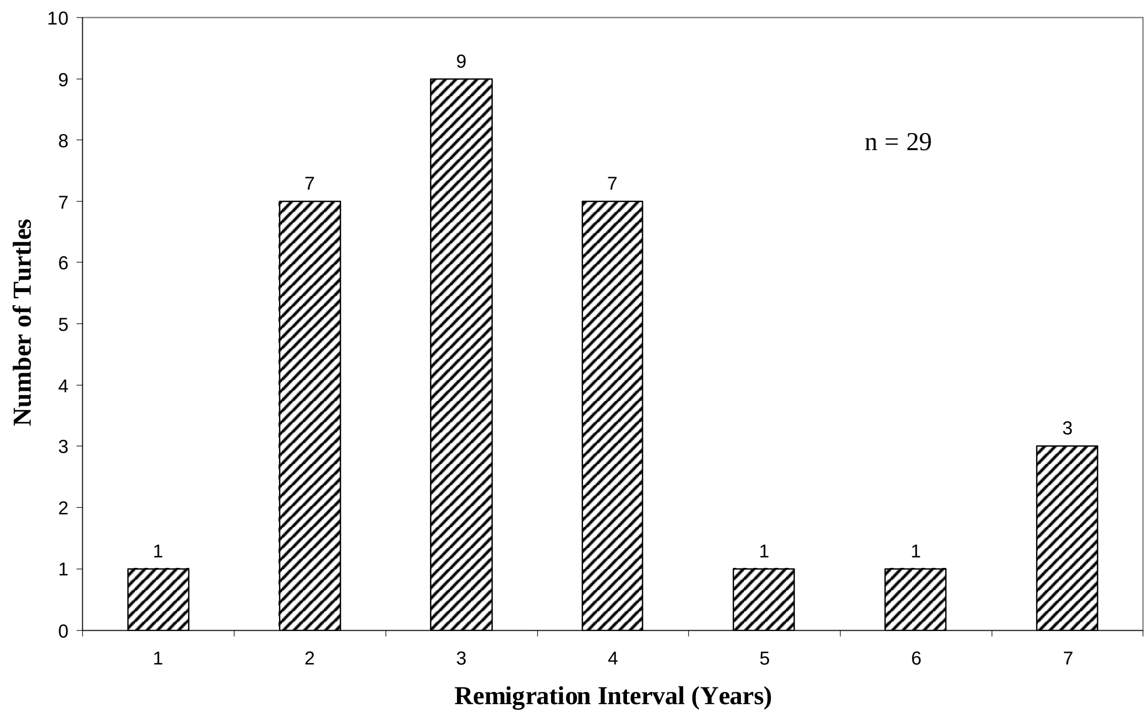


Fig. 4 Frequency Distribution of Estimated Clutch Size
(determined at time of nest excavation)

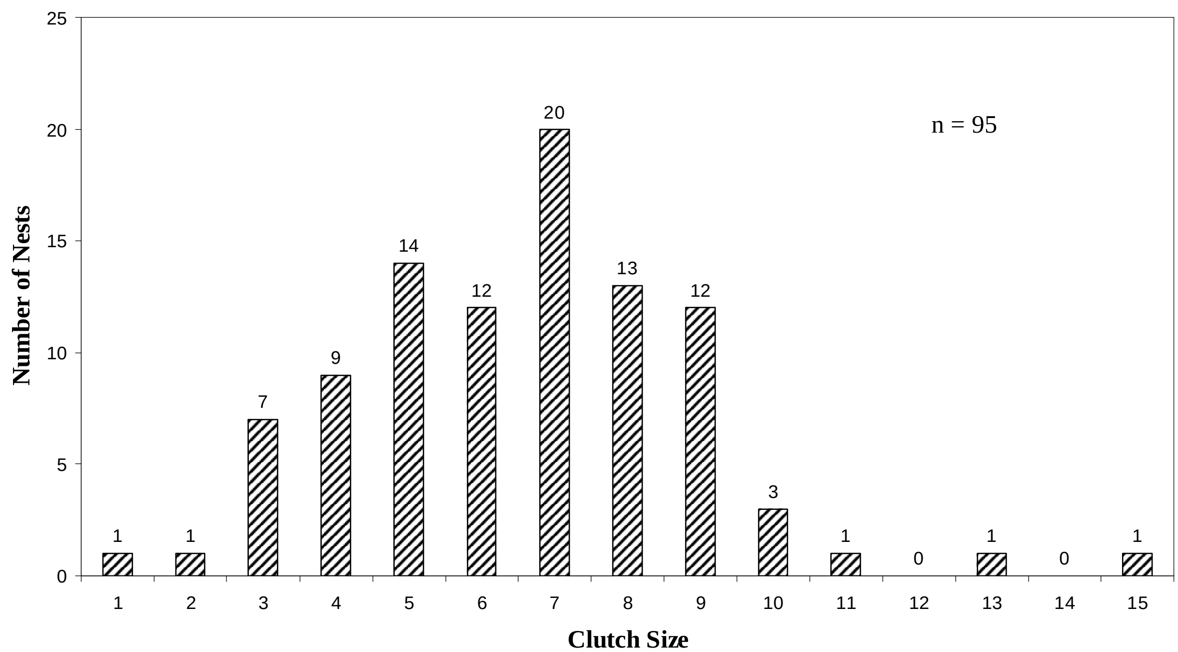
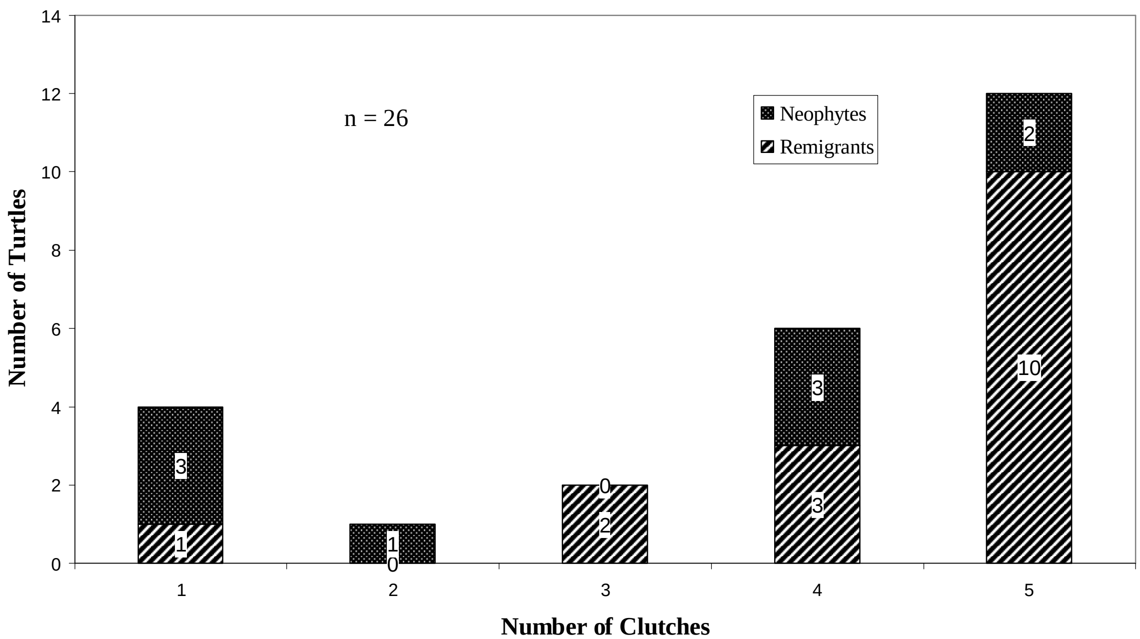


Fig. 5 Frequency Distribution of the Number of Predicated Clutches per Turtle for the 2002 Jumby Bay Season



Season Activity Levels

During nightly patrols from June 15th to November 15th, 302 activities were recorded on Pasture Bay Beach (Fig. 6). Fifty-five additional activities were also recorded, including data from a pre-season patrol on June 14th and occasional within-season patrols of Brooke House Beach and Pond Bay Beach. The first observed nest of the patrol season was recorded on June 14th, and the last observed nest was recorded on November 12th, with the last crawl activity recorded on November 15th. Activity peaked during the months of August and September, with the week of 31 August to 6 September resulting in a memorable 12 nests and 12 false crawls during the seven night sequence. Of the 302 activities recorded on Pasture Bay Beach, 149 were false crawls (49.3 %) and 153 were nesting events (50.7 %). Ten additional nests were recorded on the other two beaches, with sevens laid on Brooke House Beach and three on Pond Bay Beach. The total number of observed nests deposited on Long Island during the 153-day patrol season was 164. Using 150 eggs per clutch, this translates to an estimated 24,600 eggs for the season!

Several unknown pre-season nests were discovered when hatchlings emerged; a hatchery record sheet was filled out for each and labeled as a pre-season nest. A total of three previously unknown pre-season nests were recorded; post-emergence analysis was performed on all of them. Thus, the total number of recorded hawksbill nests deposited on Long Island in 2002 was 167, but there were probably a few additional nests that we missed during the 16 November to 14 June off-season months. It has been shown that low levels of hawksbill nesting can occur on any month of the year, in addition to the regular season.

Nest Density by Beach Sector

Nest density by beach sector was determined for Pasture Bay Beach (Fig. 7). The highest concentration of nests occurred between stakes 28 and 29. This is one of the most densely vegetated and least developed sectors of the beach. There is a mangrove that overhangs the water at this point which may act as an attraction to turtles searching along the surf for signs of vegetation. The distribution of nests in 2002 has remained somewhat similar to the distribution of nests in the project's earlier years of study. In 1987 and 1988, the area between stakes 28 and 29 was also quite popular, although the highest concentrations of nests were deposited between stakes 5 and 6 (Ryder et al., 1989). The vegetation of Sector 5/6 is now much thinner than in earlier years and probably less attractive to nesting hawksbills.

Emergence Success for Naturally Deposited Nests

The average production rate of hatchlings per nest (hatched shells minus live and dead hatchlings in nest chamber divided by the total number of yolked eggs) on Pasture Bay Beach was 72% (Fig. 8). It is important to note that at least 10 nests were deposited on Pond Bay Beach and Brook House Beach, and crawls were observed regularly at both of these sites. It is unknown how frequently the two smaller beaches were used for nesting, because the patrol team was unable to access them on a regular basis. Only one nest from each beach hatched and was excavated before the end of the patrol season. Emergence success rates were low in both

Fig. 6 Total Number of Nests and False Crawls Made Each Week by Hawksbills on Pasture Bay Beach, 2002 Nesting Season

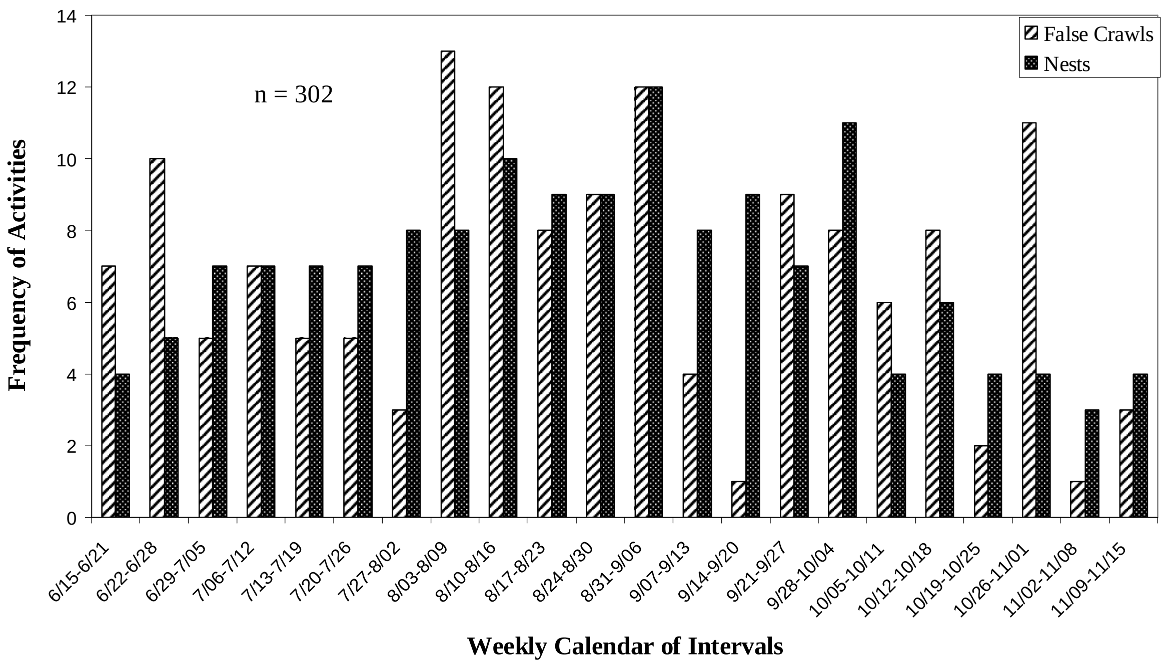


Fig. 7 Nest Concentration by Beach Sector for the 2002 Jumby Bay Season

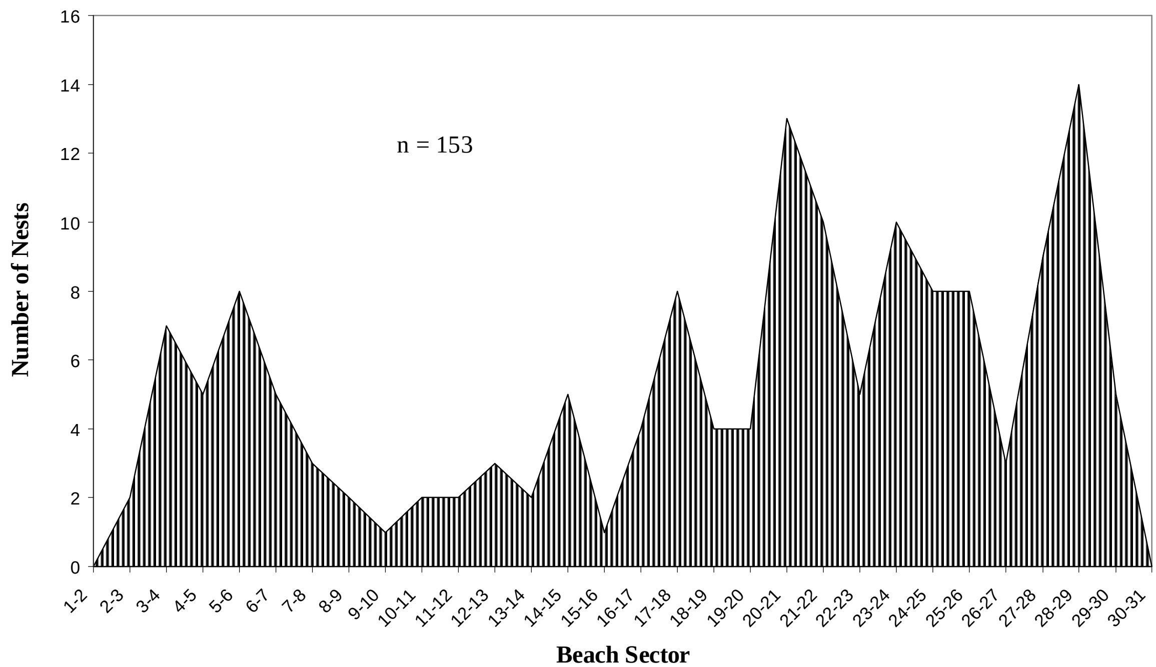
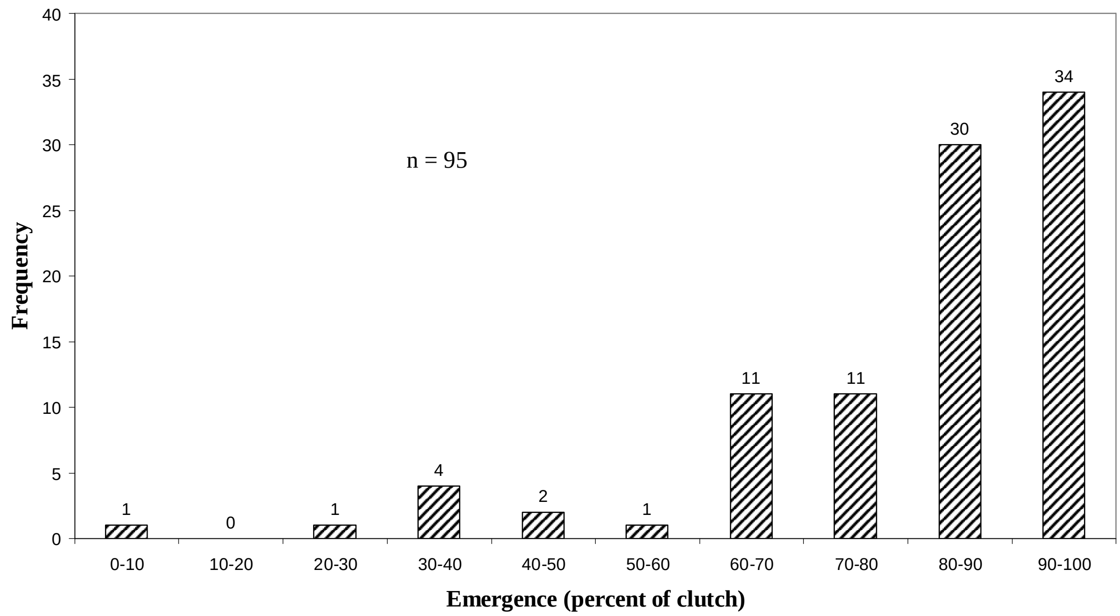


Fig. 8 Frequency Distribution of Estimated Emergence Success for Selected Nests in 2002, Pasture Bay Beach, Jumby Bay



instances due to inadequate sand depth within which to excavate the nest chamber. The Brook House nest produced a 0% success rate, and the Pond Bay Beach nest produced an 18% success rate.

Relocated Nests and Managed Hatching

A season total of three nests were relocated at the time of deposition. In all instances, the nests were vulnerable to being destroyed or damaged due to a high water table and/or a shallow nest chamber. The emergence success rates of the two relocated nests that emerged before 15 November were 84% and 13%. These nests were recorded as "managed" hatching events and were not included in determining the frequency distribution of emergence success. Two nests were caged due to a high probability of hatchling disorientation. The emergence success rates of the caged nests were 96% and 87.4%. The caged nest percentages were included in the season average emergence percentage.

Leatherback Encounter

We discovered one leatherback, *Dermochelys coriacea*, nest shortly after the hatchlings emerged during our patrol on the night of 1 July. This would place the time of nesting at roughly 1 May. Fresh tracks were evident, but no live hatchlings were witnessed because the hatchlings emerged between patrols. This nest was located in open sand between stakes 18 and 19. The nest chamber was found to be approximately twice the depth of a typical hawksbill nest chamber. The nest contained 2 dead hatchlings, 33 hatched shells, 16 rotten/undeveloped eggs, 20 embryos, 45 yokeless eggs and 2 small yokeless eggs approximately one quarter-inch in diameter. Thus, the yoked clutch size was 71 eggs, and hatching success was 46%. The majority of dead embryos were in a very late stage of development, not unusual for leatherbacks. No other leatherback nest has been recorded on Long Island in the 17-year history of the project, although leatherbacks are known to nest occasionally on mainland Antigua beaches (John Fuller, pers. comm.).

V. DISCUSSION

Public Awareness and Education

Since its inception, the Jumby Bay Hawksbill Project has provided sea turtle conservation education and public awareness talks in addition to nightly data collection. Within each season, unique challenges and experiences dictate the type and frequency of awareness activities provided to the public. Public outreach is considered to be an equally important component to research, and all efforts are made to provide as many awareness activities as possible within the unique constraints of the season. A relationship with the Environmental Awareness Group of Antigua, a member of the WIDECAST regional network, provides the opportunity for Antiguans to attend "turtle watches" on Pasture Bay beach. The EAG identifies supervised groups of interested adults and children to join the research team on scheduled dates from 7:00 PM until midnight when the last ferry returns to the mainland. The EAG turtle watches were restructured during the 2002 season to accommodate the wishes of Jumby Bay homeowners and to re-address prior management issues.

Educating the next generation of Antiguans on environmental conservation issues is critical to the survival of Antiguan hawksbill nesting populations. In seasons past, the researchers visited Antiguan schools on the mainland. These talks are arranged by the volunteer efforts of Ms. Corina Edwards. Additional funding is provided by the Cable and Wireless Corporation of Antigua for travel expenses to the schools and for educational materials such as photocopied handouts. Unfortunately, educational outreach was not possible during the 2002 season, but every effort to resume school visits will be taken in future seasons, again in close cooperation with local partners.

In addition to local public outreach, the project has a unique opportunity to reach people from all over the world while they stay at the Jumby Bay Resort. Guests of the resort are invited to sign up for turtle watching and are contacted when a nesting turtle is on the beach. The 2002 team hosted 90 Resort guests from 15 June until 15 August, at which time the resort was closed for renovations. It is the project's hope that these people lucky enough to witness a nesting hawksbill will take home with them a newfound appreciation for sea turtle conservation.

VI. 2002 ANECDOTES

We would like to share a few anecdotes from 2002 which we hope will give some insight to the history of this project and the many important relationships that have grown up around it. We provide personal names for these anecdotal moments as a measure of the fondness we hold for our study subjects.

Nina

The 2002 season was a personal "first" for the both of us as first time "turtle ladies" with the Jumby Bay Hawksbill Project. We had been reminded often of the age and reputation of the project and of the importance of the data that we were sent to collect. However, the true depth of history didn't really hit us until we met "Nina." We were into our second week of patrolling when we first encountered a small, older looking turtle in the process of nesting. We read her original tag, PPN-001, and realized that we were looking at the very first turtle ever tagged by the Jumby Bay Project sixteen years earlier. Lynn Corliss, the original "turtle lady" was on the beach at the time. We thought about all the researchers before us who had sat in the moonlight waiting for "Nina" to nest. An estimated 22,350 hours of patrolling Pasture Bay have taken place since 1987. That adds up to a lot of sore muscles, bug bites, used batteries, completed data sheets, lost flashlights, and most importantly, a tremendous amount of excellent data collected by many devoted individuals. Since the project first came to know "Nina" in 1987, she has deposited approximately 6200 eggs on Pasture Bay during 7 nesting seasons. It is a lovely idea that perhaps a few of her offspring may one day return to Pasture Bay, to be witnessed by future Jumby Bay researchers, residents and guests.

Emily

A child named Emily provided a great inspiration to us. Emily and her family visited Jumby Bay Resort during the 2002 season and accompanied us on the beach. She informed us that she had stayed at the resort in July of 2000 and that a turtle had been named after her. We looked through previous records and did indeed find turtle QQZ-156, "Emily", who was tagged in July of 2000. QQZ-156 did not nest while Emily was at Jumby Bay, but she did in fact show up to nest in September. We e-mailed Emily about this occurrence and to update her on "Emily's" carapace size and the number of eggs she laid. Emily was delighted to know that her turtle was still nesting on Pasture Bay Beach, and she took our e-mail to school for show-and-tell. There have been many "honorary turtlers" such as Emily who have followed the project over the past 16 years. Their enthusiasm has helped to keep the project supported and the researchers motivated.

Sleepy Jean

This final story reflects on the pure determination of a turtle mother. One particular turtle was on the beach for nearly seven continuous hours while attempting to dig a proper chamber in difficult substrate. She finally retreated to the sea at sunrise, exhausted, and without having deposited her eggs. The following night, she returned for another round. This time she was satisfied with her first chamber and laid her precious eggs. She then promptly fell asleep while still positioned over her chamber, exhausted from her two laborious nights on land. Approximately thirty minutes passed before she woke to cover and conceal her nest. We dubbed this determined female "Sleepy Jean", and found a deep appreciation for the incredible effort these mothers extend to provide a safe nesting habitat for their offspring.

ACKNOWLEDGEMENTS

Funding was provided by the Jumby Bay Homeowners Association to WIDECAST (The Wider Caribbean Sea Turtle Network). The consistency in the availability of funding from the homeowners is reflected in the unique and remarkable quality of the dataset, making the Jumby Bay Hawksbill Project a leading source of information on the nesting ecology of Caribbean hawksbills.

We would also like to thank Jumby Bay Resort for the many services they provide for the research team, from ferry transportation to the mainland to providing telephone and Internet access. Our deepest gratitude goes to the many resort employees who have assisted the research team in so many ways over the years. Many thanks, also, to John and Sarah Fuller who have provided a home away from home for the research team each year and the management assistance they provide from Antigua.

Dr. Jim Richardson (Scientific Director of the Jumby Bay Hawksbill Project) and Dr. Karen Eckert (Executive Director of WIDECAST) reviewed the manuscript and provided administrative assistance and advice during all phases of the project. The success of this project is due to the loyalty of the individuals mentioned above and the combined efforts of many others.

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APPENDIX I

Field data sheets for Nesting Events and Nest Contents Evaluation