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Internesting Movements and Behavior of Hawksbill Turtles (*Eretmochelys imbricata*) Around Buck Island Reef National Monument, St. Croix, U.S. Virgin Islands

Christopher H. Starbird[1], Zandy Hillis-Starr[2], James T. Harvey[1], and Scott A. Eckert[3]

[1]*Moss Landing Marine Laboratories, P.O. Box 450, Moss Landing, California 95039 USA [E-mail: chstarbird@aol.com];*
[2]*National Park Service, Buck Island Reef National Monument, 2100 Church Street, Kings Wharf #100, Christiansted, St. Croix, U.S. Virgin Islands 00820 USA;*
[3]*Hubbs-Sea World Research Institute, 2595 Ingraham Street, San Diego, California 92109 USA*

Abstract. – **Radiotelemetry was used to monitor internesting movements of 7 female hawksbill turtles near Buck Island Reef National Monument, St. Croix, U.S. Virgin Islands. Three turtles returned to short (0.06 km) sections of nesting beach on which they had previously nested. Off-shore movements were confined to approximately 1.5 km^2, and indicated some level of residency. The resident areas were within 3 km of Buck Island and water depth ranged form 9 to 20 m. Four hawksbills left the region immediately following their last seasonal nesting event, indicating that hawksbills may undergo reproductive migrations. Dive behavior and movement patterns were analyzed for days 2–12 of the internesting periods. Mean duration of dive was 56.2 min and mean surface time was 1.6 min. Mean dive duration was 33.8 to 63.5 min during the day and 41.7 to 73.5 min at night.**

Key Words. – **Reptilia; Testudines; Cheloniidae; *Eretmochelys imbricata*; sea turtle; nesting; internesting; behavior; movements; Buck Island Reef National Monument; St. Croix; U.S. Virgin Islands**

Hawksbill turtles (*Eretmochelys imbricata*) are diffuse solitary nesters averaging four to five nests per season (Richardson et al., 1989). At Buck Island Reef National Monument, St. Croix, U.S. Virgin Islands, the average internesting interval for hawksbills is 16 days and 2 to 3 years between each nesting migration (Hillis and Mackay, 1989). Nesting occurs year round with peak activity between May and November. Hawksbills nest on a variety of beach habitats although most commonly on small beaches with abundant shoreline vegetation.

Movements of sea turtles within the internesting habitat may be associated with availability of food resources (Stoneburner, 1982), propensity of an individual for movement (Limpus and Reed, 1985), courtship or mating behavior (Carr et al., 1974; Dizon and Balazs, 1982), or other unmeasured factors (e.g., water temperature, sea state, predator avoidance, photoperiod, and physiological cues). Unlike other sea turtles, adult hawksbills live primarily in association with coral reef systems, similar to those surrounding Buck Island. The reef habitat around Buck Island could possibly preclude the necessity for long distance migrations between nestings. This insular behavior may be more pronounced during internesting periods when movements away from the nesting beach would be energetically costly for females that must return to the same area within 14 days.

During the internesting period, sea turtles may be particularly vulnerable to incidental catch, collision with recreational boaters, and ecological disasters such as oil spills (Meylan, 1984). Knowledge of the internesting habitat, behavior, and ecological requirements of sea turtles during this period is important to determine the environmental requirements before subsequent nesting attempts.

The objective of this study was to use radiotelemetry to determine movement patterns of female hawksbills during and after internesting periods. We sought to quantify daily patterns of activity and determine the extent of use of near-shore reef areas around Buck Island.

MATERIALS AND METHODS

Study Area. — Buck Island Reef National Monument is located 2 km north of St. Croix, U.S. Virgin Islands, and has been under the jurisdiction of the National Park Service (NPS) since 1962 (Fig. 1). It is composed of 72 ha of dry tropical forest surrounded by 171 ha of coral reef system (Hillis and Mackay, 1989). Buck Island provides 1.5 km of nesting beach for hawksbill, green, and leatherback sea turtles (Small, 1982). Topography of nesting beaches ranges from rock and coral cobbles bordered by dense supralittoral forest (southern and northern beaches), to open beach with extensive dune grass (west beach). Beach forest vegetation is comprised of manchineel (*Hippomane mancinella*), purple sage (*Lantana involucrata*), and seagrape (*Coccoloba uvifera*) (Woodbury and Little, 1976).

Flora and fauna of reef communities surrounding Buck Island have been qualitatively described (Adey, 1975; Gladfelter, 1988). A barrier reef, dominated by elkhorn coral (*Acropora palmata*), runs adjacent to the southern shore, and forms an arc around the eastern end of the island. To the northwest, patch reefs extend 2 km away. In the Buck Island Channel, between St. Croix and Buck Island, are a series of deep patch reefs which offer a great diversity and biomass of sponge species (Gladfelter, 1988). These reefs interface with sand and sea grass beds comprised mainly of algae (*Dictyota* spp. and *Cladocelphalus* sp.) and grasses (*Syringodium* spp.).

Beach Patrol. — Data were collected between 1 July and 30 September 1991. Beaches were patrolled by two NPS employees nightly (1830–0530 hrs) on foot, at 20 min intervals. Nesting behavior was grouped into two major categories: false crawl (turtles attempted but did not complete nesting) and confirmed nest (egg deposition observed). Nesting turtles were tagged on both front flippers with numbered inconel tags issued by the National Marine Fisheries Service (tag series PPW and QQD). Barnacle patterns and carapace deformities were recorded and photographs were taken to aid in identification. Curved carapace length to the nearest 0.1 cm was measured along the median dorsal ridge from the nuchal scute to the posterior notch. Carapace width was measured at the widest point.

Radiotelemetry. — Radio transmitters (Telonics Inc., Mesa, AZ) were hermetically sealed in electrical potting resin (Scotchcast 3M, San Diego, CA). Each package weighed approximately 200 g, and measured 13 x 5 x 1 cm. Lithium batteries (Eagle Keeper LTC 7PN) were used to maximize transmission time and minimize weight. Each transmitter had a unique frequency between 148.03 and 148.86 MHz. Pulse width was between 12.0 and 13.9 msec, and life expectancy of transmitters was eight weeks.

Radio transmitters were attached to seven female hawksbills at the nest, as egg deposition began and before nest covering was complete. Turtles that were nesting for the first or second time during the 1991 season were selected for the telemetry study because these turtles were most likely to return to Buck Island to nest. This yielded a maximum amount of data from each tagged individual and increased the likelihood of recovering transmitters.

Transmitters were attached to the anterior most median ridge of the carapace in an area devoid of barnacles. The area was rinsed with fresh water, sanded with medium grit sand paper, and wiped with isopropyl alcohol. Dental acrylic (Den-mat Corp, San Diego, CA) was applied to the transmitter package, set in place on the carapace and allowed to dry for 5 min. Marine epoxy (10-min Evercoat 660, San Diego, CA) was mixed with brown fiberglass coloring agent (to

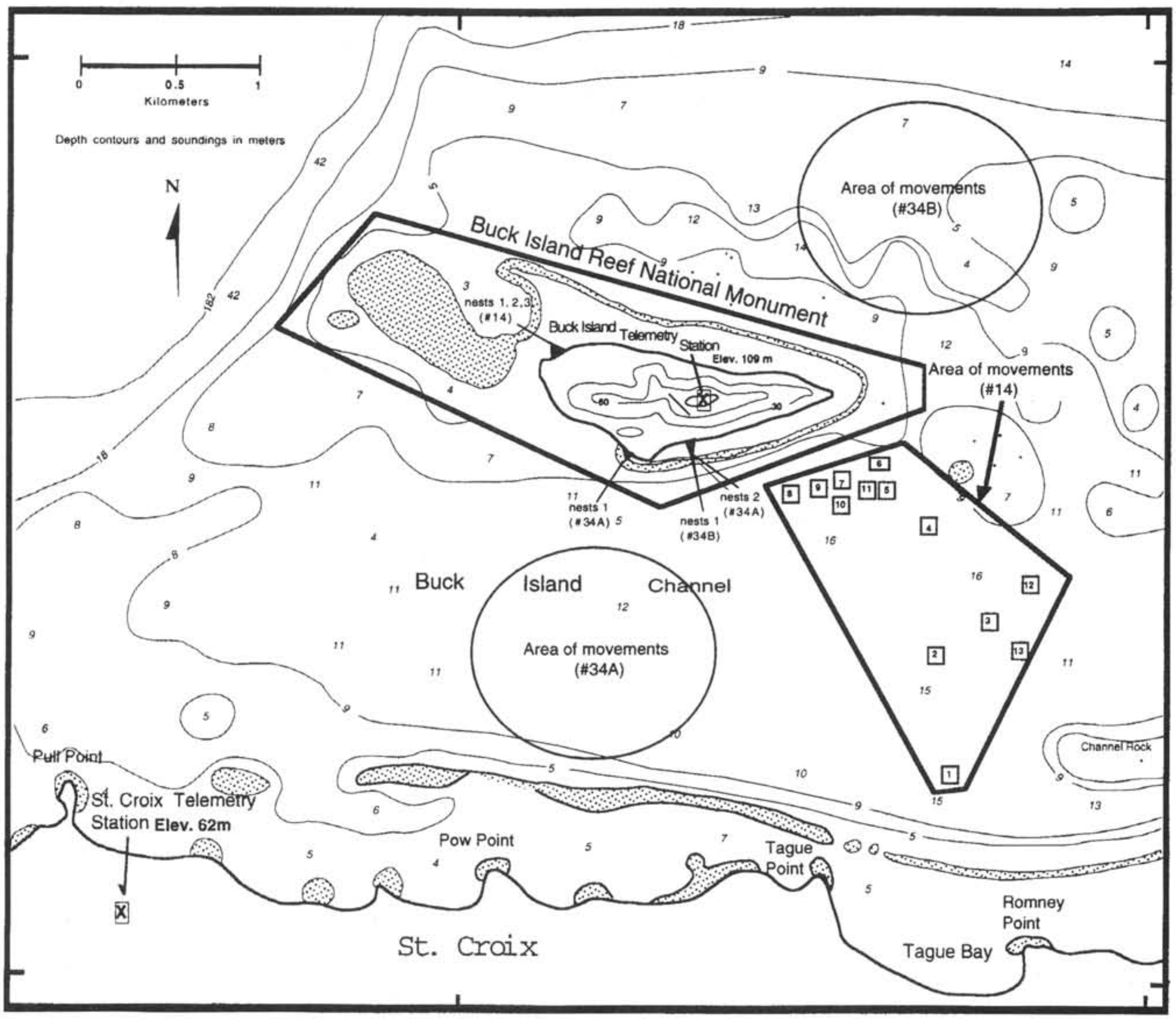

Figure 1. Areas of movements and nest sites of hawksbills #s 14, 34A, and 34B tracked near Buck Island Reef National Monument, St. Croix, U.S. Virgin Islands. Movements of #s 34A and 34B were estimated from single fixes and are represented by circles. Radio and acoustic fixes for #14 are numbered chronologically.

reduce visibility of the package) and applied around the outside of the transmitter to improve adherence and protect the package from impact.

Radiotelemetry receiving stations were located on a U.S. Coast Guard tower on Buck Island (elev. = 109 m) and on Pull Point, St. Croix (elev. = 62 m) overlooking the Buck Island Channel (Fig. 1). Five-element yagi antennas were attached to PVC pipe (5.0 cm dia.) and a mounted compass row was used to document the direction of the antenna. A radio transmitter placed on Pull Point (Fig. 1) was used to establish whether the receiving system was operational. Locations of sea turtles were determined from one station or both stations simultaneously. Reception from one station gave general locations, whereas reception from both stations allowed triangulation of the position. Maximum range (30 km) and error at 5 km (± 5°) was estimated by locating transmitters in a boat off-shore. When radio signals were not received, telemetry stations were set up on the highest peaks on the east and west ends of St. Croix to determine if turtles with transmitters remained in the area. At these stations, an omni-directional and three-element yagi antennas were used, and sessions consisted of 3 hrs of continuous monitoring.

After leaving the nesting beach, turtles were tracked for 24 hrs or until movements ceased. Thereafter, tracking sessions were interspersed among eight 3-hr time periods during the day (e.g., 0800–1059, 1100–1359 hrs, etc.). Each individual with a transmitter was located at least once during a tracking session. Assistants at both telemetry stations monitored radio transmitter frequencies, and hand-held radios were used to communicate from station to station when turtles surfaced. All positions of hawksbills were determined by triangulating signals from two stations. All positions were recorded on National Oceanic and Atmospheric Administration, National Ocean Survey Charts, or U.S. Geological Survey topographical maps.

Habitat Description. — Internesting habitat was described for two hawksbills (#s 79 and 03) because their internesting locations were known with the greatest accuracy and precision. Internesting areas were defined as the area of concentrated movements of each individual (900 m^2) and dive sites within these areas were chosen randomly.

Percent cover of three habitat types (sand, sea grass or algae, and coral reef) was estimated for each area. A diving mask was marked on the inside of the glass so the viewer, leaning over the side of a boat, saw an area of the bottom defined by these marks. A 30 m tape was extended on the bottom from the center of each study site and the viewer estimated the distance viewed along the length of tape and between marks on the mask. One viewer was used throughout the study. Depth was assumed uniform (16 m) throughout the study area and equal to the average depth measured randomly throughout the study area. The area of the bottom viewed from the surface was an estimated 64 m^2, the size of each quadrat.

Transects for estimating percent cover ran east to west and were 70 m apart. Buoys that had been placed over fish traps were used as points of reference for positioning the boat. At randomly timed intervals, the boat was stopped and the viewer estimated percent cover of the three habitat types to the nearest whole number within each quadrat. Five transects (41 quadrats) were completed in the internesting area of turtle #79 site and three transects (16 quadrats) for turtle #03.

Percent cover of flora and fauna within coral reef and sea grass habitats was described using randomly placed 1 m^2 quadrats within each of the study areas. At the center of each study area, two divers descended on an anchor line. The end of a 100 m tape was attached to the anchor and extended on a random bearing. The first reef or sea grass habitat encountered along this tape was chosen as the study site. At these sites, divers swam random distances along the 100 m tape. A 1 m^2 quadrat made of PVC pipe (1.27 cm dia.) was laid on the bottom with the center positioned over the 30 m tape. Percent cover of flora and fauna was estimated by eye, and photographs (Nikonos 5) were taken of each quadrat.

Description of Dive Behavior. — Monitoring for presence or absence of a radio signal yielded a good approximation of the time a turtle spent at the surface or underwater. Duration of surface intervals and dives (amount of time at surface and below the surface) were recorded for daytime (0600–1759 hrs) and nighttime (1800–0559 hrs). During a tracking session, dive behavior for each tagged turtle was monitored continuously for two hours to determine periodicity and variation in dive durations. If dive durations were consistent then radio frequencies were not monitored continuously but in relation to the pattern determined (i.e., for turtles surfacing each hour, the receiver was tuned to that frequency at 15 min to the hour). In this way researchers were able to monitor a number of frequencies while turtles remained submerged.

RESULTS

Seven of the 26 hawksbills that nested on Buck Island in 1991 were radiotagged. Curved carapace length was 86.5 to 99.0 cm (Table 1). Twenty nesting events and eight false crawls were recorded after tagging. Radio signals were monitored for 13 to 45 days. Signals were received from one station (n = 307) or from both stations simultaneously (n = 73) (Table 1).

Table 1. Size (curved carapace length), date of transmitter deployment, days at large, and number of fixes for 7 hawksbill sea turtles tracked. Locations are single, in which one telemetry station received a fix; or double, in which both stations received good radio signals, or an acoustic fix was obtained.

Turtle (ID #)	Size (cm)	Date Deployed	Tracking Days	Locations Single	Locations Double
86	86.5	11 July	45	62	12
14	99.0	14 July	31	48	13
79	84.0	22 July	32	46	23
34A	88.0	26 July	29	26	1
03	90.0	9 Aug	31	58	22
54	–	21 Aug	29	48	0
34B	91.0	1 Sep	13	19	2

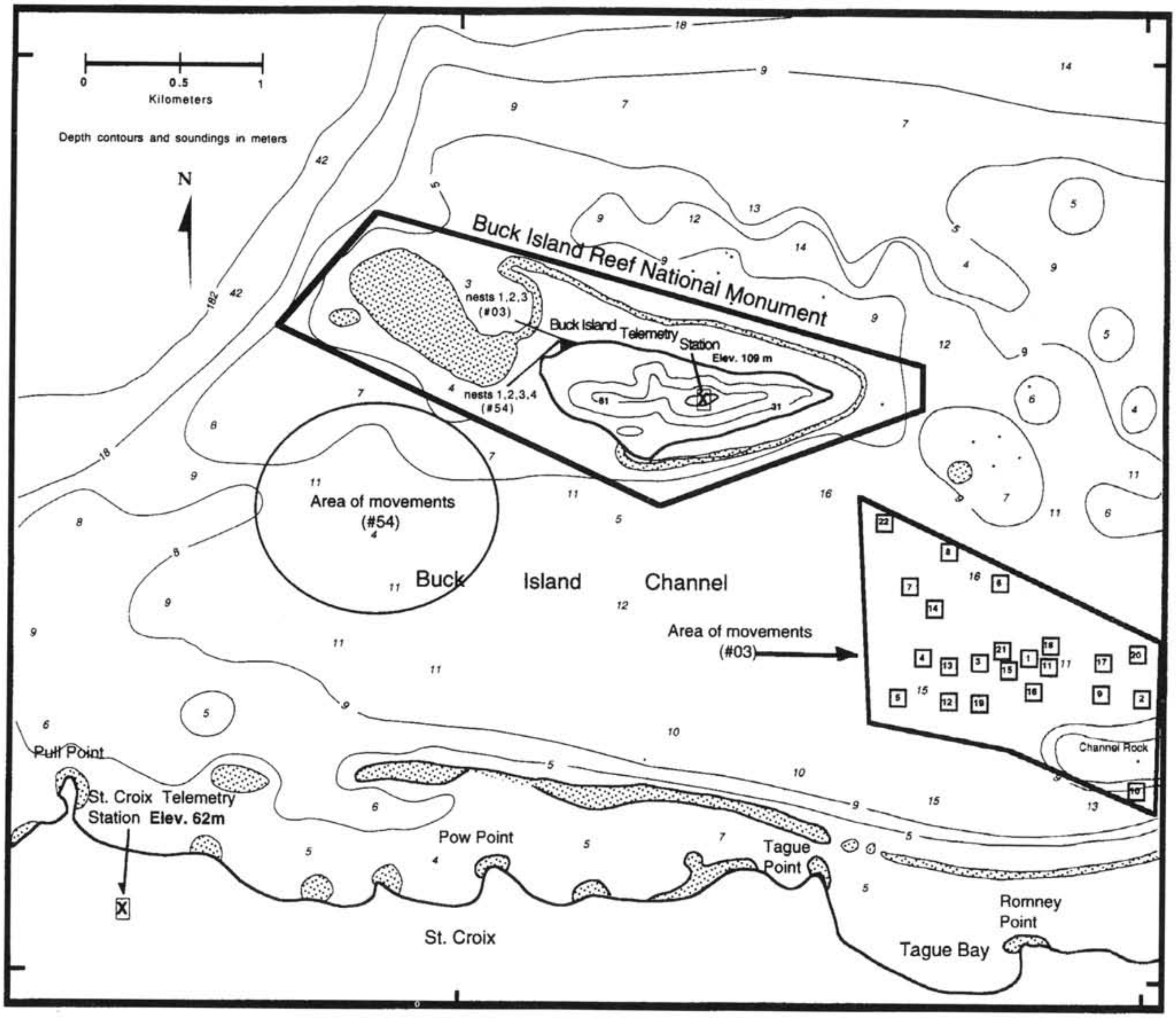

Figure 2. Areas of movements and nest sites of hawksbills #s 03 and 54. Movements of #54 were estimated from single fixes and are represented by a circle. Radio and acoustic fixes for #03 are numbered chronologically.

Hawksbill #14 nested three times on the northwestern shore but had a defined preferred in-water area southeast of Buck Island (Fig. 1). Its nests were within 0.06 km of its previous nests. Hawksbills #s 03 and 54 nested 3 and 4 times, respectively, on the northwestern shore and their preferred in-water areas were located southeast (03) and southwest (54) of the island (Fig. 2). Their nests were also within 0.06 km of their previous nests. Hawksbills #s 34A, 79, and 86 nested on different beaches but also had defined in-water areas (Figs. 1, 3).

Internesting areas of all monitored individuals were confined to areas of approximately 1.5 km^2 and were as small as 0.5 km^2. These areas were within 3 km of Buck Island, and depth ranged from 4 to 20 m. Five individuals were tracked in areas to the south (79, 03, 14, 54, 34A) and two in areas to the north (86, 34B). Six turtles returned to the same off-shore area after nesting. Hawksbill #14 did not return to the same area after nesting for a second time and moved closer to shore (Fig. 1, boxes 4–11). Movements of three individuals (03, 79, 86) were concentrated in an area of 0.5 km^2 (Figs. 2, 3) throughout their internesting periods. Using sonic telemetry, one hawksbill (79) was found on the same area on five consecutive occasions during a two-week period (Fig. 3). Hawksbill #14 had less resident time within a particular area and wandered more than any of the others (Fig. 1). Due to low battery power and damaged transmitter antennas, only the approximate area of movements of two hawksbills (34B, 54) was estimated (Figs. 1, 2). Estimated movements of #34A were based on fixes and signal strength from the Buck Island station only (Fig. 1).

Four turtles (86, 79, 14, 03) were eventually lost when they left the area following the final nesting event. These turtles were not located during subsequent tracking sessions around St. Croix.

Within the internesting area used by #03, twelve quadrats were within reef habitat and 24 were in sea grass habitat. This area was composed of approximately 53% sand, 22% patch reef, and 25% sea grass beds. Percent cover was

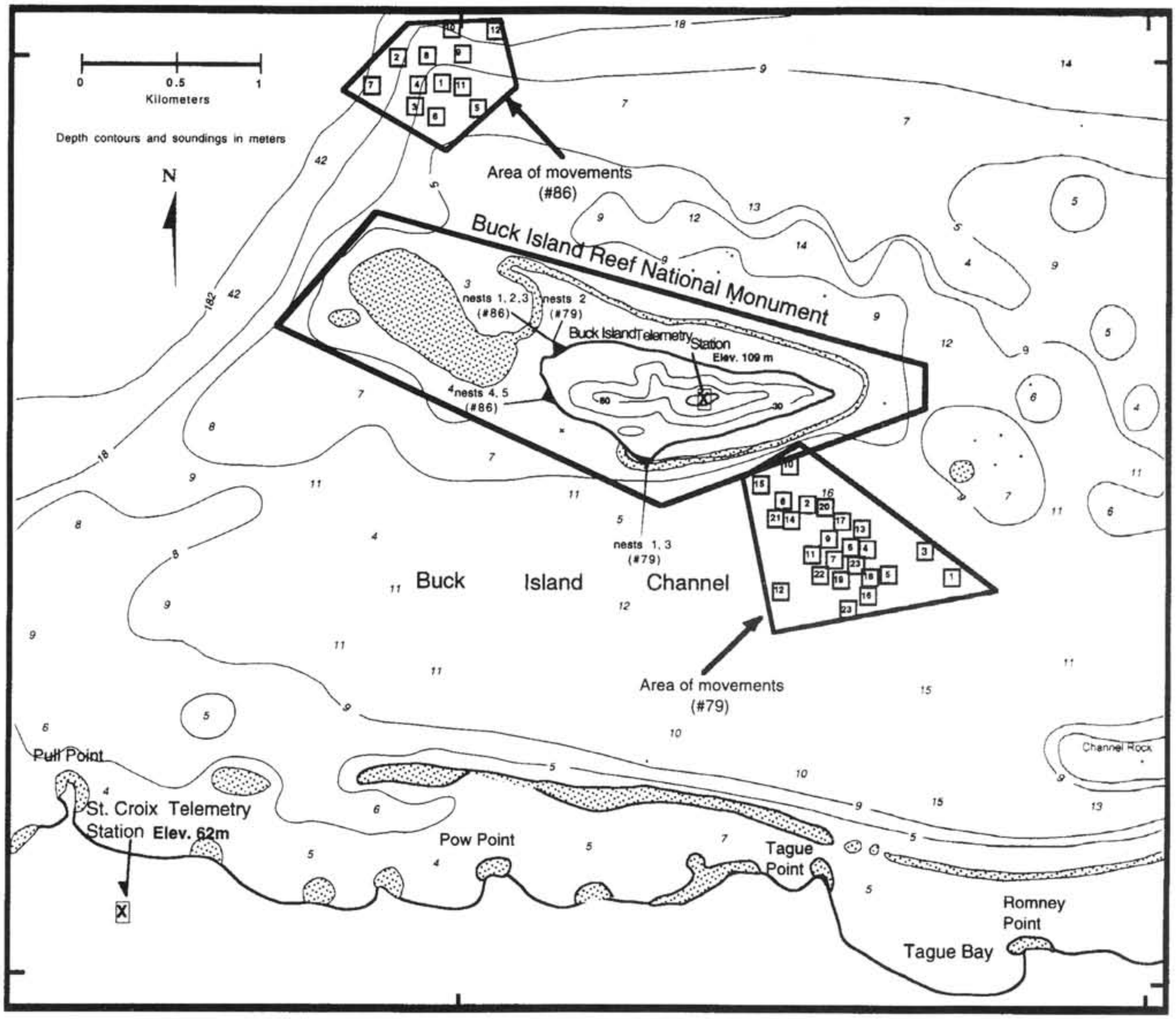

Figure 3. Areas of movements and nest sites of hawksbills #s 86 and 79. Radio and acoustic fixes are numbered chronologically.

greatest for the coral *Montastraea annularis* (5%) within the reef habitat and the grass *Syringodium* spp. (13%) within the sea grass habitat. Within the internesting area of #79, five quadrats were within reef habitat and 32 were sea grass habitat. This area was composed of approximately 76% sand, 22% sea grass beds, and 2% patch reefs (90 and 60 m^2). Percent cover was greatest for gorgonians (14%) within the reef habitat and for the algae *Halimeda* spp. (11%) within the sea grass habitat .

Mean dive duration for all individuals increased between midnight and 0559 hrs and surface interval increased between 1000 and 1759 hrs. Dive behavior of turtles approaching (during the 72 hrs preceding nesting) and departing the nesting beach (during the 24 hrs post-nesting) were analyzed separately. During these periods, dive and surface times were relatively short compared with other periods of the internesting period. Mean duration of dive for all individuals 72 hrs preceding nesting was 3.4 min (SD = 3.6, n = 127) and 24 hrs post-nesting was 7.7 min (SD = 14.1, n = 97). Mean dive duration for all other periods of the internesting period (day and night) was 56.2 min (SD = 17.3, n = 147) and cumulative mean surface duration was 1.6 min (SD = 0.9, n = 314, Table 2). Mean dive duration ranged from 33.8 to 63.5 min during the day and 41.7 to 73.5 min at night. Mean duration of dives of #34B was less than others, whereas #14 had a greater mean duration of nighttime dives than others.

DISCUSSION

Internesting movements of hawksbills were directed toward specific areas around Buck Island. Fidelity (long resident time and site specificity) for off-shore areas varies among individuals and among sea turtle species (green [*Chelonia mydas*], Carr et al., 1974; loggerhead [*Caretta caretta*], Limpus and Reed, 1985). One loggerhead was associated with a single refuge for an entire nesting season (15 November – 30 January) near Heron Island, Australia, whereas other loggerheads moved throughout an area greater

Table 2. Dive duration and surface intervals for day (0600–1759 hrs), night (1800–0559 hrs), and combined, for 7 hawksbills tracked.

Turtle ID	Period	Dive duration (min) Mean ± SD	*n*	Surface interval (min) Mean ± SD	*n*
86	Day	58.9 ± 13.29	29	1.8 ± 1.05	54
	Night	67.3 ± 11.63	14	1.4 ± 0.20	34
	Total	61.6 ± 13.20	43	1.5 ± 1.20	88
14	Day	55.4 ± 21.25	13	2.0 ± 0.96	32
	Night	73.5 ± 8.76	15	1.6 ± 0.56	26
	Total	65.1 ± 18.00	28	1.8 ± 0.82	58
78	Day	56.7 ± 8.18	6	1.7 ± 0.81	24
	Night	64.1 ± 1.72	2	1.5 ± 0.28	10
	Total	58.6 ± 7.74	8	1.7 ± 0.70	34
03	Day	63.5 ± 13.07	11	1.7 ± 1.19	29
	Night	45.8 ± 23.15	5	1.3 ± 0.58	18
	Total	58.0 ± 21.90	16	1.6 ± 1.02	47
34A	Day	–		1.4 ± 0.47	12
	Night	–		1.0 ± 0.12	8
	Total	–		1.3 ± 0.41	20
54	Day	52.9 ± 19.96	21	2.0 ± 0.77	31
	Night	42.3 ± 3.35	20	1.0 ± 0.50	26
	Total	48.6 ± 15.89	41	1.6 ± 0.81	57
34B	Day	33.8 ± 13.57	8	1.5 ± 0.65	10
	Night	41.7 ± 2.70	3	–	
	Total	36.0 ± 12.00	11	1.5 ± 0.65	10
Cumulative		56.2 ± 17.26	147	1.6 ± 0.94	314

than 1 km^2 of the reef front (Limpus and Reed, 1985). When divers repeatedly disturbed this individual she returned to the same area approximately 1 km from the nesting beach. Like loggerheads, hawksbills exhibited variation in the size of the internesting area. Hawksbills #s 03 and 14 used internesting areas encompassing approximately 2 km^2 although concentrated in 0.5 km^2. Hawksbills #s 86 and 79 used areas of 1 km^2.

Hawksbill sea turtle movements may reflect the pattern of prey distribution within the internesting habitat as do the movements of loggerheads (Stoneburner, 1982). The Buck Island Channel (Fig. 2) is composed of a series of small patch reefs (16–20 m depth) with high sponge abundance (Gladfelter, 1988), the primary prey of hawksbills (Meylan, 1984). Stoneburner (1982) reported internesting loggerheads in the Georgia Bight made similar direct movements towards small patches of natural and artificial stable substrate with abundant prey. However, such movements were in excess of 15 km, probably reflecting differences in distances between patches of prey (Stoneburner, 1982). The loggerheads did not remain on patches but moved between them on a regular basis. The localized distribution and abundance of food resources within the Buck Island Channel may enable hawksbills to successfully forage within a more confined area.

Movements of green turtles during their internesting period are also related to courtship and mating (Carr et al., 1974; Dizon and Balazs, 1982), but these are probably not a factor in directing the movements of hawksbills. Hawksbills are considered diffuse, solitary nesters, and congregations of breeding individuals are rarely observed.

All four hawksbills which retained transmitters departed from the area around St. Croix immediately after their final nesting. Satellite telemetry studies on 5 hawksbills that nested on Buck Island indicated that none remained in the area following nesting (ZHS, *pers. obs.*). One tagged hawksbills was captured in Miskito Cays, Nicaragua, having travelled 1936 km whereas another was captured of the northcoast of Cuba (ZHS, *pers. obs.*). Tagged hawksbills have been reported to undertake movements up to 3680 km (Pritchard, 1976; Meylan, 1984; Marcovaldi and Filippini, 1991; Meylan, 1999). An adult female hawksbill, captured and tagged in northern Australia near Campbell Island, was recorded nesting 1650 km away 322 days later in the Solomon Islands (Paramenter, 1983). De Silva (1986) reported one individual, captured in the Philippines, traveled 713 km in 40 days. Such evidence is contrary to some studies which have indicated that hawksbills undertake little or no migration (Carr and Stancyk, 1975; Bustard, 1979).

Carr and Main (1973) reported that indigenous turtle farmers of the Torres Strait area of northern Australia could identify the rookery where juvenile hawksbill sea turtles orginated by coloration alone. They suggested that populations of hawksbill sea turtles in the Torres Strait were isolated and underwent no migration, resulting in evolutionary divergence that produced the observed distinctive color patterns. Thurston (1976) suggested that repeated sightings of individual turtles in Puerto Rico demonstrated their sedentary nature. In Costa Rica, Bjorndal et al. (1985) found hawksbills remained in coastal areas for over a year where there was adequate reef system. A juvenile hawksbill caught on Yaeyama Island, near Japan, was released and caught again 18 months later only 9 km away (Kamezaki, 1987).

On 13 occasions individual hawksbills were found to be motionless among sea grass on a sandy bottom. Hawksbills may remain motionless on the bottom during their internesting period to camouflage themselves from predators. Both tiger sharks (*Galeocerdo cuvieri*) and bullsharks (*Carcharhinus leucas*) have been seen around Buck Island (ZHS, *pers. obs.*) and prey on sea turtles (Stancyk, 1982).

Short surface and dive intervals, characterizing approach to and from the nesting beach, may have been related to movements and metabolic demand imposed on the turtles at such times. Longer dives characterized days 2 through 12 of the internesting period and probably reflected reduced activity.

Three hawksbills returned to short (0.06 km) sections of the nesting beach where they had nested previously. Six returned to the same off-shore site after each nesting event. Studies of how hawksbills orient themselves in the marine environment are needed. The departure of four hawksbills immediately following their last nesting event indicated that some may undergo a reproductive migration. Studies should focus on the extent of these migrations and variation within a population. Dive durations were greater than reported for other species of sea turtles, except the olive ridley (*Lepidochelys olivacea*, P. Plotkin, *pers. comm.*). Long dive duration and motionless behavior of females may be related to avoidance of predators. The physiological mechanism for such long dives is not known but may involve a reduced metabolism; therefore, studies are needed on blood chemistry and physiology of hawksbills.

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LITERATURE CITED

ADEY, W. 1975. The algal ridges and coral reefs of St. Croix: their structure and Holocene development. Atoll Res. Bull. 187:1-67.

BJORNDAL, K.A., CARR, A., MEYLAN, A.B., AND MORTIMER, J.A. 1985. Reproductive biology of the hawksbill *Eretmochelys imbricata* at Tortuguero, Costa Rica, with notes on the ecology of the species in the Caribbean. Biological Conserv. 34:353-368.

BUSTARD, H.R. 1979. Population dynamics of sea turtles. In: Harless, M. and H. Morlock. (Eds.). Turtles: Perspectives and Research. New York: John Wiley and Sons, pp. 523-540.

CARR, A., AND MAIN, A.R. 1973. Turtle farming project in northern Australia. Report on an inquiry into ecological implications of a turtle farming project. Melbourne: L.P. Smart, F.C.A. Marquand and Co., pp. 45-80.

CARR, A., AND STANCYK, S. 1975. Observations on the ecology and survival outlook of the hawksbill turtle. Biol. Conserv. 8:161-172.

CARR, A., ROSS, P., AND CARR, S. 1974. Internesting behavior of the green turtle, *Chelonia mydas*, at a mid-ocean island breeding ground. Copeia 1974:703-706.

DE SILVA, G.S. 1986. Turtle tagging and international tag returns for Sabah, East Malaysia. Sarawak Mus. J. 36(57):263-272.

DIZON, A.E., AND BALAZS, G.H. 1982. Radio telemetry of Hawaiian green turtles at their breeding colony. Mar. Fish. Rev. 44:13-20.

GLADFELTER, W.B. 1988. Tropical Marine Organisms and Communities. St. Croix, VI: Argus, 149 pp.

HILLIS, Z.M., AND MACKAY, A.L. 1989. Buck Island Reef NM Sea Turtle Program, 1989. Proc. 9th Ann. Worksh. Sea Turtle Conserv. Biol. NOAA Tech. Memor. NMFS-SEFC-232, pp. 235-237.

KAMEZAKI, N. 1987. Recapture of the hawksbill turtle, *Eretmochelys imbricata* (Linne), in the Yaeyama Islands, Ryukyu Archipelago. Galaxea 6:17-20.

LIMPUS, C.J., AND REED, P.C. 1985. The loggerhead turtle, *Caretta caretta*, in Queenslamd: observations on internesting behaviour. Australian Wildl. Res. 12:535-540.

MARCOVALDI, M.A., AND FILIPPINI, A. 1991. Trans-Atlantic movement by a juvenile hawksbill turtle. Marine Turtle Newsletter 52:3.

MEYLAN, A.B. 1984. Biological synopsis of the hawksbill turtle (*Eretmochelys imbricata*). In: Bacon, P., Berry, F., Bjorndal, K., Hirth, H., Ogren, L., and Weber, M. (Eds.). Proceedings of the Western Atlantic Turtle Symposium 1:112-117.

MEYLAN, A.B. 1999. International movements of immature and adult hawksbill turtles (*Eretmochelys imbricata*) in the Caribbean region. Chelonian Conservation and Biology 3(2):189-194.

PARMENTER, C.J. 1983. Reproductive migration in the hawksbill turtle (*Eretmochelys imbricata*). Copeia 1983:271-273.

PRITCHARD, P.C.H. 1976. Post-nesting movements of marine turtles (Cheloniidae and Dermochelyidae) tagged in the Guianas. Copeia 1976:749-754.

RICHARDSON, J.I., CORLISS, L.A., RYDER, C., AND BELL, R. 1989. Demographic patterns of Caribbean hawksbills, Jumby Bay, Antigua. In: Eckert, S.A., Eckert, K.A., and Richardson, T.H. (Compilers). Proc. 9th Ann. Worksh. Sea Turtle Conserv. Biol. NOAA Tech. Memor. NMFS-SEFC-232, pp. 253-256.

SMALL, V. 1982. Sea turtle nesting at Virgin Islands National Park and Buck Island Reef National Monument, 1980 and 1981. U.S. Dept. Interior Res. Resourc. Mgmt. Rep. SER-61, 54 pp.

STANCYK, S.E. 1982. Non-human predators of sea turtles and their control. In: Bjorndal, K.A. (Ed.). Biology and Conservation of Sea Turtles. Washington, DC: Smiths. Inst. Press, pp.139-152.

STONEBURNER, D.L. 1982. Satellite telemetry of internesting movements of loggerhead sea turtles at Cumberland Island National Seashore. Atlanta: U.S. Department of Interior, Natl. Park Serv., Southeast Reg. Off., 7 pp.

THURSTON, J. 1976. Observations on the ecology of the hawksbill turtle, *Eretmochelys imbricata*, on Mona Island, Puerto Rico. In: Proceedings of the Association of Island Marine Laboratories, Caribbean Eleventh Meeting, 2-5 May 1975, St. Croix, U.S.V.I., p. 30.

WOODBURY, R.O., AND LITTLE, E.L., JR. 1976. Flora of Buck Island Reef National Monument (U.S. Virgin Islands). U.S. Forestry Serv. Res. Paper ITF-19, 27 pp.

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