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Use of PIT Tags and Photoidentification to Revise Remigration Estimates of Leatherback Turtles (*Dermochelys coriacea*) Nesting in St. Croix, U.S. Virgin Islands, 1979–1995

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ABSTRACT. – We used Passive Integrated Transponder (PIT) tags and photoidentification of pink spots on heads to supplement flipper tag data for leatherback turtles (*Dermochelys coriacea*), providing more accurate information on numbers of individuals and proportion of remigrants nesting on the Sandy Point National Wildlife Refuge, St. Croix, USVI. We estimate the actual number of individual females seen in St. Croix in 1984–95 to be 244, 18.9% fewer than indicated by flipper tags alone. Between 1989–95, the percentage of turtles that were identified as remigrants averaged 48.5%, over 10% higher than indicated by flipper tags (35.1%). In some years, over half the turtles nesting were remigrants. Of the turtles tagged from 1987–91, 58.6% have returned. Since flipper tag retention is low for leatherbacks, PIT tags and photoidentification can be valuable supplements to flipper tags, and should be used when developing life history profiles and size estimates of nesting populations.

KEY WORDS. – Reptilia; Testudines; Dermochelyidae; *Dermochelys coriacea*; sea turtle; photoidentification; PIT tag; remigration; conservation; management; St. Croix; U.S. Virgin Islands

The leatherback turtles (*Dermochelys coriacea*) nesting at Sandy Point National Wildlife Refuge in St. Croix, U.S. Virgin Islands, have been intensively monitored for over fifteen years. A few turtles were flipper-tagged in 1979, and since 1981 saturation tagging and consistent hourly patrols each night throughout the nesting season have yielded a comprehensive database of information on females nesting at Sandy Point. Based on flipper tag records, 358 leatherbacks were tagged on Sandy Point from 1979–95 (Boulon et al., 1996). However, flipper tag retention for sea turtles is notoriously low (Balazs, 1982; Henwood, 1986; Eckert and Eckert, 1989; Alvarado et al., 1993). For Sandy Point leatherbacks, only 60% are retained through the first remigration, usually 2–4 yrs. Although tag placement affects short-term retention to some extent (McDonald and Dutton, 1994), overall retention beyond four years is only 16.0% for monel tags (less for plastic, titanium, and inconel) (Eckert and Eckert, 1989; McDonald and Dutton, unpublished data). Hughes (1982) suggested that low tag retention could help explain why the majority of turtles tagged on nesting beaches are only seen once.

To form more complete records on individuals, and to obtain a more accurate population estimate, we began experimenting with more reliable identification methods. We found that photography could be used to identify remigrants that had lost all flipper tags (McDonald et al., in press), and Passive Integrated Transponder (PIT) tags showed promise as a supplement to flipper tags (Dutton and McDonald, 1994). In this study, we use information gained from photoidentification and PIT tags to reevaluate nesting census data based on flipper tags alone.

MATERIALS AND METHODS

Photoidentification. — One external physical characteristic unique to the leatherback turtle is a notable pink spot on the dorsal surface of the head of each adult, located above the pineal gland (Figs. 1 and 2). In 1986, researchers began photographing the pink spot of leatherbacks nesting at Sandy Point. The photographs were intended to serve as a backup identification method in case flipper tags were lost. McDonald et al. (in press) established that this technique is reliable and that the appearance of the pink spot is unique for individuals and persists over at least four years.

Using a 35 mm point-and-shoot camera (either a Nikon One-Touch or an Olympus Infinity Twin), color photographs were taken of the head from a distance of about three feet directly above each turtle. An identification card with the date and turtle's flipper tag number was included in each photograph (Figs. 1 and 2). We compared photographs of all untagged turtles for each year to all previous years' photographs. We analyzed photographs according to (1) shape, size, and color variations of the pink spot, and (2) patterns of other natural spots, markings, and scars on the head. We examined original records of diagnostic markings (such as missing flippers, notching, and other scars, marks, or deformities) as a final confirmation.

PIT Tags. — In 1992 we began tagging each turtle with a PIT tag, a small (14 mm x 2 mm diameter) glass-encased electromagnetically coded microchip (Prentice et al., 1990). We injected these tags directly into the shoulder muscle, 4–5 cm below the surface of the skin as described in Dutton and McDonald (1994). The area was swabbed with Betadine before and after injection, and a small amount of antibiotic ointment was injected along with each tag. A separate, sterilized 12 gauge 3.81 cm needle was used for each turtle. The tags were detected with a small portable scanner passed over the area and the identification number displayed on a digital screen on the scanner. Tags and scanners were manufactured by AVID (American Veterinary Identification Devices), Inc. The scanners operate on a frequency of 125 KHz.

RESULTS

Photoidentification. — Only 3 of the 18 turtles nesting in 1986 were photographed. In subsequent years, photographic coverage ranged from 63–94%, with coverage of untagged turtles ranging from 62–100%. For this study, we examined nearly 350 photographs representing a total of 220 turtles.

Based on pink spot photographs, we identified 26 remigrant individuals that had previously been reported as "new." In all cases, records of other diagnostic markings were consistent with pink spot identification. One turtle lost two complete sets of flipper tags and was twice misidentified as "new," for a total of 27 photoidentifications.

PIT Tags. — From 1992 through 1995, we injected a total of 175 PIT tags into 157 turtles (some turtles were double-tagged to test retention at slightly different sites). Most injection sites had healed by the next consecutive nesting following injection (8–11 days), although several of the sites were slightly swollen. In one case we did not confirm that the tag was successfully injected, and later that season we could not detect it (Dutton and McDonald, 1994). We suspect that this tag fell out of the applicator prior to injection. In all other cases, PIT tags were detected throughout the season. Based on turtles that have returned in subsequent seasons, PIT tag retention has so far been 100% ($n = 44$ tags). We feel confident that pink spot photos would have enabled us to identify any remigrants that had lost all PIT tags and flipper tags. Fourteen of the 54 turtles tagged in 1992 returned to nest in 1994, 7 returned in 1995, and 14 of the 37 turtles tagged in 1993 returned in 1995. Eight turtles, 2 in 1994 and 6 in 1995, had lost all flipper tags. Furthermore, one of these turtles was identified twice (in two previous seasons) by photographs; we now have records of this turtle having lost all sets of 2–3 flipper tags three separate times.

Figure 1. Pink spot photographs taken in (left) 1988 and (right) 1994 for turtle # VI1000 (numbers on tags refer to flipper tag number). In spite of the glare on the 1994 photograph, the turtle could be identified by the shape of the pink spot and by other markings on the head.

Revised Estimate of Individual Turtles Seen at Sandy Point. — From 1979 to 1995, 358 untagged leatherbacks were tagged with monel, titanium, and inconel flipper tags (Boulon et al., 1996). Pink spot photoidentification and PIT tags have shown that many of the untagged turtles observed prior to 1995 were remigrants that lost all their tags between seasons and were misidentified as "new."

Most leatherbacks have a minimum remigration interval of two years (Dutton et al., 1994), and 1987 was the first year of reasonably complete photographic coverage; therefore, 1989 was the first year a significant number of turtles could have been identified by previous years' photographs. From 1989–95, 185 "new" individuals were tagged. Thirty-five (18.9%) of these were subsequently identified as remigrants based on pink spot photos or PIT tags. Since saturation tagging did not begin until 1981, and most leatherbacks remigrate at two or three year intervals, any correction factor should only be applied to turtles that arrived untagged beginning in 1984 (initial year of saturation tagging plus a three year remigration interval). Applying this percentage to the total number of turtles tagged at Sandy Point from 1984–95, an estimated 57 of the 301 "new" turtles may actually have been remigrants, bringing the number of new individuals down to 244.

Proportion of Remigrants. — Photoidentification and PIT tags have shown that the numbers of remigrants at Sandy Point are consistently higher (in some cases 20% higher) than previously thought (Table 1). Flipper tag data alone from 1989–95 show that 36.4% of the turtles that nested were remigrants, as opposed to 48.5% indicated by flipper tags combined with PIT tags and photoidentification (Table 1). From 1993–95, over half of the turtles nesting were remigrants. The percentage of remigrants misidentified as "new" ranged from 5.9 to 27.5% per season, with an average of 18.9% (i.e., 18.9% of the untagged turtles were identified as remigrants using PIT tags or photoidentification).

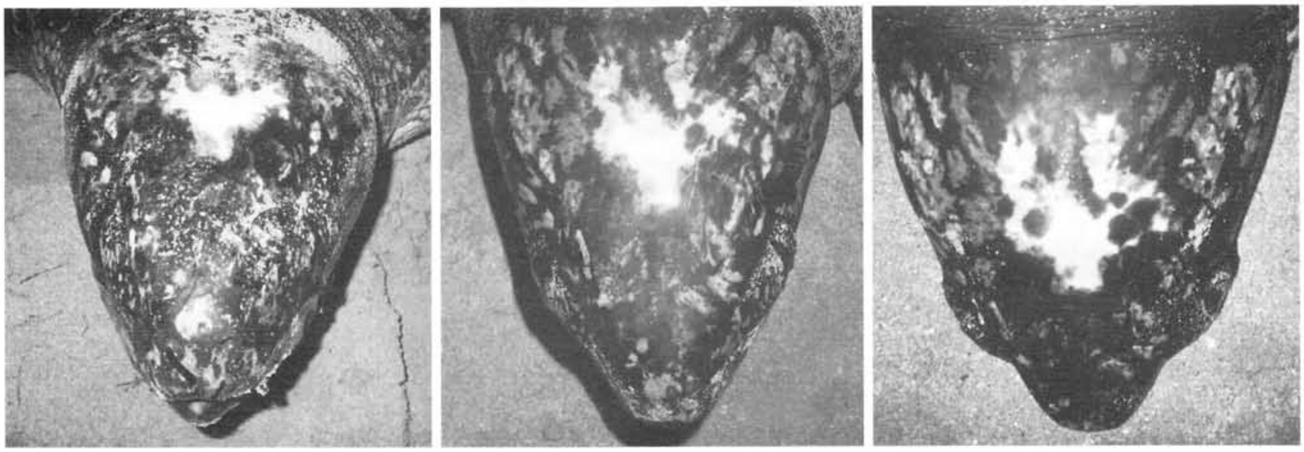

Figure 2. Pink spot photographs taken in (left) 1986, (center) 1990, and (right) 1992 of turtle # VI1131. Unlike most pink spots, this one did change considerably from year to year. However, in spite of the increasing black pigmentation within the pink spot, and the difference in angle between photographs, the general outline remained recognizable. Identification was also facilitated by other markings on the head.

These new methods have also shown that the majority of turtles tagged at Sandy Point return to nest in subsequent seasons. Of the 99 turtles tagged during 1987–91, 58 (58.6%) have returned through 1995.

DISCUSSION

PIT tagging is more reliable than flipper tagging for identifying leatherback turtles. Although we have yet to establish long-term retention of PIT tags, the observed 100% retention over the first remigration interval (2–3 years) is a dramatic improvement over the 60% (or less) retention of conventional metal flipper tags, and superior to retention rates of plastic tags (< 4%; Eckert and Eckert, 1989). PIT tags are also being used successfully on other sea turtle species. Parmenter (1993) found that PIT tags (manufactured by Identification Devices, Inc.) were superior to metal flipper tags for flatback turtles (*Natator depressus*), although he reported an 8% failure rate of PIT tags within 2 years. He attributed some of this to technological failure rather than tag loss. G. Balazs (*pers. comm.*) has applied over 200 Frearing Destron PIT tags to the dorsal left front flipper of immature green turtles (*Chelonia mydas*) in the Hawaiian Islands and has not yet detected any failure or loss over a 3 year period. Fontaine et al. (1987) reported that PIT tags injected into muscle in the flippers of Kemp's ridley turtles (*Lepidochelys kempi*) were retained while those implanted into the carapace were expelled. Our placement of PIT tags in the shoulder muscle appears to be effective and enables tags to be easily detected; furthermore, we have no evidence that tags have migrated. PIT technology is constantly improving, and some brands may perform better than others. However, in some cases where tags are not detected, tag "loss" may be due to improper placement or scanning technique rather than failure of the technology. We found that inexperienced volunteers who were initially unable to detect PIT tags in nesting turtles were able to do so easily after proper training. Tags should be injected into muscle tissue, rather than just under the skin or into adipose tissue, to prevent migration, and must lie perpendicular to the surface of the reader for optimal performance (D. Hull, AVID, *pers. comm.*).

It should be noted that there are several brands of PIT tags and scanners, operating at different frequencies.

Table 1. Revised remigration percentages for leatherbacks on Sandy Point from 1989–95 based on numbers of untagged turtles identified by either photographs or PIT tags.

Year	Turtles Nesting	Tagged Remigrants	Proportion of Tagged Remigrants	Untagged Turtles	Untagged Turtles Identified by Photo/PIT Tag	Percent of Untagged Turtles Identified	Actual Remigrants	Adjusted Proportion of Remigrants	Actual New Turtles
1989	24	7	29.2%	17	1/0	5.9%	8	33.3%	16
1990	22	6	27.3%	16	4/0	25.0%	10	45.5%	12
1991	39	16	41.0%	23	3/0	13.0%	19	48.7%	20
1992	55	15	27.3%	40	11/0	27.5%	26	47.3%	29
1993	43	18	41.9%	25	4/0	16.0%	22	51.2%	21
1994	55	22	40.0%	33	4/2	18.2%	28	50.9%	27
1995	53	22	41.5%	31	0/6	19.4%	28	52.8%	25
Totals	291	106	36.4%	185	27/8	18.9%	141	48.5%	150

Some are cross-compatible but others only read their own tags. We found that AVID scanners were also able to read Frearing Destron tags, both 125 KHz and 400 KHz.

While remigrants were identified by photographs prior to 1995, it now appears that PIT tags are replacing the need for photoidentification. As shown in Table 1, no remigrants were identified by photographs in 1995, despite 100% photographic coverage of new individuals. However, six were identified by PIT tags, and would likely have been identified by photographs had the PIT tags not precluded the necessity of using photoidentification for these individuals.

The number of remigrants recorded as "new" is probably even higher than reported here, as it is unlikely that all remigrants were discovered. Pink spot photography essentially did not begin until 1987 (only 3 turtles were photographed in 1986), and photographic coverage was never complete. Furthermore, some turtles may not have been identified. Although most pink spots remained unchanged (as in Fig. 1), one changed considerably during the 3 seasons it was photographed, with the amount of black pigmentation within the pink spot progressively increasing (Fig. 2). Another spot was almost completely obscured by a combination of head wounds and glare on the photograph. This turtle was identified more by other markings on the head than by her pink spot, and identification was confirmed by diagnostic markings recorded in previous years. Glare, sand, wounds or scarring, and photographic angles can all affect identification. An unobstructed view of the entire head is important, although some turtles were identified from less-than-ideal photographs in which the angle varied. As pointed out in McDonald et al. (in press), photoidentification is most useful on beaches where there is complete or near-complete photographic coverage over at least 3–4 nesting seasons.

These new identification methods have shown that the number of individual turtles seen nesting at Sandy Point is smaller than previously thought. Conversely, the proportion of remigrants is higher than previously reported, and many individuals presumed lost to the population are still returning to nest. Photoidentification and PIT tags have enabled us to form more complete reproductive histories of these females, increasing our knowledge of growth rates and longevity.

These methods have also shown that the majority of turtles tagged returned to nest at Sandy Point in subsequent seasons, while flipper tag data alone for the same period indicated that only 40.4% returned. It therefore seems likely that reports of high numbers of turtles only seen to nest once on other beaches (Hughes, 1982; Steyermark et al., 1996) could also be partially explained by low tag retention, and that the proportions of remigrants returning to these other beaches may actually be much higher as well.

We can now be reasonably sure that the influx of untagged turtles to Sandy Point in recent years (1991–95) represents recruitment of new individuals. Even though 45–53% of the turtles were remigrants, there have still been more new individuals than in previous years, ranging from 20 to 29 for 1991 through 1995, as compared to 16 in 1989 and 12 in 1990 (Table 1). Since we know that movements between nesting beaches occur on a regional level between Culebra, mainland Puerto Rico, Anguilla, and St. Croix (Eckert et al., 1989; Boulon et al., 1996), it would be particularly appropriate to expand photoidentification and PIT tag coverage to include these beaches. This may account for some of the 41.4% of turtles only seen once at Sandy Point. Only when this is done can an accurate estimate be obtained of the nesting population for the region.

Since tag retention is so low for leatherbacks, estimates based on flipper tags of other leatherback populations are also likely to be overestimates. Accurate population size estimates are important to making informed management decisions, and photoidentification and PIT tagging can be invaluable means to ensure that life history data collected during long-term projects are accurate, and to enable reproductive history profiles to be developed for as many individuals as possible.

Use of PIT tags, combined with continued conventional flipper tagging and improved photographic techniques and coverage, should greatly reduce the problems associated with flipper tag loss in the future, and provide more accurate information on the biology of this little-known species.

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