*Herpetological Review*, 2001, 32(3), 172–174.


# Metal Tag Loss in Wild Juvenile Hawksbill Sea Turtles (*Eretmochelys imbricata*)

**CLAUDIO BELLINI**
*Projeto TAMAR-IBAMA*
*Caixa Postal 50, Fernando de Noronha, PE 53990-000 Brazil*
*e-mail: cbellini@elogica.com.br*

**MATTHEW H. GODFREY***
*Fundação Pró-TAMAR, Caixa Postal 2219, Salvador, BA 40210-970 Brazil*

*and*

**TAISI M. SANCHES**†
*Fundação Pró-TAMAR, Caixa Postal 50, Fernando de Noronha PE 53990-000 Brazil*

**Corresponding author, current address: Université de Paris XI, Laboratoire d'Ecologie, Systematique, et Evolution, Bâtiment 362, 91405 Orsay, France e-mail: matthew.godfrey@epc.u-psud.fr*

Identification of individuals within a population is necessary for most behavioral and ecological studies of wild animals. For long lived animals, such as turtles, the ability to recognize and follow individuals over time provides critical information on aspects such as growth, survivorship, residency, and migration. A variety of techniques and tags have been developed to mark individual sea turtles, ranging from subcutaneous passive transponders to autografts of differentially pigmented tissue (Balazs 1999). The greatest challenge in marking sea turtles is durability and readability of the tag over the lifespan of individuals, which can cover decades and involve a great amount of growth. Tag loss can affect estimates of population size, survivorship, and other demographic calculations (Frazer 1983).

Mrosovsky (1983) emphasized the importance of quantifying tag loss, and since then several studies have reported the retention rates of various types of tags and markers for different turtle species (Bjorndal et al. 1986; Frazier 1986; Limpus 1992; Parmenter 1993; van Dam and Diez 1999). In general, the rates of tag loss are particular to specific species and areas. For instance, for loggerhead (*Caretta caretta*) sea turtles in northern Australia, titanium flipper tags outperformed tags made from monel or plastic (Limpus 1992) while for hawksbill (*Eretmochleys imbricata*) sea turtles, plastic tags outperformed both monel and inconel tags (van Dam and Diez 1999). In the current study, we examined the rates of tag loss of two types of commonly used metal tags, monel and inconel, in hawksbill sea turtles found in near-shore habitats in the archipelago of Fernando de Noronha, in the southern Atlantic ocean.

## Materials and Methods

The archipelago of Fernando de Noronha (3°50'S, 32°24'W), a Brazilian National Marine Park located approximately 380 km off the coast of Brazil, supports populations of juvenile hawksbill and green (*Chelonia mydas*) sea turtles in feeding areas close to shore. Since 1987, researchers of Projeto TAMAR-IBAMA, the national sea turtle conservation program in Brazil, have been monitoring these populations using a capture, mark, and recapture protocol (Sanches and Bellini 1999). Although turtles have been captured in eight different localities on the island, the majority of captures are made in Sueste Bay, which is easily accessible and contains a relatively large resident population of sea turtles. In all cases, individual animals were captured by hand during free dives with mask and snorkel, after which curved carapace length (CCL) and width, and mass were recorded and tags were placed on the front flippers.

We placed style 681 tags (National Band and Tag Company, Newport, Kentucky, USA) on the trailing edge of each front flipper, proximal of the first large scale immediately adjacent to the axilla (cf. Limpus 1992). Up until 1994, we used only tags made from monel, a nickel-copper alloy. After this, inconel tags (made from a nickel-iron-chromium alloy) were placed on all turtles en-

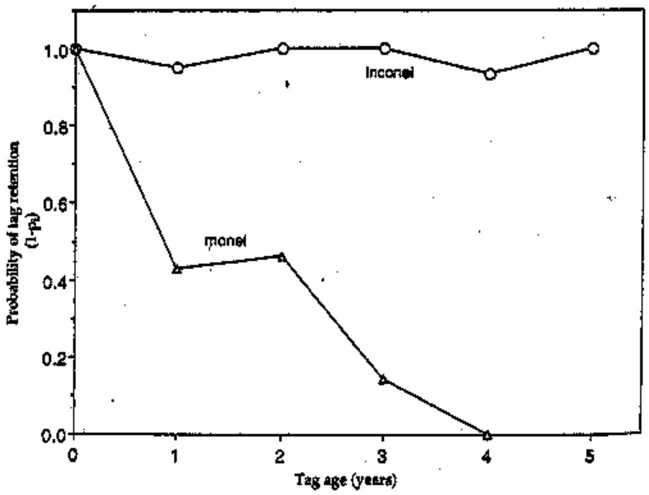


FIG. 1. Estimated probability ($1-p_i$) of tag retention over time for monel and inconel tags used on hawksbill sea turtles in Fernando de Noronha, Brazil.

countered for the first time, while for recaptured turtles, inconel tags replaced monel tags as the latter were found to be lost or unreadable. Recaptured turtles were checked for tags; encountered tags were checked for readability and also for their durability by pulling on the two sides of the tag at the same time. If unreadable, or if they opened when tested, they were considered to be "lost" and replaced with new tags. Probability of tag loss for the two types of tags was calculated using the following equation from Limpus (1992):

$$p_i = b_i/(a_i+b_i)$$

with i being the elapsed time in whole years since tag application;

$a_i$ being the number of tags still present on turtles recaptured after i years since being attached; and

$b_i$ being the number of tags lost on turtles recaptured after i years since being attached.

Standard error ($SE_{pi}$) was derived as: $\sqrt{[p_i(1-p)/(a_i+b)]}$, and the 95% confidence interval of $p_i$ being $\pm [(SE_{pi})(1.96)]$. Elapsed time since application was rounded up or down to the nearest year for recaptured tags. Only turtles recaptured at least once were included in the analysis.

## Results

A total of 69 hawksbill turtles, ranging in size from 26.5 to 64 cm CCL at initial capture, have been recaptured one or more times in the near-shore waters of Fernando de Noronha since 1987. A total of 238 tags (145 monel and 93 inconel) have been deployed on these 69 turtles. The average durability of a monel tag was 334 days ± 24.9 SEM, which was significantly shorter than the average durability of an inconel tag, 851 days ± 56.5 SEM ($p<0.001$, Mann Whitney test, $U = 3325.5$).

Tag loss increased yearly for monel tags, reaching 1.00 after four years, while for inconel tags it remained low for up to five years (Table 1). The chance of an inconel tag remaining intact over time remained extremely high, whereas the longest duration a monel tag successfully remained on a turtle was three years (Fig. 1).

Both monel and inconel tags on recaptured turtles were susceptible to biofouling by green or red algae, and by calcareous algae, and usually had to be cleaned in order to be read. Monel tags typically displayed corrosion in the locking mechanism; oftentimes when we tested tags on recaptured turtles, the tag opened easily because the locking mechanism had deteriorated (Fig. 2).

## Discussion

Because we tested the state of each tag every time a turtle was recaptured, in many cases we were able to record exactly where corrosion, if any, was occurring, and also to replace tags that were likely to have been lost if left in place. Corrosion of the monel tags, particularly in the locking mechanism, appeared to be an important contributor to the failure of these tags (Fig. 2). Monel tags displayed a poor rate of retention in hawksbill turtles feeding in the nearshore waters of Fernando de Noronha. This is consistent with other in-water studies which have also found monel tags to be inferior to tags made from other materials (Limpus 1992; van Dam and Diez 1999; but see Bjorndal et al. 1996 for contrary results for a nesting population).

The probability of tag loss for monel tags varied over time from initial tag application, with two-year-old tags having a slightly greater chance of remaining intact than one-year-old tags (Fig. 1). This suggests that there may be a variety of factors, in addition to corrosion, affecting tag loss in these turtles. For example, locations of the turtles varied, and differences in the seawater chemistry for particular areas may lead to deterioration at different rates. Also, subtle differences in the manufacturing of different batches of monel tags may affect rates of corrosion (Balazs 1999; Bjorndal et al. 1996). In contrast, the low level of tag loss for inconel tags in this study was relatively constant over time, and suggests that continued use of this tag during our study is warranted. Indeed, a nearly five-year-old inconel tag was mistaken for new on a hawksbill turtle tagged in Sueste Bay and recovered in Gabon, because the tag showed no signs of wear or corrosion (J. Fretey, pers. comm.).

Van Dam and Diez (1999) found that plastic tags had a greater retention rate than inconel and other types of tags in hawksbill captured on a feeding ground in the Caribbean. Although we have never used plastic tags, we have avoided them because it has been suggested that plastic tags increase the likelihood that turtles will become accidentally entangled in fishing nets (Nichols et al. 1998; Suggett and Houghton 1998). Although use of such nets is prohibited in the majority of waters around the archipelago of Fernando de Noronha, individuals in our study have migrated to other areas where they are likely to encounter nets (e.g., Bellini et al. 2000). It is interesting that van Dam and Diez (1999) reported that the loss of inconel tags in the Caribbean was restricted to turtles smaller than 35 cm CCL, whereas in our study, the majority of turtles captured were larger than 40 cm CCL (Sanches and Bellini 1999). Similarly, Prince (1996) found that both titanium and inconel tags were shed quickly by smaller juvenile sea turtles. Perhaps inconel tags would not perform well in Fernando de Noronha in smaller hawksbill individuals.

Passive integrated transponder tags, which are placed intramus-

Table 1. Loss of monel and inconel tags used on hawksbill seaturtles at Fernando de Noronha, Brazil. See text for description of $p_i$ and $SE_{pi}$.

| Tag type | Years since applied | Tags present | Tags lost | $p_i$ | $SE_{pi}$ | 95% Confidence interval |
|---|---|---|---|---|---|---|
| Monel | 1 | 62 | 83 | 0.572 | 0.041 | 0.492 – 0.613 |
| | 2 | 12 | 14 | 0.538 | 0.098 | 0.347 – 0.636 |
| | 3 | 1 | 6 | 0.857 | 0.132 | 0.598 – 0.989 |
| | 4 | 0 | 1 | 1.000 | 0.000 | |
| | 5 | 0 | 0 | | | |
| Inconel | 1 | 78 | 4 | 0.049 | 0.024 | 0.002 – 0.073 |
| | 2 | 65 | 0 | 0.000 | 0.000 | |
| | 3 | 44 | 0 | 0.000 | 0.000 | |
| | 4 | 29 | 2 | 0.065 | 0.044 | -0.022 – 0.109 |
| | 5 | 4 | 0 | 0.000 | 0.000 | |

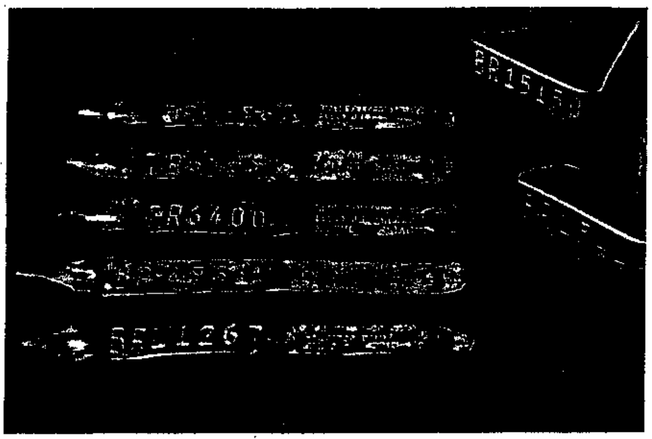

FIG. 2. Example of corrosion of monel tags used in this study. Note the deterioration of the locking mechanism in particular. Tags were fully opened in order to facilitate presentation.

cularly and then recognized with a special scanner, have been used with success in some projects (e.g., McDonald and Dutton 1996; Parmenter 1993; van Dam and Diez 1999). However, the relatively high cost of the tags and scanner and the impossibility of recognizing the tags without a scanner (e.g., by fishermen who accidentally capture sea turtles) have kept us from using them in our study.

Regardless of the efficacy of other tags reported by other sea turtle research projects, we have experienced high level of success with inconel tags (only 6 out of 97 tags have been lost over the past five years), and will continue to use them during our study. Indeed, we are currently replacing all monel tags with inconel on recaptured turtles, independent of the status of the tag, in order take advantage of the longevity of inconel tags. This is especially important for larger individuals, who are likely to migrate to other regions in the near future. Our results show that, as with almost all aspects of management of wild animals, evaluation and assessment should be done independently on a case by case basis. This is particularly important with respect for programs that rely on the tagging of sea turtles. It is highly recommended that each program evaluate the probability of tag loss, rather than extrapolating from other studies.

*Acknowledgments.*—We greatly appreciate the support and collaboration of various researchers and interns over the years in our ongoing capture, mark, and recapture study. Petrobras is the official sponsor of Projeto TAMAR-IBAMA. Additional support came from the National Marine Park of Fernando de Noronha - IBAMA, the Fundação Pró-TAMAR, and the Natural Sciences and Engineering Research Council (Canada).

### LITERATURE CITED

BALAZS, G. H. 1999. Factors to consider in the tagging of sea turtles. *In* K. L. Eckert, K. A. Bjorndal, F. A. Abreu-Grobois, and M. Donnelly (eds.), Research and Management Techniques for the Conservation of Sea Turtles, pp. 101–109. IUCN/SSC Marine Turtle Specialist Group Publication 4.

BELLINI, C., T. M. SANCHES, AND A. FORMIA. 2000. Hawksbill turtle tagged in Brazil captured in Gabon, Africa. Mar. Turtle Newsl. 87:11–12.

BJORNDAL, K. A., A. B. BOLTEN, C. J. LAGUEUX, AND A. CHAVES. 1996. Probability of tag loss in green turtles nesting at Tortuguero, Costa Rica. J. Herpetol. 30:567–571.

FRAZER, N. B. 1983. Survivorship of adult female loggerhead sea turtles, *Caretta caretta*, nesting on Little Cumberland Island, Georgia, USA. Herpetologica 39:436–447.

FRAZIER, J. 1986. Tag loss problems with Giant tortoises, *Geochelone gigantea* (Schweigger), on Aldabra. J. Zool., Lond. 209:337–339.

LIMPUS, C.J. 1992. Estimation of tag loss in marine turtle research. Wildl. Res. 19:457–469.

MCDONALD, D. L., AND P. H. DUTTON. 1996. 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. Chel. Conserv. Biol. 2:148–152.

MROSOVSKY, N. 1983. Conserving Sea Turtles. British Herpetological Society, London.

NICHOLS, W. J., J. A. SEMINOFF, AND A. RESENDIZ. 1998. Plastic "rototags" may be linked to sea turtle bycatch. Mar. Turtle Newsl. 79:20–21.

PARMENTER, C. J. 1993. A preliminary evaluation of the performance of passive integrated transponders and metal tags in a population study of the flatback sea turtle (*Natator depressus*). Wildl. Res. 20:375–381.

PRINCE, R. I. T. 1996. Loss of tags from growing juvenile loggerhead turtles in captivity. Mar. Turtle Newsl. 72:8–10.

SANCHES, T. M., AND C. BELLINI. 1999. Juvenile *Eretmochelys imbricata* and *Chelonia mydas* in the Archipelago of Fernando de Noronha, Brazil. Chel. Conserv. Biol. 3:308–311.

SUGGETT, D. J., AND J. D. R. HOUGHTON. 1998. Possible link between sea turtle bycatch and flipper tagging in Greece. Mar. Turtle Newsl. 81:10–11.

VAN DAM, R. P., AND C. E. DIEZ. 1999. Differential tag retention in Caribbean hawksbill turtles. Chel. Conserv. Biol.3:225–229.