Update on the nesting population of loggerhead sea turtles monitored by Projeto TAMAR-IBAMA, Praia do Forte, Bahia, Brazil

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Projeto TAMAR-IBAMA is the national sea turtle conservation program in Brazil. Soon to reach its 20th year of existence, Projeto TAMAR-IBAMA is a network of over 20 conservation and research stations spread out over the continental coast and oceanic islands in 8 separate states in Brazil. Currently, over 400 local people are employed by the organization, and among its many commitments are community participation and development. Future plans include greater integration of community members in the program and greater self-sufficiency (Marcovaldi & Marcovaldi 1999).

The research and conservation station at Praia do Forte, in Bahia (12°34'56"S, 38°00'02"W), was one of 3 original stations founded in 1982 (Comboios, in Espírito Santo; and Pirambu, in Sergipe being the other two). Data on nesting female turtles and their nests have been collected yearly, and a hatchery was erected to incubate eggs laid in areas which could not be left in place, due to heavy use by tourists or intense night-time lighting from nearby houses or hotels. In 1987, data collection on all nesting beaches monitored by Projeto TAMAR-IBAMA was standardized, thereby facilitating comparisons among both areas and years.

The area monitored by the base of Praia do Forte is visited mainly by loggerhead sea turtles, with hawksbills, olive ridleys, and green turtle nests also occurring, in descending order of incidence. Marcovaldi and Laurent (1996) presented data from 6 seasons of monitoring, and compared the hatching success of nests incubated in hatcheries with those left in situ. Here we present another 6 seasons of data for loggerhead turtles, again comparing emergence rates of nests subject to different management techniques. We also analyze the numbers of nests laid per year, to look for trends in the size of the nesting population. A general description of hawksbill nesting in the area was presented by Marcovaldi et al. (1999).

Materials and Methods: The details of this area were described by Marcovaldi and Laurent (1996), with 3 important differences made in the management plan since 1992/93 (discussed below). To briefly summarize, the area monitored by the base of Praia do Forte currently covers about 50 kilometers of nesting beach, running north from the Jacuipe river up until the Sauipe river (Figure 1), and is divided by several smaller rivers in between. The nesting

beaches are classified as being part of either an Intensive Study Area (ISA) or a Conservation Area (CA). The ISA, which is roughly 30 kilometers long, is monitored daily by biologists and/or local community residents trained by Projeto TAMAR-IBAMA. The majority of nests are left to incubate *in situ*, after being located, marked, and covered with a protective wire mesh (minimum mesh size 7cm to allow hatchlings to leave the nest) as a means to protect against predation by the crab-eating fox (*Cerdocyon thous*). After 45 days of incubation, nests are monitored daily for signs of hatching emergence, indicated by a mass of hatchling tracks emerging from the top of the nest (almost always, the majority of hatchlings emerge on the same night). At the first sign of emergence, the nests are opened to verify species, to count number of live hatchlings produced (estimated by counting the number of empty egg shells remaining in nest, minus any dead pipped hatchlings), and to count total number of eggs (live hatchlings plus dead pipped hatchlings plus unhatched eggs). Any live hatchlings found remaining in the nest are immediately released to the sea. Occasional nightly patrols are made in the ISA, and any nesting females encountered are tagged with monel tags (#681, National Band Co.), and length and width of the carapace (over the curve) are recorded.

The CA, roughly 20 km long, is divided into 4 sections of 5 km, each patrolled once daily by local community members hired by Projeto TAMAR-IB AMA. These areas are heavily populated and developed, making it nearly impossible to guarantee the safety of developing eggs on the beach. All nests laid the previous night are located and transferred to Styrofoam boxes (one nest per box), with a minimum of rotational movement of the eggs (Blanck & Sawyer 1981). All boxes are brought to set transfer points, and brought to the central open-air hatchery, where the majority are reburied within 8 hours of being laid.

Since the 1992/93 nesting season, which was the final nesting season presented by Marcovaldi and Laurent (1996), there have been 3 important changes in the management program in Praia do Forte, as follows: a) at the start of the 1994/95 nesting season the area of coverage in the CA was increased 7 km by the addition of the beach at Jacuipe, in the south; b) the beaches in Santo Antonio and Porto Sauipe are in transition from CA to ISA, with the majority of the nests being left in situ; c) a third management option was added in 1994/95 season in which some nests which required relocation were transferred to locations on the nesting beach, rather than to the central hatchery (Marcovaldi & Barata 1998). This occurs only in the ISA; all nests in the CA continue to be transferred to the central hatchery at the research station in Praia do Forte.

For data analysis, values for nest hatching success (number of live hatchlings divided by total number of eggs) were transformed using the arcsine transformation prior to analysis of variance followed by the Bonferroni post-hoc test (Zar 1996). For nesting trends over time, data from Jacuipe were excluded from the regression analysis in order to maintain consistency in monitoring effort since 1987.

Results. The overall number of loggerhead nests laid during the 12 nesting seasons was 4803, and the total number of hatchlings produced was 391,348. The ratio of false crawls to successful nests was 29.6% (Table 1). The yearly number of false crawls was determined only for Praia do Forte beach (14 km), since this was the only area surveyed in which data on false crawls have been recorded since 1987, although it was nearly impossible to identify species for this behaviour. Therefore, the ratio of false crawl to nest for loggerheads probably is slightly exaggerated, since false crawl data also include hawksbill, olive ridley, and green turtles which also nest in Praia do Forte. For the 1997/98 and 1998/99 nesting seasons, 29% of nests laid (and for which data on species was recorded) on Praia do Forte beach were from species other than loggerheads.

There was yearly variation in the number of nests laid by loggerhead turtles in the areas monitored by the Praia do Forte base of Projeto TAMAR-IBAMA (Figure 2). Regression analysis of the numbers of nests laid per year (excluding those laid in Jacuipe) revealed that the slope was not significantly different from zero ($p=0.15$), indicating that there was neither an increase or decrease in numbers of nests over time (regression equation: $Y=5.03X - 61.60$; $r^2 = 0.20$).

In terms of management techniques, analysis of variance revealed mat there was a significant difference in hatching success of nests subject the three different management techniques ($F=38.52$, $p<0.0001$) (Table 2). The Bonferroni post hoc test showed that nests left in situ had significantly higher hatching success than both nests relocated to the hatchery ($t=8.60$, $p<0.001$) or nest relocated to the beach ($t=5.18$, $p<0.001$). Although nests relocated to the natural nesting beach had a slightly higher hatching success than those moved to the hatchery, it was not significantly different ($p>0.05$).

Discussion:

Although there have been changes in management procedures in the last 12 nesting seasons, overall the basic strategy has been to protect nesting females and their incubating eggs on the beaches monitored by Praia do Forte base of Projeto TAMAR-IBAMA. The pattern of yearly number of nests laid by loggerhead turtles suggests that the population is stable, although care must be taken when extrapolating from nest numbers to population size (Ross 1997). For instance, the number of nests per year may reflect previous environmental conditions on the feeding grounds, rather than short-term trends in population size (Limpus & Nicholls 1987). Nevertheless, at the current time the only available estimator of population size is annual number of nests laid (Godfrey 1997; Gerrodette & Taylor 1999).

A stable nesting population is likely to be an improvement of the situation encountered in the late 1970s, when initial surveys on sea turtle activities revealed a history of consumption of nesting sea turtles and their eggs by local coastal residents (Marcovaldi & Marcovaldi 1999). Although not formally organized, use of sea turtles was widespread enough to pose a serious threat to

the survival of local populations. With the founding of Projeto TAMAR-IBAMA in 1980, public education campaigns were mounted, and all sea turtles were protected by Brazilian national law in 1986. Since then, almost all use has been eradicated, and the reproductive cycle of sea turtles on the principal nesting beaches has been protected. Given that maturation of loggerhead turtles is probably on the scale of several decades (Frazer & Ehrhart 1985), an increase in nesting population (as indicated by an increase in annual number of nests laid) is not expected at this time. Monitoring will continue into the next decade, and it is hoped that indications of a population increase will be seen in the future.

In terms of management strategies, the statistical analysis showed that there was no significant difference in hatching success between nests relocated to the central hatchery and nests relocated to areas on the natural nesting beach. However, there are other benefits to relocation to the natural nesting beach besides hatching success. For instance, relocation to the natural nesting beach is much less labor-intensive, as transportation time and its potential disturbance of the eggs are minimized, and egg incubation in the hatchery requires daily care and maintenance (e.g. Naro-Maciel et al. in press). Finally, in terms of emergence and seafinding, the hatchlings from nests relocated to the nesting beach encounter a natural situation, unlike in the hatchery, where the turtles are retained by mesh nets prior to counting and immediate release by biologists. Therefore, in general terms, the relocation of nests to natural nesting beaches is a more desirable management technique.

Unfortunately, it is not always possible to relocate nests to the natural nesting beach, for various reasons. One threat to nests in the CA is the heavy use by tourists, and the possibility that clutches will be damaged inadvertently by people on the beach. Another problem is the excessive use of artificial lights near the nesting beach, where housing or development was already established before Projeto TAMAR-IBAMA was created. Emerging hatchlings, which use differences in light as cues to find the sea (Salmon et al. 1992), are attracted to artificial lights that reach the beach (Witherington & Bjorndal 1991). This disruption in seafinding is a danger, because often as a result the hatchlings never reach the sea. Although the best possible solution would be to reduce the level of artificial lighting, at the current time this is not possible. Projeto TAMAR-IBAMA is working on the problem of photopollution, and aims to minimize as much as possible the impact of artificial lights on sea turtles.

Management and conservation of marine turtles at the Projeto TAMAR-IBAMA base of Praia do Forte is flexible, responding to changes and new approaches. The introduction of the technique of relocating clutches to safer areas on the nesting beach has resulted in higher emergence rates and hence more hatchlings. In addition, the expansion of the ISA to include the beaches of Santo Antonio and Porto Sauipe resulted in greater numbers of nests left in situ, also producing a higher percentage of hatchlings than those moved to the hatchery. This change is part of a larger philosophical effort to maintain as many

nests in situ as possible. This has been possible largely through the public education campaigns mounted by Projeto TAMAR-IBAMA, which has increased conscientiousness of local people with respect to sea turtles. It is hoped that with more time, greater numbers of nests can be left in situ.

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Table 1. Yearly number of loggerhead nests laid in areas monitored by the Praia do Forte base of Projeto TAMAR-IBAMA.

Nesting season	Nests laid for all beaches (50km)*	Nests laid in Praia do Forte beach (14km)	False crawls in Praia do Forte beach	Ratio False crawl: nests†
1987/88	284	149	38	25.50
1988/89	332	117	23	19.66
1989/90	277	122	28	22.95
1990/91	332	120	37	30.83
1991/92	348	113	14	12.39
1992/93	366	120	21	17.50
1993/94	335	127	69	54.33
1994/95	433	136	33	24.26
1995/96	600	187	68	36.36
1996/97	540	126	34	26.98
1997/98	541	154	48	31.17
1998/99	415	147	66	44.90
total	4803	1618	479	29.60

*From 1987/88 to 1993/94, area of monitoring was only 43 km (see text)

† For the majority of false crawls, species of turtle was not identified. Therefore, these values are probably inflated, as they include false crawls of hawksbill, olive ridley, and green turtles.

Table 2. Mean hatching success for loggerhead nests laid on beaches monitored by the Projeto TAMAR-IBAMA station of Praia do Forte, between the 1994/95 and 1998/99 nesting seasons. Analysis of variance of the three types of management used showed that there was a significant difference between nests left in situ and each of the other two situations ($p<0.001$ in both cases).

	In situ	Transferred to Beach	Transferred to Hatchery
mean	74.01	67.24	65.62
SEM	1.04	1.53	0.89
n	874	393	1149

Figure Legends:

Figure 1.
Schematic map of the nesting beaches (in bold) which are monitored by the Projeto TAMAR-IBAMA base of Praia do Forte. The beach of Jacuipe was added in 1994/95 nesting season. The location of the central open-air hatchery, to where all clutches laid in the Conservation Area are moved for incubation, is indicated by the arrow.

Figure 2. Numbers of loggerhead clutches laid per nesting season on beaches monitored by the Projeto TAMAR-IBAMA base in Praia do Forte, Bahia, Brazil. White bars from 1994/95 onwards represent nests laid in Jacuipe, which was added to the area covered by the base at that time.

Figure 1.

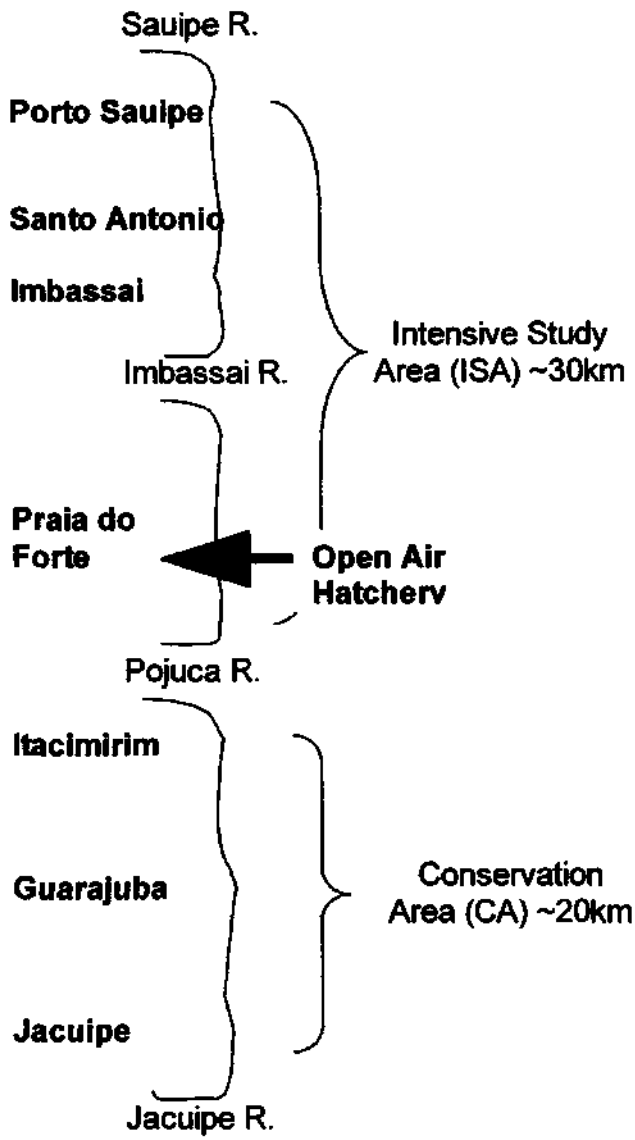
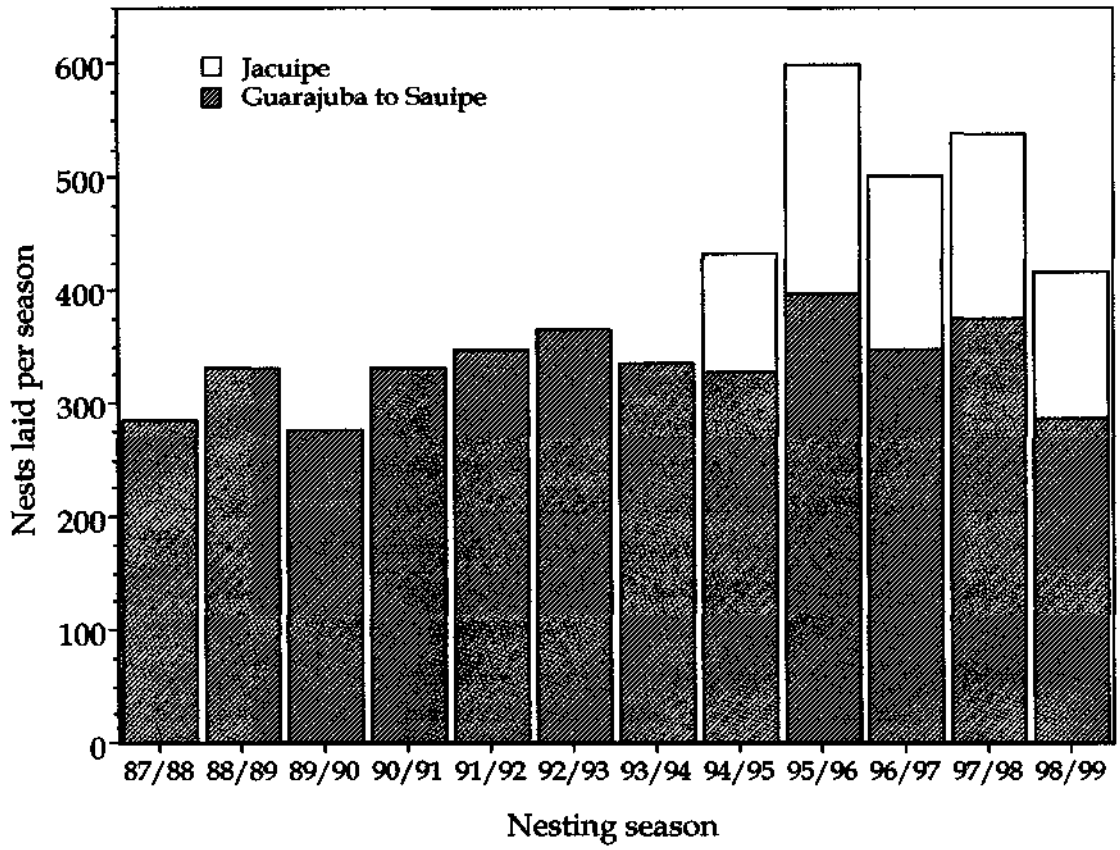

Sauipe R.
Porto Sauipe
Santo Antonio
Imbassai
Imbassai R.
Intensive Study Area (ISA) ~30km
Praia do Forte
Open Air Hatcherv
Pojuca R.
Itacimirim
Guarajuba
Jacuipe
Conservation Area (CA) ~20km
Jacuipe R.

Figure 2.


Jacuipe
Guarajuba to Sauipe
Nests laid per season
0
100
200
300
400
500
600
87/88
88/89
89/90
90/91
91/92
92/93
93/94
94/95
95/96
96/97
97/98
98/99
Nesting season