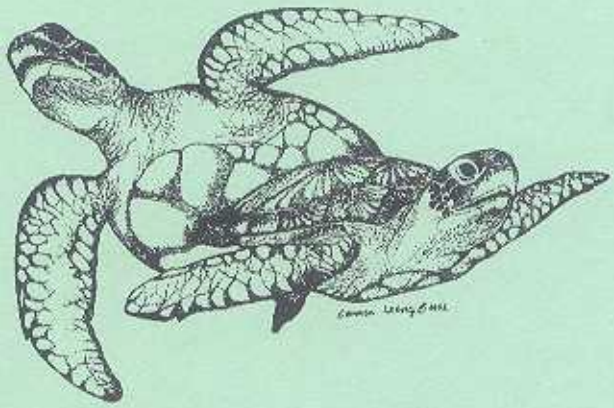
NOAA Technical Memorandum NMFS-SEFSC-536

PROCEEDINGS OF THE TWENTY-THIRD ANNUAL SYMPOSIUM ON SEA TURTLE BIOLOGY AND CONSERVATION



"Living with Turtles"

17 to 21 March 2003, Kuala Lumpur, Malaysia

Compiled by: Nicolas J. Pilcher

U.S. DEPARTMENT OF COMMERCE
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National Marine Fisheries Service
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Conrad C. Lautenbacher, Jr., Administrator

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In relation to the mean incubation periods for loggerheads, we observed a decreasing gradient from north to south (RJ-SE). With the exception of the State of ES, there were no major differences in the mean incubation period in other regions, following our conservation strategy. Hawksbills showed little variation in incubation period among the different management regimes in this same region. The averages for this species were naturally higher to those observed for loggerheads and Olive ridleys for the three species when superimposed. We have not observed any significant difference in the mean incubation period for Olive ridleys with our conservation strategy. The leatherback was the species with the highest incubation periods in Brazil. Due to the small sample size however, we observed a difference in the mean incubation times among the different conservation strategies. However, when the analysis was made between pairs of nests, the incubation periods were similar. We did not observed significant differences for greens when using different conservation strategies. (Figs. 8, 9 & 10).

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NEST INUNDATION BY SEAWATER: A THREAT TO MITIGATE OR A NATURAL "MASCULINISING" FACTOR?

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Background

Southern Kyparissia Bay, western Greece, is a major nesting area for loggerhead turtles in the Mediterranean. On average, 425 clutches are deposited per season along 8 km of beach length (Margaritoulis and Rees, 2001). ARCHELON conducts a long-term monitoring and nest management programme in the area. Because of the prevailing winds during the nesting season, many nests are naturally inundated by seawater. This has prompted ARCHELON to include in its programme the routine relocation of clutches, laid within a certain distance from the sea, to sites higher up the beach. It is known that incubation duration is negatively correlated to nest temperature, which determines the sex ratio of hatchlings (Marcovaldi *et al*., 1997). To test the impact of inundation to sex ratios, the incubation duration of inundated versus non-inundated nests was studied for the 8-year period 1994-2001.

Methods

For analysis, only "undisturbed" nests (i.e. *in situ* nests not disturbed by predation or human intervention after their location) were taken into account. Most of the clutches were, however, located by careful hand-excavation. This was done so that protective metal screens could be placed over the nests thus reducing predator success, as nest predation is a major problem in Kyparissia Bay (Margaritoulis, 1988; Rees *et al*., 2002). Nests were then observed daily in the early morning during routine beach surveys to record, along with other data, inundation events and hatching.

A nest was classified as having been inundated when, from the daily beach survey, evidence was provided that waves had passed over the nest area. Thus inundated nests possibly varied from having suffered one or two waves passing over them to considerable periods of time spent submerged in the surf. Incubation duration (ID), for the purpose of this presentation, is defined as the elapsed time (in days) from egg laying until the first emergence of hatchlings. The Kruskall-Wallis test was used to identify significant differences in ID between years and between nest categories.

Results and Discussion

The overall average ID was 49.7±4.1 days (N=1,255) for non-inundated nests and 53.2±5.2 days (N=505) for inundated nests. Inundation thus appears to increase the overall average ID by 3.5 days and also to extend the spread of ID. Inter-seasonal variations of mean ID between non-inundated and inundated nests are shown in Fig. 1. Significantly more nests had IDs at or above the calculated pivotal ID of 56.6 days identified by Mrosovsky *et al*. (2002), from which it can be inferred that a higher proportion of male hatchlings were produced.

Results show that nest inundation, if not catastrophic, prompts longer ID and thus can have a "masculinising" effect on loggerhead clutches. It is known that at some beaches where hatching sex ratios have been studied a strong bias towards production of female hatchlings has been indicated (Mrosovsky and Provancha, 1989; Marcovaldi *et al*., 1997; Godley *et al*., 2001).

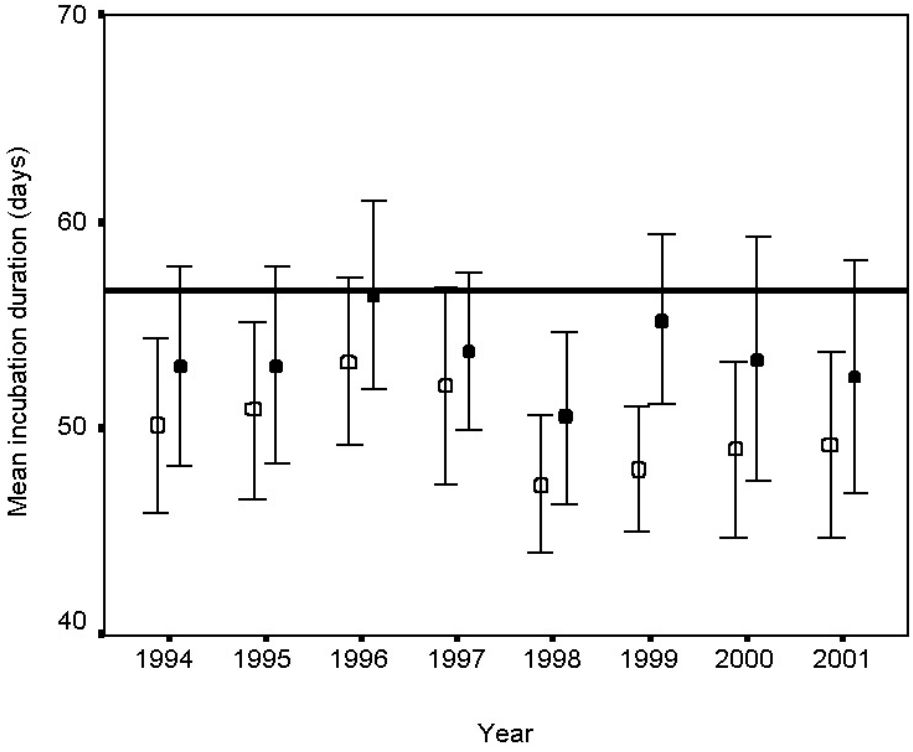

Figure 1. Comparison of yearly mean (± 1 SD) ID for inundated (filled circles) and non-inundated (open circles) nests. Thick line represents the pivotal ID (56.6 days, Mrosovsky et al., 2002).

We hypothesise that the non-lethal effects of nest inundation (as shown here) may redress the balance towards a less female-skewed sex ratio and thus nests constructed closer to the sea in areas that, unpredictably, may be covered by sea water, contribute significantly to the overall sex ratio produced. If this is the case then management programmes involving nest relocation to avoid sea-inundation may be stopping production of an important percentage of male hatchlings that may have an as yet unknown effect on the overall population.

It is recommended that nest relocation as a conservation tool should be limited to those nests that are certain to be destroyed or have drastically reduced hatching success if left to remain *in situ*. Within the context of this paper, it means that nests on the border of high-tide or storm-wave zones should be left to incubate *in situ*, subsequently possibly suffering some inundation, rather than be relocated to a hatchery or further up the beach platform where conditions are more likely to favour a female-biased sex ratio.

These initial results with basic analysis urge further investigation into the masculinising effect of nest inundation. They are put forward as indicators so that further study can be made that takes into account the complete range of factors that are involved with sex-determination and ID.

Acknowledgements
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THE IMPACT FROM BEACH EROSION AND HEAT WAVE ON THE LOGGERHEAD TURTLE HATCHING SUCCESS RATE AT SAGARA COAST IN JAPAN

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Kamehameha Ohkoku was established for monitoring loggerheads and studying with school children at Sagara, in the Shizuoka prefecture, in 1997. Thereafter the activities were expanded into marine environmental conservation projects including sands and sea grass bed surveys. The Sagara coast faces several problems such as erosion of the sands, rocky shore denudation and rising sea temperatures. These environmental changes, when combined, intensify the impact on the loggerhead turtle hatching success rate.

Beach erosion results in high sand cliff and narrow beaches which interrupts sea turtle nesting activities, and relocation of eggs is performed when its necessary. Eight clutches out of 12 were relocated during 2002 to prevent nest flooding, however three of un-relocated clutches were washed away by unusual high tides (the typhoon season overlaps with nesting and emergence season). In addition, a heat wave that hit Japan affected the relocated clutches, and their hatching and emergence rates were dramatically reduced.

Heat Wave - The heat wave in Shizuoka prefecture recorded a 36 day long hot spell (above 30□^{o}C) with no rain. As a result, sand temperatures at 60 cm depth on the nesting beach were elevated above 30 ^{o}C from 25th June to 8th September (Fig. 1). This caused high mortality of the loggerhead turtle embryos.

Five relocated clutches were examined for hatching success rates and the embryonic stage determination of dead embryos in the shell (Table 1, Fig. 2). The hatching success rates of nest A-E were 50%, 15.9%, 0%, 6.6% and 8.3% respectively. Nest A (43.2%), nest B (59.1%) and C (98.4%) showed the highest mortality rate in the late stage (stage 29 to 30), and nest D (57.0%) and E (55.8%) were in the early stage (stage 6 to 10). The approximate dates of the stages were calculated on each clutch by using Miller (1985) as an index to compare the mortality rates (Fig. 3). The high mortality was concentrated in the first half of August during the period of highest sand temperatures. At this time 98.4% of embryos in the late stage died in nest C and this result suggests that increased metabolic heat from the embryos triggered this incidence.