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William E. Margolis
Nova Southeastern University

Curtis M. Burney
Nova Southeastern University, burney@nova.edu

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EMERGENCE PERIODICITY OF *Caretta caretta* IN BROWARD COUNTY, FLORIDA, 1990

William E. Margolis
Curtis M. Burney

Nova University, Oceanographic Center, Dania, Florida 33004 USA

Burney *et al.* (1990) found a significant relationship between nesting densities and moon phase. There was a tendency for greater nesting activity near full and new moon periods, and lower activity during the quarter moons. Since both new and full moons had a similar apparent effect on the nesting pattern, it was hypothesized that semilunar tidal periodicity, rather than moon light, was the more direct cause. This hypothesis has been tested using data from the 1990 Broward County Sea Turtle Conservation Project, funded by the Broward County Department of Natural Resource Protection.

METHODS

Daily nest and false crawl counts were made during dawn patrols of all Broward beaches (38.6 km) from 20 April to 2 September, 1990. The number of total crawls was used as an index of daily turtle emergence activity. These data were smoothed with a three-point centered moving average. To prevent the seasonal pattern from dominating the subsequent analyses, data before 30 May and after 27 July (representing the rapidly ascending and descending legs of the seasonal pattern) were removed from the study. The remaining peak-season data showing possibly lunar and tidal related periodicity was compared to transformed moon and tide parameters.

Moon phase was quantified from the moon age derived from a public domain astronomy program (Kepler). Moon age varies from 0 to 1, with values of 0 and 0.5 corresponding to new and full moons, and 0.25 and 0.75 indicating the first and third quarter stages, respectively. For comparison to the total crawl pattern, moon age was transformed into a periodic function by multiplying it by 4 and subtracting the integer of each value from values with even integers and the integer value plus 1 from numbers with odd integers. The absolute values of the results gives a moon phase parameter which varies from 0, for new and full moons, to 1 for both quarter moons. This transformation was calculated in Lotus 123 with the following cell formula, where MA indicates the cell address of the untransformed moon age value.

```
@ABS(@IF(@int(MA*4)=(@INT(MA*4/2)*2),(MA*4)-@INT(MA*4),(MA*4)-(@INT(MA*4)+1)))
```

The time of the nocturnal high tide, which increases approximately 50 minutes each day, was also transformed to allow comparison with the total crawl pattern. This transformation expressed the number of hours the nocturnal high tide occurred either before or after a chosen centering time. For high tide times occurring before midnight, the transformed value was the absolute value of the difference between the high tide time and the centering time. For times after midnight, the absolute value of the high tide time plus 24, minus the centering time was taken. The Lotus cell formula, where HTT and CT represent the cell addresses for the nocturnal high tide time and centering time, respectively, was as follows. Centering times after midnight should be entered as 24+CT (ie. 2 am = 26).

```
@IF(HTT < 16, HTT+(24-CT),@ABS(HTT-CT))
```

These, as well as other tidal parameters, were compared to the total crawl pattern both visually and by linear regression and correlation analyses.

RESULTS AND DISCUSSION

Figure 1 compares the peak-season total crawl pattern with the moon phase parameter. As reported previously (Burney and Mattison, 1989; Burney et al., 1990) peaks in turtle emergence occur near minima in the moon phase parameter (ie. near new and full moons), but for the first three cycles, crawl peaks also occur near the quarter moons. This quarter-moon effect was seen to a lesser degree in 1989, and is more pronounced in the 1991 data which is still under analysis. This may possibly indicate some progressive change in the nesting population, with one component more likely to emerge during tide conditions associated with new and full moons, and another component preferring the different tide range and timing associated with quarter moons. However, tide height, range and flooding and ebbing rates were not significantly correlated with the total crawl pattern. Figure 2 shows the correlation of the moon and crawl patterns from Figure 1. The relation is inverse and nearly significant at the 0.050 level.

Figure 3 illustrates the relation of the crawl and transformed high-tide time patterns, when the latter was centered on 2200 hrs (10 pm). All other times were tried, but the pattern centered on 2200 hrs gave the best fit. The significant inverse correlation of these parameters is illustrated in Figure 4. There seems to be a preference for emergence on nights when the times of the high tide occur earlier in the night, and an avoidance of emergence when the high tide occurs near dawn. This may suggest that turtles prefer nights with an early high tide because it assists them to the beach, cuts crawling distance and allows plenty of time to complete nesting before dawn. The outgoing tide would then assist the turtle as she swims away from the beach. Tide ranges were also higher on nights with earlier high tide times (the moon phase and tide parameters are closely correlated with each other) and it is impossible to separate the possible influence of tide range and timing.

Knowledge of the nature and causes of sea turtle emergence and nesting periodicities, allowing the prediction of periods of high activity, may improve the efficiency of labor-intensive conservation efforts such as nest relocation or tagging projects.

LITERATURE CITED

Burney, C.M. and Mattison, C. 1989. Sea Turtle Conservation Project, Broward Co., Florida. 1989 Report. Broward County Erosion Prevention District, Environmental Quality Control Board. Fort Lauderdale, Florida. 58 pp.

Burney, C.M., C. Mattison and L. Fisher. 1991. The relationship of loggerhead nesting patterns and moon phase in Broward County, Florida. Proceedings of the Tenth Annual Workshop on Sea Turtle Conservation and Biology, Hilton Head SC, Feb. 20-24, 1990, p.161-164.

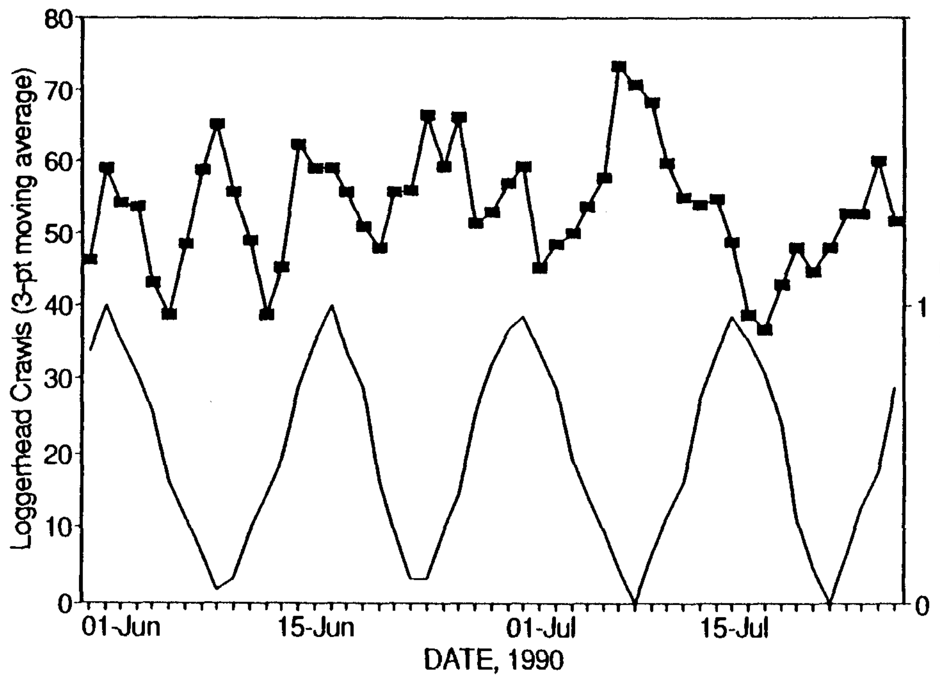

Figure 1. Comparison of the pattern of smoothed total peak-season loggerhead crawls (upper curve) with the transformed moon age parameter (lower curve), which is minimum at new and full moons, and maximum at quarter moons.

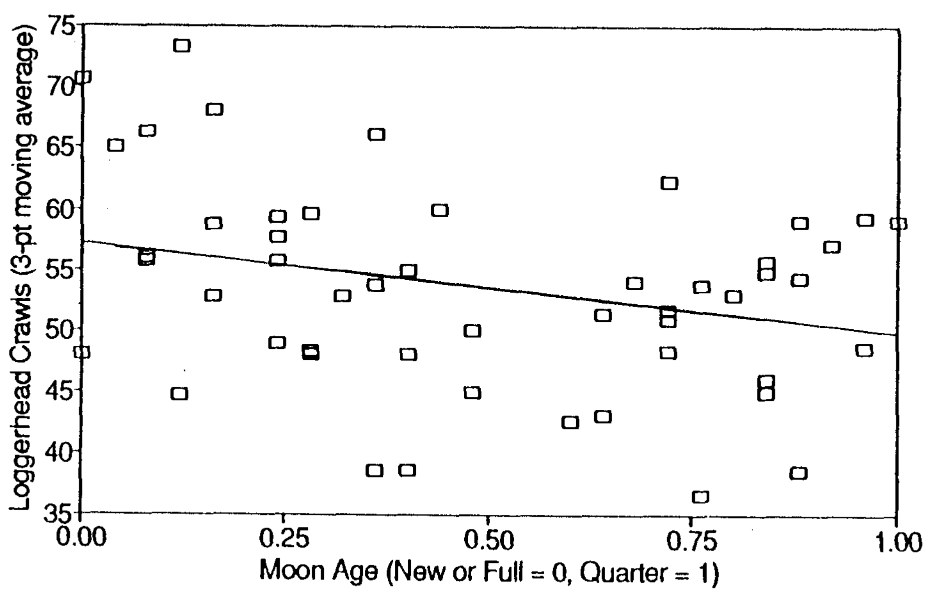

Figure 2. The correlation of daily smoothed loggerhead total crawls and the transformed moon age parameter. r = -.2731; P = .052.

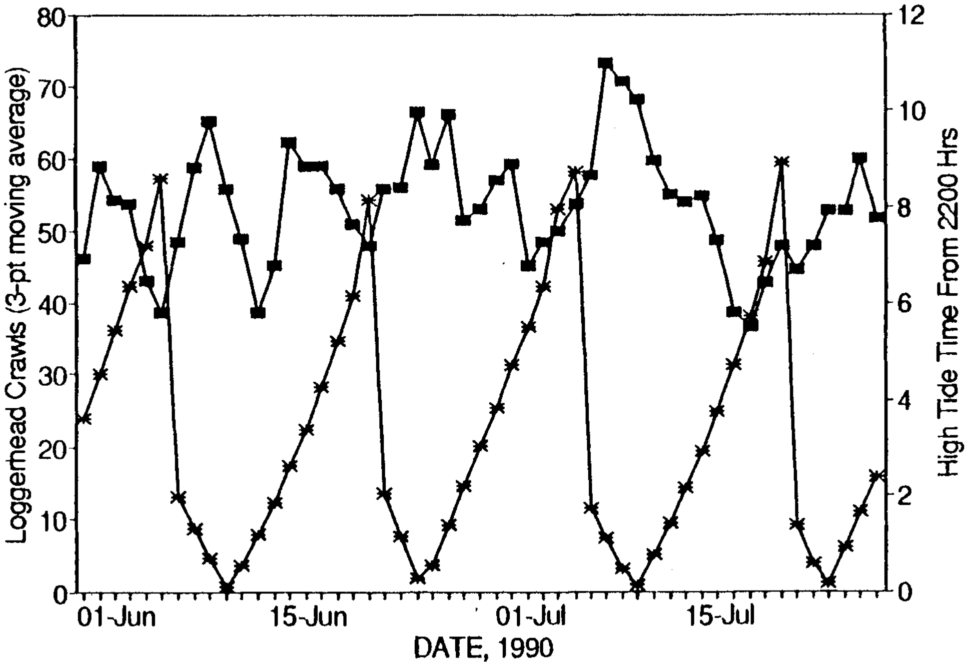

Figure 3. Comparison of the pattern of smoothed total peak-season loggerhead crawls (upper curve) with the times of the nocturnal high tide, expressed as hours before or after 2200 hrs (10 pm).

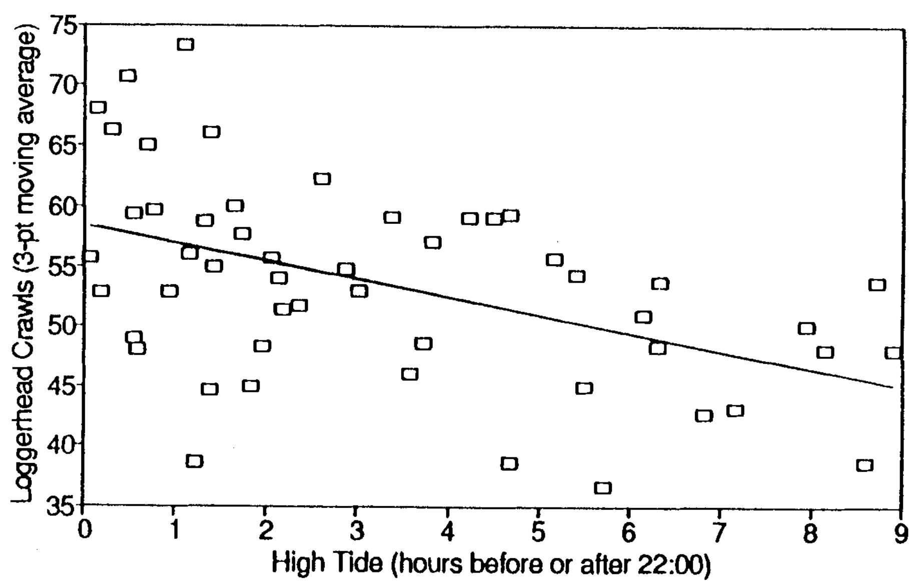

Figure 4. The correlation of daily smoothed loggerhead total crawls and the timing of the nocturnal high tide, expressed as hours before or after 2200 hrs. r = -.4876; P = .0004