DECREASING ANNUAL NEST COUNTS IN A GLOBALLY IMPORTANT LOGGERHEAD SEA TURTLE POPULATION

Blair Witherington
Paul Kubilis
Beth Brost
Anne Meylan

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Life Stage Durations for *Caretta*

- **Benthic Juvenile**: 13-20 yr
- **Pelagic Juvenile**: 7-11 yr
- **Egg to Post-hatchling**: 0.5 yr
- **Age at Maturity**: ~30 yr
- **Adult**: >25 yr

Age at Maturity: *~30 yr*

Adult: *>25 yr*
Morning-after Nest Counts Based on Crawl Evidence
US Atlantic Loggerhead Recovery Units (Metapopulations)

- **Northern Gulf Recovery Unit**: 906 nests/yr (1995-2007)
- **Peninsular Florida Recovery Unit**: 64,513 nests/yr (1989-2007)
- **Northern Recovery Unit**: 5,215 nests/yr (1989-2008)
Sea turtle nesting beaches in Florida where seasonal nest counts have been made. Gray shoreline-shading represents all Statewide beaches surveyed during the period 2001–2006. Dark shading represents Index beaches used in this study; these were surveyed daily from 1989 to 2006 for the Index sampling season (15 May – 31 August). The average percentage of total recorded Statewide nesting by loggerheads from 2001 to 2006 is presented for each region.
Statewide and Index Nesting Beach Survey Programs

Who Does the Work?

Loggerhead Index Nesting Data


Data Resolution: 109-day season x 368 zones (mean = 69% of Florida loggerhead nesting, SD = 5%)

Probability that a nest counted by an Index surveyor was actually a nest: 0.96 (95% CI: 0.92–0.99)

Missing data: 0.7% of zone-level biweekly observation intervals were not surveyed
Annual total nest counts for loggerhead turtles on Florida Index Beaches, 1989-2008. The trend line was estimated by fitting a 5-knot restricted cubic spline curve to the total counts via negative binomial regression.
Annual total nest counts for loggerhead turtles on Florida Index Beaches, 1989-2008. The trend line was estimated by fitting a 5-knot restricted cubic spline curve to the total counts via negative binomial regression. Change % (95% CI) shown relative to 1998 point in time series. All p<0.025 (% change=0%).
Annual total nest counts for loggerhead turtles on Florida Index Beaches, 1989-2008. The trend line was estimated by fitting a 5-knot restricted cubic spline curve to the total counts via negative binomial regression. Nest-count estimate for 2009 is from linear regression of May-June nest counts against total season nest counts 1989-2008.

(estimate from May-June data, 95% CI from linear, \(R^2=0.91\))
Do Index nest counts represent total nests?

Have there been spatial or temporal shifts relative to the Index zones and season?
Shoreline distribution of annual nest counts for loggerhead turtles from 368 Florida Index Beach zones surveyed during the 2008 nesting season. Shoreline extents of Index Beaches and sub-regions are indicated above and below the upper edge of the plot. The horizontal axis represents approximate shoreline distance from the Florida/Georgia state border (30.1 N, 81.4 W). Abbreviations for Florida sub-regions are NE (Northeast), CNE (Central Northeast), CE (Central East), CSE (Central Southeast), SE (Southeast), and SW (Southwest).
Our zone-level model showed strong, positive, within-zone autocorrelation ($R > 0.93$) between annual counts, indicating remarkable year-to-year consistency in the longshore spatial distribution of nests over the survey region.
Season Day (of 109) on which Florida Index Loggerhead Nesting Reached 25%, 50%, and 75% of Seasonal Totals

Season Day

- **July 18**
  - 75%
    - $R = 0.22$
    - $P = 0.35$
  - 50%
    - $R = 0.30$
    - $P = 0.20$
  - 25%
    - $R = 0.15$
    - $P = 0.40$

- **July 1**

- **June 10**

Year
Do Index nest counts represent total nests?  Yes

Have there been spatial or temporal shifts relative to the Index zones and season?

None that would explain nest count changes
Do nest counts represent adult females?
Sea Turtle Reproductive Cycles

Inter-nesting interval
2 weeks
2 weeks
2 weeks

2—3 year re-migration interval
No temporal trends known in loggerhead clutch frequency (varied approximately 20% around a median rate over 10 years; Hughes 1974, Frazer and Richardson 1985)

No temporal trends known in loggerhead remigration intervals (vary approximately 7% around a central value; Richardson et al. 1978, Bjorndal et al. 1983, Hughes 1982, Limpus 1985)
$H_0$: A decline in loggerhead adult females is similar to the decline measured in nesting

$H_1$: A decline in loggerhead adult females is less than the decline measured in nesting

$H_2$: A decline in loggerhead adult females is greater than the decline measured in nesting
Do nest counts represent adult females? We are not able to demonstrate otherwise.
What can the nesting data tell us about potential causes of the decline?

What is the relative importance of terrestrial and marine threats?
Relative Loggerhead and Green Turtle Nesting Density by Beach

% Total Nests 1989-2008 Corrected for Beach Length

- Loggerhead Nests
- Green Turtle Nests

Locations:
- Ft. Clinch SP
- Amelia Island
- Little Talbot Island SP
- Atlantic-Jax Beach
- Guana River SP
- Ft. Matanzas NM
- Canaveral NS
- Merritt Island NWR
- Canaveral AF Station
- Patrick AF Base
- South Brevard County
- Sebastian Inlet SRA
- Wabasso Beach
- Ft. Pierce Inlet SRA
- Hutchinson Island
- St. Lucie Inlet SP
- Hobe Sound NWR
- Jupiter Island
- Juno Beach
- Boca Raton
- J.D. MacArthur SP
- John U. Lloyd SRA
- Miami Beaches
- Sanibel Island
- Wiggins Pass SRA
- Keewaydin Island
Loggerhead and Green Turtle Nests on Florida Core Index Beaches, 1989-2008

Loggerhead Nests

-26%
1989-2008

Green Turtle Nests

+537%
1989-2008
Life Stage Durations for *Caretta*

**Benthic Juvenile**
13-20 yr

**Pelagic Juvenile**
7-11 yr

**Age at Maturity**
~30 yr

**Adult**
>25 yr

**Egg to Post-hatchling**
0.5 yr
<table>
<thead>
<tr>
<th>Factor</th>
<th>Consistent with timeframe of nesting decline?</th>
<th>Consistent with magnitude of nesting decline?</th>
<th>Consistent with temporal pattern of nesting decline?</th>
<th>Similar effects on nesting between subregions?</th>
<th>Different expected effects on green turtle and leatherback nesting?</th>
<th>Score*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decreased hatchling production (from predation, hurricane effects, habitat deterioration)</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td>Direct take</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>1</td>
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<tr>
<td>Fisheries bycatch</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes**</td>
<td>5</td>
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<tr>
<td>Disease (including harmful algal blooms)</td>
<td>Possibly</td>
<td>Possibly</td>
<td>Possibly</td>
<td>Yes</td>
<td>No</td>
<td>2.5</td>
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<tr>
<td>Boat-related mortality</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>1</td>
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<tr>
<td>Pollution (oil, plastics, discarded fishing nets)</td>
<td>Yes</td>
<td>Possibly</td>
<td>Possibly</td>
<td>Yes</td>
<td>No</td>
<td>3</td>
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<tr>
<td>Global warming</td>
<td>Possibly</td>
<td>No</td>
<td>Unknown</td>
<td>Yes</td>
<td>No</td>
<td>1.5</td>
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<tr>
<td>Decline of food resources</td>
<td>Yes</td>
<td>Possibly</td>
<td>Unknown</td>
<td>Yes</td>
<td>Yes</td>
<td>3.5</td>
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</tbody>
</table>

*Score is the sum of categories in which the effect of the factor is concordant with the patterns observed in the nesting data. Possible concordance was scored as 0.5.

**Longlines principally affect loggerheads and leatherbacks. Trawling affects principally loggerheads.
Where are loggerheads in the eastern Gulf of Mexico?
Questions ?
<table>
<thead>
<tr>
<th>Area</th>
<th>Mean Total Nests</th>
<th>Nesting Trend Annual Change</th>
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</thead>
<tbody>
<tr>
<td>Northern Recovery Unit</td>
<td>5,215 nests</td>
<td>1.3% 1983-2008</td>
</tr>
<tr>
<td>Peninsular Florida Recovery Unit</td>
<td>64,513 nests</td>
<td>1.6% 1989-2008</td>
</tr>
<tr>
<td>Northern Gulf Recovery Unit</td>
<td>906 nests</td>
<td>4.7% 1995-2007</td>
</tr>
<tr>
<td>Dry Tortugas Recovery Unit</td>
<td>246 nests</td>
<td>No detectable Trend</td>
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</tbody>
</table>
Summed annual loggerhead nest counts from 11 Northern Recovery Unit beaches, 1983-2008.
Summed annual loggerhead nest counts from 26 Peninsular Florida Recovery Unit beaches, 1989-2008.
Summed annual loggerhead nest counts from three Northern Gulf of Mexico Recovery Unit beaches, 1997-2008.
## Loggerhead hatchling production from Florida beaches, 2001-2008

<table>
<thead>
<tr>
<th>Year</th>
<th>Total # of Nests Statewide</th>
<th>Total # of Nests from Sample Beaches (# actually inventoried)</th>
<th>Weighted Mean Emergence Success%</th>
<th># of Hatchlings Produced</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>69,681</td>
<td>31,949 (2,276)</td>
<td>44</td>
<td>3,436,611</td>
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<tr>
<td>2002</td>
<td>62,905</td>
<td>27,964 (1,574)</td>
<td>53</td>
<td>3,733,262</td>
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<tr>
<td>2003</td>
<td>63,446</td>
<td>27,085 (1,879)</td>
<td>61</td>
<td>4,326,154</td>
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<td>2004</td>
<td>47,173</td>
<td>19,912 (1,482)</td>
<td>40</td>
<td>2,105,260</td>
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<tr>
<td>2005</td>
<td>52,469</td>
<td>23,167 (1,709)</td>
<td>51</td>
<td>2,988,159</td>
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<tr>
<td>2006</td>
<td>49,786</td>
<td>20,841 (1,626)</td>
<td>67</td>
<td>3,730,146</td>
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<tr>
<td>2007</td>
<td>45,051</td>
<td>18,158 (1,867)</td>
<td>62</td>
<td>3,116,054</td>
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<tr>
<td>2008</td>
<td>61,440</td>
<td>25,288 (2,598)</td>
<td>49</td>
<td>3,381,124</td>
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