Spatial and temporal variation in Kemp’s ridley abundance: Patterns, mechanisms, and implications

Nathan F. Putman
LGL Ecological Research Associates
Bryan, Texas USA
Outline

- The migration triangle: linkages between life-stages
- Mechanisms driving spatial variation in abundance
- Mechanisms driving temporal variation in abundance
  - Strandings as a possible recruitment index
  - Can trends in strandings provide an indication of future nesting output?
- Next steps needed
The migration triangle: linking life-stages

- Reproductive Area
- Adult Foraging Grounds
- Nursery Grounds

- Dispersal
- Recruitment
- Homing

Adapted from Harden Jones 1968, *Fish Migration*
The migration triangle in Kemp’s ridley

- Nesting Beach
- Continental Shelf Foraging Grounds
- Oceanic Nursery Habitat

- Dispersal
- Homing
- Recruitment
- Post-reproductive movement

Adapted from Harden Jones 1968, *Fish Migration*
The reproductive areas of Kemp’s ridley

Putman et al. 2013, *Biology Letters*
Residual energy from yolk sac powers first few days of offshore migration (~40 km)
Dispersal & Recruitment: ocean currents

Predicted turtle density

Predicted turtle age

Putman et al. 2013, Biology Letters
Recruitment: oriented swimming
How might sea turtles know where they are to know which way to swim?

Earth’s Magnetic Field

Natal homing is **possible** using a map based on Earth’s magnetic field.


Putman & Lohmann 2008, *Current Biology*
Using the migration triangle in Kemp’s ridley to understand mechanisms of spatiotemporal variation in abundance

Ocean currents dominate movement; compass cues are most important

Swimming dominates movement; map cues are most important

Swimming behavior and ocean currents are important; map cues become increasingly important

Ocean currents dominate movement; compass cues are most important
Spatial variation in nest abundance is related to how well offshore conditions facilitate dispersal to nursery habitat.

Mean percentage of Kemp’s ridley nesting by state (2009-2011)
Is temporal variability in nest abundance related to recruitment dynamics?

Kemp's ridley nest counts

- Tamaulipas
- Texas
- Veracruz

Caillouet et al. 2018, *Chelonian Conservation & Biology*
Shaver & Caillouet 2015, *Herpetological Conservation & Biology*
http://www.saveloraturtles.org/
Jaime Pena
Using the migration triangle in Kemp’s ridley to understand mechanisms of spatiotemporal variation in abundance

Swimming dominates movement; map cues are most important

Ocean currents dominate movement; compass cues are most important

Does hatchling production predict future nesting?

Does recruitment predict future nesting?

~10 years

Continental Shelf Foraging Grounds

Post-reproductive movement

Homing

Recruitment

Oceanic Nursery Habitat

Dispersal

~2 years

Nesting Beach
The more hatchlings that were produced 12 years ago, the more nests now.

- Hatchlings Released: Spearman $r = 0.870$, $p = 0.000000032$
Can strandings data be used to estimate recruitment?

"New" Recruits: 21.3 – 42.5 cm CCL

Use strandings across Texas, Louisiana-Alabama, and Florida to predict nesting in Tamaulipas

Rationale:

- Anthropogenic drivers (e.g., bycatch) are certainly an issue, but we assume variation in strandings is driven primarily by variation in abundance of turtles entering a region.

- Thus, we might expect the number of turtles that strand in a given year (at a size of 21.3 – 42 cm CCL) to correlate with the number of nests deposited 10 years later.
  - Oceanic dispersal stages ~ 2 years (< 21.3 cm CCL)
  - Age at sexual maturity ~ 12 years (64.8 cm CL)

- Use non-parametric correlations (Spearman) to assess whether relationship exists between strandings and nesting.

- Use regression models to produce equations to “forecast” Kemp’s ridley nesting (2019 – 2024).
More strandings in Texas predict less subsequent nesting in Tamaulipas

- Texas: Spearman $r = -0.418$, $p = 0.0418$

\[ y = -3734 \ln(x) + 22431 \]

$R^2 = 0.1961$
No relationship between strandings in Louisiana-Alabama and nesting in Tamaulipas

- Louisiana – Alabama: Spearman $r = -0.141$, $p = 0.5113$

**Graph:**
Equation: $y = -41.314x + 11929$
$R^2 = 0.0216$

<table>
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<th>Strandings</th>
<th>Nests</th>
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<tr>
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<td>60</td>
<td>25000</td>
</tr>
<tr>
<td>70</td>
<td>30000</td>
</tr>
</tbody>
</table>

- Louisiana – Alabama: Spearman $r = -0.141$, $p = 0.5113$
More strandings in Florida predict more subsequent nesting in Tamaulipas.

- Florida: Spearman $r = 0.823$, $p = 0.000000782$
Forecasting Kemp’s ridley nesting
Forecasting Kemp’s ridley nesting: Hatchling Production

\[ R^2 = 0.67 \]
\[ P = 0.0000008 \]
\[ N=23 \]
Forecasting Kemp’s ridley nesting: Recruitment to Florida (strandings)

![Graph showing nest counts and statistical analysis]

- $R^2 = 0.56$
- $P = 0.000022$
- $N = 23$
Forecasting Kemp’s ridley nesting: Production + Recruitment

$$R^2 = 0.78$$
Production, $$P = 0.00016$$
Recruitment, $$P = 0.0043$$
$$N = 23$$
Possible Implications

- Some regions are more suitable than others for maturing Kemp’s ridley in the northern Gulf.
  - Fitness (survival, fecundity) is increased for juvenile turtles reaching Florida and thus reproductive output increases.
  - Kemp’s ridley reaching Texas arrive “too early” and are subject to higher mortality than those recruiting at more eastern regions.
- Fairly robust statistical relationship between hatchling production + strandings and nesting suggests a 9 year forecast to set expectations for future population dynamics.
Next Steps Needed

- Build in corrections based on differences in probability of strandings (e.g., observer coverage, wind/current conditions).
- Consider correcting for anomalous occurrences (e.g., cold stuns, DWH oil spill)
- Incorporate into a full population demographic model to account for the contributions of other age classes to nesting (e.g., previous strong/weak cohorts).
Next Steps Needed

Focusing on the mechanisms that drive spatial and temporal variation in abundance is essential to understanding population dynamics of Kemp’s ridley.
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Sanity Check:
Do juvenile Kemp’s ridley strandings correlate with environmental data as expected?

Anthropogenic drivers (e.g., bycatch) are certainly an issue, but we assume variation in strandings is driven primarily by variation in abundance of turtles entering a region and not susceptibility to mortality.

Simple Ocean Data Assimilation model (SODA) 1980-2017 at 0.5° resolution.

Monthly means for environmental variables that may influence probability of stranding (e.g., ocean currents, wind stress) and sea turtle occurrence/habitat (temperature, salinity, sea surface height, and mixed layer depth).
Months with more eastward wind predict fewer strandings; months with more northward wind predict greater strandings.

Map coloration shows correlation coefficient for monthly winds at each Gulf of Mexico grid point and monthly strandings of juveniles in Texas (1980-2014, n = 420).