Modeling Threats to Diamondback Terrapins in a Coastal Carolina Salt Marsh.

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Faculty Scholarship Symposium
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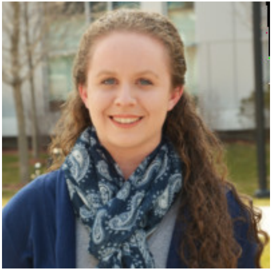
Collaborators

John Ludlam
FSU Department of Biology and Chemistry



Kristen Windoloski
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Currently Grad Student at NC State

Kristen was supported with an hourly stipend through an FSU Special Projects Grant

Diamondback Terrapins in Coastal South Carolina

Found in salt marches, creeks, and tidal flats along the Atlantic and Gulf coasts

Hatchlings tiny.
Adult females much larger than adult males

Largest threats: crab traps and nest disturbances

Modeling based on data collected by Ludlam and King in North Inlet Winyah Bay, South Carolina




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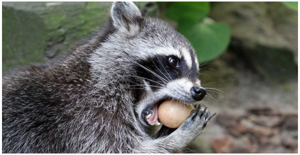

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Goal:

We model diamondback terrapins in North Inlet Winyah Bay (NIWB), SC to assess the long term survival of the population.

Methodology:

Formulate two types of mathematical models for the population. We use John's data to parameterize the model to accurately reproduce observed behavior and data.

We consider how increased numbers of crab traps and frequency of nest disturbances impact local dynamics and influence the longevity of diamondback terrapins in NIWB.

2 Matrix Models & 1 Individual Based Model (IBM)

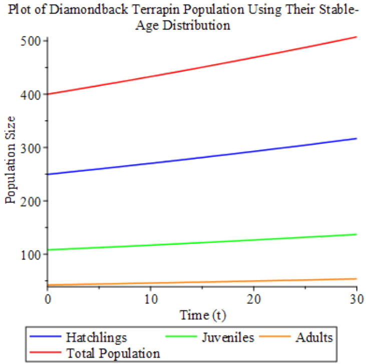
Features of Matrix Models:	**Features of IBM:**
Terrapins modeled in **aggregated age-classes**	Each terrapin modeled **individually**
Non-spatial	Geographic **space** is **explicitly modeled**
Deterministic (same input produces same output)	**Stochastic** (simulations contain randomized elements)
Time measured in **yearly** discrete steps	Time measured in **daily** discrete steps
Simulations **quick/easy** in Maple	Simulations **slow/tedious** in NetLogo

Similar parameters used in each model

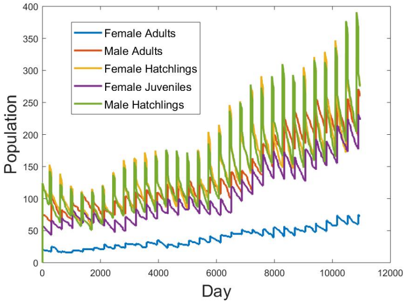
Models inform each other

Example Output

Population plot from matrix model:



Population plot from individual based model:



Female Age Classes:

Hatchlings: 0-2 years old
Juveniles: 3-7 years old
Adults: 8-40 years old

Male Age Classes:

Hatchlings: 0-2 years old
Adults: 3-40 years old

Two matrix models- A **female-only** model and a **two-sex** model

Female-only model has fewer parameters which allows us to analyze and visualize which parameters have the greatest influence on the population

Two-sex model allows us to assess how crab traps can skew the sex ratio of the population

Matrix Models

The population $\vec{p_t}$ of terrapins in NIWB t years after 2006 is given by

$$p_t = A^t \vec{p_0}$$

where, $\vec{p_t}$ is the population in year t, $\vec{p_0}$ is the initial population,

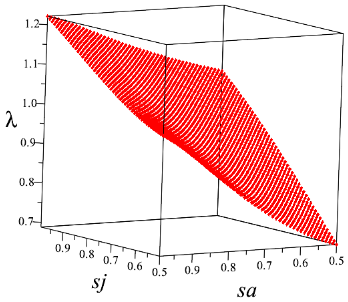
$$A = \begin{bmatrix} s_h g_h & 0 & \frac{1}{2} b_a \\ s_h(1-g_h) & s_j g_j & 0 \\ 0 & s_j(1-g_j) & s_a g_a \end{bmatrix} \text{ in female-only model,}$$

$$A = \begin{bmatrix} s_{fh} g_{fh} & 0 & \frac{1}{2} b_a & 0 & 0 \\ s_{fh}(1-g_{fh}) & s_{fj} g_{fj} & 0 & 0 & 0 \\ 0 & s_{fj}(1-g_{fj}) & s_{fa} g_{fa} & 0 & 0 \\ 0 & 0 & \frac{1}{2} b_a & s_{mh} g_{mh} & 0 \\ 0 & 0 & 0 & s_{mh}(1-g_{mh}) & s_{mb} g_{mb} \end{bmatrix} \text{ in two-sex model,}$$

s_i are survival rates, g_i are transition rates, and b_i are birth rates for each class

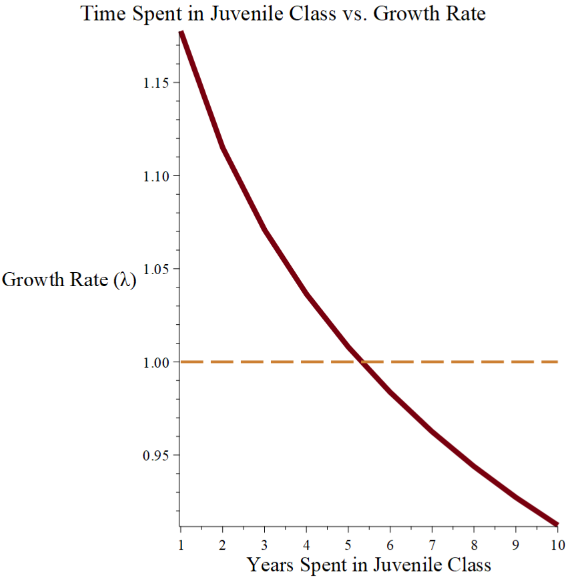
Matrix Model Results

3D Sensitivity Plot of Matrix Population Model

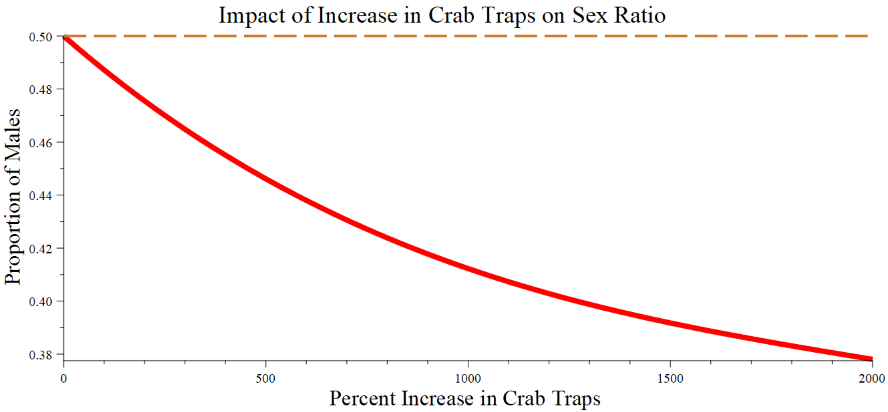


Key Elasticity Values with Respect to Growth Rate λ					
Variable	birthrate b_a	hatch. surv. s_h	juv. surv. s_j	adult surv. s_a	juv. trans. g_j
Value in Model	5.73	0.66	0.78	0.78	0.89
Elasticity Value	0.10	0.21	0.33	0.35	-0.56

Matrix Model Results



Matrix Model Results



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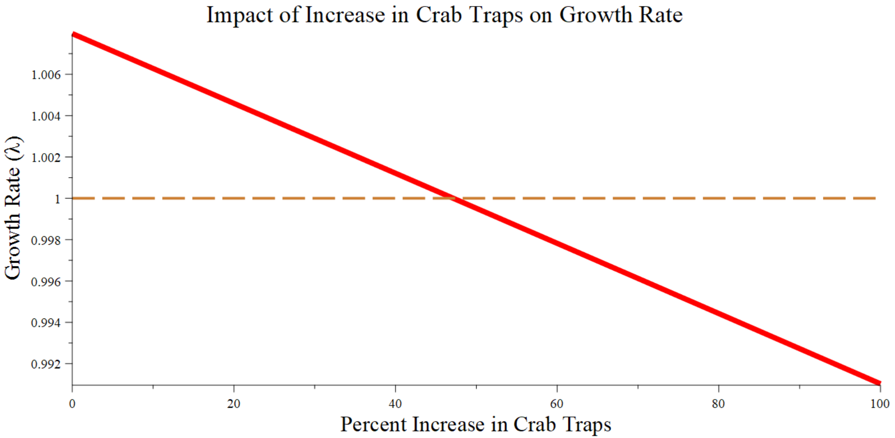
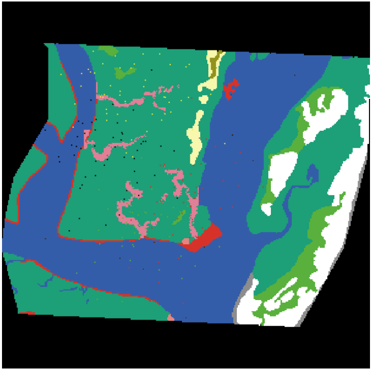


Individual Based Model

The IBM models individual terrapins in North Inlet Winyah Bay, SC

Import $\Longrightarrow$ GIS file

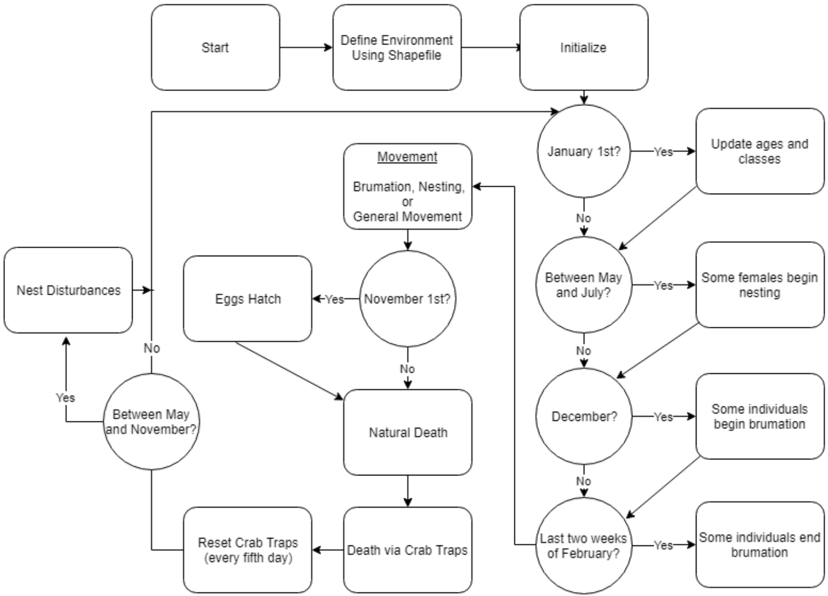


All key rates were derived from data collected by Ludlam and King.

Individual daily actions were coded to reproduce collected data and mimic observed behavior.

We deploy different levels of crab traps and consider a range of nest disturbance probabilities.

Individual Based Model Daily Flow Diagram



Individual Based Model Results

Extremely computationally challenging to obtain results for the IBM.

Want to test 7 levels of crab traps and 6 levels of nest disturbance probabilities- 42 combinations of parameters.

Each combination require us to average 100 independent 20-year simulations.
20 years is 7300 days.

This is almost 31,000,000 days to simulate.

Individual Based Model Results

Have completed 16/42 parameter combinations
11 million out of 31 million days simulated

Preliminary results: increase in crab traps more detrimental than nest disturbances

These results agree with findings from matrix models

Thank you to...

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