

# Recommendations to the Gulf of Mexico Fishery Management Council: Coordinating data and approaches to conduct a Kemp's ridley sea turtle stock assessment

Tab A, No. 8(a)



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Charles Caillouet

*Independent Researcher, Montgomery, Texas*

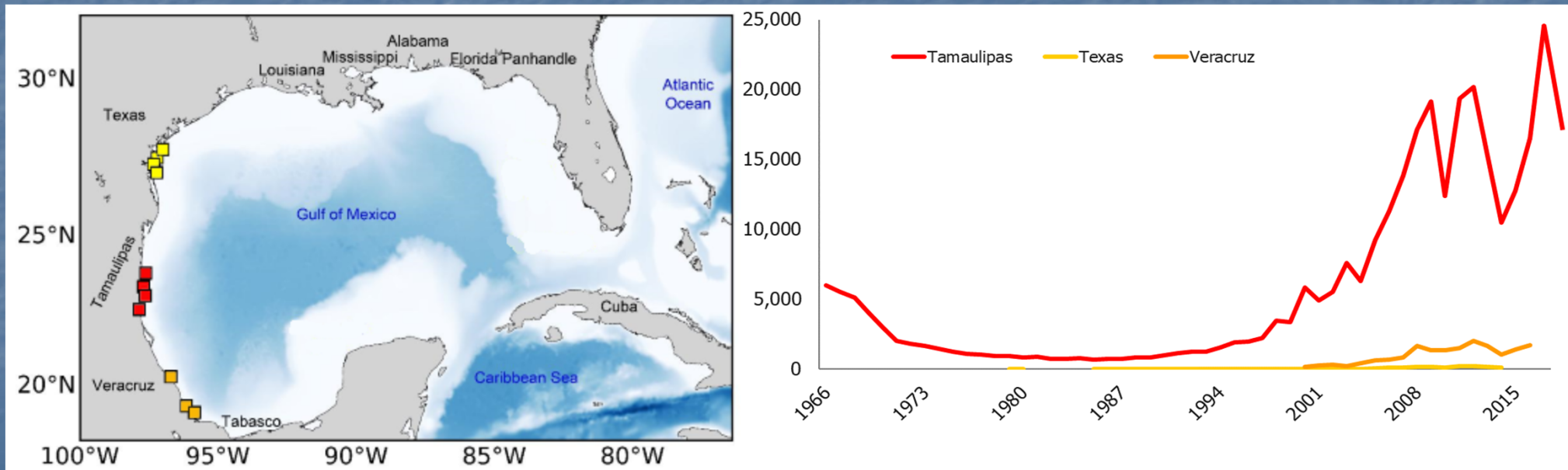


# Outline

- Introduction: Why we need a stock assessment
- Key aspects of Kemp's ridley biology
- Elements of the Gallaway et al. (2016a) Kemp's ridley stock assessment
- Other proxies, indices, and factors to include that may provide information on Kemp's ridley vital rates
- Recommended stock assessment modeling approach

# What is the Kemp's ridley population doing?

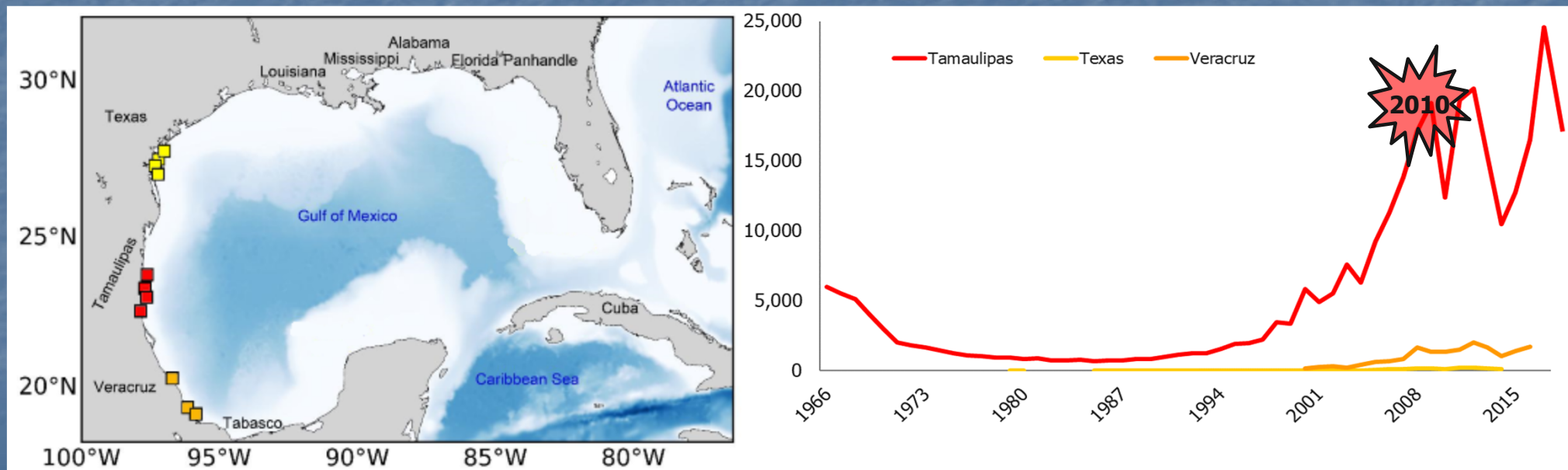
## Kemp's ridley nesting





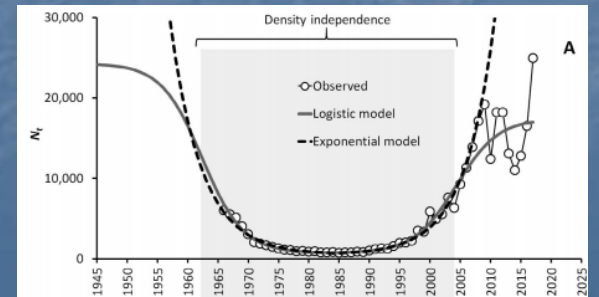
# What is the Kemp's ridley population doing?

# Kemp's ridley nesting



# What happened to population growth?

- DWH oil spill?
- Shrimping?
- Density dependence?



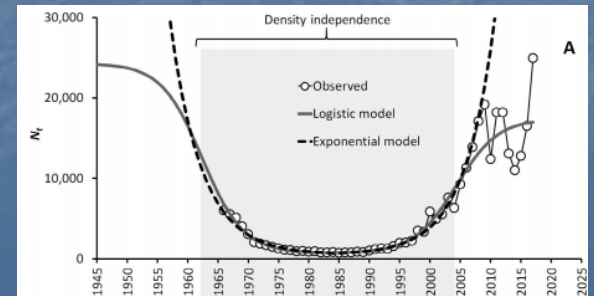
# What happened to population growth?

## ■ ~~DWH oil spill?~~

- Deepwater Horizon Natural Resource Damage Assessment Trustees (DWH NRDA TRUSTEES). 2016. Deepwater Horizon oil spill: final programmatic damage assessment and restoration plan and final programmatic environmental impact statement.)

## ■ Shrimping?

## ■ Density dependence?





# What happened to population growth?

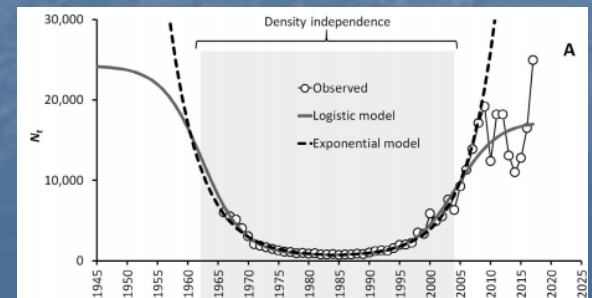
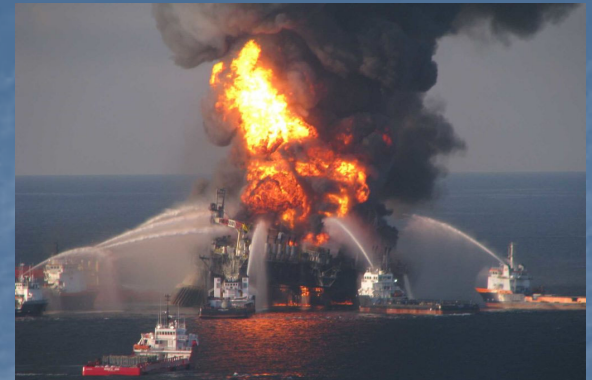
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## ■ Density dependence?



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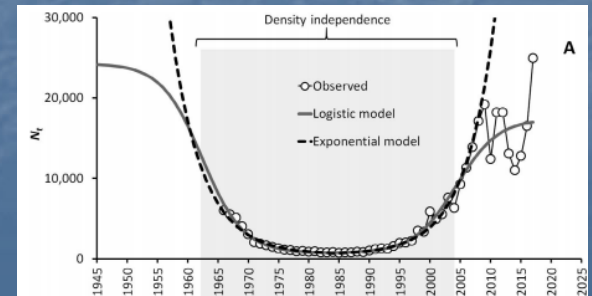
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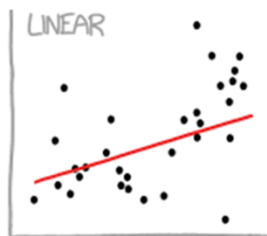
- CAILLOUET JR, C.W., RABORN, S.W., SHAVER, D.J., PUTMAN, N.F., GALLAWAY, B.J. AND MANSFIELD, K.L., 2018. Did Declining Carrying Capacity for the Kemp's Ridley Sea Turtle Population Within the Gulf of Mexico Contribute to the Nesting Setback in 2010– 2017?. Chelonian Conservation and Biology, 17(1), pp.123–133.



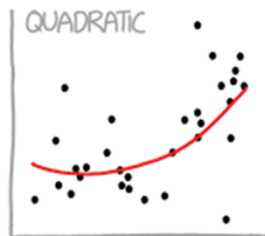


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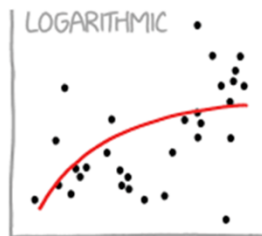
## CURVE-FITTING METHODS AND THE MESSAGES THEY SEND



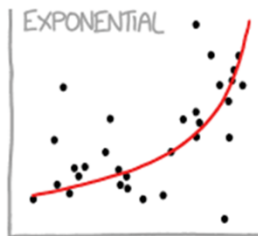
"HEY, I DID A REGRESSION."



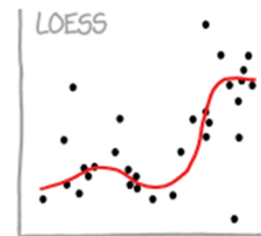
"I WANTED A CURVED LINE, SO I MADE ONE WITH MATH."



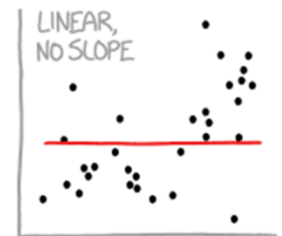
"LOOK, IT'S TAPERING OFF!"



"LOOK, IT'S GROWING UNCONTROLLABLY!"



"I'M SOPHISTICATED, NOT LIKE THOSE BUMBLING POLYNOMIAL PEOPLE."



"I'M MAKING A SCATTER PLOT BUT I DON'T WANT TO."



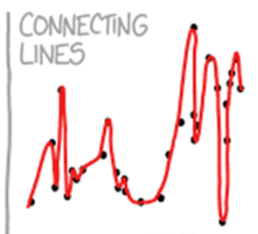
"I NEED TO CONNECT THESE TWO LINES, BUT MY FIRST IDEA DIDN'T HAVE ENOUGH MATH."



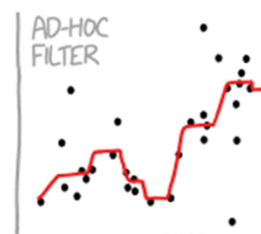
"LISTEN, SCIENCE IS HARD. BUT I'M A SERIOUS PERSON DOING MY BEST."



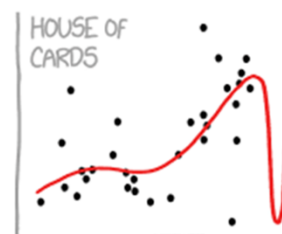
"I HAVE A THEORY, AND THIS IS THE ONLY DATA I COULD FIND."



"I CLICKED 'SMOOTH LINES' IN EXCEL."

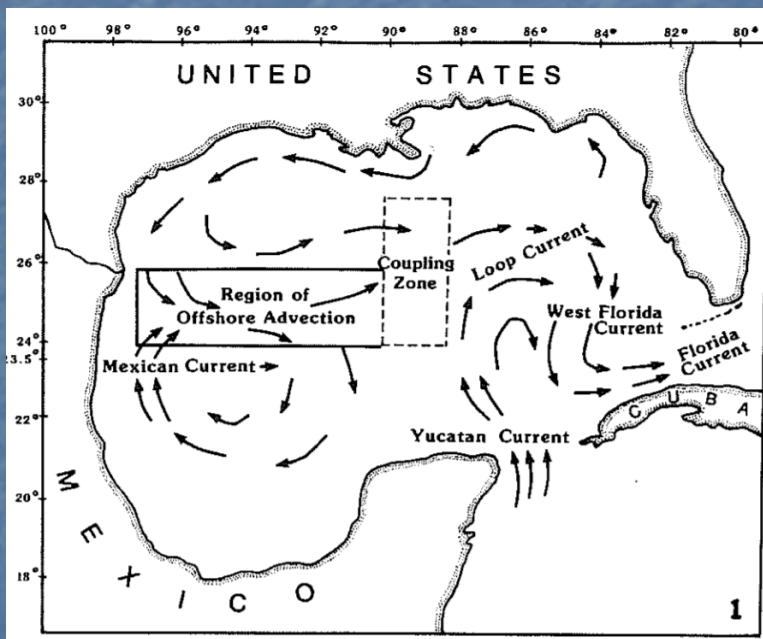


"I HAD AN IDEA FOR HOW TO CLEAN UP THE DATA. WHAT DO YOU THINK?"

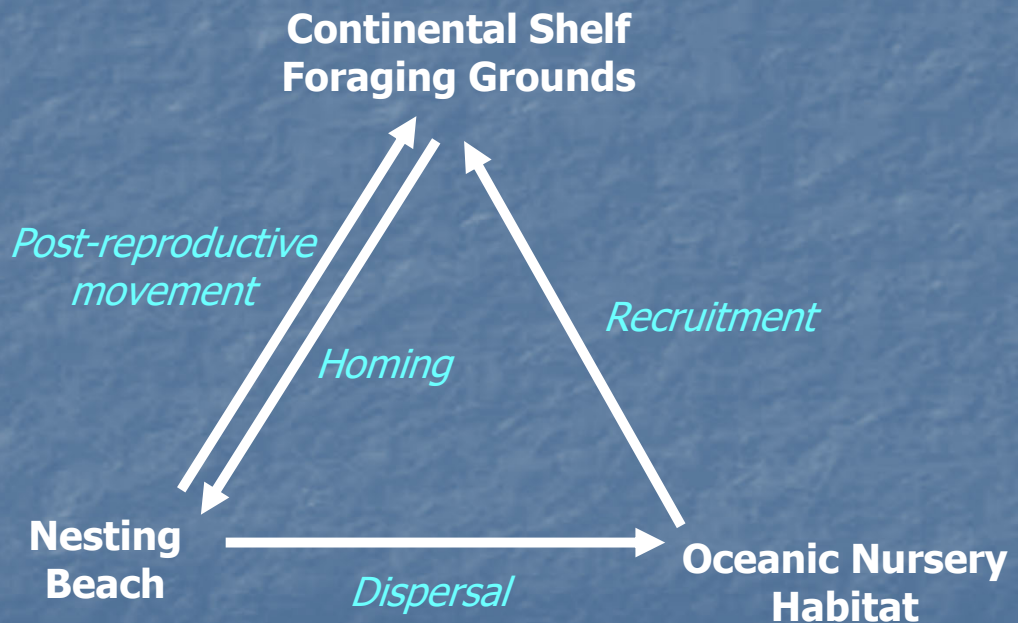


"AS YOU CAN SEE, THIS MODEL SMOOTHLY FITS THE— WAIT NO NO DON'T EXTEND IT AAAAAA!!!"

# Key aspects of Kemp's ridley biology

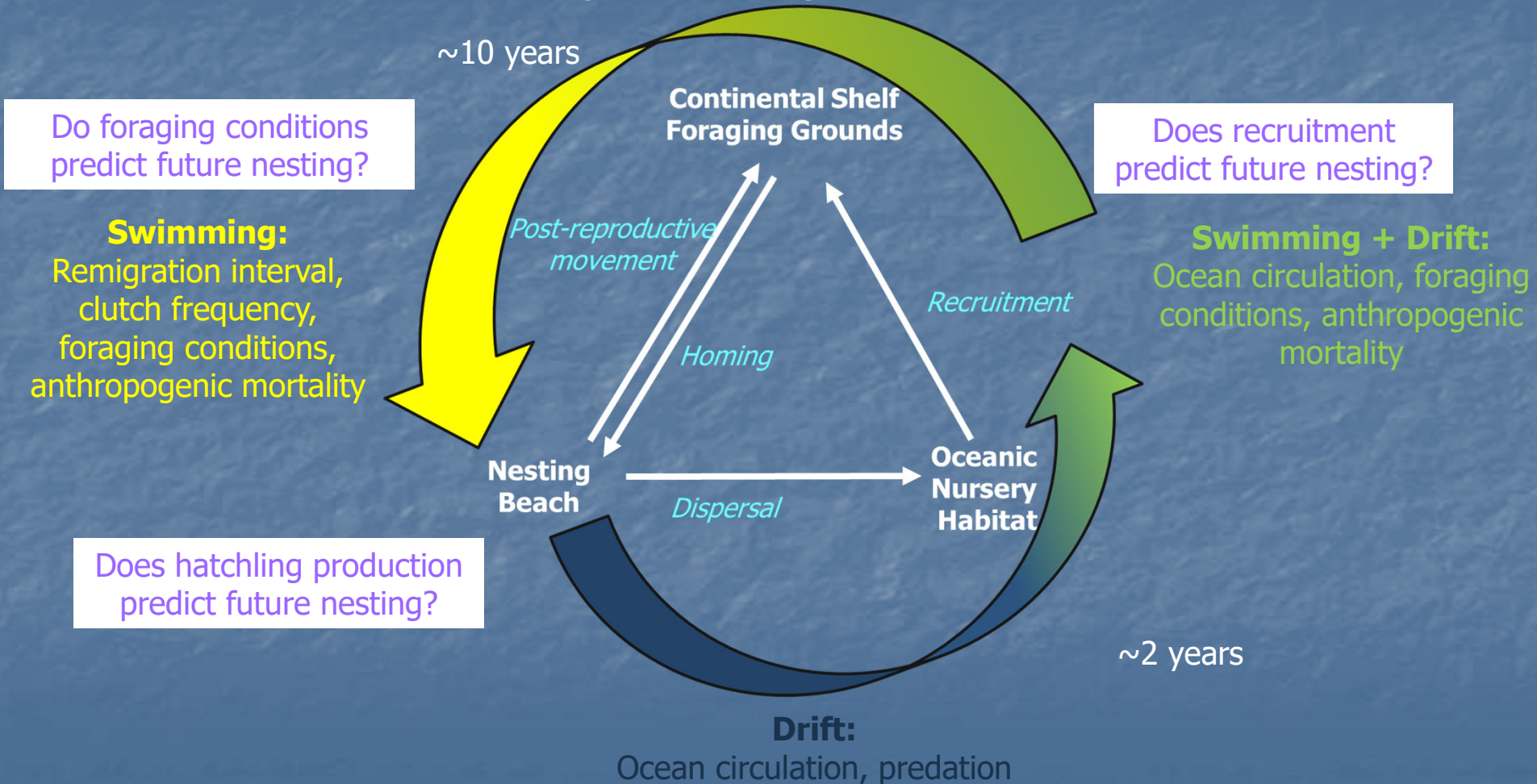


Collard & Ogren 1990, *Bulletin of Marine Science*



Adapted from Harden Jones 1968, *Fish Migration*

# Using the migration triangle in Kemp's ridley to understand mechanisms of spatiotemporal variation in abundance

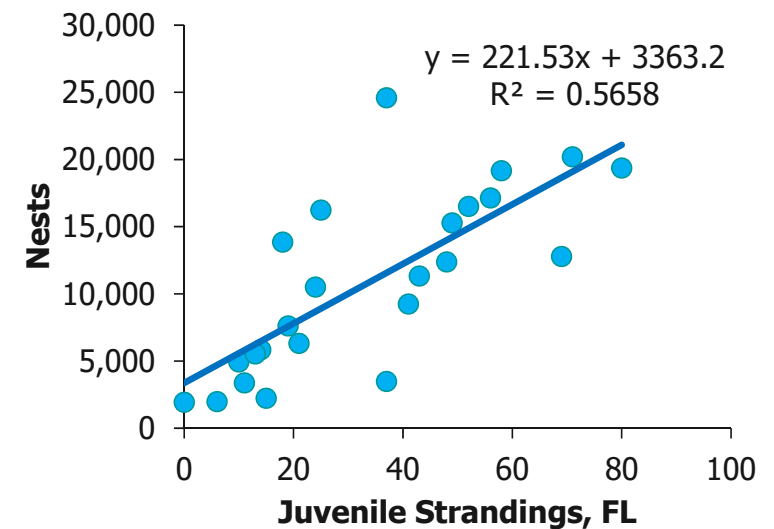
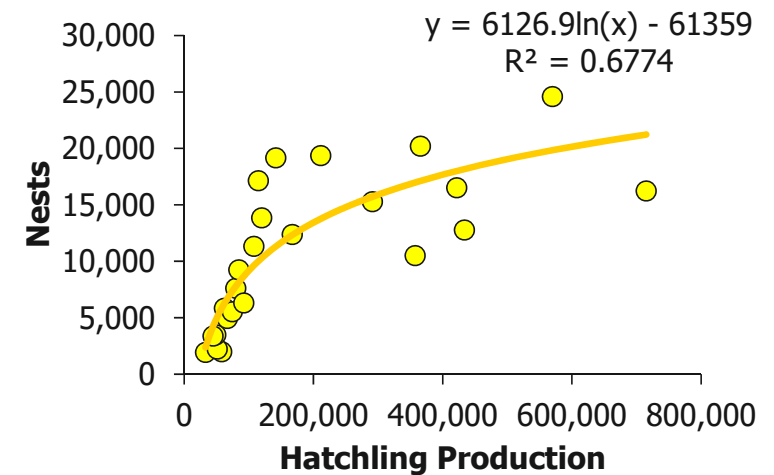




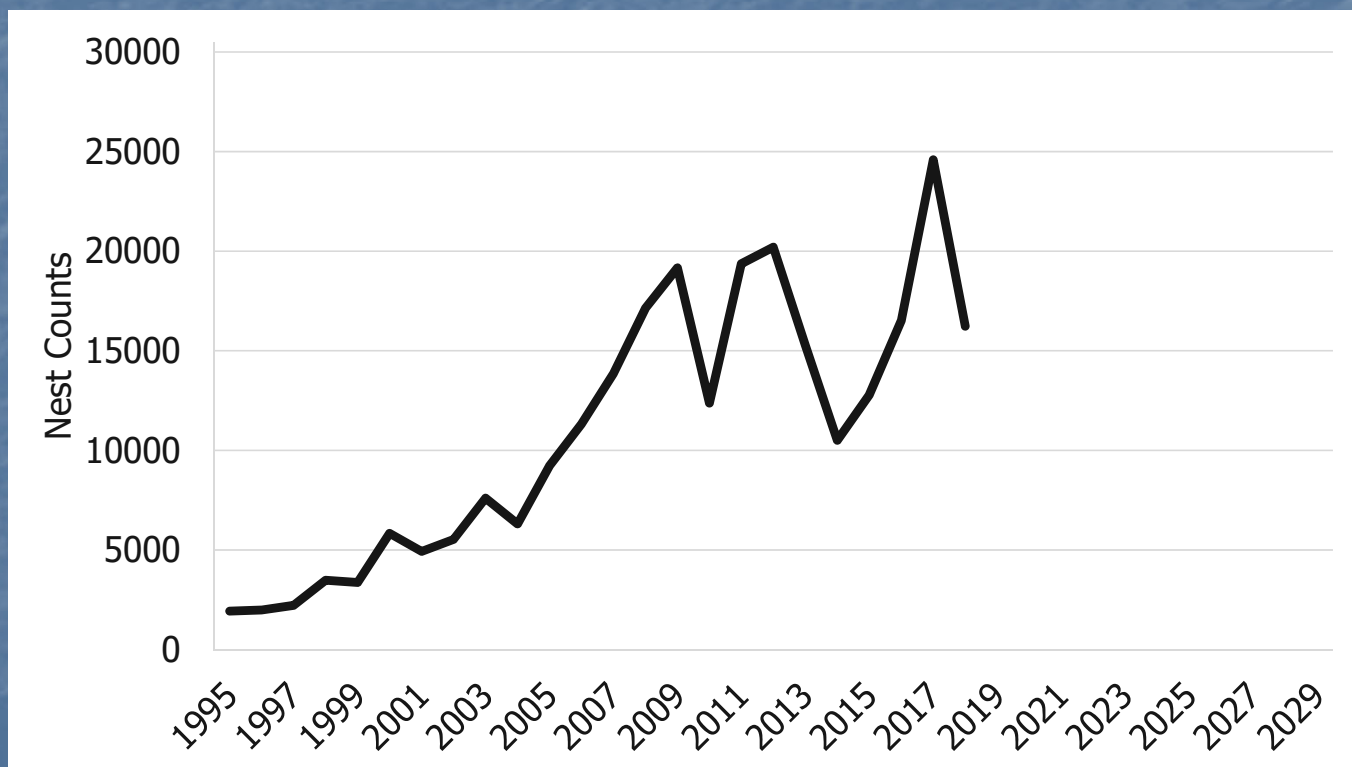
# Key aspects of Kemp's ridley biology

■ At a fundamental level, the status of a population can be determined by knowing:

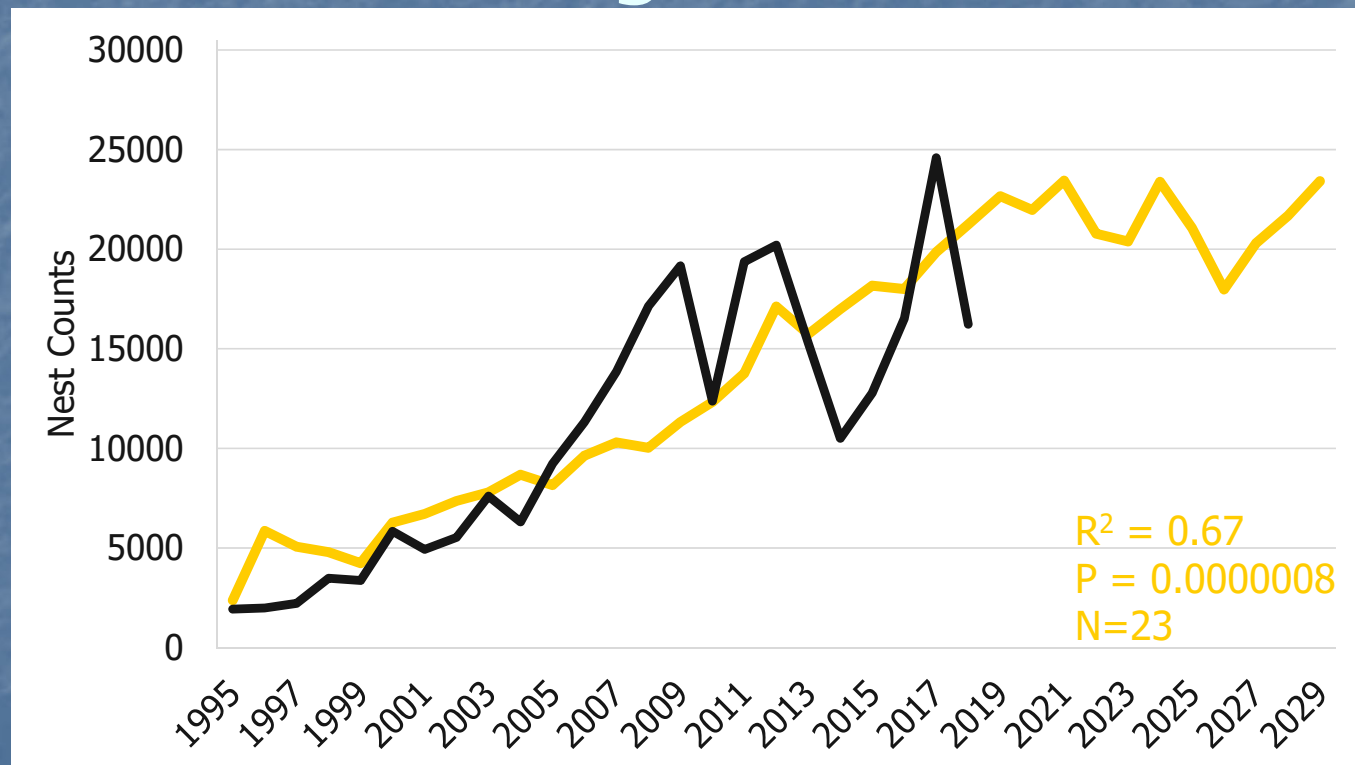
- reproductive output (+)
- immigration (+)
- natural mortality (-)
- anthropogenic mortality (-)
- emigration (-)



# Forecasting Kemp's ridley nesting

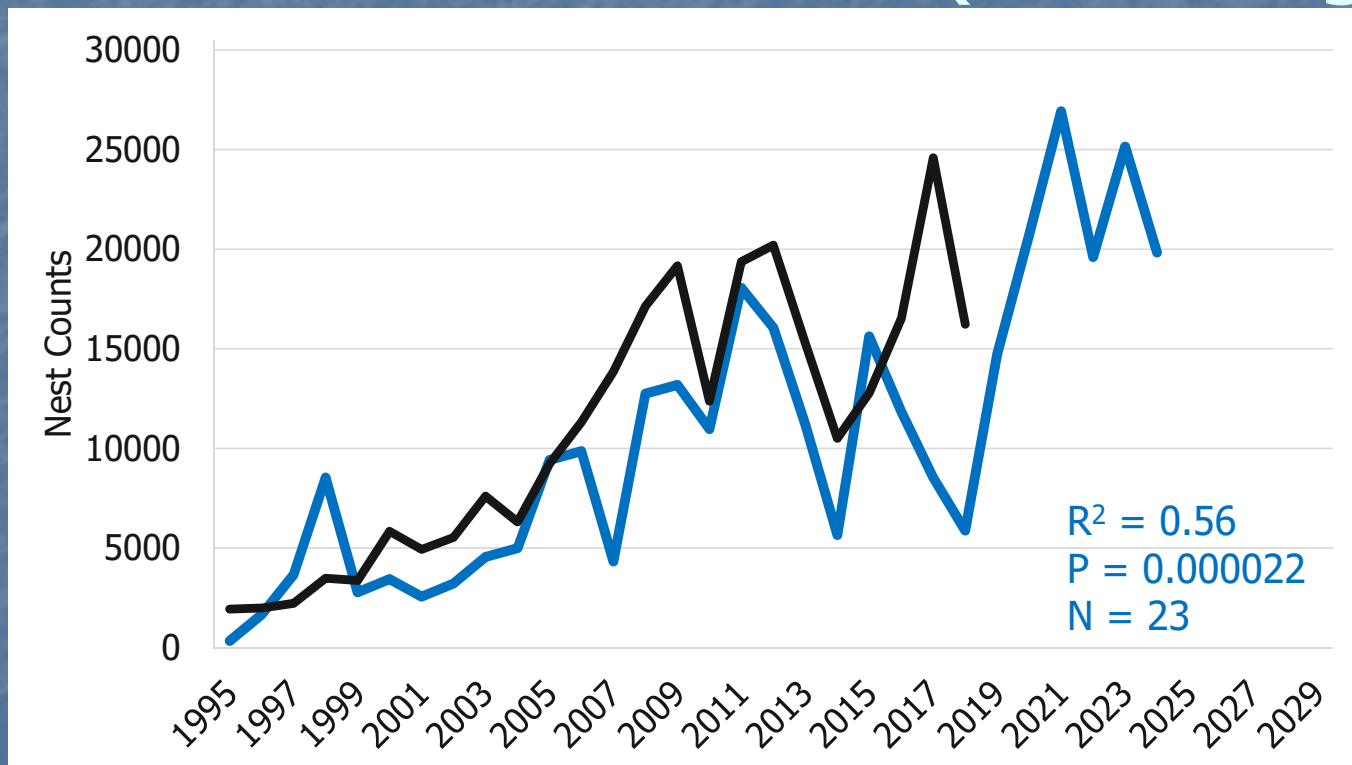


# Forecasting Kemp's ridley nesting: Hatchling Production

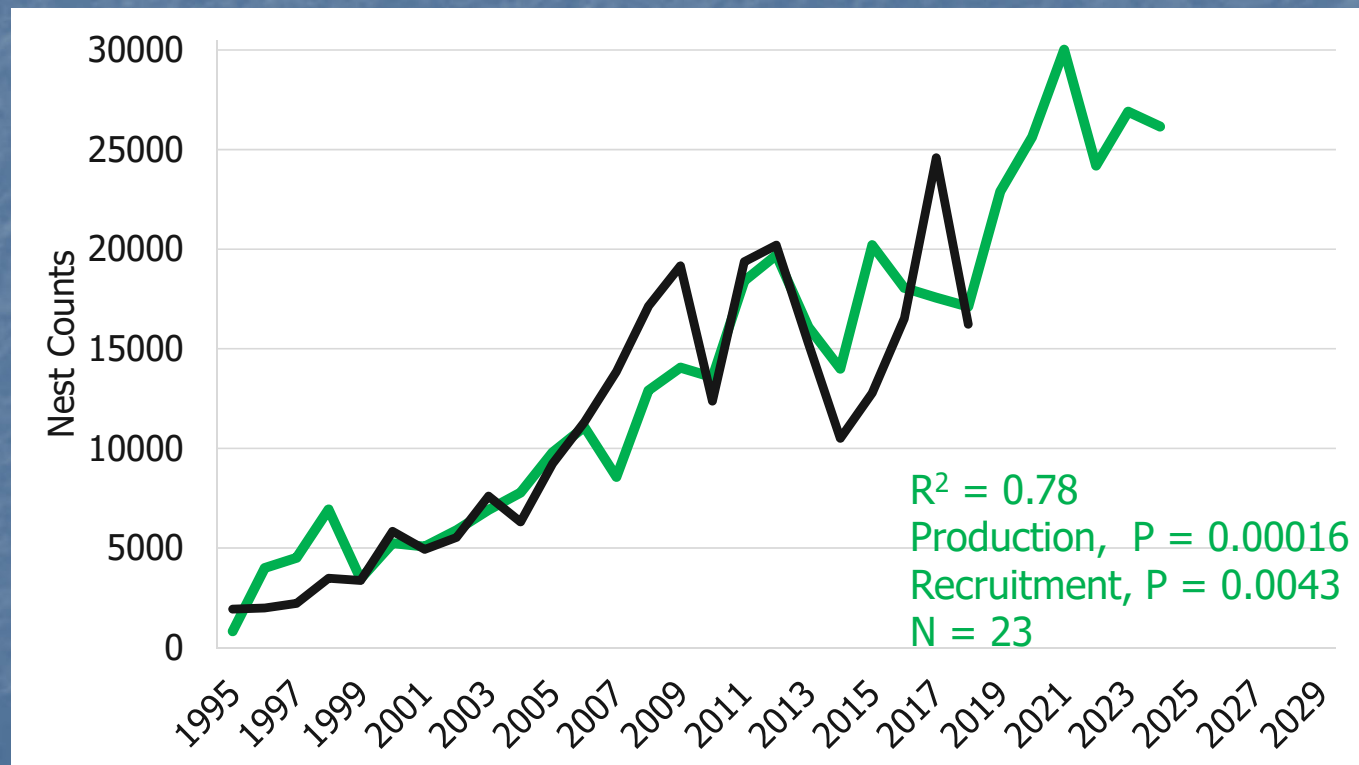




# Forecasting Kemp's ridley nesting: Recruitment to Florida (strandings)



# Forecasting Kemp's ridley nesting: Production + Recruitment



# Elements of the Gallaway et al. (2016) Kemp's Ridley Stock Assessment

*Gulf of Mexico Science*, 2016(2), pp. 138–157

## Development of a Kemp's Ridley Sea Turtle Stock Assessment Model

BENNY J. GALLAWAY, WILLIAM J. GAZEY, CHARLES W. CAILLOUET, JR., PAMELA T. PLOTKIN, F. ALBERTO ABREU GROBOIS, ANTHONY F. AMOS, PATRICK M. BURCHFIELD, RAY R. CARTHY, MARCO A. CASTRO MARTÍNEZ, JOHN G. COLE, ANDREW T. COLEMAN, MELISSA COOK, STEVEN DiMARCO, SHERYAN P. EPPERLY, MASAMI FUJIWARA, DANIEL GOMEZ GAMEZ, GARY L. GRAHAM, WADE L. GRIFFIN, FRANCISCO ILLESCAS MARTÍNEZ, MARGARET M. LAMONT, REBECCA L. LEWISON, KENNETH J. LOHMANN, JAMES M. NANCE, JONATHAN PITCHFORD, NATHAN F. PUTMAN, SCOTT W. RABORN, JEFFREY K. RESTER, JACK J. RUDLOE, LAURA SARTI MARTÍNEZ, MARK SCHEXNAYDER, JEFFREY R. SCHMID, DONNA J. SHAVER, CHRISTOPHER SLAY, ANTON D. TUCKER, MANDY TUMLIN, THANE WIBBELS, AND BLANCA M. ZAPATA NAJERA

We developed a Kemp's ridley (*Lepidochelys kempii*) stock assessment model to evaluate the relative contributions of conservation efforts and other factors toward this critically endangered species' recovery. The Kemp's ridley demographic model developed by the Turtle Expert Working Group (TEWG) in 1998 and 2000 and updated for the binational recovery plan in 2011 was modified for use as our base model. The TEWG model uses indices of the annual reproductive population (number of nests) and hatchling recruitment to predict future annual numbers of nests on the basis of a series of assumptions regarding age and maturity, remigration interval, sex ratios, nests per female, juvenile mortality, and a putative "turtle excluder device effect" multiplier starting in 1990. This multiplier was necessary to fit the number of nests observed in 1990 and later. We added the effects of shrimping effort directly, modified by habitat weightings, as a proxy for all sources of anthropogenic mortality. Additional data included in our model were incremental growth of Kemp's ridleys marked and recaptured in the Gulf of Mexico, and the length frequency of stranded Kemp's ridleys. We also added a 2010 mortality factor that was necessary to fit the number of nests for 2010 and later (2011 and 2012). Last, we used an empirical basis for estimating natural mortality, on the basis of a Lorenzen mortality curve and growth estimates. Although our model generated reasonable estimates of annual total turtle deaths attributable to shrimp trawling, as well as additional deaths due to undetermined anthropogenic causes in 2010, we were unable to provide a clear explanation for the observed increase in the number of stranded Kemp's ridleys in recent years, and subsequent disruption of the species' exponential growth since the 2009 nesting season. Our consensus is that expanded data collection at the nesting beaches is needed and of high priority, and that 2015 be targeted for the next stock assessment to evaluate the 2010 event using more recent nesting and in-water data.

**Annual number of nests:** combined for 3 index beaches in Tamaulipas (1966-2012)

**Annual number of hatchlings:** combined for 3 index beaches in Tamaulipas (1966-2012), separated by coral or in situ

**Shrimping effort:** effort (days fished) across 4 spatial zones (approximately WFL, AL-MS, LA, TX) and 3 depth zones (0-10 fm, 10-30 fm, 30+ fm) in the Gulf of Mexico

**Shrimp trawl mortality**

**Shrimp trawl catchability:** partitioned into ages 2-4 (0.2, SD = 0.04) and 5+ (0.155, SD = 0.014)

**TED effect multiplier:** starts in 1990 to influence catchability (0.233, SD = 0.069)

**Mark-recapture growth increment:** Data from CMTTP ~223 records (1980-2012)

**Strandings length frequency:** 5,953 records across the northern Gulf of Mexico (1980-2012)

**Observed proportion of strandings**

**Proportion of Mature females of age  $a$**

**Number of nests per adult female in the population:** quotient of annual number of nests per adult female divided by the remigration interval

**Proportion of coral hatchlings that are female**

**Proportion of *in situ* hatchlings that are female**

**Habitat weight:** based on expert opinion, the relative importance of each shrimping zone to mature females was determined.

**Clutch frequency:** numbers of nests laid per season

**Remigration interval:** years between nesting

**Natural mortality**



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**Natural mortality**

Other proxies, indices, and factors to include that may provide information on Kemp's ridley vital rates

**Spatiotemporal  
Variation in  
Kemp's Ridley  
Distribution**

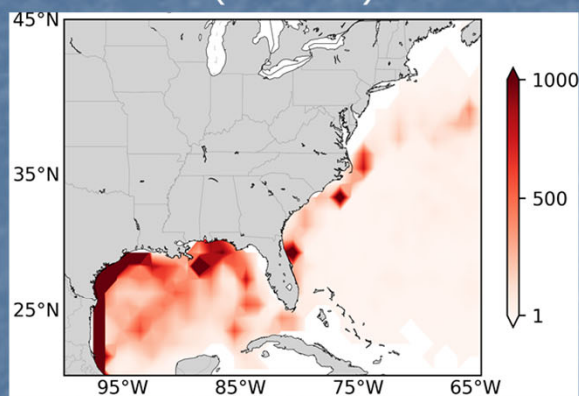
**Variation in  
Kemp's Ridley  
Demographic  
Parameters**



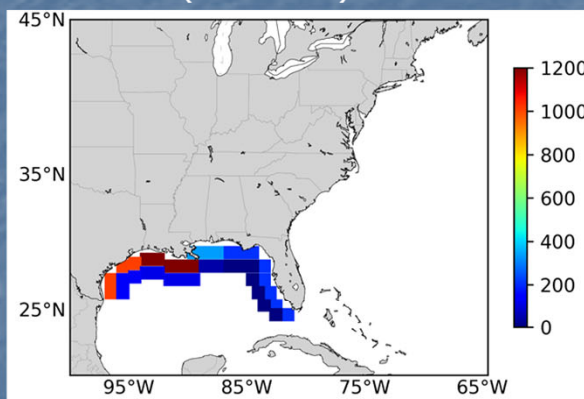
# Spatiotemporal Variation in Kemp's Ridley Distribution

Means  
(1996-2018)

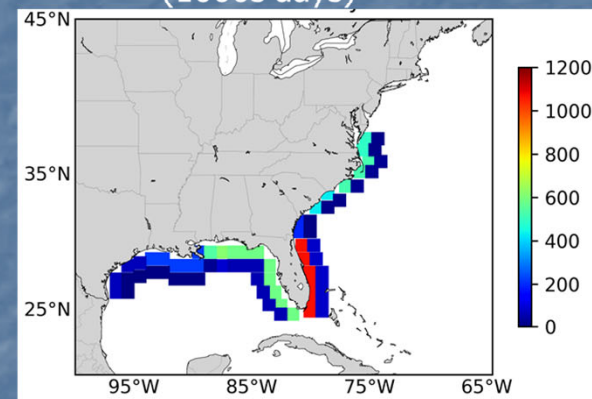
Mean Kemp's Ridley Abundance  
(# Turtles)



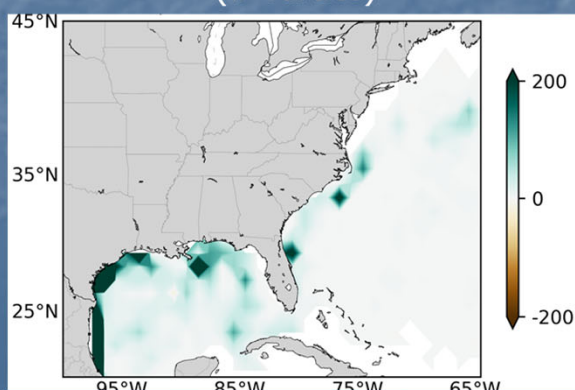
Mean Shrimping Effort  
(1000s km)



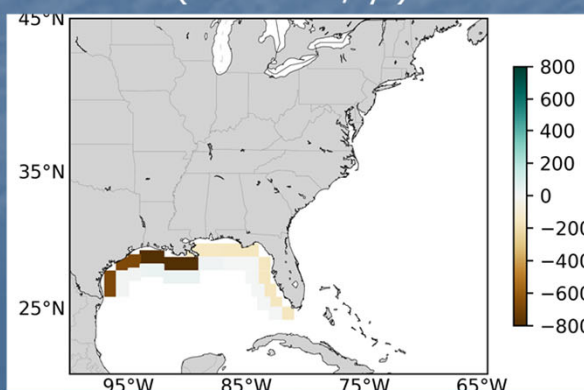
Mean Rec. Effort  
(1000s days)



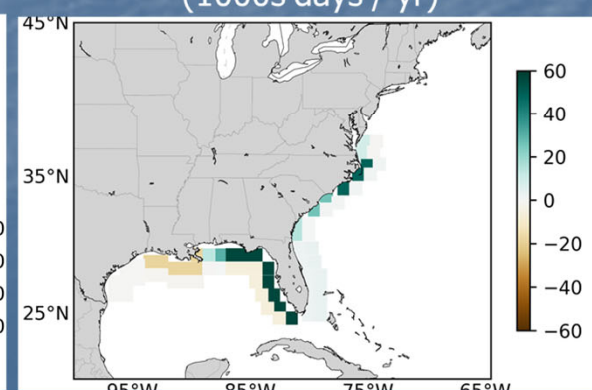
Change in Kemp's ridley Abundance  
(# Turtles)



Change in Shrimping Effort  
(1000s km / yr)



Change in Rec. Effort  
(1000s days / yr)

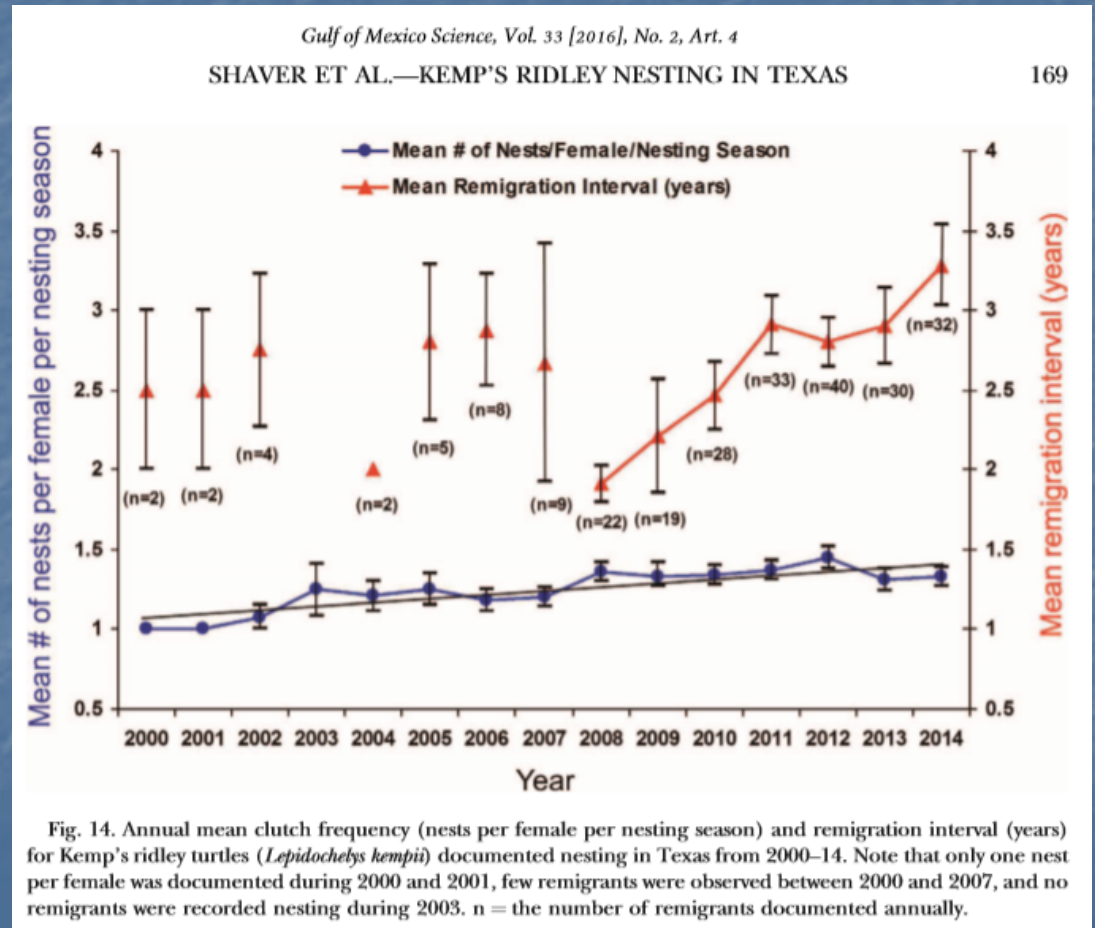


Trends  
(1996-2018)



# Variation in Kemp's Ridley Demographic Parameters

- Clutch frequency (number of nests laid by a turtle in a given year) and the remigration interval (number of years turtles take between nesting seasons) make a massive difference in assessing population size from nest counts.
- Consider whether turtles lay 1 or 2 nests in a season
  - population size differs by 50%!
- Consider whether turtles nest every 2 years or every 3 years
  - population size differs by 33%!
- Such differences might conceivably account for all of the major peaks and troughs in nesting data.



# Other proxies, indices, and factors to include that may provide information on Kemp's ridley vital rates

## Fishing Effort in U.S. waters

Bycatch / Catchability / Discard Mortality

## Anthropogenic mortality

bycatch mortality, boat strikes; entanglement in derelict gear, small artificial reefs, and marine debris.

## Clutch frequency and remigration interval

## Changes in nest monitoring effort / approaches

Kemp's ridley in Atlantic waters

## Spatiotemporal Variation in Kemp's Ridley Distribution

Kemp's ridley in Mexico's waters

Is this a major information gap?

## Prey availability

indices of blue crab abundance, CPUE data by state relative to the distribution of Kemp's ridley

## Recruitment dynamics

Variability in ocean circulation dynamics, *Sargassum* distribution, coastal recruitment

## Natural mortality

Harmful Algal Blooms (e.g., red tides) and cold stunning

## Growth rates

Estimate age at maturity and mortality rates

Avens et al. 2020, Ramirez et al. 2020a, 2020b; Lamont & Johnson 2020

## Variation in Kemp's Ridley Demographic Parameters

## Changes in hatchling sex-ratios

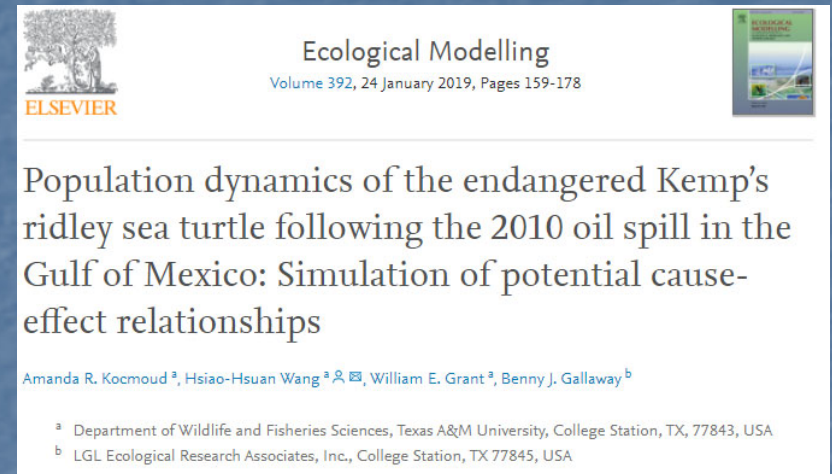
## Anthropogenic rescue and rehabilitation

## Density dependence



# Recommended stock assessment modeling approach

- We suggest that a series of range-finding analyses be conducted using the matrix model described in Kocmoud et al. (2019).
  - The benefit of this is that sensitivity analyses can be performed on each model parameter extremely quickly.
  - With this step, it will be possible to examine the sensitivity of the stock assessment model to the newly included environmental and demographic parameters (some of which may have wide confidence intervals) as well as other vital rates.
- After this initial assessment, the AD Model Builder program applied by Gallaway et al. (2016a) could be used to run the most pertinent scenarios given the identified influences of habitat weighting (as discussed above to track spatiotemporal variation in turtle distributions), prey abundance, and factors influencing natural and anthropogenic mortality.



*Gulf of Mexico Science*, 2016(2), pp. 138-157

## Development of a Kemp's Ridley Sea Turtle Stock Assessment Model

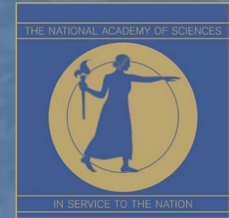
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Scott Raborn