

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



Benny J. Gallaway (PI) and Nathan F. Putman (Co-PI)

LGL Ecological Research Associates Inc., Bryan, Texas

Chris Sasso and Paul M. Richards

NOAA Fisheries, Southeast Fisheries Science Center, Miami, Florida

Charles Caillouet

Independent Researcher, Montgomery, Texas

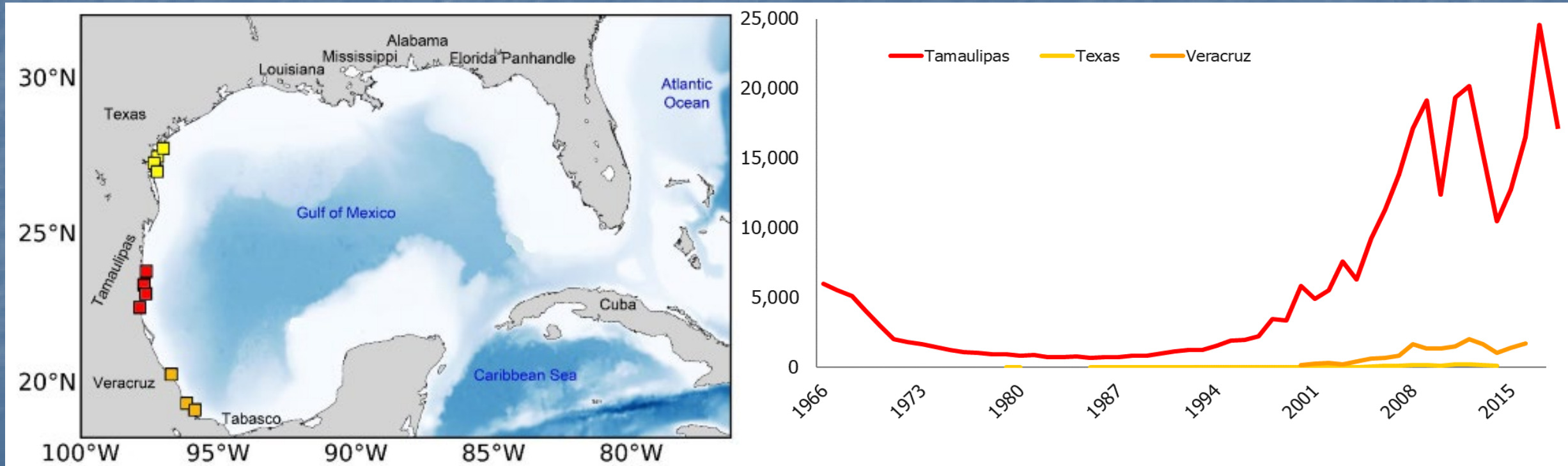


Outline

- 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

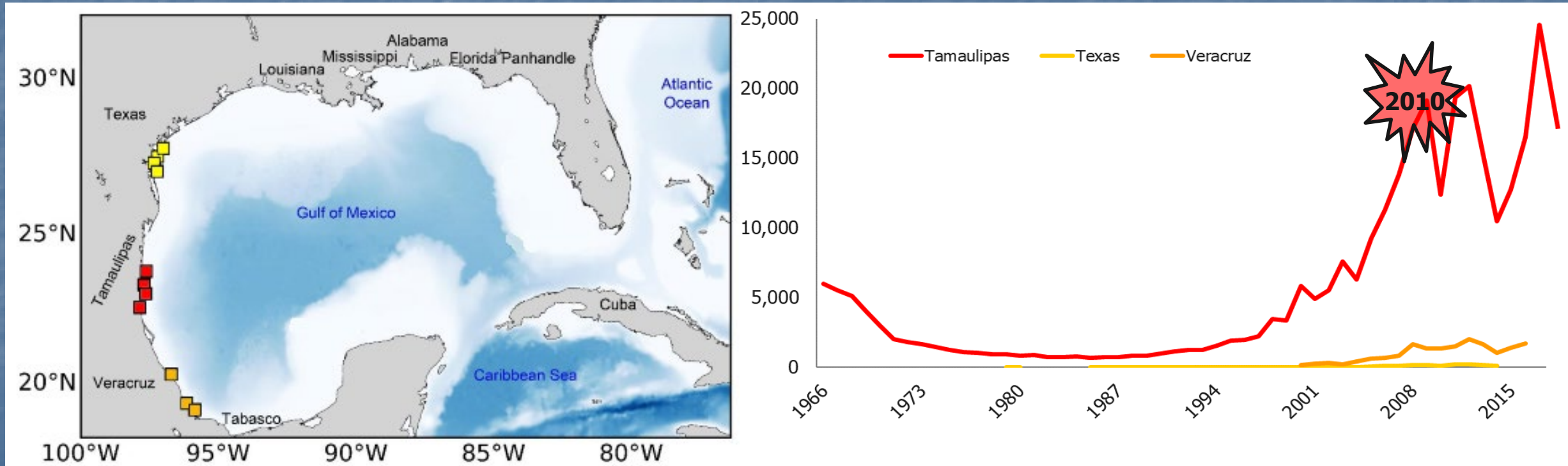
What is the Kemp's ridley population doing?

Kemp's ridley nesting



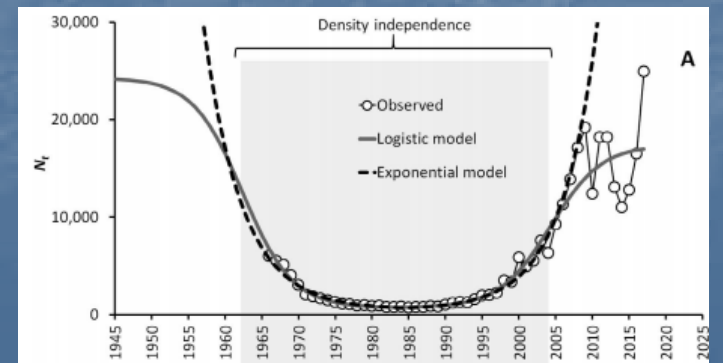
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Kemp's ridley nesting



What happened to population growth?

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



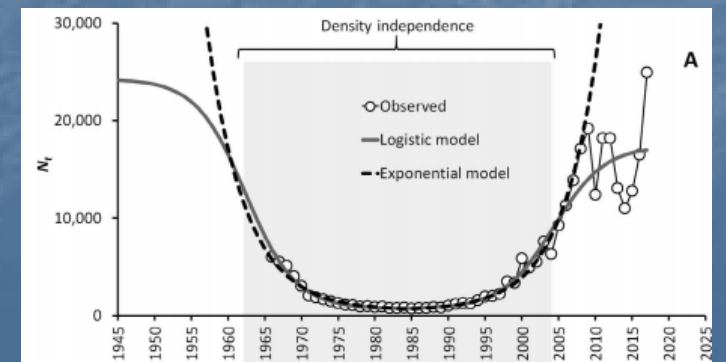
What happened to population growth?

■ ~~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?



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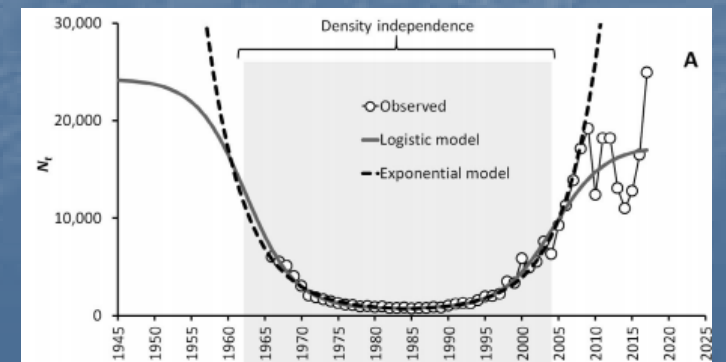
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■ Density dependence?



What happened to population growth?

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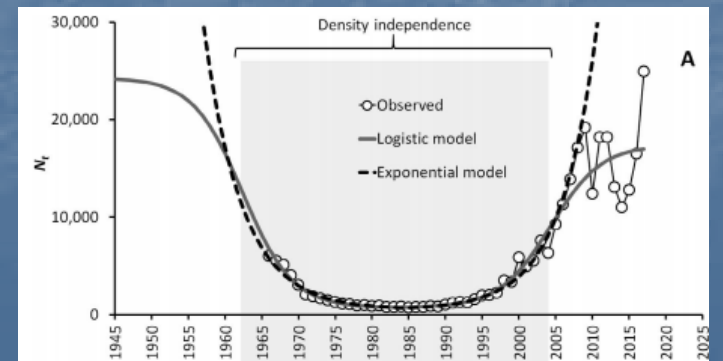
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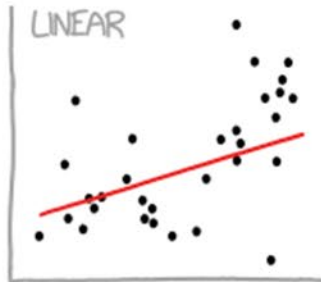
■ Density dependence?

- 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.

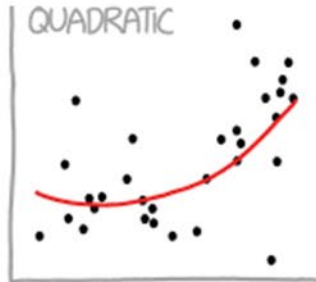


What is the Kemp's ridley population doing?

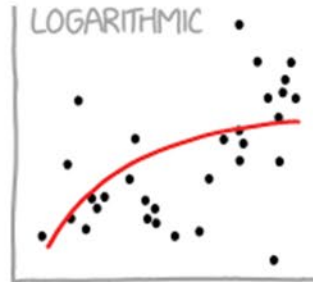
CURVE-FITTING METHODS AND THE MESSAGES THEY SEND



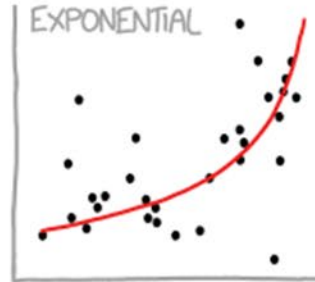
"HEY, I DID A REGRESSION."



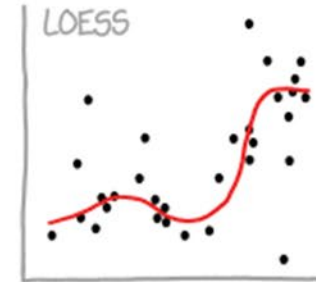
"I WANTED A CURVED LINE, SO I MADE ONE WITH MATH."



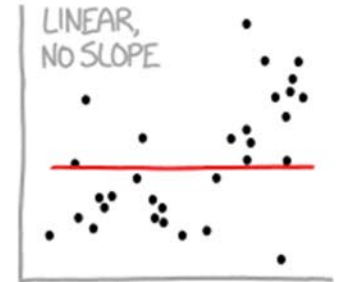
"LOOK, IT'S TAPERING OFF!"



"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."



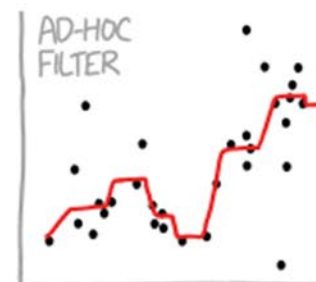
"LISTEN, SCIENCE IS HARD. BUT I'M A SERIOUS PERSON DOING MY BEST."



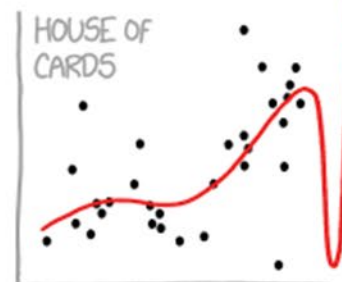
"I HAVE A THEORY, AND THIS IS THE ONLY DATA I COULD FIND."



"I CLICKED 'SMOOTH LINES' IN EXCEL."

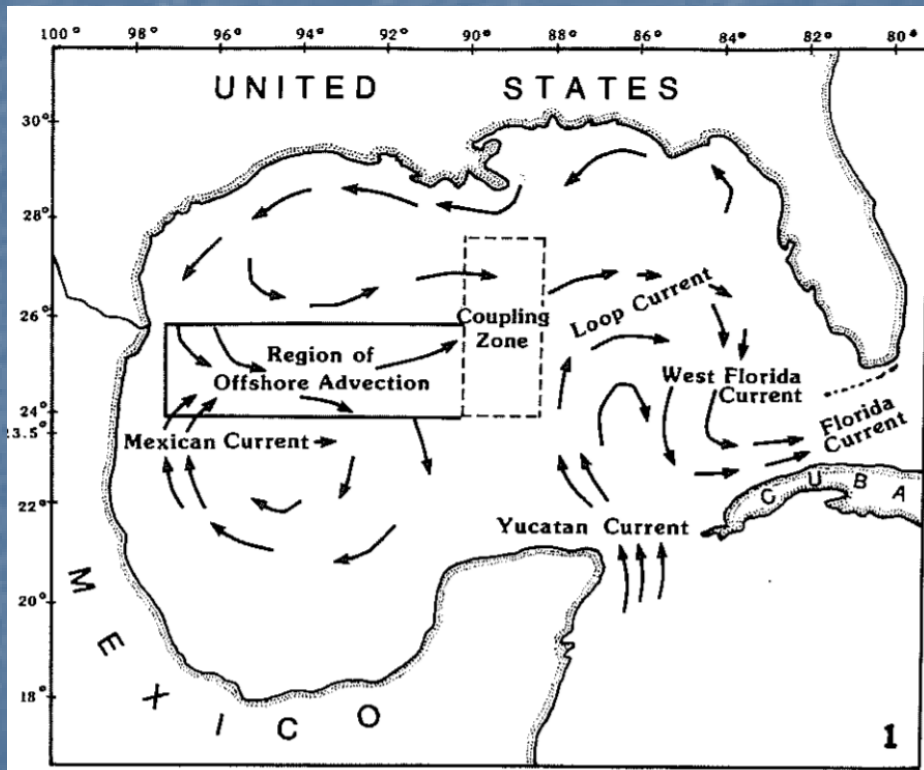


"I HAD AN IDEA FOR HOW TO CLEAN UP THE DATA. WHAT DO YOU THINK?"

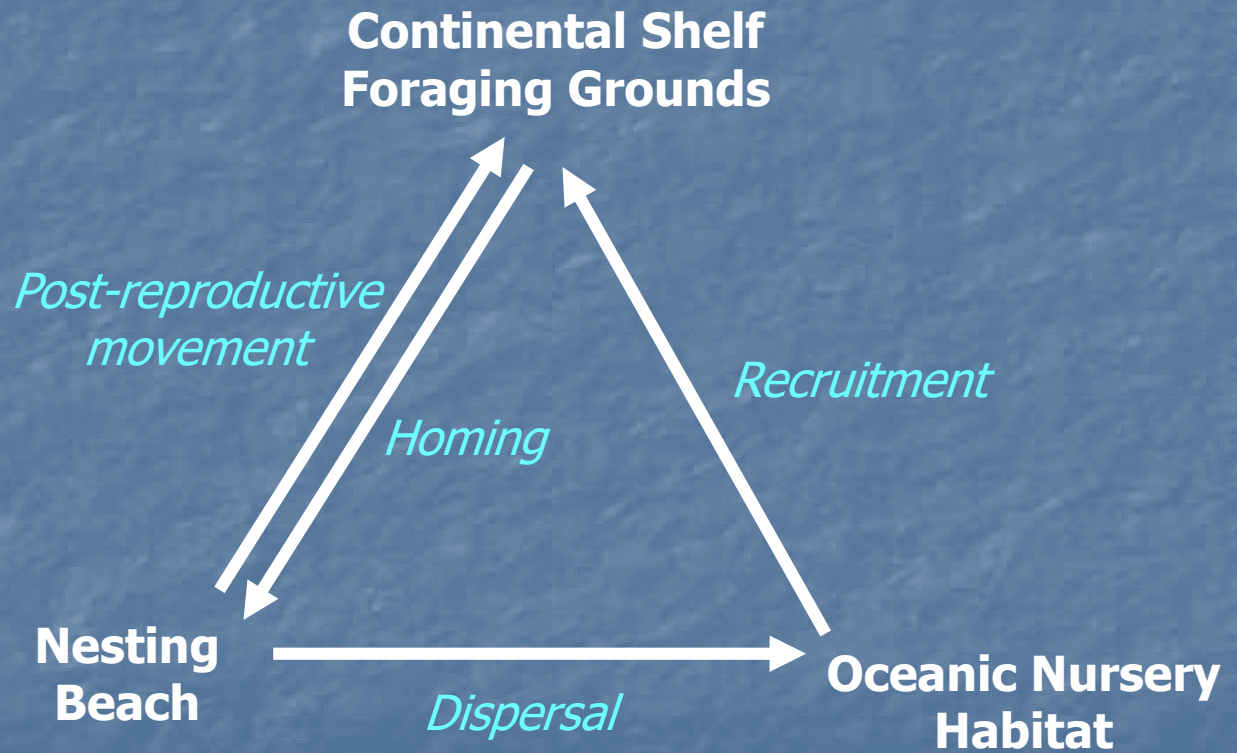


"AS YOU CAN SEE, THIS MODEL SMOOTHLY FITS THE— WAIT NO NO DON'T EXTEND IT AAAAAA!!"

Key aspects of Kemp's ridley biology

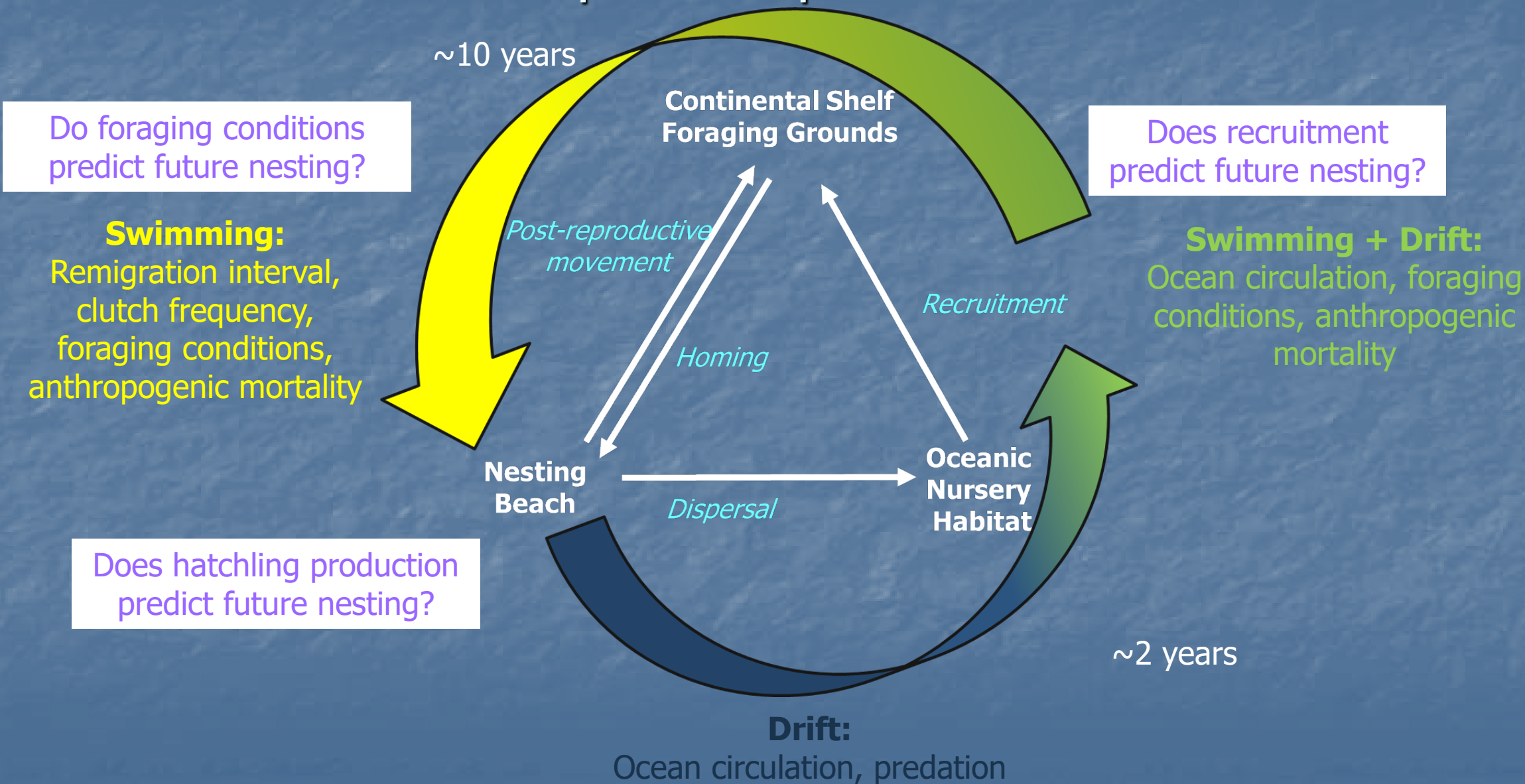


Collard & Ogren 1990, *Bulletin of Marine Science*



Adapted from Harden Jones 1968, *Fish Migration*

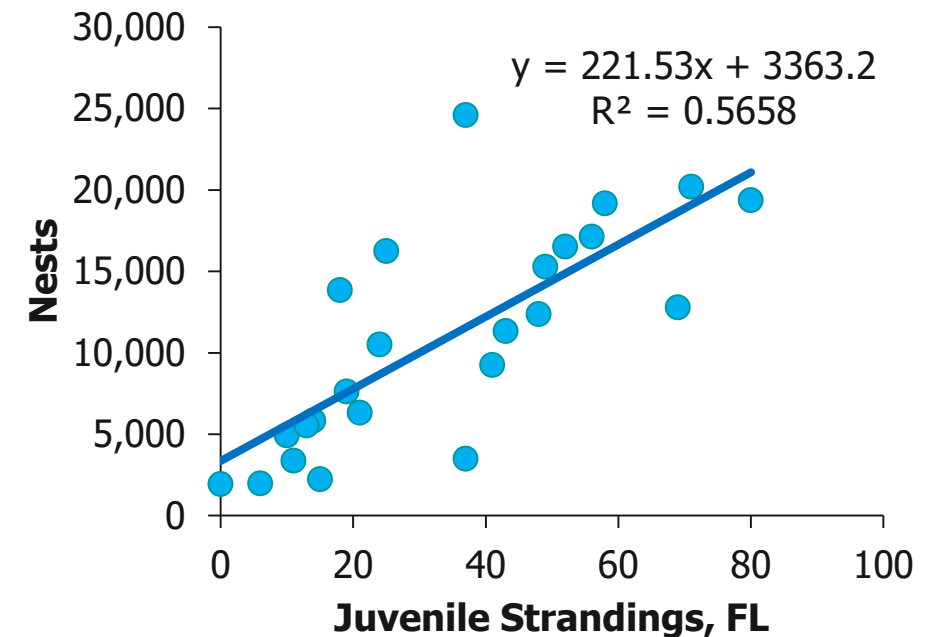
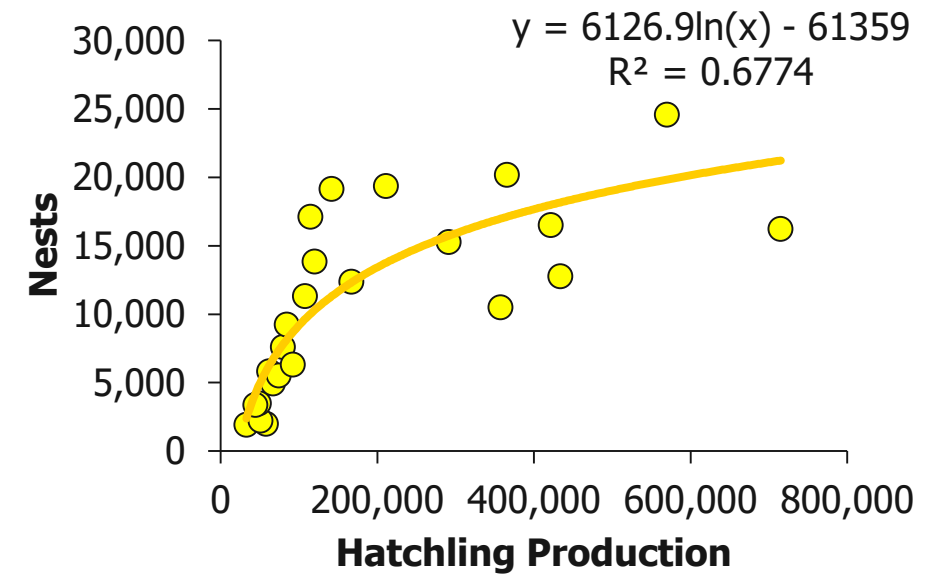
Using the migration triangle in Kemp's ridley to understand mechanisms of spatiotemporal variation in abundance



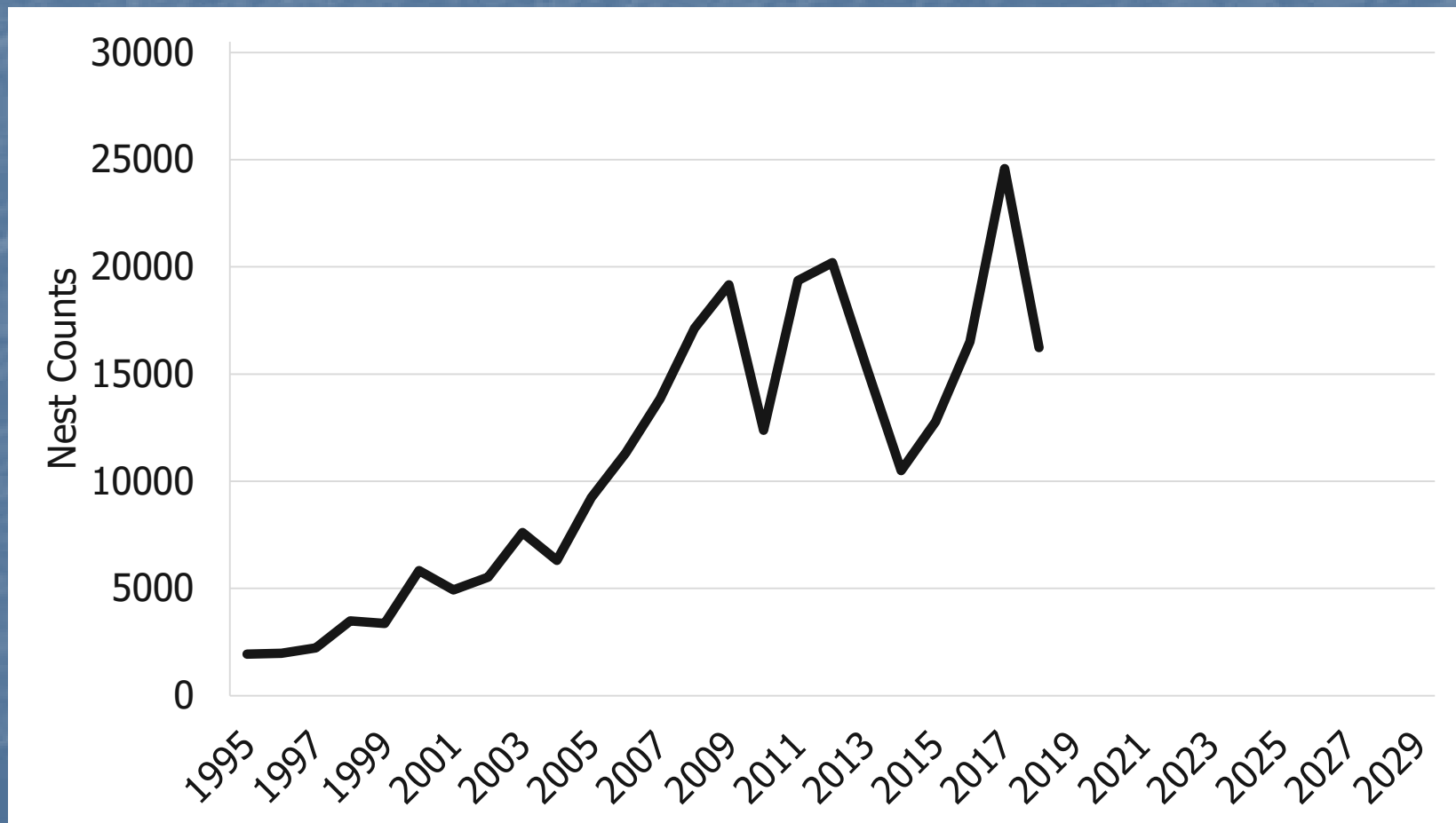
Key aspects of Kemp's ridley biology

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

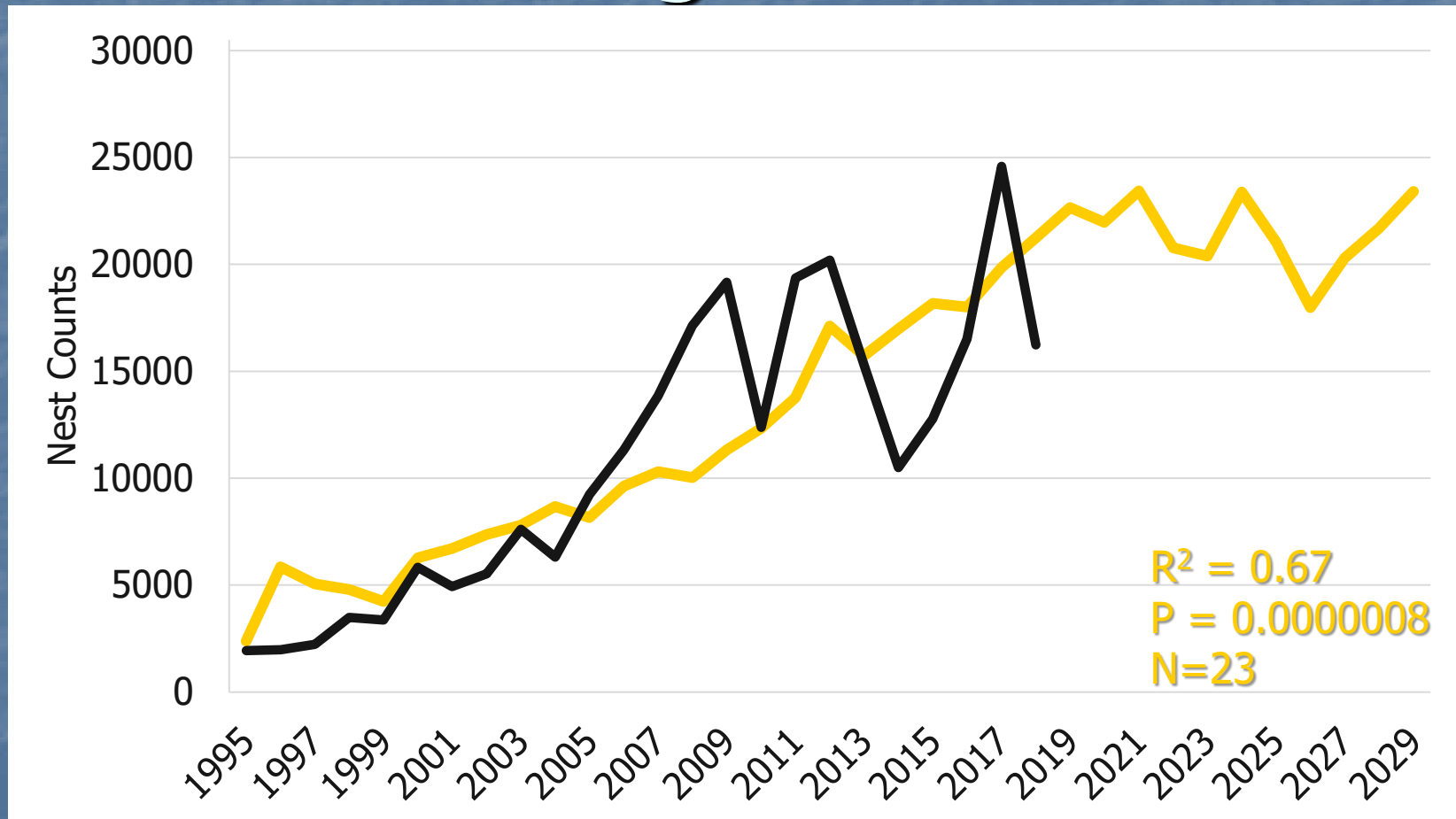
- reproductive output (+)
- immigration (+)
- natural mortality (-)
- anthropogenic mortality (-)
- emigration (-)



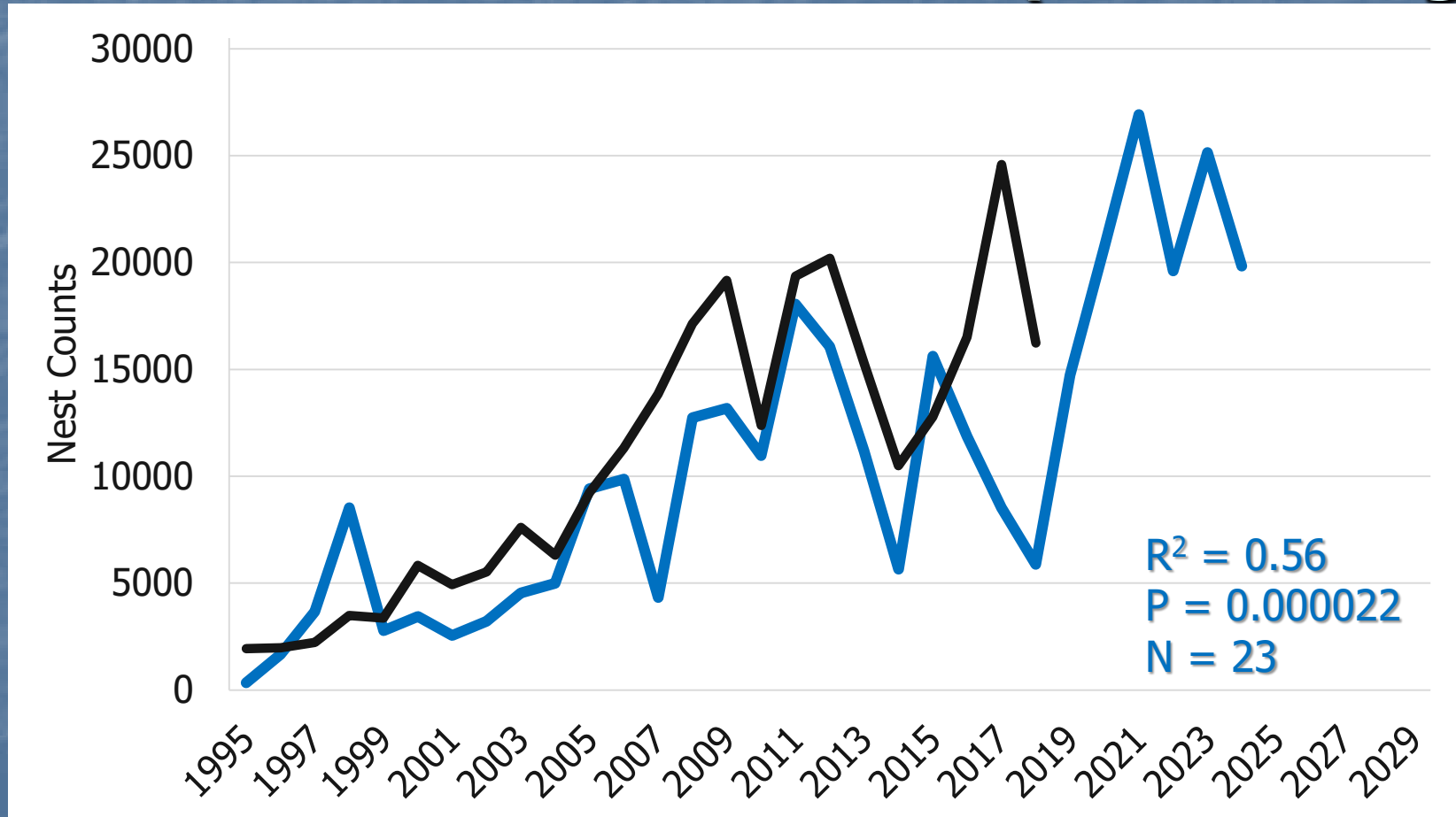
Forecasting Kemp's ridley nesting



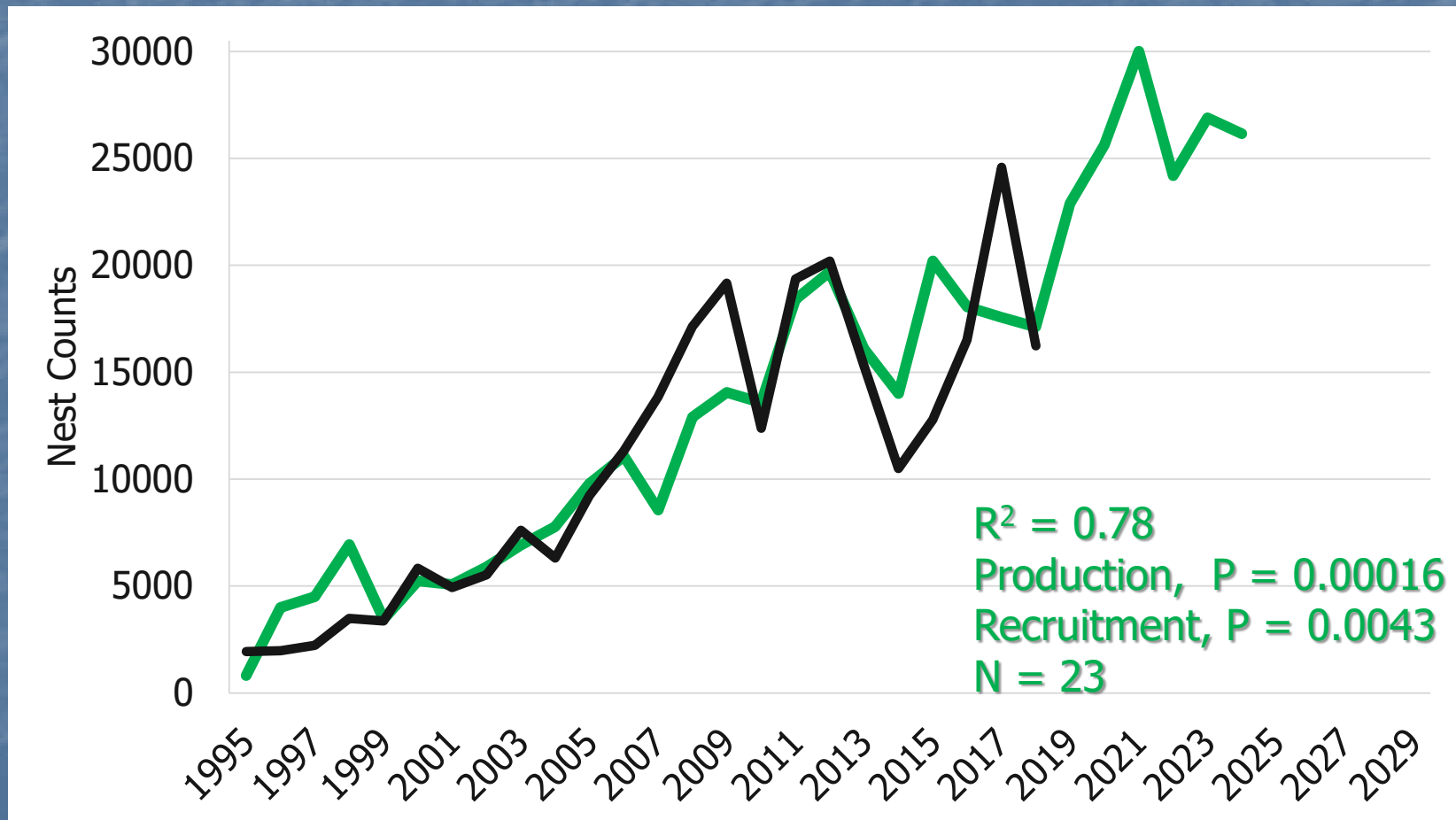
Forecasting Kemp's ridley nesting: Hatchling Production



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 SCHENXNAYDER, 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

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)

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

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

Observed proportion of strandings

Proportion of Mature females of age α

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

Natural mortality

Shrimp trawl mortality

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

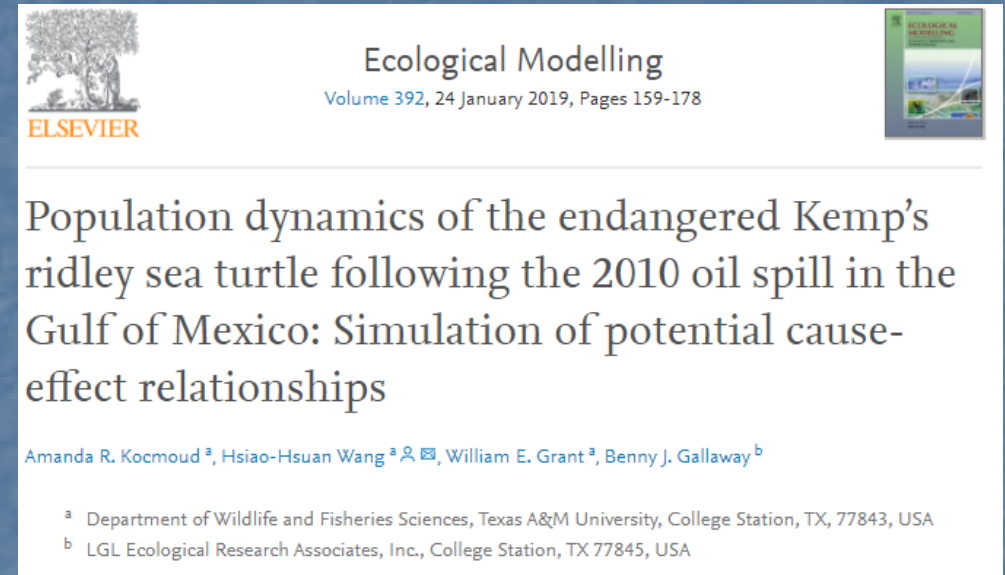
TED effect multiplier: starts in 1990 to influence catchability (0.233, SD = 0.069)

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**
- **Indirect anthropogenic /natural mortality:**
 - boat strikes; entanglement in derelict gear, small artificial reefs, and marine debris.
 - Harmful Algal Blooms (e.g., red tides) and cold stunning.
- **Anthropogenic rescue and rehabilitation**
- **Recruitment dynamics**
 - Variability in ocean circulation dynamics, *Sargassum* distribution, coastal recruitment
- **Growth rates**
 - Avens et al. 2020, Ramirez et al. 2020a, 2020b; Lamont & Johnson 2020
- **Clutch frequency and remigration interval**
- **Prey availability**
 - indices of blue crab abundance, CPUE data by state relative to the distribution of Kemp's ridley
- **Density dependence**
- **Spatiotemporal variation in Kemp's ridley distribution**
- **Kemp's ridley in Mexico's waters**
 - At a minimum, some assessment of what proportion of each Kemp's ridley life-stage occurs in Mexico is needed to help determine how major this gap of information might be.
- **Kemp's ridley in Atlantic waters**
- **Changes in nest monitoring effort / approaches**
- **Changes in hatchling sex-ratios**

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.



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