KEMP'S RIDLEY STOCK ASSESSMENT PROJECT

FINAL REPORT

Prepared By

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EXECUTIVE SUMMARY

In response to a request from Gulf States Marine Fisheries Commission, a stock assessment was conducted for the Kemp's ridley sea turtle (*Lepidochelys kempii*) in the Gulf of Mexico. The stock assessment was conducted in a Workshop Format led by LGL Ecological Research Associates, Inc., Texas Sea Grant, and Charles W. Caillouet Jr., and was attended by 22 scientists and 6 observers. The primary objectives were to examine Kemp's ridley population status, trends and temporal-spatial distribution in the Gulf of Mexico; estimate fishing mortality from shrimp trawls, and estimate total mortality. Shrimp trawl mortality was identified in 1990 as the greatest threat to sea turtles at sea, and widespread utilization of Turtle Excluder Devices (TEDs) began in 1990 or shortly thereafter. The assessment also considered other factors that may have had significant influence on the population.

The Kemp's ridley demographic model developed by the Turtle Expert Working Group (TEWG) in 1998 and 2000 was modified for use as our base model. The TEWG model uses indices of the annual reproductive population (nests) and hatchling recruitment to predict nests based on a series of assumptions regarding age and maturity, remigration interval, sex ratios, nests per female, juvenile mortality and a "TED-effect" multiplier after 1990. This multiplier was necessary to fit the data observed after 1990. To this model, we added the effects of shrimp effort directly, modified by habitat weightings. Additional data included in the model were incremental growth of tagged turtles and the length frequency of stranded turtles. We also added a 2010 nest reduction multiplier that was necessary to fit the data for 2010 and beyond. Lastly, we used an empirical-basis for estimating natural mortality, based upon a Lorenzen mortality curve and growth estimates.

Based upon data beginning in 1966, the number of nests increased exponentially through 2009 when 19,163 nests were observed at the primary nesting beaches in Mexico. In 2010, the observed numbers of nests plummeted to 12,377, a 35% reduction from 2009. Prior to 2010, the average rate of increase had been on the order of 19%. In 2011 and 2012, the preliminary estimates of nests observed were 19,368 and 20,197, respectively. While nesting has recovered to 2009 levels, it is not yet clear that the population will continue with its former rate of increase.

The female population size for age 2 and older Kemp's ridleys in 2012 was estimated to be 188,713 (SD = 32,529). If females comprise 76% of the population, the total population of age 2+ Kemp's ridley is estimated to have been 248,307. We estimate over 1.0 million hatchlings were released in 2011 and 2012. While mortality over the first two years is high, the total population of Kemp's ridleys in recent years is likely in excess of 1 million turtles including about a quarter million subadults and adults.

Prior to the use of TEDs (say 1989), shrimp trawls were estimated to kill 2,051 (76%) of the total annual mortality of 2,715 Kemp's ridleys. The population increased exponentially through 2009 when 3,679 shrimp trawl deaths were estimated to be included in the total mortality of 15,291 Kemp's ridleys. Shrimp trawl mortality was thus about 24% of the total mortality in 2009, suggesting a decrease in shrimp trawl mortality on the order of 68% as compared to 1989. The use of TEDs and shrimp effort reductions since 2003 appeared to be the primary factors associated with this reduction. In 2010, total annual mortality was estimated to be on the order of 65,505 Kemp's ridleys including 1,884 (4%) individuals killed in shrimp trawls. In 2012, shrimp trawl mortality was estimated to be on the order of 3,300 turtles (20%) within the total estimate of 16,128 Kemp's ridley deaths.

More years of data and corresponding stock assessment will be necessary to explain the 2010 nest reduction event and its effects on the population. We recommend expanded data collection at the nesting beaches be a priority, and that the next stock assessment be conducted in 2014 or 2015.

INTRODUCTION

In 2010 and 2011, increased numbers of Kemp’s ridley sea turtles (*Lepidochelys kempii*) stranded in the northern Gulf of Mexico. Among possible causes, the BP-Transocean-Macondo well blow out and ensuing oil spill in 2010 and shrimp trawling in both years received the most attention from Federal and State agencies, conservation organizations, and the media as possible causes. Dr. Charles W. Caillouet, Jr. in June 2011, proposed and widely promoted the idea that a working group be assembled to study and report on northern Gulf of Mexico Kemp’s ridley-shrimp fishery interactions. As a result of encouragement and support from the Louisiana Department of Wildlife and Fisheries, planning for the workshop by a consortium of Sea Grant Directors of the Gulf States was initiated, and the workshop received funding approval from the Gulf States Marine Fisheries Commission (GSMFC). Dr. Benny J. Gallaway of LGL Ecological Research Associates, Inc. was asked to Chair the Workshop and provide core staff necessary to carry the Workshop to fruition. The core members of the Planning and Model Development Group included Dr. Benny J. Gallaway; Dr. Charles W. Caillouet, Jr.; Dr. Pamela T. Plotkin; Mr. William J. Gazey; Dr. Scott W. Raborn; and Mr. John G. Cole.

The overarching purpose of the workshop was to conduct a Kemp’s ridley stock assessment involving objective and quantitative examination and evaluation of relative contributions of conservation efforts and other factors toward its population recovery trajectory. Because incidental capture of sea turtles in shrimp trawls was identified in 1990 as the greatest threat to sea turtles at sea, the Kemp’s ridley stock assessment focused on an evaluation of Kemp’s ridley-shrimp fishery interactions and the shrimping effort trend in the northern Gulf of Mexico where effort is greatest. Previous Kemp's ridley population models employed a "post-1990 multiplier" which forced model-predicted numbers of nests to track the post-1990 trend in actual numbers of nests. This multiplier was called a "TED effect", but it included additional, unidentified sources of post-1990 reduction in anthropogenic mortality; e.g., decreasing shrimping effort. In addition, effects of natural factors as well as other anthropogenic threats on Kemp’s ridley population recovery were also considered in the stock assessment, albeit in only a qualitative way. Despite all the potential natural and anthropogenic sources of mortality, the Kemp’s ridley population was increasing exponentially before 2010.

The specific objectives of the stock assessment were to:

1. Examine Kemp’s ridley population status, trend, and temporal-spatial distribution within the Gulf of Mexico (including Mexico and U.S.).

2. Examine status, trends, and temporal-spatial distribution of shrimping effort in the northern Gulf of Mexico.

3. Qualitatively examine other factors that may have contributed to increased Kemp's ridley-shrimp fishery interactions or otherwise caused Kemp's ridley strandings, injuries, or deaths in the northern Gulf of Mexico in 2010 and 2011, to include but not be limited to abundance of shrimp and Kemp's ridley prey species (e.g., portunid crabs), outflow from the Mississippi River, BP oil spill, surface circulation and weather patterns, hypoxic zones, and red tide.

4. Develop and apply a demographic model to assess the status and trend in the Kemp's ridley population, 1966-2011.

The project was organized into a number of tasks to accomplish these objectives. Results of each task are provided below.

TASK 1. PLANNING AND MODEL DEVELOPMENT

The first task of this project was to plan the workshop and develop the framework for an age-structured stock assessment model for the Kemp's ridley sea turtle. It was completed in June 2012 during April-June 2012, and included an extra Stakeholders Meeting held at no additional cost to the project. As a first step we prepared an age-structured model using AD Model Builder that was run using data in previous turtle stock assessment reports. Using the new model, we were able to duplicate previous model results. The new model provided an initial framework and only minor modifications were made over the course of the project. The model dictated the information that was needed. Data needed included 1) the time series of nest, eggs produced, hatchlings and number of nesters at all nesting sites in Mexico and Texas; 2) age and growth data from the strandings and mark-recapture data bases held by the National Marine Fisheries Service (NMFS); 3) age, sex, size and standardized abundance from the strandings data and causes (if known) of mortality from the strandings data; 4) turtle catch data from NMFS SEAMAP and observer data; 5) State resource survey data (effort and turtle catch) using trawls and gill nets; and 6) shrimp fishing effort data held by NMFS.

As part of this task we also prepared a workshop attendees list (Appendix 1). Preparation of that list was facilitated by a Kemp's ridley Stakeholder Meeting held in College Station, Texas at the Texas A&M Hagler Center on 23 May 2012. We believed this out-of-scope meeting was necessary due to dispel misinformation about the program. The meeting was hosted by Texas Sea Grant. The agenda for the meeting is shown by Appendix 2, and 24 people attended the meeting (Appendix 3). The Gulf State Marine Fisheries Commission was represented by Ralph Hode and the Gulf of Mexico Fisheries Management Council was represented by Corky Perret. The Southeast Fisheries Science (NMFS) Center was represented by Dr. Bonnie Ponwith

(Director), Dr. Paul Richards (Miami) and Dr. Rick Hart (Galveston); Dennis Klemm represented the NMFS Regional Office. The U.S. Fish and Wildlife Service was represented by Kelsey Gocke. Two states sent representatives. Dale Diaz represented Mississippi and Mike Ray represented Texas. Louisiana was represented by Mark Schexnayder who attended via speaker phone due to travel restrictions. Alabama expressed strong support but did not attend. No response to our invitation was received from Florida.

We invited one representative each of the conservation community and the Gulf and South Atlantic Fisheries Foundation, Inc. (GSAFF). Claudia Friess represented the Ocean Conservancy and Judy Jamison represented the GSAFF. Several academicians attended: Drs. Moby Solangi and Andy Coleman, Mississippi Institute for Marine Mammal Studies; Drs. Wade Griffin and Will Heyman, Texas A&M University. Sea Grant personnel attending included Kevin Savoie (Louisiana) and Logan Respess, Jim Hiney, and Gary Graham (Texas). The balance of the attendees consisted of project personnel (Benny Gallaway, Charles Caillouet, Pamela Plotkin, William Gazey, Scott Raborn and Connie Fields). Dr. Plotkin's assistant Peggy Foster, handled meeting logistics and did an exemplary job.

The meeting was extremely important in that it served to correct misconceptions about the program and we were able to gain support of all in attendance to assist in providing data and expertise where needed for the Assessment.

We began contacting potential workshop Participants immediately after the Stakeholders Meeting. As they were contacted it became obvious that the scheduled month for the Assessment workshop (October 2012) was not a good month because many of the people would still be in the field working on their sea turtle research projects. We delayed the Workshop until 26-30 November 2012.

TASK 2. DATA IDENTIFICATION AND ACQUISITION

One of the immediate subtasks was to provide a Background Document that would comprehensively provide information pertinent to the Kemp's ridley Stock Assessment. This effort was ongoing throughout the project. The latest version of this document (14 February 2013) is provided as Appendix 4. The assessment presented below depended, in large part, on the official nesting and hatchling dataset for Tamaulipes which has been monitored from 1966 to the present. These data were provided by Mexico scientists representing the La Comisión Nacional de Áreas Naturales Protegidas (CONANP) and their collegues from the Gladys Porter Zoo (GPZ). Shrimp effort data were obtained from the NMFS who also provided a summarized version of the shrimp trawl Observer Database describing sea turtle, shrimp and fish bycatch for the period of record. Key data from the analyses also included strandings data completed by the Sea Turtle Strandings and Salvage Network (STSSN) and sea turtle tag/release data held by the Cooperative Marine Turtle Tagging program (CMTTP). These data are only rarely allowed to be used by anyone other than the STSSN and CMTTP participants, and we particularly acknowledge and thank them for allowing this project to use their data. Fishery independent trawl surveys of the Gulf of Mexico have been conducted by NMFS and the five Gulf States as part of the Southeast Assessment and Monitoring Program (SEAMAP). This effort originated in 1972 as a NMFS Fall Groundfish Survey which ultimately became SEAMAP. These critical data were provided to the project by the GSMFC. LGL had compiled and provided a TED-Trawl Sea turtle Interaction Data Base summarized in Appendix 5. These were the large data bases available for use in our study at the time the assessment modeling was conducted.

Other biological data were necessary and were either compiled from the literature (e.g., see Appendix 4) or from Workshop Participants. These included things such as maturity schedules, nests per female, remigration interval, sex ratios (*in situ* and in corrals), egg survival rates, natural mortality by age, growth, and so on.

Incorporating shrimping mortality based on the U.S. shrimping effort for the northern Gulf of Mexico was a new contribution to Kemp's ridley stock assessment. We used the NMFS estimates of effort which have historically had issues with regard to the statistical approach used to generate the estimates. We revisited these issues before the Workshop took place (see pages 80-81 in Appendix 4). One of us (Caillouet) had recommended an alternative estimator he thought would be statistically more precise than the NMFS estimator.

Preliminary analyses by Gazey and Raborn showed that the estimator used by NMFS was less sensitive than the alternative estimator to rarely occurring, very high catch rate observations associated with high catches and low shrimping effort. Time and resources were insufficient to determine whether these rare catch rates were statistical outliers or valid data points, so we decided to adopt NMFS' approach to estimating shrimp fishing effort for purposes of Kemp's ridley stock assessment modeling.

TASK 3. WORKSHOP

The Workshop was held as rescheduled 26-30 November 2012 at the Airport Marriott hotel at George Bush Intercontinental Airport, Houston, Texas. The Workshop was attended by 19 Invitees, 6 members of the Project Team, 6 Observers and 3 persons attending electronically (Go-to-Meeting) (Table 1).

Table 1. Kemp's Ridley Workshop Attendees.

Attendees in Person	Project Team	Observers	Attendees by Phone
Patrick Burchfield	Benny Gallaway	Corky Perret	Selina Heppell
Rebecca Lewison	Charles Caillouet	Dale Diaz	Nathan Putnam
Masami Fujiwara	Scott Raborn	Judy Jamison	Mark Schexnayder
Donna Shaver	Pam Plotkin	Mike Ray	
Gary Graham	John Cole	Rom Shearer	
Sheryan Epperly	Bill Gazey	Sandi Maillian	
Wade Griffin			
Andrew Coleman			
Kenneth Lohmann			
Steven DiMarco			
Thane Wibbels			
Alberto Abreu			
Daniel Gomez			
Francisco Illescas			
Marco Castro			
Blanca Zapata			
Jonathan Pitchford			
Laura Sarti			
James Nance			
Totals 19	**6**	**6**	**2**

The Workshop Agenda (that was followed) is provided in Appendix 6. Contact information for workshop attendees is provided as Appendix 7.

The Workshop was moderated by Dr. Gallaway, and Mr. Jeffrey K. Rester, Habitat & SEAMAP Coordinator of GSMFC handled all the on-site logistics including but not limited to room set-up, PowerPoint presentations, other visuals and recording the meeting. During Monday afternoon and Tuesday morning, 17 presentations were made. These general sessions were followed by group discussions of the assessment model needs during Tuesday afternoon and Wednesday morning. We then broke into two subgroups one dealing with “threats”; the other with “life history” inputs. These subgroups continued to meet Wednesday and Thursday, coming together in Plenary Sessions at mid-day and at the end-of-the-day.

The Turtle Expert Working Group (TEWG 1998, 2000) had previously prepared a demographic model for the Kemp’s ridley population. The TEWG model uses indices of the annual reproductive population (nests) and hatchling recruitment to predict nests based on the assumptions that age at maturity = 12 yrs, remigration interval = 2 yrs, nest per female = 2.5, the female sex ratio = 0.76 and juvenile mortality (age 2-5) = 0.5. The model estimates pelagic mortality for ages 0 and 1, late juvenile and adult mortality (ages 6+) and a post-1990 “TED effect” multiplier. The predictive model assumes density independent mortality and estimates the number of nests starting from the number of hatchlings 12 yr earlier. The objective function to minimize is the sum squares of the differences between predicted and observed nests. The model has major strengths but its weaknesses include 1) the TED effect being applied to total mortality, and 2) parameter inference is not possible with least squares model fitting.

We converted this TEWG model to AD Model Builder, and added estimates of total anthropogenic mortality assuming it was governed for the most part by shrimp fishing effort. Shrimp fishing mortality has long been assumed to be the major source of anthropogenic mortality (National Academy of Sciences, National Research Council 1990). We then used the same input data (hatchlings and nesters) and assumptions of the TEWG model, plus additional assumptions and input data. The new model requires annual shrimp fishing effort data for the U.S. fleet for 6 regions by 4 depths (inshore, 0-10 fm, 10-30 fm, and >30 fm). For regions occurring in the U.S., the time/space cells are the same used in the shrimp fishing effort analyses and other stock assessments (West Coast Florida, MS/AL/E. LA, W. LA and TX). Two regions occur in Mexico, NMFS statistical areas 22-26 and 27-40. Inshore depths were not included in these regions of Mexico because they were not fished by the U.S. fleet.

The new model also required a habitat weighting for each time/space cell in the model based upon its relative value to Kemp's ridley, with the focus placed on adult female utilization. The rationale for this focus is that adult females have the highest reproductive value to the population. Estimates of natural mortality were also a requirement of the new model. A summary of the model equations are provided in Appendix 8. Parameter inference is possible with this model which bases the objective function of the negative log-likelihood of data, plus priors. Additionally the "TED effect" is applied to anthropogenic mortality only, not total mortality.

The new model outputs (based on preliminary estimates of natural mortality and habitat weightings) were provided on Wednesday afternoon. On Thursday, we developed revised estimates of habitat weighting factors and natural mortality. The model was re-run Thursday night and the results were presented on Friday morning. Model and analysis outputs were provided to GSMFC at the meeting. Because of their preliminary nature, it was agreed that these results should not be distributed or used at that time.

One issue that developed from the model runs related to definitions and labeling of results. For example, the model provides estimates of total anthropogenic mortality, the dynamics of which were assumed to be governed primarily by shrimp trawl bycatch. Total "human-caused" or "anthropogenic" impacts in the model output graphics were labeled as "shrimp bycatch". Consensus was reached that this was not an appropriate label because other factors are included here. Similarly, a "nests reduction factor" was included to address the 2010 drop in the nests numbers; in the model that factor was labeled as being "mortality". This was also an incorrect label, because many factors other than mortality could lead to reduced nests. These errors were planned to be corrected in the assessment manuscript.

The next steps for revising the model were to:

- Add a Lorenzen mortality curve
- Include stranding carapace length-frequency
- Include growth data

These analyses provided an empirical basis for estimates of natural mortality. We also agreed to:

- Add a maturation schedule
- Update the 2012 shrimp fishing effort (in this effort we assumed 2012 was the same as 2011 effort.

The plan was to prepare a modeling manuscript when the additional work was completed and send it to all for review. All workshop participants were to be included in its authorship.

TASK 4. KEMP'S RIDLEY STOCK ASSESSMENT DRAFT MANUSCRIPT

Introduction

This section describes the development and application of a population dynamics synthesis model for the integration of historical Kemp's ridley data. This section will be reformatted and submitted for publication. The final model utilized data for the number of nests at important Mexican beaches and the subsequent production of hatchlings, incremental growth of tagged turtles, length frequency of stranded turtles and directed shrimp trawling effort in the Gulf of Mexico. The motivation for the construction of a synthesis model included the characterization of (1) shrimp fishery interactions with Kemp's ridley turtles, (2) mortality events associated with 2010, (3) population size, and (4) uncertainty of parameter estimates. Modern applications of length frequency and growth information to age structured population dynamics stochastic models have been pioneered by Fournier et al. (1990, 1998). The methodology is well established in fisheries science but we are not aware of an application to sea turtles.

The portrayal of shrimp fishery interactions was a key determinant of model structure. The preferred approach was direct estimation of turtle bycatch from shrimp trawls. However, observation of Kemp's ridley caught by shrimp trawl was extremely rare and did not reflect mortality induced by shrimp trawls (TEWG 2000). As an alternative, we accepted that shrimp trawls are a significant source of mortality and assumed that mortality caused by shrimp trawls was proportional to shrimp trawling effort.

In the text that follows, we describe the data available for analysis, expand on requisite growth theory and develop a model to predict the data based on fundamental parameters. The statistical likelihoods of observing the data given the predictions are specified and computed. We estimate the fundamental parameters and provide fits to the data and subsequent estimates of key variables (e.g., mortality and population size).

Methods

The notation used to describe the model and related objective functions presented below are provided in Table 1. The variables in Table 1 are organized by indices, data and associated descriptors (any combinations of same), fundamental parameters to be estimated, logged probability density functions and interim variables (some combination of data and fundamental parameters) that were of interest.

Available Data

A listing of the available data described here can be found in Appendix A.

Number of Nests. The number of observed nests at Rancho Nuevo, Tepehaujes and Playa Dos beaches combined from 1966 through 2012 represented the best available indicator of population trends (NMFS et al. 2011). In 2012, 92.6% of all registered nests were located at these three beaches. Some additional nesting occurs elsewhere in Mexico and Texas. Thus, our estimate reflects a large portion, but not all of the population.

Number of Hatchlings. The estimated number of hatchings that entered the water produced from the Rancho Nuevo, Tepehaujes and Playa Dos beaches were available for the years 1966 through 2010. All hatchlings produced from 1966 through 2003 were from corral rearing. Starting in 2004, hatchlings were produced in corrals and *in situ*. Hatchlings for 2011 and 2012 were estimated from the number of observed nests using the maximum number of nests to be protected in corrals, number of eggs-per-nest and survival rates adopted by NMFS et al. (2011) for projections.

Mark Recapture Growth Increments. The increments in growth from mark-recaptured wild Kemp's ridley turtles in the Gulf of Mexico from 1980 through 2012 were obtained from the Cooperative Marine Turtle Tagging Program (CMTTP). The following release-recapture events were not used (censored) in our analysis: (1) captive reared, head-started or rehabilitated turtles; (2) turtles that transited in or out of the Gulf of Mexico (Mexican and U.S. waters); (3) turtles with incomplete or missing date of release or recapture; and (4) turtles with missing carapace length (curved or straight) at release or recapture. Most of the turtles had both a curved carapace length (*CCL*) and a straight carapace length (*SCL*) measure taken at release and recapture which enabled the construction of a *CCL* to *SCL* conversion for GOM turtles:

$$SCL = b_1 + b_2 \cdot CCL \,. \tag{1}$$

Simple least squares regression was used to estimate the b_1 and b_2 parameters. An estimate of *SCL* using equation (1) was used for any release or recapture event with only a CCL measure. Only turtles at large more than 30 days were used. A total of 233 mark-recapture events consisting of males, females and unknown sex were available.

Strandings Length Frequency. For the years 1980 through 2011, 5,953 SCL measurements of stranded Kemp's Ridley turtles in the Gulf of Mexico were obtained from the Sea Turtle and Salvage Network. The *SCL* measurements were summed into 5-cm *SCL* bins.

Penaeid Shrimp Trawling Effort . Penaeid shrimp effort data (nominal net days fished) in U.S. waters in the Gulf of Mexico were available for the period 1966 through 2011. The effort was stratified into four areas (statistical reporting areas 1-9, 10-12, 13-17, and 18-21) and four depth zones (inshore, 0-10 fm, 10-30 fm and > 30 fm). In Mexican waters shrimp trawling effort in units of nominal boat days was available for 1966 through 1980 in two spatial areas. We converted the data to nominal net days fished using the mean number of nets-per-boat-per-year as used in U.S. waters. Each of Mexican spatial areas were prorated into three depth zones using the adjacent U.S. area (statistical reporting units 18-21) and off-shore zones (0-10 fm, 10-30 fm, >30 fm).

The above 22 area X depth strata were assigned a habitat score to reflect susceptibility of Kemp's ridley to shrimping. Each of the effort strata were then weighted by the habitat score and a total directed shrimp effort for the year was calculated. The subsequent effort values were then scaled (mean = 1.0) over the available years. Because shrimp trawling effort data were not available for 2012 we assumed no change from 2011.

Growth Theory

An important component of the synthesis model is the determination of growth by age. While a model is technically possible with just length-frequency, substantial growth information is obtainable through incorporating mark-recapture data. However, as pointed out by Francis (1988) and others, growth parameter estimates using mark-recapture data are not consistent with the usual von Bertalanffy growth model by age because the error structures are different in the associated models. To the best of our knowledge, how to mesh growth information derived from mark-recapture sources and apply to length-at-age formulation is an unresolved issue in the published literature.

The approach used here is to derive models with the same parameters and simple error structure. The traditional three parameter von Bertalanffy growth model for length-at-age data is expressed as (e.g., Ricker 1975):

$$l_a = L_\infty \ 1 - \exp[-K(a_i - a_0)] \ , \tag{2}$$

where l_a is the expected length for a fish of age a, L_∞ is the theoretical maximum (asymptotic) length, K is the von Bertalanffy growth coefficient, a_0 is the theoretical age at length 0, and a_i is the true age of the i^{th} turtle. The residual error (ε_i) from the observed length ($\tilde{l}_i$) for the i^{th} turtle is assumed to be normally distributed, i.e.,

$$\varepsilon_i = \tilde{l}_i - l_a \ \text{ where } \ \varepsilon_i \sim N(0, \sigma_i^2)\ , \tag{3}$$

and where σ_i is the standard deviation for the residual of the i^{th} turtle. Many studies assume that the parameters L_∞, K and a_0 are common to all turtles in the population and are estimated through minimizing the negative log-likelihood with the sample variance (S^2) of the residuals used to estimate each of the σ_i^2 by a homogeneous error, i.e.,

$$\sigma^2 = S^2 = \sum_{i=1}^{n} \frac{(\varepsilon_i - \bar{\varepsilon})^2}{n-1}\ , \tag{4}$$

where n is the number of observations. The coefficient of variation (CV), assuming that it is the same for all turtles, is sometimes introduced as an additional parameter to be estimated (e.g., Cope and Punt 2007), i.e.,

$$\sigma_a = CV \cdot l_a \ . \tag{5}$$

In other words, equation (5) implies that the residual variance is larger for older (larger) turtles.

Individual variation of growth parameters has been introduced for application to mark-recapture data to address inconsistent estimators and large biases (e.g., Sainsbury 1980, James 1991, Wang and Thomas 1995, and Pilling et al. 2002). To the best of our knowledge, although very straightforward, the same application of individual variation has not been applied to models for length-at-age. Absent knowledge of ageing errors, we follow the above authors' portrayal by assuming that there are two sources of variation: (1) measurement of length and (2) maximum length varies between turtles. If these distributions are normal then the residual is normally distributed (equation 3 holds) and

$$Var(\varepsilon_i) = \hat{\sigma}_i^2 = \sigma_m^2 + \sigma_L^2 \;\; 1 - \exp[-K(a_i - a_o)] \;\; ^2 , \qquad (6)$$

where σ_m is the standard deviation of measurement error and σ_L is the standard deviation of the maximum length for individual fish. The estimate of $L\infty$ using equation (6) is then the mean maximum (asymptotic) length for the sample. Note that if the length measurement error is small relative to the total residual error (in practice, often true) then equations (5) and (6) are equivalent (set $\sigma_m = 0$ and notice that the standard deviation for the residual is then proportional to the predicted length in both equations 5 and 6).

The traditional two-parameter (L_∞, K) von Bertalanffy growth model for mark-recapture data is expressed as (e.g., Fabens 1965):

$$\Delta l_i = [L_\infty - \tilde{l}_{0,i}][1 - \exp(-K \cdot \Delta\tilde{t}_i)] , \qquad (7)$$

where Δl_i is the expected increment in length over the period $\Delta\tilde{t}_i$ and $\tilde{l}_{0,i}$ is the measured length when the i^{th} turtle was marked. Using the same error structure as for the length-at-age data then counterparts to equations (2) and (6) become:

$$\upsilon_i = \tilde{l}_{r,i} - \tilde{l}_{0,i} - \Delta l_i \qquad \upsilon_i \sim N(0, \varsigma_i^2) , \qquad (8)$$

and

$$Var(\upsilon_i) = \hat{\varsigma}_i^2 = \sigma_m^2[1 + \exp(-2K \cdot \Delta\tilde{t}_i)] + \sigma_L^2[1 - \exp(-K \cdot \Delta\tilde{t}_i)]^2 , \qquad (9)$$

where υ_i is the residual error and ς_i is the associated standard deviation. Equation (9) is equivalent to that provided by James (1991).

While the models and error structure are now consistent between the age-at-length and mark-recapture models, a reparamterization can improve the computational and statistical properties of the estimates (Schnute and Fournier 1980, Ratkowsky 1986, Pilling et al 2002). Following their advice, L_∞ and a_0 were replaced by less extreme extrapolations of μ_1, the expected mean length at age t_1, and μ_2, the expected mean length at age t_2. After algebraic manipulations, the corresponding equations for the expected length (l_a) and increment in length (Δl_i) are:

$$l_a = \mu_1 + (\mu_1 - \mu_2)\frac{1 - \exp[-K(a_i - t_1)]}{1 - \exp[-K(t_2 - t_1)]} , \qquad (10)$$

and

$$\Delta l_i = \left\{ \frac{\mu_2 - \mu_1 \exp[-K(t_2 - t_1)]}{1 - \exp[-K(t_2 - t_1)]} - \tilde{l}_{0,i} \right\} 1 - \exp(-K\Delta\tilde{t}_i) \quad . \tag{11}$$

Note that equation (11) has three parameters (μ_1, μ_2, K) but only μ_2 and K can be estimated. The parameter μ_1 (mean size at age t_1) must be set and then μ_2 is estimated (μ_2 is conditional on μ_1) and interpreted as the mean size t_2-t_1 years later. The variance estimate for the residual using length-at-age data (equation 6) also requires revision (it contains a_0),

$$Var(\varepsilon_i) = \hat{\sigma}_i^2 = \sigma_m^2 + \sigma_L^2 \left\{ 1 - \exp[-K(a_i - t_1)] \frac{\mu_2 - \mu_1}{\mu_2 - \exp[-K(t_2 - t_1)]\mu_1} \right\}^2 , \tag{12}$$

whereas, the variance estimate for the residual using mark-recapture (equation 9) data requires no revision. Equation (10) is as given by Schnute and Fournier (1980) while equations (11) and (12) are novel.

Model Definition

The purpose of this section is to describe the methods used to predict the expected number of nests as a function of the number of hatchlings, expected increment in growth of a recaptured marked turtle and the expected probability of a turtle belonging to a length interval based on the fundamental parameters to be estimated. The main assumptions were:

1. Only the population dynamics of female Kemp's ridley turtles are modeled.
2. The population consists of $A+1$ age classes starting at age 0 (the first year in the water) where the oldest age-class A represents age A and older turtles which are subject to the same mortality. For this model, A was set to 14 yr to represent ages 14+.
3. All mortality is density independent.
4. Natural mortality from age 2 is based on the Lorenzen model (Lorenzen 2000).
5. Shrimp trawl mortality is proportional to shrimp effort.
6. The trend in growth tracks a von Bertalanffy curve.
7. The age composition of females and males are the same.
8. The lengths (*SCL*) of individual turtles belonging to an age-class are normally distributed around their mean length.
9. Selectivity by age of strandings follows a logistic curve.
10. Other than selectivity by age for strandings, the mark-recapture and strandings data are from the same population.

Mortality. Total annual instantaneous mortality, Z_P, during the 2-yr pelagic stage (ages 0 and 1) was assumed to be the same (constant) for all years.

Starting at age 2, following Lorenzen (2000), an age-dependent natural mortality function was based on von Bertalanffy growth such that mortality decreases with size and age until an instantaneous rate of M_∞ is reached at age A and older, i.e.,

$$M_a = \begin{cases} \dfrac{M_\infty}{K} \ln\left\{ \dfrac{\exp(Ka) - 1}{\exp[K(a-1)] - 1} \right\} & \text{for } 1 < a < A \\ M_\infty & \text{for } a = A, \end{cases} \tag{13}$$

where M_a is the age-dependent instantaneous natural mortality for age a.

Shrimp trawl fishing mortality was assumed to be proportional to scaled directed shrimp trawling effort, i.e.,

$$F_{ya} = q_{h(a)} E_y \, , \tag{14}$$

where, F_{ya} is instantaneous fishing mortality during year y for age a, $q_{h(a)}$ is the catchabilty coefficient for a subset of h ages and E_y is the scaled directed effort for year y. Catchability was partitioned into two subsets with age a_c marking the partition, i.e.,

$$h = \begin{cases} 1, & 1 < a < a_c \\ 2, & a \geq a_c \end{cases} . \tag{15}$$

Turtle Excluder Devices (TEDs) have been in widespread use since 1990 and reduce the fishing mortality of turtles. We applied a multiplier, X_{TED}, on the instantaneous fishing mortality starting in year y_{TED}. We also found that additional mortality in 2010 was required to explain reduced nesting in 2010 through 2012. Therefore, we applied an additive instantaneous mortality, M_{2010}, in 2010 (y = 45) that included all ages ≥ a_{2010}.

In summary, total instantaneous mortality, Z_{ay}, can be portrayed as:

$$Z_{ya} = \begin{cases} Z_P, & a \leq 1 \\ M_a + F_{ay}, & a > 1 \text{ and } y < y_{TED} \\ M_a + F_{ay} X_{TED}, & a > 1 \text{ and } y \neq 45, \; y \geq y_{TED} \\ M_a + F_{ay} X_{TED} + M_{2010}, & a \geq a_{2010} \text{ and } y = 45 \end{cases} , \tag{16}$$

with six fundamental parameters associated with mortality (M_∞, Z_P, q_1, q_2, X_{TED} and M_{2010}) to be estimated.

Initial Population. By convention, we chose to reference turtles associated with the year and age that any mortality events occurred. In other words, N_{ya} refers to the number of age-*a* female turtles that survive to end of year *y*. Some models (e.g., TEWG 2000) reference these turtles as $N_{y+1,a+1}$ (at the start of the following year and age).

The model must be initialize by the number of recruits that enter the female population each year and the population size over all ages in the first year (1966 or y = 1). The number of age-0 female turtles recruited each year was calculated as the number of female hatchlings that survived the first year in the water, i.e.,

$$N_{y0} = (\tilde{H}_{Cy} \cdot r_C + \tilde{H}_{Iy} \cdot r_I)\exp(-Z_{y0}), \qquad (17)$$

where $\tilde{H}_{Cy}$ and $\tilde{H}_{Iy}$ are the estimated number of hatchlings entering the water reared in a corral and *in situ* each year, and r_C and r_I are the female sex ratios for a corral and *in situ*, respectively. For the first year of the model we assumed that there were no turtles alive greater than age 0 except in the accumulating age A where the number of turtles was based on the observed nests, $\tilde{P}_1$, divided by the assumed number of nests per mature female in the population (n_M, ratio of nests per breeding female and breeding interval),i.e.,

$$N_{1a} = \begin{cases} 0 & \text{for } 0 < a < A \\ \dfrac{\tilde{P}_1}{n_M} & \text{for } a = A \end{cases}. \qquad (18)$$

Update of Population. With recruitment and the initial year defined, the population in the remaining years and ages were updated for mortality:

$$N_{ya} = \begin{cases} N_{y-1,a-1} \cdot \exp(-Z_{ya}) & \text{for } 0 < a < A \\ (N_{y-1,A-1} + N_{y-1,A}) \cdot \exp(-Z_{yA}) & \text{for } a = A \end{cases} \qquad (19)$$

The predicted total number of deaths (D_{ya}) and shrimp based mortality (C_{ya}) were also calculated using the Baranov catch equations:

$$D_{ya} = \begin{cases} N_{y-1,a-1}\left[1-\exp(-Z_{ya})\right] & \text{for } 1 < a < A \\ (N_{y-1,A-1} + N_{y-1,A})\cdot\left[1-\exp(-Z_{yA})\right] & \text{for } a = A \end{cases}, \qquad (20)$$

and,

$$C_{ya} = \frac{F_{ya}}{Z_{ya}} D_{ya} . \qquad (21)$$

Note that total deaths were not reported for the pelagic stage (age 0 and 1) because of likely confounding of pelagic mortality, sex ratio and nests-per-adult-female parameters (see Discussion).

Predicted Nests. The number of predicted nests per year (P_y) was the product of number of mature females in the population and the number of nests produced per mature female (ratio of nests per breeding female and the breeding interval). The number of mature females in the population of females by year was calculated as the sum of the products of the population size and proportion mature by age, i.e.,

$$P_y = n_M \sum_a N_{ya} G_a , \qquad (22)$$

where G_a is the assumed known proportion mature by age a.

Predicted Standings Length Frequency. The expected age composition of the strandings by year and age-class a (p_{ya}) was provided by:

$$p_{ya} = \frac{s_a N_{ya}}{\sum_a s_a N_{ya}} , \qquad (23)$$

where s_a is the selectivity of the strandings by year a. Two alternative selectivity functions were undertaken: an ascending logistic shaped function (equation 24) or a dome shaped function (equation 25, double logistic with ascending and descending limbs),

$$s_a = \frac{\dfrac{1}{1+\exp\left(\dfrac{a_{50}-a}{a_{sl}}\right)}}{\max_a(s_a)} \qquad (24)$$

$$s_a = \frac{\dfrac{1}{1+\exp\left(\dfrac{a_{50}-a}{a_{sl}}\right)}}{\max_a(s_a)} \cdot \left[1 - \frac{1}{1+\exp\left(\dfrac{b_{50}-a}{b_{sl}}\right)}\right], \qquad (25)$$

where a_{50} is the age of 50% selectivity for ascending limb, a_{sl} is the slope for ascending limb, b_{50} is the age of 50% selectivity for descending limb and b_{sl} is the slope for descending limb. Note that the selectivity's are scaled to a maximum of 1.

The expected lengths and the associated variance for turtles in each age class were obtained through the application of equations (10) and (12), respectively. Individual turtle variation was assumed to be normally distributed and, following Fournier et al. (1990), the probability of a turtle measured in year *y* belonging to length interval *j* (f_{yj}) was approximated by

$$f_{yj} = \frac{w}{\sqrt{2\pi}} \sum_a \frac{p_a}{\sigma_a} \exp\left\{\frac{-(v_j - l_a)^2}{2\sigma_a^2}\right\}, \qquad (26)$$

where w is the width of each length interval and v_j is midpoint of length interval j. For this model, w was set to 5 cm.

Model Objective Function

The objective of the analysis was to minimize the sum of the negative log-likelihood density functions (L) through the evaluation of alternative fundamental parameter values. In this model we considered four sources of log-likelihood,

$$L = L_{prior} + L_P + L_{\Delta t} + L_f \ , \qquad (27)$$

where L_{prior} is associated with prior information for the fundamental parameters, L_P with the number of observed nests, $L_{\Delta t}$ with *SCL* at release and recapture using the mark-recapture data and L_f with length frequency of the strandings data.

Priors. A prior normal distribution was assumed for every estimated fundamental parameter to allow any prior information to be included in the objective function. Therefore, the contribution to the objective function (excluding all constant values) was:

$$L_{prior} = \sum_{\theta} \frac{(\tilde{\theta} - \theta)^2}{2\tilde{\sigma}_{\theta}^2}, \quad (28)$$

where $\tilde{\theta}$ is the prior value of the estimated parameter, $\tilde{\sigma}_{\theta}$ is the prior standard deviation of the parameter and θ is the estimate of the parameter when the model function was minimized. Note that a large prior standard deviation makes the distribution uninformative (i.e., has little influence on the objective function).

Observed Nests. Observed nests from 1978 to 2012 (y = 13, 14 … 47) were used to fit the model. Thus, the population cells (the N_{ya}) were populated (initialized) over the 1966 to 1977 (y = 1, 2 … 12) period. The predicted residuals were assumed to have a log-normal distribution. Therefore, the contribution to the objective function (excluding all constant values) was:

$$L_P = \sum_{y=13}^{47} \ln(S) + \sum_{y=13}^{47} \frac{\xi_y^2}{2S^2}, \quad (29)$$

where,

$$\xi_y = \ln(P_y) - \ln(\tilde{P}_y) \quad \text{and} \quad S = Var(\xi).$$

Mark-Recapture Growth Increment. The mark-recapture data applied to growth were the length at release ($\tilde{l}_{0i}$), length at recapture ($\tilde{l}_{ri}$) and the time the turtle was at large ($\Delta\tilde{t}_i$). An assumed measurement error of 0.5 cm (σ_m) was based on 82 turtles that exhibited no growth since they were larger than 63 cm or less than 10 days at large. The ages for the mean size parameters (μ_1 and μ_2) were set to age 1 (t_2 = 1) and age 10 (t_2 = 10). As pointed out above (see Growth Theory), the residuals for the increments in length obtained from the mark-recapture data were assumed to be normally distributed (see equation 8) where the expected increment in length (Δl_i) and variance (ς_i^2) were obtained using equations (9) and (11).

The negative log-likelihoods for an individual variance weighted normal distribution were then (excluding all constant values):

$$L_{\Delta t} = \sum_i \ln(\varsigma_i) + \sum_i \frac{(\tilde{l}_{ri} - \tilde{l}_{0i} - \Delta l_i)^2}{2\varsigma_i^2}. \quad (30)$$

This likelihood mainly impacts fundamental parameters μ_2, K and σ_L.

Length Frequency of Strandings. The length frequencies were assumed to exhibit a multinomial distribution. Following Gazey et al. (2008) a robustified version of the negative log-likelihood was used ignoring all constant terms, i.e.,

$$L_f = \sum_{y=}\sum_{j} \tilde{f}_{yj}\sqrt{n_{Fy}}\ln\left(\frac{0.01}{J} + f_{yj}\right) , \qquad (31)$$

where n_{Fy} is the sample size for year y, $\tilde{f}_{yj}$ is the sample length frequency by year y and length interval j, J is the total number of length bins (intervals) and f_{yj} the model predicted proportion via equation (26).

Parameter Estimation

Parameter estimation was accomplished through calculating the mode of the posterior distribution. This is equivalent to finding the fundamental parameter values that minimize the model objective function (equation 27).

The model definition and minimization of the model objective function were implemented through the software package AD Model Builder (Fournier et al. 2012). Variable declaration (Table 1), model definition and model objective function detailed above follow the structure required by AD Model Builder. Each of the sub-headings in the above sections was coded as a subroutine in AD Model Builder. The package allowed for the restriction or bounding of parameter values, stepwise optimization and report production of standard deviations, marginal posterior profiles and correlation between parameter estimates. AD Model Builder approximates the covariance matrix for parameter estimates with the inverse of the second partial derivatives of the objective function.

Several parameters were assumed to be known or fixed as specified by NMFS et al. (2011). The female sex ratios (r_I and r_C) in equation (17) were set to 0.64 and 0.74 for *in situ* and corral reared turtles, respectively. The number of nests per adult females (n_M in equations 18 and 22) was set to 1.25 (the ratio of 2.5 nests per breeder and a 2 yr migration interval). The maturity schedule (G_a in equation 22) was assumed to be knife edge 12 years after hatching, i.e.,

$$G_a = \begin{cases} 0 & \text{for } a < 11 \\ 1 & \text{otherwise} \end{cases}$$

The model was initially run with the prior standard deviations for the fundamental parameters set to very large values (uninformative). If parameter estimation problems were encountered then prior information was introduced or some parameter values were set (removed from estimation). The synthesis model was executed for three alternative ages (5, 6 and 7) to partition catchability (a_c in equation 15) and three alternative years (1989, 1990 and 1991) to commence the TED multiplier (y_{TED} in equation 16). The run with the lowest objective function value was used for our report. The additional mortality for 2010 was set to start at age 2 (a_{2010} = 2) under the rationale that all non-pelagic turtles would be impacted equally. Alternatively, a run was made starting at age 9 (a_{2010} = 9) such that only the 2010 age classes necessary to fit the 2010 through 2012 nest count observations were impacted.

Appendix A specifies scoping values (number of years, number of age classes, age of youngest and oldest age-class etc.), prior distributions, assumed parameters and all data input. Appendix B lists the ADMB code for the synthesis model.

Results

For the mark-recapture events used for incremental growth, 10 turtles at release (4.3%) and 11 turtles (4.7%) at recapture had only *CCL* measures. Figure 1 displays the relationship used (equation 1) to convert these *CCL* values to *SCL*. Given the small number of required conversions and the very strong relationship (R^2 = 0.998), this small source of error was not included the synthesis model. The 22 habitat scores to reflect the susceptibility of Kemp's ridley to shrimping are listed in Table 3. The ensuing scaled directed effort weighted by the habitat scores is plotted in Figure 2. Also plotted in Figure 2 is the scaled directed effort assuming equal habitat scores.

Sensible parameter estimates could not be achieved for the TED multiplier (X_{TED}) and the asymptotic instantaneous natural mortality (M_∞) because the parameters were highly negatively correlated. We resolved the issue by setting M_∞ to 0.05 (i.e., removed as a fundamental parameter to be estimated). When the dome shaped double logistic curve (equation 25) was applied the slope (b_{sl}) of the descending limb was near 0 producing a logistic shaped curve. Therefore, the simple logistic relationship (equation 24) was adopted in the model for selectivity of strandings by age. In subsequent model runs the objective function had the smallest value (best fit to the data) when catchability was partitioned at age 5 (a_c = 5) and the TED multiplier started in 1990 (y_{TED} = 25). Parameter estimates and associated SD of the remaining 11 fundamental parameters are listed in Table 3 with the 2010 mortality event set to impact ages 2+. Also listed in Table 3 are population estimates and associated SD for ages 2-4, 5+ and total population of age 2+.

Model predictions compared to the observed number of nests are displayed in Figure 3. The log residuals versus the predicted number of nests (residual plot) are plotted in Figure 4. Note that residuals were homogeneous and there did not appear to be a readily apparent trend consistent with the assumed log normal sampling distribution. The model fit to the strandings length frequency data is provided in Figure 5. Note that both the observations and the predicted frequencies had increased representation of older turtles in more recent years (i.e., the age classes were "filling up" over time). In Figure 6 the growth rate (cm/yr) for every capture-recapture event is plotted as a function of the mean *SCL*. For von Bertalanffy growth, the model predicted mean was linear. Also note that each point (turtle) did not provide equal weight to the likelihood (see equation 9); however, Figure 6 does provide a graphical illustration of the variation and the identification of possible outliers. In this case, the two turtles larger than 60 cm with substantial growth rates had little influence on the model because of the mass of large turtles with near 0 growth rate.

Parameter combinations of interest can be shown through several plots. Figure 7 displays the mean von Bertalanffy growth with associated error by age (equations 10 and 12). Figure 8 presents the Lorenzen curve for instantaneous natural mortality for ages 2+ (equation 13). Figure 9 displays the selectivity of strandings by age (equation 24). Figure 10 plots instantaneous fishing mortality by year for ages 2 to 4 and ages 5+ (two mortality profiles, equation 14). Note the significant mortality drop in 1990 when the TED multiplier was applied. Figure 11 plots instantaneous total mortality by year for age 2, age 5 and age-class 14+ (equation 16). Note that each age has a different mortality profile because natural mortality is monotonically decreasing function of age (see Figure 8). Also, note the significant mortality event in 2010 that was required to fit the 2010, 2011 and 2012 observed number of nests. Mortalities summed over ages 2 to 4 and ages 5 to 14+ assigned to shrimp trawls (equation 21) and from all sources (total, equation 20) are plotted in Figures 12 and 13, respectively. Note that the increasing trend in mortalities over time was caused by the increasing population. The mortalities assigned to shrimp trawls in comparison to total mortalities by years (1980 to 2012) are listed in Table 4. The major factors that influence the percent mortality from shrimp trawls were directed shrimp effort, TEDs commencing in 1990 and the 2010 mortality event.

The alternative run with the 2010 mortality event set to impact ages 9+ had almost identical fit to the data and very similar parameter estimates (not shown). The major differences were the lack of mortality spikes in 2010 for ages 2 through 8 (not shown), the marked reduction in total mortality in 2010 (65,505 versus 26,637, see Table 4) and somewhat larger shrimp trawl mortality 2010 through 2012 because of a larger population size in these years (see Table 4).

The population sizes with the 2010 event set to impact ages 2+ by year and age class are charted in Figure 14. The Figure was partitioned into two panels (ages 2 to 8 and ages 9 to 14+) because of the substantial difference in population scale over the age-classes. Terminal (2012) population estimates summed over ages 2 to 4, ages 5 to 14+ and ages 2 to 14+ (total) with the associated 95% confidence intervals are plotted in Figure 15 (also see Table 3).

Discussion

Kemp's ridley turtles nest on beaches other than Rancho Nuevo, Tepehaujes and Playa Dos (7.4% of registered nests were located at other beaches in 2012); therefore, our population estimates of female turtles were incomplete.

The scaled directed effort profile was, in general, insensitive to alternative habitat scores (the weighted and un-weighted profiles were very similar, see Figure 2). Habitats in U.S. waters with the greatest potential to impact the scaled directed shrimp effort are the offshore areas (> 30 fm) because they are unique in terms of temporal trends. However, they were discounted (low habitat score in terms of susceptibility of Kemp's ridley to shrimping) and had little impact on the directed shrimp effort. On the other hand, large weights (habitat score) were given to the 0 – 10 fm areas. Given the constraints of large habitat scores on the 0 – 10 fm areas and small scores to the > 30 fm habitats, we found that the scaled directed effort was insensitive to alternative weightings in the other U.S. areas. In terms of model fit to the nesting data the effective US shrimp effort worked well for the 1981-2012 period. Better fits in the earlier years could have been obtained with additional directed shrimp effort over 1966 to 1980. This could be achieved most directly with augmented Mexican shrimp effort.

The model was not useful for the estimation of several parameters. These parameters were subsequently fixed (assumed). The number of nests per adult female (1.25, calculated from the ratio of nests-per-breeder and the breeding interval as provided by NMFS et al 2011) served to scale the number of adult females in the population (given the observed number of nests). Moreover, this scaling allowed total pelagic mortality, which functioned to scale the number of juvenile females (age 2) to enter the population, to be estimable.

Similarly, the asymptotic instantaneous natural mortality (M_∞) had to be set to allow estimation of the TED multiplier. Setting M_∞ at 0.05 implied a TED efficiency of 77% for the exclusion of Kemp's ridley turtles. The TED efficiency was sensitive to a higher asymptotic natural mortality. For example, M_∞ set to 0.06 would yield an 88% TED efficiency. On the other hand, M_∞ set to 0.05 implies that many Kemp's ridley turtles could live to a very old age (see Figure 16). Our model suggests that values beyond $0.04 < M_\infty < 0.06$ would result in unreasonable estimates for other parameters.

Knife edge maturity at age 11 (12 years from hatching at a mean length of 59 cm) was also set following NMFS et al. (2011). The parameter dictated the age distribution of adults and mainly impacted the generation time of the population. A current size distribution of breeders would greatly enhance our ability to quantify a maturity schedule by age.

The female sex ratios were also set from NMFS et al. (2011); however, if applied as stationary values as in equation (17), there was little influence on the female population size because of complete confounding with pelagic mortality (i.e., estimates of pelagic mortality were directly related to the sex ratio such that population size did not change). However, any inference with respect to the male population size is dependent on the sex ratios.

As noted above, pelagic mortality served to scale the number of hatchlings to the number of turtles entering the population as age-2 juveniles. Our model subjected the pelagic stage to two years of estimated equal mortality; however, age 0 turtles are actually only exposed for about 6 months. Therefore, our partitioning of the population between age 0 and 1 is suspect. Moreover, pelagic mortality is confounded with the assumed (fixed) parameters of the sex ratios, nests-per-female, asymptotic natural mortality and the maturity schedule. Consequently, we do not present estimates of age-0 and age-1 population size.

The nesting observations from 2010 through 2012 were significantly different ($P < 0.001$) than using data prior to 2010 and projections based on 2009 terminal mortalities. In order to achieve better fits to the nesting data we estimated a 2010 mortality event applied to turtles ages 2+ and ages 9+. Alternative explanations or models to explain the 2010 through 2012 nesting observations are feasible. For example, nesting may have been interrupted (breeding interval extended for some adult females) for some unknown reason and the females will eventually show up on the beaches. Perhaps density independent mortality is no longer applicable because the population has reached a limiting factor (e.g., habitat carrying capacity). These alternative models imply alternative projections of population size and predicted number of nests in the next few years (see Figure 17). Ongoing monitoring of the population plus some additional data (e.g., size frequency of breeders, and hatchlings) will likely enable many of these hypotheses to be tested or discarded in the near future.

The analysis of the mark-recapture growth increment data is preliminary. A concern is that the time-at-large criteria of 30 days was too short and introduced bias in the K and σ_L parameters because of seasonal growth. Unfortunately, using only turtles at large more than a year resulted in a 40% loss in observations and an inability to estimate the lower size parameter μ_1 (size at age 1). Setting μ_1 to 17.2 cm (the value obtained using the 30 days-at-large criteria) and carrying through with the parameter estimation with capture-recapture events of more than a year resulted in slightly smaller K and σ_L which in turn lead to somewhat higher estimates of natural mortality and lower estimates of shrimp mortality. Additional analysis is required to determine if turtles residing in Atlantic waters could be included and the impact of alternative time-at-large criteria. Also, additional data (if available) on the size and individual variation of age 0 and age 1 turtles could be included as prior information for the μ_1 parameter.

Literature Cited

Bi-National Plan. 2011. (http://www.fws.gov/kempsridley/Finals/kempsridley_revision2.pdf).

Cope, J.M., and A.E. Punt. 2007. Admitting ageing error when fitting growth curves: an example using von Bertalanffy growth function with random effects. Canadian Journal of Fisheries and Aquatic Sciences, 64: 205-218.

Fabens, A.J. 1965. Properties and fitting of the von Bertalanffy growth curve. Growth, 29: 265-289.

Fournier, D. A., and J. R. Sibert, J. Majkowski, and J. Hampton. 1990. MULTIFAN a likelihood-based method for estimating growth parameters and age composition from multiple length-frequency data sets illustrated using data for southern bluefin tuna (*Thunnus maccoyii*). Canadian Journal of Fisheries and Aquatic Sciences 47:301-317.

Fournier, D. A., J. Hampton, and J. R. Sibert. 1998. MULTIFAN-CL: a length based, age-structured model for fisheries stock assessment, with application to South Pacific albacore, *Thunnus alalunga*. Canadian Journal of Fisheries and Aquatic Sciences 55:2105-2116.

Fournier, D. A., H. J. Skaug, J. Ancheta, J. Ianelli, A. Magnusson, M. N. Maunder, A. Nielsen and J. Sibert. 2012. AD Model Builder: using automatic differentiation for statistical inference of highly parameterized complex nonlinear models. Optimization Methods and Software, 27(2): 233-249.

Francis, R. I. C. C. 1988. Are growth parameters estimated from tagging and age-length data comparable? Canadian Journal of Fisheries and Aquatic Sciences 45:936-942.

Gazey, W. J., Gallaway, B. J., Cole, J. G., Fournier, D. A., 2008. Age composition, growth and density dependent mortality in juvenile red snapper estimated from observer data from the Gulf of Mexico penaeid shrimp fishery. North American Journal of Fisheries Management. 28:1828–1842.

James, I.R. 1991. Estimation of von Bertalanffy growth curve parameters from recapture data. Biometrics, 47: 1519-1530.

Lorenzen, K. 2000. Allometry of natural mortality as a basis for assessing optimal release size in fish stocking programs. Canadian Journal of Fisheries and Aquatic Sciences, 57: 2374-2381.

National Marine Fisheries Service, U.S. Fish and Wildlife Service, and SEMARNAT (NMFS et al.). 2011. Bi National Recovery Plan for the Kemp's Ridley Sea Turtle (*Lepidochelys* *kempii*), Second Revision. National Marine Fisheries Service. Silver Spring, Maryland. 156 p.+appendices.

Pilling, G.M., G.P. Kirkwood, and S.G. Walker. 2002. An improved method for estimating individual growth variability in fish, and the correlation between von Bertalanffy growth parameters. Canadian Journal of Fisheries and Aquatic Science, 47: 424-432.

Ratkowsky, D.A. 1986. Statistical properties of alternative parameterizations of the von Bertalanffy growth curve. Canadian Journal of Fisheries and Aquatic Science, 43:742-747.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada Bulletin 191.

Sainsbury, K.J. 1980. Effect of individual variability on the von Bertalanffy growth equation. Canadian Journal of Fisheries and Aquatic Science, 37: 241-247.

Schnute, J. and D. Fournier. 1980. A new approach to length frequency analysis: growth structure. Journal of the Fisheries Research Board of Canada, 37: 1337-1351.

Turtle Expert Working Group (TEWG). 1998. An assessment of the Kemp's

1751 ridley (Lepidochelys kempii) and loggerhead (Caretta caretta) sea turtle

1752 populations in the western north Atlantic. NOAA Tech. Memo. NMFS-

1753 SEFSC-409. 96 pp.

1754.

Turtle Expert Working Group (TEWG). 2000. Assessment Update for the Kemp's Ridley and Loggerhead Sea Turtle Populations in the Western North Atlantic. U.S. Department of Commerce. NOAA Technical Memorandum. NMFS-SEFSC-444, 115p.

Wang, Y.-G, and M.R. Tomas. 1995. Accounting for individual variability in the von Bertalanffy growth model. Canadian Journal of Fisheries and Aquatic Science, 52: 1368-1375.

Table 1. Notation used in the Kemp's ridley growth theory and synthesis model.

Indices:	
a	age (t = 0, 1, 2, …A)
i	individual observation
h	subset of ages for catchability coefficient
j	length frequency interval (j = 1, 2, …J)
y	year (y = 1, 2, 3, … 47; 1966 through 2012)
Data or assumed known variables:	
E_y	scaled shrimp effort in year y
$\tilde{f}_{yj}$	observed length frequency of strandings in year y and interval j
G_a	proportion of mature turtles of age a
$\tilde{H}_{Cy}$	estimated corral hatchlings entering the water in year y
$\tilde{H}_{Iy}$	estimated *in situ* hatchlings entering the water in year y
$\tilde{l}_{0,i}$	SCL for the i^{th} individual turtle at capture
$\tilde{l}_{r,i}$	SCL for the i^{th} individual turtle at recapture
n_{Fy}	number of SCL strandings measures in year y
n_M	nests per mature female in the population (ratio of nests per breeding female and remigration interval)
$\tilde{P}_y$	observed nests in year y
r_C	corral sex ratio (not required if constant because confounded with Z_P)
r_I	*in situ* sex ratio (not required if constant because confounded with Z_P)
v_j	mid-point of the j^{th} length frequency interval
w	bin width of each length frequency interval
σ_m	SCL measurement error
$\Delta\tilde{t}_i$	time at large for the i^{th} capture-recapture event
Fundamental parameters to be estimated:	
a_{50}	age of 50% selectivity for ascending limb of logistic function
a_{sl}	selectivity slope for ascending limb of logistic function
b_{50}	age of 50% selectivity for descending limb of logistic function
b_{sl}	selectivity slope for descending limb of logistic function
b_1, b_2	regression parameters of SCL on CCL
K	von Bertalanffy growth coefficient
M_∞	instantaneous natural mortality of the accumulation age A+
M_{2010}	added mortality for the 2010 event for age a_{2010} and older

Table 1. Continued….

q_h	catchability coefficient where h = 1 if 1 < a < a_c and h = 2 if $a \geq a_c$
X_{TED}	fishing mortality multiplier starting in year y_{TED}
Z_P	total pelagic annual instantaneous mortality
μ_1	mean size at age t_1
μ_2	mean size at age t_2
σ_L	standard deviation of maximum *SCL*

Interim and other variables:

a_0	age when *SCL* = 0 (original von Bertalanffy parameter that was reassigned)
C_{ya}	number of mortalities from shrimp trawls
CV	growth coefficient of variation
D_{ya}	total number of mortalities
F_{ya}	instantaneous fishing mortality in year *y* of age *a*
f_{yj}	expected length frequency of strandings in year *y* and interval *j*
l_i	expected *SCL* for the i^{th} individual turtle
$\tilde{l}_i$	*SCL* for the i^{th} individual turtle
Δl_i	expected increment in *SCL* for the i^{th} turtle
l_a	expected *SCL* at age *a*
L_∞	*SCL* length at infinity (original von Bertalanffy parameter that was reassigned)
M_a	instantaneous natural mortality for age *a*
N_{ya}	predicted number of female turtles in year *y* of age *a*
P_y	predicted nests in year *y*
p_{ya}	expected age composition by year *y* and age *a*
s_a	selectivity of strandings of age *a*
S^2	sample variance
Z_{ya}	instantaneous total mortality in year *y* of age *a*
ε_i	error in i^{th} individual *SCL* observation
σ_a	standard deviation of individual *SCL* at age *a*
σ_i	standard deviation of i^{th} individual turtle

Negative Log Likelihoods:

L	model objective function
L_{prior}	prior information for fundamental parameters
L_p	observed nests
$L_{\Delta t}$	*SCL* growth at release-recapture event
L_f	length frequency of strandings

Table 2. Habitat score to reflect susceptability of Kemp's ridley to shrimping.

Area	Inshore	< 10 fm	20-30 fm	>30 fm
US 1	2	4	2	1
US 2	4	7	4	1
US 3	4	7	4	1
US 4	3	8	4	1
Mexico 1	-	10	10	10
Mexico 2	-	4	2	1

Table 3. Fundamental parameter estimates and population size with standard deviations (SD).

Parameter	Notation	Estimate	SD
Mortality:			
Instan. mortality (age 0 and 1)	M_P	1.330	0.117
Instan. mortality 2010 event	M_{2010}	0.345	0.118
Catchability (age 2-4)	q_1	0.200	0.040
Catchability (age 5+)	q_2	0.155	0.014
TED multiplier	X_{TED}	0.233	0.069
Growth:			
Size at age 1	μ_1	17.2	0.51
Size at age 10	μ_2	58.0	0.63
von Bertalanffy growth coef.	K	0.232	0.013
Individ. length variation (SD)	σ_L	9.37	0.56
Selectivity:			
Age when 50%	a_{50}	1.75	0.22
Slope	a_{sl}	0.552	0.071
Terminal population size (2012)			
Ages 2-4		90,706	18,293
Ages 5+		98,007	14,856
Ages 2+		188,713	32,529

Table 4. Mortalities assigned to shrimp trawls in comparison to total mortalities with the 2010 mortality event set to ages 2+ and 9+.

	a_{2010} = 2			a_{2010} = 9		
Year	Shrimp Trawl	Total	Percent	Shrimp Trawl	Total	Percent
1980	912	1,344	67.8	922	1,355	68.0
1981	1,210	1,751	69.1	1,227	1,769	69.3
1982	1,504	2,191	68.7	1,526	2,214	68.9
1983	1,489	2,124	70.1	1,509	2,144	70.4
1984	1,703	2,392	71.2	1,724	2,415	71.4
1985	1,726	2,419	71.4	1,746	2,439	71.6
1986	1,827	2,436	75.0	1,845	2,455	75.2
1987	2,222	2,895	76.8	2,246	2,919	76.9
1988	1,905	2,578	73.9	1,925	2,598	74.1
1989	2,051	2,715	75.5	2,073	2,737	75.7
1990	511	1,210	42.2	512	1,212	42.3
1991	659	1,532	43.0	662	1,537	43.1
1992	741	1,766	42.0	745	1,775	42.0
1993	802	1,990	40.3	807	2,001	40.4
1994	920	2,265	40.6	926	2,278	40.7
1995	947	2,490	38.0	953	2,505	38.1
1996	1,097	2,752	39.9	1,105	2,769	39.9
1997	1,379	3,254	42.4	1,389	3,274	42.4
1998	1,473	3,510	42.0	1,483	3,533	42.0
1999	1,677	3,884	43.2	1,688	3,910	43.2
2000	1,799	4,293	41.9	1,811	4,322	41.9
2001	2,093	4,945	42.3	2,109	4,979	42.4
2002	2,544	5,904	43.1	2,564	5,946	43.1
2003	2,812	7,427	37.9	2,837	7,483	37.9
2004	2,508	7,640	32.8	2,531	7,697	32.9
2005	1,937	7,952	24.4	1,955	8,011	24.4
2006	2,404	9,580	25.1	2,425	9,649	25.1
2007	2,459	10,474	23.5	2,479	10,550	23.5
2008	2,525	12,114	20.8	2,546	12,202	20.9
2009	3,679	15,291	24.1	3,709	15,403	24.1
2010	2,884	65,505	4.4	3,346	26,637	12.6
2011	2,888	13,978	20.7	3,956	19,260	20.5
2012	3,328	16,128	20.6	4,592	22,363	20.5

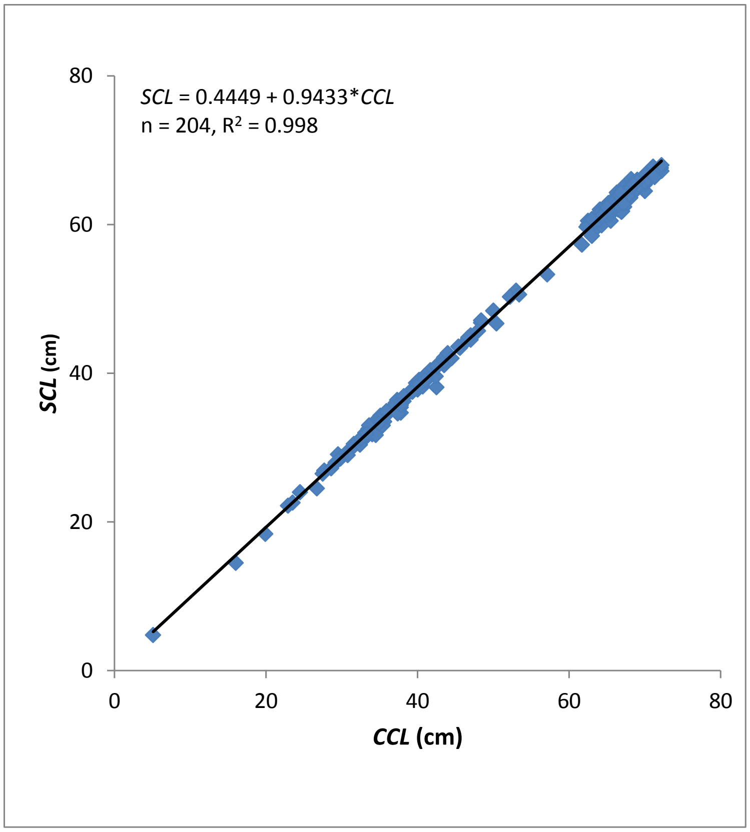


Figure 1. Relationship for conversion of *CCL* to *SCL*.

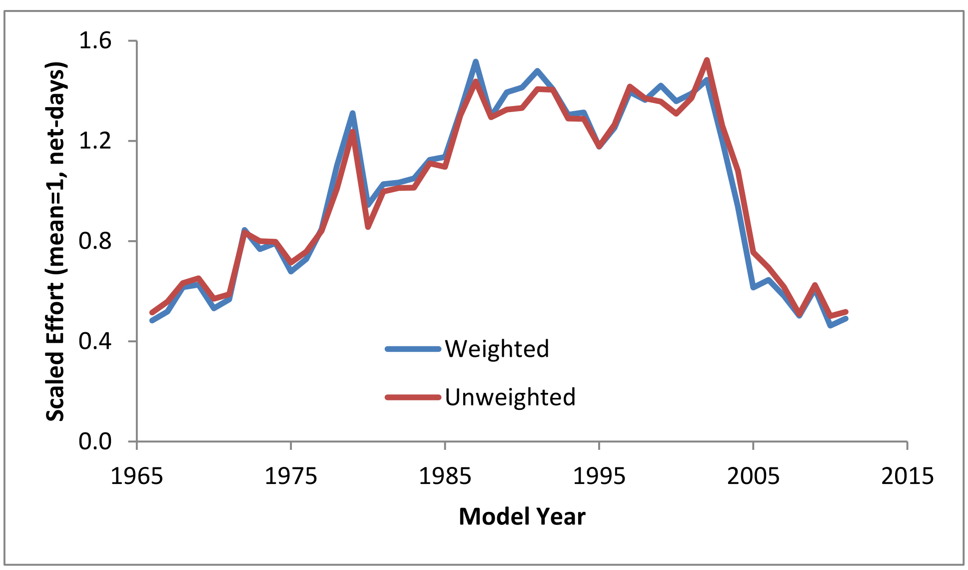


Figure 2. Scaled directed effort weighted by the habitat scores (Table 2) and unweighted (equal habitat scores).

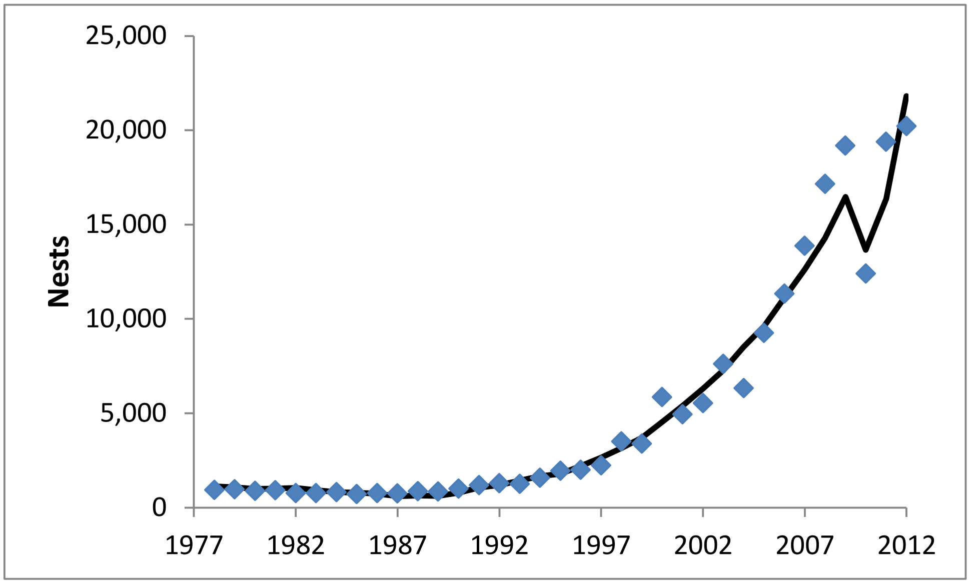


Figure 3. Observed (points) and predicted (line) nests.

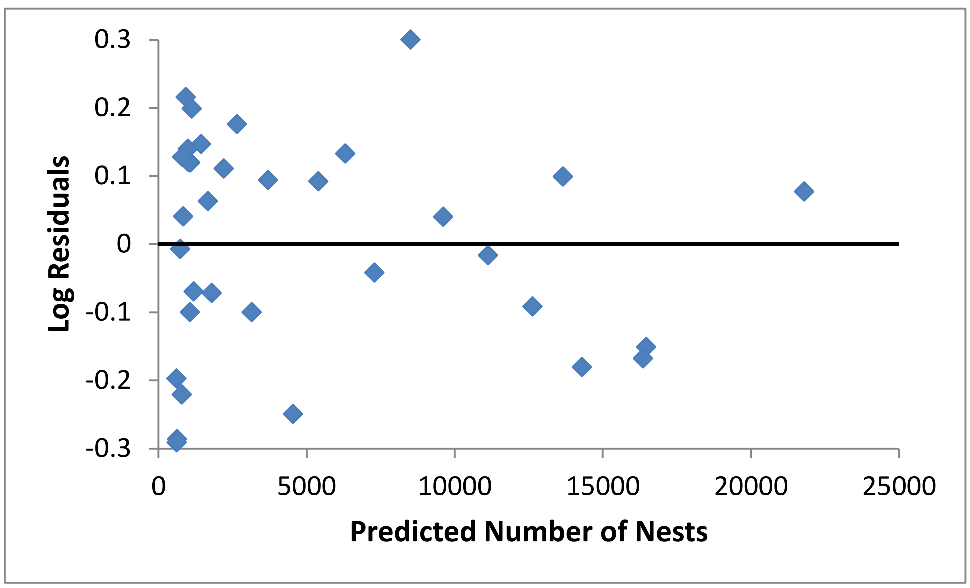


Figure 4. Log residuals versus predicted number of nests.

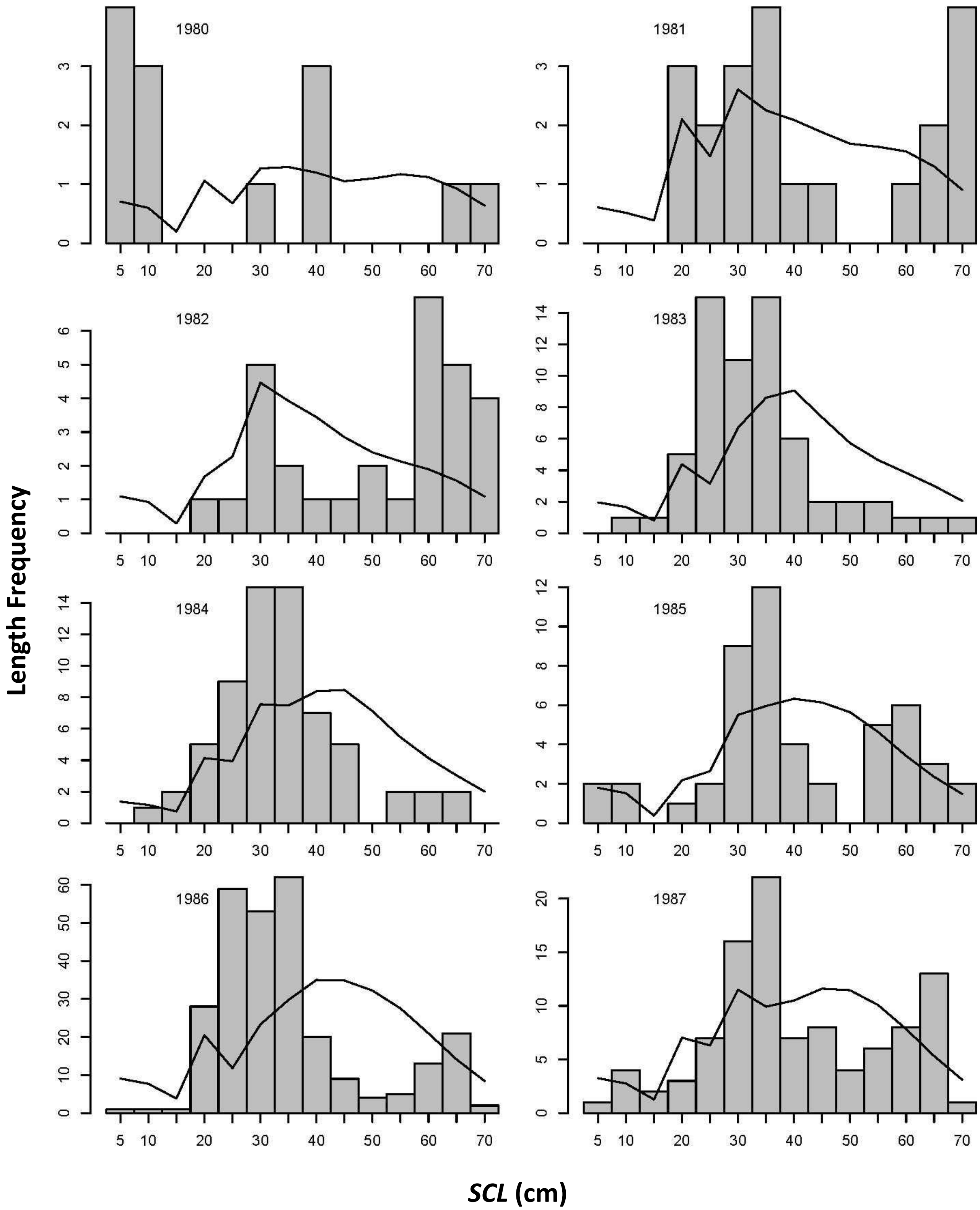


Figure 5. Length frequency data (histogram) and model fit (line).

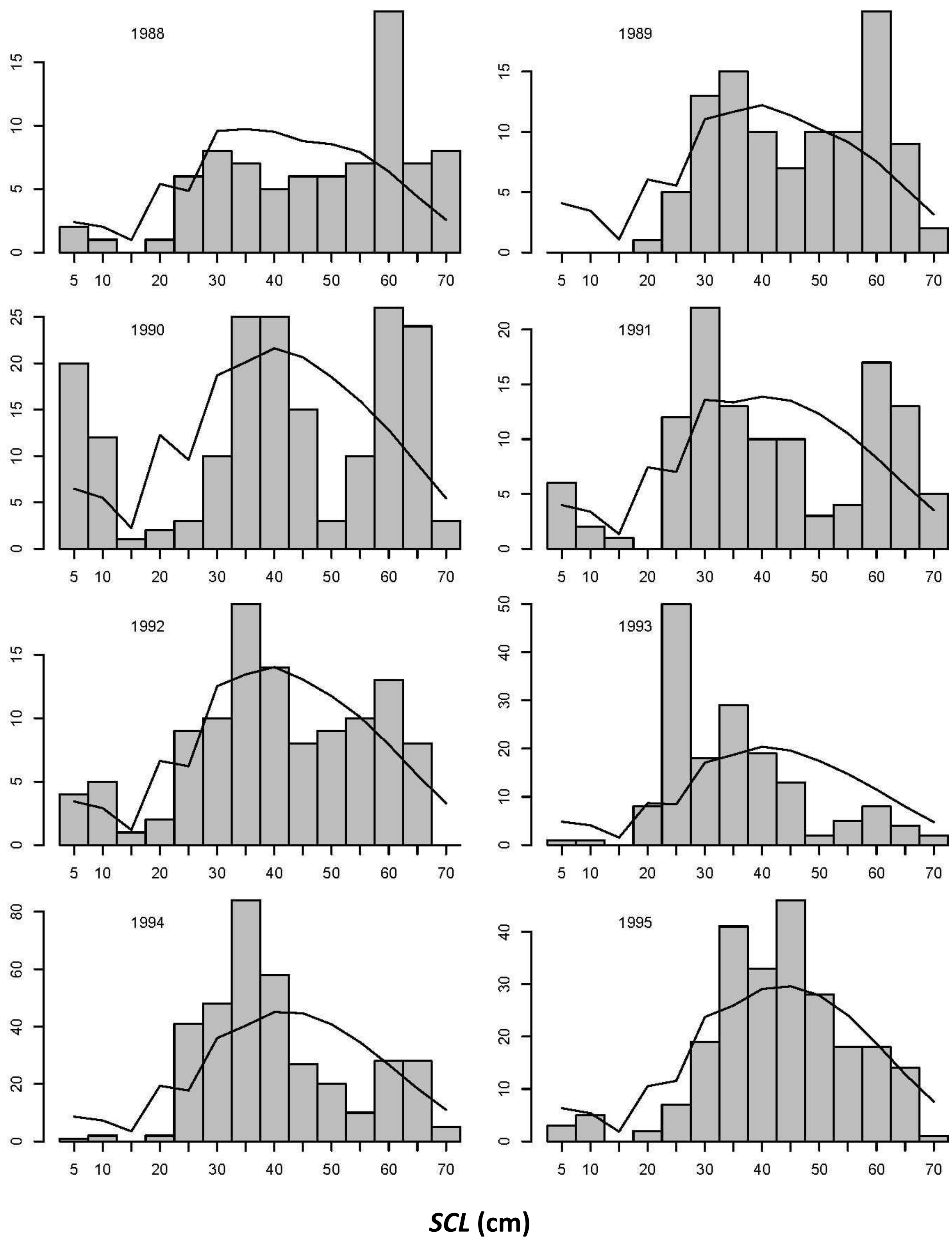


Figure 5. Continued …

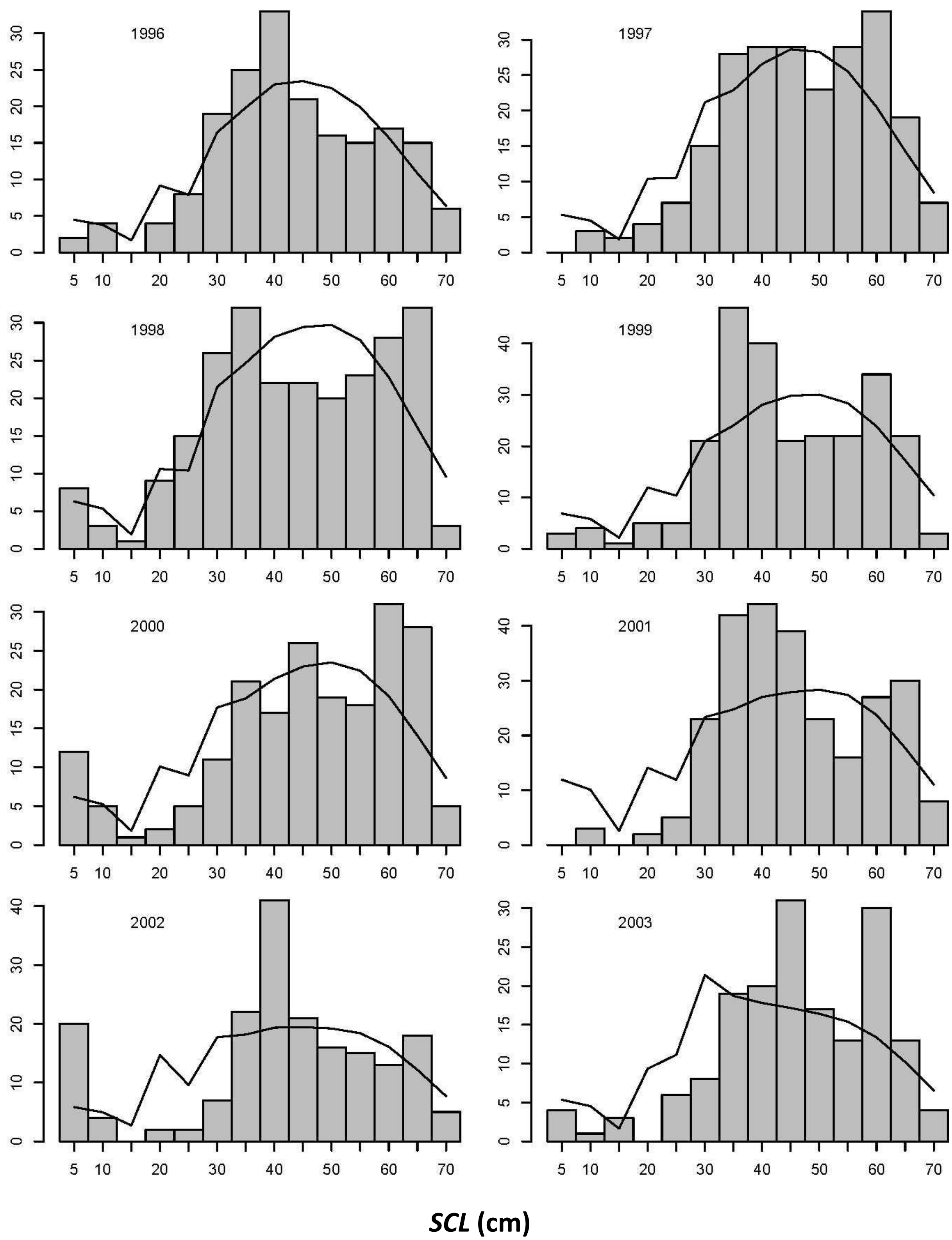
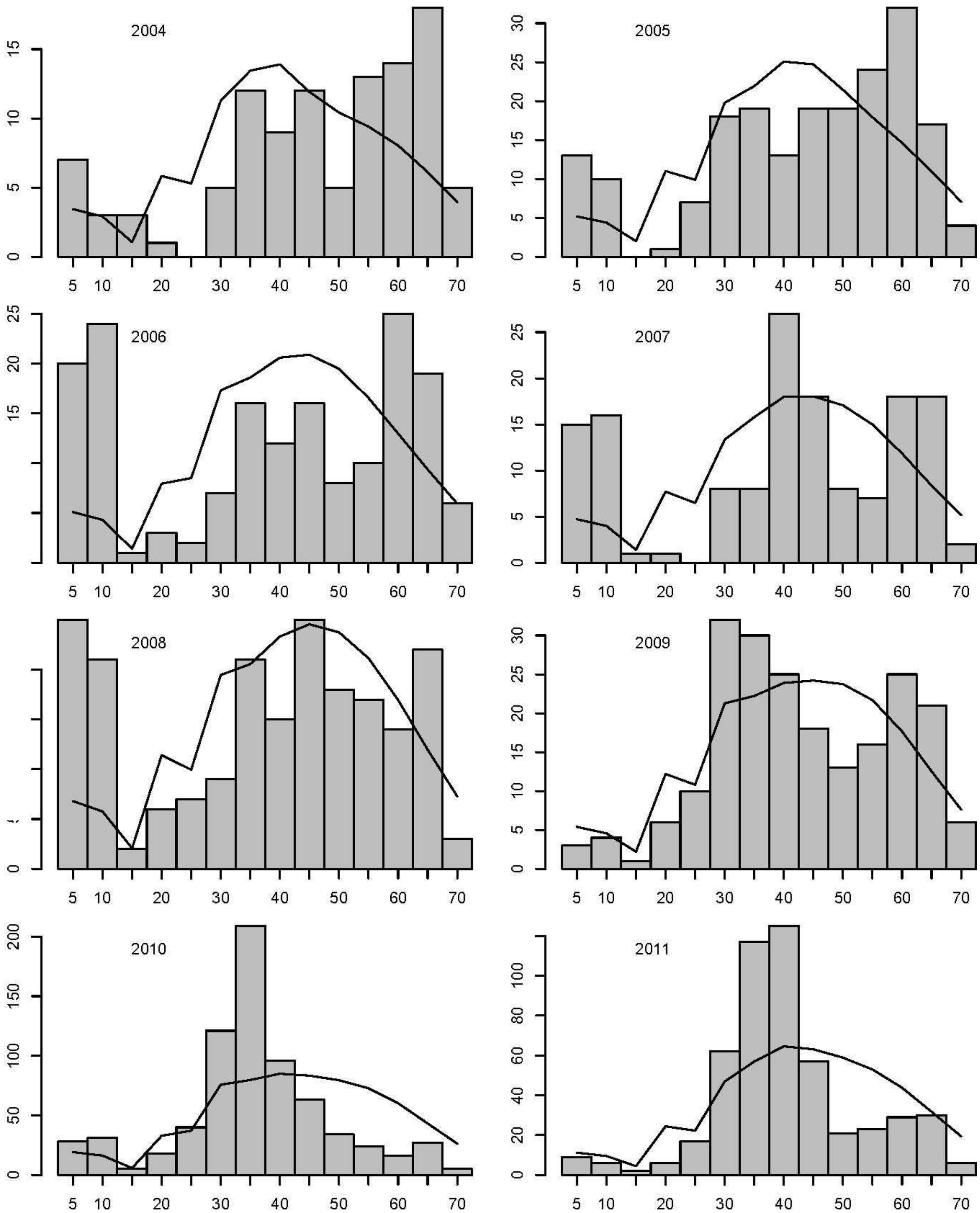


Figure 5. Continued …



SCL **(cm)**

Figure 5. Continued …

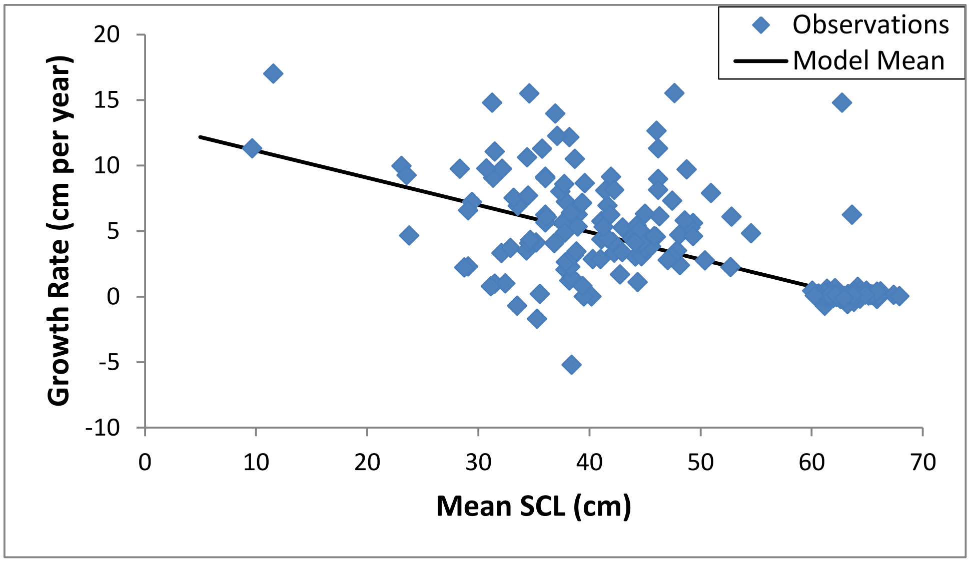


Figure 6. Growth rate (cm/yr) as a function of the mean *SCL* interval (points) and the predicted model mean (line).

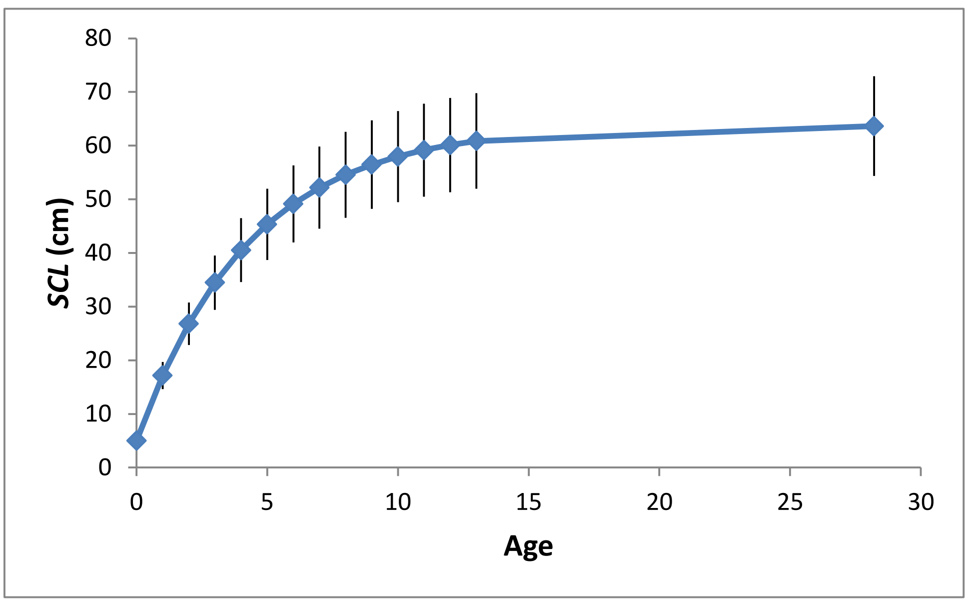


Figure 7. Von Bertalanffy growth with associated error by age (± 1 SD). The last point is the mean age of the 14+ age-class in 2012.

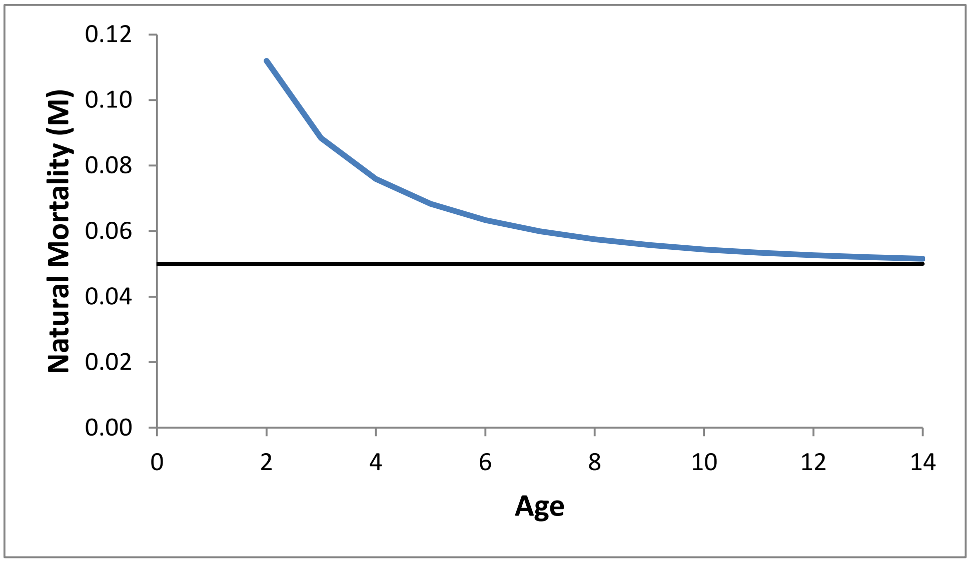


Figure 8. Lorenzen curve for instantaneous natural mortality

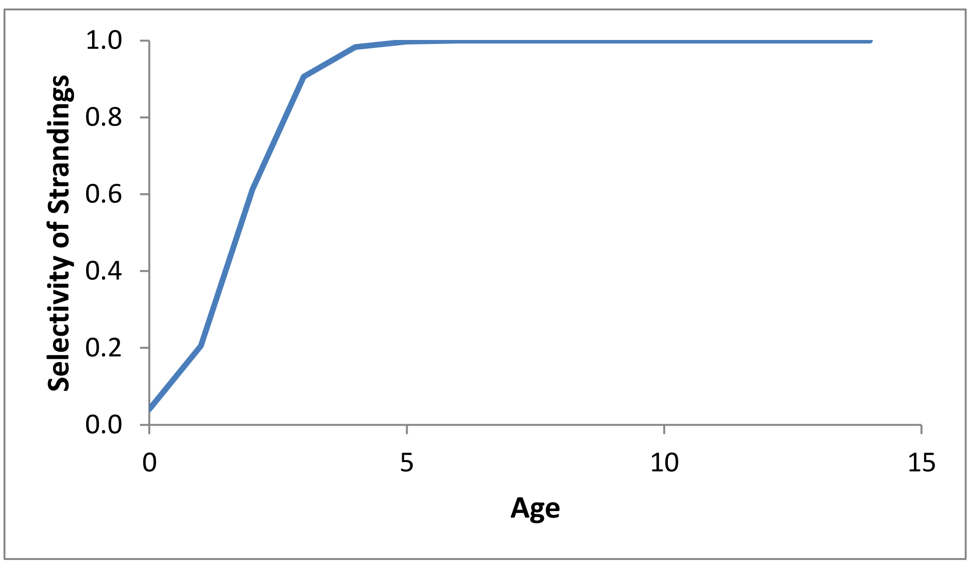


Figure 9. Selectivity of strandings by age.

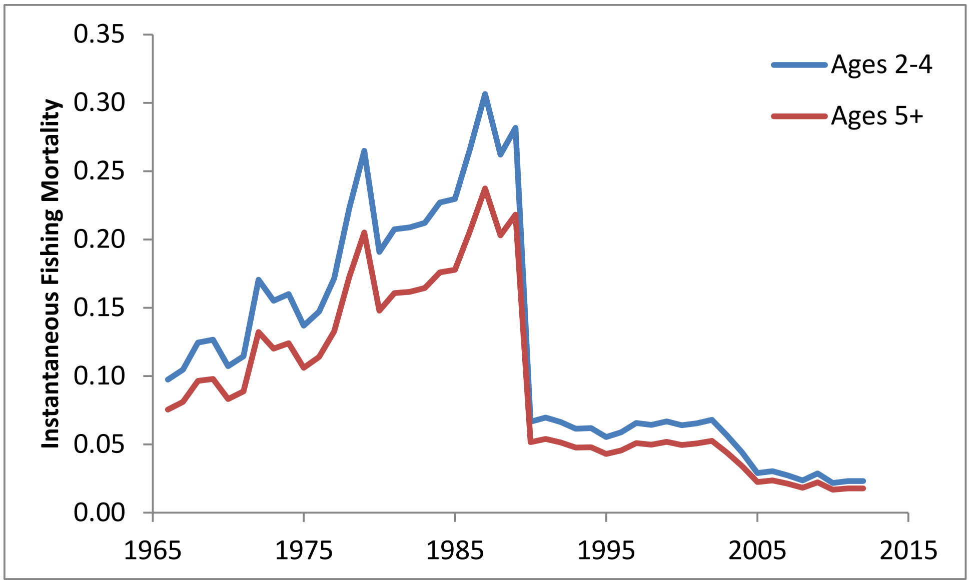


Figure 10. Instantaneous fishing mortality by year.

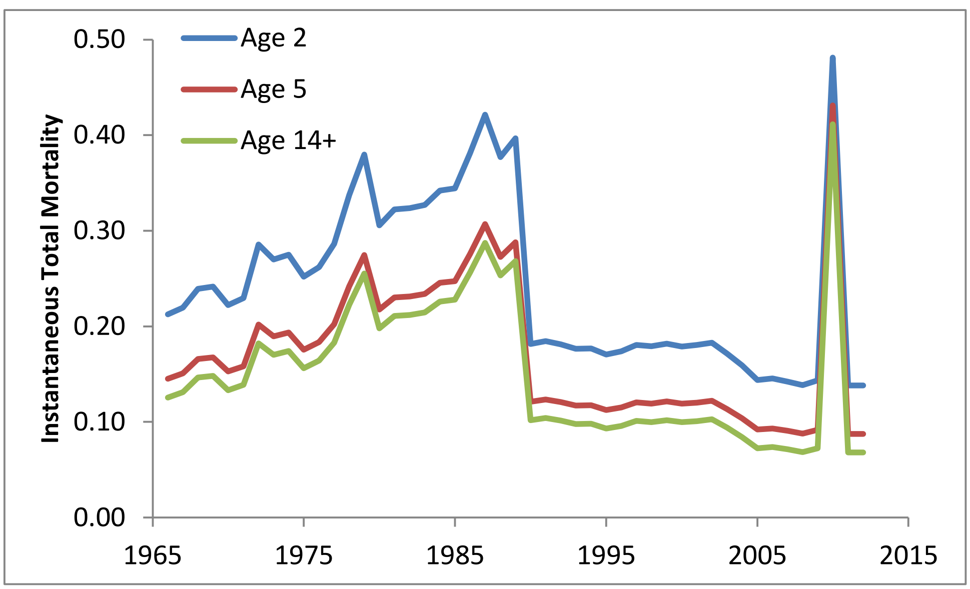


Figure 11. Instantaneous total mortality by year.

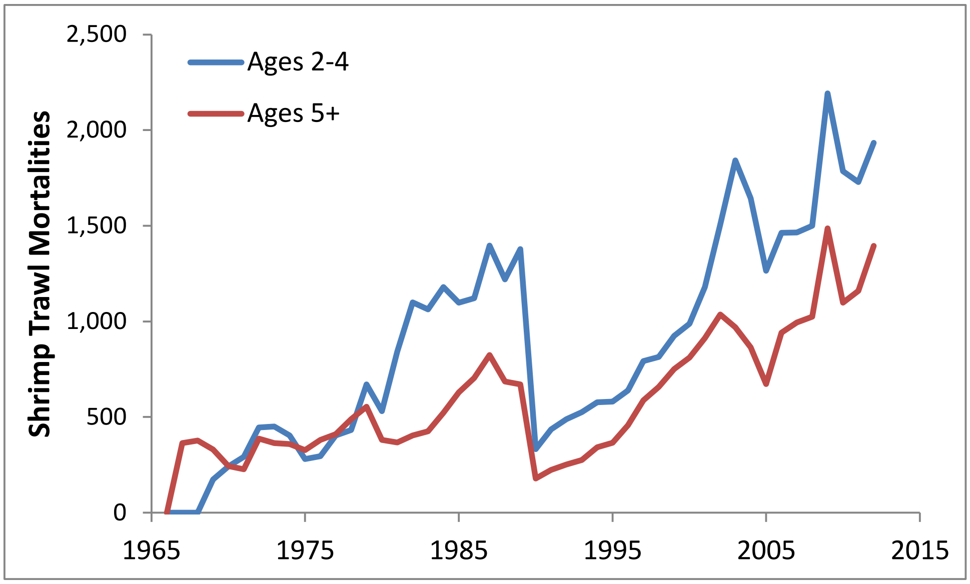


Figure 12. Mortalities assigned to shrimp trawls.

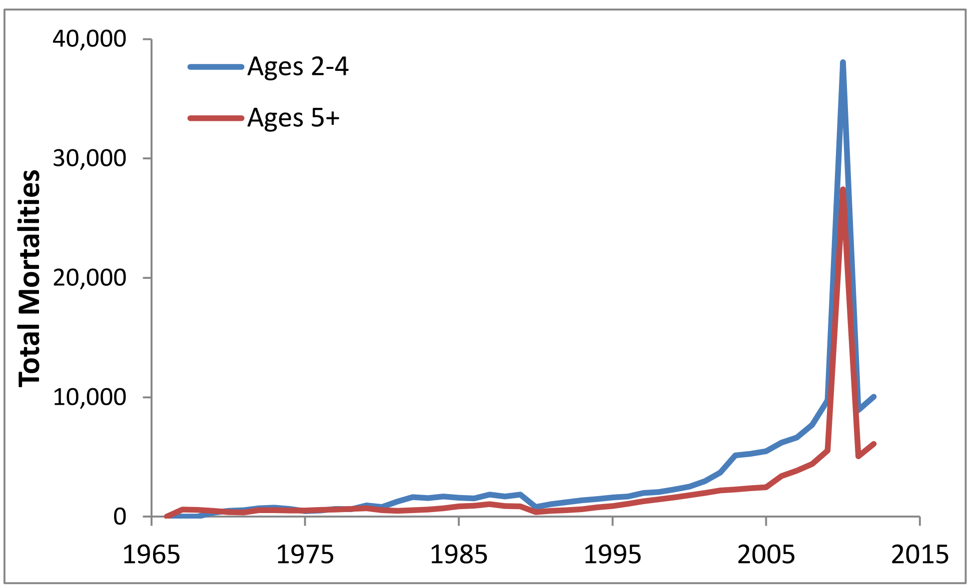


Figure 13. Total mortalities.

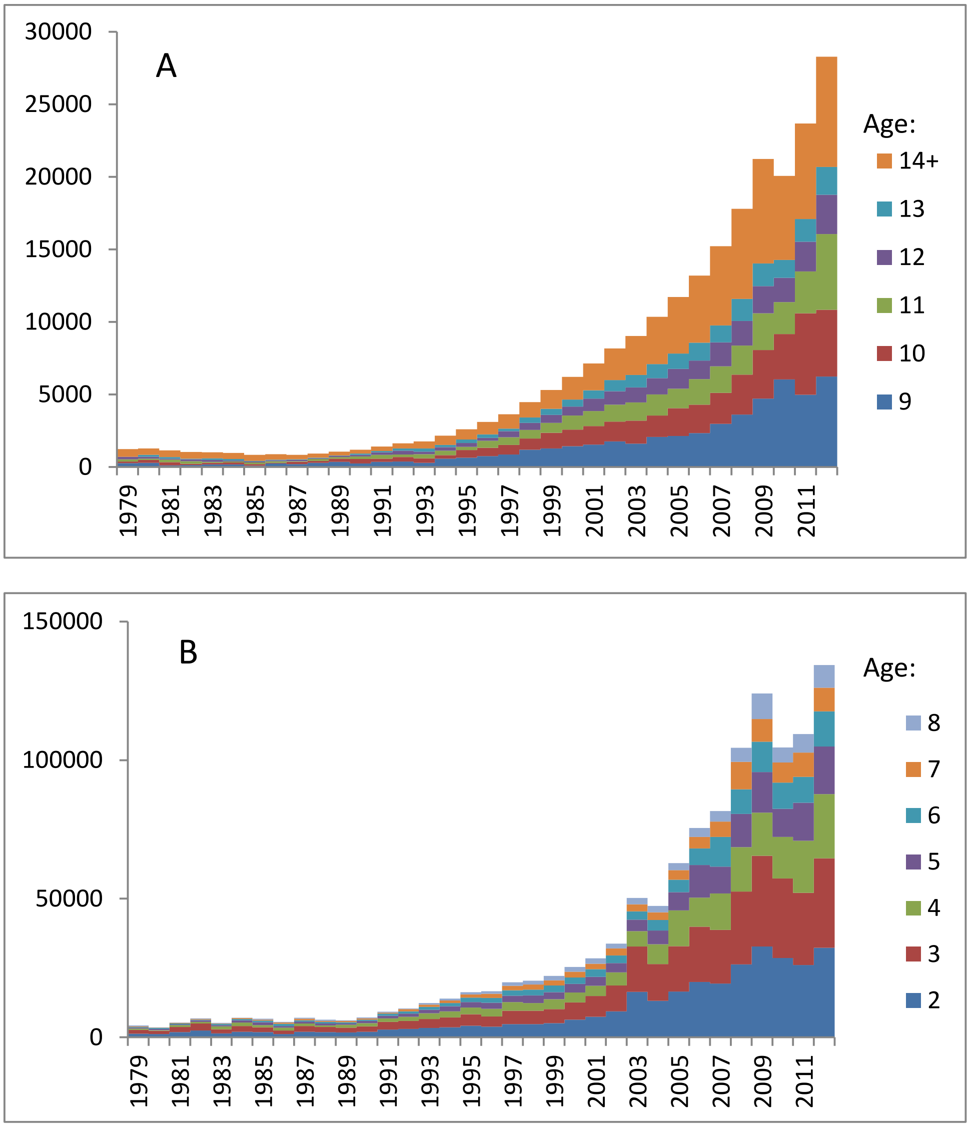


Figure 14. Estimated population size by year and age class. Panel A shows ages 9 to 14+. Panel B shows ages 2 to 8.

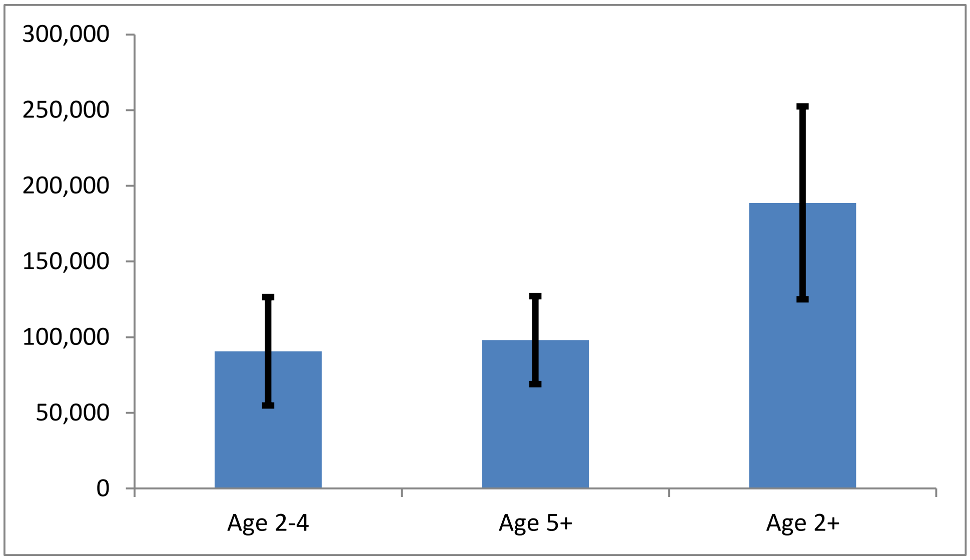


Figure 15. Terminal (2012) population estimates with the 95% confidence interval for ages 2-4, 5+ and 2+ (see Table 3).

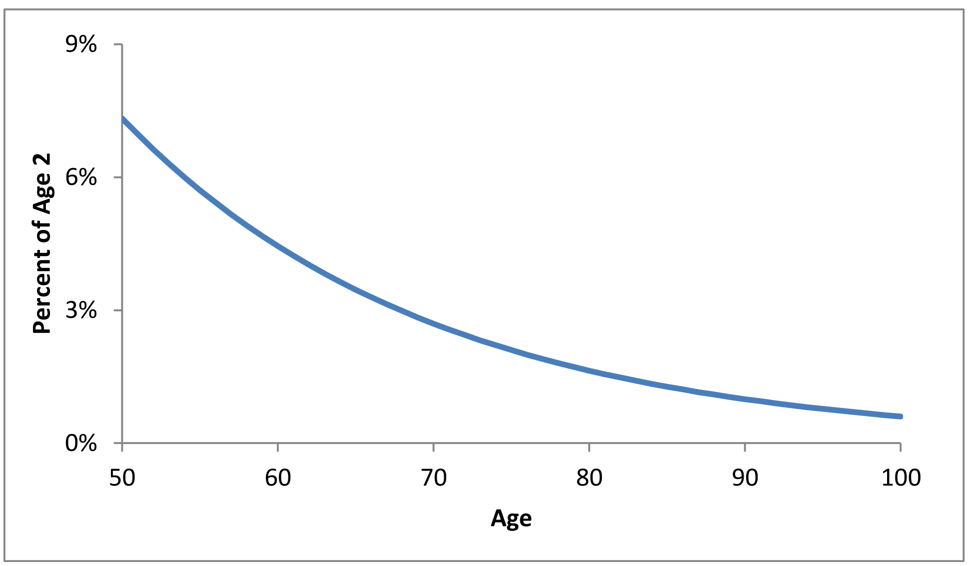


Figure 16. Percent of age 2 turtles, in the absence of shrimping, that would reach very old age (50 to 100 years).

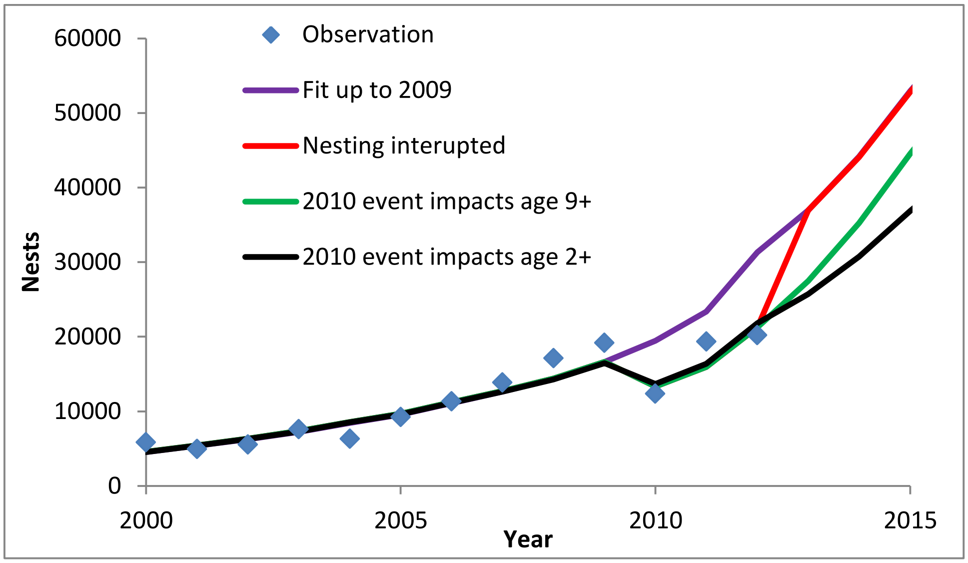


Figure 17. Predicted number of nests for some alternative models to account for the 2010 event with projections to 2015. The “Fit up to 2009” used 2009 terminal mortalities and population by age estimates to make the 2010 through 2015 projections. Similarly, the remaining alternatives used 2012 terminal mortalities and population by age estimates to make the 2013 through 2015 projections.

Appendix A. Listing of data input to the synthesis model.

```
#control flags
# 1 - 2010 event
#   -  value of 1 ... all to die
#   -  value of 2 ... ages 10-14+ die (minimum to get the same result)
#   -  value of 3 ... turtles lost in 2010 are added back for 2013
projection
1 0 0
#index (Index+1 is the plus age)
14
#maturity schedule
#1  2  3  4  5  6  7  8  9  10  11  12  13  14  15+
# 0  0  0  0  0  0  0  0  0  .1 .25  .5 .75  .9   1
 0  0  0  0  0  0  0  0  0 0 0 1 1 1 1
#Nests/female
2.5
#Remigration interval (yr)
2
#primary sex ratio for insitu and corral
0.64  0.76
#year to start mortality multiplier
1989
#period to fit
1978  2012
#small and large age
1  10
#measurement error
0.5
#priors (mean, std dev)
#small mean (mu1)
17.5 100
#large mean (mu2)
60 100
#von B growth (K)
0.2  10
#individual SD (sigL)
8.0 100
#asymptotic mortality (Mz)
.05 .001
#logistic selectivity (left) 50% age, SD age, slope SD slope
2 10 5 10
#logistic selectivity (right) 50% age, SD age, slope SD slope
#8 10 5 1
#number of years to project
20
#maximum nests protected in corrals
14500
#number of eggs-per-nest
97
#egg survival in-situ and in-corral
0.5  0.678
# number of observations (years)
47
```

```
#year nests  in-situ  corral
1966  5991  0     29100
1967  5519  0     24100
1968  5117  0     15000
1969  4018  0     28400
1970  3017  0     31400
1971  2012  0     13100
1972  1824  0     14600
1973  1643  0     23500
1974  1466  0     23500
1975  1266  0     11100
1976  1110  0     36100
1977  1036  0     30100
1978  924   0     48009
1979  954   0     63996
1980  868   0     37378
1981  897   0     53282
1982  750   0     48007
1983  746   0     32921
1984  798   0     58124
1985  702   0     51033
1986  744   0     48818
1987  737   0     44634
1988  842   0     62218
1989  828   0     66802
1990  992   0     74339
1991  1178  0     79749
1992  1275  0     92116
1993  1241  0     84605
1994  1562  0     107687
1995  1930  0     107688
1996  1981  0     114842
1997  2221  0     141770
1998  3482  0     167168
1999  3369  0     211355
2000  5834  0     365479
2001  4927  0     291268
2002  5525  0     357313
2003  7604  0     433719
2004  6309  7923  413761
2005  9236  14079 555884
2006  11322 26247 688755
2007  13849 192671      709619
2008  17131 74696 731383
2009  19163 257394      767633
2010  12377 18949 644665
2011  19368 236098  953607
2012  20197 276305  953607
#
#Effort (net days)
#Year A1-D0 A1-D1 A1-D2 A1-D3 A2-D0 A2-D1 A2-D2 A2-D3 A3-D0 A3-D1 A3-D2 A3-D3
      A4-D0 A4-D1 A4-D2 A4-D3 M1D1  M1D2  M1D3  M2D1  M2D2  M2D3
1966  1349  6245  26748 106   18641 5923  8368  1339  49815 28288 14044 5520
      6606  12501 50760 1875  2892  11744 434   1948  7908  292
```

1967	1369	3980	24854	141	21571	5451	8472	1233	48987	43806	14553	5353
	4561	10312	65387	5585	1257	7972	681	1297	8224	702		
1968	1852	3724	26345	80	27404	5347	13732	724	55575	45115	14424	5865
	9121	20323	57592	1041	4645	13162	238	4363	12363	223		
1969	1589	3249	27022	319	20419	9181	10883	1646	50389	43005	20830	5477
	9914	26134	76193	2897	2849	8307	316	3069	8947	340		
1970	1407	3336	27661	62	18948	8770	10237	1329	47492	29802	25017	3829
	10474	15392	64554	1794	2262	9485	264	1757	7370	205		
1971	1352	3517	22603	148	19038	9067	9912	1188	54530	37433	19996	5220
	5907	14895	71620	2552	2500	12019	428	1080	5194	185		
1972	1815	7945	29013	133	17346	9091	15188	1172	67146	66619	29737	8935
	8228	29478	93019	3586	6256	19741	761	2727	8606	332		
1973	2327	10924	36947	314	20501	6768	11988	1241	58821	70407	13516	18101
	15980	27780	68950	8005	5173	12840	1491	4600	11418	1326		
1974	2570	10502	36586	325	15081	7785	10574	1120	74014	58610	17159	11075
	8972	42125	69966	8408	7058	11723	1409	4578	7603	914		
1975	2662	13269	36678	294	17429	4498	11542	247	70675	55546	15920	7362
	9962	18606	70197	8004	3234	12201	1391	1127	4251	485		
1976	3120	12743	31909	842	15805	3317	13135	1040	46209	84098	35943	16567
	10462	32392	62372	7605	1193	2296	280	1969	3792	462		
1977	1899	14883	45479	603	15279	12614	14564	253	43044	106512		36262
	12785	13888	46245	58706	7159	12	16	2	58	74	9	
1978	1013	20169	38149	406	24059	9671	10517	683	24623	183086		62343
	11887	9336	52349	64800	3122	10	12	1	0	0	0	
1979	1566	17070	42193	738	34603	9274	9056	1697	45207	230554		55337
	19238	18264	35869	73336	7466	3170	6480	660	6545	13381	1362	
1980	1521	10634	26475	604	15354	7382	6063	593	31459	162525		23485
	5976	17196	40400	56175	11024	3245	4511	885	4656	6473	1270	
1981	1993	20911	45501	466	18839	14481	7515	258	37578	163708		35370
	8079	15681	32379	95499	12570	0	0	0	0	0	0	
1982	2835	13613	41184	333	35375	17607	9853	2565	25257	146256		37206
	14704	21360	45548	92954	10999	0	0	0	0	0	0	
1983	2780	15874	44765	347	36930	24874	11841	1443	24864	156420		30174
	12357	32682	41493	74045	7833	0	0	0	0	0	0	
1984	2601	19172	49062	63	39866	35813	13007	5407	42635	150612		35093
	12272	18040	35676	99533	9294	0	0	0	0	0	0	
1985	2386	17107	46295	74	40804	24421	16632	2113	24801	177436		35156
	15198	16462	40659	86927	14364	0	0	0	0	0	0	
1986	2126	12823	52772	549	38661	18667	12982	990	55953	207616		60617
	17930	21757	33433	116781		12669	0	0	0	0	0	0
1987	2081	12400	48222	418	62111	20557	7115	833	40001	243782		60770
	14127	25289	51951	135783		10430	0	0	0	0	0	0
1988	2655	15083	39447	423	55838	25458	12237	1540	65970	176401		56359
	16413	19381	32807	133035		9595	0	0	0	0	0	0
1989	4876	11879	40640	156	32453	32356	24443	506	60553	216782		44991
	12641	16265	40702	127189		11353	0	0	0	0	0	0
1990	2877	10659	37287	299	38343	31295	20783	642	61462	212190		43807
	1761	25552	46831	133606		14059	0	0	0	0	0	0
1991	1515	6395	40041	577	27411	22794	22997	733	49066	242015		78129
	4850	23956	33714	154983		10775	0	0	0	0	0	0
1992	1468	10565	50749	1310	29252	14729	22708	539	81853	195216		80981
	6117	27721	35131	154269		6246	0	0	0	0	0	0
1993	1144	10300	39490	944	36720	11220	19650	2051	52403	177484		88169
	5845	24122	39974	144686		5642	0	0	0	0	0	0

```
1994  2668  15834 45959 434   30483 16203 15019 2870  70196 184837      59597
      7249  33631 44791 124282      5166  0     0     0     0     0     0
1995  2175  23232 59136 375   32964 17488 18662 2973  44655 167630      60180
      4206  20440 31480 109548      7881  0     0     0     0     0     0
1996  1688  36586 76807 106   23250 8197  16396 2017  42262 176255      57012
      6499  18446 46356 122638      12599 0     0     0     0     0     0
1997  3162  28353 74294 426   27899 11792 23802 1804  52500 176516      98713
      9210  26981 55999 123135      10219 0     0     0     0     0     0
1998  1317  26685 92321 535   20597 16114 26904 1337  43573 199900      69157
      6215  19539 41764 126298      8648  0     0     0     0     0     0
1999  1870  13799 54095 410   32788 22204 21593 2063  51413 230102      68157
      10384 11996 44366 113998      14825 0     0     0     0     0     0
2000  2110  13185 39512 514   26452 15798 25655 1956  52715 209408      77761
      6712  13142 41180 129255      14086 0     0     0     0     0     0
2001  2225  12309 48438 166   31289 13434 24962 2330  58463 220408      83788
      7964  18186 25029 142568      9692  0     0     0     0     0     0
2002  2447  14364 65363 707   41513 18893 25403 2131  80216 186305
      133065      25117 14419 29560 120864      18836 0     0     0     0
      0     0
2003  1752  9988  58093 564   28626 14826 18933 417   84624 152989
      109714      19303 9210  25095 101694      9603  0     0     0     0
      0     0
2004  1313  4573  60009 634   21652 12527 14570 2154  68992 115243      66142
      32869 6278  24077 73415 48321 0     0     0     0     0     0
2005  1072  2673  46206 503   9587  8533  14169 4277  52220 68972 41576 32306
      4901  13892 49032 36664 0     0     0     0     0     0
2006  1036  5266  23740 1882  8193  8392  11299 5320  58070 99456 32225 24316
      1495  11882 44690 17887 0     0     0     0     0     0
2007  410   3690  13798 1438  14849 12885 6136  10350 47145 90008 21126 25256
      2895  15862 30218 19504 0     0     0     0     0     0
2008  108   1983  11437 1035  18692 17920 6272  1995  44735 64856 12764 16851
      1697  20236 24237 15085 0     0     0     0     0     0
2009  3126  3122  19682 3148  17808 19270 6002  3111  59345 82921 20753 15590
      1833  17866 32182 13529 0     0     0     0     0     0
2010  3758  3917  16748 602   16415 4714  1378  1309  44803 58718 16609 24086
      3315  19960 29320 10246 0     0     0     0     0     0
2011  3518  2103  12170 230   17197 9362  3766  5062  58276 58811 31953 9315
      1195  11459 32845 7282  0     0     0     0     0     0
2012  3518  2103  12170 230   17197 9362  3766  5062  58276 58811 31953 9315
      1195  11459 32845 7282  0     0     0     0     0     0
#
#Habitat weight
#(first try) 0.5  1.000 0.200 0.010 0.2   1.000 0.200 0.010 0.5   1.000 0.200
      0.010 0.2   1.000 0.200 0.010 3.300 3.300 3.300
2       4       2       1       4       7       4       1       4       7
4       1       3       8       4       1       10      10      10      4
2    1
#
# number of length freq. years and start year
32 1980
# number of bins, start length and width
14  0  5
#
```

#yr	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66+	Total
1980	4	3	0	0	0	1	0	3	0	0	0	0	1	1	13
1981	0	0	0	3	2	3	4	1	1	0	0	1	2	4	21
1982	0	0	0	1	1	5	2	1	1	2	1	7	5	4	30
1983	0	1	1	5	15	11	15	6	2	2	2	1	1	1	63
1984	0	1	2	5	9	15	15	7	5	0	2	2	2	0	65
1985	2	2	0	1	2	9	12	4	2	0	5	6	3	2	50
1986	1	1	1	28	59	53	62	20	9	4	5	13	21	2	279
1987	1	4	2	3	7	16	22	7	8	4	6	8	13	1	102
1988	2	1	0	1	6	8	7	5	6	6	7	19	7	8	83
1989	0	0	0	1	5	13	15	10	7	10	10	20	9	2	102
1990	20	12	1	2	3	10	25	25	15	3	10	26	24	3	179
1991	6	2	1	0	12	22	13	10	10	3	4	17	13	5	118
1992	4	5	1	2	9	10	19	14	8	9	10	13	8	0	112
1993	1	1	0	8	50	18	29	19	13	2	5	8	4	2	160
1994	1	2	0	2	41	48	84	58	27	20	10	28	28	5	354
1995	3	5	0	2	7	19	41	33	46	28	18	18	14	1	235
1996	2	4	0	4	8	19	25	33	21	16	15	17	15	6	185
1997	0	3	2	4	7	15	28	29	29	23	29	34	19	7	229
1998	8	3	1	9	15	26	32	22	22	20	23	28	32	3	244
1999	3	4	1	5	5	21	47	40	21	22	22	34	22	3	250
2000	12	5	1	2	5	11	21	17	26	19	18	31	28	5	201
2001	0	3	0	2	5	23	42	44	39	23	16	27	30	8	262
2002	20	4	0	2	2	7	22	41	21	16	15	13	18	5	186
2003	4	1	3	0	6	8	19	20	31	17	13	30	13	4	169
2004	7	3	3	1	0	5	12	9	12	5	13	14	18	5	107
2005	13	10	0	1	7	18	19	13	19	19	24	32	17	4	196

```
2006  20    24    1     3     2     7     16    12    16    8     10    25
      19    6     169
2007  15    16    1     1     0     8     8     27    18    8     7     18
      18    2     147
2008  25    21    2     6     7     9     21    15    25    18    17    14
      22    3     205
2009  3     4     1     6     10    32    30    25    18    13    16    25
      21    6     210
2010  28    31    5     18    40    121   209   96    63    34    24    16
      27    5     717
2011  9     6     2     6     17    62    117   125   57    21    23    29
      30    6     510
# growth data
# number of observations
233
# tal   lo      lr
33    31.0  32.0
33    33.9  35.3
34    36.3  37.6
34    40.2  40.2
34    65.7  65.7
35    47.1  47.8
37    30.5  32.0
37    62.0  63.5
39    63.5  63.5
40    46.8  48.5
42    38.7  38.1
44    41.4  42.5
47    23.5  24.1
49    39.5  39.5
52    37.2  38.0
53    44.5  45.1
55    34.9  36.6
58    35.6  36.5
59    34.3  38.1
59    38.9  40.3
60    37.4  38.2
60    52.3  53.3
64    28.9  29.3
66    22.2  24.0
71    33.0  38.4
75    22.6  24.5
76    28.7  30.2
76    47.9  48.4
79    32.8  34.3
82    28.5  29.0
84    43.8  44.5
90    39.3  39.5
97    49.9  52.0
98    40.0  46.2
101   44.3  47.8
104   47.4  48.4
114   33.8  34.9
133   29.7  33.0
```

139	42.0	44.0
144	53.6	55.5
161	30.0	34.3
162	46.6	50.9
167	40.1	42.1
168	43.6	48.8
173	42.8	44.9
225	31.2	31.8
228	47.6	51.1
237	37.8	38.6
239	42.7	45.5
240	34.2	42.2
243	31.0	33.2
251	36.8	41.1
251	44.2	48.4
266	37.1	38.6
276	31.5	34.3
277	47.1	51.1
281	30.3	36.1
284	32.5	39.6
287	32.5	39.6
287	33.6	38.5
288	26.5	31.7
288	26.9	34.6
289	33.8	38.6
292	32.2	42.0
292	51.8	53.6
294	4.7	18.4
295	40.9	43.6
296	24.4	32.3
297	40.4	43.8
298	37.8	39.0
298	43.9	44.8
300	36.0	34.6
302	33.5	36.9
303	34.9	40.9
309	43.4	46.0
312	63.5	63.6
313	4.8	14.5
314	46.2	48.8
318	38.6	43.6
328	33.8	41.0
328	33.9	41.6
332	43.4	46.7
334	42.1	50.3
337	39.6	43.7
339	61.8	62.4
342	36.0	42.7
342	45.9	50.3
355	45.7	48.4
358	38.9	41.7
359	63.4	63.5
364	29.1	39.7
364	64.0	63.6

369	60.5	66.8
370	30.6	38.4
375	60.5	60.7
377	45.6	51.6
378	41.2	44.7
385	43.6	48.4
403	34.6	39.1
405	31.9	33.0
418	34.7	42.0
426	37.6	45.7
473	31.9	45.5
505	42.9	48.2
505	48.5	52.3
530	35.4	35.7
532	40.3	48.2
546	41.5	44.0
574	31.4	37.8
577	37.1	45.5
614	36.4	40.2
616	38.6	43.4
635	35.6	40.2
637	39.1	53.3
655	41.0	48.4
675	61.7	61.3
682	62.4	62.8
685	39.8	49.3
692	62.2	62.4
694	63.8	62.7
700	35.6	41.7
707	30.4	31.9
707	62.1	62.4
717	62.4	62.4
717	63.5	63.5
719	62.8	62.4
722	65.5	65.7
723	60.6	60.6
724	61.4	61.6
724	61.9	60.5
726	65.0	65.2
728	61.5	61.4
729	65.2	65.4
730	62.9	62.8
731	66.1	65.7
733	61.5	61.3
733	63.0	62.7
734	62.2	62.5
735	62.3	62.2
738	60.9	61.5
738	62.1	62.4
740	62.0	61.8
740	65.6	66.0
742	65.5	65.8
743	64.5	65.4
745	61.5	62.0

745	61.5	62.0
745	62.0	62.3
746	61.8	61.8
746	63.6	64.4
749	63.4	64.9
749	65.5	65.7
752	41.1	50.6
754	60.8	62.0
755	39.9	48.4
760	35.4	48.4
763	38.4	51.6
763	61.8	62.0
811	29.9	39.5
840	32.8	45.1
925	31.2	51.7
969	34.3	43.4
1067	64.0	64.5
1072	63.7	65.1
1073	61.3	61.6
1077	60.4	60.6
1078	61.9	61.8
1083	65.6	66.8
1084	61.0	62.0
1085	60.5	60.7
1085	63.6	63.8
1087	63.2	64.4
1088	62.5	62.4
1088	65.5	66.4
1089	59.4	60.7
1093	63.3	63.6
1094	63.3	64.0
1094	64.6	64.1
1094	64.6	65.3
1095	62.9	63.0
1095	63.7	63.8
1100	67.2	67.6
1106	63.6	63.9
1118	61.9	62.0
1119	64.2	64.3
1127	63.4	63.5
1351	27.2	57.3
1432	63.7	64.5
1437	62.2	61.7
1440	62.4	62.5
1445	64.0	63.8
1452	64.9	65.4
1456	65.0	65.3
1459	64.9	65.7
1460	60.9	61.3
1461	60.8	62.4
1461	66.0	66.0
1465	65.2	65.8
1473	60.8	61.3
1480	63.3	63.6

```
1494  61.0  61.3
1703  38.6  60.1
1812  62.8  63.8
1818  63.4  63.9
1819  60.8  62.0
1848  61.5  61.8
1853  61.5  61.6
1853  62.1  62.0
1862  63.2  63.5
2083  35.5  31.5
2154  67.8  68.0
2161  61.6  61.3
2165  62.9  63.0
2179  61.2  61.8
2180  63.9  65.3
2180  64.8  67.0
2188  61.5  62.0
2198  60.5  61.3
2201  63.8  64.3
2215  60.0  61.3
2520  63.2  63.8
2542  60.3  62.0
2549  64.3  65.4
2555  62.0  62.4
2885  59.7  61.3
2905  61.7  62.5
2919  61.9  62.8
2919  63.2  63.9
3316  61.2  62.0
3640  61.6  62.8
3650  63.1  64.3
4034  59.9  60.7
4037  63.6  62.3
#  read check
1214
```

Appendix B. Listing of synthesis model code.

```
DATA_SECTION
  //inputs
  init_ivector flag(1,3)     //control flags
  init_int agemat      //age of maturity
  init_number nestpf         //nests per female
  init_number brint          //breeding interval
  init_vector sexr(1,2)            //sex ratio
  init_int multyear          //year to multiply mortality
  init_ivector fityear(1,2)  //years for fit
  init_int h1                //small age
  init_int h2                //large age
  init_number sigm           //measurement error
  init_number pmu1           //prior small mean
  init_number sdmu1          //prior small sd
  init_number pmu2           //prior large mean
  init_number sdmu2          //prior large sd
  init_number pK       //prior von B coeff
  init_number sdK      //prior von B coeff sd
  init_number psigL          //prior ind. length sd
  init_number sdsigL         //prior ind. length sd sd
  init_number pMinf          //prior asymptotic mortality
  init_number sdMinf         //prior asymptotic mortality sd
  init_number pa50           //prior 50% age for selectivity (left)
  init_number sda50          //prior 50% age for selectivity sd (left)
  init_number pasl           //prior slope for selectivity (left)
  init_number sdasl          //prior slope for selectivity sd (left)
  //init_number pb50         //prior 50% age for selectivity (right)
  //init_number sdb50        //prior 50% age for selectivity sd (right)
  //init_number pbsl         //prior slope for selectivity (right)
  //init_number sdbsl        //prior slope for selectivity sd (right)
  init_int pyear                   //number or years to project
  init_number pnest          //maximum nests protected in corrals
  init_number pegg                 //number of eggs-per-nest
  init_vector pS(1,2)        //egg survival
  init_int nyears            //number of years
  init_matrix nhobs(1,nyears,1,4)  //nest and hatching observations
  init_matrix effobs(1,nyears,1,23)     //nominal days fished
observations
  init_vector habwt(1,22)          //habitat weights
  init_int nlfyears                //number of length freq years
  init_int syear             //start year for length freq
  init_int nbins             //number of length freq bins
  init_number slen                 //start length of first length freq
bin
  init_number width                //bin width
  init_matrix lfobs(1,nlfyears,1,nbins+2)     //length freq
observations
  init_int nlenobs
  init_matrix Xlen(1,nlenobs,1,3)
  init_int readchk                 //read check
  !!cout << readchk << endl;
```

```
  //data
  vector nests(1,nyears)
  vector  hatch(1,nyears)
  vector eff(1,nyears)
  vector v(1,nbins)
  vector t_lr(1,nlenobs)                           //length at
recapture
  vector t_l0(1,nlenobs)                          //length at release
   vector t_dt(1,nlenobs)                          //time at large
  int fyears
  matrix t_lf(1,nlfyears,1,nbins)
  vector t_n(1,nlfyears)
 LOCAL_CALCS
    //bin mid points
   v.fill_seqadd(slen+0.5*width,width);
   //extract nests, hatchlings and effort
   int i,j;
   for (j=1;j<=nyears;j++)
    {
      nests(j)=nhobs(j,2);
      hatch(j)=nhobs(j,3)*sexr(1)+nhobs(j,4)*sexr(2);
      eff(j)=0.0;
      for (int k=1;k<=22;k++) eff(j)+=effobs(j,k+1)*habwt(k);
    }
   //scale
   fityear(1)=fityear(1)-1965;
   fityear(2)=fityear(2)-1965;
   syear=syear-1965;
   fyears=fityear(2)-fityear(1)+1;
   multyear=multyear-1966+1;
   eff/=mean(eff);
   //extract length freq
   for (i=1;i<=nlfyears;i++)
      {
      t_n(i)=lfobs(i,nbins+2);
      for (j=1;j<=nbins;j++)
         t_lf(i,j)=lfobs(i,j+1)/t_n(i);
      }
    //extract marck recap lengths
   t_l0=column(Xlen,2);
   t_lr=column(Xlen,3);
   t_dt=column(Xlen,1);
   t_dt/=365;
   cout<<t_dt<<endl;

 END_CALCS

PARAMETER_SECTION
  objective_function_value f
  //fundamental
  init_bounded_number Zhatch(.01,3,2)
  init_bounded_vector q(1,2,1e-12,4,2)
  init_bounded_number multiply(.01,3,2)
  init_bounded_number M2010(.01,3,2)
```

```
  init_bounded_number mu1(0.1,30,1)
  init_bounded_number mu2(31,100,1)
  init_bounded_number K(.01,1,1)
  init_bounded_number sigL(.1,15.,1)
  init_bounded_number Minf(.01,.2,2)
  init_bounded_number a50(1,4,2)
  init_bounded_number asl(.01,10,2)
  //init_bounded_number b50(4,12,2)
  //init_bounded_number bsl(.01,10,2)
  //interim
  matrix Z(1,nyears,1,agemat+1)
  vector M(1,agemat+1)
  vector epsilon(1,fyears)
  vector pred(1,nyears)
  matrix lf(1,nlfyears,1,nbins)
  vector el(1,agemat+1)
  vector ev(1,agemat+1)
  vector sel(1,agemat+1)
  matrix N(1,nyears,1,agemat+1)
  matrix F(1,nyears,1,agemat+1)
  matrix C(1,nyears,1,agemat+1)
  matrix TM(1,nyears,1,agemat+1)
  matrix pN(1,pyear,1,agemat+1)
  vector ppred(1,pyear);
  //sd report
  sdreport_vector totalN(1,3)

  PROCEDURE_SECTION
     calc_priors();
     get_length_mr();
     calc_mortality();
     calc_numbers();
     get_lf();
     get_totalN();
     calc_obj();
     //if (last_phase()) get_proj();

FUNCTION calc_priors
  f=0.0;
  f+=dnorm(mu1,pmu1,sdmu1);
  f+=dnorm(mu2,pmu2,sdmu2);
  f+=dnorm(K,pK,sdK);
  f+=dnorm(sigL,psigL,sdsigL);
  f+=dnorm(Minf,pMinf,sdMinf);
  f+=dnorm(a50,pa50,sda50);
  f+=dnorm(asl,pasl,sdasl);
  //f+=dnorm(b50,pb50,sdb50);
  //f+=dnorm(bsl,pbsl,sdbsl);

FUNCTION get_length_mr
   dvariable xx=exp(-(h2-h1)*K);
   dvar_vector qq=1.-exp(-K*t_dt);
   dvar_vector lhat=elem_prod(mu2-t_l0+xx*(t_l0-mu1),qq/(1.-xx))-(t_lr-
t_l0);
```

```
   dvar_vector tmp1=square(sigm)*(1.+exp(-2.*K*t_dt));
   dvar_vector tmp2=square(sigL*qq);
   dvar_vector sdt=sqrt(tmp1+tmp2);
   f+=dnorm(lhat,sdt);

FUNCTION calc_mortality
  int i,j,h;
  F.initialize();
  M(1)=Zhatch;
  M(2)=Zhatch;
  for (i=1;i<=nyears;i++)
  {
     Z(i,1)=Zhatch;
     Z(i,2)=Zhatch;
     for (j=3;j<=agemat+1;j++)
     {
        if (j<6)
           h=1;
        else
           h=2;
      if (i>multyear)
         F(i,j)=q(h)*eff(i)*multiply;
      else
         F(i,j)=q(h)*eff(i);
      if (j<agemat+1)
         M(j)=Minf/K*log((exp(K*j)-1)/(exp(K*(j-1))-1));
      else
         M(j)=Minf;
      Z(i,j)=M(j)+F(i,j);
     }
  }
  if (flag(1)==1) for (j=1;j<=agemat+1;j++) Z(45,j)+=M2010;
  if (flag(1)>1) for (j=10;j<=agemat+1;j++) Z(45,j)+=M2010;

FUNCTION calc_numbers
  int i,j;
  C.initialize();
  N(1)(1,agemat)=0.0;
  N(1,agemat+1)=nests(1)*brint/nestpf;
  for (i=1;i<=nyears;i++)
  {
     TM(i,1)=hatch(i)*(1-exp(-Z(i,1)));
     N(i,1)=hatch(i)*exp(-Z(i,1));
  }
  for (i=2;i<=nyears;i++)
  for (j=2;j<=agemat;j++)
  {
     TM(i,j)=N(i-1,j-1)*(1-exp(-Z(i,j)));
     C(i,j)=F(i,j)/Z(i,j)*N(i-1,j-1)*(1-exp(-Z(i,j)));
     N(i,j)=N(i-1,j-1)*exp(-Z(i,j));
  }
  for (i=2;i<=nyears;i++)
  {
```

```
    TM(i,agemat+1)=(N(i-1,agemat)+N(i-1,agemat+1))*(1-exp(-
Z(i,agemat+1)));
    C(i,agemat+1)=F(i,agemat+1)/Z(i,agemat+1)*(N(i-1,agemat)+N(i-
1,agemat+1))*(1-exp(-Z(i,agemat+1)));
    N(i,agemat+1)=(N(i-1,agemat)+N(i-1,agemat+1))*exp(-Z(i,agemat+1));
  }
  for (i=1;i<=nyears;i++)
pred(i)=(N(i,agemat)+N(i,agemat+1))*nestpf/brint;

FUNCTION get_lf
   //mean growth and selectivity
   dvariable diffsize=mu2-mu1;
   dvariable lscale=exp(-K*(h2-h1));
   dvariable a;
   int i,j;
   for (i=1;i<=agemat+1;i++)
      {
      a=i-1;
      if (i==agemat+1) a=agemat+1/(1-exp(-Z(nyears,agemat+1)));
      el(i)=mu1+diffsize*(1-exp(-K*(a-h1)))/(1-lscale);
      ev(i)=square(sigm)+square(sigL)*square(1-exp(-K*(a-
h1))*diffsize/(mu2-mu1*lscale));
      //sel(i)=1/(1+exp((a50-i+1)/asl))*(1-1/(1+exp((b50-i+1)/bsl)));
      sel(i)=1/(1+exp((a50-i+1)/asl));
      }
   sel/=max(sel);
   //predicted length frequency
   lf.initialize();
   dvar_vector tmp(1,nbins);
   for (i=1;i<=nlfyears;i++)
      {
      for (j=1;j<=agemat+1;j++)
         {
         tmp=exp(-0.5*square(v-el(j))/ev(j));
         tmp/=sum(tmp);
         tmp*=N(syear+i-1,j)*sel(j);
         lf(i)+=tmp;
         }
      lf(i)/=sum(lf(i));
      }

FUNCTION calc_obj
  int i;
  //nests
  for (i=fityear(1);i<=fityear(2);i++) epsilon(i-
fityear(1)+1)=log(pred(i))-log(nests(i));
  dvariable std=sqrt(var(epsilon));
  f+=dnorm(epsilon,std);
  //length freq
  const double eps=0.01/nbins;
  dvariable lv;
  dvariable tmp=0.0;
  for (i=1;i<=nlfyears;i++)
     {
```

```
      if (t_n(i)>0)
         {
         lv=t_lf(i)*log(eps+lf(i));
         tmp-=sqrt(t_n(i))*lv;
         }
      }
   f+=tmp;

FUNCTION get_totalN
   totalN(1)=sum(N(fityear(2))(3,6));
   totalN(2)=sum(N(fityear(2))(7,agemat+1));Zhatch;
   totalN(3)=totalN(1)+totalN(2);

FUNCTION get_proj
   int i,j,jj;
   int y=fityear(2);
   dvariable shatch,chatch,Ztot;
   //estimate 2011 and 2012 hatchlings (index 46 and 47)
   if (flag(2))
   {
      for (i=46;i<=47;i++)
      {
         if (pred(i)>pnest)
         {
            shatch=(pred(i)-pnest)*pegg*pS(1);
            chatch=pnest*pegg*pS(2);
         }
         else
         {
            shatch=0.0;
            chatch=pred(i)*pegg*pS(2);
         }
         if (i==46)
         {
            N(i+1,1)=shatch*sexr(1)+chatch*sexr(2);
            TM(i+1,1)=N(i+1,1)*(1-exp(-Z(i+1,1)));
            N(i+1,1)*=exp(-Z(i+1,1));
         }
         else
            pN(1,1)=(shatch*sexr(1)+chatch*sexr(2))*exp(-Z(i,1));
      }
   }
   else
      pN(1,1)=hatch(y)*exp(-Z(y,1));
   //first year
   for (i=2;i<=agemat;i++) pN(1,i)=N(y,i-1)*exp(-Z(y,i));
   pN(1,agemat+1)=(N(y,agemat)+N(y,agemat+1))*exp(-Z(y,agemat+1));
   if (flag(1)==3)
   {
      for (j=10;j<=agemat+1;j++)
      {
         Ztot=0.0;
         for (i=45;i<=47;i++)
         {
```

```
            jj=j+i-44;
            if (jj>agemat) jj=agemat+1;
            Ztot+=(M(jj)+F(i,jj));
         }
         pN(1,agemat+1)+=(TM(45,j)*M2010/Z(45,j)*exp(-Ztot));
      }
   }
   //all the rest
   for (i=2;i<=pyear;i++)
   {
      ppred(i-1)=(pN(i-1,agemat)+pN(i-1,agemat+1))*nestpf/brint;
      if (ppred(i-1)>pnest)
      {
         shatch=(ppred(i-1)-pnest)*pegg*pS(1);
         chatch=pnest*pegg*pS(2);
      }
      else
      {
         shatch=0.0;
         chatch=ppred(i-1)*pegg*pS(2);
      }
      pN(i,1)=(shatch*sexr(1)+chatch*sexr(2))*exp(-Z(y,1));
      for (j=2;j<=agemat;j++)  pN(i,j)=pN(i-1,j-1)*exp(-Z(y,j));
      pN(i,agemat+1)=(pN(i-1,agemat)+pN(i-1,agemat+1))*exp(-
Z(y,agemat+1));
   }
   ppred(pyear)=(pN(pyear,agemat)+pN(pyear,agemat+1))*nestpf/brint;

REPORT_SECTION
      REPORT(eff)
      REPORT(nests)
      REPORT(pred)
      REPORT(epsilon)
      REPORT(sqrt(var(epsilon)))
      REPORT(N)
      REPORT(C)
      REPORT(TM)
      REPORT(M)
      REPORT(Z)
      REPORT(F)
      REPORT(sel)
      REPORT (t_n)
      REPORT(t_lf)
      REPORT(lf)
      REPORT(pN)
      REPORT(ppred)

GLOBALS_SECTION
      /**
      \def REPORT(object)
      Prints name and value of \a object on ADMB report %ofstream file.
      */
      #undef REPORT
```

```
	#define REPORT(object) report << "#"<< #object "\n" << object <<
endl;

	#undef COUT
	#define COUT(object) cout << #object "\n" << object <<endl;

	#include <admodel.h>
	#include <time.h>
	#include <stats.cxx>

TOP_OF_MAIN_SECTION
	arrmblsize = 50000000;
	gradient_structure::set_GRADSTACK_BUFFER_SIZE(1.e7);
	gradient_structure::set_CMPDIF_BUFFER_SIZE(1.e7);
	gradient_structure::set_MAX_NVAR_OFFSET(5000);
	gradient_structure::set_NUM_DEPENDENT_VARIABLES(5000);
```

TASK 5. PRESENTATION MEETING

A presentation of project results were presented at the 63rd Annual Meeting of the Gulf States Marine Fisheries Commission held 19-21 March 2013 in Destin, Florida. Two presentations were given; a long one for those interested in project details (Appendix 9) and a shorter version for managers (Appendix 10).

TASK 6. KEMP'S RIDLEY STOCK ASSESSMENT REPORT

This product represents the Draft Kemp's Ridley Stock Assessment Report. The information in Task 4 will be reformatted into manuscript format and submitted for publication. The authors of this report will include all the Workshop participants as listed in Table 1 of Table 3. Appendices 10 and 11 constitute the formal MS PowerPoint presentation which can be used at other meetings. Also, Appendix 4 of this report will also likely be submitted for formal publication.

APPENDICES

Appendix 1: Preliminary List of Individuals to be Invited to Participate as a Member of Kemp's Ridley Stock Assessment Working Group

Appendix 1: Preliminary List of Individuals to be Invited to Participate as a Member of Kemp's Ridley Stock Assessment Working Group

Benny Gallaway (Program Manager and Workshop Chairman)

http://wvvw.gulfbase.org/person/view.php?uid -bgallaway

http://www.lgltex.com/gallawNy.htm

Charles Caillouet	http://www.gulfbase.org/persoview.php?uid=ccaillouet
Pamela Plotkin	http://texas-sea-grant.tamu.edu/About/pam.html
William Gazey W.J.	Gazey Research, 1214 Camas Court, Victoria BC V8X 4R1
John Cole	http://lgl.com/en/staff-directory
Scott Raborn	http://wv1/47.1g1tex.com/Key%20Persormel.htm#sraborn
Gary Graham	http://wvvvv.gulfbase.org/person/view.php?uid=ggraham
Laura Sarti Martinez	http://osuno.fciencias.unam.nDdlaboratorios/Tortugas/Bienvenida.html
Selina Heppell	http://oregonstate.edu/heppell/documents/selinaheppellcv.pdf
Donna Shaver	http://www.gulfbase.org/person/view.php?uid=dshaver
Patrick Burchfield	http://wvvw.gpz.org/staff.html
Sheryan Epperly	http://wwvv.sefsc.noaa.gov/staff/sheryanepperly.htm
James Nance	http://wwvv.gulfbase.org/person/view.php?uid=jnance
Nathan Putman	http://wwvv.unc.edu/depts/geomag/Nathan.html
Steve DiMarco	http://ocean.tamu.edu/profile/SDiMarco
Nelson Ehrhardt	http://www.rsmas.miami.edu/people/faculty-index/?p=nelson-ehrhardt
Rebecca Lewison	http://www.bio.sdsu.edu,ifaculty/lewison.html
Wade Griffin	http://agecon.tamu.edu/people/faculty bios/griffin w.html
Masami Fujiwara	http://wfsc.tamu.edu/fujiwara.html
Richard Kazmierczak	http://www.lsuncenter.com/en/communications/authors/RKazmierczak.htm
Jame Geaghan	Professor/Department Head, LSU Department of Experimental Statistics
Jeanette Wyneken	Assistant Professor, Florida Atlantic University
Ken Lohmann	http://www.unc.edu/depts./geomag

Appendix 2: Kemp's Ridley Stakeholder Meeting Agenda

Sea Grant

Texas • Louisiana • Florida
Mississippi-Alabama

Kemp's Ridley Stakeholder Meeting Agenda

Texas A&M University, Hagler Center, Kennedy Room

May 23, 2012

10:00-10:15	Welcome & Introductions	Dr. Pamela Plotkin
10:15-10:30	Background for the Kemp's Ridley Stock Assessment	Dr. Benny J. Gallaway
10:30-10:45	Why Kemp's Ridley?	Dr. Charles W. Caillouet, Jr.
10:45-11:15	Kemp's Ridley Ecology	Dr. Pamela Plotkin
11:15-12:00	Shrimp Fishing Effort in the GOM	Dr. Benny J. Gallaway
12:00-1:00	LUNCH BREAK	
1:00-1:30	Quantifying the TED Effect	Dr. Scott W. Raborn
1:30-2:00	Assessment Modeling	Mr. William J. Gazey
2:00-2:30	Historical Data in Hand	Dr. Benny J. Gallaway
2:30-3:30	Data Needs and Discussion	Dr. Benny J. Gallaway
3:30-3:45	BREAK	
3:45-4:30	Workshop Participants & Discussion	Dr. Benny J. Gallaway
4:30-5:00	Path Forward (Schedule)	Dr. Benny J. Gallaway

Appendix 3: Stakeholder Meeting Attendees

COMPANY	NAME	EMAIL	MAILING
	Moby Solangi	m.solangi@imms.com	President Institute for Marine Mammal Studies P.O. Box 207 Gulfport, MS 39502
	Wade Griffin		Department of Agricultural Economics Texas A&M University College Station, TX 77843-2124
	Will Heyman	wheyman@tamu.edu	Associate Professor of Geography Texas A&M University CSA 205D College Station, TX 77843-3147
SEAGRANT	Gary Graham	glgshrimp@embarqmail.com	P.O. Box 1125 West Columbia, TX 77486
	Jim Hiney	bohiney@tamu.edu	Texas Sea Grant Program Texas A&M University, MS 4115 College Station, TX 77843
	Logan Respess		Texas Sea Grant Program Texas A&M University, MS 4115 College Station, TX 77843
	Kevin Savoie	ksavoi@agctr.lsu.edu	LSU Ag Center 7101 Gulf Hwy Lake Charles, LA 70607
PROJECT TEAM	Benny J. Gallaway	bjg@lgltex.com	LGL Ecological Research Associates, Inc. 721 Peach Creek Cut-Off Rd. College Station, TX 77845
	Charles Caillouet, Jr.	waxmanjr@aol.com	106 Victoria Dr. West Montgomery, TX 77356-8445
	William J. Gazey	bill@gazey.com	Gazey Research 1214 Camas Court Victoria, B.C. Canada V8X 4R1
	Scott Raborn	sraborn@lgl.com	LGL Ecological Research Associates, Inc. 207 Pearce Rd. Pineville, LA 71360
	Connie Fields	connie@lgltex.com	LGL Ecological Research Associates, Inc. 721 Peach Creek Cut-Off Rd. College Station, TX 77845

Attachment 3. Stakeholders Meeting Attendees.

COMPANY	NAME	EMAIL	MAILING
GSMFC	Ralph Hode	rhode@gsmfc.org	Fisheries Diaster Program Coordinator Gulf States Marine Fisheries Commission P.O. Box 726 Ocean Springs, MS 39566-0726
GMFMC	Corky Perret	corky.perret@dmr.ms.gov	Mississippi Dept. of Marine Resources 1141 Bayview Avenue Biloxi, MS 39530
NOAA	Dennis Klemm	dennis.klemm@noaa.gov	NOAA/NMFS Southeast Regional Office 263 13th Avenue south St. Petersburg, FL 33701-5505
	Bonnie Ponwith	Bonnie.ponwith@noaa.gov	NMFS/SEFSC 75 Virginia Beach Dr. Miami, FL 33149
	Paul Richards	paul.richards@noaa.gov	NOAA 76 Virginia Beach Drive Miami, FL 33149
	Rick Hart	rick.hart@noaa.gov	NMFS Galveston Laboratory 4700 Avenue U Galveston, TX 77551
FWS	Kelsey Gocke	Kelsey_Gocke@fws.gov	U.S. Fish & Wildlife Service 17629 El Camino Real, Ste. 211 Houston, TX 77058
STATE AGENCIES Mississippi	Dale Diaz	d.diaz@dmr.ms.gov	Director Marine Fisheries Department of Marine Resources 1141 Bayview Avenue Biloxi, MS 39530
Texas	Mike Ray		Texas Parks and Wildlife Department 4200 Smith School Road Austin, TX 78744
GSAFF	Judy Jamison	judy.jamison@att.net	Gulf & South Atlantic Fisheries Foundation, Inc. 5401 W. Kennedy Blvd., Suite 740 Tampa, FL 33609-2447
CONSERVATION	Claudia Friess	cfriess@oceanconservancy.org	Ocean Conservancy 106 E. 5th Street, Suite 400 Austin, TX 78701
ACADEMIA	Andrew Coleman	acoleman@imms.org	Sea Turtle Ecologist IMMS P.O. Box 207 Gulfport, MS 39502

Appendix 4: Kemp’s Ridley Background Information

THE ATTACHED MANUSCRIPT IS A DRAFT
(I.E., A WORK IN PROGRESS)

14 FEBRUARY 2013 REVISION

IT WAS PREPARED IN 2012 TO PROVDE BACKGROUND INFORMATION TO
KEMP'S RIDLEY STOCK ASSESSMENT WORKSHOP (KRSAW) PARTICIPANTS AND OBSERVERS

THE KRSAW WAS HELD 26-30 NOVEMBER 2012, AIRPORT MARRIOTT HOTEL, BUSH INTERCONTENTAL AIRPORT, HOUSTON, TEXAS)

PLEASE SEND YOUR COMMENTS AND SUGGESTIONS TO CHARLES CAILLOUET (WAXMANJR@AOL.COM)

KEMP'S RIDLEY STOCK ASSESSMENT PROJECT AND WORKSHOP: BACKGROUND INFORMATION

14 FEBRUARY 2013

Charles W. Caillouet, Jr.[1], Benny J. Gallaway[2], Pamela T. Plotkin[3], William G. Gazey[4], Scott W. Raborn[5], and John G. Cole[6]

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[2]Workshop Chairman and Project Leader; President, LGL Ecological Research Associates, Inc., Bryan, Texas: bjg@lgltex.com (http://www.gulfbase.org/person/view.php?uid=bgallaway)

[3]Director, Texas Sea Grant Program; Associate Research Professor, Department of Oceanography, Texas A&M University, College Station, Texas: plotkin@tamu.edu (http://www.gulfbase.org/person/view.php?uid=pplotkin)

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[5]Biometrician, LGL Ecological Research Associates, Inc., Pineville, Louisiana: sraborn@lgl.com

[6]Computer Programmer and Systems Manager; Executive Vice-President, LGL Ecological Research Associates, Inc., Bryan, Texas: cole@lgltex.com

Definition of fisheries stock assessment

According to Hilborn and Walters (1992), fisheries "*stock assessment involves use of various statistical and mathematical calculations to make quantitative predictions about the reactions of fish populations to alternative management choices.*" It provides the scientific basis for management of exploited fishery species, and involves determining the effects of exploitation levels on annual yield from and sustainability of the exploited stock within its natural environment (Cadima 2003; Cooper 2006).

Definition of Kemp's ridley stock assessment

For application to Kemp's ridley, we altered Hilborn's and Walters' definition as follows: "*Kemp's ridley stock assessment involves use of various statistical and mathematical calculations to make quantitative predictions about reactions of the population to alternative conservation choices and exogenous factors*". According to the National Research Council's Committee on the Review of Sea-Turtle Population Assessment Methods (CRSTPAM 2010), sea turtle "*Population assessments seek to measure the current status, evaluate trends over previous years, and predict the status of populations under various management scenarios by quantitatively evaluating population abundance and assessing such demographic parameters as productivity and survivorship (called "vital rates" that indicate the potential for change in a population).*" The Kemp's ridley stock assessment project and workshop respond to CRSTPAM (2010) recommendations. They supplement the scientific basis for recovery, downlisting, and delisting of the Kemp's ridley population (National Marine Fisheries Service (NMFS) et al. (2011), and evaluate the effects of selected threats to and sustainability of the Kemp's ridley population within its natural environment.

Reducing anthropogenic "take" (both incidental and directed or targeted) of various life stages has been the primary focus of conservation efforts directed toward recovery of the Kemp's ridley population, and many different approaches have been used for this purpose (U.S. Fish and Wildlife Service (USFWS) and NMFS 1992; Turtle Expert Working Group (TEWG) 1998, 2000; Heppell et al. 2005, 2007; NMFS et al. 2011). According to NMFS et al. (2011), the three greatest "takes" (i.e., anthropogenic threats to the Kemp's ridley population) were:

1. Intense commercial exploitation of eggs at Rancho Nuevo
2. Directed take of adults from the nesting beaches and adjacent waters near Rancho Nuevo
3. Incidental take of neritic life stages in shrimp trawls in Gulf of Mexico and western Atlantic waters of the U.S.

All of these "takes" have been substantially reduced through conservation efforts and other factors over 47 yr (1966-2012), and the population is recovering.

Agencies and organizations that have contributed toward Kemp's ridley recovery

In Mexico and the U.S., Federal and State agencies, conservation organizations, universities, industries, industry organizations, local governments, educational programs, and volunteers have contributed to Kemp's ridley recovery (USFWS and NMFS 1992; Marquez-M. 1994; Heppell et al. 2005, 2007; NMFS and USFWS 2007; NMFS et al. 2011). The major contributors have been:

1. Mexico

Secretaría del Medio Ambiente y Recursos Naturales (SEMARNAT)

Comisión Nacional de Áreas Naturales Protegidas (CONANP)

Procuraduría Federal de Protección al Ambiente (PROFEPA)

Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación (SAGARPA).

Instituto Nacional de Pesca (INP) (its predecessor was Instituto Nacional de Investigaciones Biológico-Pesqueras; http://www.inapesca.gob.mx/portal/conoce-al-inapesca/historia)

2. U.S.

USFWS

NMFS

National Park Service (NPS)

U.S. Coast Guard (USCG)

Texas Parks and Wildlife Department (TPWD)

Gladys Porter Zoo (GPZ)

Florida Audubon Society (FAS)

Texas Shrimpers Association (TSA)

Help Endangered Species – Ridley Turtles (HEART)

Rationale for Kemp's ridley stock assessment

In 2010 and 2011, increased numbers of sea turtles, predominantly Kemp's ridleys, stranded in the north-central Gulf of Mexico, especially in coastal Louisiana, Mississippi, and Alabama. Among possible causes, the Deepwater Horizon rig explosion and BP-Macondo well blow out, ensuing oil spill, and remedial or mitigating responses to them in 2010, as well as incidental capture of sea turtles in shrimp trawls in both years, received the most attention from Federal and State agencies, conservation organizations, and the media as possible causes of the strandings[1,2,3] (Caillouet 2011; Crowder and Heppell 2011). Kemp's ridley strandings continued at high levels in the north-central Gulf of Mexico in 2012[4].

The commonly used index of Kemp's ridley population size has been the annual total number of nests (i.e., clutches of eggs laid) recorded for three combined segments of beach in Tamaulipas, Mexico: Rancho Nuevo, Tepehuajes (North Camp), and Playa Dos-Barra del Tordo (South Camp)(TEWG 1998, 2000; Heppell et al. 2005, 2007; NMFS et al. 2011; Burchfield and Peña 2012). Using an updated demographic model, NMFS et al. (2011) predicted that the Kemp's ridley population would grow 19% per yr during 2010-2020, assuming survival rates within each life stage remained constant. Instead, the number of nests declined abruptly and substantially in 2010 (Figure 1) (Burchfield 2009; Burchfield and Peña 2010, 2011, 2012). Although nest numbers in 2011 and 2012 returned to near the 2009 level, they seem to have plateaued (Figure 1). It is extremely important that the cause or causes of this unexpected and substantial slowing of the population growth rate be identified if possible.

Previous demographic models (TEWG 1998, 2000; Heppell et al. 2005, 2007; NMFS et al. 2011) have been used to examine major influences on the Kemp's ridley population's trajectory over varying time-series of years. These models were deterministic, and their input "parameters" (i.e., vital rates) were point estimates that were treated as constants. Additional issues[5] (Caillouet 2010a)

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[1] The Heartbreak Turtle Today (http://seaturtles.org/article.php?id=1928); Why is the Kemp's ridley turtle population recovering? (http://www.caller.com/news/2011/dec/18/why-is-the-kemps-ridley-turtle-population)

[2] http://response.restoration.noaa.gov/deepwaterhorizon

[3] http://sero.nmfs.noaa.gov/pr/esa/Fishery%20Biops/SoutheastShrimpBiop_Final.pdf

[4] http://www.nmfs.noaa.gov/pr/species/turtles/gulfofmexico.htm ; http://www.sefsc.noaa.gov/turtledocs/UPR_Teas_2012_PRBD_2012_07.pdf)

[5] http://www.nmfs.noaa.gov/pr/pdfs/species/kemspsridley_recovery_review.pdf

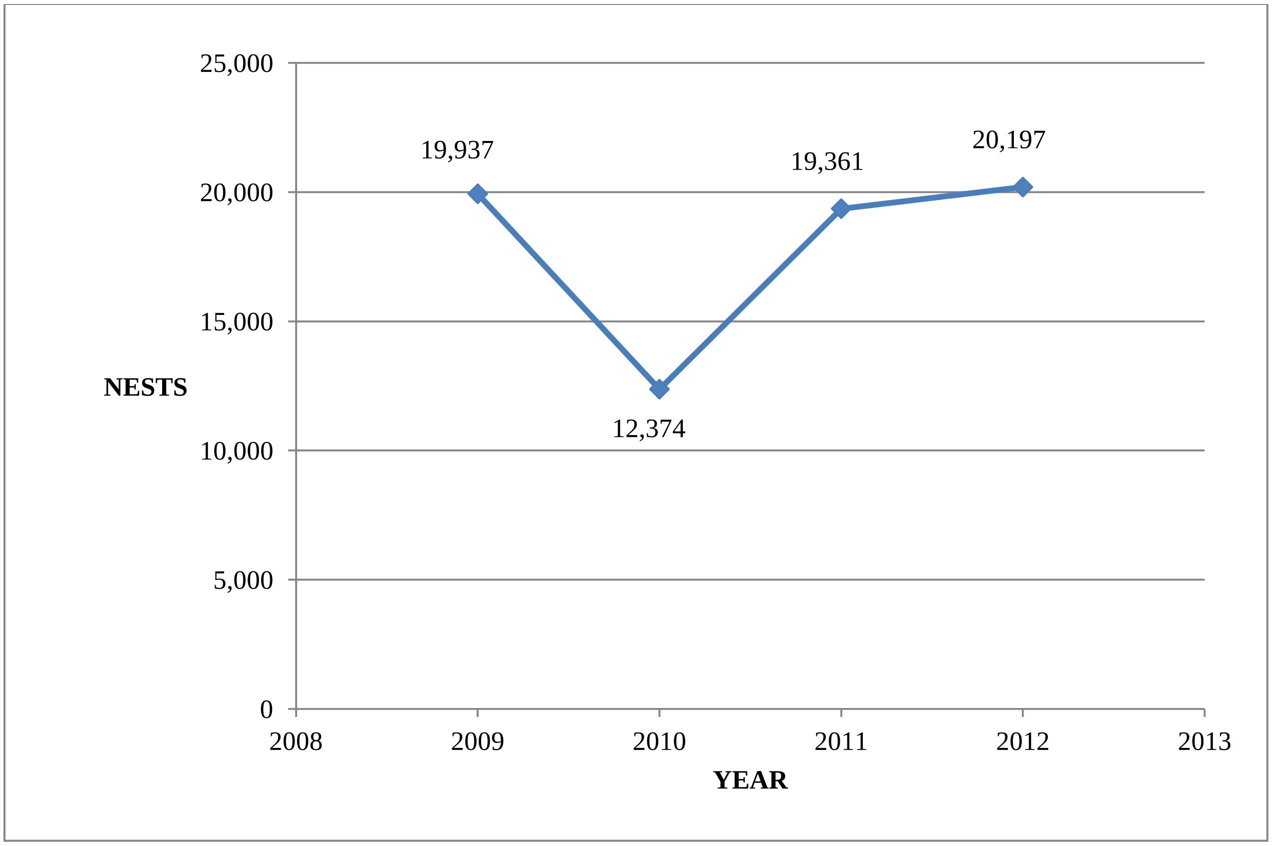

Figure 1. Annual registered nests for Rancho Nuevo, Tepehuajes, and Playa Dos-Barra del Tordo beach segments combined, in years 2009-2012 (data from Burchfield 2009; Burchfield and Peña 2010, 2011, 2012).

concerning previous demographic modeling and analyses in NMFS et al. (2011) have not yet been addressed. The major issue is that no time-series of annual shrimp fishing effort (or shrimping-related Kemp’s ridley mortality) has been incorporated into previous models (Caillouet 2006, 2010a), although decreases in shrimping effort have been mentioned among factors contributing to Kemp’s ridley recovery (Caillouet 2006, 2010a; Heppell et al. 2007; NMFS and FWS 2007; NMFS et al. 2011; Crowder and Heppell 2011). This is especially problematic, since incidental capture in shrimp trawls has long been identified as the most important human-associated source of mortality in sea turtles (Committee on Sea Turtle Conservation (CSTC) 1990).

Kemp’s ridley stock assessment project and workshop

The Kemp’s stock assessment project evolved from an idea, originating in May 2011, for a Kemp’s ridley-shrimp fishery interactions workshop (Appendix I). The project was later funded by the Gulf States Marine Fisheries Commission (GSMFC), and Dr. Benny Gallaway agreed to be Project Leader and Chairman of the Kemp’s Ridley Stock Assessment Workshop (KRSAW), held at the Airport Marriott Hotel, Bush Intercontinental Airport, Houston, Texas, on 26-30 November 2012. The overarching purpose of the project was to conduct, to the extent practicable, an objective and quantitative examination and evaluation of relative contributions of various conservation methods, other anthropogenic influences, and environmental factors to the 1966-2012 Kemp’s ridley population trajectory. CRSTPAM (2010) recommendations were used as general guides in the project, and AD Model Builder (Fournier et al. 2012) was applied in the stock assessment modeling. Project deliverables are due in April 2013.

Specific objectives of the project were:

1. Examine Kemp’s ridley temporal-spatial distribution, population status, and historical trajectory within the Gulf of Mexico, along the coasts of Mexico and the U.S.
2. Examine temporal-spatial distribution, status, and historical trajectory of shrimp fishing effort in the Gulf of Mexico, along the coasts of Mexico and the U.S.
3. Determine relative contributions of conservation efforts, changes in shrimp fishing effort, and TED regulations and enforcement toward the Kemp’s ridley population trajectory, using statistical analyses and stock assessment modeling.

4. To the extent practicable, examine other factors that may have contributed to increased Kemp's ridley-shrimp fishery interactions or otherwise caused Kemp's ridley strandings, injuries, or deaths in the north-central Gulf of Mexico in 2010-2012, to include but not be limited to abundance of shrimp and Kemp's ridley prey species (e.g., portunid crabs), river outflow (especially from the Mississippi River), 2010 oil spill and dispersant (NALCO Corexit®), surface circulation, hypoxic zones, locations and characteristics of nesting beaches, tropical storms and hurricanes, droughts, red tide, harmful algae blooms, etc. (see sections on terrestrial and marine threats below).

5. Develop and apply a Kemp's ridley stock assessment model to assess the current status and historical trajectory of the Kemp's ridley population, 1966-2012.

Kemp's ridley population characteristics

Anthropogenic impacts contributing to extinction of marine megafauna have lagged relative to those of terrestrial megafauna, and many extinct or endangered marine animals are relatively large and long-lived (Heppell et al. 2005). Below we examine characteristics of the Kemp's ridley population that are relevant to its stock assessment modeling:

1. A distinct single species (Bowen et al. 1991; NMFS et al. 2011), without a listing of distinct population segments (DPSs) (NMFS and USFWS 2007)

2. A "significant portion of its range" (SPR) has not been defined

3. A single regional management unit (RMU) has been defined by Wallace et al. (2010), but not officially by USFWS or NMFS (see also http://seamap.env.duke.edu/swot)

4. Highly migratory

a. Pelagic-early juvenile life stages are distributed passively by surface circulation (Collard and Ogren 1990; Putman et al. 2010; NMFS et al. 2011; Witherington et al. 2012)

(1) Gulf of Mexico circulation is generally clockwise, except for coastal countercurrents and gyres:

(a) Yucatan current

(b) Florida current

(c) Loop current

(d) Miscellaneous gyres

(2) North Atlantic Gyre (clockwise)

(3) Nesting site locations may be influenced by surface currents that are most favorable to survival of the pelagic life stages (hatchlings to early juveniles ≤ 2 yr old) (Putman et al. 2010)

b. Neritic life stages (juveniles, subadults, and adults)

(1) Foraging grounds exist along the Gulf of Mexico and U.S. Atlantic Coasts (NMFS et al. 2011)

5. Overall range is known, and it is smaller than that of other sea turtles; it includes the Gulf of Mexico and North Atlantic Ocean from the U.S. east coast to Europe

6. Long-lived, but longevity has not been determined; it has been guessed to be ≈50 yr or longer

7. Age at first reproduction appears to be ≈10-12 yr in the Gulf of Mexico and older in the western North Atlantic Ocean

8. Most nesting occurs in the western Gulf of Mexico, in Tamaulipas and Veracruz, Mexico and in Texas, but sporadic nesting also occurs elsewhere in the Gulf and U.S. east coast; the nesting epicenter is Rancho Nuevo, but nesting site fidelity is not absolute

9. Mature females are iteroparous, nesting 1-4 times in a given season and exhibiting interannual remigration intervals of 1-4 yr (Hildebrand 1963; Márquez-M. et al. 1982; Márquez-M. 1990; Pritchard 1990; USFWS and NMFS 1992; Marquez-M. 1994; Rostal et al. 1997; Witzell et al. 2005b, 2007); for demographic modeling, NMFS et al. (2011) used 2.50 nests per female per season and a 2-yr remigration interval

10. Terrestrial habitats (nesting beaches) are occupied briefly by adult females, eggs, and emergent hatchlings during the nesting-hatching season, but most of the life span is spent in aquatic habitats

11. Anthropogenic influences on nesting beaches (especially in Tamaulipas and Texas) and in coastal waters of the Gulf of Mexico logically have greater effects on the population than elsewhere within the species' range

12. Assessment of Kemp's ridley population status and trajectory must consider jurisdictional boundaries of Mexico and the U.S.

13. Data needed for stock assessments are plentiful compared to most if not all other sea turtle species

Kemp's ridley conservation history

Accounts by Carr and Caldwell (1958) and Carr (1961) listed Kemp's ridley nesting sites Little Shell, on Padre Island, Texas and Náutla, Antón Lizardo, Alvarado, and Montepío, in the State of Veracruz, Mexico, but not the State of Tamaulipas. Hildebrand (1963) later wrote "*It has long been known that marine turtles nest in abundance on the coasts of Tamaulipas, and in fact, the historian Alexandro Prieto (1873) considered both them and their eggs an important resource of the coast. Moreover, some old fishermen of Port Isabel (Texas), whose ancestors were engaged in the purchase of saltwater fish in Soto la Marina,* *informed me that it was a known fact that the largest concentrations of nests were located in the region between the mouth of the Río Soto la Marina and Punta Jerez.*" Hildebrand (1963) was the first to recognize the need for conservation measures to prevent Kemp's ridley extinction, at a time when near total, commercial-level exploitation of clutches of eggs laid annually at Rancho Nuevo threatened continued existence of this species.

Based on a movie of a Kemp's ridley arribada (Spanish for arrival from the sea) of nesters filmed by Andrés Herrera near Rancho Nuevo on 18 June 1947, Hildebrand (1963) estimated there were 40 thousand nesters. Hildebrand (1963) did not describe how he derived his estimate, but Carr (1967) later did[6]. Hildebrand's (1963) estimate was 16.7 times higher than the 2,396 nesters estimated for the entire 1966 nesting season, by dividing 5,991 nests (reported by TEWG 2000) by the average 2.50 nests per adult female per season applied in demographic modeling by NMFS et al. (2011). These estimates suggest a 94.0 % reduction in nesters from 1947 to 1966. However, if the total number of Kemp's ridleys that nested during the 1947 season were known, it logically would be higher than the true number of nesters in that single, 18 June 1947 arribada (Caillouet 2006). Dickerson and Dickerson (2006) reported their "best" estimate of the number of nesters in the 1947 arribada to be 5,746 , based on imagery analysis of the Herrera film.

Caillouet (2006) back-calculated (estimated) the total number of nesters in the 1947 season, based on declining numbers of nests at Rancho Nuevo during

[6] According to Carr (1967) , "*Dr. Henry Hildebrand … made a careful estimate of their numbers and decided there were ten thousand turtles on shore. Counting those clearly in view on the beach, and reckoning the average time it took a female to finish nesting, and the length of time there were turtles out on the beach that day, Henry calculated that the whole arribada had forty thousand ridleys in it. I have not gone through the sort of calculations he did, but just looking at the film I see no reason to think he overestimated*."

1966-1977 (data from TEWG 2000), which preceded implementation of the joint Mexico-U.S restoration and enhancement program in 1978 (Figure 2). However, in addition to nestings by "old" nesters (residual population), this time series included two years (1976 and 1977) in which "young" nesters contributed laid; these young nesters apparently originated from restored hatchling recruitment beginning in 1966 (Marquez-M. 1994). Nevertheless, young nesters in 1976

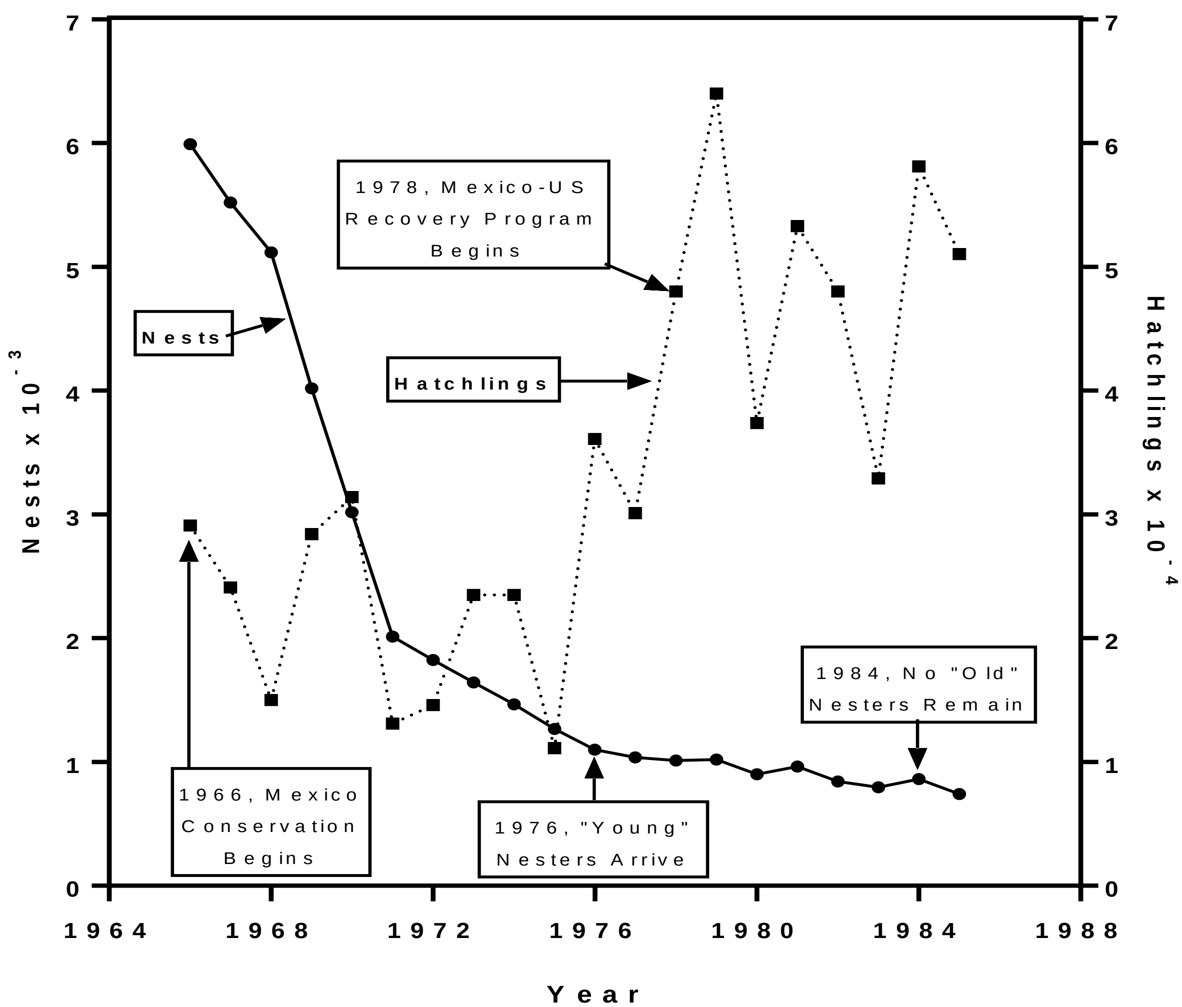

Figure 2. Documented nests and hatchlings at Rancho Nuevo, Tamaulipas, Mexico during 1966-1985, which preceded reversal of the population's decline (data from TEWG 2000, p. 20).

and 1977 probably represented small proportions of total nesters in those years. For each year, 1966-1977, Caillouet (2006) converted nests to nesters, based on 2.5 nests per nester, and then converted numbers of nesters to natural logarithms, to which he fitted a linear regression; he then extrapolated the regression back to 1947, to estimate 70,911 nesters for that season. If this estimate were correct, the decline in nesters from 1947-1966 would have been 96.6 %. This back-calculation method assumed explicitly that the rate of decline from 1947-1977 was constant, and that mortality rates for all life stages were also constant, assumptions not likely to have been met and which cannot be tested. Dickerson and Dickerson (2006)

In 1966, the Mexican government initiated a Kemp's ridley conservation program and began protecting nesters, eggs, and hatchlings at Rancho Nuevo. This protection substantially reduced human take of eggs and restored annual hatchling recruitment (USFWS and NMFS 1992; TEWG 1998, 2000; Heppell et al. 2005, 2007; Crowder and Heppell 2011; NMFS et al. 2011). It is important not to overlook the evidence (i.e., the appearance of "young nesters" at Rancho Nuevo) that Mexico's program began adding nesters to the population as early as 1976 , only 10 yr after hatchling recruitment was restored (Marquez-M. 1994). Apparently unaware of the appearance of young nesters at Rancho Nuevo, and because the annual number of nesters was declining, Carr's (1977) warned that the species was clearly "*on the skids*", and that if conditions at that time continued, it would be gone in 2-5 yr. He attributed the dramatic drop in numbers of nesters during the 1950s to overexploitation of eggs combined with very heavy natural predation, and the decline taking place in 1977 to incidental capture by shrimp trawlers which was "*wiping out the species*".

In 1978, agencies in Mexico (INP) and the U.S. (NPS, USFWS, NMFS, and TPWD) initiated efforts to reintroduce Kemp's ridley to Padre Island National Seashore (PAIS) and to enhance hatchling recruitment at Rancho Nuevo[7] (Wauer 1978, 1999; USFWS and NMFS 1992; TEWG 1998, 2000; Heppell et al. 2005, 2007; Crowder and Heppell 2011; NMFS et al. 2011). However, the annual number of nests continued declining (Frazer 1986), albeit at a decreasing rate, to its lowest level in 1985 (TEWG 1998, 2000; Márquez et al. 2005; Caillouet 2010a). Marquez-M. (1994) noted that "old" nesters (representing the residual population remaining when Mexico's conservation efforts began in 1966) disappeared by 1984; these "old" nesters apparently originated from hatchling recruitment prior to 1966 (Caillouet et al. 2011). Marquez-M.'s (1994) observation that only "young" nesters were present by 1984 suggests that they originated entirely from Mexico's hatchling releases during 1966-1974, assuming 10 yr to maturity. In other words, the Kemp's ridley population existing when the population decline reversed in 1986 probably did not result from the enhanced hatchling recruitment that began in 1978. Had hatchling recruitment (sufficient to produce nesters) occurred in 1965, the age of youngest "old" nesters from that year-class would have been 18 yr in 1983. In 1984, surviving nesters of the 1978 cohort would have been only 6 yr old, which is considered too young for Kemp's ridleys to mature, except when reared from hatchlings to maturity in captivity (Márquez, 1972; Marquez-M. 1994; Caillouet et al. 2011; NMFS et al. 2011). Based on the NMFS et al. (2011) assumption of 12 yr to maturity, the 1978 cohort of hatchlings would not have matured until 1990.

[7] NPS, FWS, NMFS, TPWD, and INP. 1978. Action Plan Restoration and Enhancement of Atlantic Ridley Turtle Populations Playa de Rancho Nuevo, Mexico and Padre Island National Seashore, Texas 1978-1988. January 1978, 30 p. including Appendices I-III.

In the late 1970s, NMFS developed turtle excluder devices (TEDs) to allow incidentally caught sea turtles to escape shrimp trawls[8,9,10] (Watson et al. 1986; Durrenberger 1989,1990; White 1989; Condrey and Fuller 1992; Iversen et al. 1993; Yaninek 1995; Epperly 2003; Aguilar and Grande-Vidal 2008). However, the Kemp's ridley population showed signs of increasing as early as 1986, before any TEDs were required in shrimp trawls in the Gulf of Mexico shrimp fishery (Caillouet 1999, 2010a). No doubt, later use of TEDs in shrimp trawls reduced shrimp trawl-related sea turtle mortality (Heppell et al. 2005, 2007; NMFS and FWS 2007; NMFS et al. 2011). However, seasonal and spatial closures to shrimp fishing in waters of Mexico and the U.S. also reduced shrimp trawl-related sea turtle mortality (Condrey and Fuller 1992; USFWS and NMFS 1992; Iversen et al. 1993; Yaninek 1995; Shaver 1998; TEWG 1998, 2000; Epperly 2003; Heppell et al. 2005, 2007; NMFS et al. 2011). According to USFWS and NMFS (1992), fishing was minimal during WWII, the Kemp's ridley population decline coincided with build-up of the shrimp fishery in the late 1940s and 1950s, and high mortality of the reproductive segment of the population in shrimp trawls was not offset by recruitment in the years following the extensive Mexican harvest of eggs. In retrospect, additions to the Kemp's ridley population through restored hatchling recruitment at Rancho Nuevo, coupled with reductions in at-sea mortality associated with temporal and spatial closures to shrimp fishing in Mexico and the

[8] Sea Turtle Conservation Regulation History (http://www.seagrantfish.lsu.edu/management/TEDs&BRDs/teds_history.htm)

[9] Turtle Excluder Device (TED) Chronology (http://www.nmfs.noaa.gov/prot_res/PR3/Turtles/TEDS.html)

[10] History of Turtle Excluder Devices (TEDs) (http://www.sefsc.noaa.gov/labs/mississippi/ted/history/htm)

U.S., were indeed offsetting mortality of the reproductive segment by 1986 (Caillouet 1999, 2010a).

Condrey and Fuller (1992) and Iversen et al. (1993) provided important historical accounts of technological development and expansion of the Gulf of Mexico shrimp fishery following WWII. In the northern Gulf of Mexico, shrimp fishing effort targeting brown shrimp (*Farfantepenaeus aztecus*) (Caillouet et al. 2008) and white shrimp (*Litopenaeus setiferus*) (Nance et al. 2010) began declining in the late 1980s or early 1990s, and that targeting pink shrimp (*Farfantepenaeus duorarum*) began declining in 1997 (Hart et al. 2012). Aguilar and Grande-Vidal (2008) described historical development of Mexico's shrimp fishery. Reduction in shrimp fishing effort in the Gulf of Mexico has been mentioned numerous times as a possible contributor toward Kemp's ridley recovery (Caillouet 1999, 2010a; Heppell et al. 2007; Crowder and Heppell 2011; NMFS and FWS 2007; NMFS et al. 2011). Therefore, it is surprising that the effects of changing levels of shrimp fishing effort on the Kemp's ridley population trajectory have not been quantitatively evaluated or included in previous demographic modeling (Caillouet 2010a).

Conservation efforts in Tamaulipas created a powerful feed-back loop between hatchling recruitment and time-lagged increases in nesters and nests which, when coupled with reductions in mortality of neritic life stages, led to reversal of the population's decline, restoration of population momentum, and an exponential trend toward recovery (Heppell et al. 2007; Caillouet 2010a; Caillouet et al. 2011). This indicates that all sources of Kemp's ridley were eventually overwhelmed, allowing the population to increase.

It should not be concluded that all Kemp's ridley conservation approaches that have been applied to date, nor all the changes in shrimp fishing effort that have occurred to date, have equally influenced the observed trend toward population recovery. Heppell et al. (2007) pointed out that "…*all conservation efforts have contributed in some way*". However, all conservation efforts did not begin at the same time, and some of them overlapped in time; one (e.g., head-start[11]) was discontinued (Byles 1993; Williams 1993; Caillouet et al. *in press*). The history of exposure to environmental and human-caused threats differed for each cohort over its life span, and overlapped multiple cohorts to varying extents. Fortunately, hatchling cohort recruitment in Tamaulipas is known for years 1966-2012, so its contribution to the population can be assessed. Records of major environmental and human threats also are available over time. Heppell et al. (2007) concluded that a precise, quantitative assessment of relative impacts of critical events in the conservation of Kemp's ridley is impossible. While this may be true in an absolute sense, the KRSAW represents an additional attempt to evaluate effects of major anthropogenic and environmental influences on the population trajectory.

To our knowledge, only two quantitative comparisons of relative contributions of selected Kemp's ridley conservation methods toward Kemp's ridley recovery have been attempted (excluding those implied from previous

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[11] Clarification is required with regard to head-start, which involved rearing hatchlings to 9-11 months of age in captivity, then tagging and releasing survivors into the Gulf of Mexico. Head-start was essential to evaluating the Mexico-U.S. reintroduction of Kemp's ridley to PAIS near Corpus Christi, Texas, because it made it possible to tag the turtles after rearing them in captivity to sizes as which they could be safely tagged (see footnote 7 above); at the time, hatchlings could not be safely tagged. Clutches of eggs were collected from Rancho Nuevo during 1978-1988 and were transferred to PAIS where they were incubated, hatched, and the hatchlings "imprinted" to PAIS. Hatchlings were head-started at the NMFS Laboratory in Galveston, Texas, and survivors were tagged in multiple ways so they could be distinguished from free-living Kemp's ridleys after release into the Gulf of Mexico. Imprinting at PAIS was terminated after 1988, but head-starting (captive-rearing, tagging, and release) continued on its own merit until terminated after release of the 2000 year-class (Caillouet et al. *in press*; Shaver and Caillouet *in press)*.

demographic modeling). The first[12] was largely ignored, probably because results were not published; however, a report was drafted and copies may still be available for examination during the KRSAW. The second (Caillouet 2006) roughly estimated the relative contributions of Kemp's ridley hatchling recruitment in Tamaulipas (40.7%) and post-1990 reductions in benthic stage Kemp's ridley mortality caused by humans (59.3%) to the annual rate of increase in nests, based on results from demographic modeling by Heppell et al. (2005). Caillouet (2006) calculated the proportion (0.8695) that shrimp trawl-related annual mortality represented of the total annual human-caused mortality, based on geometric mid-points of class intervals of various sources of human-caused mortality listed in Table 6-2 of CSTC (1990). He multiplied the estimated relative contribution of the post-1990 effect (59.3 %) by the estimated proportion related to shrimp trawling, to estimate the relative contribution (51.6%) of reduction in shrimp-trawling related mortality to the annual rate of increase in nests: 59.3% x 0.8695 = 51.6%. Although the method used by Caillouet (2006) has not been scientifically evaluated, it should be revisited during the KRSAW.

In summary, many factors have contributed to exponential increase in the Kemp's ridley population through 2009 (TEWG 1998, 2000; Heppell et al. 2005, 2007; Caillouet 2010; NMFS et al. 2011). Heppell et al. (2007) stated that population growth occurs when births exceed deaths and/or immigration exceeds emigration; immigration can be ignored for Kemp's ridley because data available represent virtually the entire species. Kemp's ridley population growth could not have occurred unless births exceeded deaths (Heppell et al. 2007); this should be a dominant consideration in the KRSAW.

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[12] *Biggest Bang for the Buck: Really Melding Demographic Theory with Economics*, a project initiated in 2000 by the National Center for Ecological Analysis and Synthesis (NCEAS) (http://www.nceas.ucsb.edu/projects/3560).

Critical events in Kemp's ridley conservation

Critical events in the conservation of Kemp's ridley (Table 15.1 in Heppell et al. (2007), are paraphrased as follows:

1. Conservation efforts on nesting beaches in Tamaulipas
2. Head-start
3. Exclusion of U.S. shrimp trawlers from Mexican waters
4. Use of TEDs in the U.S. and Mexican waters
5. Ban on sea turtle product trade in Mexico
6. Reduction in fishing effort off the primary nesting beaches[13] [sic] in Mexico
7. Closure of the Mexican shrimping season during the primary nesting season
8. Closure of south Texas waters to shrimping during the primary nesting season

Additional critical events in Mexico could be added to this list (see Marquez et al. 1989, 2004).

Factors contributing to reductions in shrimp trawl-related mortality in Mexico and the U.S. included post-1975 changes in the distribution of shrimp fishing effort related to extended jurisdiction, permanent or temporary areal closures to in waters of Mexico and the U.S., post-1986 use of turtle excluder devices (TEDs) in shrimp trawls, and declining shrimp fishing effort beginning in the late 1980s or early 1990s in areas where neritic life stages of Kemp's ridley occur (USFWS and NMFS 1992; NMFS and USFWS 2007; Caillouet 2010; NMFS et al. 2011). The annual Texas Closure, a closure of waters to in Texas' offshore waters and the federal EEZ to allow brown shrimp (*Farfantepenaeus*

[13] By definition, there can be only one primary nesting beach; others are secondary, tertiary, etc.

aztecus) to grow to larger sizes before harvest, was initiated in 1981; it reduced shrimping-related sea turtle mortality along the Texas coast, as indicated by drops in strandings during the closures (Shaver 1998).

Other factors that affect the Kemp's ridley population include but are not limited to Mississippi River outflow, hypoxic zones, abundance of prey species, cold stunning, and red tide.

Terrestrial (on nesting beaches) threats (adapted from NMFS et al. 2011)

1. Resource use
    a. Illegal harvest
    b. Beach cleaning
    c. Human presence
    d. Recreational beach equipment
    e. Beach vehicular driving
2. Construction
    a. Beach nourishment
    b. Other shoreline stabilizations
    c. Energy exploration, development, and removal
3. Ecosystem alteration by human activities
    a. Beach erosion and vegetation alteration in coastal habitats
4. Pollution
    a. Oil, fuel, tar, and chemical
    b. Nighttime lighting
    c. Toxins
5. Species interactions
    a. Predation

b. Pathogens and diseases

c. Habitat modification by invasive species

6. Other factors

a. Climate change

b. Natural catastrophes

c. Conservation and research activities

d. Military activities

e. Funding

Marine (neritic and oceanic) threats (adapted from NMFS et al. 2011)

1. Resource use: fisheries bycatch

a.Trawls, bottom

b.Trawls, top and mid-water

c. Dredges

d. Longlines, pelagic and demersal

e. Gillnets, demersal, sink, and drift

f. Pots and traps

g. Haul seines

h. Channel nets

i. Purse seines

j. Hooks & lines (commercial)

k. Hooks & lines (recreational)

2. Resource use (non-fisheries)

a. Illegal harvest

b. Industrial plant intake and entrainment

c. Boat strikes

3. Construction

a. Beach nourishment

b. Dredging

c. Oil, gas, and liquid natural gas exploration, development, and removal

4. Ecosystem alteration

a. Trophic changes due to fishing

b. Trophic changes from benthic habitat alteration

c. Dams and water diversions

d. Runoff, harmful algal blooms, and hypoxia

e. Sand mining

5. Pollution

a. Marine debris ingestion and entanglement

b. Oil, fuel, tar, and chemical

c. Low frequency noise

d. Toxins

6. Species interactions

a. Predation

b. Pathogens

c. Toxic species

7. Other factors

a. Climate change

b. Conservation and research activities

c. Military activities

d. Cold stunning

Data sources

1. Annual numbers of nests, eggs, and hatchlings, 1966-2012, available from CONANP, Mexico

2. Kemp's ridley catches and fishing effort in fishery-independent, trawl sampling surveys, available from NMFS and States. Included are SEAMAP, SEDAR, TED efficiency studies and certification trials

3. Incidental Kemp's ridley catches (i.e., bycatch) and fishing effort from fishery-dependent trawling, available from NMFS' observer program

4. Kemp's ridley strandings data, available from NMFS' Sea Turtle Stranding and Salvage Network (STSSN), 1980-2011

5. Shrimp fishing effort available from NMFS (see Nance et al. 2008)

Statistical estimation and modeling considerations

1. Most if not all Kemp's ridley population vital rates represent variables expressed in numbers of individuals (i.e., count data). Some variables represent rare events, and samples may contain large proportions of zero (0) observations. Therefore, estimation of central tendency and variability of many if not all such variables should not be based on an assumption of normality of their distributions, but instead should be based on statistical distributions appropriate to such variables.

2. Time series of key variables such as the annual numbers of nests, eggs, and hatchlings are essential to population modeling; however, not all of the clutches laid or the females that lay them can be observed (Pritchard 1990). The annual intensities of effort expended in searching for nests (and protecting them) have varied over time, and the nesting range has expanded over the years, especially within Mexico and Texas. Also, it is clear from its pre-2010 exponential trajectory that the Kemp's ridley population had been increasing rapidly. There is evidence

of its population increase as far away from Mexico and the U.S. as European Atlantic waters (Witt et al. 2007).

3. Nesting is extremely rare on the U.S. east coast, even though adults have been documented to occur there. Of all the Kemp's ridleys of various sizes that have been tagged and released along the U.S. east coast over the years, the number later documented to have returned to the Gulf of Mexico has been relatively small, and the number documented to nest on Gulf beaches has been even smaller. Demographic modeling to date has not incorporated information on Kemp's ridleys along the U.S. east coast, except for application of somatic growth curves used to estimate age at maturity for Kemp's ridleys found there. Kemp's ridley growth probably is slower in the Atlantic than in the Gulf of Mexico (Fontaine et al. 1989); therefore, estimates of age at maturity based on somatic growth curves for Kemp's ridleys in the Atlantic would likely be higher than those derived from Kemp's ridleys that spend most or all of their lives in the Gulf of Mexico (Caillouet et al. 2011). However, growth rates of individual Kemp's ridleys that spend time in the Atlantic as well as in the Gulf of Mexico could be affected by environmental conditions in both areas.

4. Previous demographic modeling has been female-specific; early models assumed a 1F:1M sex ratio for hatchlings, but the most recent model assumed that all hatchling cohorts were 76.0% females (NMFS et al. 2011).

5. Nesters in any given year represent multiple cohorts (year-classes and age-groups) accumulated over the years; they range widely in size and somewhat in fecundity (Witzell et al. 2005b, 2007). Therefore, nests laid by multi-aged nesters in a given year should not be expected to be correlated with hatchling recruitment in any single prior year. In other words, it is not surprising that efforts to detect relationships between time-lagged numbers of nests and hatchling recruitment have

not been successful. Based on observations by Marquez-M. (1994), the residual subpopulation of old nesters during 1966-1975 began to be replaced by young nesters 1976, but replacement was not complete until 1984.

6. Choice of nesting beaches as population index sites for modeling was an important consideration in previous modeling (TEWG 1998, 2000; Heppell et al. 2005, 2007; and NMFS et al. 2011), and it is also important to our stock assessment.

7. Somatic growth curves have been based on samples containing males and females, usually in unknown proportions (Caillouet et al. 2011).

8. Total annual mortality rates of selected neritic age-groups have been estimated from catch curves applied to estimated age-structure of samples of stranded Kemp's ridleys (TEWG 1998, 2000; Heppell et al. 2005, 2007; NMFS et al. 2011), implicitly (if not explicitly) assuming a 1F:1M sex ratio for strandings. Transformation of carapace lengths to age for purposes of catch curve analyses has been based on selected somatic growth curves which, for the most part, were based on data with unknown proportions of males as well as females, under an implied if not explicit assumption that growth patterns of males and females do not differ.

9. Sex ratios of all life stages appear to be dominated by females (Geis et al. 2005; Ruckdeschel et al. 2005; Witzell et al. 2005a; Coyne and Landry 2007; Wibbels 2007), perhaps the result of the manipulative conservation methods used on nesting beaches, which resulted for the most part in incubation temperatures favoring production of more females than males.

10. Hildebrand (1963, 1982) and Carr (1963) estimated there were ≈ 40-42 thousand nesters on the primary nesting beach at Rancho Nuevo on 18 June 1947, based on undisclosed and therefore unevaluated estimation methods applied to images (frames) of nesters in an amateur movie made by Andrés Herrera.

Dickerson and Dickerson (2006) conducted a statistical analysis of counts of nesters in images from the same film, but NMFS et al. (2011) dismissed their results. Evaluation of the estimates by Hildebrand (1963, 1982) and Carr (1963) is important because these indices of population size have been applied as benchmarks by USFWS, NMFS, and SEMARNAT in establishing Kemp's ridley recovery criteria (USFWS and NMFS 1992; NMFS et al. 2011). Fortunately, copies of the Herrera film are available for re-analysis using statistically sound image analysis methods. However, this will not be undertaken by the KRSAW.

11. Age of individuals has been estimated from somatic growth curves, or determined by skeletochronological analysis of growth rings on bones from dead specimens. Estimation of age from somatic growth curves is challenging (Chaloupka and Musick 1997), and its application to mature turtles that grow slowly is especially challenging (Bjorndal et al. 2012). It is likely that the range in carapace length among individuals within cohorts, age-groups, and year-classes increases with age. If true, estimation of age of nesters, by decomposing size distributions into modal size or age-groups, under the assumption that size range is independent of age (or vice versa), could produce faulty results. Nevertheless, changes in annual size distributions, based on data from bycatches, strandings, and nesters on nesting beaches, reflect changes in age-structure of the population (Heppell et al. 2007).

12. Issues related to the statistical approach NMFS uses to estimate annual shrimp trawling effort in the Gulf of Mexico (Nance et al. 2008; Caillouet 2012a) were revisited and considered by all authors of this document (except John Cole) well before the KRSAW took place (Appendix II). While participating in the Gulf of Mexico Fishery Management Council's Ad Hoc Shrimp Effort Working Group in 2006 (Nance et al. 2008), one of us (Caillouet) recommended an alternative

estimator thought to be statistically more precise than the one used historically by NMFS. Preliminary analyses by Gazey and Raborn showed that the estimator used by NMFS was less sensitive than the alternative estimator to rarely occurring, very high catch rate observations associated with high catches and low shrimping effort. Time and resources were insufficient to determine whether these rare catch rates were statistical outliers or valid data points, so we decided to adopt NMFS' approach to estimating shrimp fishing effort for purposes of Kemp's ridley stock assessment modeling.

References (including but not limited to those cited)

Aguilar, D., and J. Grande-Vidal. 2008. Shrimp fishing in Mexico. In: Gillett, R., Global study of shrimp fisheries. Food and Agriculture Organization of the United Nations, Fisheries Technical Paper 475. Pp. 235-245. (http://www.fao.org/docrep/011/i0300e/i0300e00.htm)

Antonio, F.J., R.S. Mendes, and S.M. Thomaz. 2011. Identifying and modeling patterns of tetrapod vertebrate mortality rates in the Gulf of Mexico oil spill. Aquatic Toxicology 105:177-179. (http://arxiv.org/ftp/arxiv/papers/1106/1106.3293.pdf)

Barleycorn, A.A., and A.D. Tucker. 2005. *Lepidochelys kempii* (Kemp's ridley seaturtle): diet. Herpetological Review 36(1):58-59.

Barichivich, W.J., K.J. Sulak, and R.R. Carthy. 1999. Feeding ecology and habitat affinities of Kemp's ridley sea turtles *(Lepidochelys kempi)* in the Big Bend, Florida. Final report submitted to Southeast Fisheries Science Center, National Marine Fisheries Service, Panama City, Florida, Research Work

Order No. 189. 15 pp. (http://www.sefsc.noaa.gov/species/turtles/techmemos.htm#sefsc)

Barlow, P.F., and J. Berkson. 2012. Evaluating methods for estimating rare events with zero-heavy data: a simulation model estimating sea turtle bycatch in the pelagic longline fishery. Fishery Bulletin 110:344-360. (http://fishbull.noaa.gov/1103/barlow.pdf)

Barot, S., M. Heino, L. O'Brien, and U. Dieckmann. 2004. Estimating reaction norms for age and size at maturation when age at first reproduction is unknown *Evolutionary Ecology Research* 6:659–678. (http://evolutionary-ecology.com/ddar1617.pdf)

Baster, P.W.J., M.A. McCarthy, H.P. Possingham, P.W. Menkhorst, and N. McLean. 2006. Accounting for management costs in sensitivity analysis of matrix population models. Conservation Biology 20(3), 893–905. (http://www.uq.edu.au/ecology/docs/publications/2006_Baxter_etal_Accounting_for_management.pdf)

Bjorndal, K.A. (Editor). 1995. Biology and Conservation of Sea Turtles. Smithsonian Institution Press, Washington, D.C., 615 pp. (originally published in 1982).

Bjorndal, K.A., B.W. Bowen, M. Chaloupka, L.B. Crowder, S.S. Heppell, C.M. Jones, M.E. Lutcavage, D. Policansky, A.R. Solow, and B.E. Witherington. 2011. Better science needed for restoration in the Gulf of Mexico. Science 331(6017):537-538. (http://www.seaturtle.org/PDF/BjorndalKA_2011_Science.pdf)

Blue, L., and T.J. Espenshade. 2011. Population momentum across the demographic transition. Population Development Review 37(4):721–747. (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3345894)

Bolten, A.B. 2003. Variation in sea turtle life history patterns: neritic versus oceanic developmental stages. In: Lutz, P.L., J. Musick, and J. Wyneken (Editors), The Biology of Sea Turtles, Volume II, CRC Press, Boca Raton, Florida. Pp. 243-257. (http://accstr.ufl.edu/accstr-resources/publications/Bolten_chapter9(CRC%20Press).pdf)

Boyd, P.W., and D.A. Hutchins. 2012. Understanding the responses of ocean biota to a complex matrix of cumulative anthropogenic change. Marine Ecology Progress Series 470:125-135. (http://www.int-res.com/articles/theme/m470p125.pdf)

Bradshaw, C.J.A. 2005. Survival of the fittest technology — problems estimating marine turtle mortality. Marine Ecology Progress Series 287:261-262. (http://www.int-res.com/articles/meps2005/287/m287p261.pdf)

Braun-McNeill, J., and S.P. Epperly. 2002. Spatial and temporal distribution of sea turtles in the western North Atlantic and the U.S. Gulf of Mexico from marine recreational fishery statistics survey (MRFSS). Marine Fisheries Review 64(4):50-56. (http://spo.nwr.noaa.gov/mfr644/mfr6444.pdf)

Brongersma, L.D. 1972. European Atlantic turtles. Zoologische Verhandelingen 121:1-367.

Brongersma, L.D. 1982. Marine turtles of the eastern Atlantic Ocean. In: Bjorndal, K.A. (Editor). Biology and Conservation of Sea Turtles. Smithsonian Institution Press, Washington, D.C. Pp. 407-416 (also in second edition published in 1995).

Burchfield, P., and W. Tunnell. 2004. Obituary: Henry H. Hildebrand (1922-2003) as remembered by two friends. Marine Turtle Newsletter 103:20-21. (http://www.seaturtle.org/mtn/archives/mtn103/mtn103p20.shtml)

Burchfield, P.M. 2005. Texans, turtles, and the early Kemp's ridley population restoration project, 1063-67. Chelonian Conservation and Biology 4(4):835-837.

Burchfield, P.M. 2009. Report on the Mexico/United States of America population restoration project for the Kemp's ridley sea turtle, *Lepidochelys kempii*, on the coasts of Tamaulipas, Mexico 2009. Gladys Porter Zoo, Brownsville, Texas. 12 pp. (file uploaded to LGL's ShareFile account)

Burchfield, P.M., and L.J. Peña. 2010. Report on the Mexico/United States of America population restoration project for the Kemp's ridley sea turtle, *Lepidochelys kempii*, on the coasts of Tamaulipas, Mexico 2010. Gladys Porter Zoo, Brownsville, Texas. 12 pp. (file uploaded to LGL's ShareFile account)

Burchfield, P.M., and L.J. Peña. 2011. Report on the Mexico/United States of America population restoration project for the Kemp's ridley sea turtle, *Lepidochelys kempii*, on the coasts of Tamaulipas, Mexico 2011. Gladys Porter Zoo, Brownsville, Texas. 32 pp. (file uploaded to LGL's ShareFile account)

Burchfield, P.M., and L.J. Peña. 2012. Report on the Mexico/United States of America population restoration project for the Kemp's ridley sea turtle, *Lepidochelys kempii*, on the coasts of Tamaulipas, Mexico. 2012. Gladys Porter Zoo, Brownsville, Texas. 23 pp. (file uploaded to LGL's ShareFile account)

Byles, R. 1993. Head-start experiment [no] longer rearing Kemp's ridleys. Marine Turtle Newsletter 63:1-2. (http://www.seaturtle.org/mtn/archives/mtn63/mtn63p1.shtml)

Cadima, E.L. 2003. Fish Stock Assessment Manual. FAO Fisheries Technical

Paper 393. xx plus 66 pp. (ftp://ftp.fao.org/docrep/fao/006/x8498e/x8498e00.pdf)

Caillouet, C.W., Jr. (Compiler). 1999. Marine Turtle Newsletter articles on status of the Kemp's ridley population and actions taken toward its recovery. Marine Turtle Newsletter Archives. 133 pp. (http://www.seaturtle.org/mtn/special/MTN_Kemps.pdf)

Caillouet, C.W., Jr. 2003. Improved assessments and management of shrimp stocks could benefit sea turtle populations, shrimp stocks and shrimp fisheries. Marine Turtle Newsletter 100:22-27. (http://www.seaturtle.org/mtn/archives/mtn100/mtn100p22.shtml)

Caillouet, C. W., Jr. 2005. Guest Editorial: Wild and head-started Kemp's ridley nesters, eggs, hatchlings, nesting beaches and adjoining nearshore waters in Texas should receive greater protection. Marine Turtle Newsletter 110:1-3. (http://www.seaturtle.org/mtn/archives/mtn110/mtn110p1.shtml)

Caillouet, C.W., Jr. 2006. Guest Editorial: Revision of the Kemp's Ridley Recovery Plan. Marine Turtle Newsletter 114:2-5. (http://www.seaturtle.org/mtn/archives/mtn114/mtn114p2.shtml)

Caillouet, C.W., Jr. 2009. Editorial: Kemp's ridley hatchlings produced and nests laid annually should be posted on government agency web sites. Marine Turtle Newsletter 126:1. (http://www.seaturtle.org/mtn/archives/mtn126/mtn126p1.shtml)

Caillouet, C.W., Jr. 2010a. Editorial: Demographic modeling and threats analysis in the draft 2nd revision of the bi-national recovery plan for the Kemp's ridley sea turtle (*Lepidochelys kempii*). Marine Turtle Newsletter 128:1-6. (http://www.seaturtle.org/mtn/archives/mtn128/mtn128p1.shtml)

Caillouet, C.W., Jr. 2010b. Hildebrand (1963): a transcription and translation.

Marine Turtle Newsletter Archives. 39 pp. (http://www.seaturtle.org/PDF/CaillouetCW_2010_Hildebrand1963ATranscriptionandTran.pdf)

Caillouet, C.W., Jr. 2011. Guest Editorial: Did the BP-Deepwater Horizon-Macondo oil spill change the age structure of the Kemp’s ridley population? Marine Turtle Newsletter 130:1-2. (http://www.seaturtle.org/mtn/archives/mtn130/mtn130p1.shtml)

Caillouet, C.W., Jr. 2012a. Challenges in estimation and standardization of shrimping effort in the northern Gulf of Mexico. Unpublished White Paper prepared for the Kemp’s Ridley Stock Assessment Workshop. 16 pp. (file uploaded to LGL’s ShareFile account).

Caillouet, C.W., Jr. 2012b. Editorial: Do male-producing Kemp’s ridley nesting beaches exist north of Tamaulipas, Mexico? Marine Turtle Newsletter 134:1-2. (http://www.seaturtle.org/mtn/archives/mtn134/mtn134p1.shtml)

Caillouet, C.W., Jr. 2012c. Editorial: Does delayed mortality occur in sea turtles that aspirate seawater into their lungs during forced submergence or cold stunning? Marine Turtle Newsletter 135:1-4. (http://www.seaturtle.org/mtn/archives/mtn135/mtn135p1.shtml)

Caillouet, C.W., Jr., M.J. Duronslet, A.M. Landry Jr., D.B. Revera, D.J. Shaver, K.M. Stanley, R.W. Heinly, and E.K. Stabenau. 1991. Sea turtle strandings and shrimp fishing effort in the northwestern Gulf of Mexico, 1986-1989. U.S. Fishery Bulletin 89:712-718. (http://galveston.ssp.nmfs.gov/publications/pdf/120.pdf)

Caillouet, C.W., Jr., C.T. Fontaine, S.A. Manzella-Tirpak, and D.J. Shaver. 1995a. Survival of head-started Kemp's ridley sea turtles (*Lepidochelys kempii*) released into the Gulf of Mexico or adjacent bays. Chelonian Conservation and Biology 1:285-292. (http://galveston.ssp.nmfs.gov/publications/pdf/104.pdf)

Caillouet, C.W., Jr., C.T. Fontaine, S.A. Manzella-Tirpak, and T.D. Williams. 1995b. Growth of head-started Kemp's ridley sea turtles (*Lepidochelys kempii*) following release. Chelonian Conservation and Biology 1:231-234. (http://galveston.ssp.nmfs.gov/publications/pdf/105.pdf)

Caillouet, C.W., Jr., C.T. Fontaine, T.D. Williams, and S.A. Manzella-Tirpak. 1997. Early growth in weight of Kemp’s ridley sea turtles (*Lepidochelys kempii*) in captivity. Gulf Research Reports 9:239-246. (http://galveston.ssp.nmfs.gov/publications/pdf/107.pdf)

Caillouet, C.W., Jr., R.A. Hart, and J.M. Nance. 2008. Growth overfishing in the brown shrimp fishery of Texas, Louisiana, and adjoining Gulf of Mexico EEZ. Fisheries Research 92:289–302. (file uploaded to LGL’s ShareFile account)

Caillouet, C.W., Jr., and A.M. Landry, Jr. (Editors). 1989. Proceedings of the First International Symposium on Kemp’s Ridley Sea Turtle Biology, Conservation and Management. Texas A&M University, Sea Grant College Program, Galveston, Texas, TAMU-SG-89-105. 260 pp.

Caillouet, C. W., Jr., D. J. Shaver, and A. M. Landry, Jr. (*in press*). Head-start and reintroduction of Kemp’s ridley sea turtle (*Lepidochelys kempii*) to Padre Island National Seashore, Texas. Herpetological Conservation and Biology.

Caillouet, C.W., Jr., D.J. Shaver, A.M. Landry, Jr., D.W. Owens, and P.C.H. Pritchard. 2011. Kemp's ridley sea turtle (*Lepidochelys kempii*) age at first nesting. Chelonian Conservation and Biology 10(2):288-293. (file uploaded to LGL’s ShareFile account)

Caillouet, C.W., D.J. Shaver, W.G. Teas, J.M. Nance, D.B. Revera, and A.C.

Cannon. 1996. Relationship between sea turtle stranding rates and shrimp fishing intensities in the northwestern Gulf of Mexico: 1986-1989 versus 1990-1993. Fishery Bulletin 94(2):237-249. (http://galveston.ssp.nmfs.gov/publications/pdf/114.pdf)

Cadigan, N.G., and J.J. Dowden. 2010. Statistical inference about the relative efficiency of a new survey protocol, based on paired-tow survey calibration data. Fishery Bulletin 108:15-29. (http://fishbull.noaa.gov/1081/cadigan.pdf)

Camilli, R., C.M. Reddy, D.R. Yoerger, B.A.S. Van Mooy, M.V. Jakuba, J.C. Kinsey, C.P. McIntyre, S.P. Sylva, and J.V. Maloney. 2010. Tracking hydrocarbon plume transport and biodegradation at Deepwater Horizon. Science 330:201-204, and Science Express, 8 pp. (http://www.reefrelieffounders.com/drilling/wp-content/uploads/2010/08/Woods-Hole-Tracking-Hydrocarbon-plumes-paper.pdf).

Carr, A. 1957. Notes on the zoogeography of the Atlantic sea turtles of the genus *Lepidochelys*. Revista de Biología Tropical 5(1):45-61. (Republished in 2002, Revista de Biología Tropical 50(2) (http://www.scielo.sa.cr/scielo.php?pid=S0034-77442002000200031&script=sci_arttext)

Carr, A. 1963. Pan-specific reproductive convergence in *Lepidochelys kempi* Garman). Ergebnisse der Biologie 26:298-303.

Carr, A. 1967. So Excellent A Fishe: A Natural History of Sea Turtles. American Museum of Natural History, The Natural History Press, Garden City, New York. 248 pp.

Carr, A. 1977. Crisis for the Atlantic ridley. Marine Turtle Newsletter 4:2-3. (http://www.seaturtle.org/mtn/archives/mtn4/mtn4p2.shtml)

Carr, A. and D.K. Caldwell. 1958. The problem of the Atlantic ridley turtle (*Lepidochelys kempi*) in 1958. Revista de Biologia Tropical 6:245-262. (http://www.seaturtle.org/PDF/CarrA_1958_RevBiolTrop.pdf)

Carr, A., A. Meylan, J. Mortimer, K. Bjorndal, and T. Carr. 1982. Surveys of sea turtle populations and habitats in the western Atlantic. NOAA Technical Memorandum NMFS-SEFC-91. 96 pp. (http://www.sefsc.noaa.gov/turtles/TM_91_Carr_etal.pdf)

Caswell, H. 2010. Reproductive value, the stable stage distribution, and the sensitivity of the population growth rate to changes in vital rates. Demographic Research 23 (Article 19):531-548. (http://www.demographic-research.org/Volumes/Vol23/19/23-19.pdf)

Chaloupka, M., and G.R. Zug. 1997. A polyphasic growth function for the endangered Kemp's ridley sea turtle, *Lepidochelys kempii*. Fishery Bulletin 95:849-856. http://fishbull.noaa.gov/954/chaloupka.pdf

Chaloupka, M.Y., and C.J. Limpus. 1997. Robust statistical modeling of hawksbill sea turtle growth rates (southern Great Barrier Reef). Marine Ecology Progress Series 146:1-8. (http://www.int-res.com/articles/meps/146/m146p001)

Chaloupka, M.Y., and J.A. Musick. 1997. Age, growth, and population dynamics. In: Lutz, P.L., and J.A. Musick (Eds.). The Biology of Sea Turtles. CRC Press, Boca Raton, Florida. Pp. 233-276.

Chávez, H. 1968. Marcado y recapture de individuos de tortugas lora, *Lepidochelys kempi* (Garman) México. Instituto Nacional de Investigaciones Biológico-Pesqueras 19:1-28.

Chávez, H. 1967. Nota preliminar sobre la recaptura de ejemplares marcados de tortuga lora, *Lepidochelys olivacea kempii*. Instituto Nacional de

Investigaciones Biológico-Pesqueras, Boletin del Programa Nacional de Marcado de Tortugas Marinas I(6):1-5.

Chávez, H., M. Contreras, y E. Hernandez D. 1967. Aspectos biológicos y protección de tortuga lora, *Lepidochelys kempi* (Garman) en la costa de Tamaulipas. Instituto Nacional de Investigaciones Biológico-Pesqueras 17:1-39.

Chavez, H., M. Contreras G., and T.P.E. Hernandez D. 1968. On the coast of Tamaulipas. International Turtle and Tortoise Society Journal 2(4):20-29, 37, and 2(5):16-19, 27-34.

Cole, J.G., B.J. Gallaway, L.R. Martin, J.M. Nance, and M. Longnecker. 2006. Spatial allocation of shrimp catch based on fishing effort: adjusting for the effects of the Texas opening. North American Journal of Fisheries Management 26:789–792. (http://galveston.ssp.nmfs.gov/publications/pdf/867.pdf)

Cole, J.G., L.R. Martin, and B.J. Gallaway. 2003. Turtle-trawl interaction study data dictionary. Gulf and South Atlantic Fisheries Foundation, Inc. Contract #86-01-96808/0, 13 pp. plus Appendices I-III.

Collard, S B. and L.H. Ogren. 1990. Dispersal scenarios for pelagic post-hatchling sea turtles. Bulletin of Marine Science 47(1):233-243. (http://www.sefsc.noaa.gov/turtles/PR_Collard_Ogren_1990_BMS.pdf)

CRSTPAM (Committee on the Review of Sea-Turtle Population Assessment Methods). 2010. Assessment of Sea-Turtle Status and Trends: Integrating Demography and Abundance. The National Academies Press, Washington, D.C. 162 pp. (http://www.nap.edu/catalog.php?record_id=12889)

CSTC (Committee on Sea Turtle Conservation). 1990. Decline of the Sea

Turtles: Causes and Prevention. National Academy Press, Washington, D.C. 259 pp. (http://dels.nas.edu/Report/Decline-Turtles-Causes/1536)

Condrey, R., and D. Fuller. 1992. The U.S. Gulf shrimp fishery. In: Glantz, M.H. (Editor). Climate Variability, Climate Change and Fisheries. Cambridge University Press, Cambridge, UK. Pp. 89-119.

Cooper, A.B. 2006. A Guide to Fisheries Stock Assessment From Data to Recommendations. New Hampshire Sea Grant Program Publication UNHMP-TR-SG-06-17. 44 pp. (http://www.seagrant.unh.edu/stockassessmentguide.pdf)

Cope, J.M., and A. E. Punt. 2007. Admitting ageing error when fitting growth curves: an example using the von Bertalanffy growth function with random effects. Canadian Journal of Fisheries and Aquatic Sciences 64(2):205-218. (http://fish.washington.edu/research/MPAM/Pubs/CopePunt2007.pdf)

Coreil, P.D. 1989. Trawling efficiency device acceptance and use by Louisiana commercial shrimpers. In: Caillouet, C.W., Jr., and A.M. Landry, Jr. (Editors), Proceedings of the First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and Management, Texas A&M University, Sea Grant College Program, Galveston, Texas, TAMU-SG-89-105. Pp. 33-35.

Coyne, M., and A.M. Landry, Jr. 2007. Population sex ratio and its impact on population models. In: Plotkin, P.T. (Editor). Biology and Conservation of Ridley Sea Turtles, Johns Hopkins University Press, Baltimore, MD. Pp. 191-121.

Crouse, D. 1993. Tragic mass stranding confirms presence of Kemp's ridley turtles in Louisiana. Marine Turtle Newsletter 63:5-6. (http://www.seaturtle.org/mtn/archives/mtn63/mtn63p5.shtml)

Crowder, L., D. Crouse, S. Heppell, and T. Martin. 1994. Predicting the impact of turtle excluder devices on loggerhead sea turtle populations. Ecological Applications 4(3):437-445. (http://www-rohan.sdsu.edu/~jmahaffy/courses/f09/math636/lectures/les_mat/loggerhead.pdf)

Crowder, L. and S. Heppell. 2011. The decline and rise of a sea turtle: how Kemp's ridleys are recovering in the Gulf of Mexico. The Solutions Journal 2:67-73. (http://www.thesolutionsjournal.com/node/859)

Day, T., and P.D. Taylor. 1997. Von Bertalanffy's growth equation should not be used to model age and size at maturity. The American Naturalist 149(2):381-393. (http://www.mrgesa.com/LinkClick.aspx?fileticket=fpr%2BLu5Z%2BlM%3D&tabid=390&mid=1066)

De Roos, A.M. 2008. Demographic analysis of continuous-time life-history models. Ecological Letters; 11(1):1–15. (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2228373)

Dickerson, V.L., and D.D. Dickerson. 2006. Analysis of arribada in 1947 Herrera film at Rancho Nuevo, Mexico. U.S. Corps of Engineers, Engineer Research and Development Center, Vicksburg, Mississippi. 2 pp.

Diop, H., W.R. Keithly, Jr., R.F. Kazmierczak, Jr., and R.F. Shaw. 2005. Predicting white shrimp, *Penaeus setiferus*, abundance based on environmental parameters and previous life stages. Gulf and Caribbean Fisheries Institute 56:549-557.

Diop, H., W.R. Keithly, Jr., R.F. Kazmierczak, Jr. and R.F. Shaw. 2007. Predicting the abundance of white Shrimp (*Litopenaeus setiferus*) from environmental parameters and previous life stages. Fisheries Research

86(1):31–41.

Diop, H., W.R. Keithly, Jr., R.F. Kazmierczak, Jr., and R.F. Shaw. 2008. Relationship between early life stages of Louisiana white shrimp and subsequent landings. In: Nielson, J., J. Dodson, K. Friedland, T. Hamon, N. Hughes, J. Musick, and E. Verspoor (Editors), Reconciling Fisheries with Conservation, Proceedings of the Fourth World Fisheries Congress, Bethesda, MD, American Fisheries Society Symposium 49:1387-1396.

Dobrzynski, T. Strategy for sea turtle conservation and recovery in relation to Atlantic and Gulf of Mexico fisheries. NOAA National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD. 2 pp. (http://www.nmfs.noaa.gov/pr/pdfs/interactions/strategy_brochure.pdf)

Duronslet, M.J., D.B. Revera, and K.M. Stanley. 1991. Man-made marine debris and sea turtle strandings on beaches of the upper Texas and southwestern Louisiana coasts, June 1987 through September 1989. NOAA Technical Memorandum NMFS-SEFC-279. 46 pp. (http://www.sefsc.noaa.gov/turtles/TM_279_Duronslet_etal_1991.pdf)

Durrenberger, E. P. 1988. Shrimpers and turtles on the Gulf coast: The formation of fisheries policy in the United States. Maritime Anthropological Studies 1(2):196-214. (http://www.marecentre.nl/mast/documents/ShrimpersandTurtlesontheGulfCoast.pdf)

Durrenberger, E.P. 1990. Policy, power and science: the implementation of turtle excluder device regulations in the U.S. Gulf of Mexico shrimp fishery. Maritime Anthropological Studies 3(1) 69-86. (http://www.marecentre.nl/mast/documents/Policypowerandscience.pdf)

Eckert, K.L., K.A. Bjorndal, F. A. Abreu-Grobois, and M. Donnelly. 1999.

Research and Management Techniques for the Conservation of Sea Turtles. IUCN/SSC Marine Turtle Specialist Group Publication No. 4. 248 pp. (http://mtsg.files.wordpress.com/2010/11/techniques-manual-full-en.pdf)

Engen, S., R. Lande, B.-E. Sæther, and F.S. Dobson. 2009. Reproductive value and the stochastic demography of age-structured populations. American Naturalist 174(6):795-804. (http://www.math.ntnu.no/~steinaen/papers/repr_am_nat_2009.pdf)

Engen, S., R. Lande, B.-E. Sæther, and M. Festa-Bianchet. 2007. Using reproductive value to estimate key parameters in density-independent age-structured populations. Journal of Theoretical Biology 244:308-317. (http://pages.usherbrooke.ca/mfesta/pdffiles/EngenTheorBiol07.pdf)

Engen, S., R. Lande, B.-E. Sæther, and P. Gienapp. 2010. The ratio of effective to actual size of an age-structured population from individual demographic data. Journal of Evolutionary Biology 23:1148–1158. (http://onlinelibrary.wiley.com/doi/10.1111/j.1420-9101.2010.01979.x/pdf)

Epperly, S.P., A. Nunes, H. Zwartepoorte, L. Byrd, M. Koperski, L. Stokes, M. Bragança, A.D. Tucker, and C.R. Sasso. 2013. Repatriation of a Kemp's ridley from the eastern North Atlantic to the Gulf of Mexico. Marine Turtle Newsletter 136:1-2. (http://www.seaturtle.org/mtn/PDF/MTN136.pdf)

Epperly, S.P. 2003. Fisheries-related mortality and turtle excluder devices (TEDs). In: Lutz, P.L., J.A. Musick, and J. Wyneken (Eds.). The Biology of Sea Turtles. Vol. II. CRC Press, Boca Raton, Florida. Pp. 339-353. (http://www.sefsc.noaa.gov/turtles/PR_Epperly_2003_BSTVol2.pdf)

Epperly, S., L. Avens, L. Garrison, T. Henwood, W. Hoggard, J. Mitchell, J. Nance, J. Poffenberger, C. Sasso, E. Scott-Denton, and C. Yeung. 2002. Analysis of sea turtle bycatch in the commercial shrimp fisheries of southeast U.S. waters and Gulf of Mexico. NOAA Technical Memorandum NMFS-SEFSC-490. 92 pp. (http://www.sefsc.noaa.gov/turtles/TM_490_Epperly_etal.pdf)

Espenshade, T.J., A.S. Olgiati, and S.A. Levin. 2009. On “weak” and “strong” population momentum. Working Paper No. 2009-01, 40 pp. (http://opr.princeton.edu/papers/opr0901.pdf)

Ezard, T.H.G., J.M. Bullock, H.J. Dalgleish, A. Millon, F. Pelletier, A. Ozgul1, and D.N. Koons. 2010. Matrix models for a changeable world: the importance of transient dynamics in population management Journal of Applied Ecology 47, 515–523. (http://research.amnh.org/~rfr/hbp/ezardetal10.pdf)

Finkbeiner, E.M., B.P. Wallace, J.E. Moore, R.L. Lewison, L.B. Crowder, and A.J. Read. 2011. Cumulative estimates of sea turtle bycatch and mortality in USA fisheries between 1990 and 2007. Biological Conservation 144:2719-2727. (http://swfsc.noaa.gov/uploadedFiles/Divisions/PRD/Programs/Coastal_Marine_Mammal/Finkbeiner%20et%20al%20Sea%20Turtle%20Bycatch%20in%20US%20fisheries.%20%20Biol.%20Consv..pdf)

Fisher, R. 1930. The Genetical Theory of Natural Selection. Oxford University Press, Oxford, Great Britain. 272 pp.

Fossette, S., N.F. Putman, K.J. Lohmann, R. Marsh, and G.C. Hays. 2012. A biologist’s guide to assessing ocean currents: a review. Marine Ecology Progress Series 457:285-301. (http://www.int-res.com/articles/theme/m457p285.pdf)

Fournier, D.A., H.J. Skaug, J. Ancheta, J. Ianelli, A. Magnusson, M.N. Maunder, A. Nielsen, and J. Sibert. 2012. AD Model Builder: using automatic differentiation for statistical inference of highly parameterized complex nonlinear models. Optim. Methods Softw. 27:233-249. (http://admb-project.org)

Francis, K. 1978. Kemp’s ridley sea turtle conservation programs at South Padre Island, Texas, and Rancho Nuevo, Tamaulipas, Mexico. In: Henderson, G.E. (Editor). Proceedings of the Florida and Interregional Conference on Sea Turtles. Florida Marine Research Publications No. 33, St. Petersburg, FL. Pp. 51-52. (http://aquaticcommons.org/882/1/FMRP033.pdf)

Frazer, N.B. 1986. Kemp's decline: special alarm or general concern? Marine Turtle Newsletter 37:5-7. (http://www.seaturtle.org/mtn/archives/mtn37/mtn37p5.shtml)

Frazier, J., R. Arauz, J. Chevalier, A. Formia, J. Fretey, M.H. Godfrey, R. Márquez-M., B. Pandav, and K. Shanker. 2007. Human-turtle interactions at sea. In: Plotkin, P.T. (Editor). Biology and Conservation of Ridley Sea Turtles. John’s Hopkins University Press, Baltimore, MD. Pp. 253-295.

Frick, M.G., C.A. Quinn, and C.K. Stay. 1999. *Dermochelys corieacea* (leatherback sea turtle), *Lepidochelys kempi* (Kemp’s ridley sea turtle), and Caretta caretta (loggerhead sea turtle). pelagic feeding. Herpetological Review 30(3):165. (*http://carettaresearchproject.org/pubs/herp-review%2030-3-1999.pdf*)

Fuentes, M.M.P.B., and M. Hamann. 2008. A rebuttal to the claim natural beaches confer fitness benefits to nesting marine turtles. Biology Letters 5:266-267. (http://rsbl.royalsocietypublishing.org/content/5/2/266.full.pdf+html)

Galindo, C. 2007. On Fisher’s reproductive value and Lotka’s stable population. Annual Meeting of the Population Association of America, New York. (http://paa2007.princeton.edu/papers/72160) 26 pp.

(http://epc2008.princeton.edu/papers/80487) 40 pp.

Gallaway, B.J., C.W. Caillouet, Jr., and P.M. Plotkin. 2012. Kemp's ridley stock assessment workshop proposal. March 5, 2012. Submitted to Gulf States Marine Fisheries Commission, Ocean Springs, MS. Attention: Dr. Larry Simpson, Executive Director. (file uploaded to LGL's ShareFile account)

Gallaway, B.J., J.G. Cole, L.R. Martin, J.M. Nance, and M. Longnecker. 2003a. Description of a simple electronic logbook designed to measure effort in the Gulf of Mexico shrimp fishery. North American Journal of Fisheries Management 23:591-589.

Gallaway, B.J., J.G. Cole, L.R. Martin, J.M. Nance, and M. Longnecker. 2003b. An evaluation of an electronic logbook as a more accurate method of estimating spatial patterns of trawling effort and bycatch in the Gulf of Mexico shrimp fishery. North American Journal of Fisheries Management 23:787-809.

Gallaway, B.J., J.G. Cole, J.M. Nance, R.A. Hart, and G.L. Graham. 2008. Shrimp loss associated with turtle excluder devices: are the historical estimates statistically biased? North American Journal of Fisheries Management 28:203-211.

García, A., G. Ceballos, and R. Adaya. 2003. Intensive beach management as an improved sea turtle conservation strategy in Mexico. Biological Conservation 111:253-261. (http://www.ecologia.unam.mx/laboratorios/eycfs/faunos/art/GCe/AA06.pdf)

Gazey, W.J., B.J. Gallaway, J.G. Cole, and D.A. Fournier. 2008. Age composition, growth, and density-dependent mortality in juvenile red snapper estimated from observer data from the Gulf of Mexico Penaeid shrimp fishery. North

American Journal of Fisheries Management 28:1828-1842.

Geis, A.A., W.J. Barichivich, T. Wibbels, M. Coyne, A.M. Landry, Jr., and D. Owens. 2005. Predicted sex ratio of juvenile Kemp's ridley sea turtles captured near Steinhatchee, Florida. Copeia 2005:393-398.

Gerber, L.R., and S.S. Heppell. 2004. The use of demographic sensitivity analysis in marine species conservation planning. Biological Conservation 120:121-128. (http://gerberlab.faculty.asu.edu/wordpress/wp-content/uploads/docs/gerber_heppell_04.pdf)

Gitschlag, G.R. 1996. Migration and diving behavior of Kemp's ridley (Garman) sea turtles along the U.S. southeastern Atlantic coast. Journal of Experimental Marine Biology and Ecology 205:115-135. (http://galveston.ssp.nmfs.gov/publications/pdf/256.pdf)

Gómez, M.A., and A. Gracia. 2007. Dispersal patterns of shrimp larvae and postlarvae of the genus *Solenocera*. Revista de Biologia Marina y Oceanografia 42(2)157-165. (http://redalyc.uaemex.mx/pdf/479/47942203.pdf)

Goshe, L.R., L. Avens, J. Bybee, and A.A. Hohn. 2009. An evaluation of histological techniques used in skeletochronological age estimation of sea turtles. Chelonian Conservation and Biology 8(2):217-222. (http://www.sefsc.noaa.gov/turtles/PR_Goshe_etal_2009_ChelConservBiol.pdf)

Gracia, A. 1991. Spawning stock–recruitment relationships of white shrimp in the southwestern Gulf of Mexico. Transactions of the American Fisheries Society. 120(4):519-527.

Gracia, A. 1996. White shrimp (*Penaeus setiferus*) recruitment overfishing. Marine and Freshwater Research 47:59-65.

Gracia, A. 1997. Simulated and actual effects of the brown shrimp, *Penaeus aztecus*, closure in Mexico. Marine Fisheries Review 59(2):18-24.

Gracia, A., and A.R. Vázquez Bader. 1998. The effects of artisanal fisheries on Penaeid shrimp stocks in the Gulf of Mexico. Fisheries Stock Assessment Models, Alaska Sea Grant College Program, AK-SG-98-01, pp. 977-998.

Grafen, A. 2006. A theory of Fisher's reproductive value. Journal of Mathematical Biology 53:15-60. (http://users.ox.ac.uk/~grafen/papers/classes.pdf). See also: (http://www.ncbi.nlm.nih.gov/pubmed/16791649)

Graham, G., and J. Jamison. 2006. Industry/NMFS TED/BRD Workshop. Final Report, Gulf & South Atlantic Fisheries Foundation, Inc., NOAA/NMFS/SER) Purchase Order #GA133F06SE1629/#98, 59 pp. (http://www.gulfsouthfoundation.org/uploads/reports/98%20final%20report_20100831082454.pdf)

Griffin, W., J. Ward, and J. Nance. 1996. A bioeconomic analysis of management alternatives to control sea turtle mortality in the Gulf of Mexico shrimp fishery. Proceedings of the Symposium on the Consequences and Management of Fisheries Bycatch. Alaska Sea Grant Report 97-02:57-62. (http://www.seaturtle.org/pdf/ocr/GriffinW_1997_InProceedingsFisheriesBycatchConseque_p57-62.pdf)

Griffin, W.L., A.K. Shah, and J.M. Nance. 1997. Estimation of standardized effort in the heterogeneous Gulf of Mexico shrimp fleet. Marine Fisheries Review 59(3):23-33. (http://spo.nmfs.noaa.gov/mfr593/mfr5933.pdf)

Gunter, G., and J.C. Edwards. 1968. The relation of rainfall and fresh-water drainage to the production of the Penaeid shrimps (*Penaeus fluviatilis* Say and *Penaeus aztecus* Ives) in Texas and Louisiana waters. In: Mistakidis, M.N. (Editor), Proceedings of the World Scientific Conference on the

Biology and Culture of Shrimps and Prawns, FAO Fisheries Report R57, Volume 3, Chapter E/49. (http://www.fao.org/docrep/005/AC741T/AC741T20.htm#ch20)

Haas, H.L. 2010. Using observed interactions between sea turtles and commercial bottom-trawling vessels to evaluate the conservation value of trawl gear modifications. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 2:263-276. (http://www.sefsc.noaa.gov/turtles/PR_Haas_2010_MarCoastFish.pdf)

Hart, R.A., J.M. Nance, and J.A. Primrose. 2012. The U.S. Gulf of Mexico pink Shrimp, *Farfantepenaeus duorarum*, fishery: 50 years of commercial catch statistics. Marine Fisheries Review 74(1):1-6. (http://spo.nmfs.noaa.gov/mfr741/mfr7411.pdf)

Hart, K.M., P. Mooreside, and L.B. Crowder. 2006. Interpreting the spatio-temporal patterns of sea turtle strandings: going with the flow. Biological Conservation 129:283-290.

He, J.X., and D.J. Stewart. 2001. Age and size at first reproduction of fishes: predictive models based only on growth trajectories. Ecology 82(3):784-791. (http://qfc.fw.msu.edu/Ji%20He/He%20and%20Stewart%202001.pdf)

Heino, M., U. Dieckmann, and O.R. Godø. 2002. Measuring probabilistic reaction norms for age and size at maturation. Evolution 56(4):669-678. (http://www.bio.uib.no/evofish/papers/Heino_2002_Measuring_probabilistic.pdf)

Hendrickson, L.P., and J.R. Hendrickson. 1981. A new method for marking sea turtles. Marine Turtle Newsletter 19:6-7. (http://www.seaturtle.org/mtn/archives/mtn19/mtn19p6b.shtml)

Hendrickson, L.P., and J.R. Hendrickson. 1983. Experimental marking of sea turtles by tissue modification. In: Owens, D., D. Crowell, G. Dienberg, M. Grassman, S. McCain, Y. Morris, N. Schwantes, and T. Wibbels (Editors). Western Gulf of Mexico Sea Turtle Workshop Proceedings. Texas A&M University, Sea Grant College Program, TAMU-SG-84-105, College Station, Texas. Pp. 30-31.

Heppell, S.S. 1997. On the importance of eggs. Marine Turtle Newsletter 76:6-8. (http://www.seaturtle.org/mtn/archives/mtn76/mtn76p6.shtml)

Heppell, S.S., P.M. Burchfield, and L.J. Peña. 2007. Kemp's ridley recovery: how far have we come, and where are we headed? In: Plotkin, P.T. (Editor). Biology and Conservation of Ridley Sea Turtles. John's Hopkins University Press, Baltimore, MD. Pp. 325-335.

Heppell, S.S., D.T. Crouse, L.B. Crowder, S.P. Epperly, W. Gabriel, T.R. Henwood, R. Márquez, R., and N.B. Thompson. 2005. A population model to estimate recovery time, population size, and management impacts on Kemp's ridley sea turtles. Chelonian Conservation and Biology 4:767-773.

Heppell, S.S., and L.B. Crowder. 1998. Prognostic evaluation of enhancement programs using population models and life history analysis. Bulletin of Marine Sciences 62:405-507. (http://docserver.ingentaconnect.com/deliver/connect/umrsmas/00074977/v62n2/s14.pdf?expires=1353787653&id=71638272&titleid=10983&accname=Guest+User&checksum=E0B88DF9E38CB058E72DED1BC7E7B3EF)

Heppell, S.S., S.A. Heppell, A.J. Read, and L.B. Crowder. 2005. Effects of fishing on long-lived marine organisms. In: Norse, E.A. et al. (Ed.) (2005). Marine Conservation Biology: The Science of Maintaining the Sea's Biodiversity. Island Press: Washington D.C., Pp. 211-231.

Heppell, S.S., M.L. Snover, and L.B. Crowder. 2003. Sea Turtle Population

Ecology. Chapter 11 In: Lutz, P.L., J. Musick, and J. Wyneken (Editors), The Biology of Sea Turtles, Volume II, CRC Press, Boca Raton, Florida. Pp. 275-306. (http://www.seaturtle.org/PDF/Ocr/HeppellSS_2003_InThebiologyofseaturtlesVolume2_p275-306.pdf)

Herrando-Pérez, S., S. Delean, B.W. Brook, and C.J.A. Bradshaw. 2012. Strength of density feedback in census data increases from slow to fast life histories. Ecology and Evolution 2(8):1922-1934. (http://onlinelibrary.wiley.com/doi/10.1002/ece3.298/pdf)

Hilborn, R., and C.J. Walters. 1992. Quantitative Fisheries Stock Assessment: Choice, Dynamics and Uncertainty. Chapman and Hall, New York. 570 p.

Hildebrand, H.H. 1963. Hallazgo del area de anidacion de la Tortuga marina, “lora”, *Lepidochelys kempi* (Garman) en la costa occidental del Golfo de Mexico. Ciencia, Méx. 22:105-112. (http://www.seaturtle.org/PDF/CaillouetCW_2010_Hildebrand1963ATranscriptionandTran.pdf)

Hildebrand, H.H. 1982. A historical review of the status of sea turtle populations in the western Gulf of Mexico. In: Bjorndal, K.A. (Editor). Biology and Conservation of Sea Turtles. Smithsonian Institution Press, Washington, D.C. Pp. 447-453 (also in second edition published in 1995).

Hopkins, S.R., and J.I. Richardson (Editors). 1984. Recovery plan for marine turtles. National Marine Fisheries Service, St. Petersburg, Florida. 355 pp.

Insacco, G., and F. Spadola. 2010. First record of Kemp's ridley sea turtle, *Lepidochelys kempii* (Garman, 1880) (Cheloniidae), from the Italian waters (Mediterranean Sea). Acta Herpetologica 5:113-117. (file uploaded to

LGL’s ShareFile Account)

Iversen, E.S., D.M. Allen, and J.B. Higman. 1993. Shrimp Capture and Culture Fisheries of the United States. Halsted Press, NY. 247 pp.

Jepson, M. 2008a. A Project to Augment the Data Collection and Development of an Electronic Logbook System Used Within the Gulf of Mexico Shrimp Fishery. Final Report, NOAA/NMFS Cooperative Agreement Number NA05NMF4540044 (GSAFFI #94), 13 pp. plus Appendix. (http://www.gulfsouthfoundation.org/uploads/reports/94_Final_Report.pdf)

Jepson, M. 2008b. An Assessment of Turtle Excluder Devices within the Southeastern Shrimp Fisheries of the United States. Final Report, NOAA/NMFS Cooperative Agreement Number NA04NMFS4540112: #92. 18 pp. (http://spo.nmfs.noaa.gov/mfr481/mfr4811.pdf)

Jiménez-Quiroz, M. del Carmen, R. Márquez-Millán, J. Diaz-Flores, and A.S. Leo-Paredo. 2003. Characteristicas de las arribazones de la Tortuga marina lora en Rancho Nuevo (Tamaulipas, México). Oceánides 18(2):69-81. (http://www.cicimar.ipn.mx/oacis/Medios/oceanides/1826981.pdf)

Kemp's Ridley Recovery Team (KRRT). 2009. A brighter future for the Kemp's ridley. Endangered Species Bulletin, Summer 2009:16-18. (http://www.sefsc.noaa.gov/turtles/PR_KempsRidleyRecoveryTeam_2009_Endang_Spp_Bull.pdf)

Keyfitz, N. 1971. On the momentum of population growth. Demography 8:71-80. (http://www.jstor.org/discover/10.2307/2060339?uid=3739920&uid=2&uid=4&uid=3739256&sid=21101470657077)

Koons, D.N., J.B. Grand, and J.M. Arnold. 2006. Population momentum across vertebrate life histories. Ecological Modelling 197:418-430. (http://research.amnh.org/~rfr/hbp/koonsetal06b.pdf)

Koons, D.N., R.F. Rockwell, and J.B. Grand. 2006. Population momentum: implications for wildlife management. The Journal of Wildlife Management 70(1):19-26. (http://research.amnh.org/~rfr/momentum.pdf)

Koons, D.N., J.B. Grand, B. Zinner, and R.F. Rockwell. 2005. Transient population dynamics: relations to life history and initial population state. Ecological Modelling 185:283-297. (http://demogr.mpg.de/publications%5Cfiles%5C2364_1155281974_1_Koons%20et%20al%202005.pdf)

Kraak, S.B.M. 2007. Does the probabilistic maturation reaction norm approach disentangle phenotypic plasticity from genetic change? Marine Ecology Progress Series 335:295-300. (http://www.int-res.com/articles/theme/m335p295.pdf)

Kutkuhn, J.H. 1962. Gulf of Mexico commercial shrimp populations—trends and characteristics, 1956-59. Fishery Bulletin 212, Volume 62, pp. 343-402. (http://fishbull.noaa.gov/62-1/kutkuhn.pdf)

Kvamsdal, S., and S.M. Stohs. 2010. A Market-Based Approach to Manage Endangered Species Interactions. NHH Department of Finance & Management Science Discussion Paper No. 2010/11, 17 pp. (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1676117)

LaFleur, E., D. Yeates, and A. Aysen. 2005. Estimating the economic impact of the wild shrimp, Penaeus sp., fishery: a study of Terrebonne parish, Louisiana. Marine Fisheries Review 67(1):28-42. (http://spo.nmfs.noaa.gov/mfr671/mfr6712.pdf)

Landry, A.M., Jr., D.T. Costa, F.L. Kenyon, II, and M.S. Coyne. 2005. Population characteristics of Kemp's ridley sea turtles in nearshore waters of the upper Texas and Louisiana coasts. Chelonian Conservation and Biology 4(4):799-

805.

Landry, A.M., Jr., D.T. Costa, F.L. Kenyon, M.C. Hadler, M.S. Coyne, L.A. Hoopes, L.M. Orvik, K.E. St. John, and K.J. VanDenburg. 1996. Exploratory analysis of the occurrence of Kemp's ridleys in inland waters of Texas and Louisiana. A report of the Texas A&M Research Foundation pursuant to U.S. Fish and Wildlife Grant No. 1448-00002-94-0823. 77 pp. (http://www.seaturtle.org/biblio/USFW96.pdf)

Lavers, J.L., C. Wilcox, C.J. Dolan, D.K. Wingfield, and L.B. Crowder. *In press*. Incorporating economic costs to changes in demographic rates for long-lived marine birds and turtles: elasticity ratios as a guide. Advanced Conservation Strategies (http://advancedconservation.org/library/Lavers%20etal%20-%20Ecol%20Apps%20DRAFT%20(Mar%2017).pdf)

Lawler, J.J., S.P. Campbell, A.D. Guerry, M.B. Kolozsvary, R.J. O'Conner, and L.C.N. Seward. 2002. The scope and treatment of threats in endangered species recovery plans. Ecological Applications 12:663-667. (http://depts.washington.edu/landecol/PDFS/Threats.pdf)

Lee, J. 2012. The 2012 Shrimp Biological Opinion on the Sea Turtle Conservation Regulations (Including Proposed Skimmer Trawl Rule) and Federal Shrimp Fisheries. NOAA Fisheries Service, Southeast Regional Office, Protected Resources Division, St. Petersburg, Florida. 35 pp. (http://www.safmc.net/LinkClick.aspx?fileticket=R9I0PKo9wtA%3D&tabid=736)

Leo Peredo,, A.S., R.G. Castro Meléndez, A.L. Cruz Flores, A. González, and E. Conde Galaviz. 1999. Distribution and abundance of the Kemp's ridley (*Lepidochelys kempii*) neophytes at the Rancho Nuevo nesting beach, Tamaulipas, Mexico, during 1996-1998. P. 272, In: Kalb, H., and T.Wibbels Compilers). Proceedings of 19th Annual Symposium on Sea Turtle Conservation and Biology. NOAA Tech. Memo. NMFS-SEFSC-443. (http://www.sefsc.noaa.gov/turtles/TM_443_Kalb_Wibbels_19.pdf)

Lester, N.P., B.J. Shuter, and P.A. Abrams. 2004. Interpreting the von Bertalanffy model of somatic growth in fishes: the cost of reproduction. Proceedings of the Royal Society of London B:271:1625-1631.

Lewison, R.L., L.B. Crowder, and D.J. Shaver, D. 2003. The impact of turtle excluder devices and fisheries closures on loggerhead and Kemp's ridley strandings in the western Gulf of Mexico. Conservation Biology 17(4):1089-1097. (http://www.bio.sdsu.edu/Pub/lewison/conservation/uploads/Main/lewison_et_al_2003.pdf)

Limpus, C. and M. Chaloupka. 1997. Nonparametric regression modeling of green sea turtle growth rates (southern Great Barrier Reef). Marine Ecology Press Series 149:23-34. (http://www.int-res.com/articles/meps/149/m149p023.pdf)

Lohmann, K.J. 2010. Magnetic-field perception. Nature 464:1140-1142. (http://www.unc.edu/depts/geomag/PDFGeomag/2010LohmannNatureQ&A.pdf)

Lohmann, K.M., C.M.F. Lohmann, J.R. Brothers, and N.F. Putman. 2012. Natal homing and imprinting in sea turtles. ()

Lohmann, K.J., N.F. Putman, and C.M.F. Lohmann. 2008. Geomagnetic imprinting: a unifying hypothesis of long-distance natal homing in salmon and sea turtles. Proceedings of the National Academy of Sciences 105:19096-19101. (http://www.unc.edu/depts/geomag/PDFGeomag/2008PNAS.pdf)

Lutz, P.L., and M. Lutcavage. 1989. The effects of petroleum on sea turtles: applicability to Kemp's ridley. In: Caillouet, C.W., Jr., and A.M. Landry, Jr. (Editors), Proceedings of the First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and Management, Texas A&M University, Sea Grant College Program, Galveston, Texas, TAMU-SG-89-105. Pp. 52-54.

Manzella, S.A., and J.A. Williams. 1992. The distribution of Kemp's ridley sea turtles (*Lepidochelys kempi*) along the Texas coast: an atlas. NOAA Technical Report NMFS 110. 52 pp. (http://www.sefsc.noaa.gov/turtles/TR_NMFS_110_1992.pdf)

Márquez, R. 1972. Resultados preliminares sobre edad y crecimiento de la tortuga lora, *Lepidochelys kempi* (Garman). Memorias, IV Congreso Nacional de Oceanografia, México, D.F., 17-19 Noviembre 1969. Pp. 419-427. (file uploaded to LGL's ShareFile account)

Marquez M., R. 1978. Natural reserves for the conservation of marine turtles of Mexico. In: Henderson, G.E. (Editor), Proceedings of the Florida and Interregional Conference on Sea Turtles, 24-25 July 1976, Jensen Beach, Florida. Florida Marine Research Publications Number 33. Pp. 56-60. (http://aquaticcommons.org/882/1/FMRP033.pdf)

Márquez M., R. 1990. FAO Species Catalogue, Vol. 11 Sea Turtles of the World, An Annotated and illustrated Catalogue of Sea Turtle Species Known to Date. FAP Fisheries Synopsis No. 125, 81 pp. (http://www.fao.org/docrep/009/t0244e/t0244e00.htm)

Marquez-M., R. 1994. Synopsis of biological data on the Kemp's ridley turtle, *Lepidochelys kempi* (Garman, 1880). NOAA Tech. Memo. NMFS-SEFSC-343, 91 pp.

(http://www.sefsc.noaa.gov/turtles/TM_343_Marquez_M_1994.pdf)

Márquez-M., R., P.M. Burchfield, J. Diaz-F., M. Sánchez-P., M. Carrasco-A., C. Jiménez-Q., A. Leo-P., R. Bravo-G. and J. Peña-V. 2005. Status of the Kemp's ridley sea turtle, *Lepidochelys kempii*. Chelonian Conservation and Biology 4:761-766.

Marquez-M., R., Ma. M.A. Carrasco-A., C. Jimenez-O., R.A. Byles, P.M. Burchfield, M. Sanchez-P., J. Diaz-F., and A.S. Leo-P. 1996. Good news! rising numbers of Kemp's ridleys nest at Rancho Nuevo, Tamaulipas, México. Marine Turtle Newsletter 73:2-5. (http://www.seaturtle.org/mtn/archives/mtn73/mtn73p2.shtml)

Márquez, R., y M. Contreras. 1967. Marcado de tortuga lora *Lepidochelys kempi* en la costa de Tamaulipas. Instituto Nacional de Investigaciones Biológico-Pesqueras, Boletin del Programa Nacional de Marcado de Tortugas Marinas II(1):1-8.

Márquez-M., R., J. Díaz-F., V. Guzmán-H., R. Bravo-G., and M. del Carmen Jimenez-Q. 2004. Marine turtles of the Gulf of Mexico. Abundance, distribution and protection. In: Caso, M., I. Pisanty, and E. Ezcurra (Editors, Spanish Version); Withers, K., and M. Nipper (Editors, English Translation). Environmental Analysis of the Gulf of Mexico. Harte Research Institute. Pp. 89-107. (http://www.harteresearchinstitute.org/images/Environmental_Analysis/6.pdf)

Márquez-M., R., D. Ríos-O., J.M. Sánchez-P., and J. Díaz. 1989. Mexico's contribution to Kemp's ridley sea turtle recovery. In: Caillouet, C.W., Jr., and A.M. Landry, Jr. (Editors), Proceedings of the First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and

Management, Texas A&M University, Sea Grant College Program, Galveston, Texas, TAMU-SG-89-105. Pp. 4-6.

Márquez M., R., A. Villanueva O., and P.M. Burchfield. 1989. Nesting population and production of hatchlings of Kemp's ridley sea turtle at Rancho Nuevo, Tamaulipas, Mexico. In: Caillouet, C.W., Jr., and A.M. Landry, Jr. (Editors), Proceedings of the First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and Management, Texas A&M University, Sea Grant College Program, Galveston, Texas, TAMU-SG-89-105. Pp. 16-19.

Márquez M., R., A. Villanueva O., and M. Sanchez Perez. 1982. The population of the Kemp's ridley sea turtle in the Gulf of Mexico—*Lepidochelys kempii*. In: Bjorndal, K.A. (Editor). Biology and Conservation of Sea Turtles. Smithsonian Institution Press, Washington, D.C. Pp. 159-164 (also in second edition published in 1995).

Mazaris, A.D., B. Broder, and Y.G. Matsinos. 2006. An individual based model of a sea turtle population to analyze effects of age dependent mortality. Ecological Modelling 198:174-182.

Mazaris, A.D., Ø. Fiksen, and Y.G. Matsinos. 2005. Using an individual-based model for assessment of sea turtle population viability. Population Ecology 47:179-191. (http://www.bio.uib.no/evofish/papers/Mazaris_2005_Using_an_individual.pdf)

Mazaris, A.D., and Y.G. Matsinos. 2006. An individual based model of sea turtles: investigating the effect of temporal variability on population dynamics. Ecological Modelling 194(1–3):114–124. (http://www.sciencedirect.com/science/article/pii/S0304380005005028)

Mazaris, A.D., S. Kramer-Schadt, J. Tzanopoulos, K. Johst, G. Matsinos, and J.D.

Pantis. 2009. Assessing the relative importance of conservation measures applied on sea turtles: comparison of measures focusing on nesting success and hatchling recruitment success. Amphibia-Reptilia 30:221-231.

McCluskey, S.M., and R.L. Lewison. 2008. Quantifying fishing effort: a synthesis of current methods and their applications. Fish and Fisheries 9:188-200. (http://bycatch.nicholas.duke.edu/publicationsandreports/McClusky2008.pdf)

McDaniel, C.J., L.B. Crowder, and J.A. Priddy. 2000. Spatial dynamics of sea turtle abundance and shrimping intensity in the U.S. Gulf of Mexico. Conservation Ecology 4(1):Article l5. (http://www.sefsc.noaa.gov/turtles/PR_McDaniel_etal_2000_Conserv_Ecology.pdf)

McGuire, T.R. 1991. Science and the destruction of a shrimp fleet. Maritime Anthropological Studies 4(1):32-55. (http://marecentre.nl/mast/documents/artikel3.pdf)

Metz, T.L. 2004. Factors influencing Kemp's ridley sea turtle (*Lepidochelys kempii*) distribution in nearshore waters and implications for management. Ph.D. Dissertation, Texas A&M University, College Station, Texas. 1 63 pp. (http://repository.tamu.edu/bitstream/handle/1969.1/1247/etd-tamu-2004B-2-WFSC-Metz-2.pdf?sequence=1)

Moore, J.E., and A.J. Read. 2008. A Bayesian uncertainty analysis of cetacean demography and bycatch mortality using age-at-death data. Ecological Applications 18(8)1914-1931. (http://bycatch.nicholas.duke.edu/publicationsandreports/Moore2008b.pdf)

Montoya, A.E., y E. Vargas. 1968. Marcado de tortuga lora *Lepidochelys kempi* (Garman), en la costa de Tamaulipas. Instituto Nacional de Investigaciones

Biológico-Pesqueras, Boletin del Programa Nacional de Marcado de Tortugas Marinas II(2):1-11.

Nance, J., W. Keithly, Jr., C. Caillouet, Jr., J. Cole, W. Gaidry, B. Gallaway, W. Griffin, R. Hart, and M. Travis. 2008. Estimation of effort, maximum sustainable yield, and maximum economic yield in the shrimp fishery of the Gulf of Mexico. NOAA Technical Memorandum NMFS-SEFSC-570. 69 pp. (http://galveston.ssp.nmfs.gov/publications/pdf/885.pdf)

Nance, J.M. 1992. Estimation of effort for the Gulf of Mexico shrimp fishery. NOAA Technical Memorandum NMFS-SEFSC-300. 12 pp. (http://galveston.ssp.nmfs.gov/publications/pdf/489.pdf)

Nance, J.M. 1993. Analysis of white shrimp closures in the Gulf of Mexico. NOAA Technical Memorandum NMFS-SEFSC-321, 11 pp. (http://galveston.ssp.nmfs.gov/publications/pdf/491.pdf)

Nance, J.M. 2004. Estimation of effort in the offshore shrimp trawl fishery of the Gulf of Mexico. Red Snapper SEDAR Data Workshop, SEDAR7-DW-24, 41 pp. (http://www.sefsc.noaa.gov/sedar/download/SEDAR7_DW24.pdf?id=DOCUMENT)

Nance, J.M., C.W. Caillouet, Jr., and R.A. Hart. 2010. Size-composition of annual landings in the white shrimp fishery of the northern Gulf of Mexico, 1960-2006: its trend and relationships with other fishery-dependent variables. Marine Fisheries Review 72:1-13. (http://spo.nmfs.noaa.gov/mfr722/mfr7221.pdf)

NMFS (National Marine Fisheries Service). 2007. Report to Congress on the impacts of hurricanes Katrina, Rita, and Wilma on Alabama, Louisiana, Florida, Mississippi, and Texas Fisheries. U.S. Department of Commerce, NOAA, NMFS, Silver Spring, MD. 133 pp. (http://www.nmfs.noaa.gov/msa2007/docs/Fisheries_Report_Final.pdf)

NMFS. 2011. Scoping document for preparation of a draft environmental impact statement to reduce incidental bycatch and mortality of sea turtles in the southeastern U.S. shrimp fishery. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Regional Office, St. Petersburg, FL. 9 pp. (http://sero.nmfs.noaa.gov/pr/endangered%20species/Shrimp%20Fishery/SCOPING%20DOCUMENT.pdf)

NMFS. 2012. Draft environmental impact statement to reduce incidental bycatch and mortality of sea turtles in the southeastern U.S. shrimp fisheries. National Oceanic and Atmospheric, Administration, National Marine Fisheries Service, Southeast Regional Office, Protected Resources Division, St. Petersburg, Florida. 261 pp. (http://www.nmfs.noaa.gov/pr/pdfs/species/deis_seaturtle_shrimp_fisheries_interactions.pdf)

NMFS and USFWS (U.S. Fish and Wildlife Service). 2007. Kemp's ridley sea turtle (*Lepidochelys kempii*) 5-year review: summary and evaluation. U.S. Department of Commerce and U.S. Department of the Interior. 50 pp. (http://www.nmfs.noaa.gov/pr/pdfs/species/kempsridley_5yearreview.pdf)

NMFS, USFWS, and SEMARNAT. 2011. Bi-National Recovery Plan for the Kemp's Ridley Sea Turtle (*Lepidochelys kempii*), Second Revision. National Marine Fisheries Service. Silver Spring, Maryland. 156 pp. + appendices. (http://www.nmfs.noaa.gov/pr/pdfs/recovery/kempsridley_revision2.pdf)

Ogren, L.H. 1978. Survey and reconnaissance of sea turtles in the northern Gulf of Mexico. Report prepared for the National Marine Fisheries Service, Southeast Fisheries Center, 8 pp.

Ogren, L.H. 1989. Distribution of juvenile and subadult Kemp's ridley turtles: preliminary results from the 1984-1987 surveys. In: Caillouet, C.W., Jr., and André M. Landry, Jr. (Editors). Proceedings of the First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and Management. Texas A & M University, Sea Grant College Program TAMU-SG-89-105, Galveston, Texas. Pp. 116-123.

Oravetz, C.A. 1989. The National Marine Fisheries Service's Kemp's ridley sea turtle research and management plan: progress and needs. In: Caillouet, C.W., Jr., and A.M. Landry, Jr. (Editors), Proceedings of the First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and Management, Texas A&M University, Sea Grant College Program, Galveston, Texas, TAMU-SG-89-105. Pp. 10-13.

Owens, D., D. Crowell, G. Dienberg, M. Grassman, S. McCain, Y. Morris, N. Schwantes, and T. Wibbels. 1983. Western Gulf of Mexico Sea Turtle Workshop Proceedings January 13-14, 1983. Texas A&M University Sea Grand College Program, College Station, Texas, TAMU-SG-84-105. 74 pp.

Plot, V., F. Criscuolo, S. Zahn, and J.-Y. Georges. 2012. Telomeres, age and reproduction in a long-lived reptile. PLoS ONE 7(7):e40855.doi:10.1371/ journal.pone.0040855. (http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0040855)

Plotkin, P.T. 2007. Biology and Conservation of Ridley Sea Turtles. The John's Hopkins University Press, Baltimore, MD. 356 pp.

Pörtner, H.-O. 2012. Integrating climate-related stressor effects on marine organisms: unifying principles linking molecule to ecosystem-level changes.

Marine Ecology Progress Series 470:273-290. (http://www.int-res.com/articles/theme/m470_ThemeSection.pdf)

Pritchard, P.C.H. 1973. Research and conservation of Kemp's ridley turtle, *Lepidochelys kempi*, in Tamaulipas, Mexico, in 1973. Unpublished report for work performed under a World Wildlife Fund Grant, 5 pp. plus a 5-p. description of the beach and adjacent ecosystem.

Pritchard, P.C.H. 1976. Endangered species: Kemp's ridley turtle. Florida Naturalist 49(3):15-19.

Pritchard, P.C.H. 1980. Report on United States/Mexico conservation of Kemp's ridley sea turtle at Rancho Nuevo, Tamaulipas, Mexico, 1980. Preliminary Report on U.S. Fish and Wildlife Service Contract No. 14-16-0002-80-216. Florida Audubon Society, Maitland, Florida, 42 pp.

Pritchard, P.C.H. 1990. Kemp's ridleys are rarer than we thought. Marine Turtle Newsletter 49:1-3. (http://www.seaturtle.org/mtn/archives/mtn49/mtn49p1.shtml)

Pritchard, P.C.H. 2007. Evolutionary relationships, osteology, morphology, and zoogeography of ridley sea turtles. In: Plotkin, P.T. (Editor). Biology and Conservation of Ridley Sea Turtles. The John Hopkins University Press, Baltimore, Maryland. Pp. 45-57.

Pritchard, P.C.H., and D.F. Gicca. 1978. Report on United States/Mexico Conservation of Kemp's Ridley Sea Turtle at Rancho Nuevo, Tamaulipas, Mexico, 1978. Final Report on U.S. Fish and Wildlife Service Contract No. 14-16-022-78-055, in cooperation with Mexico's Instituto Nacional de la Pesca. Edited by S.F. Wehrle, USFWS, 71 pp.

Pritchard, P.C.H., and R. Márquez M. 1973. Kemp's ridley turtle or Atlantic ridley *Lepidochelys kempi*. International Union for Conservation of Nature and

Natural Resources Monograph No. 2: Marine Turtle Series. IUCN, Morges, Switzerland, 30 pp. (http://www.seaturtle.org/pdf/ocr/PritchardPCH_1973_IUCNTechReport.pdf)

Putman, N.F., and K.J. Lohmann. 2008. Compatibility of magnetic imprinting and secular variation. Current Biology 18(14):R596-R597. (http://www.unc.edu/depts/geomag/PDFGeomag/Putman&LohmannCB2008.pdf)

Putman, N.F., T.J. Shay, and K.J. Lohmann. 2010. Is the geographic distribution of nesting in the Kemp's ridley turtle shaped by the migratory needs of offspring? Integrative and Comparative Biology, a symposium presented at the annual meeting of the Society for Integrative and Comparative Biology, Seattle, Wash., p 1-10. (http://www.seaturtle.org/PDF/PutmanNF_2010_IntegrCompBiol.pdf)

Raborn, S.W., B.J. Gallaway, J.G. Cole, W.J. Gazey, and K.I. Andrews. 2012. Effects of turtle excluder devices (TEDs) on the bycatch of three small coastal sharks in the Gulf of Mexico Penaeid shrimp fishery. North American Journal of Fisheries Management 32:333-345.

Rayburn, R. 1989. Fishing industry perspective on conservation and management of sea turtles. In: Caillouet, C.W., Jr., and A.M. Landry, Jr. (Editors), Proceedings of the First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and Management, Texas A&M University, Sea Grant College Program, Galveston, Texas, TAMU-SG-89-105. Pp. 27-29.

Renaud, M., g. Gitschlag, E. Klima, A. Shah, D. Koi, and J. Nance. 1993. Loss of shrimp by turtle excluder devices (TEDs) in coastal waters of the United States, North Carolina to Texas: March 1988-August 1990. Fishery Bulletin

91:129-137. (http://galveston.ssp.nmfs.gov/publications/pdf/565.pdf)

Renaud, M.L., J.M. Nance, E. Scott-Denton, and G.R. Gitschlag. 1997. Incidental capture of sea turtles in shrimp trawls with and without TEDs in the U.S. Atlantic and Gulf waters. Chelonian Conservation and Biology 2(3):425-427. (http://galveston.ssp.nmfs.gov/publications/pdf/576.pdf)

Renaud, M.L., and J.A. Williams. 1997. Movements of Kemp's ridley (*Lepidochelys kempii*) and green (*Chelonia mydas*) sea turtles using Lavaca Bay and Matagorda Bay 1996-1997. Final Report to the Environmental Protection Agency, Office of Planning and Coordination, Region 6, Dallas, Texas. 62 pp. (http://galveston.ssp.nmfs.gov/publications/pdf/562.pdf)

Renaud, M.L., and J.A. Williams. 2005. Kemp's ridley sea turtle movements and migrations. Chelonian Conservation and Biology 4(4):808-816. (http://www.sefsc.noaa.gov/turtles/PR_Renaud_Williams_2005_CCB.pdf)

Rivera-Velázquez, G., L.A. Soto, I.H. Salgado-Ugarte, and E.J. Naranjo. 2008. Growth, mortality and migratory pattern of white shrimp (*Litopenaeus vannamei*, Crustacea, Penaeidae) in the Carretas-Pereyra coastal lagoon system, Mexico. Revista de Biologia Tropical 56(2): 523-533. (http://www.biologiatropical.ucr.ac.cr/attachments/volumes/vol56-2/10-Rivera-Growth.pdf)

Rostal, D.C. 2005. Seasonal reproductive biology of the Kemp's ridley sea turtle (*Lepidochelys kempii*): comparison of captive and wild populations. Chelonian Conservation and Biology 4:788-800.

Rostal, D.C. 2007. Reproductive physiology of the ridley sea turtle. In: Plotkin, P.T. (Editor). Biology and Conservation of Ridley Sea Turtles. The John Hopkins University Press, Baltimore, Maryland. Pp. 151-165.

Rostal, D.C., J.S. Grumbles, R.A. Byles, R. Márquez-M., and D.W. Owens. 1997.

Nesting physiology of wild Kemp's ridley turtles, *Lepidochelys kempii,* at Rancho Nuevo, Tamaulipas, Mexico. Chelonian Conservation and Biology 2:538-547.

Rostal, D.C., D.W. Owens, J.S. Grumbles, D.S. McKenzie, and M.S. Amoss. 1998. Seasonal reproductive cycle of the Kemp's ridley sea turtle (*Lepidochelys kempii*). General and Comparative Endocrinology 109:232-243.

Rostal, D.C., T.R. Robeck, D.W. Owens, and D.C. Kraemer. 1990. Ultrasound imaging of ovaries and eggs in Kemp's ridley sea turtles (*Lepidochelys kempii*). Journal of Zoo and Wildlife Medicine 21:27-35.

Ruckdeschel, C., C.R. Shoop, and R.D. Kenny. 2005. On the sex ratio of juvenile *Lepidochelys kempii* in Georgia. Chelonian Conservation and Biology 4(4):860-863.

Salgado-Ugarte, I.H., J. Martínez-Ramírez, J.L. Gómez-Márquez and B. Peña-Mendoza. 2000. Some programs for growth estimation in fisheries biology. Stata Technical Bulletin 53: 35-47.

Salgado-Ugarte, I.H., M. Shimizu, and T. Taniuchi. 1993. Exploring the shape of univariate data using kernel density estimators. Stata Technical Bulletin 16: 8-19.

Salgado-Ugarte, I.H., M. Shimizu, and T. Taniuchi. 1994. Semi-graphical determination of Gaussian components in mixed distributions. Stata Technical Bulletin 18: 15-27.

Salgado-Ugarte, I.H., M. Shimizu, and T. Taniuchi. 1995a. ASH, WARPing, and kernel density estimation for univariate data. Stata Technical Bulletin 26: 2-10.

Salgado-Ugarte, I.H., M. Shimizu, and T. Taniuchi. 1995b. Practical rules for bandwidth selection in univariate density estimation. Stata Technical

Bulletin 27: 5-19.

Salgado-Ugarte, I.H., M. Shimizu, and T. Taniuchi. 1997. Nonparametric assessment of multimodality for univariate data. Stata Technical Bulletin 32: 27-35.

Salgado-Ugarte, I.H., M. Shimizu, T. Taniuchi, and K. Matsushita. 2000. Size frequency analysis by averaged shifted histograms and kernel density estimators. Asian Fisheries Science 13:1-12.

Salgado-Ugarte, I.H., M. Shimizu, T. Taniuchi, and K. Matsushita. 2002. Nonparametric assessment of multimodality for size frequency distributions. Asian Fisheries 15:295-303.

Samuelson, P.A. 1977. Generalizing Fisher's "reproductive value": linear differential and difference equations of "dilute" biological systems. Proceedings of the National Academy of Sciences (Population Biology)74(11):5189-5192. (http://www.pnas.org/content/74/11/5189.full.pdf)

Sasso, C.R., and S.P. Epperly. 2006. Seasonal sea turtle mortality risk from forced submergence in bottom trawls. Fisheries Research 81:86-88. (http://www.sefsc.noaa.gov/turtles/PR_Sasso_Epperly_2006_FishRes.pdf)

Sasso, C.R., and W.N. Witzell. 2006. Diving behavior of an immature Kemp’s ridley turtle (*Lepidochelys kempii*) from Gullivan Bay, Ten Thousand Islands, south-west Florida. Journal of Marine Biological Association of the United Kingdom 86(4):919-925. (http://www.sefsc.noaa.gov/turtles/PR_Sasso_Witzell_2006_JMarBiolAssUK.pdf)

Schmid, J.R. 1998. Marine turtle populations on the west-central coast of Florida: results of tagging studies at the Cedar Keys, Florida, 1986-1995. Fishery Bulletin 96:589-602. (http://www.sefsc.noaa.gov/turtles/PR_Schmid_1998_FBull.pdf)

Schmid, J.R., and W.J. Barichivich. 2005. Developmental biology and ecology of the Kemp's ridley sea turtles (*Lepidochelys kempii*) in the eastern Gulf of Mexico. Chelonian Conservation and Biology 4(4):828-834.

Schmid, J.R., A.B. Bolten, K.A. Bjorndal, and W.J. Lindberg. 2002. Activity patterns of Kemp's ridley turtles, *Lepidochelys kempii*, in the coastal waters of the Cedar Keys, Florida. Marine Biology 140:215-228. (http://accstr.ufl.edu/accstr-resources/publications/Schmid_et_al_MarBiol2002.pdf)

Schmid, J.R., and A. Woodhead. 2000. Von Bertalanffy growth models for wild Kemp's ridley turtles: analyses of the NMFS Miami Laboratory tagging database. In: Turtle Expert Working Group (TEWG). Assessment update for the Kemp's ridley and loggerhead sea turtle populations in the western North Atlantic. NOAA Technical Memorandum NMFS-SEFSC-444. Pp. 94-102. (http://www.nmfs.noaa.gov/pr/pdfs/species/tewg2000.pdf)

Schoen, R. 2011. Age-specific growth, reproductive values, and intrinsic r. Demographic Research 24(33):825-830. (http://www.demographic-research.org/Volumes/Vol24/33/24-33.pdf)

Seager, R., M. Ting, M. Davis, M. Cane, N. Naik, J. Nakamura, C. Li, E. Cook, and D.W. Stahle. 2009. Mexican drought: an observational modeling and tree ring study of variability and climate change. Atmósfera 22(1):1-31. (http://www.ldeo.columbia.edu/res/div/ocp/pub/seager/Seager_etal_atmosfera_2009.pdf)

Seidel, W.R., and C.A. Oravetz. 1989. TED—trawling efficiency device (turtle excluder device): promoting its use. In: Caillouet, C.W., Jr., and A.M. Landry, Jr. (Editors), Proceedings of the First International Symposium on Kemp’s Ridley Sea Turtle Biology, Conservation and Management, Texas A&M University, Sea Grant College Program, Galveston, Texas, TAMU-SG-89-105. Pp. 30-32.

Seney, E.E., and A.M. Landry, Jr. 2008. Movements of Kemp’s ridley sea turtles nesting on the upper Texas coast: implications for management. Endangered Species Research 4:73-84. (http://www.int-res.com/articles/esr2008/4/n004p073.pdf)

Seney, E.E., and A.M. Landry, Jr. 2011. Movement patterns of immature and adult female Kemp’s ridley sea turtles in the northwestern Gulf of Mexico. Marine Ecology Progress Series 440:241-254.

Seney, E.E., and J.A. Musick. 2005. Diet analysis of Kemp’s ridley sea turtles (*Lepidochelys kempii*) in Virginia. Chelonian Conservation and Biology 4(4):864-871.

Shaver, D.J. 1991. Feeding ecology of wild and head-started Kemp's ridley sea turtles in south Texas waters. Journal of Herpetology 25:327-334.

Shaver, D.J. 1998. Sea turtle strandings along the Texas coast, 1980-94. In: Zimmerman, R. (Editor). Characteristics and causes of Texas marine strandings. NOAA Technical Report NMFS 143. Pp. 57-72. (http://spo.nwr.noaa.gov/tr143opt.pdf)

Shaver, D.J., and C.W. Caillouet, Jr. *in press*. Reintroduction of Kemp’s ridley (*Lepidochelys kempii*) sea turtle to Padre Island National Seashore, Texas and its connection to head-starting. Herpetological Conservation and Biology.

Shaver, D.J., D.W. Owens, A.H. Chaney, C.W. Caillouet, Jr., P. Burchfield, and R. Marquez M. 1988. Styrofoam box and beach temperatures in relation to incubation and sex ratios of Kemp's ridley sea turtles. In: Schroeder, B.A. (Compiler). Proceedings of the Eighth Annual Workshop on Sea Turtle Conservation and Biology. NOAA Technical Memorandum NMFS-SEFC-214. Pp. 103-108. (http://www.sefsc.noaa.gov/turtles/TM_214_Schroeder_8.pdf)

Shaver, D.J., and C. Rubio. 2008. Post-nesting movement of wild and head-started Kemp's ridley sea turtles *Lepidochelys kempii* in the Gulf of Mexico. Endangered Species Research 4:43-55. (http://www.int-res.com/articles/esr2008/4/n004p043.pdf)

Shaver, D.J., B.A. Schroeder, R.A. Byles, P.M. Burchfield, J. Peña, R. Márquez, and H.J. Martinez. 2005. Movements and home ranges of adult male Kemp’s ridley sea turtles (Lepidochelys kempii) in the Gulf of Mexico investigated by satellite telemetry. Chelonian Conservation and Biology 4(4):817-827.

Shuter, B.J., N.P. Lester, J. LaRose, C.F. Purchase, K. Vascotto, G. Morgan, N.C. Collins, and P.A. Abrams. 2005. Optimal life histories and food web position: linkages among somatic growth, reproductive investment, and mortality. Canadian Journal of Fisheries and Aquatic Sciences 62:738-746. (http://www.freewebs.com/craigpurchase/Shuter_CJFAS.pdf)

Sizemore, E. 2002. The Turtle Lady Ila Fox Loetscher of South Padre. Republic of Texas Press, Plano, Texas. 200 pp.

Southwood, A., and L. Avens. 2010. Physiological, behavioral, and ecological aspects of migration in reptiles. Journal of Comparative Physiology B 180:1-

23. (http://people.uncw.edu/williarda/Southwood%20and%20Avens%20JCPB%202010.pdf)

Snover, M. L., C.W. Caillouet, Jr., C.T. Fontaine, and D.J. Shaver. 2008. Application of a biphasic growth model to describe growth to maturity in the head-start Kemp’s ridley sea turtle. In: Rees, A.F., M. Frick, A. Panagopoulou, and K. Williams. Proceedings of the 27th Annual Symposium on Sea Turtle Biology and Conservation. NOAA Tech. Memo. NMFS-SEFSC-509, p. 140. (http://www.sefsc.noaa.gov/turtles/TM_569_Rees_etal_2008_27.pdf)

Snover, M.L., and S.S. Heppell. 2009. Application of diffusion approximation for risk assessments of sea turtle populations. Ecological Applications 19(3):774-785. (http://www.sefsc.noaa.gov/turtles/PR_Snover_Heppell_2009_Ecol_Applications.pdf)

Snover, M.L., and A.H. Hohn. 2004. Validation and interpretation of annual skeletal marks in loggerhead (*Caretta caretta*) and Kemp's ridley (*Lepidochelys kempii*) sea turtles. Fishery Bulletin 102:682-692. (http://fishbull.noaa.gov/1024/snove.pdf)

Snover, M.L., A.A. Hohn, L.B. Crowder, and S.S. Heppell. 2007. Age and growth in Kemp’s ridley sea turtles: evidence from mark-recapture and skeletochronology. In: P.T. Plotkin (Editor). Biology and Conservation of Ridley Sea Turtles. John’s Hopkins University Press, Baltimore, Maryland, Pp. 89-105.

Snover, M.L., A.A. Hohn, and S.A. Macko. 2005. Skeletochronological analysis of humeri from coded wire tagged (CWT) Kemp's ridleys: interpretation of early growth marks. In: Coyne, M.S., and R.D. Clark (Compilers). Proceedings of the Twenty-First Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-528. P. 331. (http://www.sefsc.noaa.gov/turtles/TM_528_Coyne_Clark_21.pdf)

Snover, M.L., and A.G.J. Rhodin. 2007. Comparative ontogenetic and phylogenetic aspects of chelonian chondro-osseous growth and skeletochronology. In: J. Wyneken, J., M.H. Godfrey, and V. Bels (Editors). Biology of Turtles. CRC Press, Boca Raton, Florida, Pp. 17-43. (http://www.sefsc.noaa.gov/turtles/PR_Snover_Rhodin_2008_Biology_of_Turtles.pdf)

Stahle, D.W., E.R. Cook, J. Villanueva Díaz, F.K. Fye, D.J. Burnette, R.D. Griffin, R. Acuña Soto, R. Seager, and R.R. Heim, Jr. 2009. Early 21st- century drought in Mexico. Eos 90(11):89-90. (http://www.ldeo.columbia.edu/res/div/ocp/pub/seager/Stahle_etal_2009-Eos.pdf)

Stohs, S.M. 2006. A Poisson probability model of protected species take risk. Selected paper for presentation at the American Agricultural Economics Association Annual Meeting, Long Beach, California. 31 pp. (http://ageconsearch.umn.edu/bitstream/21129/1/sp06st04.pdf)

Stohs, S.M., and S. Kvamsdal. 2008. A Kalman filter for environmental risk: spatio-temporal variation in sea turtle bycatch rates. IIFET 2008 Vietnam Proceedings. 21 pp. (http://econ.ucsd.edu/CEE/papers/Stohs.pdf)

Sutton, G., and T. Wagner. 2007. Stock assessment of blue crab (*Callinectes sapidus)* in Texas coastal waters. Texas Parks and Wildlife Coastal Fisheries

Division, Management Data Series No. 249. (http://www.tpwd.state.tx.us/publications/pwdpubs/media/pwd_rp_v3400_1440.pdf)

Thompson, N. B. 1988. The status of loggerhead, *Caretta caretta*; Kemp's ridley, *Lepidochelys kempi*; and green, *Chelonia mydas*, sea turtles in U.S. waters. Marine Fisheries Review 50(3):16-23. (http://www.sefsc.noaa.gov/turtles/PR_Thompson_1988_MFRev.pdf)

Thompson, N. B. 1991. The status of loggerhead, *Caretta caretta*; Kemp's ridley, *Lepidochelys kempi*; and green, *Chelonia mydas*, sea turtles in U.S. waters: a reconsideration. Marine Fisheries Review 53(3):30-33. (http://spo.nmfs.noaa.gov/mfr533/mfr5334.pdf)

TEWG (Turtle Expert Working Group). 1998. An assessment of the Kemp's ridley (*Lepidochelys kempii*) and loggerhead (*Caretta caretta*) sea turtle populations in the western north Atlantic. NOAA Tech. Memo. NMFS-SEFSC-409. 96 pp. (http://www.nmfs.noaa.gov/pr/pdfs/species/tewg1998.pdf)

TEWG. 2000. Assessment update for the Kemp's ridley and loggerhead sea turtle populations in the western north Atlantic. NOAA Tech. Memo. NMFS-SEFSC-444. 115 pp. (http://www.nmfs.noaa.gov/pr/pdfs/species/tewg2000.pdf)

Tomás, J., and J A. Raga. 2007. Occurrence of Kemp's ridley sea turtle (*Lepidochelys kempii*) in the Mediterranean. Marine Biological Association of the United Kingdom, Marine Biodiversity Records, volume 1, 3 pp.

Uusi-Heikkilä, S., A. Kuparinen, C. Wolter, T. Meinelt, A.C. O'Toole, and R. Artinghaus. 2011. Experimental assessment of the probabilistic maturation reaction norm: condition matters. Proceedings of the Royal Society

Biological Sciences 278(1706):709-717. (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3030844/)

USFWS (U.S. Fish and Wildlife Service) and National Marine Fisheries Service (NMFS). 1992. Recovery plan for the Kemp's ridley sea turtle (*Lepidochelys kempii*). National Marine Fisheries Service, St. Petersburg, Florida, 40 p. (http://www.nmfs.noaa.gov/pr/pdfs/recovery/turtle_kempsridley.pdf)

USFWS. 1999. Kemp's Ridley Sea Turtle *Lepidochelys kempii*. In: South Florida Multi-Species Recovery Plan, U.S. Fish and Wildlife Service Reference Service, Bethesda, Maryland. Pp. 4-649 to 4-663. (http://www.fws.gov/verobeach/MSRPPDFs/KempsRidley.pdf)

Valverde, R.A., and C.E. Gates. 1999. Population surveys on mass nesting beaches. In: Eckert, K.L., K.A. Bjorndal, and F.A. Abreu-Grobois (Editors), Research and Management Techniques for the Conservation of Sea Turtles, IUCN/SCC Marine Turtle Specialist Group publication #4, Pp. 1-5. (http://mtsg.files.wordpress.com/2010/07/09-population-surveys-on-mass-nesting-beaches.pdf)

Vargas Molinar, T.P.E. 1973. Resultados preliminaries de marcado de tortugas marinas en aquas Mexicanas (1966-1970). Instituto Nacional de Pesca, Serie Informativa INP/SI:il2, 27 pp.

Vindenes,Y., B.E. Sæther, and S. Engen. 2011. Effects of demographic structure on key properties of stochastic density-independent population dynamics. Theoretical Population Biology. (http://www.math.ntnu.no/~steinaen/papers/yngvild_theor_pop_biol_2012.pdf)

Vincent, P. 1945. Potentiel d'accroissement d'une population. Journal de la Société de Statistique de Paris 86: 16-39.

Wakida-Kusunoki, A.T., F. Arreguín-Sánchez, A. González-Cruz, and J.T. Ponce-Palafox. 2010. Análisas de la distribución espacial del esfuerzo pesquero de la flota camaronera mexicana en el Golfo de México y el mar Caribe por medio del sistema satelital de monitoreo de embarcaciones. Ciencia Pesquera 18(1):43-50. (http://www.inapesca.gob.mx/portal/documentos/publicaciones/cienciapesquera/CP18/An%C3%A1lisis+de+la+distribuci%C3%B3n+espacial+del+esfuerzo+pesquero+de+la+flota+camaronera.pdf)

Wallace, B.P., A.D. DiMatteo, A.B. Bolten, M.Y. Chaloupka, B.J. Hutchinson, F. A. Abreu-Grobois, J.A. Mortimer, J.A. Seminoff, D. Amorocho, K.A. Bjorndal, J. Bourjea, B.W. Bowen, R. Biseño-Dueñas, P. Casale, B.C. Choudhury, A. Costa, P.H. Dutton, A. Fallabrino, E.M. Finkbeiner, A. Girard, M. Girondot, M. Hamann, B.J. Hurley, M. López-Mendilaharsu, M.A. Marcovaldi, J.A. Musick, R. Nel, N.J. Pilcher, S. Troëng, B. Witherington, and R.B. Mast. 2011. Global conservation priorities for marine turtles. PLoS ONE 6(9):e24510. (http://www.plosone.org/article/info:doi/10.1371/journal.pone.0024510)

Wallace, B.P., S.S. Heppell, R.L. Lewison, S. Kelez, and L.B. Crowder. 2008. Impacts of fisheries bycatch on loggerhead turtles worldwide inferred from reproductive value analyses. Journal of Applied Ecology 45:1076-1085. (http://web.mac.com/bryan.wallace/bryan_wallace/publications_files/Wallace_etal_JApplEcol2008.pdf)

Wang, H-C. 2005. Trace metal uptake and accumulation pathways in Kemp's ridley sea turtles (*Lepidochelys kempii*). Ph.D. Dissertation, Texas A&M University, College Station, Texas, USA. 257 p.

Warden, M.L., and K.T. Murray. 2011. Reframing protected species interactions with commercial fishing gear: moving toward estimating the unobservable. Fisheries Research 110:387-390. (file uploaded to LGL's ShareFile account)

Watson, J.W., J.F. Mitchell, and A.K. Shah. 1986. Trawling efficiency device: a new concept for selective shrimp trawling gear. Marine Fisheries Review 48(1):1-9. (http://spo.nmfs.noaa.gov/mfr481/mfr4811.pdf)

Wauer, R.H. 1978. "Head start" for an endangered turtle. National Parks & Conservation Magazine, November 1978:16-20. (file uploaded to LGL's ShareFile account)

Wauer, R.H. 1999. Birder's Mexico. Texas A & M University Press, College Station, Texas. 304 pp.

Werler, J.E. 1951. Miscellaneous notes on the eggs and young of Texas and Mexican reptiles. Zoologica 36:37-48.

Werner, S.A. 1994. Feeding ecology of wild and head-started Kemp's ridley sea turtles. M.S. Thesis, Texas A & M University, College Station, Texas. 65 pp.

Werner, S.A., and A.M. Landry, Jr. 1994. In: Bjorndal, K.A., A.B. Bolten, D.A. Johnson, and P.J. Eliazar (Compilers). Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-351. P. 163.

West, J., H. Blanchet, M. Bourgeois, and J.E. Powers. 2011. Assessment of blue crab *Callinectes sapidus* in Louisiana waters 2011 report. 58 pp.

Whistler, R.G. 1989. Kemp's ridley sea turtle strandings along the Texas coast, 1983-1985. In: Caillouet, C.W., Jr., and A.M. Landry, Jr. (Editors), Proceedings of the First International Symposium on Kemp's Ridley Sea

Turtle Biology, Conservation and Management, Texas A&M University, Sea Grant College Program, Galveston, Texas, TAMU-SG-89-105. Pp. 43-50.

White, D.R.M. 1989. Sea turtles and resistance to TEDs among shrimp fishermen of the U.S. Gulf Coast. Maritime Anthropological Studies 2(1):69-79. (http://www.marecentre.nl/mast/documents/SeaTurtlesandResistancetoTEDs.pdf)

Wibbels, T. 2007. Sex determination and sex ratios in ridley turtles. In: Plotkin, P.T. (Editor). Biology and Conservation of Ridley Sea Turtles, Johns Hopkins University Press, Baltimore, MD. Pp. 169-189.

Williams, P. 1993. NMFS to concentrate on measuring survivorship, fecundity of head-started Kemp's ridleys in the wild. *Marine Turtle Newsletter* 63:3-4. (http://www.seaturtle.org/mtn/archives/mtn63/mtn63p3.shtml)

Witherington, B., S. Hirama, and R. Hardy. 2012. Young sea turtles of the pelagic *Sargassum*-dominated drift community: habitat use, population density, and threats. Marine Ecology Progress Series 463:1-22. (http://www.int-res.com/articles/feature/m463p001.pdf)

Witt, M.J., R. Penrose, and B.J. Godley. 2007. Spatio-temporal patterns of juvenile marine turtle occurrence in waters of the European continental shelf. Marine Biology 151(3):873-885.

Witzell, W.N. 1994. The origin, evolution, and demise of the U.S. sea turtle fisheries. Marine Fisheries Review 54(4):8-23. (http://spo.nmfs.noaa.gov/mfr564/mfr5642.pdf)

Witzell, W.N., P.M. Burchfield, L.J. Peña, R. Marquez-M., and G. Ruiz-M. 2007. Nesting success of Kemp’s ridley sea turtles, *Lepidochelys kempi*, at Rancho Nuevo, Tamaulipas, Mexico, 1982-2004. Marine Fisheries Review 69(1-4):46-52. (http://spo.nmfs.noaa.gov/mfr691-4/mfr691-43.pdf)

Witzell, W.N., A.A. Geis, J.R. Schmid, and T. Wibbels. 2005a. Sex ratio of immature Kemp's ridley turtles (*Lepidochelys kempi*) from Gullivan Bay, Ten Thousand Islands, south-west Florida. Journal of the Marine Biological Association of the United Kingdom 85:205-208. (http://www.sefsc.noaa.gov/turtles/PR_Witzell_etal_2005_JMarBiolAss.pdf)

Witzell, W.N., A. Salgado-Quintero, and M. Garduño-Dionte. 2005b. Reproductive parameters of the Kemp's ridley sea turtle (*Lepidochelys kempii*) at Rancho Nuevo, Tamaulipas, Mexico. Chelonian Conservation and Biology 4(4):781-787. (http://www.sefsc.noaa.gov/turtles/PR_Witzell_et_al_2005_CCB.pdf)

Witzell, W.N., and J.R. Schmid. 2005. Diet of immature Kemp's ridley turtles (*Lepidochelys kempi*) from Gullivan Bay, Ten Thousand Islands, southwest Florida. Bulletin of Marine Science 77(2):191-199. (http://www.sefsc.noaa.gov/turtles/PR_Witzell_Schmid_2005_BullMS.pdf)

Woody, J.B. 1986. Kemp's ridley sea turtle. In: Eno, A.S. (Project Director), R.L. Di Silvestro (Editor), and W.J. Chandler (Research Director). Audubon Wildlife Report 1986. The National Audubon Society, New York, NY. Pp. 919-931.

Woody, J.B. 1989. International efforts in the conservation and management of Kemp's ridley sea turtle (*Lepidochelys kempi*). In: Caillouet, C.W., Jr., and A.M. Landry, Jr. (Editors), Proceedings of the First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and Management, Texas A&M University, Sea Grant College Program, Galveston, Texas, TAMU-SG-89-105. Pp. 1-3.

Yaninek, K.D. 1995. Turtle excluder device regulations: laws sea turtles can live with. North Carolina Central University School of Law, North Carolina Central Law Journal, 21 N.C. Cent. L.J. 265. 40 pp.

Young, N. 2006. Guidelines for developing a potential biological removal (PBR) framework for managing sea turtle bycatch in the Pamlico Sound flounder gillnet fishery. Master of Environmental Management degree, Nicholas School of the Environment and Earth Sciences, Duke University, Durham, NC. 36 pp. (http://dukespace.lib.duke.edu/dspace/bitstream/handle/10161/106/Young%20MP%202006.pdf?sequence=1)

Zimmerman, R. (Editor) 1998. Characteristics and causes of Texas marine strandings. NOAA Technical Report NMFS 143. 85 pp. (http://spo.nwr.noaa.gov/tr143opt.pdf)

Zug, G.R., H.J. Kalb, and S.J. Luzar. 1997. Age and growth in wild Kemp's ridley seaturtles *Lepidochelys kempii* from skeletochronological data. Biological Conservation 80:261-268. (http://si- pddr.si.edu/jspui/bitstream/10088/4778/1/Zug_1997- Age_growth.kempii.pdf)

APPENDIX I

Evolution of the Kemp's Ridley Stock Assessment Workshop

The idea for a workshop to investigate Kemp's ridley-shrimp fishery interactions in the northern Gulf of Mexico originated with one of us (Caillouet) in May 2011. In early June 2011, he sent an email, describing and recommending a Kemp's ridley-shrimp fishery interactions workshop, to Dr. Roy Crabtree, Director of the NMFS Southeast Regional Office, St. Petersburg, Florida. Dr. Crabtree's email reply was positive, and indicated the idea would be discussed with NMFS Southeast Fisheries Science Center scientists. On 20 June 201, NMFS released a scoping document (NMFS 2011), announcing its intent to conduct public hearings, prepare an Environmental Impact Statement (EIS), and promulgate regulations to reduce mortality of sea turtles in the shrimp fishery of the southeastern U.S.

Later in June 2011, officials of Mississippi Department of Marine Resources added their support to the workshop idea and promoted it. Beginning 31 October 2011, Caillouet's email and phone discussions of the workshop idea with officials of Louisiana Department of Wildlife and Fisheries (LDWF) led to further discussions among marine fisheries agency officials of Texas, Louisiana, Mississippi, Alabama, and Florida, Directors of Sea Grant Programs of Texas, Louisiana, Mississippi-Alabama, and Florida, and the Gulf States Marine Fisheries Commission (GSMFC). A detailed proposal (Gallaway, Caillouet, and Plotkin 2012) was submitted to the GSMFC. Gallaway agreed to Chair the workshop, act as Project Manager, and provide core staff necessary to carry the workshop idea to fruition. A Planning and Model Development Group (PMDG; Gallaway, Caillouet, Plotkin, Gazey, and Raborn) was formed, and LGL established an online

ShareFile account (http://www.sharefile.com) to which workshop documents and relevant literature have been uploaded for access by project and workshop participants and observers.

A stakeholders meeting was held on 23 February 2012, at Texas A&M University, College Station, Texas (Kemps Ridley Stock Assessment Worksho Kemps Ridley Stock Assessment Why Ken Kemp's Ridley Stock Assessment Shrimp F Kemps Ridley Stock Assessment Path For Kemps Ridley Stock Assessment Historical Kemps Ridley Stock Assessment Data Nee Kemps Ridley Stock Assessment Bill Gaze Kemps Ridley Stock Assessment Backgrou Kemp's Ridley Agenda (3).docx). Beginning in July 2012, informal invitations were sent to potential workshop participants, along with background information about the workshop. Formal letters of invitation were then sent to those who committed to participating, either on site or by remote conferencing technology.

APPENDIX II

Most NMFS-archived records of shrimp landings (in pounds, *p*) and shrimp fishing effort (in days fished, *d*) contain data fields that categorize them by month, statistical subarea, and 5-fathom depth zone within calendar years; this represents the highest level of temporal-spatial resolution of shrimp landings and shrimp fishing effort data. Biases in NMFS port agents' allocation of landings and effort data to temporal-spatial cells (Kutkuhn 1962) were evaluated by Gallaway et al. (2003a, 2003b, 2006). To reduce the effects of allocation biases, detailed landings and effort records have previously been combined (pooled) into larger, lower-resolution temporal-spatial cells for various shrimp fishery analyses and stock assessments (Nance et al. 2008).

There are three possible unbiased estimators of average pounds of shrimp landed per day fished in a temporal-spatial cell. The choice among them is a matter of statistical precision. Each of these estimators represents the slope, β, of the linear regression of *p* on *d* through the origin (i.e., $p = 0$ when $d = 0$):

$$p = \beta d + \varepsilon \qquad (1)$$

where ε is the residual (i.e., deviation from regression) in a sample of shrimping trips (or individual trawl tows) within a temporal-spatial cell The least squares estimator, *b*, of β is:

$$b = \sum dp / \sum d^2 \qquad (2)$$

Application of equation (2) would be statistically appropriate only if ε were normally distributed with mean 0 and homogeneous variance σ^2. Plots of *p* on *d* (Nance 1992; GMFMC 1994) showed clearly that variability in *p* increases as *d* increases, suggesting that ε is not normally distributed with mean 0, and that its variance is heterogeneous. Plots of *p* on *d*, prepared during deliberations of the *Ad*

Hoc Shrimp Effort Working Group (SEWG)(Nance et al. 2008) also showed that variability in p increases as d increases, again suggesting that ε is not normally distributed with mean 0, nor is its variance homogeneous. Therefore, equation (2) clearly was not the statistically appropriate estimator of β.

Historically, NMFS has used the following estimator (Kutkuhn 1962):

$$b = \sum p / \sum d \tag{3}$$

Application of equation (3) is statistically appropriate when the variance of ε is proportional to d, but the SEWG's preliminary plots and analyses suggested that the variance of ε is proportional to d^2; i.e., that the standard deviation of ε is proportional to d (Nance et al. 2008). This is relatively easy to demonstrate with sample data sets of p and d. During SEWG deliberations in 2006, one of us (Caillouet) suggested further evaluation of the following estimator of β, but the issue was tabled (Nance et al. 2008):

$$b = \sum (p/d)/n \tag{4}$$

When the authors re-visited the effort estimation issue in 2012, William Gazey and Scott Raborn conducted preliminary analyses which detected small numbers of apparent outlier high values of p/d associated with very low levels of d in temporal-spatial cells. These small numbers of outliers highly leveraged the estimates of b based on equation (4), but had little effect on estimates of b based on equation (3). Time and resources were insufficient to determine whether these outliers were valid data points, so the authors decided to adopt equation (3) to estimate temporal-spatial cell shrimp fishing effort for the KRSAW.

Appendix 5: Ted-Trawl Interaction Study Data Dictionary

TED-TRAWL INTERACTION STUDY

DATA DICTIONARY

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February 2003

DATA DICTIONARY

The TED-trawl interaction database consists of 22 datasets from ten separate programs. Two SAS datasets (stations and turtles) are provided for each study, as well as the combined database products, which are provided as two additional SAS data sets. The two combined database products are also provided as two comma separated files and several ArcView shape files. Included in the combined datasets are 67,787 tows, producing 108,013 standardized net hours of TED nets and 46,139 standardized net hours of non-TED nets (Appendix 1). Each standardized net hour represents one hour of trawling with 100' of net headrope. There are 1,254 turtle captures in the combined turtle dataset. The following is a description or key to the information contained in the combined database. Section One contains descriptions of each data set included in the database with references to original reports, if any. Section Two describes the common structure of the data sets from the nine studies.

Section One—Study Descriptions

Study Code: FDNNAKED

Dataset Files: fdnnaked_stats.sas7bdat, fdnnaked_turts.sas7bdat

Original References: GSAFDF (1998) and Jamir (1999)

Source of Data: Gulf and South Atlantic Fisheries Foundation, Tampa, FL

Comments: The Gulf and South Atlantic Fisheries Development Foundation, Inc. conducted this study for NMFS during 1997 and 1998. The project conducted monitoring efforts aboard commercial shrimp trawlers in the South Atlantic and the Gulf of Mexico to determine current catch of turtles in nets not equipped with TEDs. For the Gulf of Mexico analyses, the report only used data west of 91 degrees Longitude. The report included 641 tows and 274 turtle captures in the Atlantic and 1,165 tows and 26 turtle captures in the Gulf of Mexico. Sightings of turtles (5 in the Atlantic and 2 in the Gulf) were not included in the analyses, and are not included in this dataset. An additional set of 8 Atlantic turtles that fell or crawled out of the net on retrieval and 9 turtles (7 in the Atlantic and 2 in the Gulf) that were caught in the try net were not included in the analysis but are included in this dataset. For additional comments, see Appendix 2.

Reconciliation – data included in this set:

Atlantic: tows - 641, captured turtles - 289

Gulf of Mexico: tows - 1,165; captured turtles - 28

Study Code: FNBRDSTD

Reconciliation – data included in this set:

Tows - 2,314

Standardized net hours (TEDs) - 21,496

Turtle captures - 29

Study Code: NREDSNAP

Dataset Files: nredsnap_stats.sas7bdat, nredsnap_turts.sas7bdat

Original References:

Source of Data: Dennis Koi, NMFS, Galveston, TX

Comments:

Reconciliation – data included in this set:

Tows - 1,899

Standardized net hours (TEDs) - 3,888

Turtle captures - 7

Study Code: NTEDSTDY

Dataset Files: ntedstdy_stats.sas7bdat, ntedstdy_turts.sas7bdat

Original References: Renaud et al. (1990) and Renaud et al. (1991)

Source of Data: NMFS, Galveston, TX 1995

Comments: The data included from this study were from two years of sampling for the TED Observer Program by the NMFS Galveston Laboratory. They were originally reported in two NOAA Technical Memorandums (Renaud et al., 1990 and Renaud et al., 1991). Renaud et al. (1990) reported on 4159 hours fishing time for the period March 1988 through July 1989. Renaud et al. (1991) covers September 1989 through August 1990.

Reconciliation – data included in this set:

Tows - 1,717

Standardized net hours (TED) - 6,289

Standardized net hours (STD) - 5,085

Turtle captures - 72

Comments: The original report describes the data from three programs, the sea turtle incidental catch and mortality project, from 1979 through 1981; the excluder trawl project, from 1977 through 1984; and the shrimp fleet discards project, from 1973 through 1978. The three studies accounted for 27,578 standardized net hours and 884 turtle captures. For their analysis, Henwood and Stuntz removed all tows and turtles that occurred in the Cape Canaveral ship channel (between 28.25 and 28.50 decimal degrees latitude on the east coast). This reduced the total standardized net hours reported to 26,728, and turtle encounters to 534. For additional comments, see Appendix 2.

Reconciliation -- data included in this set:

Standardized net hours - 26,759

Turtles - 551

Study Code: NMODNOBS

Dataset Files: nmodnobs_stats.sas7bdat, nmodnobs_turts.sas7bdat

Original References:

Source of Data: Dennis Koi, NMFS, Galveston, TX

Comments: The NMFS modern observer program contains all observer studies conducted since July 1997. The majority of records are from after 1999.

Study Code: OREGONII

Dataset Files: oregonii_stats.sas7bdat, oregonii_turts.sas7bdat

Original References: Cruise reports only

Source of Data: NMFS Oracle Database at Pascagoula, MS

Comments: These data are from the fishery independent sampling program aboard the NMFS R/V Oregon II, pulling a single 40-foot shrimp trawl. The sampling is targeted between 5 and 50 fathom, is random within areas sampled, and generally occurs during two seasons per year. This data includes trips from 1972 through fall of 2000.

Reconciliation – data included in this set:

Tows - 26,260

Standardized net hours (STD) - 3,035

Turtle captures - 18

Dataset Files: fnbrdstd_stats.sas7bdat, fnbrdstd_turts.sas7bdat

Original References: Study results were reported in several Foundation and LGL reports; however, none of these reports addressed turtle/trawl interactions. The effort study was reported in Gallaway et al. 2000, 2001.

Source of Data: Dennis Koi, NMFS, Galveston, TX

Comments: The data in this study reflect observer programs during Gulf and South Atlantic Fisheries Development Foundation, Inc. BRD testing from 1980 through 2002 and the effort study conducted in 1999 through 2001. Neither program was designed to test turtle/trawl interactions, but all such encounters were recorded. A comprehensive listing of turtle captures during the program has not been reported. The Foundation name was changed effective February 15, 1999 by dropping the word "Development."

Reconciliation – data included in this set:

Tows - 3,126

100' headrope net hours - 30,066

Turtles captured - 8

Study Code: NCHAREVL

Dataset Files: ncharevl_stats.sas7bdat, ncharevl_turts.sas7bdat

Original References: Nance (1998)

Source of Data: Dennis Koi, NMFS, Galveston, TX

Comments: These bycatch characterization and evaluation studies were conducted in the South Atlantic and Gulf of Mexico between 1992 and 1996. The studies included observers on commercial shrimp vessels. Catch was recorded from samples from one each control and experimental net, however, all turtle encounters were recorded.

Reconciliation – data included in this set:

Tows - 5,807

100' headrope net hours - 46,203

Turtles - 63

Study Code: NHISTOBS

Dataset Files: nhistobs_stats.sas7bdat, nhistobs_turts.sas7bdat

Original References: Henwood and Stuntz (1987)

Source of Data: Dr. Warren Stuntz (March 1995)

Study Code: STSEAMAP

Dataset Files: stseamap_stats.sas7bdat, stseamap_turts.sas7bdat

Original References: ASMFC (2000)

Source of Data: NMFS Oracle Database at Pascagoula, MS (stations) and Mr. Pearce Webster, South Carolina DNR (turtles)

Comments: Data from state vessels used in the Atlantic states SEAMAP program. Turtle data used in this dataset limited to that with matching station data from the NMFS SEAMAP database.

Reconciliation – data included in this set:

Tows - 7,439

Standardized net hours (STD) – 991

Turtle captures - 184

Study Code: GUSEAMAP

Dataset Files: guseamap_stats.sas7bdat, guseamap_turts.sas7bdat

Original References:

Source of Data: NMFS Oracle Database at Pascagoula, MS

Comments: Data from state vessels used in the Gulf of Mexico SEAMAP program.

Reconciliation – data included in this set:

Tows - 5,846

Standardized net hours (STD) – 647

Turtle captures – 5

Section Two—Data Descriptions

Data from ten separate studies (Appendix 3) are incorporated in this database. Each study contributed two separate files, a station dataset and a turtle capture dataset. Variables for the station dataset are described in Table 1 and variables for the turtle capture dataset are described in Table 2.

Table 1. Station Data Fields. There are 21 fields in the station data files that are consistent across all eleven-station datasets (10 study datasets and the combined dataset). Not every data set includes entries for all fields

#	Variable	Variable description
1	HRSTOW	time in hours that nets were towed
2	BEGTIME	time of day that the tow began
3	ENDTIME	time of day that the tow ended (haul back)
4	YR	year (YYYY)
5	STATAREA	NMFS Statistical Area (see Figure 1)
6	VESS	vessel code
7	TRIP	trip number
8	TOW	tow number on a trip
9	DPTHFM	water depth in fathoms
10	DAY	day of the month (DD)
11	LATDD	latitude in decimal degrees
12	LONDD	longitude in decimal degrees
13	MON	month of year (MM)
14	CFTHDHRTED	TED net hours standardized to 100' of headrope
15	CFTHDHRNON	std net hours standardized to 100' of headrope
16	HABZONE	LGL shrimp effort Habitat Zones (see Note 1 and Figure 2 and Figure 2a)

17	STUDY	study code (see Appendix 3)
18	NUMNETSTED	number of TED nets
19	NUMNETSSTD	number of standard (non-TED) nets
20	VSPEED	vessel speed in knots
21	STATID	a unique station ID added to facilitate matching turtles and the stations where they were caught

Table 2. Turtle Data Fields. There are 23 fields in the turtle data files that are consistent across all eleven datasets (10 study datasets and the combined dataset). Not every data set includes all fields.

#	Variable	Variable description
1	NET	number assigned to net positions in some studies
2	TRIP	trip number
3	VESS	vessel code
4	SP	species code (see Note 2)
5	STATAREA	NMFS Statistical Area, Gulf of Mexico only (Figure 1)
6	TOW	tow number on the trip
7	LATDD	latitude in decimal degrees
8	LONDD	longitude in decimal degrees
9	TAGNO	tag number that was attached to a turtle
10	MON	month of year (MM)
11	DAY	day of the month (DD)
12	DPTHFM	water depth in fathoms
13	CCLCM	curved carapace length in cm
14	CCWCM	curved carapace width in cm
15	SCLCM	straight line carapace length in cm
16	STATUS	turtle status (see Note 3)
17	STUDY	study code (Appendix 3)
18	NETTYPE	TED, STD, or TRY net
19	YR	four digit year (YYYY)
20	HABZONE	LGL shrimping effort Habitat Zones (see Note 1 and Figure 2 and Figure 2a)
21	P_S	port (P) or starboard (S) position of the net
22	I_O	inboard (I) or outboard (O) position of the net

23 STATID unique station ID to facilitate matching station files

Note 1: Definitions of the Habitat Zones as described in Gallaway et al. In press.

Zone	Description	Habitat
110	Area 1, 0-10 fathoms, Stat. Areas 19-21	Shallow,S. TX, Texas Transitional Faunal Province
120	Area 1, 11-20 fathoms, Stat. Areas 19-21	Brown Shrimp Grounds
130	Area 1, 21-30 fathoms, Stat. Areas 19-21	Brown Shrimp Grounds
210	Area 2, 0-10 fathoms, Stat. Areas 13-18	White Shrimp Grounds Shallow, N. TX, W. LA
320	Area 3, 11-20 fathoms, Stat. Areas 13-18	Brown Shrimp Grounds
330	Area 3, 21-30 fathoms, Stat. Areas 13-18	Brown Shrimp Grounds
440	Area 4, 31-40 fathoms, Stat. Areas 10-21	Deep, W. Gulf Shelf
450	Area 4, 41 fathoms and above	Deep, W. Gulf Shelf
510	Area 5, 0-10 fathoms	Mississippi Bight White Shrimp Grounds
620	Area 6, 11-20 fathoms	Mississippi Bight Brown Shrimp Grounds
630	Area 6, 21-30 fathoms	Mississippi Bight Brown Shrimp Grounds
700	Eastern Gulf, Stat. Areas 1-9, all depths	Carbonate Province Eastern Gulf Faunal Assemblage

Note 2: Species codes and number of each species captured.

Species Code	Scientific name	Common name	Records
??		turtle (?) or no entry	1
CC	*Caretta caretta*	loggerhead	1,062
CM	*Chelonia mydas*	green	23
DC	*Dermochelys coriacea*	leatherback	12
EI	*Eretmochelys imbricata*	hawksbill	4
LK	*Lepidochelys kempii*	Kemp's ridley	142
OT		other species	7
UN		unidentified	3

Note 3: Turtle status (condition) codes when captured with number in each code.

Status Code	Code Description	Records
	none noted	212
AC	alive conscious	575
DD	dead decomposed	22
FD	fresh dead	164
SA	slid out of net alive	42
SU	slid out of net unconscious	4
UA	alive unconcious	235

Note 4: Net type codes and captures..

Status Code	Code Description	Records
STD	standard net (no TED)	1129
TED	TED-equipped net	100
TRY	trynet	25

Note 5: Study codes and captures.

Study	Records
FDNNAKED	317
FNBRDSTD	8
GUSEAMAP	5
NCHAREVL	63
NHISTOBS	551
NMODNOBS	29
NREDSNAP	7
NTEDSTDY	72
OREGONII	18
STSEAMAP	184

Note 6: Turtle captures by area.

Area	Records
Atlantic	1076
Gulf of Mexico	178

Note 7: Capture records by year.

Year	Records
1976	4
1977	1

1978	193
1979	98
1980	207
1981	54
1983	1
1984	2
1985	1
1988	20
1989	45
1990	26
1991	12
1992	25
1993	33
1994	42
1995	16
1996	21
1997	231
1998	151
1999	23
2000	34
2001	3
2002	11

References

ASMFC (Atlantic States Marine Fisheries Commission). 2000. SEAMAP-SA 10-year trawl report: Results of trawling efforts in the coastal habitat of the South Atlantic bight, FY 1990-1999. Special Report No. 71. Special Report of the Atlantic States Marine Fisheries Commission to U.S. DOC, NOAA (Award No. ANA07 FSO 003). 143p.

Gallaway, B.J., J.G. Cole, and L.R. Martin. 2000. Development of direct measures of Gulf of Mexico shrimp fishing effort as a means to evaluate existing measures of effort and juvenile red snapper bycatch¾A Pilot Study. Final Report by LGL Ecological Research Associates, Inc. to the Gulf and South Atlantic Fisheries Foundation, Inc. Bryan, TX. 97 p.

Gallaway, B.J., J.G. Cole, and L.R. Martin. 2001. Development of direct measures of Gulf of Mexico shrimp fishing effort as a means to evaluate existing measures of effort and juvenile red snapper bycatch¾Year II Pilot Study. Final Report by LGL Ecological Research Associates, Inc. to the Gulf and South Atlantic Fisheries Foundation, Inc. Bryan, TX. 119 p.

Gallaway, B.J., J.G. Cole, L.R. Martin, J.M. Nance and M. Longnecker. In Press. An evaluation of an electronic logbook (ELB) as a more accurate method of estimating spatial patterns of trawling effort and bycatch in the Gulf of Mexico shrimp fishery. North American Journal of Fisheries Management.

GSAFDF (Gulf and South Atlantic Fisheries Development Foundation). 1998. Alternatives to TEDs. Final Report of the Gulf and South Atlantic Fisheries Development Foundation, Inc. to NOAA. Contract 50WCNF606083. Tampa, FL. 19p.

Henwood, T.A. and W.E. Stuntz. 1987. Analysis of sea turtle captures and mortalities during commercial shrimp trawling. Fishery Bulletin 85(4):813-817.

Henwood, T.A. and W.E. Stuntz. Unknown. Analysis of sea turtle captures and mortalities aboard commercial shrimp trawling vessels. Unpublished manuscript. NMFS-SEFC. Pascagola, MS. 35 p.

Jamir, T.V.C. 1999. Revisions to the estimates of incidental sea turtle capture aboard commercial shrimp trawling vessels. Supplemental report by the Gulf and South Atlantic Fisheries Foundation, Inc. to NOAA. Contract 50WCNF606083. Tampa, FL. 17p.

Nance, J.M. (Ed.). 1998. Southeastern United States trawl bycatch program. Report to Congress by NMFS, NOAA. 154 p. (Contributors in alphabetical order: D. Foster, E. Martinez, T. McIlwain, J. Nance, S. Nichols, R. Raulerson, M. Schirripa, G. Scott, E. Scott-Denton, A. Shah and J. Watson).

Patella, F. 1975. Water surface area within statistical subareas used in reporting Gulf coast shrimp data. Marine Fisheries Review 37(12):22-24.

Renaud, M., G. Gitschlag, E. Klima, A. Shah, D. Koi and J. Nance. 1991. Evaluation of the impacts of turtle excluder devices (TEDs) on shrimp catch rates in coastal waters of the United States along the Gulf of Mexico and Atlantic, September 1989 through August 1990. NOAA Technical Memorandum, NMFS-SEFC-288. 80p.

Renaud, M., G. Gitschlag, E. Klima, A. Shah, J. Nance, C. Caillouet, Z. Zein-Eldin, D. Koi and F. Patella. 1990. Evaluation of the impacts of turtle excluder devices (TEDs) on shrimp catch rates in the Gulf of Mexico and south Atlantic, March 1988 through July 1989. NOAA Technical Memorandum, NMFS-SEFC-254. 165p.

Appendices

Annual Study Summaries of Standarized Hours and Turtle Captures

study	tows	tedhrs	stdhrs	TED	STD	TRY	tedcpue	stdcpue
FDNNAKED	1,806	59	9,610	0	308	9	0.00000	0.03205
FNBRDSTD	3,126	30,066	0	7	0	1	0.00023	.
GUSEAMAP	5,846	0	658	0	5	0	.	0.00760
NCHAREVL	5,807	46,203	0	54	0	9	0.00117	.
NHISTOBS	11,573	0	26,759	0	551	0	.	0.02059
NMODNOBS	2,314	21,496	0	29	0	0	0.00135	.
NREDSNAP	1,899	3,889	0	7	0	0	0.00180	.
NTEDSTDY	1,717	6,289	5,085	3	63	6	0.00048	0.01239
OREGONII	26,260	10	3,035	0	18	0	0.00000	0.00593
STSEAMAP	7,439	0	991	0	184	0	.	0.18560
	67,787	*108,013*	*46,139*	*100*	*1,129*	*25*		

Data Dictionary Appendices

Appendix 2

Appendix 3

Annual Study Summaries of Standarized Hours and Turtle Captures

study	tows	tedhrs	stdhrs	TED	STD	TRY	tedcpue	stdcpue
FDNNAKED	1,806	59	9,610	0	308	9	0.00000	0.03205
FNBRDSTD	3,126	30,066	0	7	0	1	0.00023	.
GUSEAMAP	5,846	0	658	0	5	0	.	0.00760
NCHAREVL	5,807	46,203	0	54	0	9	0.00117	.
NHISTOBS	11,573	0	26,759	0	551	0	.	0.02059
NMODNOBS	2,314	21,496	0	29	0	0	0.00135	.
NREDSNAP	1,899	3,889	0	7	0	0	0.00180	.
NTEDSTDY	1,717	6,289	5,085	3	63	6	0.00048	0.01239
OREGONII	26,260	10	3,035	0	18	0	0.00000	0.00593
STSEAMAP	7,439	0	991	0	184	0	.	0.18560
	67,787	*108,013*	*46,139*	*100*	*1,129*	*25*		

Annual Study Summaries of Standarized Hours and Turtle Captures

YEAR	study	TOWS	TEDHRS	STDHRS	TED	STD	TEDCPUE	STDCPUE
1972	NHISTOBS	71	0	8	0	0	.	0.00000
	OREGONII	665	0	50	0	0	.	0.00000
1972		*736*	*0*	*58*	*0*	*0*		
1973	NHISTOBS	120	0	66	0	0	.	0.00000
	OREGONII	1,184	0	81	0	0	.	0.00000
1973		*1,304*	*0*	*147*	*0*	*0*		
1974	NHISTOBS	191	0	75	0	0	.	0.00000
	OREGONII	1,910	0	130	0	0	.	0.00000
1974		*2,101*	*0*	*205*	*0*	*0*		
1975	NHISTOBS	235	0	385	0	0	.	0.00000
	OREGONII	1,639	0	130	0	0	.	0.00000
1975		*1,874*	*0*	*515*	*0*	*0*		
1976	NHISTOBS	432	0	595	0	1	.	0.00168
	OREGONII	1,643	0	110	0	3	.	0.02727
1976		*2,075*	*0*	*705*	*0*	*4*		
1977	NHISTOBS	317	0	777	0	1	.	0.00129
	OREGONII	1,356	0	98	0	0	.	0.00000
1977		*1,673*	*0*	*874*	*0*	*1*		
1978	NHISTOBS	4,276	0	8,146	0	192	.	0.02357
	OREGONII	1,293	10	78	0	1	0.00000	0.01287
1978		*5,569*	*10*	*8,223*	*0*	*193*		
1979	NHISTOBS	2,692	0	5,004	0	98	.	0.01959
	OREGONII	1,028	0	69	0	0	.	0.00000
1979		*3,720*	*0*	*5,073*	*0*	*98*		
1980	NHISTOBS	2,426	0	8,510	0	206	.	0.02421

YEAR	study	TOWS	TEDHRS	STDHRS	TED	STD	TEDCPUE	STDCPUE
	OREGONII	1,418	0	97	0	1	.	0.01035
1980		*3,844*	*0*	*8,607*	*0*	*207*		
1981	NHISTOBS	813	0	3,193	0	53	.	0.01660
	OREGONII	1,674	0	143	0	1	.	0.00700
1981		*2,487*	*0*	*3,336*	*0*	*54*		
1982	GUSEAMAP	151	0	22	0	0	.	0.00000
	OREGONII	1,551	0	129	0	0	.	0.00000
1982		*1,702*	*0*	*151*	*0*	*0*		
1983	GUSEAMAP	188	0	25	0	0	.	0.00000
	OREGONII	1,191	0	104	0	1	.	0.00966
1983		*1,379*	*0*	*129*	*0*	*1*		
1984	GUSEAMAP	34	0	4	0	0	.	0.00000
	OREGONII	1,527	0	131	0	2	.	0.01524
1984		*1,561*	*0*	*136*	*0*	*2*		
1985	GUSEAMAP	165	0	19	0	0	.	0.00000
	OREGONII	975	0	120	0	1	.	0.00831
1985		*1,140*	*0*	*139*	*0*	*1*		
1986	GUSEAMAP	190	0	23	0	0	.	0.00000
	OREGONII	472	0	58	0	0	.	0.00000
	STSEAMAP	160	0	21	0	0	.	0.00000
1986		*822*	*0*	*102*	*0*	*0*		
1987	GUSEAMAP	404	0	46	0	0	.	0.00000
	OREGONII	408	0	84	0	0	.	0.00000
	STSEAMAP	262	0	35	0	0	.	0.00000
1987		*1,074*	*0*	*165*	*0*	*0*		
1988	GUSEAMAP	368	0	39	0	0	.	0.00000
	NTEDSTDY	727	2,415	2,236	0	16	0.00000	0.00716
	OREGONII	431	0	92	0	0	.	0.00000

YEAR	study	TOWS	TEDHRS	STDHRS	TED	STD	TEDCPUE	STDCPUE
	STSEAMAP	416	0	55	0	0	.	0.00000
1988		*1,942*	*2,415*	*2,422*	*0*	*16*		
1989	GUSEAMAP	454	0	47	0	0	.	0.00000
	NTEDSTDY	591	2,647	1,943	1	38	0.00038	0.01956
	OREGONII	459	0	90	0	0	.	0.00000
	STSEAMAP	530	0	71	0	5	.	0.07075
1989		*2,034*	*2,647*	*2,151*	*1*	*43*		
1990	GUSEAMAP	381	0	41	0	0	.	0.00000
	NTEDSTDY	399	1,228	907	2	9	0.00163	0.00992
	OREGONII	524	0	109	0	1	.	0.00917
	STSEAMAP	548	0	73	0	13	.	0.17831
1990		*1,852*	*1,228*	*1,130*	*2*	*23*		
1991	GUSEAMAP	379	0	40	0	0	.	0.00000
	OREGONII	520	0	118	0	1	.	0.00849
	STSEAMAP	538	0	72	0	11	.	0.15369
1991		*1,437*	*0*	*230*	*0*	*12*		
1992	GUSEAMAP	333	0	36	0	1	.	0.02804
	NCHAREVL	838	6,433	0	9	0	0.00140	.
	OREGONII	493	0	104	0	0	.	0.00000
	STSEAMAP	554	0	74	0	14	.	0.18974
1992		*2,218*	*6,433*	*214*	*9*	*15*		
1993	GUSEAMAP	379	0	43	0	0	.	0.00000
	NCHAREVL	1,805	14,869	0	14	0	0.00094	.
	OREGONII	517	0	116	0	1	.	0.00859
	STSEAMAP	554	0	74	0	14	.	0.18953
1993		*3,255*	*14,869*	*233*	*14*	*15*		
1994	GUSEAMAP	426	0	47	0	0	.	0.00000
	NCHAREVL	1,828	13,071	0	18	0	0.00138	.

YEAR	study	TOWS	TEDHRS	STDHRS	TED	STD	TEDCPUE	STDCPUE
	OREGONII	499	0	114	0	0	.	0.00000
	STSEAMAP	554	0	74	0	24	.	0.32497
1994		*3,307*	*13,071*	*234*	*18*	*24*		
1995	GUSEAMAP	305	0	31	0	0	.	0.00000
	NCHAREVL	1,032	9,407	0	7	0	0.00074	.
	OREGONII	454	0	107	0	0	.	0.00000
	STSEAMAP	554	0	74	0	6	.	0.08124
1995		*2,345*	*9,407*	*212*	*7*	*6*		
1996	GUSEAMAP	338	0	38	0	0	.	0.00000
	NCHAREVL	304	2,423	0	6	0	0.00248	.
	OREGONII	542	0	122	0	2	.	0.01639
	STSEAMAP	554	0	74	0	12	.	0.16245
1996		*1,738*	*2,423*	*234*	*6*	*14*		
1997	FDNNAKED	1,515	59	8,085	0	201	0.00000	0.02486
	GUSEAMAP	315	0	34	0	0	.	0.00000
	NMODNOBS	50	429	0	2	0	0.00466	.
	OREGONII	455	0	116	0	1	.	0.00863
	STSEAMAP	554	0	74	0	19	.	0.25727
1997		*2,889*	*489*	*8,308*	*2*	*221*		
1998	FDNNAKED	291	0	1,526	0	107	.	0.07014
	GUSEAMAP	309	0	33	0	0	.	0.00000
	NMODNOBS	180	1,237	0	12	0	0.00970	.
	NREDSNAP	1,899	3,889	0	7	0	0.00180	.
	OREGONII	402	0	104	0	0	.	0.00000
	STSEAMAP	553	0	74	0	24	.	0.32573
1998		*3,634*	*5,126*	*1,736*	*19*	*131*		
1999	FNBRDSTD	1,009	8,948	0	1	0	0.00011	.
	GUSEAMAP	399	0	54	0	1	.	0.01847

YEAR	study	TOWS	TEDHRS	STDHRS	TED	STD	TEDCPUE	STDCPUE
	NMODNOBS	240	2,163	0	1	0	0.00046	.
	OREGONII	525	0	117	0	2	.	0.01714
	STSEAMAP	554	0	74	0	18	.	0.24368
1999		*2,727*	*11,111*	*245*	*2*	*21*		
2000	FNBRDSTD	1,038	9,351	0	2	0	0.00021	.
	GUSEAMAP	304	0	32	0	3	.	0.09246
	NMODNOBS	385	3,906	0	5	0	0.00128	.
	OREGONII	505	0	116	0	0	.	0.00000
	STSEAMAP	554	0	74	0	24	.	0.32491
2000		*2,786*	*13,257*	*222*	*7*	*27*		
2001	FNBRDSTD	327	3,638	0	1	0	0.00027	.
	GUSEAMAP	24	0	3	0	0	.	0.00000
	NMODNOBS	935	10,251	0	2	0	0.00020	.
2001		*1,286*	*13,889*	*3*	*3*	*0*		
2002	FNBRDSTD	752	8,128	0	3	0	0.00037	.
	NMODNOBS	524	3,510	0	7	0	0.00199	.
2002		*1,276*	*11,639*	*0*	*10*	*0*		
		67,787	*108,013*	*46,139*	*100*	*1,129*		

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yr	study	tows	tedhrs	stdhrs	TED	STD	tedcpue	stdcpue
1972	NHISTOBS	71	0	8	0	0	.	0.00000
	OREGONII	665	0	50	0	0	.	0.00000
1972		*736*	*0*	*58*	*0*	*0*		
1973	NHISTOBS	120	0	66	0	0	.	0.00000
	OREGONII	1,184	0	81	0	0	.	0.00000
1973		*1,304*	*0*	*147*	*0*	*0*		
1974	NHISTOBS	191	0	75	0	0	.	0.00000
	OREGONII	1,910	0	130	0	0	.	0.00000
1974		*2,101*	*0*	*205*	*0*	*0*		
1975	NHISTOBS	235	0	385	0	0	.	0.00000
	OREGONII	1,639	0	130	0	0	.	0.00000
1975		*1,874*	*0*	*515*	*0*	*0*		
1976	NHISTOBS	431	0	594	0	1	.	0.00168
	OREGONII	1,642	0	110	0	3	.	0.02729
1976		*2,073*	*0*	*704*	*0*	*4*		
1977	NHISTOBS	317	0	777	0	1	.	0.00129
	OREGONII	1,356	0	98	0	0	.	0.00000
1977		*1,673*	*0*	*874*	*0*	*1*		
1978	NHISTOBS	1,608	0	4,313	0	9	.	0.00209
	OREGONII	1,293	10	78	0	1	0.00000	0.01287
1978		*2,901*	*10*	*4,390*	*0*	*10*		
1979	NHISTOBS	1,237	0	2,817	0	11	.	0.00391
	OREGONII	1,028	0	69	0	0	.	0.00000
1979		*2,265*	*0*	*2,885*	*0*	*11*		
1980	NHISTOBS	1,153	0	5,039	0	17	.	0.00337

yr	study	tows	tedhrs	stdhrs	TED	STD	tedcpue	stdcpue
	OREGONII	1,417	0	97	0	1	.	0.01036
1980		*2,570*	*0*	*5,136*	*0*	*18*		
1981	NHISTOBS	686	0	2,740	0	12	.	0.00438
	OREGONII	1,674	0	143	0	1	.	0.00700
1981		*2,360*	*0*	*2,883*	*0*	*13*		
1982	GUSEAMAP	151	0	22	0	0	.	0.00000
	OREGONII	1,551	0	129	0	0	.	0.00000
1982		*1,702*	*0*	*151*	*0*	*0*		
1983	GUSEAMAP	188	0	25	0	0	.	0.00000
	OREGONII	1,191	0	104	0	1	.	0.00966
1983		*1,379*	*0*	*129*	*0*	*1*		
1984	GUSEAMAP	34	0	4	0	0	.	0.00000
	OREGONII	1,527	0	131	0	2	.	0.01524
1984		*1,561*	*0*	*136*	*0*	*2*		
1985	GUSEAMAP	165	0	19	0	0	.	0.00000
	OREGONII	975	0	120	0	1	.	0.00831
1985		*1,140*	*0*	*139*	*0*	*1*		
1986	GUSEAMAP	190	0	23	0	0	.	0.00000
	OREGONII	472	0	58	0	0	.	0.00000
1986		*662*	*0*	*80*	*0*	*0*		
1987	GUSEAMAP	404	0	46	0	0	.	0.00000
	OREGONII	408	0	84	0	0	.	0.00000
1987		*812*	*0*	*130*	*0*	*0*		
1988	GUSEAMAP	368	0	39	0	0	.	0.00000
	NTEDSTDY	461	1,858	1,724	0	3	0.00000	0.00174
	OREGONII	431	0	92	0	0	.	0.00000
1988		*1,260*	*1,858*	*1,855*	*0*	*3*		
1989	GUSEAMAP	454	0	47	0	0	.	0.00000

yr	study	tows	tedhrs	stdhrs	TED	STD	tedcpue	stdcpue
	NTEDSTDY	412	2,014	1,472	1	9	0.00050	0.00612
	OREGONII	459	0	90	0	0	.	0.00000
1989		*1,325*	*2,014*	*1,609*	*1*	*9*		
1990	GUSEAMAP	381	0	41	0	0	.	0.00000
	NTEDSTDY	158	631	387	0	0	0.00000	0.00000
	OREGONII	524	0	109	0	1	.	0.00917
1990		*1,063*	*631*	*537*	*0*	*1*		
1991	GUSEAMAP	379	0	40	0	0	.	0.00000
	OREGONII	520	0	118	0	1	.	0.00849
1991		*899*	*0*	*158*	*0*	*1*		
1992	GUSEAMAP	333	0	36	0	1	.	0.02804
	NCHAREVL	622	5,650	0	5	0	0.00088	.
	OREGONII	493	0	104	0	0	.	0.00000
1992		*1,448*	*5,650*	*140*	*5*	*1*		
1993	GUSEAMAP	379	0	43	0	0	.	0.00000
	NCHAREVL	1,266	12,577	0	5	0	0.00040	.
	OREGONII	517	0	116	0	1	.	0.00859
1993		*2,162*	*12,577*	*159*	*5*	*1*		
1994	GUSEAMAP	426	0	47	0	0	.	0.00000
	NCHAREVL	1,203	11,168	0	12	0	0.00107	.
	OREGONII	499	0	114	0	0	.	0.00000
1994		*2,128*	*11,168*	*160*	*12*	*0*		
1995	GUSEAMAP	305	0	31	0	0	.	0.00000
	NCHAREVL	705	7,242	0	5	0	0.00069	.
	OREGONII	454	0	107	0	0	.	0.00000
1995		*1,464*	*7,242*	*139*	*5*	*0*		
1996	GUSEAMAP	338	0	38	0	0	.	0.00000
	NCHAREVL	236	1,954	0	2	0	0.00102	.

yr	study	tows	tedhrs	stdhrs	TED	STD	tedcpue	stdcpue
	OREGONII	542	0	122	0	2	.	0.01639
1996		*1,116*	*1,954*	*160*	*2*	*2*		
1997	FDNNAKED	988	59	7,401	0	20	0.00000	0.00270
	GUSEAMAP	315	0	34	0	0	.	0.00000
	NMODNOBS	50	429	0	2	0	0.00466	.
	OREGONII	455	0	116	0	1	.	0.00863
1997		*1,808*	*489*	*7,551*	*2*	*21*		
1998	FDNNAKED	177	0	1,372	0	6	.	0.00437
	GUSEAMAP	309	0	33	0	0	.	0.00000
	NMODNOBS	25	647	0	0	0	0.00000	.
	NREDSNAP	1,899	3,889	0	7	0	0.00180	.
	OREGONII	402	0	104	0	0	.	0.00000
1998		*2,812*	*4,535*	*1,509*	*7*	*6*		
1999	FNBRDSTD	1,009	8,948	0	1	0	0.00011	.
	GUSEAMAP	399	0	54	0	1	.	0.01847
	NMODNOBS	185	2,017	0	1	0	0.00050	.
	OREGONII	525	0	117	0	2	.	0.01714
1999		*2,118*	*10,965*	*171*	*2*	*3*		
2000	FNBRDSTD	1,038	9,351	0	2	0	0.00021	.
	GUSEAMAP	304	0	32	0	3	.	0.09246
	NMODNOBS	250	3,172	0	0	0	0.00000	.
	OREGONII	505	0	116	0	0	.	0.00000
2000		*2,097*	*12,524*	*148*	*2*	*3*		
2001	FNBRDSTD	327	3,638	0	1	0	0.00027	.
	GUSEAMAP	24	0	3	0	0	.	0.00000
	NMODNOBS	908	10,107	0	2	0	0.00020	.
2001		*1,259*	*13,745*	*3*	*3*	*0*		
2002	FNBRDSTD	752	8,128	0	3	0	0.00037	.

yr	study	tows	tedhrs	stdhrs	TED	STD	tedcpue	stdcpue
	NMODNOBS	456	2,942	0	7	0	0.00238	.
2002		*1,208*	*11,070*	*0*	*10*	*0*		
		51,280	*96,434*	*32,862*	*56*	*112*		

Annual Habitat Zone Summaries of Standarized Hours and Turtle Captures

YEAR	HAB	TOWS	TEDHRS	STDHRS	TED	STD	TEDCPUE	STDCPUE
1972	210	54	0	4	0	0	.	0.00000
	320	112	0	7	0	0	.	0.00000
	330	105	0	7	0	0	.	0.00000
	440	152	0	12	0	0	.	0.00000
	450	99	0	11	0	0	.	0.00000
	510	51	0	4	0	0	.	0.00000
	620	106	0	7	0	0	.	0.00000
	630	56	0	4	0	0	.	0.00000
1972		*735*	*0*	*57*	*0*	*0*		
1973	110	5	0	3	0	0	.	0.00000
	120	24	0	24	0	0	.	0.00000
	130	6	0	3	0	0	.	0.00000
	210	145	0	26	0	0	.	0.00000
	320	225	0	15	0	0	.	0.00000
	330	129	0	9	0	0	.	0.00000
	440	189	0	13	0	0	.	0.00000
	450	109	0	7	0	0	.	0.00000
	510	122	0	9	0	0	.	0.00000
	620	150	0	10	0	0	.	0.00000
	630	120	0	8	0	0	.	0.00000
	720	10	0	1	0	0	.	0.00000
	730	23	0	2	0	0	.	0.00000
	740	9	0	1	0	0	.	0.00000
	750	6	0	1	0	0	.	0.00000
1973		*1,272*	*0*	*131*	*0*	*0*		

YEAR	HAB	TOWS	TEDHRS	STDHRS	TED	STD	TEDCPUE	STDCPUE
1974	110	4	0	1	0	0	.	0.00000
	120	39	0	18	0	0	.	0.00000
	130	5	0	3	0	0	.	0.00000
	210	229	0	17	0	0	.	0.00000
	320	323	0	23	0	0	.	0.00000
	330	253	0	24	0	0	.	0.00000
	440	232	0	15	0	0	.	0.00000
	450	187	0	13	0	0	.	0.00000
	510	282	0	19	0	0	.	0.00000
	620	313	0	35	0	0	.	0.00000
	630	209	0	14	0	0	.	0.00000
	720	7	0	17	0	0	.	0.00000
1974		*2,083*	*0*	*198*	*0*	*0*		
1975	110	8	0	2	0	0	.	0.00000
	120	1	0	0	0	0	.	0.00000
	210	215	0	131	0	0	.	0.00000
	320	283	0	43	0	0	.	0.00000
	330	234	0	55	0	0	.	0.00000
	440	239	0	35	0	0	.	0.00000
	450	158	0	40	0	0	.	0.00000
	510	285	0	141	0	0	.	0.00000
	620	250	0	32	0	0	.	0.00000
	630	166	0	23	0	0	.	0.00000
	710	26	0	11	0	0	.	0.00000
	720	8	0	3	0	0	.	0.00000
1975		*1,873*	*0*	*515*	*0*	*0*		
1976	110	20	0	18	0	0	.	0.00000
	120	48	0	211	0	0	.	0.00000

YEAR	HAB	TOWS	TEDHRS	STDHRS	TED	STD	TEDCPUE	STDCPUE
	130	21	0	114	0	0	.	0.00000
	210	336	0	72	0	0	.	0.00000
	320	481	0	166	0	3	.	0.01812
	330	244	0	21	0	0	.	0.00000
	440	215	0	25	0	0	.	0.00000
	450	174	0	12	0	0	.	0.00000
	510	148	0	15	0	0	.	0.00000
	620	200	0	13	0	1	.	0.07500
	630	147	0	10	0	0	.	0.00000
	720	26	0	16	0	0	.	0.00000
	730	1	0	1	0	0	.	0.00000
	800	2	0	1	0	0	.	0.00000
1976		*2,063*	*0*	*694*	*0*	*4*		
1977	110	44	0	76	0	0	.	0.00000
	120	125	0	290	0	1	.	0.00345
	130	58	0	50	0	0	.	0.00000
	210	211	0	73	0	0	.	0.00000
	320	262	0	59	0	0	.	0.00000
	330	164	0	25	0	0	.	0.00000
	440	221	0	69	0	0	.	0.00000
	450	252	0	34	0	0	.	0.00000
	510	94	0	36	0	0	.	0.00000
	620	115	0	12	0	0	.	0.00000
	630	60	0	6	0	0	.	0.00000
	710	33	0	55	0	0	.	0.00000
	720	11	0	34	0	0	.	0.00000
	730	5	0	17	0	0	.	0.00000
1977		*1,655*	*0*	*836*	*0*	*1*		

YEAR	HAB	TOWS	TEDHRS	STDHRS	TED	STD	TEDCPUE	STDCPUE
1978	110	42	0	119	0	0	.	0.00000
	120	66	0	258	0	1	.	0.00387
	130	9	0	57	0	0	.	0.00000
	210	1,244	1	3,059	0	8	0.00000	0.00262
	320	248	2	99	0	0	0.00000	0.00000
	330	143	1	139	0	0	0.00000	0.00000
	440	142	1	8	0	0	0.00000	0.00000
	450	53	0	3	0	0	0.00000	0.00000
	510	126	2	45	0	0	0.00000	0.00000
	620	153	2	8	0	0	0.00000	0.00000
	630	119	1	6	0	0	0.00000	0.00000
	710	146	0	177	0	0	.	0.00000
	720	120	0	27	0	0	.	0.00000
	730	83	0	90	0	0	.	0.00000
	740	51	0	11	0	1	.	0.09245
	750	50	0	5	0	0	.	0.00000
	800	2,668	0	3,833	0	183	.	0.04774
1978		*5,463*	*10*	*7,946*	*0*	*193*		
1979	110	33	0	75	0	1	.	0.01338
	210	623	0	1,081	0	3	.	0.00278
	320	226	0	59	0	0	.	0.00000
	330	111	0	7	0	0	.	0.00000
	440	190	0	13	0	0	.	0.00000
	450	93	0	6	0	0	.	0.00000
	510	117	0	8	0	0	.	0.00000
	620	131	0	9	0	0	.	0.00000
	630	99	0	7	0	0	.	0.00000
	710	86	0	197	0	2	.	0.01013

YEAR	HAB	TOWS	TEDHRS	STDHRS	TED	STD	TEDCPUE	STDCPUE
	720	502	0	1,270	0	4	.	0.00315
	730	38	0	124	0	1	.	0.00807
	800	1,455	0	2,187	0	87	.	0.03978
1979		*3,704*	*0*	*5,043*	*0*	*98*		
1980	110	113	0	952	0	6	.	0.00630
	120	108	0	768	0	2	.	0.00260
	210	516	0	1,466	0	1	.	0.00068
	320	332	0	274	0	2	.	0.00731
	330	233	0	144	0	0	.	0.00000
	440	221	0	79	0	0	.	0.00000
	450	125	0	33	0	0	.	0.00000
	510	421	0	702	0	3	.	0.00427
	620	193	0	120	0	1	.	0.00830
	630	213	0	176	0	0	.	0.00000
	720	66	0	230	0	3	.	0.01305
	730	12	0	100	0	0	.	0.00000
	750	2	0	6	0	0	.	0.00000
	800	1,274	0	3,471	0	189	.	0.05445
1980		*3,829*	*0*	*8,522*	*0*	*207*		
1981	110	55	0	98	0	0	.	0.00000
	120	213	0	523	0	0	.	0.00000
	130	31	0	78	0	0	.	0.00000
	210	363	0	888	0	5	.	0.00563
	320	424	0	411	0	2	.	0.00486
	330	201	0	53	0	0	.	0.00000
	440	182	0	37	0	0	.	0.00000
	450	162	0	17	0	0	.	0.00000
	510	306	0	400	0	3	.	0.00750

YEAR	HAB	TOWS	TEDHRS	STDHRS	TED	STD	TEDCPUE	STDCPUE
	620	213	0	104	0	1	.	0.00965
	630	121	0	8	0	0	.	0.00000
	710	37	0	171	0	1	.	0.00585
	720	43	0	83	0	1	.	0.01202
	800	127	0	453	0	41	.	0.09046
1981		*2,478*	*0*	*3,324*	*0*	*54*		
1982	110	13	0	1	0	0	.	0.00000
	120	38	0	5	0	0	.	0.00000
	130	23	0	3	0	0	.	0.00000
	210	147	0	13	0	0	.	0.00000
	320	268	0	23	0	0	.	0.00000
	330	228	0	22	0	0	.	0.00000
	440	226	0	20	0	0	.	0.00000
	450	212	0	23	0	0	.	0.00000
	510	169	0	13	0	0	.	0.00000
	620	225	0	17	0	0	.	0.00000
	630	153	0	10	0	0	.	0.00000
1982		*1,702*	*0*	*151*	*0*	*0*		
1983	110	16	0	2	0	0	.	0.00000
	120	40	0	4	0	0	.	0.00000
	130	20	0	2	0	0	.	0.00000
	210	157	0	13	0	0	.	0.00000
	320	183	0	16	0	0	.	0.00000
	330	125	0	11	0	0	.	0.00000
	440	142	0	11	0	0	.	0.00000
	450	141	0	25	0	0	.	0.00000
	510	184	0	14	0	0	.	0.00000
	620	214	0	20	0	1	.	0.05097

YEAR	HAB	TOWS	TEDHRS	STDHRS	TED	STD	TEDCPUE	STDCPUE
	630	131	0	10	0	0	.	0.00000
	710	4	0	0	0	0	.	0.00000
	720	12	0	1	0	0	.	0.00000
	730	3	0	0	0	0	.	0.00000
	740	4	0	0	0	0	.	0.00000
	750	2	0	0	0	0	.	0.00000
1983		*1,378*	*0*	*129*	*0*	*1*		
1984	110	10	0	1	0	0	.	0.00000
	120	32	0	3	0	0	.	0.00000
	130	14	0	2	0	0	.	0.00000
	210	142	0	11	0	0	.	0.00000
	320	250	0	18	0	0	.	0.00000
	330	187	0	14	0	0	.	0.00000
	440	215	0	17	0	0	.	0.00000
	450	226	0	33	0	0	.	0.00000
	510	174	0	13	0	0	.	0.00000
	620	185	0	14	0	2	.	0.14627
	630	126	0	9	0	0	.	0.00000
1984		*1,561*	*0*	*136*	*0*	*2*		
1985	110	115	0	18	0	0	.	0.00000
	120	210	0	32	0	0	.	0.00000
	130	19	0	3	0	0	.	0.00000
	210	104	0	10	0	0	.	0.00000
	320	119	0	11	0	0	.	0.00000
	330	63	0	6	0	0	.	0.00000
	440	66	0	7	0	0	.	0.00000
	450	147	0	21	0	0	.	0.00000
	510	141	0	14	0	1	.	0.07163

YEAR	HAB	TOWS	TEDHRS	STDHRS	TED	STD	TEDCPUE	STDCPUE
	620	99	0	9	0	0	.	0.00000
	630	41	0	4	0	0	.	0.00000
1985		*1,124*	*0*	*136*	*0*	*1*		
1986	110	24	0	3	0	0	.	0.00000
	120	58	0	6	0	0	.	0.00000
	130	29	0	3	0	0	.	0.00000
	210	102	0	13	0	0	.	0.00000
	320	94	0	11	0	0	.	0.00000
	330	40	0	5	0	0	.	0.00000
	440	57	0	7	0	0	.	0.00000
	450	79	0	9	0	0	.	0.00000
	510	42	0	4	0	0	.	0.00000
	620	52	0	5	0	0	.	0.00000
	630	30	0	3	0	0	.	0.00000
	710	2	0	0	0	0	.	0.00000
	720	12	0	1	0	0	.	0.00000
	730	3	0	0	0	0	.	0.00000
	740	9	0	1	0	0	.	0.00000
	750	28	0	7	0	0	.	0.00000
	800	160	0	21	0	0	.	0.00000
1986		*821*	*0*	*102*	*0*	*0*		
1987	110	80	0	7	0	0	.	0.00000
	120	90	0	12	0	0	.	0.00000
	130	20	0	6	0	0	.	0.00000
	210	188	0	25	0	0	.	0.00000
	320	125	0	19	0	0	.	0.00000
	330	47	0	12	0	0	.	0.00000
	440	50	0	15	0	0	.	0.00000

YEAR	HAB	TOWS	TEDHRS	STDHRS	TED	STD	TEDCPUE	STDCPUE
	450	57	0	12	0	0	.	0.00000
	510	67	0	8	0	0	.	0.00000
	620	62	0	9	0	0	.	0.00000
	630	22	0	5	0	0	.	0.00000
	800	262	0	35	0	0	.	0.00000
1987		*1,070*	*0*	*164*	*0*	*0*		
1988	110	175	109	126	0	0	0.00000	0.00000
	120	156	249	242	0	0	0.00000	0.00000
	130	70	257	237	0	0	0.00000	0.00000
	210	256	410	427	0	2	0.00000	0.00469
	320	169	178	201	0	1	0.00000	0.00498
	330	63	98	103	0	0	0.00000	0.00000
	440	46	64	74	0	0	0.00000	0.00000
	450	79	29	46	0	0	0.00000	0.00000
	510	94	123	88	0	0	0.00000	0.00000
	620	62	104	110	0	0	0.00000	0.00000
	630	38	120	124	0	0	0.00000	0.00000
	710	9	11	8	0	0	0.00000	0.00000
	720	36	98	64	0	0	0.00000	0.00000
	730	1	4	2	0	0	0.00000	0.00000
	750	1	4	2	0	0	0.00000	0.00000
	800	682	557	567	0	13	0.00000	0.02291
1988		*1,937*	*2,415*	*2,422*	*0*	*16*		
1989	110	96	39	21	0	0	0.00000	0.00000
	120	120	96	82	0	0	0.00000	0.00000
	130	28	7	16	0	0	0.00000	0.00000
	210	252	81	84	0	0	0.00000	0.00000
	320	252	569	448	0	1	0.00000	0.00223

YEAR	HAB	TOWS	TEDHRS	STDHRS	TED	STD	TEDCPUE	STDCPUE
	330	91	256	192	0	0	0.00000	0.00000
	440	79	209	156	0	0	0.00000	0.00000
	450	88	176	163	0	0	0.00000	0.00000
	510	148	207	69	0	0	0.00000	0.00000
	620	55	21	27	0	0	0.00000	0.00000
	630	19	17	20	0	0	0.00000	0.00000
	710	39	138	130	1	7	0.00726	0.05373
	720	40	135	135	0	1	0.00000	0.00740
	730	11	42	42	0	0	0.00000	0.00000
	740	2	10	10	0	0	0.00000	0.00000
	750	3	12	12	0	0	0.00000	0.00000
	800	709	632	542	0	34	0.00000	0.06278
1989		*2,032*	*2,647*	*2,150*	*1*	*43*		
1990	110	88	13	9	0	0	0.00000	0.00000
	120	125	139	67	0	0	0.00000	0.00000
	130	53	148	61	0	0	0.00000	0.00000
	210	211	53	77	0	0	0.00000	0.00000
	320	149	22	47	0	0	0.00000	0.00000
	330	49	31	24	0	0	0.00000	0.00000
	440	58	28	34	0	0	0.00000	0.00000
	450	71	37	44	0	0	0.00000	0.00000
	510	115	53	28	0	0	0.00000	0.00000
	620	68	18	28	0	0	0.00000	0.00000
	630	18	7	12	0	1	0.00000	0.08557
	710	19	0	39	0	0	.	0.00000
	720	32	84	68	0	0	0.00000	0.00000
	800	789	596	593	2	22	0.00336	0.03709
1990		*1,845*	*1,228*	*1,130*	*2*	*23*		

YEAR	HAB	TOWS	TEDHRS	STDHRS	TED	STD	TEDCPUE	STDCPUE
1991	110	93	0	9	0	1	.	0.11601
	120	91	0	12	0	0	.	0.00000
	130	28	0	8	0	0	.	0.00000
	210	206	0	28	0	0	.	0.00000
	320	151	0	27	0	0	.	0.00000
	330	50	0	16	0	0	.	0.00000
	440	58	0	18	0	0	.	0.00000
	450	73	0	19	0	0	.	0.00000
	510	82	0	8	0	0	.	0.00000
	620	45	0	8	0	0	.	0.00000
	630	17	0	6	0	0	.	0.00000
	800	538	0	72	0	11	.	0.15369
1991		*1,432*	*0*	*229*	*0*	*12*		
1992	110	144	340	8	1	0	0.00295	0.00000
	120	159	467	16	1	0	0.00214	0.00000
	130	61	330	10	0	0	0.00000	0.00000
	210	323	642	24	2	0	0.00312	0.00000
	320	229	914	26	0	0	0.00000	0.00000
	330	103	924	10	0	0	0.00000	0.00000
	440	110	680	17	0	0	0.00000	0.00000
	450	73	235	16	0	0	0.00000	0.00000
	510	78	69	6	1	1	0.01447	0.15593
	620	41	24	4	0	0	0.00000	0.00000
	630	13	19	2	0	0	0.00000	0.00000
	720	33	176	0	0	0	0.00000	.
	730	7	41	0	0	0	0.00000	.
	800	770	783	74	4	14	0.00511	0.18974
1992		*2,144*	*5,644*	*213*	*9*	*15*		

YEAR	HAB	TOWS	TEDHRS	STDHRS	TED	STD	TEDCPUE	STDCPUE
1993	110	118	184	9	0	0	0.00000	0.00000
	120	312	2,364	17	0	0	0.00000	0.00000
	130	119	1,174	9	0	0	0.00000	0.00000
	210	247	466	23	0	0	0.00000	0.00000
	320	230	818	27	0	1	0.00000	0.03691
	330	206	2,357	12	1	0	0.00042	0.00000
	440	268	3,114	20	1	0	0.00032	0.00000
	450	87	210	17	0	0	0.00000	0.00000
	510	226	392	9	0	0	0.00000	0.00000
	620	103	181	11	0	0	0.00000	0.00000
	630	35	113	5	0	0	0.00000	0.00000
	710	43	332	0	1	0	0.00301	.
	720	106	730	0	2	0	0.00274	.
	730	6	41	0	0	0	0.00000	.
	800	1,093	2,292	74	9	14	0.00393	0.18953
1993		*3,199*	*14,769*	*233*	*14*	*15*		
1994	110	109	200	8	0	0	0.00000	0.00000
	120	234	1,092	15	0	0	0.00000	0.00000
	130	57	307	9	1	0	0.00325	0.00000
	210	224	95	28	0	0	0.00000	0.00000
	320	385	1,836	28	0	0	0.00000	0.00000
	330	236	1,885	14	0	0	0.00000	0.00000
	440	123	682	20	0	0	0.00000	0.00000
	450	80	9	19	0	0	0.00000	0.00000
	510	77	250	6	1	0	0.00401	0.00000
	620	82	219	8	1	0	0.00457	0.00000
	630	28	39	5	0	0	0.00000	0.00000
	710	78	673	0	3	0	0.00445	.

YEAR	HAB	TOWS	TEDHRS	STDHRS	TED	STD	TEDCPUE	STDCPUE
	720	306	2,820	0	4	0	0.00142	.
	730	88	955	0	2	0	0.00209	.
	740	6	30	0	0	0	0.00000	.
	750	3	18	0	0	0	0.00000	.
	800	1,179	1,904	74	6	24	0.00315	0.32497
1994		*3,295*	*13,013*	*234*	*18*	*24*		
1995	110	100	101	8	0	0	0.00000	0.00000
	120	143	308	17	0	0	0.00000	0.00000
	130	53	209	7	0	0	0.00000	0.00000
	210	148	44	19	0	0	0.00000	0.00000
	320	209	761	23	2	0	0.00263	0.00000
	330	147	961	15	0	0	0.00000	0.00000
	440	251	2,729	19	0	0	0.00000	0.00000
	450	81	152	17	0	0	0.00000	0.00000
	510	27	0	4	0	0	.	0.00000
	620	42	0	6	0	0	.	0.00000
	630	9	0	2	0	0	.	0.00000
	710	37	185	0	2	0	0.01079	.
	720	181	1,571	0	1	0	0.00064	.
	730	26	214	0	0	0	0.00000	.
	800	881	2,165	74	2	6	0.00092	0.08124
1995		*2,335*	*9,401*	*212*	*7*	*6*		
1996	110	99	41	8	0	1	0.00000	0.12637
	120	143	247	15	0	0	0.00000	0.00000
	130	32	0	10	0	0	.	0.00000
	210	159	76	21	1	0	0.01314	0.00000
	320	183	97	30	0	0	0.00000	0.00000
	330	47	88	14	0	0	0.00000	0.00000

YEAR	HAB	TOWS	TEDHRS	STDHRS	TED	STD	TEDCPUE	STDCPUE
	440	98	531	21	0	0	0.00000	0.00000
	450	79	0	20	0	1	.	0.05056
	510	77	20	8	0	0	0.00000	0.00000
	620	48	0	7	0	0	.	0.00000
	630	34	0	7	0	0	.	0.00000
	710	6	56	0	0	0	0.00000	.
	720	96	714	0	1	0	0.00140	.
	730	12	77	0	0	0	0.00000	.
	800	622	469	74	4	12	0.00853	0.16245
1996		*1,735*	*2,417*	*234*	*6*	*14*		
1997	110	355	0	294	0	12	.	0.04085
	120	191	137	338	1	0	0.00729	0.00000
	130	95	9	812	0	0	0.00000	0.00000
	210	176	0	73	0	4	.	0.05471
	320	277	185	368	1	2	0.00542	0.00544
	330	283	100	3,284	0	3	0.00000	0.00091
	440	225	13	2,226	0	0	0.00000	0.00000
	450	86	0	137	0	0	.	0.00000
	510	58	0	13	0	0	.	0.00000
	620	42	32	5	0	0	0.00000	0.00000
	630	15	13	3	0	0	0.00000	0.00000
	800	1,081	0	757	0	200	.	0.26405
1997		*2,884*	*489*	*8,308*	*2*	*221*		
1998	110	162	19	95	0	3	0.00000	0.03157
	120	487	833	110	3	1	0.00360	0.00907
	130	116	171	182	1	0	0.00584	0.00000
	210	318	291	49	0	2	0.00000	0.04046
	320	579	883	96	2	0	0.00226	0.00000

YEAR	HAB	TOWS	TEDHRS	STDHRS	TED	STD	TEDCPUE	STDCPUE
	330	296	484	375	0	0	0.00000	0.00000
	440	288	1,010	481	0	0	0.00000	0.00000
	450	136	124	109	0	0	0.00000	0.00000
	510	86	123	4	1	0	0.00815	0.00000
	620	190	303	4	0	0	0.00000	0.00000
	630	90	167	3	0	0	0.00000	0.00000
	720	30	58	0	0	0	0.00000	.
	730	13	27	0	0	0	0.00000	.
	740	1	2	0	0	0	0.00000	.
	750	6	15	0	0	0	0.00000	.
	800	822	590	227	12	125	0.02032	0.55110
1998		*3,620*	*5,102*	*1,736*	*19*	*131*		
1999	110	264	1,563	8	0	0	0.00000	0.00000
	120	294	1,521	21	0	0	0.00000	0.00000
	130	110	486	16	0	0	0.00000	0.00000
	210	203	307	18	1	0	0.00325	0.00000
	320	270	1,142	26	0	1	0.00000	0.03818
	330	228	2,055	14	0	0	0.00000	0.00000
	440	286	2,415	23	0	0	0.00000	0.00000
	450	151	533	25	0	0	0.00000	0.00000
	510	191	487	10	0	1	0.00000	0.10366
	620	66	105	7	0	1	0.00000	0.14648
	630	37	228	3	1	0	0.00438	0.00000
	750	3	26	0	0	0	0.00000	.
	760	7	59	0	0	0	0.00000	.
	800	609	146	74	0	18	0.00000	0.24368
1999		*2,719*	*11,074*	*244*	*2*	*21*		
2000	110	166	609	8	0	0	0.00000	0.00000

YEAR	HAB	TOWS	TEDHRS	STDHRS	TED	STD	TEDCPUE	STDCPUE
	120	374	2,334	16	1	0	0.00043	0.00000
	130	147	948	11	0	0	0.00000	0.00000
	210	147	15	19	0	1	0.00000	0.05187
	320	231	749	27	0	0	0.00000	0.00000
	330	268	2,456	13	0	0	0.00000	0.00000
	440	266	2,502	18	0	0	0.00000	0.00000
	450	138	622	23	0	0	0.00000	0.00000
	460	1	9	0	0	0	0.00000	.
	510	52	196	3	0	0	0.00000	0.00000
	620	107	616	6	1	2	0.00162	0.32362
	630	36	247	3	0	0	0.00000	0.00000
	720	139	1,086	0	0	0	0.00000	.
	730	1	10	0	0	0	0.00000	.
	740	1	0	0	0	0	0.00000	.
	750	10	78	0	0	0	0.00000	.
	760	5	39	0	0	0	0.00000	.
	800	689	734	74	5	24	0.00682	0.32491
2000		*2,778*	*13,249*	*222*	*7*	*27*		
2001	110	25	135	0	0	0	0.00000	.
	120	221	2,022	0	1	0	0.00049	.
	130	95	1,008	0	0	0	0.00000	.
	210	23	192	1	0	0	0.00000	0.00000
	320	127	1,089	2	0	0	0.00000	0.00000
	330	304	3,734	0	0	0	0.00000	.
	440	228	3,058	0	2	0	0.00065	.
	450	76	884	0	0	0	0.00000	.
	510	65	758	0	0	0	0.00000	.
	620	22	256	0	0	0	0.00000	.

YEAR	HAB	TOWS	TEDHRS	STDHRS	TED	STD	TEDCPUE	STDCPUE
	630	11	114	0	0	0	0.00000	.
	720	48	367	0	0	0	0.00000	.
	730	10	88	0	0	0	0.00000	.
	800	27	144	0	0	0	0.00000	.
2001		*1,282*	*13,848*	*3*	*3*	*0*		
2002	110	24	95	0	0	0	0.00000	.
	120	82	770	0	0	0	0.00000	.
	130	33	383	0	0	0	0.00000	.
	210	261	1,416	0	0	0	0.00000	.
	320	35	306	0	0	0	0.00000	.
	330	60	867	0	0	0	0.00000	.
	440	258	3,742	0	1	0	0.00027	.
	450	40	501	0	0	0	0.00000	.
	460	2	34	0	0	0	0.00000	.
	510	77	320	0	2	0	0.00624	.
	620	46	460	0	2	0	0.00435	.
	630	10	108	0	0	0	0.00000	.
	710	91	650	0	1	0	0.00154	.
	720	165	1,350	0	4	0	0.00296	.
	730	4	26	0	0	0	0.00000	.
	800	68	568	0	0	0	0.00000	.
2002		*1,256*	*11,597*	*0*	*10*	*0*		
		67,304	*106,902*	*45,653*	*100*	*1,129*		

Western Gulf of Mexico Studies Only -- Less than 10 Fathoms

SP	tows	tedhrs	stdhrs	TED	STD	tedcpue	stdcpue
CC	14,307	10,936	12,556	1	33	0.00009	0.00263
CM	14,307	10,936	12,556	1	3	0.00009	0.00024
DC	14,307	10,936	12,556	2	1	0.00018	0.00008
EI	14,307	10,936	12,556	0	1	0.00000	0.00008
LK	14,307	10,936	12,556	5	25	0.00046	0.00199
OT	14,307	10,936	12,556	1	0	0.00009	0.00000
				10	*63*		

Observer data only (all areas)

dpz		Index
1	5.4e-04	1
2	6.1e-05	0.1
3	0	0.01

Area

dpz	1	2	3	4
1	.0017	0.0002	0.0006	0.00007
2	.0002	0.000	0.00004	.00003
3	.0000	0.000	0	0

Season

1	0.0003
2	0.0003
3	0.00012

Western Gulf of Mexico Studies Only -- Between 10 and 30 Fathoms

SP	tows	tedhrs	stdhrs	TED	STD	tedcpue	stdcpue
CC	24,416	46,234	12,938	13	23	0.00028	0.00178
CM	24,416	46,234	12,938	2	1	0.00004	0.00008
DC	24,416	46,234	12,938	2	0	0.00004	0.00000
LK	24,416	46,234	12,938	2	3	0.00004	0.00023
OT	24,416	46,234	12,938	2	0	0.00004	0.00000
				21	*27*		

Western Gulf of Mexico Studies Only -- Greater than or Equal to 30 Fathoms

SP	tows	tedhrs	stdhrs	TED	STD	tedcpue	stdcpue
CC	9,316	26,209	4,195	1	1	0.00004	0.00024
DC	9,316	26,209	4,195	1	0	0.00004	0.00000
LK	9,316	26,209	4,195	1	0	0.00004	0.00000
				3	*1*		

COMMENTS ON DATA ISSUES FOR SELECTED STUDIES

Foundation Naked Net Study

Gulf of Mexico data included in the FDNNAKED study must be used with the consideration that the nearshore samples, which were intended to represent the white shrimp fishery, resulted in groups of stations around the passes at Corpus Christi, Palacios, Freeport, and Calcasieu (Figure 2-1). Because these stations are all in such close proximity to passes, they probably are not representative of turtle densities and expected catch rates throughout the western Gulf of Mexico in waters less than ten fathoms deep. This warning is provided because the distribution is not evident except when reviewing a spatial representation of the data.

Henwood and Stuntz (1987)

Numerous relatively small differences in numbers of standardized net hours and captured turtles have been reported by the original analysts, Henwood and Stuntz (1987), Henwood and Stuntz (unknown), and subsequent analysts, GSAFDF (1998) and Jamir (1999). We also have arrived at different numbers from the datasets provided to us by Dr. Stuntz in March 1995 (Table 2-1).

Henwood and Stuntz (1987) reported 26,714 standardized net hours in both the text and table of their paper. However, they reported different numbers of turtles captured in the text (total of 534 turtles, 482 Atlantic and 52 Gulf of Mexico) than they reported in the table (total of 528 turtles, 478 Atlantic and 50 Gulf). See Table 2-1 below.

An earlier Henwood and Stuntz (unknown) draft paper which included several data tables not included in Henwood and Stuntz (1987) contains additional variations in the numbers of both net hours and turtle captures. In the project descriptions, a total of 27,578 standardized trawling hours and 884 captured turtles are derived by summing the numbers given for each of the three included studies. Before removal of Cape Canaveral stations, our data set reconciles exactly to the standardized net hours, and within nine of the captured turtles. Four of their data tables (see Table below) reflect minor discrepancies among them.

In the Atlantic data, Henwood and Stuntz (1987) omitted data from the Cape Canaveral ship channel (between 28.25 and 28.50 decimal degrees latitude). This reduced net hours by 850 hours and turtle captured by 350 turtles. Henwood and Stuntz (1987 and unknown) report Atlantic turtle captures ranging from 478 to 484 (see table below). GSAFDF (1998) and Jamir (1999) report 509 Atlantic turtle captures. We reconciled 500 Atlantic turtle captures and attribute our difference to the problem of deleting the Cape Canaveral ship channel turtles. Position data provided to us were in 1 minute latitude and longitude increments that created a problem when reconciling the turtles Henwood and Stuntz (1987) removed from the edges of the ship channel.

Table 2-1.Summary of varying totals presented for standardized net hours and captured turtles from data of the three programs reported in the Henwood and Stuntz (1987) text and Table 1, the Henwood and Stuntz (unknown) text (two separate parts) and four tables, Jamir (1999) Table 2, and from this combined database. Some totals were derived by summing reported component numbers.

	Henwood Stuntz 87		Henwood and Stuntz unknown					Jamir	This
	Text	Table 1	Proj. descrip.	Results	Tables 3 and 7	Table 5	Table 6	1999	database
S. Atlantic net hrs	9,943	9,943		9,943	9,943	9,943	9,943	9998	9,945
Gulf net hours	16,771	16,771		16,785	16,785	16,771	*16,785	16,484	16,813
Total net hours	26,714	26,714	27,578		26,728	26,714	26,728	26,482	26,758
S. Atlantic turtles	482	478		484				509	500
Gulf turtles	52	50		52				52	51
Total turtles	534	528	884	536				561	551

* The number 16,785 in Table 6 of Henwood and Stuntz (unknown) was an incorrect total for the component numbers in that table. The correct total for the numbers presented should have been 26,771.

Appendix 6: Kemp's Ridley Stock Assessment Workshop Agenda

Kemp's Ridley Stock Assessment Workshop
Agenda
November 26-30, 2012

26 November 2012 (Monday)

1:00 - 1:30 PM	Welcome, Commendations and Introductions (Benny Gallaway)
1:30 - 1:45 PM	Background, Goals and Objectives (Benny Gallaway)
1:45 - 2:30 PM	Kemp's Ridley Recovery Program Overview –a video presentation with commentary (Patrick Burchfield and Laura Sarti)
2:30 - 2:45 PM	Field Studies and Management (Laura Sarti, Marco Antonio Castro Martinez, Patrick Burchfield)
2:45 - 3:15 PM	The 2012 Nesting Season (CONANP)
3:15 - 3:30 PM	Break
3:30 - 4:00 PM	Previous Population Modeling (Selina Heppell)
4:00 - 4:30 PM	Preliminary Stock Assessment Modeling Framework (Bill Gazey)
4:30 - 5:00 PM	Tamaulipas Data and Vital Statistics Needed for Stock Assessment Modeling (Charles Caillouet)

27 November 2012 (Tuesday)

8:00 - 8:30 AM	Strandings Data Descriptions (Bill Gazey)
8:30 - 9:15 AM	Shrimp Fishing Effort Data Descriptions (Benny Gallaway)
9:15 - 9:30 AM	Observer Data Descriptions (John Cole)
9:30 - 9:45 AM	Break
9:45 - 10:15 AM	SEAMAP Data Descriptions (Jeff Rester)
10:15 - 10:20 AM	Other Environmental and Anthropogenic Factors (Pam Plotkin)
10:20 - 10:45 AM	Prey Abundance and Distributions (Jeff Rester)
10:45 - 11:00 AM	Hypoxic Zones (Steve DiMarco)
11:00 - 11:15 AM	Toxic Algae Blooms (Pam Plotkin)
11:15 AM - 11:30 AM	Tropical Storms and Hurricanes (Scott Raborn)

11:30 AM - 12:00 PM	Discussion
12:00 - 1:30 PM	Lunch
1:30 - 5:00 PM	Group Discussion of Stock Assessment Model Needs
	Population Index Nesting Beaches
	Age at Maturity (Distribution vs. Sensitivity Analysis)
	Remigration Interval
	Nests per Female
	Nesting Female Size Distribution
	Nesting Female Fecundity-Size Relationships
	Sex Ratios
	Life Stages (eggs, hatchlings, pelagic stage juveniles, benthic stage juveniles, subadults, adults)
	Habitat Utilization by Life Stage
	Habitat Weighting
	Natural Mortality
	Shrimp Fishing Effort (U.S., Mexico)
	Strandings Data (All, cold stuns, etc.)
	Growth Rates and Somatic Growth Curves
	TED Effects
	Population Trends 2010 and Beyond

28 November 2012 (Wednesday)

8:30 - 10:30 AM	Group Discussions Continued
10:30 - 10:45 AM	Break
10:45 AM - 12:00 PM	Working Group Definitions and Assignments
	1) Life History/Reproduction (Pam Plotkin, Lead)
	2) Mortality/Growth (Scott Raborn, Lead)
	3) Threats (Benny Gallaway, Lead)
12:00 - 1:30 PM	Lunch

1:30 - 4:30 PM	Working Group Sessions
4:30 – 5:00 PM	Plenary Meeting

29 November 2012 (Thursday)

8:30 - 11:30 AM	Working Group Sessions
11:30 AM - 12:00 PM	Plenary Meeting
12:00 - 1:30 PM	Lunch
1:30 - 4:30 PM	Working Group Sessions
4:30 - 5:00 PM	Modeling Status and Results

30 November 2012 (Friday)

8:30 AM to 12:00 PM	Modeling Results and Discussion Path Forward

Appendix 7: Kemp's Ridley Stock Assessment Workshop 2012 Attendance

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Appendix 8: Model Equations

Initial condition:

$$N_{1,j} = 0 \qquad \text{for } j \le a$$
$$N_{1,a+1} = \frac{\tilde{P}_1}{n_f}$$

Update of female population:

$$N_{i,1} = \ \tilde{H}_{Ci} \cdot r_C + \tilde{H}_{Ii} \cdot r_I \ \cdot \exp\ -Z_{i,1}$$
$$N_{i,j} = N_{i-1,j-1} \cdot \exp\ -Z_{i,j} \qquad \text{for } 2 \le j \le a$$
$$N_{i,a+1} = \ N_{i-1,a} + N_{i-1,a+1} \ \cdot \exp\ -Z_{i,a+1}$$

Prediction of nests:

$$P_i = \ N_{i,a} + N_{i,a+1} \ \cdot n_f$$

Negative log likelihood:

$$L = 0.5n\ln(2\Pi) + \sum_{i \ge a} \ln(S) + \sum_{i \ge a} \frac{\varepsilon_i^2}{2S^2}$$

where,

$$\varepsilon_i = \ln(P_i) - \ln(\tilde{P}_i) \quad \text{and} \quad S = Var(\varepsilon) \quad \text{for} \quad i \ge a$$

TEWG model:

$$Z_{ij} = \begin{cases} Z_H & j = 1 \text{ or } j = 2 \\ Z_J & i < y \text{ and } 3 \le j \le 6 \\ Z_J \cdot T_T & i \ge y \text{ and } 3 \le j \le 6 \\ Z_A & i < y \text{ and } 7 \le j \le a+1 \\ Z_A \cdot T_T & i \ge y \text{ and } 7 \le j \le a+1 \end{cases}$$

Shrimp effort model:

$$Z_{ij} = \begin{cases} Z_H & j = 1 \text{ or } j = 2 \\ M_1 + q_1 E_i & i < y \text{ and } 3 \le j \le 6 \\ M_1 + q_1 E_i T & i \ge y \text{ and } 3 \le j \le 6 \\ M_2 + q_2 E_i & i < y \text{ and } 7 \le j \le a+1 \\ M_2 + q_2 E_i T & i \ge y, i \ne 45 \text{ and } 7 \le j \le a+1 \\ M_2 + q_2 E_i T + M_{2010} & i = 45 \text{ and } 7 \le j \le a+1 \end{cases}$$

Indices:

i	year (i = 1, 2, 3, … 47)
j	age (j = 1, 2, 3, …a+ to portray true ages of 0, 1, …)

Data variables:

a	age of maturity
E_i	scaled shrimp effort in year i (shrimp effort model)
$\tilde{H}_{Ci}$	observed corral hatchlings in year i
$\tilde{H}_{Ii}$	observed in-situ hatchlings in year i
M_1	juvenile (ages 3 to 6) instantaneous natural mortality (shrimp effort model)
M_2	late juvenile and adult (ages 3 to a+) instantaneous natural mortality (shrimp effort model)
n_f	nests per mature female in the population (ratio of nests per breeding female and breeding interval)
$\tilde{P}_i$	observed nests in year i
r_C	corral sex ratio (not required if constant because confounded with Z_H)
r_I	in-situ sex ratio (not required if constant because confounded with Z_H)
y	year that multiplier on mortality starts
Z_J	juvenile (ages 3 to 6) instantaneous total mortality (TEWG model)

Fundamental parameters to be estimated:

M_{2010}	added mortality for the 2010 event (shrimp effort model)
q_1	catchability coefficient for juvenile (ages 3 to 6, shrimp effort model)
q_2	catchability coefficient for late juvenile and adult (ages 7 to a+, shrimp effort model)
T_E	fishing mortality multiplier starting in year y (shrimp effort model)
T_T	total mortality multiplier starting in year y (TEWG model)
Z_A	total late juvenile and adult instantaneous mortality (TEWG model)
Z_H	total hatchling instantaneous mortality

Interim variables:

N_{ij}	predicted females in year i of age j
P_i	predicted nests in year i

Appendix 9: Kemp’s Ridley Stock Assessment Project PowerPoint

Appendix 9: Kemp’s Ridley Stock Assessment Project PowerPoint

KEMP'S RIDLEY STOCK ASSESSMENT PROJECT

For
Gulf States Marine Fisheries Commission
2404 Government Street
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28 June 2013

Special Thanks

- The Stock Assessment would not have been possible without data provided by the

Sea Turtle Strandings and Salvage Network (STSSN)

and the

Cooperative Marine Turtle Tagging Program (CMTTP)

- Permission to use these data is gratefully acknowledged.

Workshop Participants

The Kemp's Ridley Stock Assessment Workshop was held 26-30 November 2012 with the following persons in attendance.

Attendees in Person	Project Team	Observers	Attendees by Phone
Patrick Burchfield	Benny Gallaway	Corky Perret	Selina Heppell
Rebecca Lewison	Charles Caillouet	Dale Diaz	Nathan Putman
Masami Fujiwara	Scott Raborn	Judy Jamison	Mark Schexnayder
Donna Shaver	Pam Plotkin	Mike Ray	
Gary Graham	John Cole	Rom Shearer	
Sheryan Epperly	Bill Gazey	Sandi Maillian	
Wade Griffin	Jeff Rester		
Andrew Coleman			
Kenneth Lohmann			
Steven DiMarco			
Thane Wibbels			
Alberto Abreu			
Daniel Gomez			
Francisco Illescas			
Marco Castro			
Blanca Zapata			
Jonathan Pitchford			
Laura Sarti			
James Nance			
Totals 19	**7**	**6**	**3**

Background

- In 2010 and 2011, increased numbers of Kemp's ridley sea turtles stranded in the northern Gulf of Mexico.
- Among possible causes for these events, the "BP Oil Spill" in 2010 and shrimp trawling in both years received the most attention from Federal and State agencies, conservation organizations and media.
- NOAA Fisheries Service released a scoping document and Proposed Rule in June 2011, scheduled public hearings and initiated an evaluation of the need for additional fishery regulations.

Background (continued)

- At about the same time NOAA Fisheries was initiating their investigation (June 2011), Dr. Charles W. Caillouet, Jr. widely circulated a proposal to assemble a working group to study and report on northern Gulf of Mexico Kemp's ridley shrimp-fishery interactions and other anthropogenic effects.

- Kemp's ridley had dominated the stranding events of 2010 and 2011 and, compared to other sea turtles, there is a wealth of data for conducting an assessment for this species.

- This proposal was strongly supported by the Louisiana Department of Wildlife and Fisheries and planning for such a study that focused around an Assessment Workshop was initiated by a consortium of the Sea Grant Directors of the Gulf States.

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Purpose

- The overarching purpose of the Assessment Workshop was to conduct a Kemp's ridley stock assessment involving objective and quantitative examination and evaluation of selected key factors contributing to its population recovery trajectory.
- Because incidental capture of sea turtles in shrimp trawls was identified in 1990 as the greatest threat to sea turtles at sea, the Kemp's ridley stock assessment focused on objective and quantitative examination and evaluation of Kemp's ridley-shrimp fishery interactions in the northern Gulf of Mexico, where effort is greatest.
- The assessment included the effects of TEDs versus the effects of shrimping effort.

Objectives

The specific objectives of the stock assessment were to:

1. Examine Kemp's ridley population status, trend, and temporal-spatial distribution within the Gulf of Mexico (including Mexico and U.S.).
2. Examine status, trends, and temporal-spatial distribution of shrimping effort in the northern Gulf of Mexico.

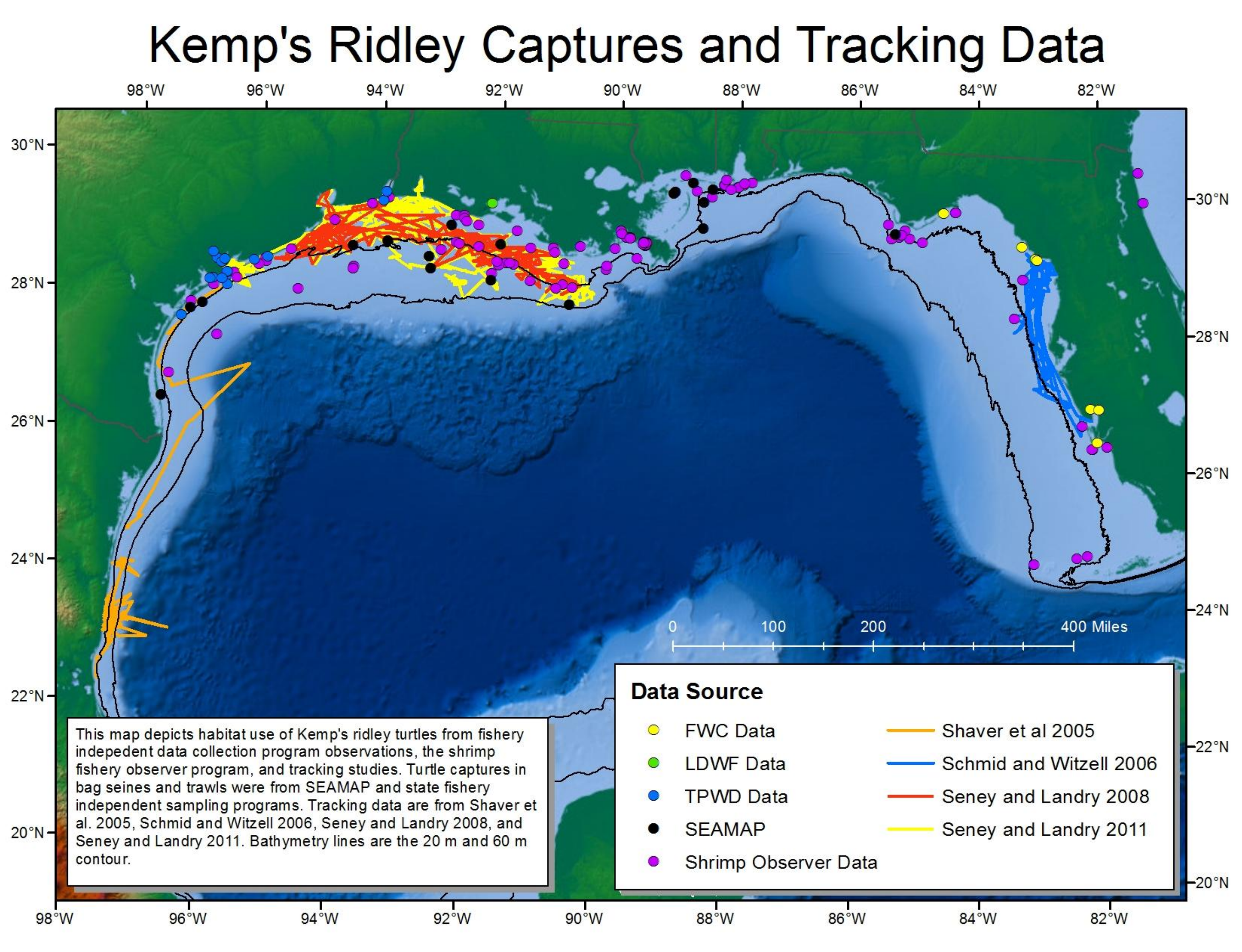
Objectives (continued)

3. Qualitatively examine other factors that may have contributed to increased Kemp's ridley-shrimp fishery interactions or otherwise caused Kemp's ridley strandings, injuries, or deaths in the northern Gulf of Mexico in 2010 and 2011, to include but not be limited to abundance of shrimp and Kemp's ridley prey species (e.g., portunid crabs), outflow from the Mississippi River, BP oil spill, surface circulation and weather patterns, hypoxic zones, and red tide.
4. Develop and apply a demographic model to assess the status and trend in the Kemp's ridley population, 1966-2011.

Examples of Data Used at the Assessment Workshop and Later

- Shrimp Effort Data
- Kemp's Ridley Capture & Tracking Data
- Kemp's ridley Mark Recapture Data
- Strandings Data
- Prey Abundance Data

ELB Detected Tows 2009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This map depicts habitat use of Kemp's ridley turtles from fishery independent data collection program observations, the shrimp fishery observer program, and tracking studies. Turtle captures in bag seines and trawls were from SEAMAP and state fishery independent sampling programs. Tracking data are from Shaver et al. 2005, Schmid and Witzell 2006, Seney and Landry 2008, and Seney and Landry 2011. Bathymetry lines are the 20 m and 60 m contour.
Data Source
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LDWF Data
TPWD Data
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Shrimp Observer Data
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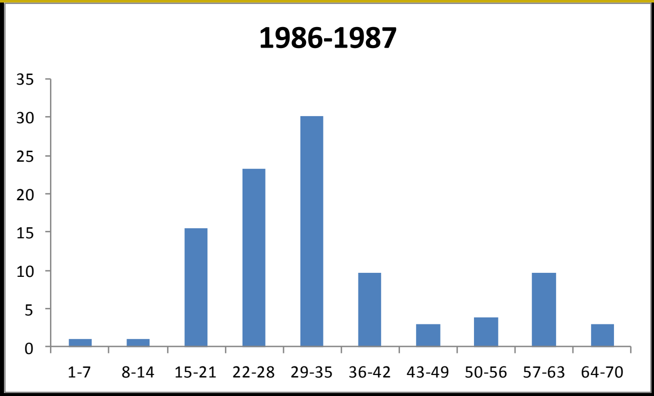
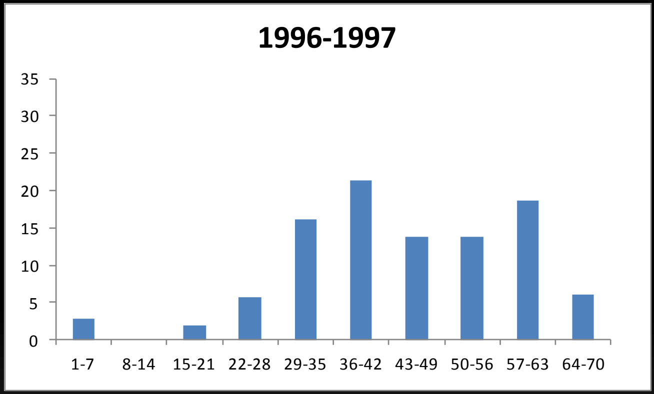
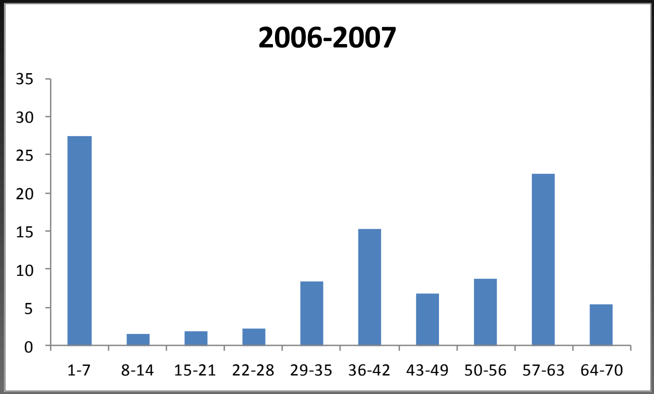
Schmid and Witzell 2006
Seney and Landry 2008
Seney and Landry 2011

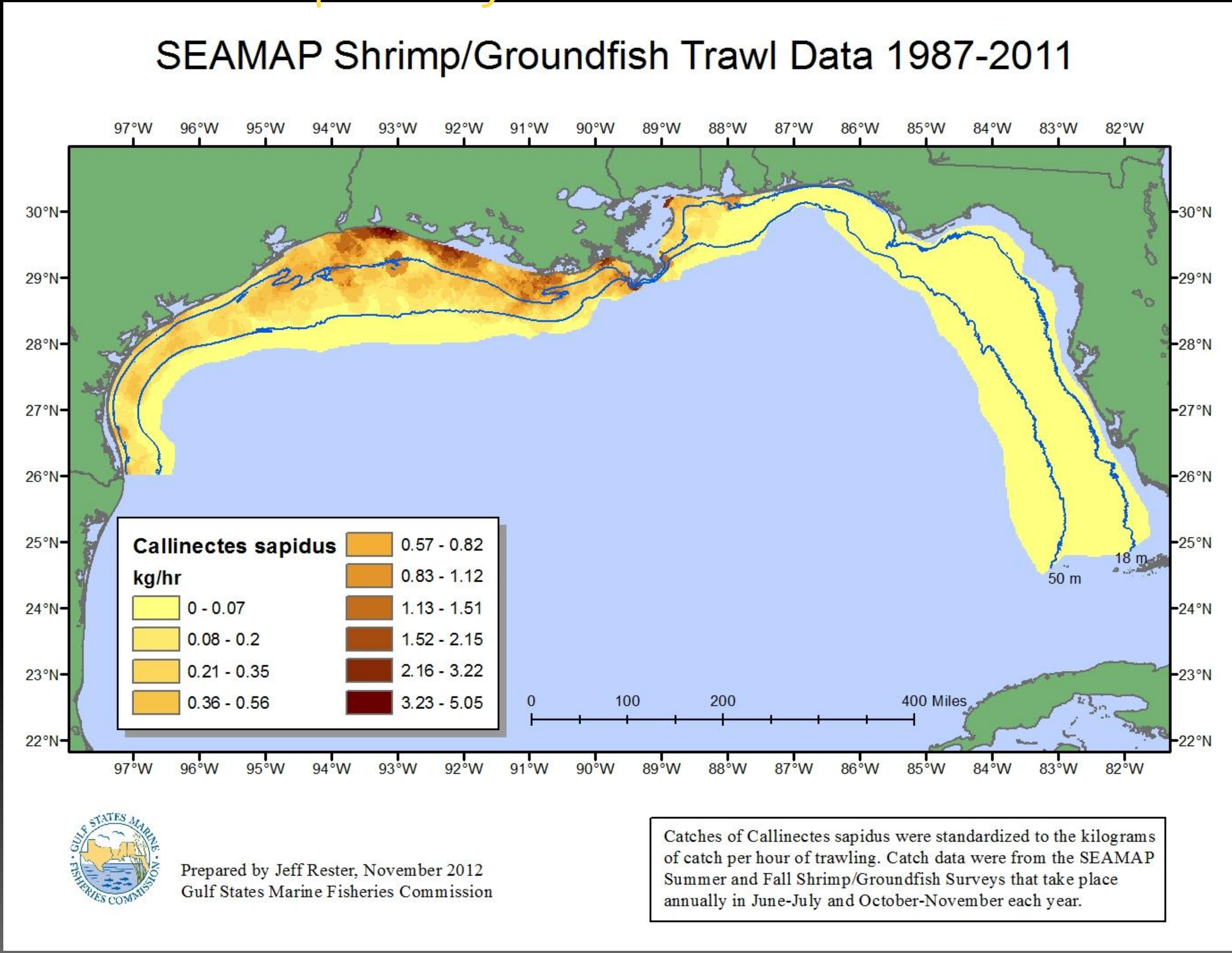
Strandings Data



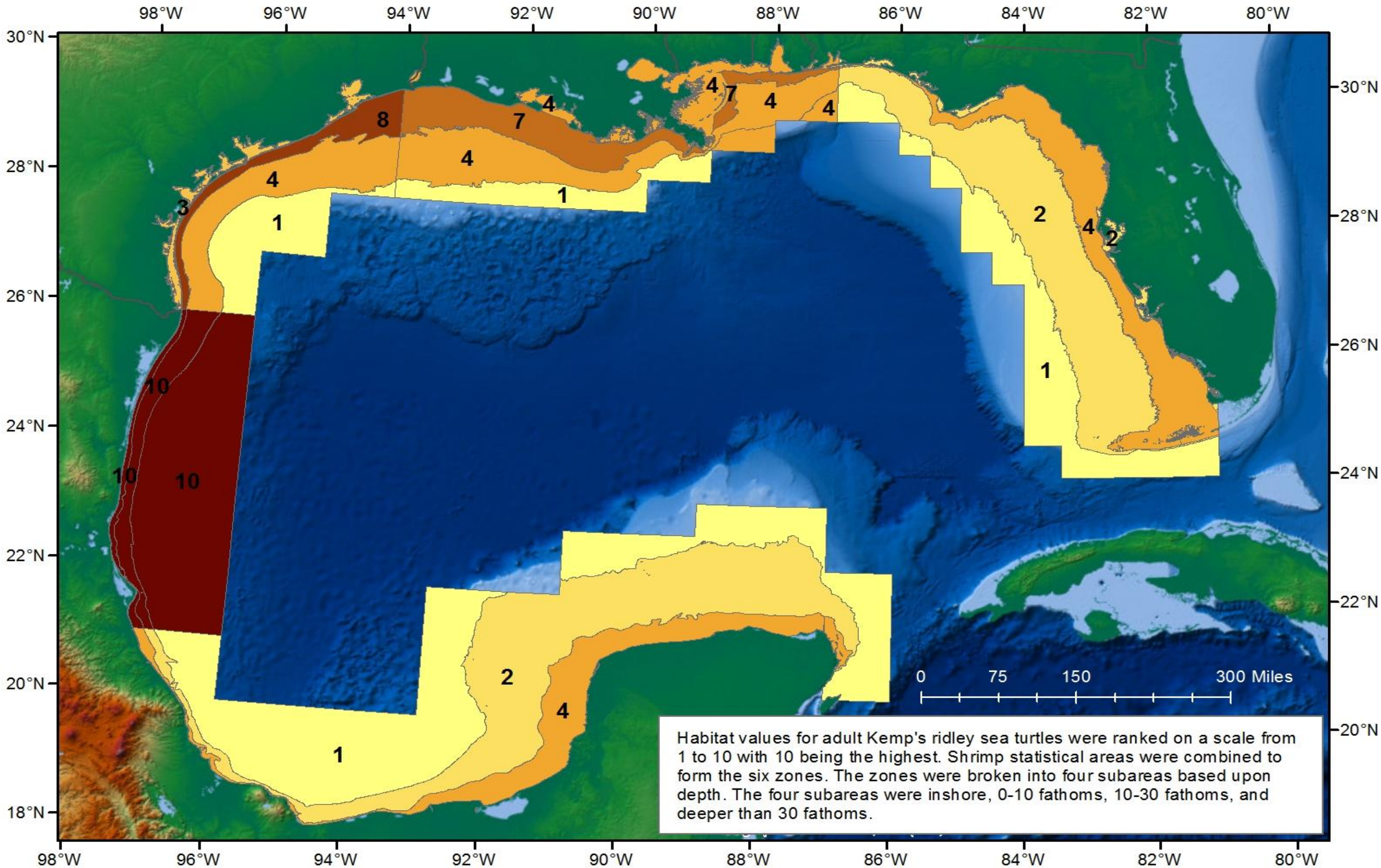




Example Prey Abundance-Blue Crabs

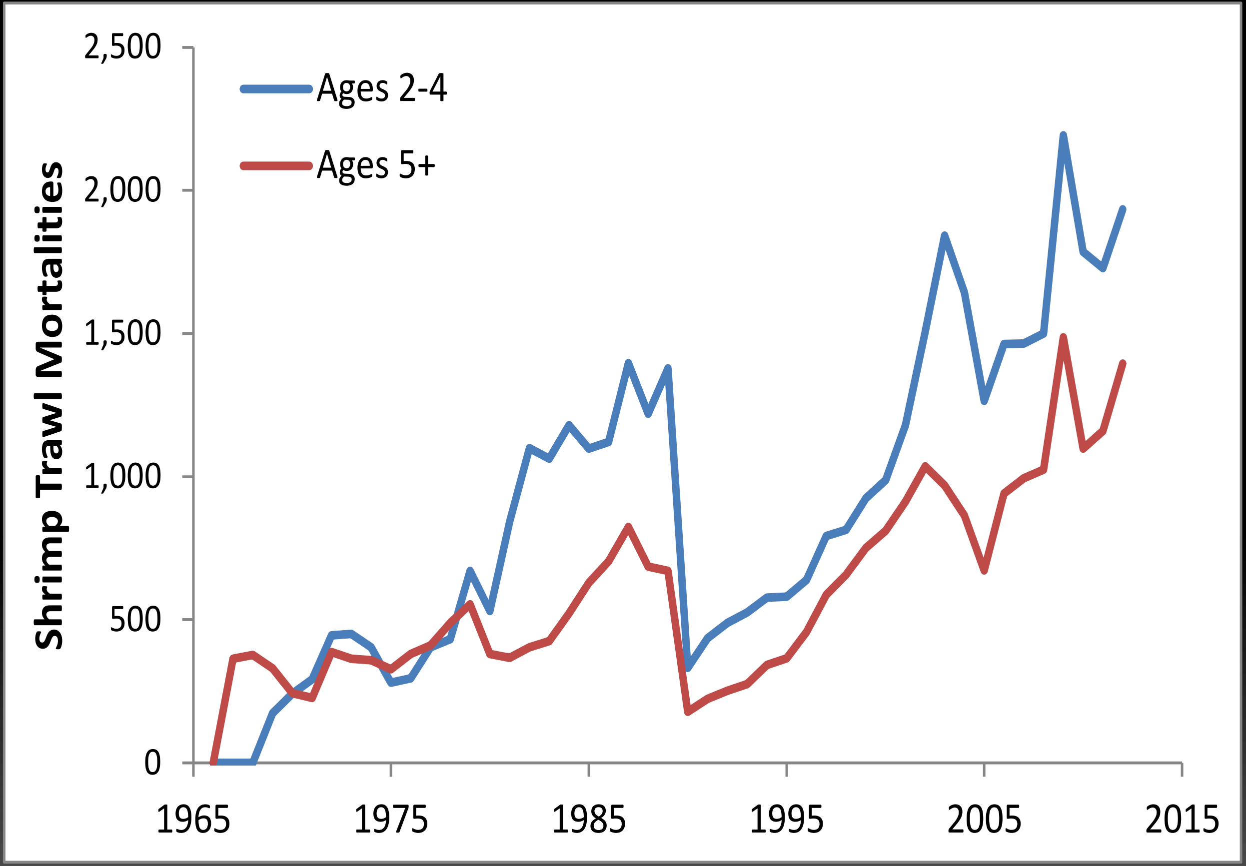


Habitat Values for Neritic Kemp's Ridley Turtles



Directed Shrimp Effort

Mortalities assigned to shrimp trawls.



Model Results Obtained at the Workshop

- At the workshop, model structure was defined and preliminary runs were made using incomplete data.
- The purpose was to demonstrate the process/output to the participants and define additional data that were needed to create the preliminary runs presented below.
- A key finding of the preliminary analysis was the nesting trend reflected an unexplained 2010 event requiring a mortality adjustment to fit the data.

Results

Assumed (fixed) Parameters

Maturity schedule = 12 years after nesting (knife edge)

Nests per mature female $= \frac{\text{nests per breeder}}{\text{migration interval}}$

$$= \frac{2.5}{2} = 1.25$$

Female sex ratio: *in situ* = 0.64

corral = 0.76

TED multiplier effect starts in 1990

Model Predictions

1. Number of nests starting from hatchlings
2. Increment in growth for individual turtles
3. Length frequency of strandings

Parameter estimates that maximize the likelihood of observing the data (nests, growth increment and length frequency of strandings).

Major Model Assumptions

1. Density independent mortality
2. Natural mortality from age 2 based on Lorenzen curve (mortality inversely related to size)
3. Shrimp trawl mortality proportional to shrimp effort
4. Trend in growth tracks a von Bertalanffy curve
5. Age composition of females reflects the population
6. Age selectivity of strandings follows a logistic curve
7. Mark-recapture and strandings data have the same sex composition

How to Portray Total Anthropogenic Mortality?

Estimate bycatch directly

Very rare Observer and SEAMAP "hits" imply very small estimate of shrimp trawl mortality

$Z = M + qE$

Implemented: assumes mortality in excess of natural morality caused by shrimp trawls

Assumption: Shrimp Trawl Mortality is the largest source of anthropogenic mortality and can be used to index total man-caused mortality.

Growth Component

Objective:

Use individual growth information obtained from mark-recapture data to estimate age at length

The problem:

Usual models of growth for mark-recapture and age-length have different error structures

Solution:

We reparameterized the von Bertalanffy growth equations with consistent parameters and error structure.

Size Frequency of Strandings

Numbers by age

Selectivity

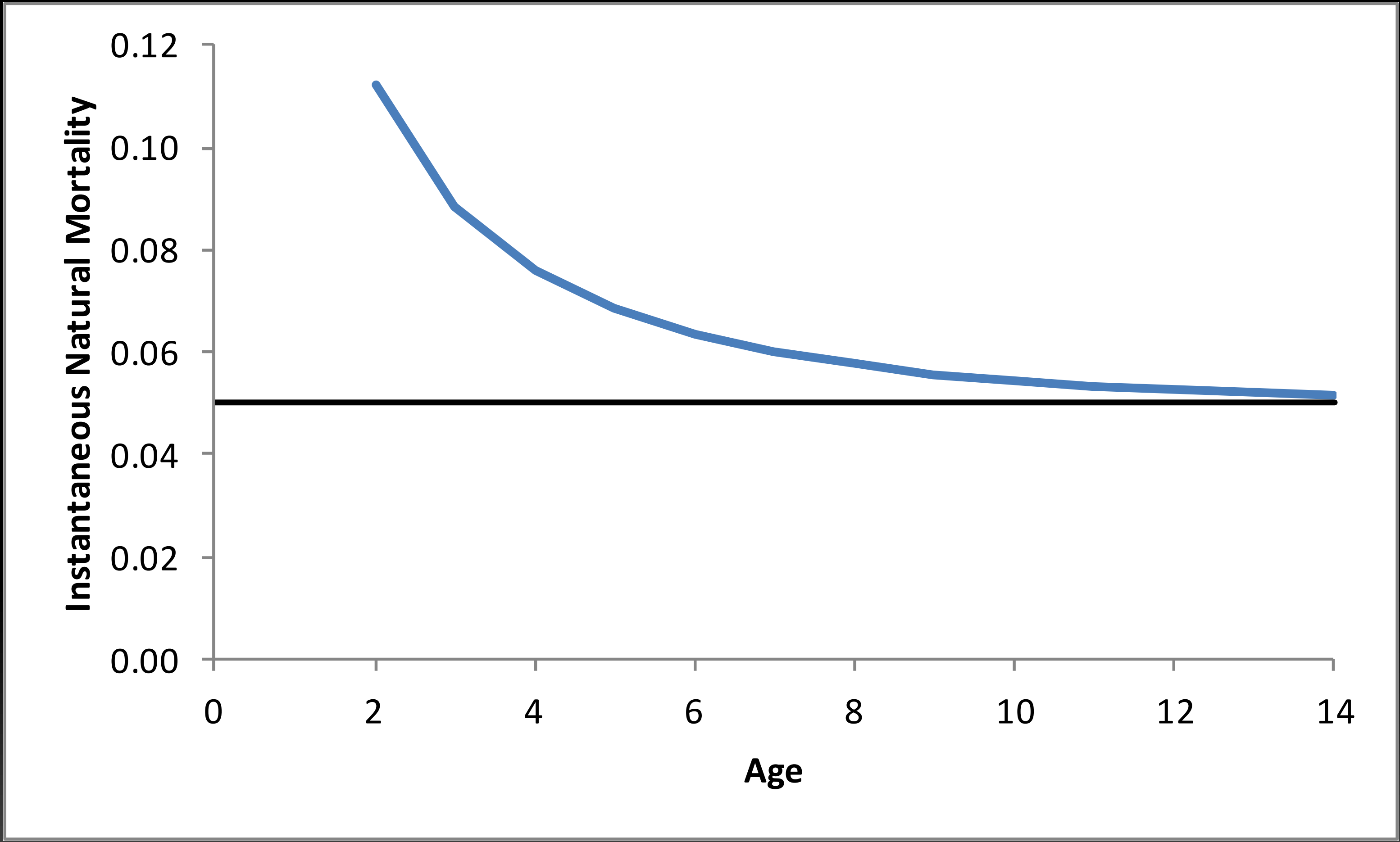
Growth by age

Predicted size frequency of strandings

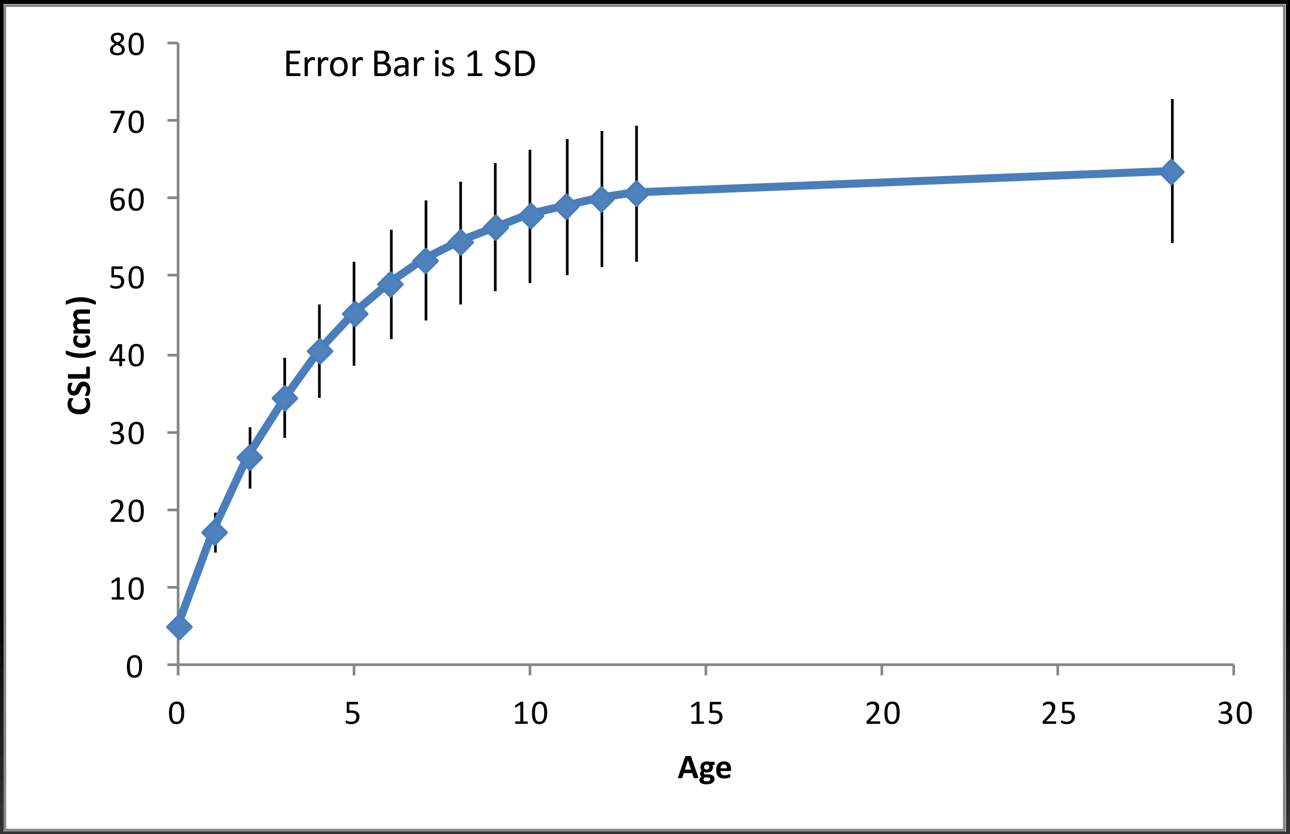
Results – Parameter Estimates

Parameter	Estimate	SD
Mortality:		
Instan. mortality (age 0 and 1)	1.330	0.117
Instan. mortality 2010 event	0.345	0.118
Catchability (age 2-4)	0.200	0.040
Catchability (age 5+)	0.155	0.014
TED multiplier	0.233	0.069
Growth:		
Size at age 1	17.2	0.5
Size at age 10	58.0	0.6
von Bertalanffy growth coef.	0.232	0.013
Individ. Length Variation (SD)	9.37	0.56
Selectivity:		
Age when 50%	1.75	0.22
Slope	0.552	0.071

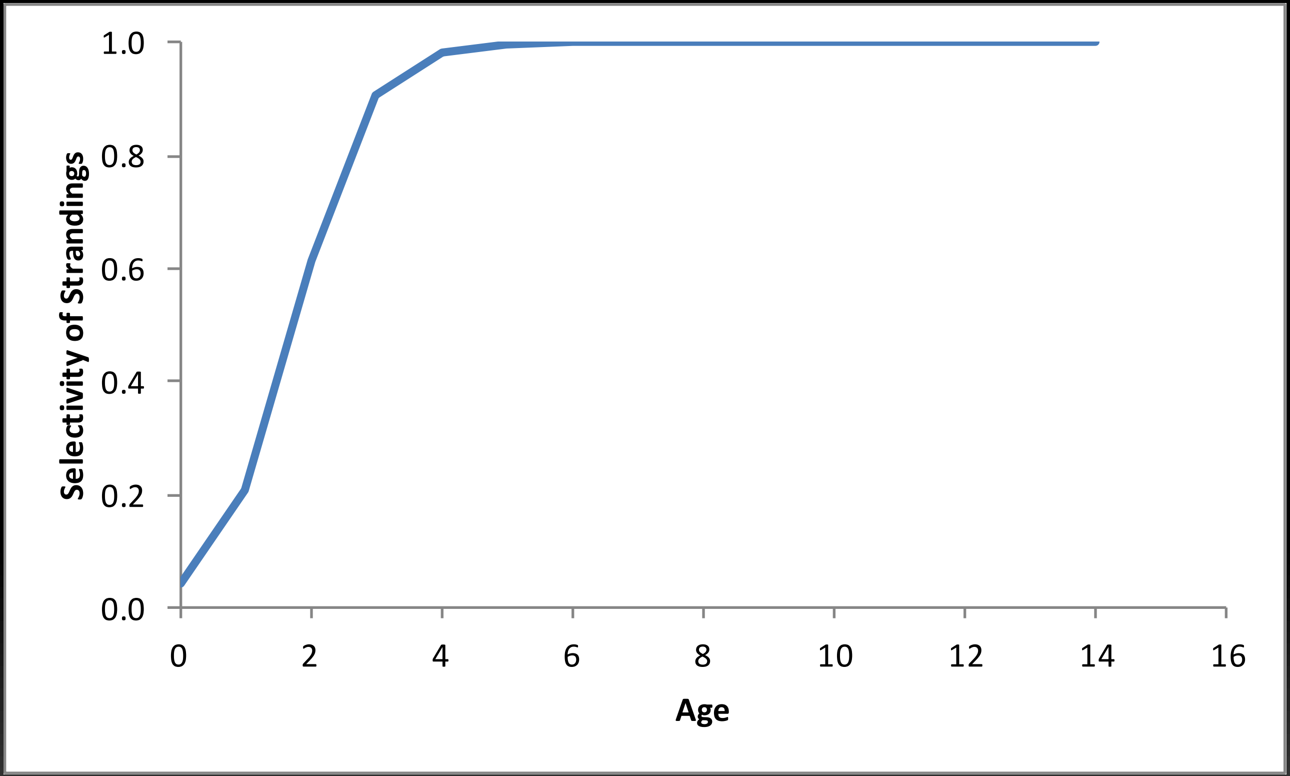
Results – Natural Mortality Based on Lorenzen Curve



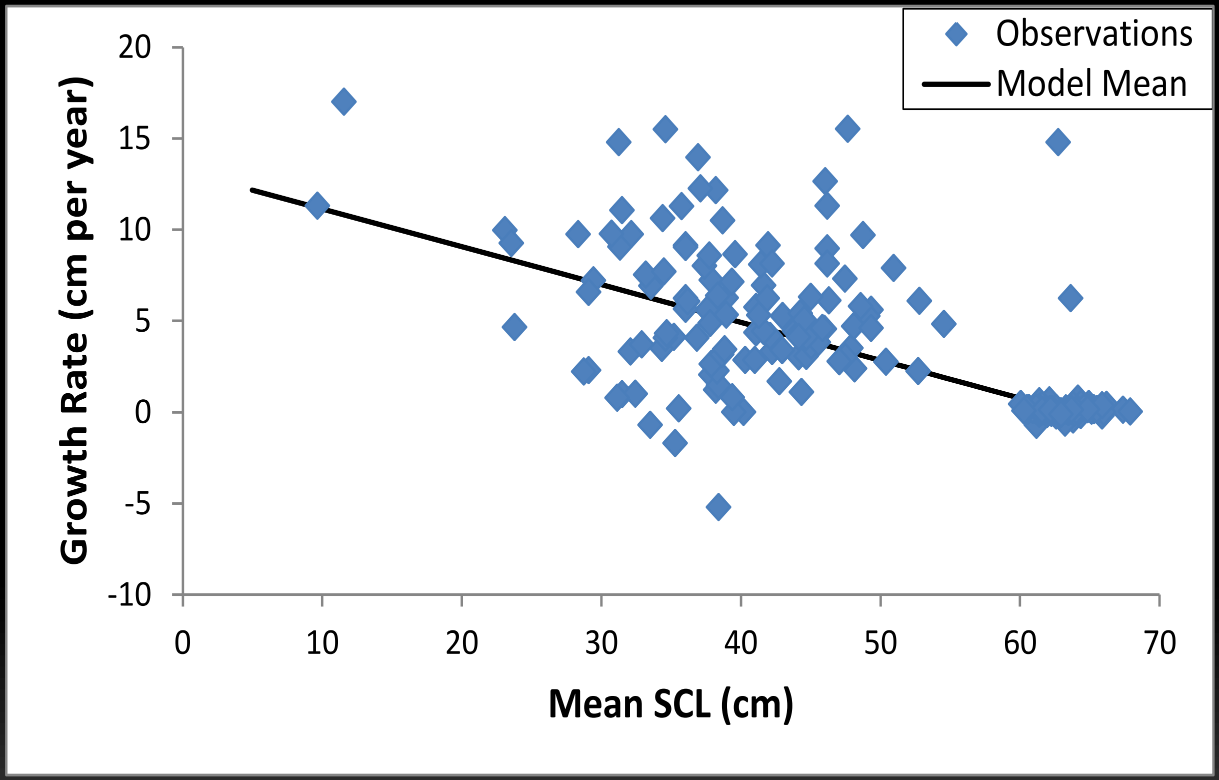
Results – Von Bertalanffy Growth



Results – Selectivity for Strandings



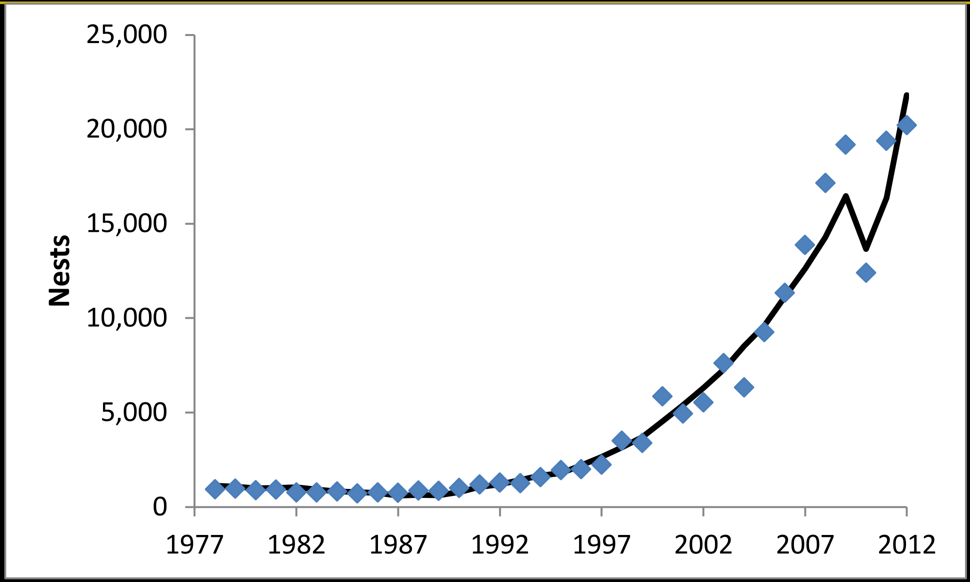
Results – Mark Recapture Increments



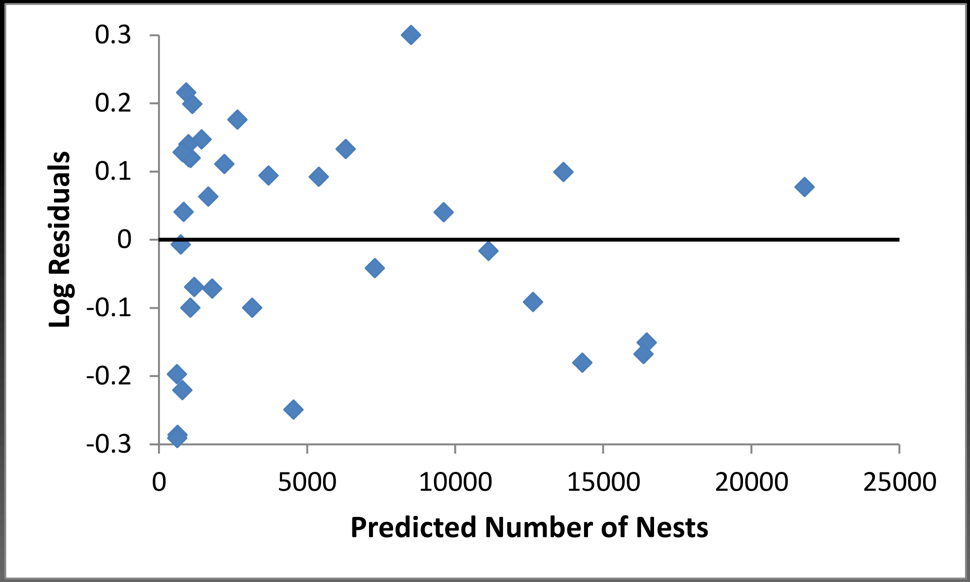
Growth rate (cm/yr) as a function of the mean *SCL* interval (points) and the predicted model mean (line).

Results - Nests

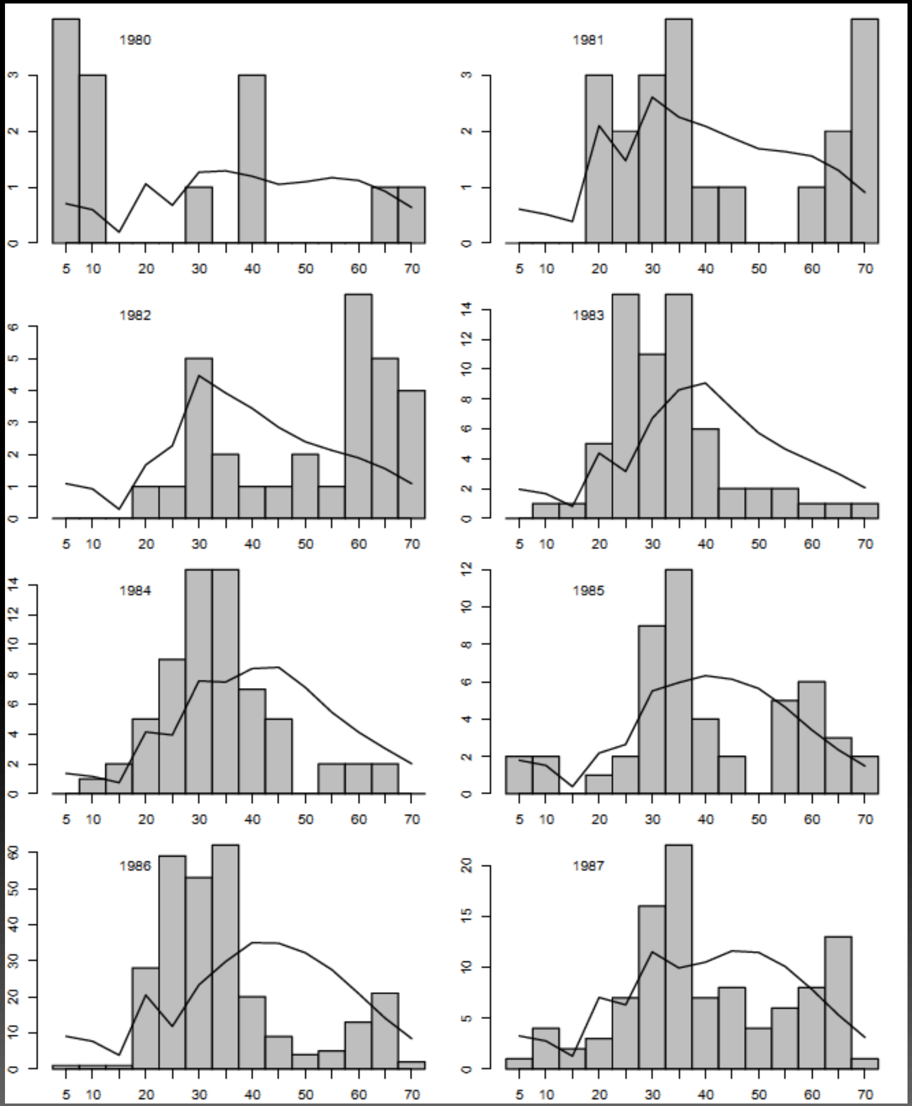
Observed (points) and predicted (line) nests.



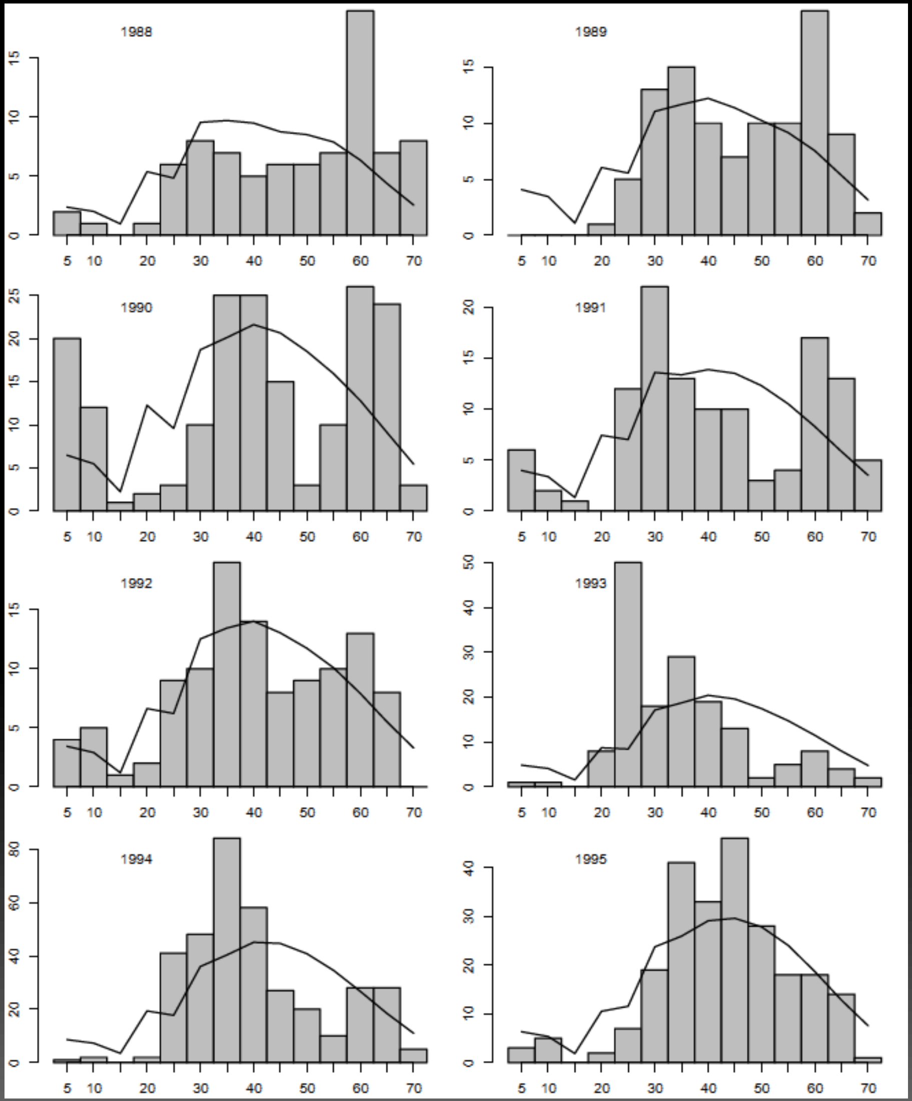
Log residuals versus predicted number of nests.



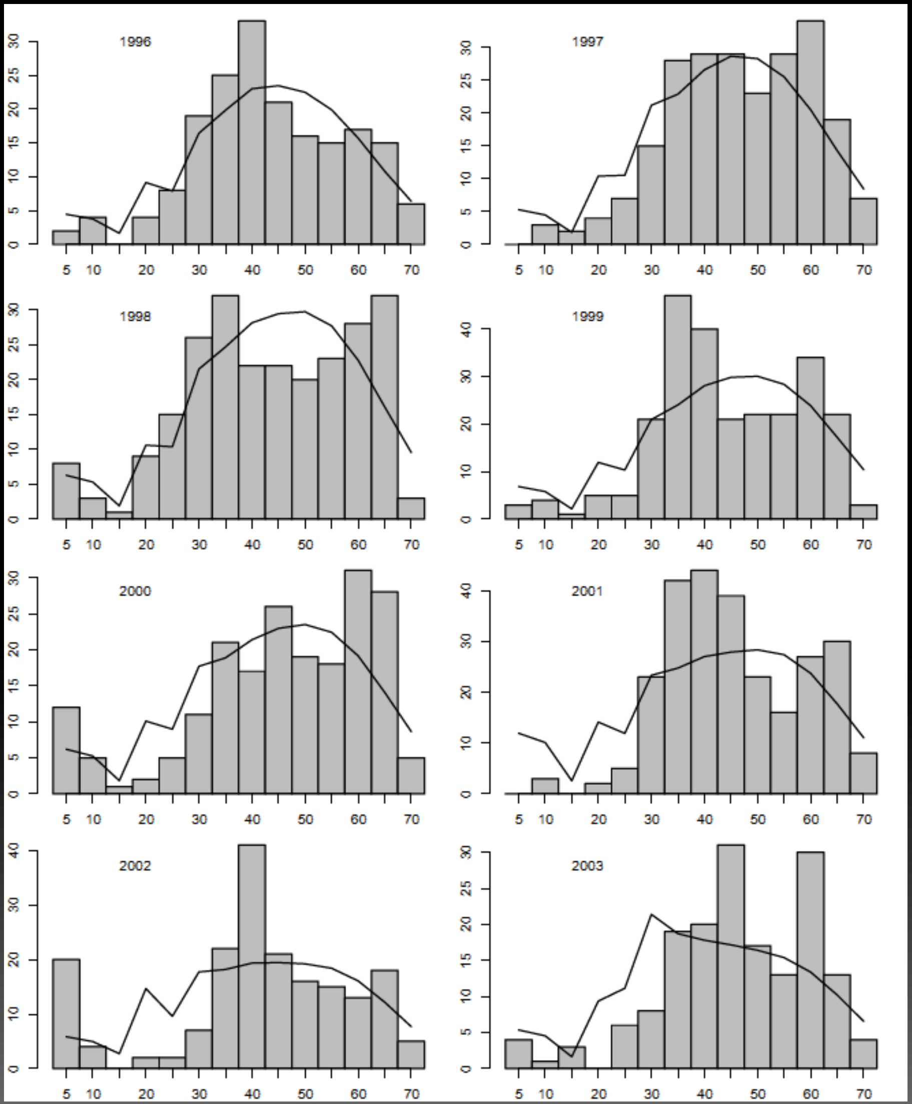
Results – Strandings (1980-1987)



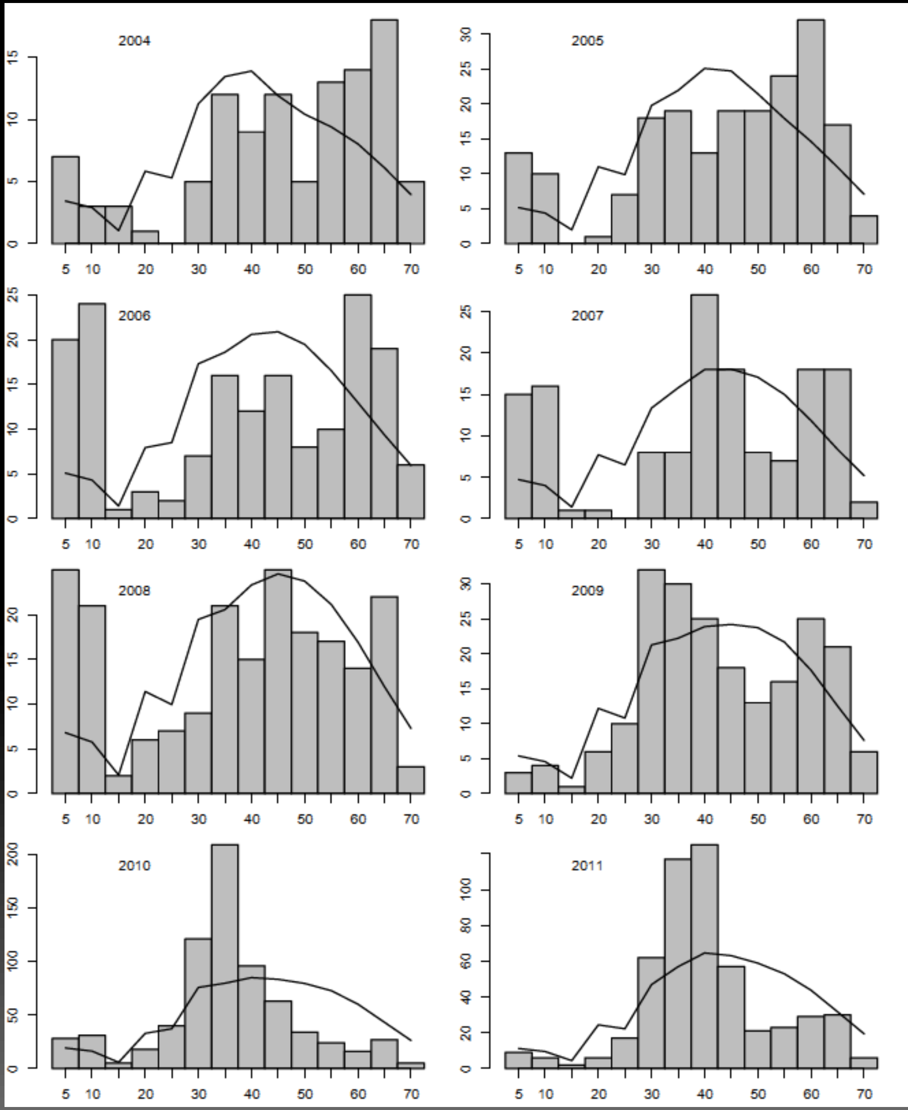
Results – Strandings (1988-1995)



Results – Strandings (1996-2003)

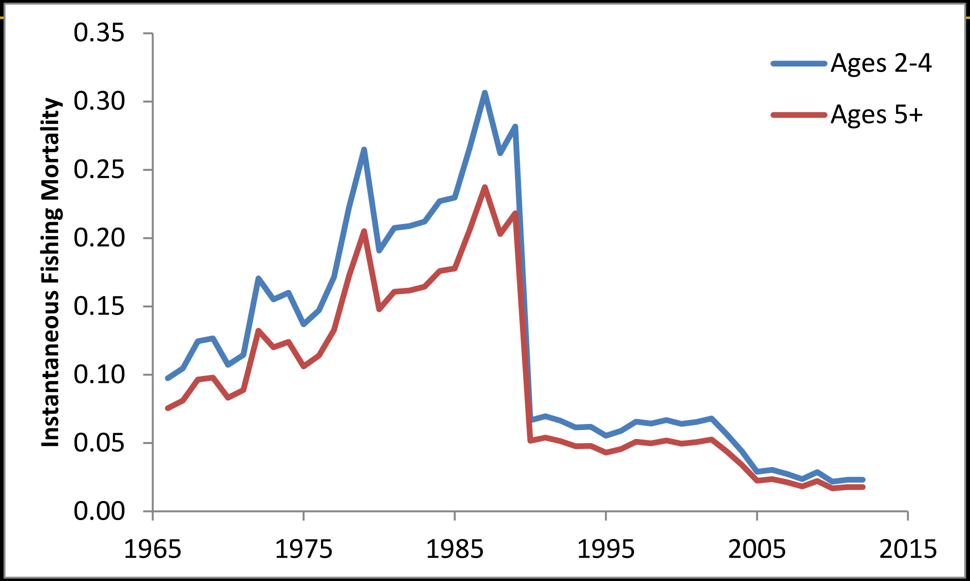


Results – Strandings (2004-2011)

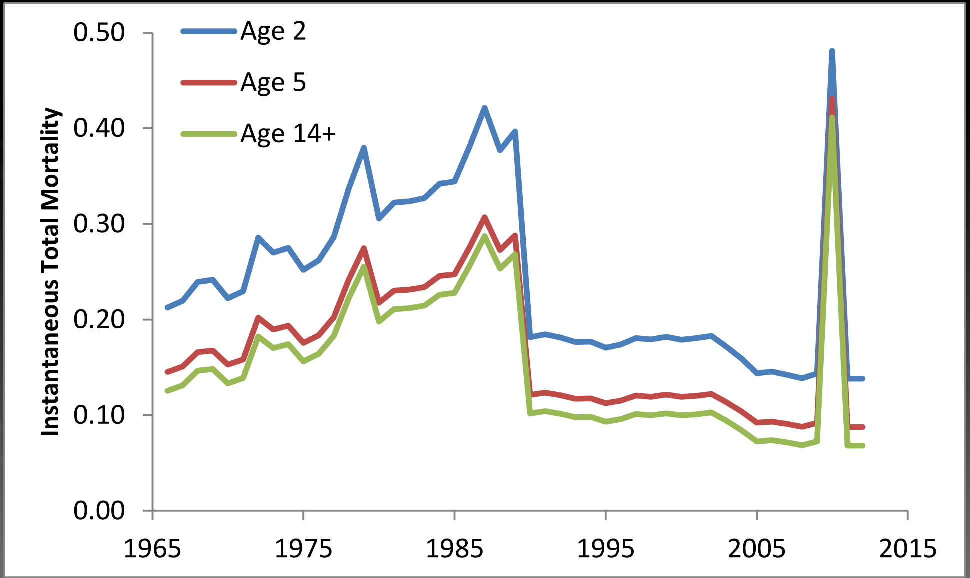


Results – Instantaneous Mortality Rates

Instantaneous fishing mortality by year.

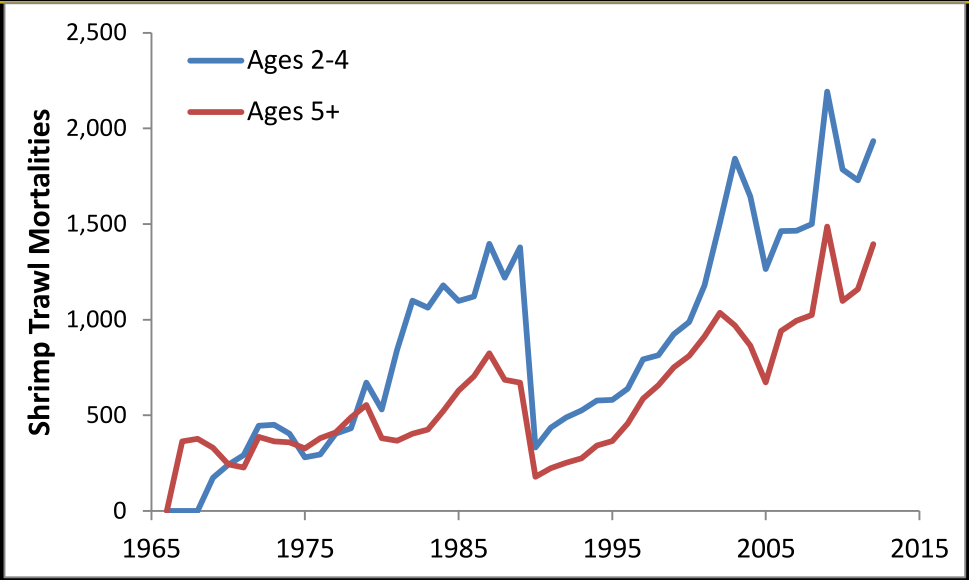


Instantaneous total mortality by year.

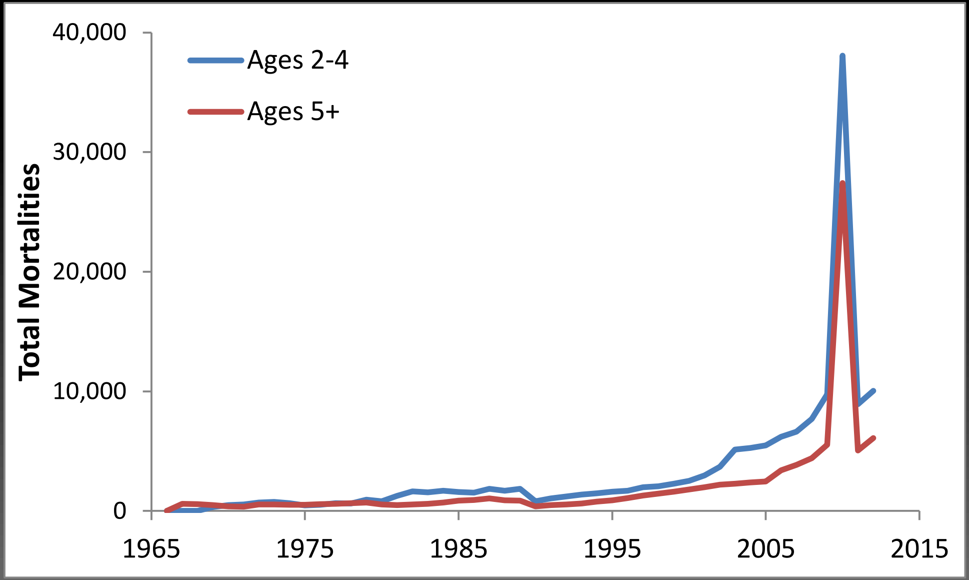


Results – Mortalities

Mortalities assigned to shrimp trawls.



Total mortalities.



Results – Anthropogenic Mortality Comparison

Year	Anthropogenic	Total	%
1989	2,051	2,715	75.5
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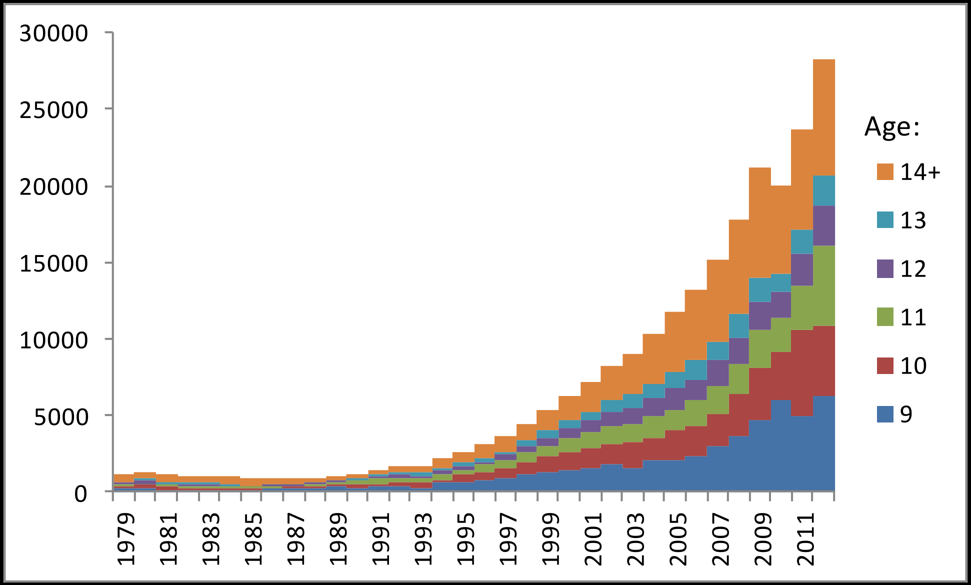
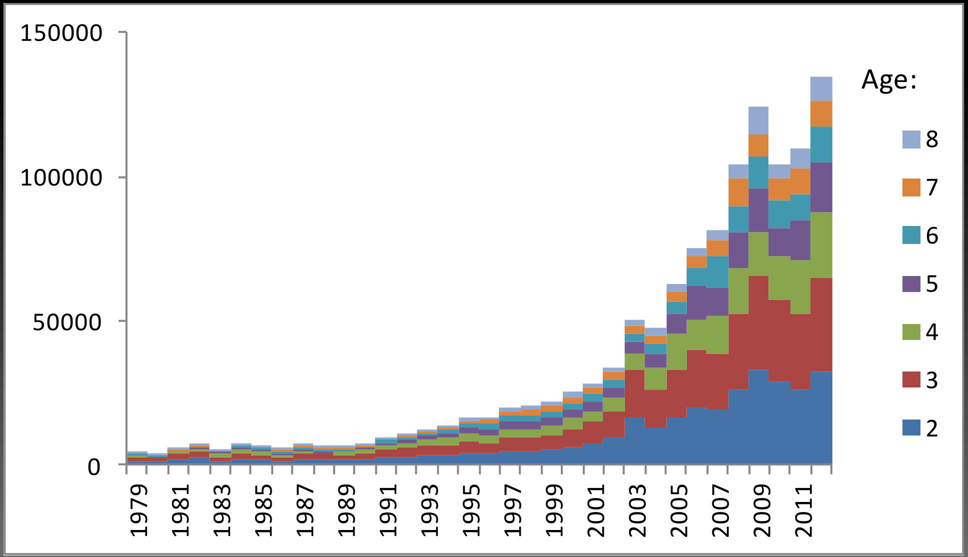
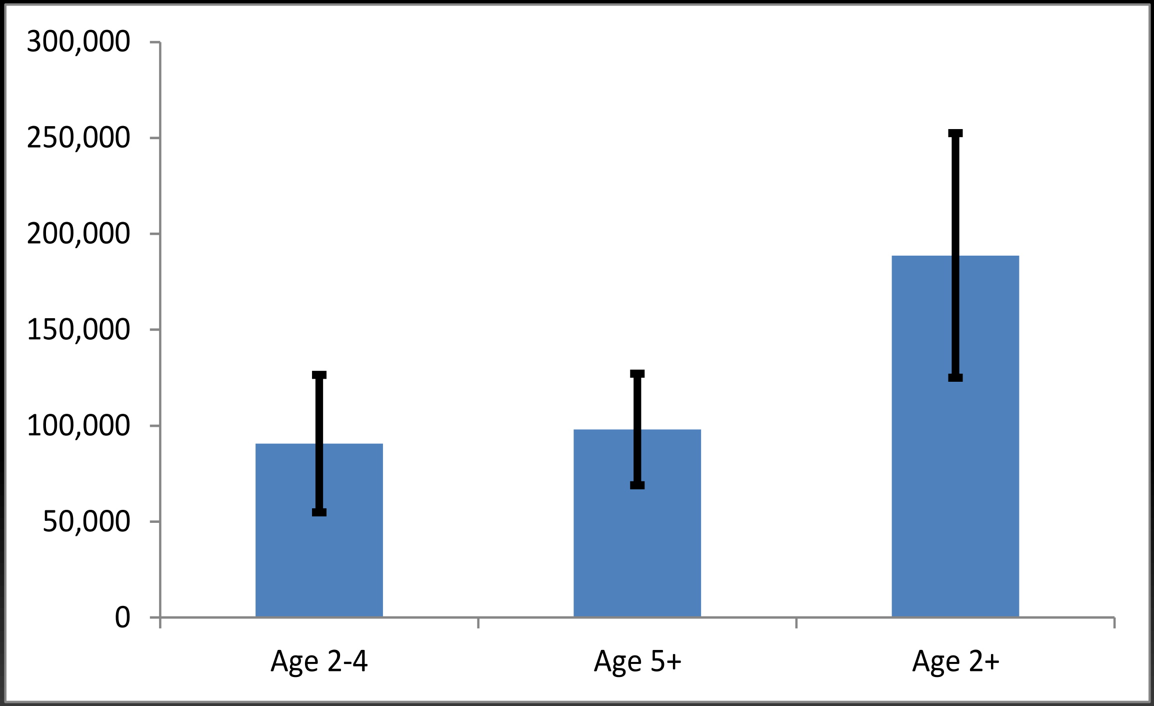
Results – Population Ages 2 to 14+





Results – Population in 2012

Terminal (2012) population estimates with the 95% confidence interval for ages 2-4, 5+ and 2+ (see Table 3).



Next Steps – Fixed Parameters

(Maturity schedule, nests-per-adult and sex ratio)

- Model not useful in quantifying these parameters.
- All scale the size of the population.
- Require biological information on variability and if they change over time.

Next Steps - Growth Analysis

- Analysis of data preliminary.
- Expect to increase the minimum time-at-large (currently 30 days) because of bias from seasonal growth.
- Need to determine optimum trade-off between elimination of seasonal bias and loss of sample size.
- Issue not expected to have a large impact on model results.

Next Steps – Shrimp Effort

- Obtain 2012 US penaeid shrimp trawl effort .

- Substantial improvement to the model fit would be obtained with more effective shrimp effort in the 1966-1980 period. Since this corresponds with the Mexican data further review is warranted.

Future Work

- Complete co-authored manuscripts for possible publication.
- Submit proposal for continued assessment.

Appendix 10: Kemp’s Ridley Stock Assessment Project PowerPoint

KEMP'S RIDLEY STOCK ASSESSMENT PROJECT

For
Gulf States Marine Fisheries Commission
2404 Government Street
Ocean Springs, MS 39564
By
LGL Ecological Research Associates, Inc.
721 Peach Creek Cutoff Rd.
College Station, TX 77845

28 June 2013

Special Thanks

- The Stock Assessment would not have been possible without data provided by the

  Sea Turtle Strandings and Salvage Network (STSSN)

  and the

  Cooperative Marine Turtle Tagging Program (CMTTP)

- Permission to use these data is gratefully acknowledged.

Workshop Participants

The Kemp's Ridley Stock Assessment Workshop was held 26-30 November 2012 with the following persons in attendance.

Attendees in Person	Project Team	Observers	Attendees by Phone
Patrick Burchfield	Benny Gallaway	Corky Perret	Selina Heppell
Rebecca Lewison	Charles Caillouet	Dale Diaz	Nathan Putman
Masami Fujiwara	Scott Raborn	Judy Jamison	Mark Schexnayder
Donna Shaver	Pam Plotkin	Mike Ray	
Gary Graham	John Cole	Ron Shearer	
Sheryan Epperly	Bill Gazey	Sandi Maillian	
Wade Griffin	Jeff Rester		
Andrew Coleman			
Kenneth Lohmann			
Steven DiMarco			
Thane Wibbels			
Alberto Abreu			
Daniel Gomez			
Francisco Illescas			
Marco Castro			
Blanca Zapata			
Jonathan Pitchford			
Laura Sarti			
James Nance			
Totals 19	**7**	**6**	**3**

Background

- In 2010 and 2011, increased numbers of Kemp’s ridley sea turtles stranded in the northern Gulf of Mexico.
- Among possible causes for these events, the “BP Oil Spill” in 2010 and shrimp trawling in both years received the most attention from Federal and State agencies, conservation organizations and media.
- NOAA Fisheries Service released a scoping document and Proposed Rule in June 2011, scheduled public hearings and initiated an evaluation of the need for additional fishery regulations.

Background (continued)

- At about the same time NOAA Fisheries was initiating their investigation (June 2011), Dr. Charles W. Caillouet, Jr. widely circulated a proposal to assemble a working group to study and report on northern Gulf of Mexico Kemp's ridley shrimp-fishery interactions and other anthropogenic effects.
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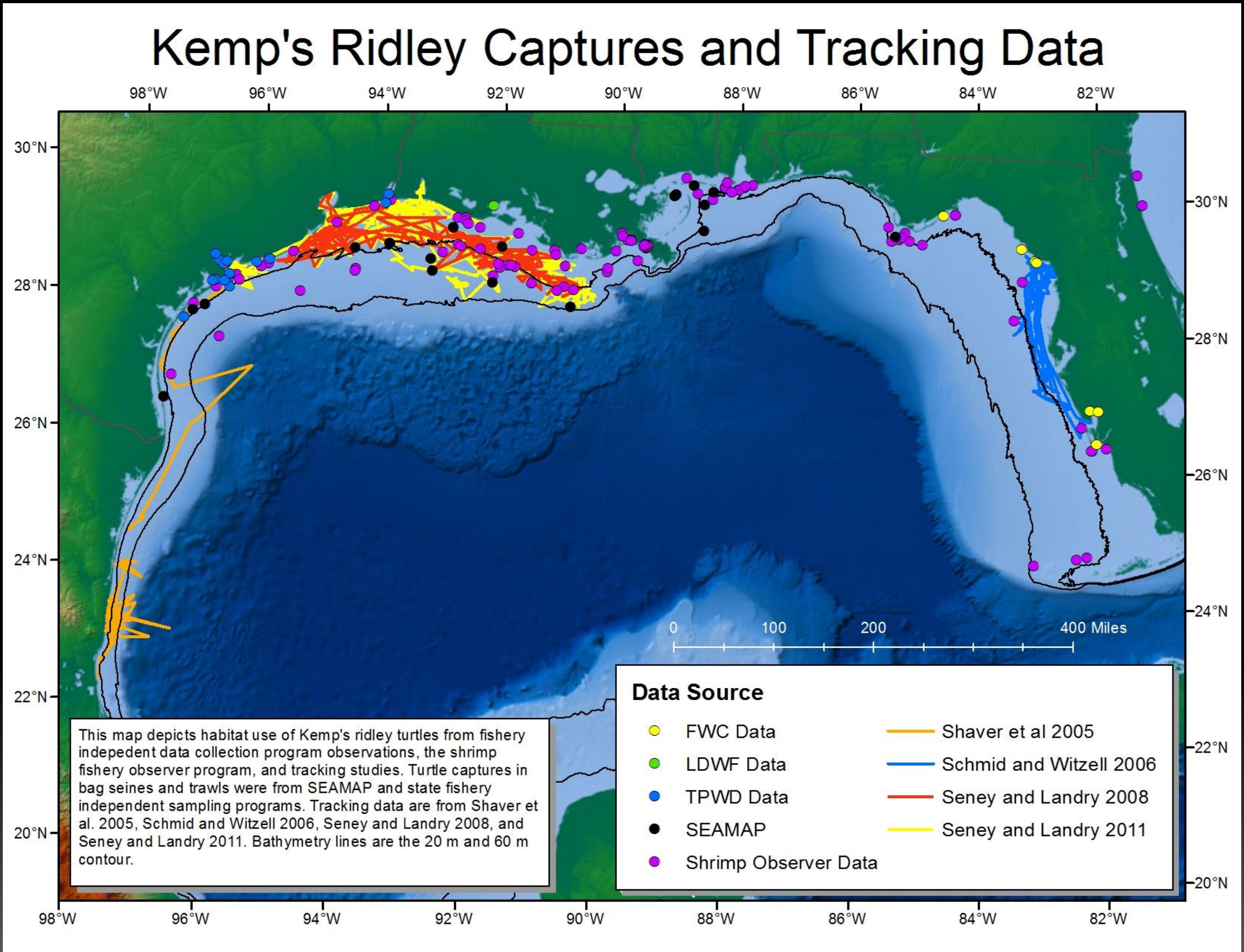
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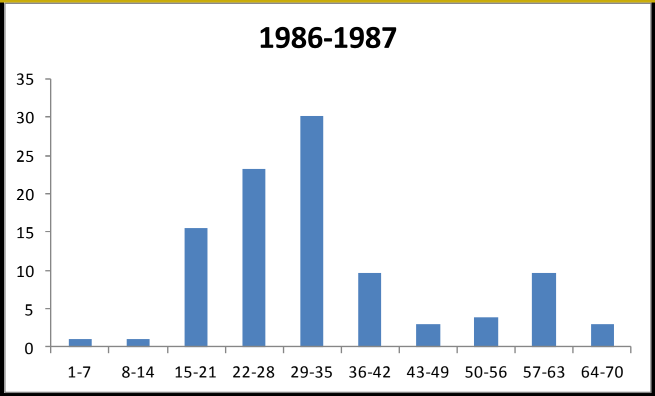

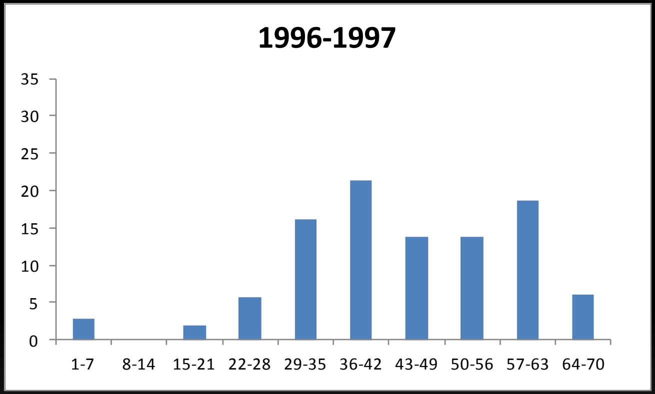

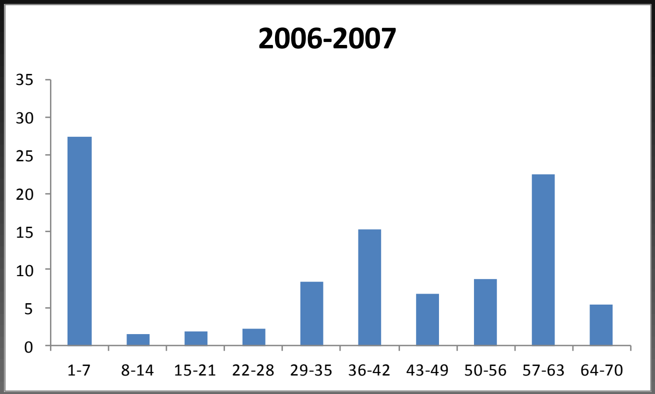

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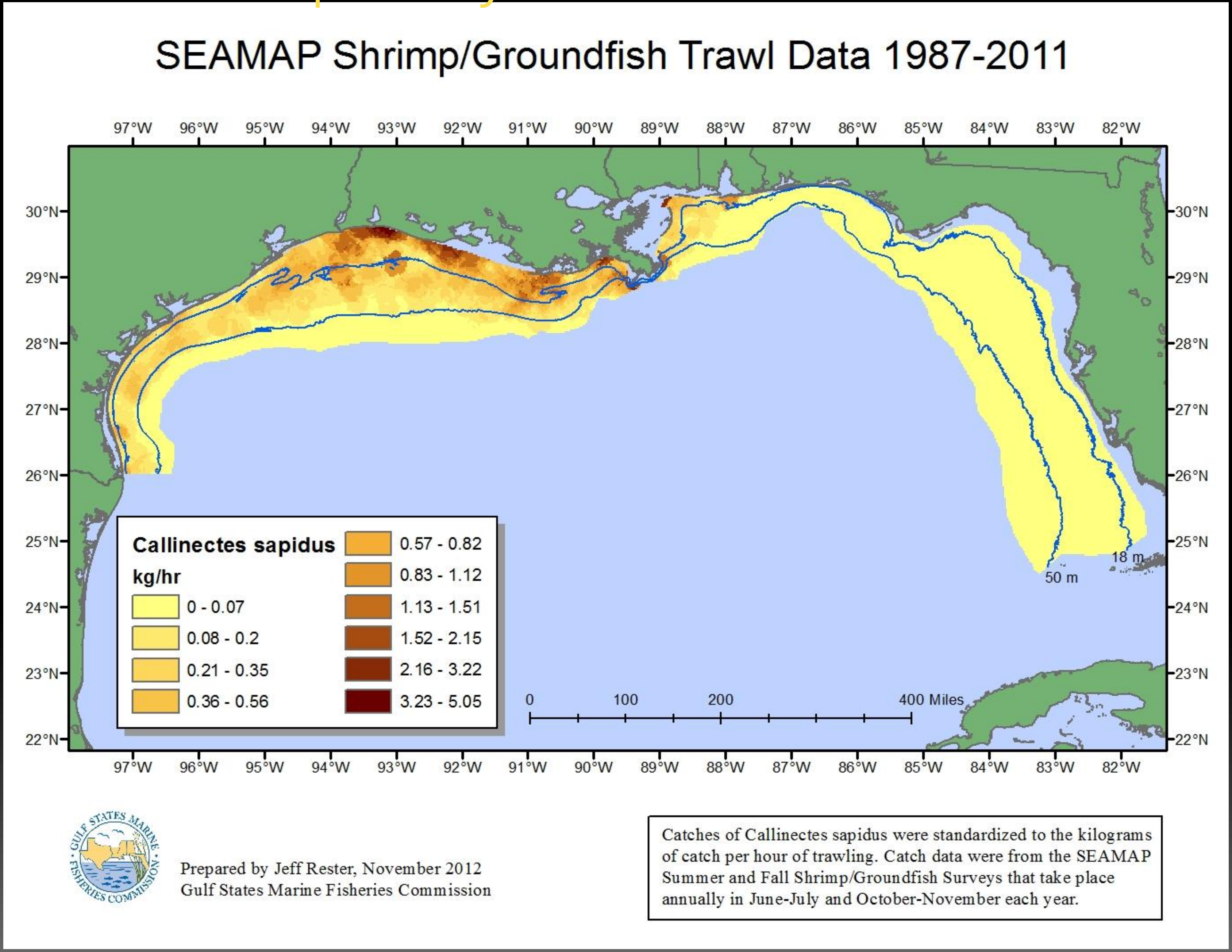

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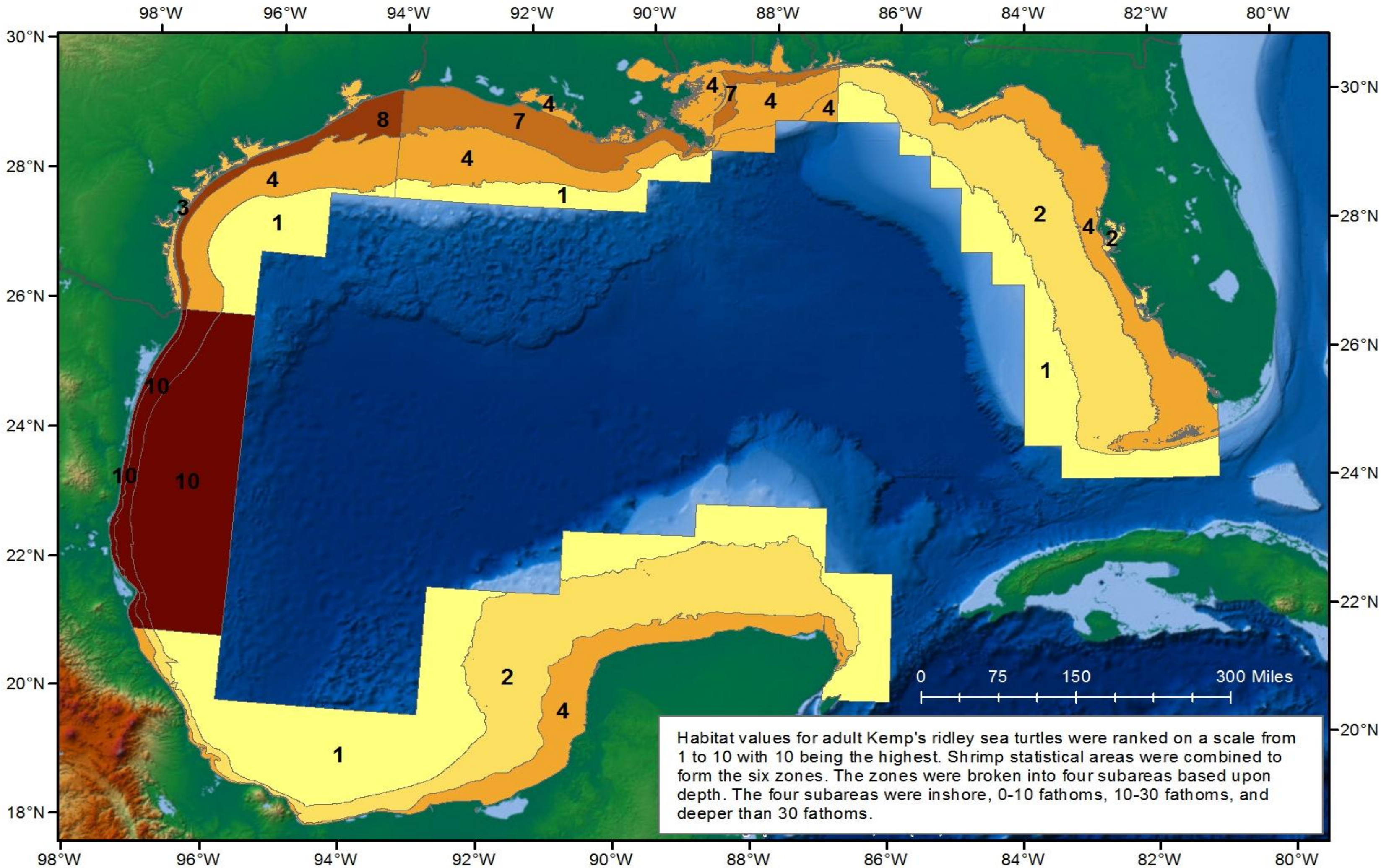
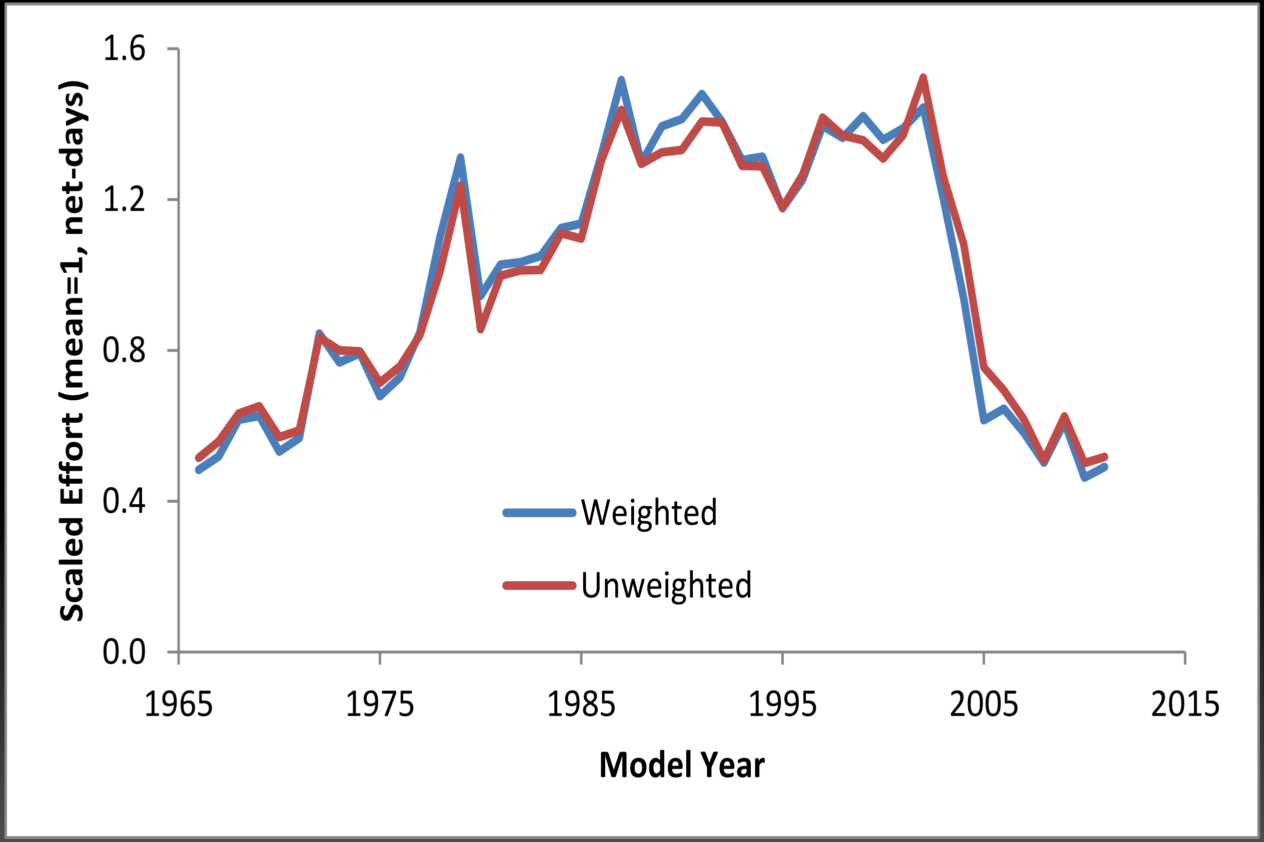


Directed Shrimp Effort

Consensus weighting



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- A key finding of the preliminary analysis was the nesting trend reflected an unexplained 2010 event requiring a mortality adjustment to fit the data.

Model Predictions

1. Number of nests starting from hatchlings
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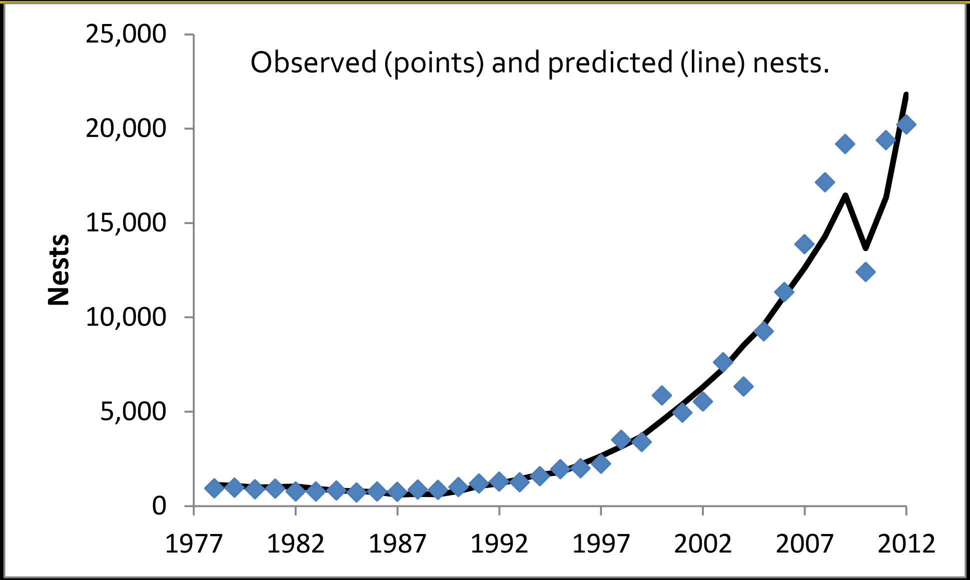
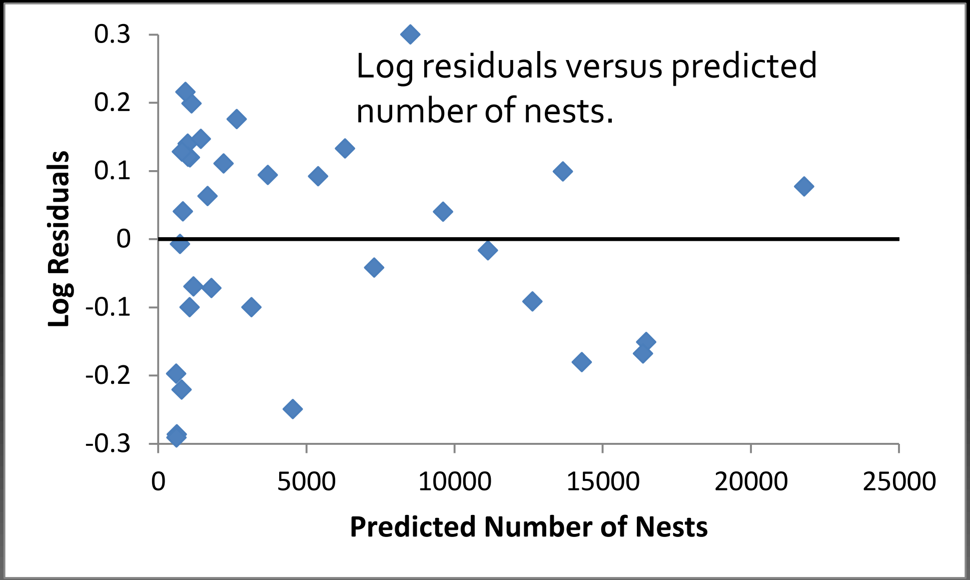
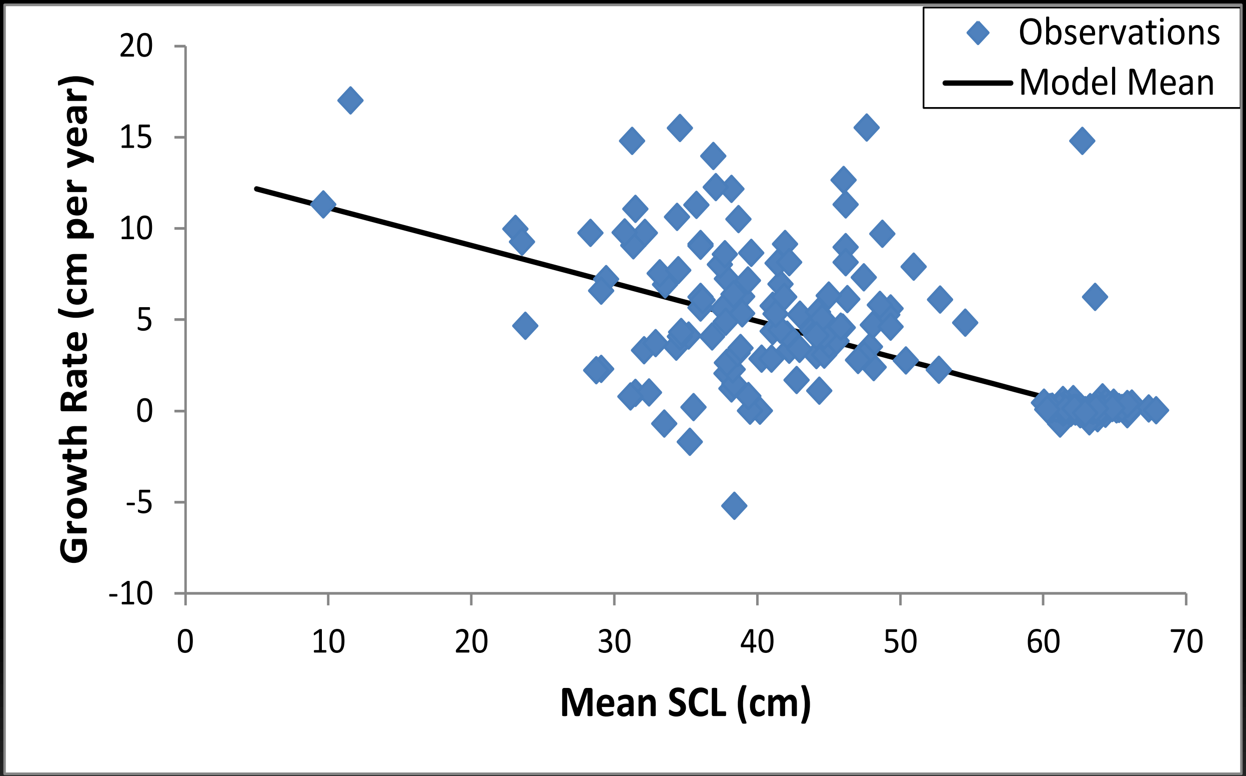
Parameter estimates that maximize the likelihood of observing the data (nests, growth increment and length frequency of strandings).

Results - Nests





Results – Mark Recapture Increments



Growth rate (cm/yr) as a function of the mean *SCL* interval (points) and the predicted model mean (line).

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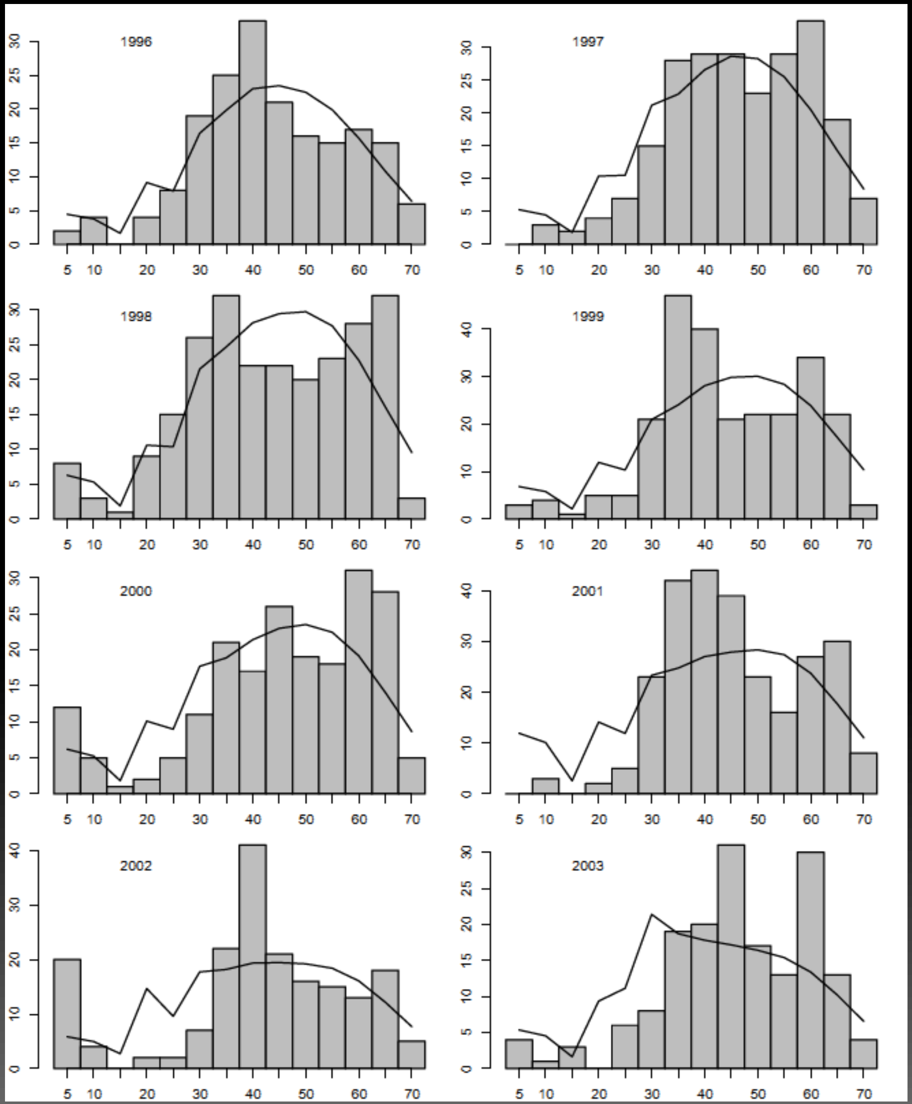
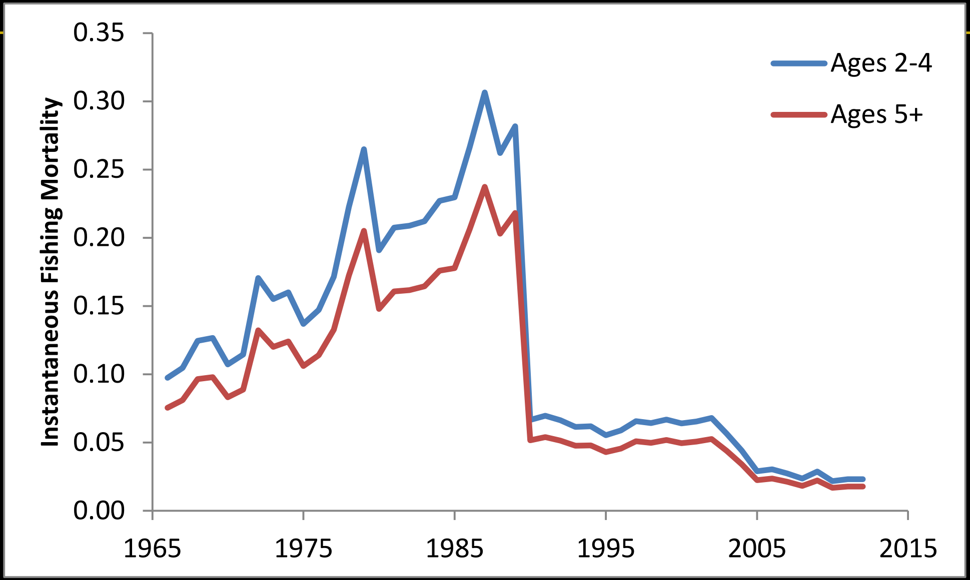
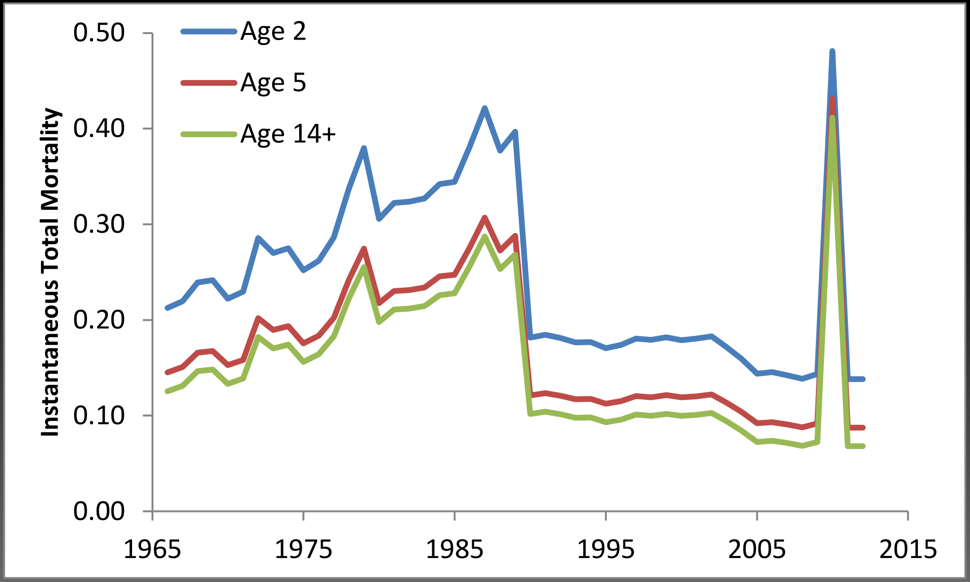


Results – Instantaneous Mortality Rates

Instantaneous fishing mortality by year.



Instantaneous total mortality by year.



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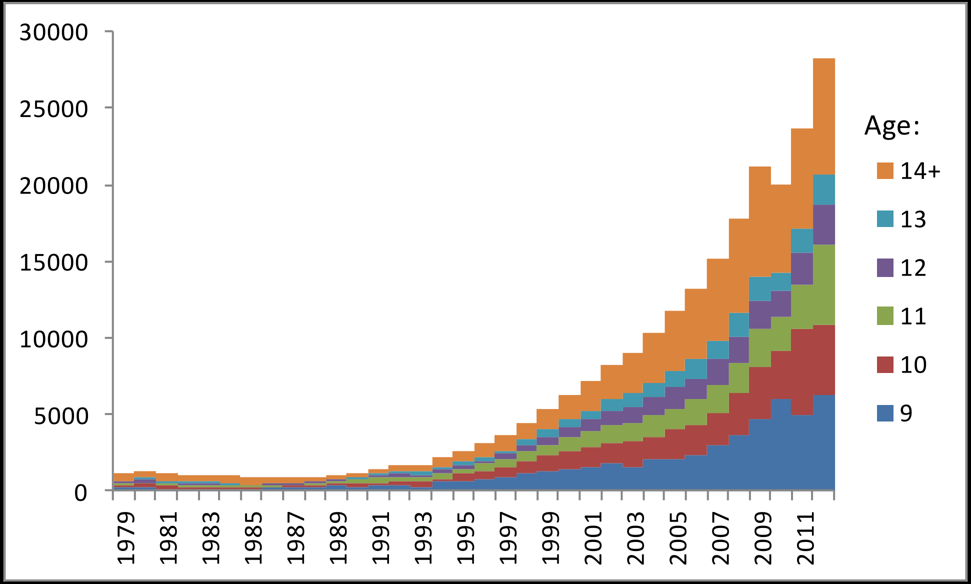
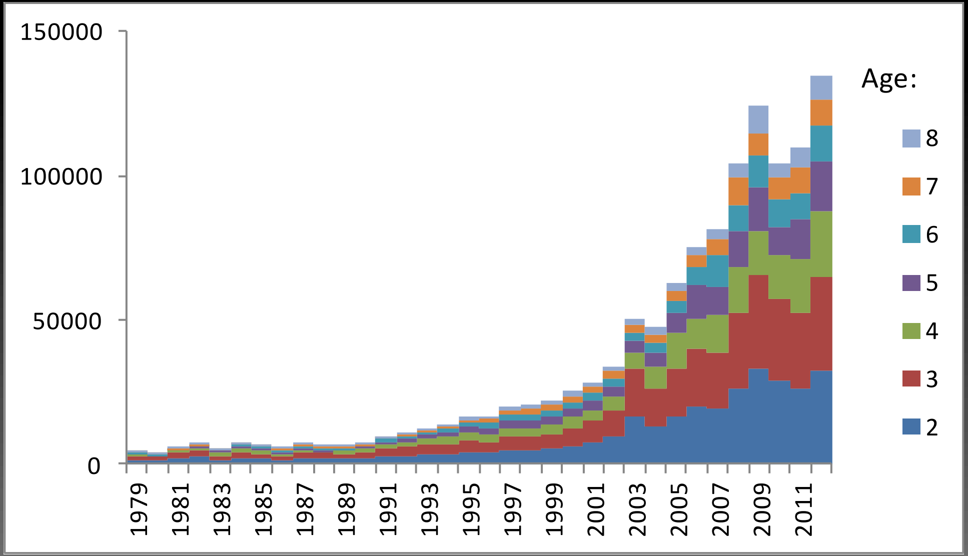
Results – Population ages 2 to 14+





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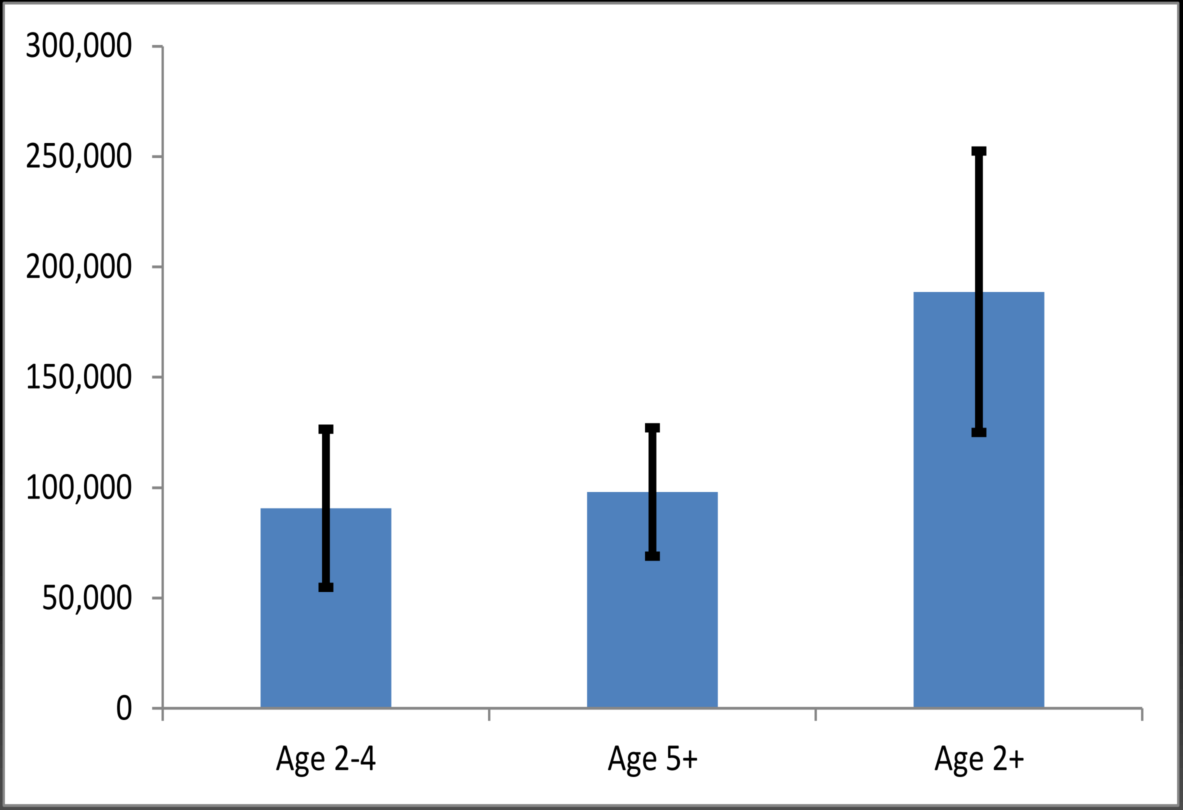

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- Substantial improvement to the model fit would be obtained with more effective shrimp effort in the 1966-1980 period. Since this corresponds with the Mexican data further review is warranted.

Future Work

- Complete co-authored manuscripts for possible publication.
- Submit proposal for continued assessment.