Current Status of Adult Red Drum (*Sciaenops ocellatus*) in the North Central Gulf of Mexico: An Update of Abundance, Age Composition, and Mortality Estimates

Crystal L. Hightower, J. Marcus Drymon, and Sean P. Powers

SEDAR49-DW-16

2 May 2016
Updated: 8 May 2016

Please cite this document as:

Hightower, C.L., J. M. Drymon, and S.P. Powers. 2016. Current Status of Adult Red Drum (*Sciaenops ocellatus*) in the North Central Gulf of Mexico: An Update of Abundance, Age Composition, and Mortality Estimates. SEDAR49-DW-16. SEDAR, North Charleston, SC. 19 pp.

Current Status of Adult Red Drum (*Sciaenops ocellatus*) in the North Central Gulf of Mexico: An Update of Abundance, Age Composition, and Mortality Estimates

Crystal L. Hightower, J. Marcus Drymon, and Sean P. Powers

Department of Marine Sciences, University of South Alabama
Dauphin Island Sea Lab
101 Bienville Blvd, Dauphin Island, Alabama 36528

Submitted May 6, 2016

Abstract
Red Drum (*Sciaenops ocellatus*) in the Gulf of Mexico (GOM) have been overfished since the late 1980s. In an effort to stop overfishing, a recreational and commercial harvest moratorium was established for GOM federal waters (Gulf of Mexico Fishery Management Council, 1987). Almost three decades later, the status of the stock remains unknown (Hogarth, 2004; Powers and Burns, 2010). We focused on addressing several issues relevant to evaluating the current status of GOM Red Drum. Specifically, we: 1) developed a current index of relative abundance for Red Drum in the north central GOM with fishery independent bottom longline catch data from 2006-2015 and 2) examined updated length frequency, age composition, and mortality in adult Red Drum in the north central GOM from fishery independent and dependent sources. The relative abundance index showed consistent catch throughout the study. Age composition showed an increase in average age during the current moratorium from 2008-2011 but a more consistent pattern for 2012-2014. Total mortality (Z) calculated using catch curve analysis for 2006-2013 was estimated at 0.23 for fishery independent bottom longline catch and 0.08 for fishery dependent catch. Fishing mortality was estimated between 0.14 to 0.18 for fishery independent catch and 0 to 0.01 for fishery dependent catch when using the Hoenig (1983) and Hewitt and Hoenig (2005) estimates for M, respectively. Our abundance and age compositions provide a clear indication of a rebuilding stock following the moratorium and indicate the need for assessment based on the distribution of large adults in state waters that are susceptible to current state recreational fishing mortality as seen in our fishery dependent data.

Introduction

Based on the paucity of data available for adult Red Drum (*Sciaenops ocellatus*) in the Gulf of Mexico (GOM) and the recommendation from the GOM Fishery Management Council's Special Red Drum Working Group, the University of South Alabama (USA) at the Dauphin Island Sea Lab have been using fishery independent and fishery dependent methods to collect Red Drum in the north central GOM. These data, along with those provided by the Alabama Marine Resources Division (ALMRD) gillnet survey were provided to SEDAR 49 for consideration for use in the stock assessment. Data were provided to inform several inputs of the proposed DLMtoolkit model including an index of relative abundance, age composition, and mortality based on longevity.

A standardized index of relative abundance for GOM Red Drum was constructed based on a long-term fishery independent bottom longline survey. This survey, conducted by USA, was designed to complement the National Marine Fisheries Service (NMFS) bottom longline sampling effort. Stations were randomly selected and methods have remained consistent since 2006 and follow the NMFS and Southeastern Monitoring and Assessment Program (SEAMAP) standardized protocols. For the index of relative abundance, only bottom longline stations between 0-20m depths were provided to maintain consistency with other surveys in the GOM. (Figure 1).

Adult Red Drum meristic and age data were provided from fishery independent bottom longline, purse seine and gillnet surveys conducted by USA and ALMRD. Red Drum collected from the bottom longline (2006-2014) for all depths were included in the supplied length frequency and age composition. In 2014, a purse seine survey was conducted in Alabama state waters off of Dauphin Island, AL (Figure 2). To further supplement the younger year classes of data for life history parameters, additional fishery independent data including standard morphometrics and ages were collected by ALMRD using experimental gillnets in Alabama state waters. These age and length data were collected during monthly gillnet sampling from 2006 to 2009. These data were not included in the abundance index but were used to increase the number of smaller individuals to improve estimates of parameters in Red Drum growth models. Since 2009, Red Drum were also sampled through a fishery dependent source, the Alabama Deep Sea Fishing Rodeo (ADSFR). The ADSFR data presented here are from July 2009, 2011-2015, and fish were caught within territorial waters of the ADSFR (see Methods for definition). The ADSFR was cancelled in 2010 because of the Deepwater Horizon Oil Spill.

Methods

Sample Collection

For all longline sets from 2006-2015, commercial-style bottom longline gear was used. A monofilament mainline (1000 lb. test, 1 nautical mile length) was deployed through a block off the stern of the research vessel. High flier buoys were used at the start and end of each set. Five kg weights (start, mid-set, end set), and 3.66 m monofilament gangions (318 kg test) with 15/0 Mustad 39960D circle hooks were clipped to the mainline during deployment. Bottom longline effort was 100 hooks fished for one hour soak time. Soak time was determined from the time the last high flier buoy was deployed until the first high flier buoy was retrieved to begin the haul back (Drymon et al., 2010). Hooks were baited with dead Atlantic Mackerel

(*Scomber scombrus*). All fish were boated, measured to the nearest mm, and weighed to the nearest 0.1 kg. Haul back speed was approximately 3.5 - 4 knots. In addition, a hydrolab cast was made during the soak time to measure surface and bottom temperature, salinity, and dissolved oxygen.

A spotter plane and purse seine team were employed to collect adult Red Drum from Alabama waters in 2014. The commercial style purse seine net measured 600 yds long and 130 ft deep and was constructed of one inch mesh. Once a school was spotted, the striker boat was used to set the net. The net was then pursed and fish were left in the water until they were processed. A sample size of ~100-200 fish were culled from each school to collect meristics and otoliths for age composition.

Additional fishery independent data were collected by ALMRD using experimental gillnets in Alabama state waters. These age and length data were collected during monthly gillnet sampling from 2006 to 2009. These data were not included in the relative abundance index but were used to increase the number of smaller individuals to improve estimates of parameters in Red Drum growth models.

Red Drum were also sampled through a fishery dependent source, the ADSFR. The ADSFR was held in July 2009 and 2011-2014, and fish were caught within territorial waters of the ADSFR. The ADSFR was cancelled in 2010 because of the Deepwater Horizon Oil Spill. The coordinates for the ADSFR territorial waters are: north: all bays and inlets of the GOM; east: 85°W longitude; south: 28°N latitude; and, west: 91°W longitude. In 2009 and 2011-2012, anglers who brought in a Red Drum above the slot limit size (660 mm TL) were entered into a random drawing for prizes. Alabama state law allows one Red Drum above 26 inches total length per day, and all fishing was conducted in accordance with state regulations. In 2012, a regular category was added to the ADSFR for largest slot sized Red Drum.

For all Red Drum, morphometrics and otoliths were collected. Standard length (SL), fork length (FL) natural total length (NTL) and maximum total length (TL) were recorded to the nearest mm and mass was recorded to the nearest 0.1 kg. Sagittal otoliths were removed and stored dry for future processing. Following extraction, sagittal otoliths were used to estimate ages of Red Drum in this study following Beckman et al. (1988). Otolith processing techniques for this study were conducted according to the methods for thin sectioning described in the Gulf of Mexico Marine Fisheries Commission otolith manual (VanderKooy and Guidon-Tisdel, 2003) and Beckman et al. (1988). The left otolith was processed, leaving the right otolith for use when the left was not available or when there was a disagreement between otolith readers (Beckman et al., 1988). Otoliths were cut along the transverse plane as close to the core as possible with a Model 1010 Hillquist Thin-Sectioning Petrographic Saw. Sectioned otoliths were polished with a Crystal Master 6 Plus polishing wheel affixed with a Buehler microfiber polishing cloth treated with 0.3 μm aluminum oxide powder and water. Polished sections were placed sectioned side down on a glass microscope slide and secured using Loctite 349™ ultraviolet adhesive. The slides were placed under a blacklight overnight to cure. The remaining otolith section was trimmed with the cut-off saw followed by the precision grinder to grind the otolith until it reached approximately 50 μm. The slide was then polished on the Crystal Master 6 Plus wheel with aluminum oxide and water, cleaned, and covered with Flo-Texx liquid cover slip to remove scratches. All otoliths were aged independently by two readers. Integer age was determined by counting number of opaque zones. Year at birth was estimated for all Red Drum by subtracting opaque zone count from year of capture with the assumption that the initial annulus was deposited during the winter of year two (Beckman et al., 1988).

Index of Relative Abundance

Powers et al. (2012) concluded that an index of relative abundance could be calculated using standardized bottom longline catch data. In their approach, all fishery independent longline catch data were converted to nominal CPUE, expressed as fish caught/100 hooks/hour. Differences in nominal CPUE by year were tested using a one-way ANOVA. To standardize CPUE for an index of relative abundance, the delta-lognormal index (dGLM) of relative abundance (I_y) as described by Lo *et al*. (1992) and Ingram *et al*. (2010) was estimated as

$$I_y = c_y p_y,$$

where c_y is the estimate of mean CPUE for positive catches only for year y, and p_y is the estimate of mean probability of occurrence during year y. Both c_y and p_y are estimated using generalized linear models. Data used to estimate abundance for positive catches (c) and probability of occurrence (p) are assumed to have lognormal and binomial distributions, respectively. The final index was the product of the back-transformed year effects from the two above mentioned generalized linear models (GLMs). All GLMs were computed with year and month as factors. The standard error and coefficient of variation of index values were estimated using a jackknife routine on factors with greater than two positive observations. These models were estimated using code provided by E.J. Dick using the R (3.2.4) statistical software package.

Length Frequency and Age Composition

Length frequency and age composition were plotted by gear type for fishery independent bottom longline, purse seine, gillnet and fishery dependent ADSFR data. Length at age was also reported. All lengths were reported as maximum total length (TL; tail pinched) for this study. Length/length and length weight regressions were also provided for comparison to other studies (Figures 3-4).

Mortality Estimates

A catch curve was computed to estimate total mortality (Z) by fitting a linear regression to the fully-recruited ages in a scatterplot of the natural log of numbers versus age. Two methods were employed to estimate natural mortality (M) from the maximum observed longevity. Hoenig's (1983) regression equation was used to predict M from t_{max} (maximum age observed) using the equation:

$$\ln(M) = 1.44-0.982*\ln(t_{max}).$$

A simpler rule-of-thumb approach evaluated by Hewitt and Hoenig (2005) using P = 0.05 (the proportion of the population that survives to the t_{max}) was also used.

$$M = \frac{-\ln (P)}{t_{max}}$$

Because $Z = M + F$, F can be estimated if you have accurate estimates of Z and M. These three estimates were calculated using the entire 2008-2013 data set including that from Powers et al. (2012). The estimates were then compared to those of previous studies.

Results and Discussion

Between 2006-2015, 731 Red Drum were collected via fishery independent bottom longline; 758 were collected via fishery dependent ADSFR; 468 were collected via purse seine; and 684 collected via 2006-2009 AMRD gillnet. Differences in selectivity between fishery independent bottom longlines and gillnets and fishery dependent hook and line allowed a broad survey of Red Drum size and age.

1540 Red Drum were aged in our study and 591 were aged by AMRD in their gillnet study as seen in the length at age plot (Figure 5). Age composition and length frequency were calculated for both fishery independent and fishery dependent samples from 2008-2014 (Figures 6-7). The APE for all Red Drum in this study was 0.002 resulting in 99.998% agreement between two independent readers. The youngest fish in this study were 0 years old and collected in an AMRD gillnet and the ADSFR and the oldest fish was 40 and collected during the 2011 ADSFR using hook and line. The highest proportion age class for the fishery independent longline was age 20 and the size range was 770-1090 mm TL. The fishery independent purse seine collected fish from 561-1012 mm TL with the highest proportion of 10-12 year olds. The fishery dependent ADSFR provided younger fish with 3 year olds being the highest proportion covering a size range of 235-1195 mm TL. The AMRD gillnet provided the most fish from 0-2 ages and 179-889 mm TL size classes.

Temporal analysis of Red Drum relative abundance showed no differences in CPUE by year (one-way ANOVA, $F_{9, 611}$=1.118, p=0.348) (Figure 8). The standardized index of relative abundance closely tracked the nominal catch and showed an overall consistent abundance of Red Drum for all years (2006-2015) (Figure 9). The variability around the annual means was relatively high but remained consistent year to year. The proportion positive for Red Drum is relatively low for the bottom longline; however, we would expect an increase in catch with increased sampling effort. The bottom longline continues to provide a consistent means of estimating relative abundance of large adults, given long-term consistent spatial coverage and standardized protocols.

An interesting trend was observed in the age composition through time. Age composition for the fishery independent bottom longline was plotted by year (Figure 10). A shift in age can be seen from 2008-2011. This suggests a strong year class moving through the age composition over time that is not being replaced by younger fish. This is suggestive of higher mortality of the younger year classes. The trend seems to slow in 2012-2015.

Several methods used to calculate Red Drum mortality reflected differences in mortality estimates with collection type. Catch curve regressions were plotted starting with the ages fully selected for the fishery independent longline (20 years old) and fishery dependent hook and line (3 years old). Total mortality (*Z*) was estimated as 0.25 for fishery independent catch and 0.08 for fishery dependent catch (Figure 11). Hoenig's (1983) model and Hewitt and Hoenig's (2005) rule-of-thumb model to estimate *M* were calculated using a t_{max} of 40 years. Hoenig's (1983) model calculated *M* at 0.11 and the Hewitt and Hoenig (2005) rule-of-thumb model calculated *M* at 0.07. Fishing mortality was estimated between 0.14 to 0.18 for fishery independent catch and 0 to 0.01 for fishery dependent catch when using the Hoenig (1983) and Hewitt and Hoenig (2005) estimates for *M*, respectively.

Literature Cited

Beckman, D.W., C.A. Wilson, and A.L. Stanley.
1988. Age and growth of red drum, *Sciaenops ocellatus*, from offshore waters of the Gulf of Mexico. Fish. Bull. 87:17-28.

Drymon, J.M., S. P. Powers, J. Dindo, B. Dzwonkowski, T.A. Henwood.
2010. Distributions of sharks across a continental shelf in the northern Gulf of Mexico. Mar. Coast. Fish. 2:440-450.

Gulf of Mexico Fishery Management Council, 1987. Amendment number 1 and environmental assessment and supplemental regulatory impact review, regulatory flexibility analysis for the Red Drum fishery of the Gulf of Mexico.

Hewitt, D.A. and J.M. Hoenig.
2005. Comparison of two approaches for estimating natural mortality based on longevity. Fish. Bull. 103:433-437.

Hoenig, J.M.
1983. Empirical use of longevity data to estimate mortality rates. Fish. Bull. 82:898-903.

Hogarth, W.T.
2004. A message from the NOAA assistant administrator for fisheries; Welcome to NOAA's National Marine Fisheries Service report on the status of the U.S. fisheries for 2004. NOAA, Washington D.C.

Ingram, G.W., Jr., W.J. Richards, J.T. Lamkin, and B. Muhling.
2010. Annual indices of Atlantic bluefin tuna (*Thunnus thynnus*) larvae in the Gulf of Mexico developed using delta-lognormal and multivariate models. Aquat. Living Resour. 23:35-47.

Lo, N.C.H., L.D. Jacobson, and J.L. Squire.
1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49:2515-2526.

Powers, S.P. and K. Burns.
2010. Summary report of the red drum special working group for the Gulf of Mexico Fishery Management Council. Special Red Drum Assessment Report. Prepared for the Gulf of Mexico Fishery Management Council, Scientific and Statistical Committee.

Powers, S.P., C.L. Hightower, J.M. Drymon, and M.W. Johnson.

2012. Age composition and distribution of red drum (*Sciaenops ocellatus*) in offshore waters of the north central Gulf of Mexico: an evaluation of a stock under a federal harvest moratorium. Fish. Bull. 110:283-292.

VanderKooy, S.J. and K. Guidon-Tisdel.
2003. A practical handbook for determining the ages of Gulf of Mexico fishes, 128p. Gulf States Mar. Fish. Comm., Oceans Spring, MS.

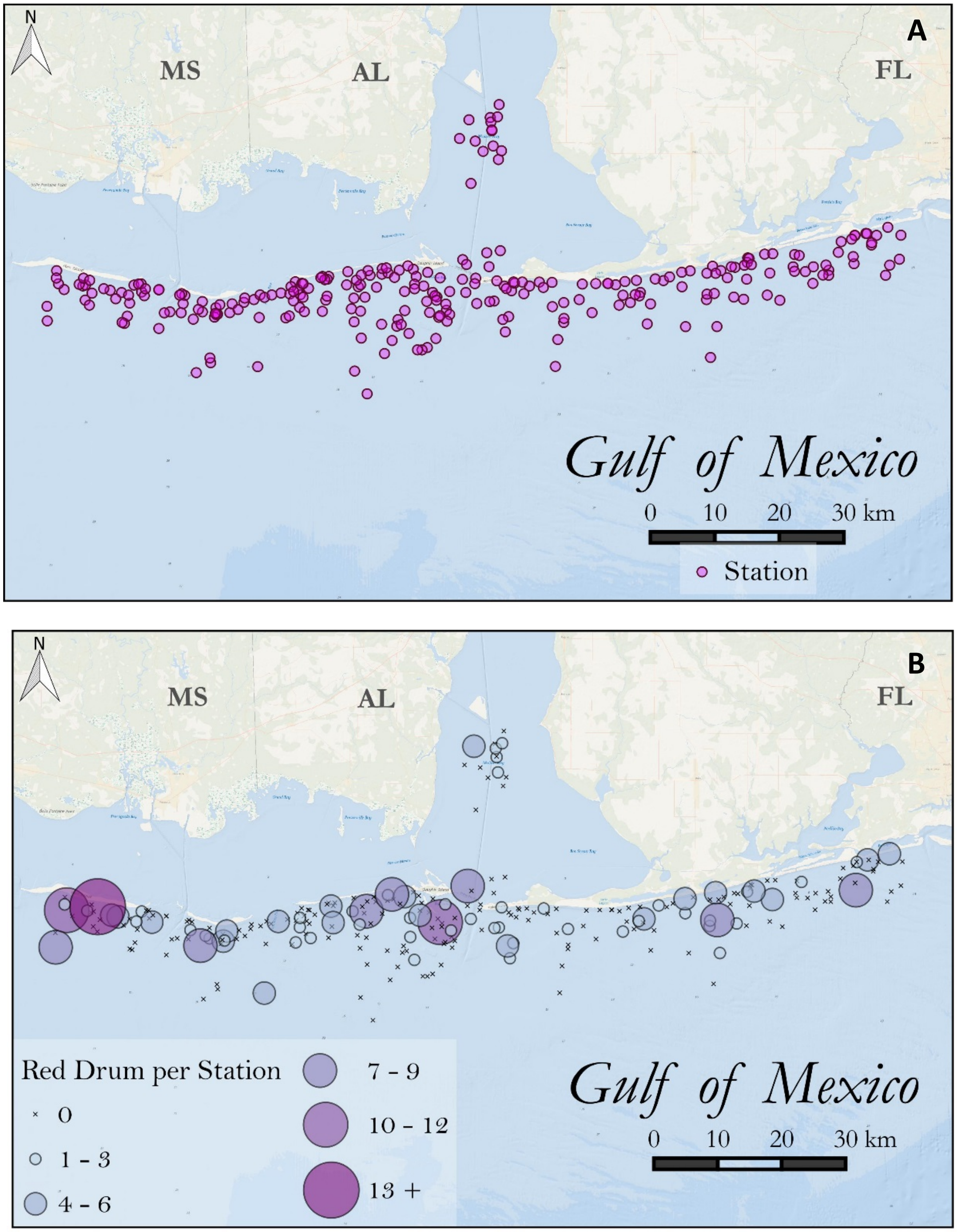


Figure 1. Fishery independent bottom longline effort (A) and catch (B) from 0-20m depths (2006-201) used for the standardized index of abundance.

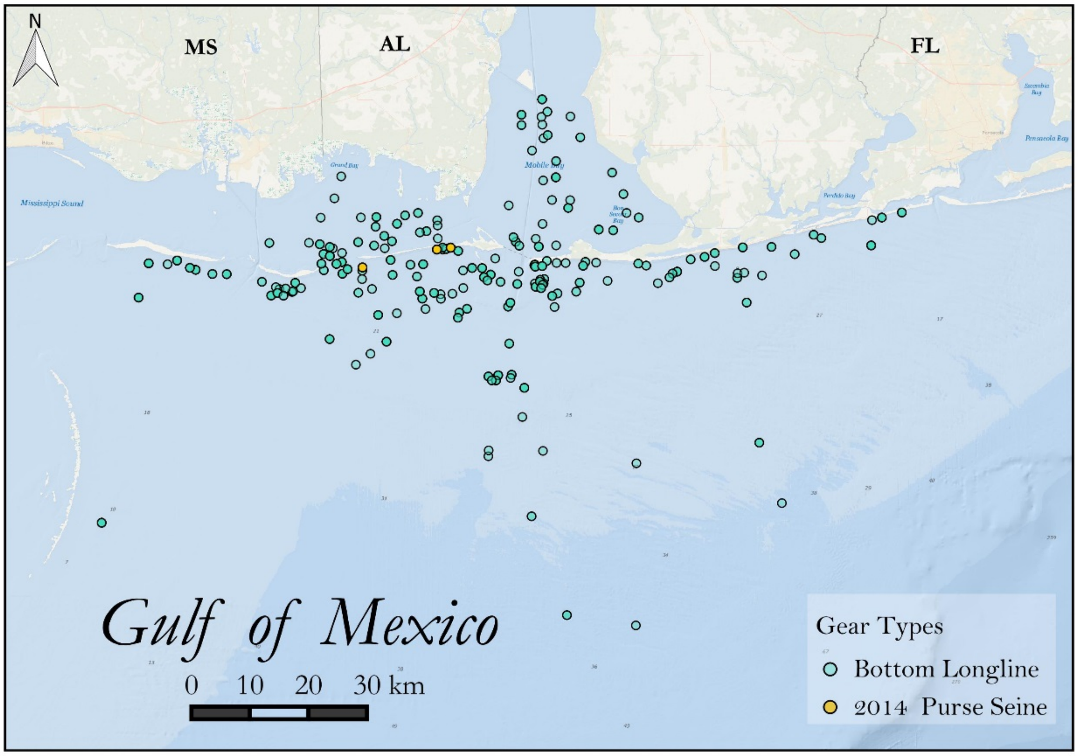


Figure 2. Location of Red Drum sampled during USA/DISL fishery independent bottom longline and purse seine collections (2006-2015) used for length frequency and age composition.

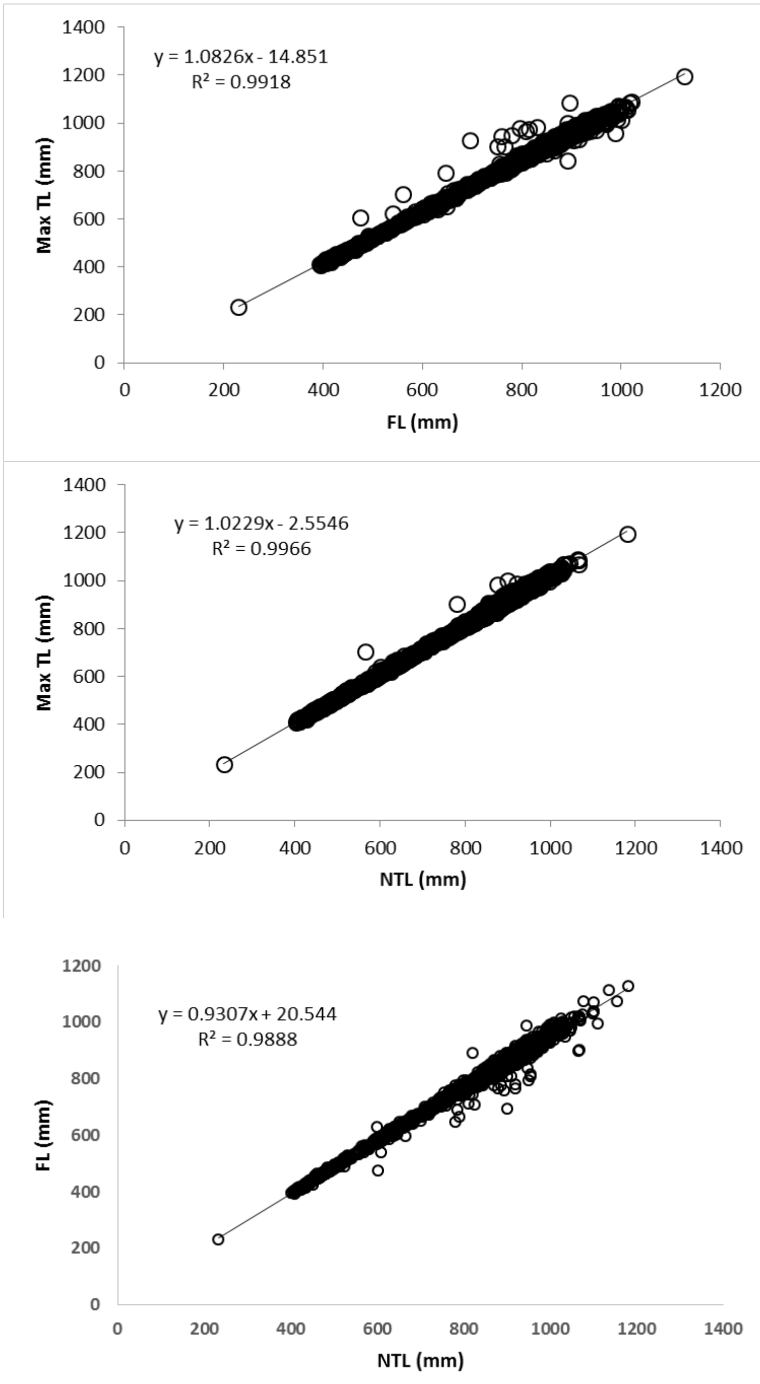


Figure 3. Length length regressions for all gears (bottom longline, purse seine, gillnet, ADSFR) and all years (2006-2015) used for comparison with other Gulf of Mexico studies.

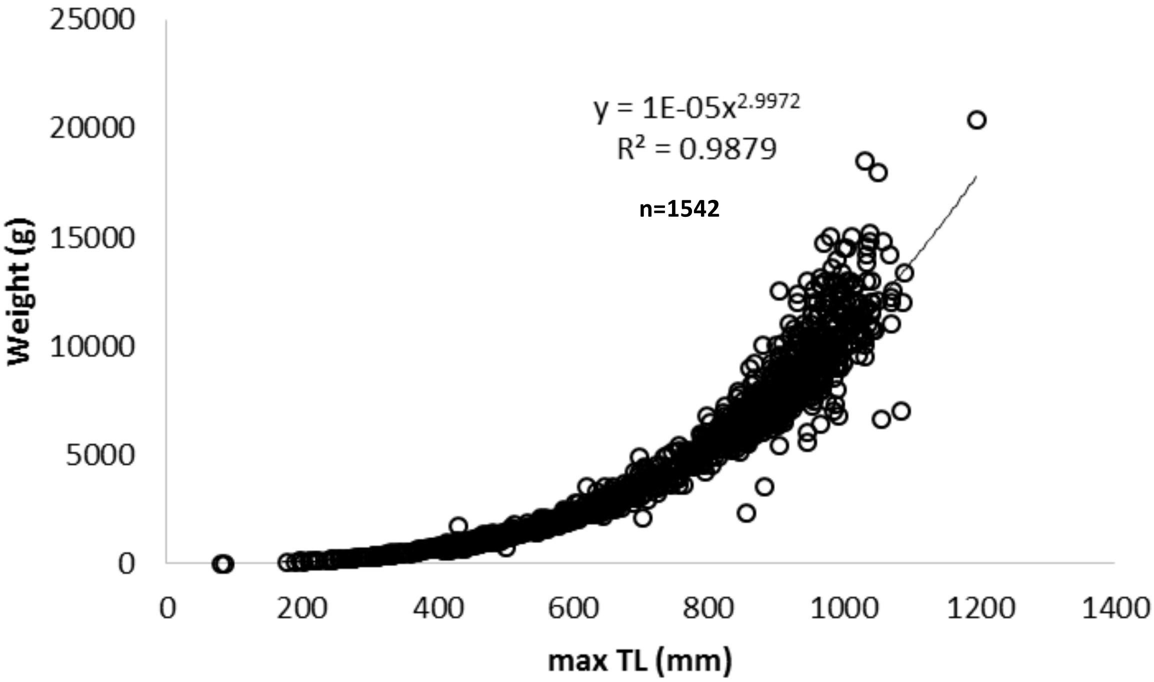


Figure 4. Length weight regression for all gears (bottom longline, purse seine, gillnet, ADSFR) and all years (2006-2015).

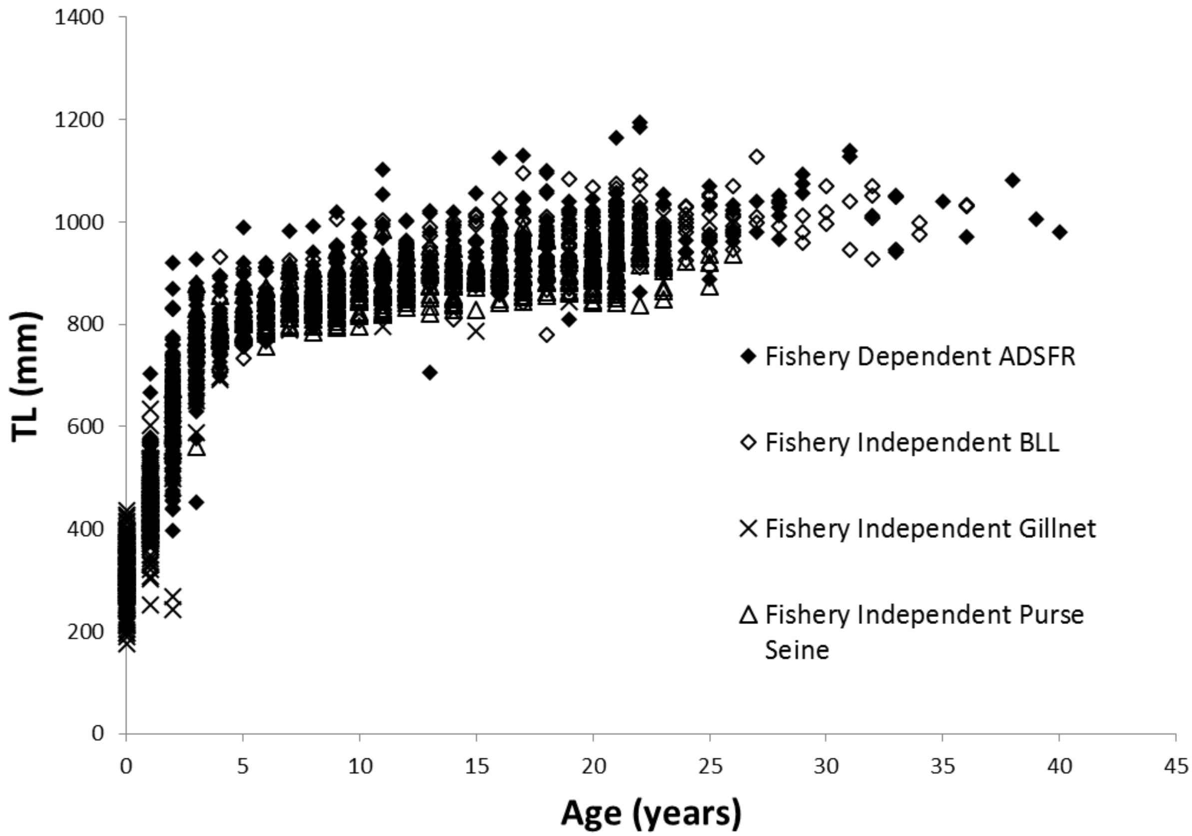


Figure 5. Length at age for Red Drum 2006-2014. All gears.

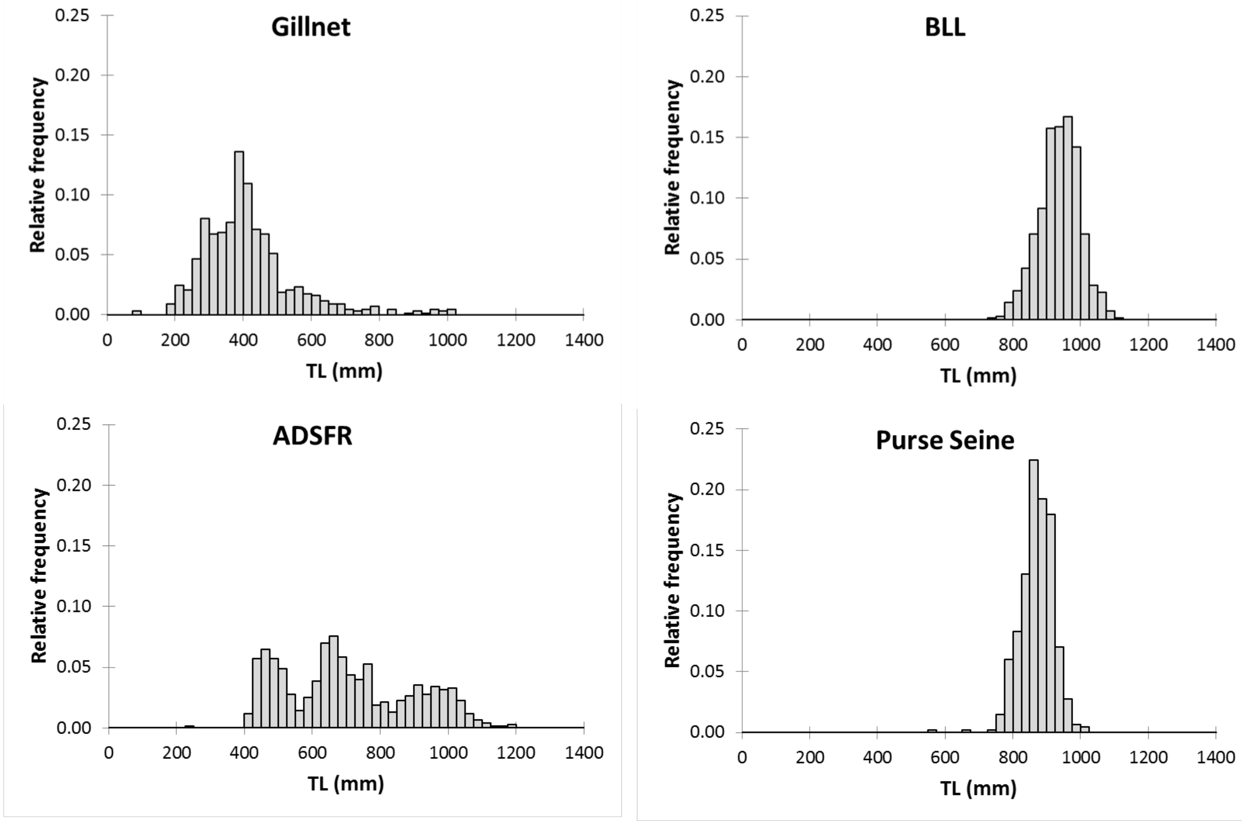


Figure 6. Length Frequency of Red Drum; all gears (2006-2014). Lengths are reported as maximum total length (TL) in mm.

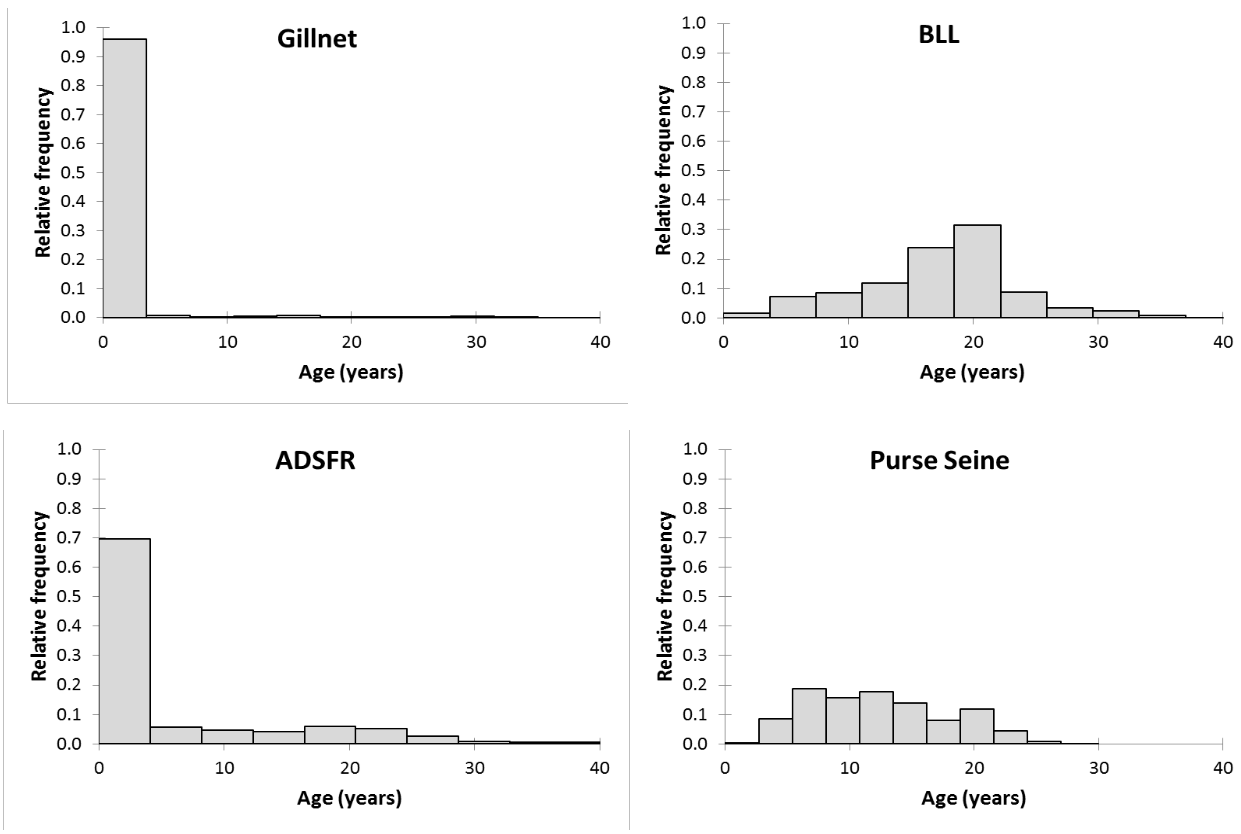


Figure 7. Age distribution of Red Drum; all gears (2006-2014). Number of annuli were used to report age in years.

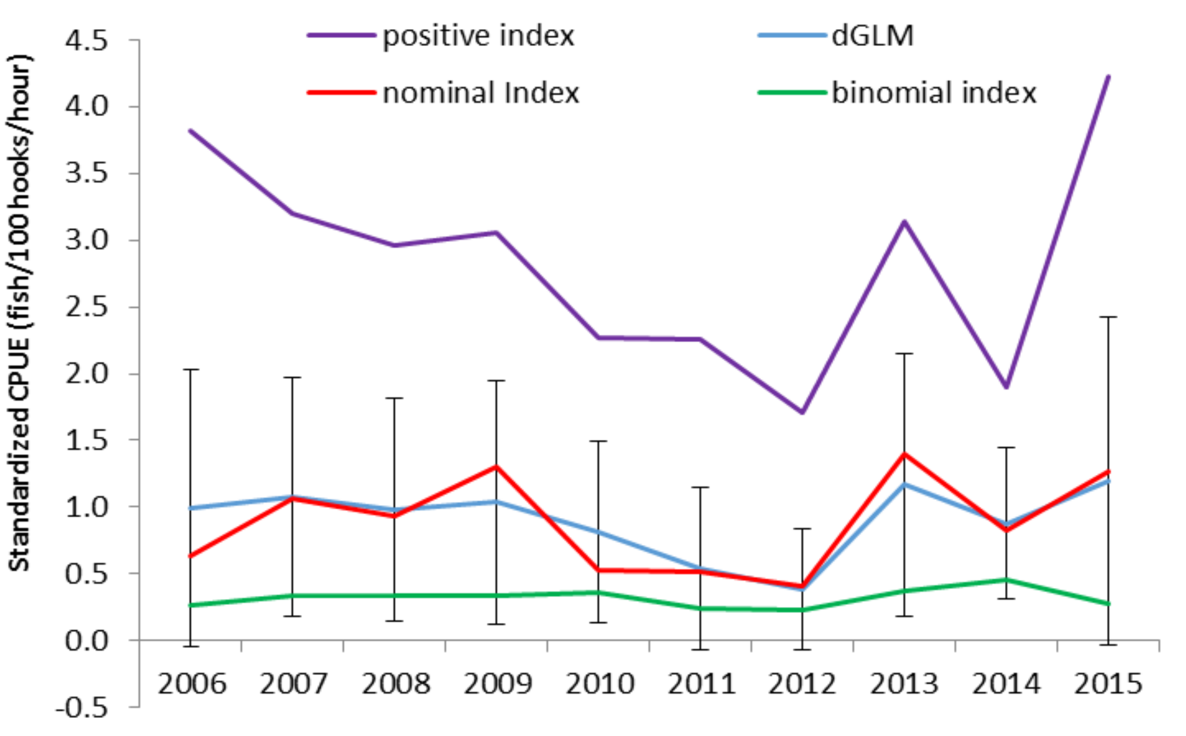


Figure 8. Fishery independent bottom longline abundance indices by year (2006-2015). Error bars represent standard error of the mean.

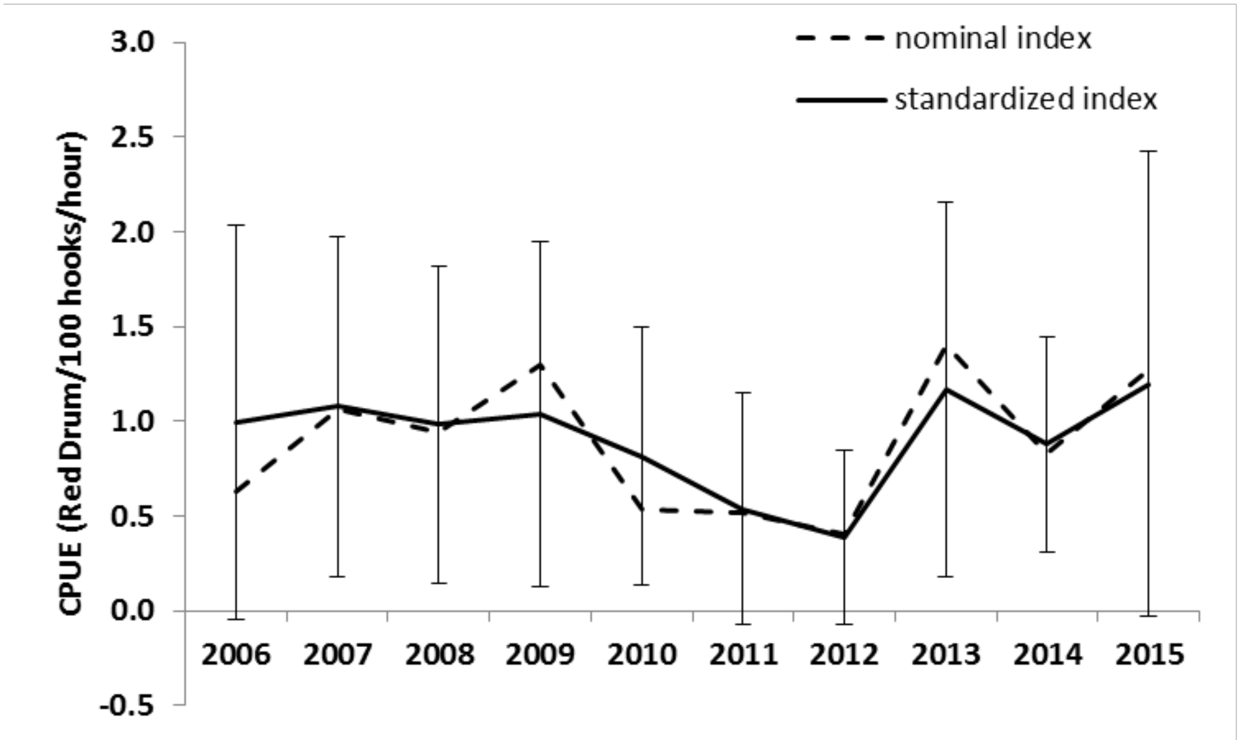


Figure 9. Nominal (dashed line) and standardized (solid line) indices of relative abundance generated from fishery independent bottom longline sampled Red Drum (2006-2015). Error bars represent standard error of the mean.

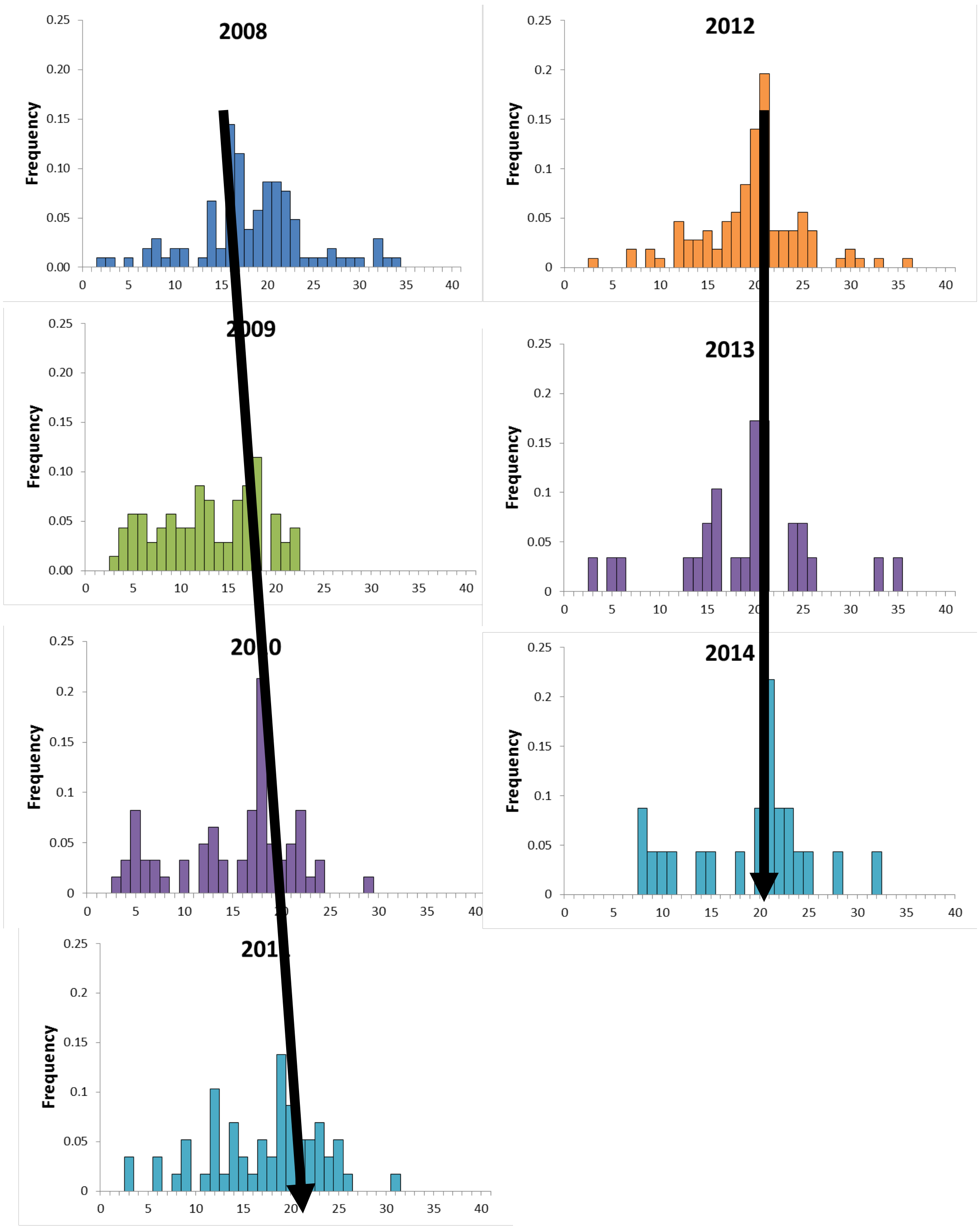
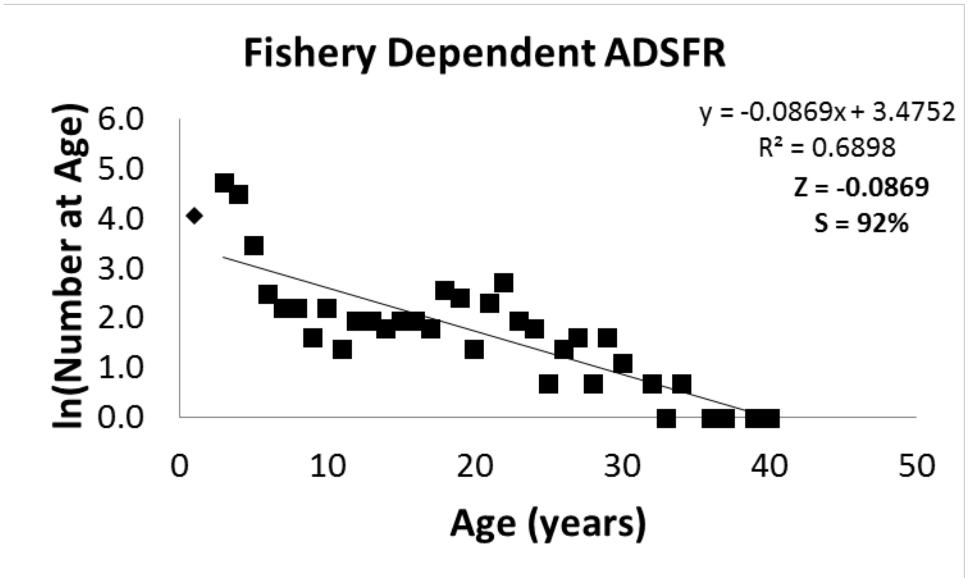


Figure 10. Age composition of the fishery independent BLL by year (2006-2014). Arrows indicate shift in strong year class moving through time.



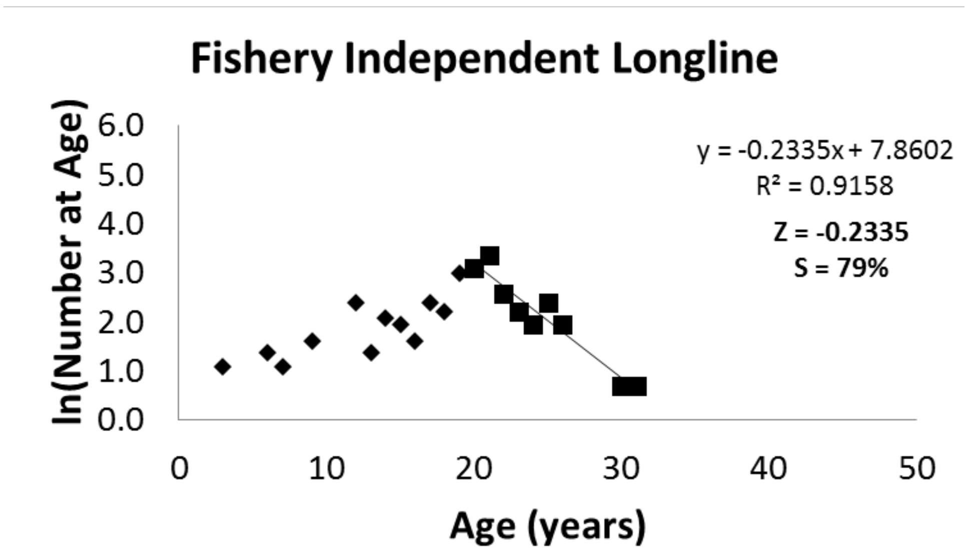


Figure 11. Catch curves used to estimate mortality for Red Drum collected via fishery dependent and independent collections from 2006-2013.