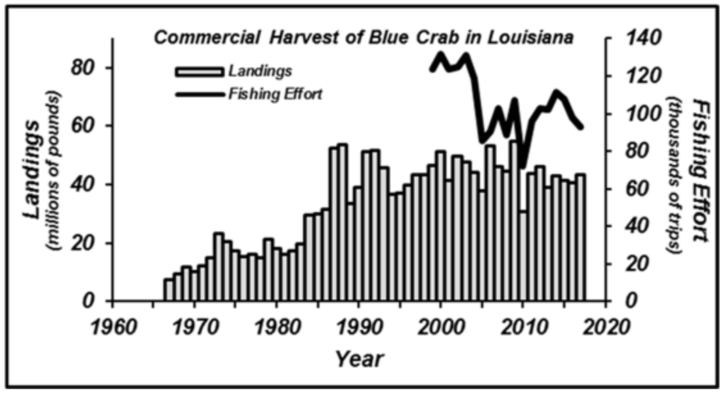
**Update Assessment of Blue Crab in Louisiana Waters**
**2019 Report**

*Executive Summary*

- Based on results of this assessment update, the Louisiana blue crab stock is currently not overfished or exceeding the exploitable biomass target, but was considered overfished in 1995, 2013, and 2015. Further, the stock is currently not experiencing overfishing or exceeding the fishing mortality target.




- Commercial landings of blue crab in Louisiana have remained above 40 million pounds per year since 1997 with the exception of 2005, 2010, and 2013. The highest reported landings were 53.7 and 55.0 million pounds harvested in 1988 and 2009, respectively.
- This assessment update is based on a Collie-Sissenwine or catch-survey analysis and results in estimates of exploitable biomass and recruitment of the Louisiana blue crab stock, 1968-2018. Annual fishing mortality is estimated, but is not available for the last year of the time-series. This assessment model has been extensively used in crustacean stock assessments. Data requirements include a time-series of observed landings and corresponding abundance indices for juvenile and exploitable life stages. Indices of abundance are derived from the Louisiana Department of Wildlife and Fisheries fishery-independent marine inshore trawl survey. Landings are taken from National Marine Fisheries Service statistical records, 1968-1998, and the Louisiana Department of Wildlife and Fisheries Trip Ticket Program, 1999-2018.
- In an earlier assessment (West et al. 2011), explicit limits and targets of fishing were proposed as conservation standards to ensure sustainability of the Louisiana blue crab resource. The Louisiana Wildlife and Fisheries Commission adopted a resolution on February 6, 2014 establishing the following policy based on the proposed limits and targets of fishing: "Should the fishing mortality or exploitable biomass exceed the overfished or overfishing limits, or exceed the targets for three consecutive years, as defined in the most current Louisiana blue crab stock assessment, LDWF shall come before the Commission with an updated assessment and a series of management options for the Commission to review and act upon, intended to keep the fishery from becoming overfished, and that management options for review and action shall include provisions for emergency closures, time based closures, and spatial closures."
- In the 2016 assessment update (West et al. 2016), the Louisiana blue crab stock was identified as overfished. Based on that status, the Louisiana Legislature and the Wildlife and Fisheries Commission took actions to reduce harvest. Management actions included: legislation to modify escape rings and to expand crab trap cleanup abilities; commission rule to ban harvest of immature females, allow seasonal closures of all crab harvest in 2017, and allow seasonal closure of female crab harvest in 2018 and 2019. This update assessment is intended to explore the response of the blue

crab stock to recent environmental conditions and the effectiveness of those management actions enacted.

*Summary of Changes from Previous Assessment*

- Assessment model inputs have been updated through 2018. A correction was made to the assessment model in this update. Recruit abundance is estimated in the time-series terminal year by using the observed relative abundance of juvenile crabs. In the previous assessment update (West et al. 2018), the observed relative abundance of juvenile crabs was also used to generate the recruit abundance estimates in 2015 and 2016 rather than model predicted relative abundance. This correction increased the 2015 and 2016 recruit abundance estimates and lowered the corresponding fishing mortality rate estimates from above the fishing mortality target to below. This correction had no effect on the 2015 and 2016 exploitable biomass estimates.

# Update Assessment of Blue Crab in Louisiana Waters
# 2019 Report

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## *1. Introduction*

A catch-survey or Collie-Sissenwine analysis (Collie and Sissenwine, 1983) is applied to the Louisiana (LA) blue crab *Callinectes sapidus* stock. This model balances the number of individuals from one life stage to the next (i.e., juveniles to exploitable sizes) given constant natural mortality, while scaling these values to harvest. Data requirements are a time-series of observed landings and corresponding abundance indices for juvenile and adult life stages. Indices of abundance are derived from the Louisiana Department of Wildlife and Fisheries (LDWF) fishery-independent marine inshore trawl survey. Landings are taken from National Marine Fisheries Service (NMFS) statistical records, 1968-1998, and the LDWF Trip Ticket Program, 1999-2018.

### *1.1 Regulations*

The Louisiana blue crab fishery and its industry are governed by the Louisiana State Legislature, the Wildlife and Fisheries Commission, and the Department of Wildlife and Fisheries. The Louisiana commercial blue crab fishery is currently regulated with a minimum size limit (i.e., a minimum carapace width of 5 inches) in addition to gear restrictions. Recreationally caught blue crabs are not subject to a minimum size limit. No bag and possession limits exist for the recreational and commercial fisheries.

In the 2016 assessment update (West et al., 2016), the Louisiana blue crab stock was identified as overfished. Based on that status, the Louisiana Legislature and the Wildlife and Fisheries Commission took actions to reduce harvest as described below.

Regulations were enacted by the Wildlife and Fisheries Commission protecting commercially landed immature female blue crabs from harvest provisionally from 2017 through 2019 except when in a pre-molt stage being held for processing as a soft-shell crab. In September 2018, the prohibition on the commercial harvest of immature female blue crabs was made permanent. Additional regulations were also enacted for a seasonal closure of all crab harvest in 2017 (30-day period beginning on 3$^{rd}$ Monday in February) and seasonal closures of all female crab harvest in 2018 and 2019 (March 1$^{st}$ through April 30$^{th}$).

Legislation that become effective November 2017 modified escape ring requirements where each crab trap must now have a minimum of three escape rings that are 2-3/8 inches in inside diameter or larger. Legislation enacted in 2016 expanded crab trap cleanup abilities where at any time crab harvest is closed for biological or technical reasons, the Wildlife and Fisheries commission may prohibit the usage of crab traps for the duration of the closure. Additional legislation was enacted in 2018 allowing the Wildlife and Fisheries Commission to determine the disposition of abandoned crab traps removed from a closed area. This modification will allow future programs to be established, such as trap recycling or buyback programs.

### *1.2 Trends in Harvest*

Trends in harvest were reviewed in the earlier assessment report (West et al. 2011). The time-series of annual LA commercial hard crab landings used in this assessment (1968-2018) is presented (Table 1, Figure 1).

## *2. Data Sources*

*2.1 Fishery Dependent*

Louisiana blue crab commercial harvest is derived from NMFS statistical records, 1968-1998, and the LDWF Trip Ticket program, 1999-2018 (Table 1). A time-series of recreational harvest records currently does not exist. Guillory (1999b) estimates the recreational harvest rate as 4.1% of the reported commercial harvest in a survey of the recreational blue crab fishery in Terrebonne Parish, LA.

*2.2 Fishery Independent*

Blue crab abundance indices are derived from the LDWF fishery-independent marine inshore 16-foot trawl survey. This survey is primarily used to sample peniad shrimp, blue crabs, and bottomfish in inshore bays and lakes. Sampling gear is a 4.9m flat otter trawl with a body and cod-end consisting of 19mm and 6.4mm bar meshes, respectively. Samples are 10 minute tows. All captured crabs are enumerated and a maximum of 50 randomly selected crabs per sample are measured (in 5mm CW bins). When more than 50 crabs are captured, catch-at-size is derived as the product of total catch and proportional subsample-at-size.

The survey has been conducted from 1967 to present at fixed sampling locations. In October of 2010, additional fixed sampling locations were added to this survey. To alleviate time-series bias associated with addition of these new stations, relative abundance time-series used in this assessment are constructed by retaining only the long-term stations for analysis.

Abundance indices are developed for life stages relative to the fishery. These include: 1) adult or exploitable crabs (i.e., ≥125mm CW), 2) juveniles or crabs that will recruit to the fishery during the survey year (i.e., by December 31st), and 3) young-of-the year or crabs that will not recruit to the fishery during the survey year (Tables 2-4). Due to size selectivity of the survey gear, crabs <25mm CW are excluded from index development. Crabs that will not recruit to the fishery during the survey year are identified by seasonal growth functions (see *Growth* section).

Mean catch-per-tow and its variance are calculated by assuming a delta-lognormal distribution. This method is appropriate for log-normally distributed survey datasets when a proportion of zero catches occur (Pennington, 1983; Pennington, 1996). In this case, the means are the product of the proportion of positive catches (assuming a binomial error structure) and the geometric mean catch-per-unit effort of successful trips (assuming a lognormal error structure). Its variance is approximated as:

$$Var(XY) \approx \mu_Y^2\sigma_X^2 + \mu_X^2\sigma_Y^2 + 2\mu_X\mu_Y\rho\sigma_X\sigma_Y \quad [1]$$

where $\mu_Y$ is the binomial mean proportion of positive catches, $\mu_X$ is the geometric mean catch-per-unit-effort of successful tows, $\sigma_Y^2$ and $\sigma_X^2$ are the respective variances, and $\rho$ is the correlation between $X$ and $Y$.

*3. Life History Information*

Guillory et al. (1996) summarized literature and data on the biology and ecology of blue crabs in a source document for the management of the Louisiana blue crab fishery. In addition to describing the fishery and commenting on research needs, the authors described blue crab taxonomy and nomenclature; larval, juvenile and adult morphology; distribution and abundance; habitat utilization; reproduction; age and growth; trophic relationships; behavior; movement and migration; pathology and parasitology; environmental tolerances; recruitment mechanisms; and mortality.

In “The Blue Crab Fishery of the Gulf of Mexico, United States: A Regional Management Plan”, Guillory et al. (2001) developed a broad and comprehensive document addressing all relevant aspects of blue crab biology and the fishery. In addition to describing stock habitat, fishery management jurisdiction, economic and sociocultural characteristics of the fishery, management considerations/recommendations, and research needs, the authors provided detailed information on blue crab life history, including: geographic distribution; classification, morphology and genetic characterization; age, growth and maturation; reproduction; stock-recruitment relationship; larval development, distribution and abundance; megalopal settlement and recruitment; juvenile development, distribution and abundance; seasonal and areal distribution; factors influencing survival; parasites and diseases; food habits; predator/prey relationships; interspecific and intraspecific predation; foraging behavior; larval, juvenile and adult behavior; autonomy; and movements/migrations. This document was updated in 2015 by the Blue Crab Technical Task Force of the Gulf States Marine Fisheries Commission.

### *3.1 Unit Stock Definition*

Adult blue crabs in the northern Gulf of Mexico (GOM) generally remain within one estuary for life. Females, however, migrate to higher salinity nearshore waters to spawn, where larvae are then dispersed offshore via tidal transport (Guillory et al. 2001). Recruitment and settlement of larvae into northern GOM estuaries as megalopae is likely influenced by wind and tidal circulation processes (Perry et al. 1995). Stock mixing between estuaries (and states) is very probable given these larval transport mechanisms. Nonetheless, blue crab landings from the northern Gulf of Mexico (GOM) are primarily of Louisiana origin.

For purposes of this assessment the blue crab unit stock is defined as those crabs occurring in LA waters. This approach is consistent with the current non-regional or statewide management strategy.

### *3.2 Maturity*

Carapace width (CW) at maturity is reported by Guillory and Hein (1997a) for blue crabs from the Terrebonne Basin, LA. Males and females reached 50% sexual maturity at 110mm and 125mm CW, respectively. The CW-at-50% sexual maturity for female crabs corresponds with the minimum size limit of the LA commercial blue crab fishery (i.e., 127mm CW). Males and females reached 100% sexual maturity at 130mm and 160mm CW, respectively.

### *3.3 Growth*

Blue crabs exhibit a discontinuous growth pattern; where growth occurs during the molting process (Guillory et al., 2001). Continuous growth models, however, are used to describe blue crab growth (Helser and Kahn, 2001; Pellegrin et al., 2001; Rugolo et al., 1998; Smith, 1997). In this assessment, Gompertz growth functions developed in the earlier LDWF crab assessment (West et al. 2011) are used to describe LA blue crab growth. The Gompertz model is configured as:

$$CW_t = CW_\infty e^{\alpha(e^{\beta t})} \quad [2]$$

where $CW_t$ is CW-at-age, $CW_\infty$ is the asymptotic average maximum CW, and $\alpha$ and $\beta$ are constant growth coefficients. The seasonal and non-seasonal parameter estimates are presented in Table 5.

A monthly size-at-capture matrix is developed from the seasonal growth functions (Table 6) to identify crabs that will not recruit to the fishery during the survey year (i.e., by December 31$^{st}$). This matrix represents CW-at-capture of monthly crab cohorts and implies variation in CW-at-age is primarily due to time of hatching. Carapace widths of crabs not fully-recruited to the trawl gear (i.e., < 25mm CW) are excluded. Rows represent monthly cohorts (or seasonal growth trajectories), with the current year-class above the diagonal and the previous year-class below the diagonal. Columns represent months of the LDWF fishery independent trawl survey. As an example, blue crabs captured by the trawl survey in August that are ≤63mm CW (or the current year's March-August cohorts) are considered young-of-the year crabs.  An obvious discrepancy exists for the survey month of June, where the previous years' December cohort is approximately the same size as the current years' March cohort. To account for this, young-of-the-year crabs are only identified from July-December captures.

*<u>3.4 Morphometrics</u>*

Carapace width-weight regressions were developed by Guillory and Hein (1997a) for blue crabs from the Terrebonne Basin, LA. For the purpose of this assessment, only the pooled (or non-sex specific) model is used. Blue crab weight at CW is calculated from:

$$W = 8.26 \times 10^{-4} CW^{2.446} \quad [3]$$

where $W$ is weight in grams and $CW$ is carapace width in mm.

*<u>3.5 Natural Mortality</u>*

Due to the difficulty of directly estimating instantaneous natural mortality (M) of blue crab, M is estimated based on assumptions of maximum age and the proportion of the stock surviving to the maximum age (Quinn and Deriso, 1999). Reported maximum age of blue crab along the Atlantic Coast range from 3-6 years (Kahn and Helser, 2005; Miller et al., 2005; Murphy et al., 2007). There are no longevity estimates for blue crab in the GOM (Guillory et al., 2001). Instantaneous natural mortality in this assessment is estimated as M=1.0, based on the assumption that approximately 5% of the stock remains alive to 3 years of age.

*<u>3.6 Relative Productivity/Resilience</u>*

Productivity is a function of fecundity, growth rates, natural mortality, age of maturity, and longevity and can be a reasonable proxy for resilience. We characterize the relative productivity of GOM blue crab based on life-history characteristics, following methods described in SEDAR 9 (SEDAR, 2006), with a classification scheme developed at the FAO second technical consultation on the suitability of the CITES criteria for listing commercially-exploited aquatic species (FAO 2001; Table 7). Each life history characteristic (von Bertalanffy growth rate, age at maturity, longevity, and natural mortality rate) was assigned a rank (low=1, medium=2, and high=3) and then averaged to compute an overall productivity score. Parameter estimates are taken from West et al. (2011) and VanderKooy (2013). In this case, the overall productivity score is 3.0 for GOM blue crab indicating high productivity and resilience.

*4. Assessment Model*

A catch-survey (CS) or Collie-Sissenwine analysis (Collie and Sissenwine, 1983) is used in this assessment to describe the dynamics of the LA blue crab stock. The CS modeling approach is intended for data moderate situations where a full age structure is lacking. Model requirements include: 1) annual abundance indices for juvenile and adult life stages, 2) annual harvest estimates as individuals, 3) an estimate of instantaneous natural mortality, and 4) the relative selectivity of the juvenile and adult life stages to the survey gear.

*4.1 Catch-Survey Model Configuration*

The CS model is based on the modified Delury discrete difference equation (Collie and Sissenwine, 1983):

$$N_{y+1} = (N_y + R_y - C_y)e^{-M} \quad [4]$$

where $y$ is the fishing and survey year (i.e., January 1st through December 31st), $N_y$ is the abundance of adult crabs in that year, $N_{y+1}$ is the abundance of adult crabs in the following year, $R_y$ is the abundance of juveniles, $C_y$ is harvest as individuals, and $M$ is the constant natural mortality rate. To approximate landings occurring throughout the year, the model equation is reconfigured as:

$$N_{y+1} = \left[\left(N_y + R_y\right)e^{-0.50M} - C_y\right)\right]e^{-0.50M} \quad [5]$$

where juvenile and adult crabs are reduced by a half year of natural mortality before the catch is removed. Remaining survivors from the fishery are then reduced by another half year of natural mortality.

Survey indices of abundance are scaled to absolute abundance as:

$$n_y = q_n N_y e^{\eta_y} \text{ and } r_y = q_r R_y e^{\delta_y} \quad [6, 7]$$

where $r_y$ and $n_y$ are the observed abundance indices of juvenile and adult blue crabs, $q_r$ and $q_n$ are the respective catchabilities of the survey gear for juvenile and adult crabs, and $e^{\delta_y}$ and $e^{\eta_y}$ are the log-normally distributed observation errors for the juvenile and adult abundance indices. Reconfiguring the model equation by substituting abundance indices for absolute abundance and incorporating lognormal process error $e^{\varepsilon_y}$ yields:

$$n_{y+1} = \left[\left(n_y + \frac{r_y}{s_r}\right)e^{-0.50M} - q_n C_y\right)\right]e^{-0.50M}e^{\varepsilon_y} \quad [8]$$

where $s_r = \frac{q_r}{q_n}$ is the relative selectivity of juveniles to adult crabs in the sampling gear. Log-normal process error $e^{\varepsilon_y}$ is taken as the difference between $n_y$ calculated from equations [6] and [8]. Equation [8] is solved iteratively by minimizing the following objective function:

$$SSQ(\Theta_{CS}) = \lambda_\varepsilon \sum_{y=2}^{Y} \varepsilon_y^2 + \sum_{y=1}^{Y} \eta_y^2 + \lambda_\delta \sum_{y=1}^{Y-1} \delta_y^2$$

[9]

where $\Theta_{CS}$ is the parameter vector and $\lambda_{\varepsilon}$ and $\lambda_{\delta}$ are user-defined weights of the process and juvenile observation error relative to the adult observation error. Thus, $2Y$ parameters are estimated: $n_y$ for all years, $r_y$ for all years except the terminal year, and $q_n$. Given these estimates, absolute abundances are estimated from the following:

$$R_y = \frac{\hat{r}_y}{s_r \hat{q}_n} \text{ and } N_y = \frac{\hat{n}_y}{\hat{q}_n} \quad [10, 11]$$

where $\hat{r}_y$ and $\hat{n}_y$ are the model estimated abundance indices of juvenile and adult crabs, respectively, and $\hat{q}_n$ is the model estimated catchability of adult crabs to the survey gear. Recruit abundance is estimated in the terminal year by using observed $r_y$.

*4.2 Fishing Mortality Estimation*

Annual estimates of instantaneous total mortality are derived from the following survival ratio:

$$Z_y = log_e \left[\frac{N_y + R_y}{N_{y+1}}\right] \quad [12]$$

Estimating annual instantaneous fishing mortality $F_y$ from $Z_y - M$ would include $R_y$ (or crabs not available to the fishery) into the fishing mortality calculation. Because harvest occurs concurrently with $M$ in this fishery (i.e., type II fishery; Ricker, 1975) and to avoid additional bias from $F_y = Z_y - M$, we estimate $F_y$ from the following rearrangement of Baranov's catch equation:

$$F_y = \frac{u_y Z_y}{1 - e^{-Z_y}} \quad [13]$$

where annual exploitation is estimated as:

$$u_y = \left[\frac{C_y}{(R_y + N_y)}\right] \quad [14]$$

*4.3 Biomass Conversions*

Annual size distributions of Louisiana blue crab landings currently do not exist. Due to this lack of fishery dependent information, annual size distributions of blue crab captured from the LDWF FI marine inshore trawl survey are used as proxies to describe the annual size compositions of blue crab landings (see *Research and Data Needs*).

Annual landings in biomass are converted to individuals as:

$$C_y = H_y / \overline{W}_{y,\geq 125mm} \quad [15]$$

where $C_y$ is annual harvest as individuals, $H_y$ is annual harvest as biomass, and $\overline{W}_{y,\geq 125mm}$ are annual mean weights of adult blue crab catches derived from the LDWF FI marine inshore trawl survey (Table 8).

Model estimated abundance is converted to biomass as:

$$B_y = R_y \overline{W}_{y,<125mm} + N_y \overline{W}_{y,\geq 125mm} \quad [16]$$

where $B_y$ is total annual biomass, $R_y$ and $N_y$ are model estimated annual abundances of juvenile and adult crabs, and $\overline{W}_{y,<125mm}$ and $\overline{W}_{y,\geq 125mm}$ are annual mean weights of juvenile and adult blue crab catches derived from the LDWF FI marine inshore trawl survey (Table 8).

*4.4 Model Inputs / Assumptions*

Catch-survey model assumptions are: 1) the stock is closed to migration, 2) natural mortality occurs at a constant rate, and 3) all surviving recruits will grow into the fully-recruited stage within the model year. Survey indices of abundance are assumed proportional to absolute abundance. Crabs greater than 25mm CW are assumed equally vulnerable to the survey gear implying $s_r$=1.0. Relative weights $\lambda_\varepsilon$ and $\lambda_\delta$ are fixed as 1.0 in this assessment.

Louisiana blue crab harvest is derived from commercial hard crab landings, which include: NMFS statistical records, 1968-1998, and the LDWF Trip Ticket Program, 1999-2018 (Table 1). Commercial hard crab landings as individuals are expanded by 5% to approximate for recreational harvest. This rate is consistent with Guillory's (1999b) survey of the recreational blue crab fishery in Terrebonne Parish, LA.

Through simulation analysis, Mesnil (2003) demonstrates how staging error (i.e., analogous to aging error in a VPA) can bias estimates of absolute abundance and recommends "carefully allocating members to either stage". Individuals that will not recruit to the fishery during the survey year are accounted for by reconfiguring $r_y$ as the sum of the young-of-the-year index in year and the juvenile index in year+1 (Table 9). This creates an index where all surviving recruits will recruit to legal-size within the survey year.

*4.5 Model Results*

The assessment model provides reasonable fits to the adult and juvenile abundance indices (Figures 2-4); however, patterning of the residuals is apparent in the more recent years of the time-series where model predictions of adult relative abundance are consistently underestimated and model predictions of juvenile relative abundance are consistently overestimated. The juvenile index suggests a considerable decline over the latter half of the time-series examined. The assessment model tracks this decline, but underestimates its magnitude suggesting additional processes aren't captured by the assessment model (e.g. temporal, spatial, and/or environmental; see *Research and Data Needs* Section).

The catchability coefficient is estimated as $\hat{q}_n$ =0.0045 in this assessment. Annual exploitable (adult) biomass estimates range from 16 to 97 million pounds (Table 10, Figure 5). The 2018 exploitable biomass estimate is 40 million pounds. Exploitable biomass levels generally decline after 1990, where estimates from previous years were rarely below 40 million pounds. Increases in exploitation during the 1990s coincide with this decline (Figure 6). A large population response is evident in the years following the passages of Hurricane Katrina and Rita which caused a substantial reduction in the directed effort and supporting infrastructure of the Louisiana commercial blue crab fleet. These storms also provided optimum environmental conditions for settlement of megalopae and young crabs into Louisiana estuaries via storm surge and likely enhanced recruitment.

Juvenile abundance estimates range from 169 to 602 million individuals (Table 10, Figure 5) and exhibit a considerable decline over the latter half of the time-series examined. The nine most recent juvenile abundance estimates are the lowest on record with the exception of the 1976 estimate. The 2018 juvenile abundance estimate (169 million individuals) is the lowest on record. Additionally, in the last twenty years only one juvenile abundance estimate is above the time-series average and in the most recent decade no estimates are above the time-series average (Figure 7). It's important to point out here the consequence of this decline on management reference point estimation. Because equilibrium conditions (i.e., average recruitment) are assumed in reference point estimation, biomass-based management benchmarks will generally be biased when below average conditions persist for extended time periods.

Annual instantaneous fishing mortality estimates range from 0.07-0.88, with peaks in exploitation occurring in 2002, 2012 and 2014 (Table 10, Figure 8). Trends in fishing mortality estimates, 1999-2017, are generally consistent with fishing effort (i.e., trap fisher trips) derived from the LDWF Trip Ticket Program (Figure 8). A large reduction in fishing mortality/effort was observed in the years following the passages of Hurricane Katrina and Rita. Fishing effort is not used in the assessment model but is presented here to validate trends in fishing mortality. However, the number of trap fisher trips may not be a suitable measure of fishing effort (specifically for catch per unit effort analysis) if the number of traps fished per trip increases (or decreases) through time and should be considered with caution.

A downward trend has become apparent between exploitable biomass and subsequent recruitment (Figure 9). With one exception, the two most recent decades of data pairs are all below the recruitment time-series average and are some of the lowest adult biomasses observed.

*4.6 Management Benchmarks*

Overfishing and overfished limits should be defined for exploitable stocks. The implication is that when biomass falls below a specified limit, there is an unacceptable risk that recruitment will be reduced to undesirable levels. Management actions are needed to avoid approaching this limit and to recover the stock if biomass falls below the limit.

Precautionary limits to fishing were established in an earlier assessment (West et al. 2011) by requiring that exploitable biomass not fall below the three lowest levels observed (1968-2009) where the stock demonstrated sustainability (i.e., no observed declines in recruitment over a wide-range of exploitable biomasses). This is equivalent to maintaining the stock above a limit spawning potential ratio (SPR; Goodyear, 1993). The method for calculating $SPR_{limit}$ or equivalently $SSB_{limit}$ is presented below.

Equilibrium recruitment (under current biomass) is assumed as the average recruitment $\bar{R}$, 1968-2017. This is the horizontal line in Figure 10. Exploitable biomass (i.e., crabs ≥125mm) is used as a measure of spawning stock biomass (SSB). When the stock is in equilibrium, equations [5, 12, and 13] can be rearranged excluding the year index into SSB/R for any given exploitation rate as:

$$\frac{SSB}{R}|F = \sum_a p_{Na} W_a \times \frac{e^{-M} - F/Z(1-e^{-Z})e^{-0.5M}}{1-[e^{-M} - F/Z(1-e^{-Z})e^{-0.5M}]} \quad [17]$$

where $a$ are ages in months ($a = 1\ to\ 36$), $p_{Na}$ is the proportional equilibrium abundance of crabs ≥125mm (see below), $W_a$ is the average weight-at-age, and $M, F, Z$ are the instantaneous natural, fishing and total mortality rates. Equilibrium abundance-at-age is estimated as:

$$N_a = \bar{R} S_a \quad [18]$$

where survivorship is calculated recursively from $S_a = S_{a-1}e^{-Z_a}$ , $S_1 = 1$. Size-at-age, vulnerability-at-age $v_a$ (i.e., knife-edged selection for ages ≥125mm) and resulting monthly mortality vectors (i.e., $Z_a = M/12 + F_a$ and $F_a = v_a F/12$) are derived from the non-seasonal Gompertz growth parameters (Table 5). To approximate changes in growth through the age interval, size-at-age is calculated using the midpoints of the months. Equilibrium $N_a$ of exploitable sized crabs is normalized to 1 as $p_{Na}=\frac{N_{a\geq 125mm}}{\sum_a N_{a\geq 125mm}}$.

If the biomass limit is chosen as the geometric mean of the three lowest exploitable biomasses observed (1968-2009), then the recruitment per SSB ($R/SSB_{limit}$) that is equivalent to the biomass limit is the slope of the diagonal line from the origin that intersects equilibrium recruitment at $SSB_{limit}$. This is the left-most diagonal line in Figure 10; unfished recruits per SSB ($R/SSB_{F=0}$) is a slope equivalent to the rightmost diagonal line.

The equilibrium SPR corresponding with the exploitable biomass limit is:

$$SPR_{limit} = \frac{R/SSB_{F=0}}{R/SSB_{limit}} \quad [19]$$

and is estimated to be 21.0%. This is equivalent to specifying $SSB_{limit}$ equal to the average of the three years with the lowest biomasses (1968-2009) in which the stock demonstrated sustainability. Additionally, equations [17, 19] are solved for the fishing mortality rates that correspond with the $SPR_{limit}$ and a $SPR_{target}$ discussed below.

*Overfishing, Overfished, and Target Definitions*

The existing Louisiana blue crab data does not allow reliable estimates of MSY. Therefore, we have defined a limit based upon the history of the fishery as defined above (i.e., a 21.0% $SPR_{limit}$). The fishing mortality rate limit $F_{limit}$ and $SSB_{limit}$ that are equivalent to this $SPR_{limit}$ are estimated as 0.93 years$^{-1}$ and 19.4 million pounds, respectively (Table 11).

The targets of fishing, (i.e., SSB, F, and SPR) should not be so close to the limits that the limits are exceeded by random variability of the environment. Therefore, the biomass target reference point $SSB_{target}$ is defined as $SSB_{limit} \times 1.5$, or 29.1 million pounds. This biomass is achieved when there is an equilibrium $SPR_{target}$ of 31.5% and $F_{target}$ of 0.70 years$^{-1}$ (Table 11).

*5. Stock Status*

The history of the Louisiana blue crab stock relative to the reference points described above is illustrated in Figures 11 and 12. Fishing mortality rates exceeding $F_{limit}$ (or ratios of $F/F_{limit}>1.0$) indicate overfishing; stock biomasses below $SSB_{limit}$ (or ratios of $SSB/SSB_{limit}<1.0$) indicate an overfished condition.

*Overfishing Status*

The 2017 estimate of F/Flimit is 0.60 suggesting the stock is not currently experiencing overfishing. The 2017 fishing mortality rate estimate is also below its target. Estimates of fishing mortality are not available for the terminal year of the assessment.

*Overfished Status*

The 2018 estimate of SSB/SSBlimit is 2.05, suggesting the stock is currently not in an overfished condition. The 2018 SSB estimate is also above its target. The stock was considered overfished in 1995, 2013, and 2015.

*Control Rule*

The Louisiana Wildlife and Fisheries Commission adopted a resolution on February 6, 2014 establishing the following policy based on the overfishing and overfished limits and targets of fishing described above: "Should the fishing mortality or exploitable biomass exceed the overfished or overfishing limits, or exceed the targets for three consecutive years, as defined in the most current Louisiana blue crab stock assessment, LDWF shall come before the Commission with an updated assessment and a series of management options for the Commission to review and act upon, intended to keep the fishery from becoming overfished, and that management options for review and action shall include provisions for emergency closures, time based closures, and spatial closures."

In an earlier assessment update (West et al., 2016), the Louisiana blue crab stock was identified as overfished. Based on that status, the Louisiana Legislature and the Wildlife and Fisheries Commission took actions to reduce harvest. This update assessment is intended to be the second measure of the effectiveness of those management actions enacted.

*7. Research and Data Needs*

Research emphasis on the Louisiana blue crab fishery is lacking, particularly in consideration of the value and size of the fishery (Guillory et al. 1996). The authors suggest that blue crab research done on the Atlantic coast may not be applicable to Gulf of Mexico populations. Based on this assessment, the following research and data needs are identified as priorities for future assessment of the Louisiana blue crab stock.

Due to the rapid growth and short life span of blue crab an annual time-step in the assessment model may not adequately describe the population dynamics of blue crab. Future assessment modeling efforts should explore finer temporal scales.

Environmental factors influencing year-class strength and the survival of recruits to exploitable life stages are not well understood. Further analysis of these factors could elucidate the link between the environment and blue crab productivity. Contributing factors could also be used in development of predictive models allowing for short-term forecasts for resource managers and industry.

In addition to research specific to the Louisiana blue crab stock, continuous fishery dependent monitoring programs, as part of a comprehensive monitoring plan, are needed. Differences in exploitation rates of male and female blue crabs likely exist. Continuous information on size and sex distributions of the commercial and recreational harvest are not available. Continuous harvest data for the recreational sector is also lacking. These data would reduce the number of assumptions required in future assessments.

The magnitude of blue crab catch in the trawl fishery and the associated mortality is currently unknown. In this assessment, this mortality was assumed negligible. Future estimates of blue crab catches in trawls and the mortality induced would reduce the number of assumptions required in future assessments.

Commercial effort data is currently only available in terms of the number of trips taken. A more useful measure of effort that could improve future blue crab stock assessment and management is the number of traps fished by basin/season/region.

Estimates of natural mortality in this assessment are based on assumptions of longevity. Without the ability to directly age blue crabs with conventional methods, growth estimation and resulting longevity estimates remain difficult to quantify. Estimates of these life history parameters for the Louisiana blue crab stock, perhaps from tagging or pond studies, would aid in refining life history assumptions in future assessments.

Assessment of regional or basin-specific sub-populations could differentiate exploitation rates and stock status within the state. If available data is adequate for regional assessment, results could be used to determine if regional management is an effective alternative to optimize yield within the state.

The relationship between wetlands losses and the continuation of fishery production within Louisiana has been discussed by numerous authors. Understanding this relationship as it applies to the Louisiana blue crab stock should be an ongoing priority.

With the recent trend toward ecosystem-based assessment models, more data is needed linking blue crab population dynamics to environmental conditions. The addition of environmental data coupled with food web data may lead to a better understanding of the blue crab stock and its habitat.

Fishery dependent data alone is not sufficient to accurately assess stock status and trends in abundance. Consistent fishery independent monitoring, in addition to fishery dependent monitoring, are integral components of this ability. Present monitoring programs should be assessed for adequacy with respect to their ability to evaluate stock status and should be modified or enhanced to optimize their capabilities.

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## 10. Tables

Table 1: Louisiana blue crab *Callinectes sapidus* landings and dockside value (1968-2018). Landings and values, 1968-1998, are taken from NMFS statistical records. Landings and values, 1999-2018 (shaded values), are taken from the LDWF Trip Ticket Program. Landings are millions of pounds. Values are millions of dollars.

| | **Total** | | **Hard crab** | | **% Hard crabs** | | **Soft/peeler** | | **% Soft/peeler** | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | Landings | Value | Landings | Value | Landings | Value | Landings | Value | Landings | Value |
| 1968 | 9.83 | 1.01 | 9.55 | 0.81 | 97.11 | 79.64 | 0.28 | 0.21 | 2.89 | 20.36 |
| 1969 | 11.80 | 1.23 | 11.60 | 1.07 | 98.33 | 86.93 | 0.20 | 0.16 | 1.67 | 13.07 |
| 1970 | 10.34 | 1.01 | 10.25 | 0.93 | 99.13 | 92.11 | 0.09 | 0.08 | 0.87 | 7.89 |
| 1971 | 12.31 | 1.38 | 12.19 | 1.26 | 98.97 | 90.90 | 0.13 | 0.13 | 1.03 | 9.10 |
| 1972 | 15.18 | 1.89 | 15.08 | 1.78 | 99.33 | 94.21 | 0.10 | 0.11 | 0.67 | 5.79 |
| 1973 | 23.20 | 2.94 | 23.08 | 2.81 | 99.48 | 95.53 | 0.12 | 0.13 | 0.52 | 4.47 |
| 1974 | 20.74 | 2.83 | 20.64 | 2.70 | 99.54 | 95.51 | 0.10 | 0.13 | 0.46 | 4.49 |
| 1975 | 17.25 | 2.67 | 17.14 | 2.51 | 99.36 | 94.18 | 0.11 | 0.16 | 0.64 | 5.82 |
| 1976 | 15.30 | 3.21 | 15.21 | 3.06 | 99.42 | 95.48 | 0.09 | 0.14 | 0.58 | 4.52 |
| 1977 | 16.38 | 4.33 | 16.15 | 3.77 | 98.63 | 86.86 | 0.22 | 0.57 | 1.37 | 13.14 |
| 1978 | 15.21 | 3.47 | 15.07 | 3.19 | 99.13 | 92.04 | 0.13 | 0.28 | 0.87 | 7.96 |
| 1979 | 21.48 | 5.11 | 21.33 | 4.78 | 99.32 | 93.40 | 0.15 | 0.34 | 0.68 | 6.60 |
| 1980 | 18.30 | 4.60 | 18.18 | 4.33 | 99.35 | 94.06 | 0.12 | 0.27 | 0.65 | 5.94 |
| 1981 | 16.34 | 4.71 | 16.24 | 4.47 | 99.39 | 94.94 | 0.10 | 0.24 | 0.61 | 5.06 |
| 1982 | 17.45 | 5.28 | 17.28 | 4.84 | 99.06 | 91.82 | 0.16 | 0.43 | 0.94 | 8.18 |
| 1983 | 19.72 | 6.66 | 19.62 | 6.37 | 99.49 | 95.64 | 0.10 | 0.29 | 0.51 | 4.36 |
| 1984 | 29.69 | 8.40 | 29.62 | 8.19 | 99.75 | 97.58 | 0.08 | 0.20 | 0.25 | 2.42 |
| 1985 | 29.93 | 8.59 | 29.85 | 8.39 | 99.73 | 97.68 | 0.08 | 0.20 | 0.27 | 2.32 |
| 1986 | 31.69 | 9.48 | 31.61 | 9.30 | 99.75 | 98.09 | 0.08 | 0.18 | 0.25 | 1.91 |
| 1987 | 52.48 | 20.51 | 52.34 | 20.13 | 99.74 | 98.19 | 0.14 | 0.37 | 0.26 | 1.81 |
| 1988 | 53.72 | 21.89 | 53.55 | 21.45 | 99.70 | 97.99 | 0.16 | 0.44 | 0.30 | 2.01 |
| 1989 | 33.56 | 15.20 | 33.39 | 14.78 | 99.49 | 97.23 | 0.17 | 0.42 | 0.51 | 2.77 |
| 1990 | 39.14 | 14.83 | 38.89 | 14.21 | 99.36 | 95.81 | 0.25 | 0.62 | 0.64 | 4.19 |
| 1991 | 51.29 | 17.77 | 51.09 | 17.47 | 99.61 | 98.32 | 0.20 | 0.30 | 0.39 | 1.68 |
| 1992 | 51.98 | 27.20 | 51.74 | 26.67 | 99.54 | 98.04 | 0.24 | 0.53 | 0.46 | 1.96 |
| 1993 | 45.95 | 24.47 | 45.85 | 24.04 | 99.79 | 98.26 | 0.10 | 0.43 | 0.21 | 1.74 |
| 1994 | 36.76 | 22.53 | 36.66 | 22.09 | 99.73 | 98.07 | 0.10 | 0.44 | 0.27 | 1.93 |
| 1995 | 36.97 | 29.54 | 36.91 | 29.05 | 99.86 | 98.36 | 0.05 | 0.48 | 0.14 | 1.64 |
| 1996 | 40.00 | 24.48 | 39.90 | 23.96 | 99.75 | 97.89 | 0.10 | 0.52 | 0.25 | 2.11 |
| 1997 | 43.53 | 27.74 | 43.44 | 27.14 | 99.80 | 97.86 | 0.09 | 0.59 | 0.20 | 2.14 |
| 1998 | 43.66 | 30.74 | 43.48 | 29.34 | 99.59 | 95.45 | 0.18 | 1.40 | 0.41 | 4.55 |
| 1999 | 46.66 | 26.18 | 46.35 | 25.46 | 99.33 | 97.25 | 0.31 | 0.72 | 0.67 | 2.75 |
| 2000 | 52.04 | 34.40 | 51.44 | 33.23 | 98.84 | 96.62 | 0.60 | 1.16 | 1.16 | 3.38 |
| 2001 | 41.87 | 32.05 | 41.46 | 30.98 | 99.04 | 96.66 | 0.40 | 1.07 | 0.96 | 3.34 |
| 2002 | 50.08 | 30.69 | 49.71 | 29.76 | 99.26 | 96.99 | 0.37 | 0.92 | 0.74 | 3.01 |
| 2003 | 48.09 | 33.63 | 47.70 | 32.60 | 99.20 | 96.94 | 0.38 | 1.03 | 0.80 | 3.06 |
| 2004 | 44.41 | 29.70 | 44.08 | 28.83 | 99.26 | 97.08 | 0.33 | 0.87 | 0.74 | 2.92 |
| 2005 | 38.12 | 27.41 | 37.90 | 26.83 | 99.42 | 97.89 | 0.22 | 0.58 | 0.58 | 2.11 |
| 2006 | 53.29 | 32.31 | 53.15 | 31.91 | 99.74 | 98.77 | 0.14 | 0.40 | 0.26 | 1.23 |
| 2007 | 46.20 | 35.77 | 46.00 | 35.22 | 99.56 | 98.45 | 0.20 | 0.55 | 0.44 | 1.55 |
| 2008 | 44.66 | 34.61 | 44.56 | 34.32 | 99.77 | 99.15 | 0.10 | 0.29 | 0.23 | 0.85 |
| 2009 | 54.99 | 38.43 | 54.78 | 37.89 | 99.62 | 98.59 | 0.21 | 0.54 | 0.38 | 1.41 |
| 2010 | 30.90 | 30.50 | 30.76 | 30.10 | 99.56 | 98.69 | 0.13 | 0.40 | 0.44 | 1.31 |
| 2011 | 43.97 | 36.91 | 43.78 | 36.32 | 99.57 | 98.41 | 0.19 | 0.58 | 0.43 | 1.59 |
| 2012 | 46.38 | 44.15 | 46.22 | 43.64 | 99.65 | 98.84 | 0.16 | 0.51 | 0.35 | 1.16 |
| 2013 | 39.22 | 51.65 | 39.08 | 51.24 | 99.64 | 99.20 | 0.14 | 0.41 | 0.36 | 0.80 |
| 2014 | 43.30 | 67.15 | 43.13 | 66.65 | 99.61 | 99.25 | 0.17 | 0.50 | 0.39 | 0.75 |
| 2015 | 41.47 | 58.43 | 41.28 | 57.88 | 99.55 | 99.07 | 0.19 | 0.55 | 0.45 | 0.93 |
| 2016 | 40.79 | 50.18 | 40.63 | 49.71 | 99.61 | 99.06 | 0.16 | 0.47 | 0.39 | 0.94 |
| 2017 | 44.11 | 54.72 | 43.98 | 54.33 | 99.72 | 99.28 | 0.12 | 0.39 | 0.28 | 0.72 |
| 2018 | 43.70 | 61.85 | 43.59 | 61.39 | 99.75 | 99.26 | 0.11 | 0.46 | 0.25 | 0.74 |

Table 2: Catch-per-unit-effort of adult blue crab *Callinectes sapidus*. Abundance indices are the delta-lognormal mean of fully-recruited crabs per tow from the LDWF fishery-independent marine trawl survey, 1967-2018. Adult crabs are≥125mm carapace width. Shaded areas represent the maximum of the monthly-cpue distributions.

| Catch-per-unit- effort (adults) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sept** | **Oct** | **Nov** | **Dec** | **est** | **CV** |
| **1967** | 1.4 | 0.3 | 1.4 | 0.8 | 1.1 | 1.6 | 1.6 | 1.1 | 0.9 | 0.6 | 0.4 | 0.7 | 0.9 | 0.5 |
| **1968** | 0.5 | 0.3 | 0.9 | 1.1 | 0.8 | 1.3 | 1.0 | 0.6 | 0.8 | 0.8 | 0.5 | 0.5 | 0.7 | 0.5 |
| **1969** | 0.3 | 0.2 | 0.4 | 0.9 | 0.7 | 1.2 | 0.9 | 0.9 | 0.7 | 0.8 | 0.6 | 1.4 | 0.7 | 0.6 |
| **1970** | 0.7 | 1.3 | 1.4 | 1.8 | 1.1 | 1.2 | 1.0 | 0.9 | 1.3 | 0.6 | 1.2 | 1.2 | 1.1 | 0.5 |
| **1971** | 0.6 | 0.7 | 1.3 | 1.1 | 1.8 | 1.7 | 1.5 | 1.3 | 0.8 | 0.6 | 0.6 | 0.9 | 1.1 | 0.5 |
| **1972** | 0.7 | 0.9 | 1.7 | 1.0 | 0.8 | 1.3 | 0.5 | 1.0 | 0.9 | 0.8 | 0.8 | 0.5 | 0.9 | 0.5 |
| **1973** | 0.2 | 0.4 | 0.6 | 0.7 | 1.3 | 1.2 | 1.8 | 1.2 | 0.8 | 0.9 | 0.8 | 0.6 | 0.9 | 0.5 |
| **1974** | 0.7 | 0.5 | 0.8 | 1.2 | 1.4 | 1.9 | 1.4 | 1.3 | 0.7 | 1.0 | 0.8 | 0.4 | 1.0 | 0.5 |
| **1975** | 0.8 | 0.5 | 0.5 | 0.6 | 0.7 | 1.1 | 1.9 | 0.9 | 0.6 | 0.5 | 0.5 | 0.3 | 0.8 | 0.5 |
| **1976** | 0.2 | 0.6 | 0.7 | 0.9 | 0.5 | 0.9 | 0.5 | 0.5 | 0.2 | 0.1 | 0.2 | 0.2 | 0.5 | 0.6 |
| **1977** | . | 0.1 | 0.3 | 0.1 | 0.2 | 0.6 | 0.5 | 0.7 | 0.2 | 0.6 | 0.6 | 0.7 | 0.4 | 0.7 |
| **1978** | 0.1 | 0.1 | 0.2 | 0.2 | 0.7 | 0.7 | 1.3 | 0.8 | 0.5 | 0.4 | 0.7 | 0.2 | 0.5 | 0.6 |
| **1979** | 0.1 | 0.2 | 0.6 | 0.5 | 0.4 | 1.4 | 1.4 | 0.9 | 0.9 | 0.9 | 0.7 | 0.4 | 0.8 | 0.5 |
| **1980** | 0.7 | 0.1 | 0.6 | 0.9 | 2.0 | 1.6 | 1.5 | 0.9 | 0.8 | 0.9 | 0.4 | 0.9 | 1.0 | 0.5 |
| **1981** | 0.1 | 0.2 | 0.5 | 0.4 | 1.0 | 1.8 | 1.2 | 1.2 | 1.0 | 0.9 | 0.6 | 0.3 | 0.9 | 0.5 |
| **1982** | 0.4 | 0.1 | 0.2 | 0.6 | 0.7 | 1.0 | 1.2 | 1.0 | 0.7 | 0.4 | 0.2 | 0.3 | 0.6 | 0.5 |
| **1983** | 0.3 | 0.3 | 0.2 | 0.3 | 0.4 | 0.9 | 1.4 | 1.1 | 0.8 | 0.4 | 0.2 | 0.5 | 0.6 | 0.5 |
| **1984** | 0.2 | 0.4 | 0.7 | 0.6 | 0.8 | 1.2 | 2.1 | 1.1 | 0.7 | 0.5 | 0.4 | 0.3 | 0.9 | 0.5 |
| **1985** | 0.2 | 0.3 | 0.6 | 0.9 | 1.4 | 1.4 | 1.3 | 0.6 | 0.5 | 0.5 | 0.5 | 0.4 | 0.8 | 0.5 |
| **1986** | 0.2 | 0.5 | 0.4 | 0.8 | 0.8 | 1.6 | 1.4 | 0.6 | 0.5 | 0.4 | 0.3 | 0.4 | 0.7 | 0.6 |
| **1987** | 0.4 | 0.3 | 0.2 | 0.5 | 0.9 | 1.1 | 1.0 | 0.6 | 0.5 | 0.3 | 0.3 | 0.3 | 0.6 | 0.6 |
| **1988** | 0.3 | 0.3 | 0.5 | 0.7 | 0.6 | 0.6 | 0.7 | 0.7 | 0.4 | 0.4 | 0.2 | 0.0 | 0.5 | 0.6 |
| **1989** | 0.1 | 0.1 | 0.2 | 0.1 | 0.5 | 1.2 | 0.8 | 0.7 | 0.4 | 0.3 | 0.1 | 0.1 | 0.4 | 0.6 |
| **1990** | 0.2 | 0.5 | 0.3 | 0.5 | 1.1 | 1.6 | 1.6 | 0.9 | 0.8 | 0.7 | 0.5 | 0.3 | 0.8 | 0.5 |
| **1991** | 0.6 | 0.5 | 0.5 | 0.7 | 1.0 | 1.4 | 1.0 | 0.9 | 0.4 | 0.3 | 0.2 | 0.2 | 0.7 | 0.5 |
| **1992** | 0.1 | 0.2 | 0.2 | 0.3 | 0.5 | 0.5 | 0.6 | 0.2 | 0.5 | 0.1 | 0.2 | 0.4 | 0.3 | 0.7 |
| **1993** | 0.1 | 0.1 | 0.1 | 0.1 | 0.3 | 0.8 | 0.9 | 0.5 | 0.5 | 0.4 | 0.3 | 0.1 | 0.4 | 0.6 |
| **1994** | 0.2 | 0.2 | 0.3 | 0.2 | 0.3 | 0.6 | 0.5 | 0.2 | 0.1 | 0.3 | 0.1 | 0.2 | 0.3 | 0.7 |
| **1995** | 0.2 | 0.1 | 0.1 | 0.1 | 0.2 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.1 | 0.9 |
| **1996** | 0.1 | 0.1 | 0.2 | 0.1 | 0.2 | 0.3 | 0.2 | 0.3 | 0.2 | 0.2 | 0.3 | 0.1 | 0.2 | 0.7 |
| **1997** | 0.1 | 0.1 | 0.0 | 0.1 | 0.2 | 0.6 | 0.5 | 0.3 | 0.3 | 0.4 | 0.3 | 0.2 | 0.3 | 0.7 |
| **1998** | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.6 | 0.7 | 0.5 | 0.4 | 0.3 | 0.3 | 0.2 | 0.3 | 0.7 |
| **1999** | 0.1 | 0.2 | 0.2 | 0.2 | 0.4 | 0.7 | 0.8 | 0.6 | 0.1 | 0.2 | 0.1 | 0.1 | 0.3 | 0.6 |
| **2000** | 0.2 | 0.2 | 0.1 | 0.3 | 0.7 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.3 | 0.7 |
| **2001** | 0.0 | 0.1 | 0.1 | 0.0 | 0.1 | 0.4 | 0.5 | 0.3 | 0.3 | 0.2 | 0.3 | 0.1 | 0.2 | 0.8 |
| **2002** | 0.2 | 0.1 | 0.1 | 0.1 | 0.2 | 0.5 | 0.9 | 0.7 | 0.4 | 0.1 | 0.4 | 0.2 | 0.3 | 0.6 |
| **2003** | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.4 | 0.3 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | 0.2 | 0.7 |
| **2004** | 0.0 | 0.2 | 0.1 | 0.1 | 0.2 | 0.6 | 0.5 | 0.4 | 0.2 | 0.2 | 0.3 | 0.1 | 0.2 | 0.7 |
| **2005** | 0.2 | 0.1 | 0.1 | 0.0 | 0.1 | 0.7 | 1.1 | 1.3 | 1.4 | 0.6 | 0.7 | 0.6 | 0.5 | 0.5 |
| **2006** | 0.9 | 0.8 | 0.5 | 0.6 | 1.5 | 2.5 | 2.4 | 1.3 | 0.7 | 0.5 | 0.6 | 0.4 | 1.1 | 0.5 |
| **2007** | 0.4 | 0.3 | 0.3 | 0.3 | 0.3 | 1.0 | 1.1 | 0.9 | 0.5 | 0.4 | 0.2 | 0.2 | 0.5 | 0.6 |
| **2008** | 0.2 | 0.4 | 0.1 | 0.1 | 0.2 | 0.6 | 0.8 | 0.6 | 0.4 | 0.4 | 0.4 | 0.6 | 0.4 | 0.6 |
| **2009** | 0.6 | 0.4 | 0.2 | 0.2 | 0.7 | 1.3 | 1.4 | 0.6 | 0.3 | 0.3 | 0.3 | 0.2 | 0.5 | 0.6 |
| **2010** | 0.1 | 0.0 | 0.1 | 0.1 | 0.2 | 0.7 | 0.9 | 0.6 | 0.5 | 0.2 | 0.5 | 0.2 | 0.3 | 0.6 |
| **2011** | 0.2 | 0.1 | 0.1 | 0.3 | 0.5 | 0.9 | 1.1 | 0.5 | 0.3 | 0.5 | 0.4 | 0.2 | 0.5 | 0.5 |
| **2012** | 0.1 | 0.4 | 0.1 | 0.1 | 0.3 | 0.5 | 0.5 | 0.2 | 0.2 | 0.2 | 0.2 | 0.1 | 0.3 | 0.6 |
| **2013** | 0.2 | 0.1 | 0.0 | 0.1 | 0.1 | 0.4 | 0.4 | 0.1 | 0.2 | 0.3 | 0.2 | 0.1 | 0.2 | 0.7 |
| **2014** | . | 0.2 | 0.0 | 0.1 | 0.3 | 0.6 | 0.8 | 0.5 | 0.4 | 0.2 | 0.2 | 0.1 | 0.3 | 0.6 |
| **2015** | 0.1 | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 | 0.1 | 0.2 | 0.2 | 0.2 | 0.8 |
| **2016** | 0.1 | 0.1 | . | 0.2 | 0.2 | 0.6 | 0.7 | 0.5 | 0.5 | 0.3 | 0.4 | 0.2 | 0.3 | 0.7 |
| **2017** | 0.0 | 0.2 | 0.4 | 0.3 | 0.4 | 0.4 | 0.4 | 0.2 | 0.4 | 0.0 | 0.4 | 0.2 | 0.3 | 0.7 |
| **2018** | 0.2 | 0.2 | 0.2 | 0.2 | 0.6 | 1.1 | 1.3 | 0.4 | 0.4 | 0.3 | 0.4 | 0.2 | 0.5 | 0.5 |
| **est** | 0.3 | 0.3 | 0.3 | 0.3 | 0.5 | 0.9 | 0.9 | 0.7 | 0.5 | 0.4 | 0.4 | 0.3 | | |
| **CV** | 0.6 | 0.6 | 0.6 | 0.6 | 0.5 | 0.5 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | | |

Table 3: Catch-per-unit-effort of juvenile blue crab *Callinectes sapidus*. Abundance indices are the delta-lognormal mean of juvenile crabs per tow from the LDWF fishery-independent marine trawl survey, 1967-2018. Juveniles are crabs ≥25mm and <125mm carapace width that will grow to legal size during the survey year. Shaded areas represent the maximum of the monthly-cpue distributions.

| | Catch-per-unit- effort (juveniles) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec | est | CV |
| 1967 | 1.8 | 1.0 | 2.6 | 3.0 | 3.9 | 2.5 | 1.6 | 0.8 | 0.5 | 0.2 | 0.1 | 0.1 | 1.0 | 0.4 |
| 1968 | 1.2 | 1.4 | 2.0 | 2.1 | 3.0 | 3.5 | 1.4 | 0.6 | 0.4 | 0.2 | 0.1 | 0.1 | 1.3 | 0.4 |
| 1969 | 1.1 | 1.6 | 1.7 | 3.1 | 2.3 | 2.5 | 0.6 | 0.5 | 0.5 | 0.2 | 0.1 | 0.2 | 1.6 | 0.4 |
| 1970 | 2.2 | 2.2 | 2.5 | 2.5 | 1.6 | 1.9 | 1.2 | 0.5 | 0.6 | 0.3 | 0.1 | . | 1.2 | 0.4 |
| 1971 | 2.1 | 2.1 | 4.1 | 2.6 | 4.8 | 3.1 | 1.9 | 0.6 | 0.2 | 0.1 | 0.0 | 0.1 | 1.5 | 0.3 |
| 1972 | 4.6 | 5.3 | 2.6 | 2.9 | 1.8 | 2.9 | 1.0 | 0.7 | 0.6 | 0.4 | 0.1 | 0.1 | 1.6 | 0.3 |
| 1973 | 1.8 | 2.2 | 1.8 | 2.1 | 5.0 | 2.9 | 2.0 | 0.9 | 0.7 | 0.3 | 0.1 | 0.1 | 1.6 | 0.3 |
| 1974 | 1.6 | 2.2 | 2.3 | 2.7 | 3.3 | 3.7 | 1.2 | 0.7 | 0.4 | 0.3 | 0.1 | 0.0 | 1.7 | 0.3 |
| 1975 | 2.1 | 1.8 | 1.8 | 1.4 | 2.3 | 2.1 | 1.6 | 0.6 | 0.3 | 0.2 | . | 0.0 | 1.3 | 0.4 |
| 1976 | 0.4 | 0.7 | 1.8 | 1.4 | 1.2 | 1.9 | 0.7 | 0.2 | 0.2 | 0.1 | 0.0 | . | 0.7 | 0.5 |
| 1977 | 0.6 | 1.8 | 1.5 | 1.1 | 1.6 | 1.6 | 0.5 | 0.3 | 0.1 | 0.3 | 0.1 | . | 0.8 | 0.5 |
| 1978 | 1.4 | 1.8 | 1.3 | 1.9 | 2.7 | 2.3 | 1.4 | 0.5 | 0.5 | 0.1 | 0.1 | . | 1.0 | 0.4 |
| 1979 | 1.9 | 2.4 | 5.5 | 2.1 | 2.3 | 6.4 | 2.9 | 1.3 | 1.3 | 0.4 | 0.2 | 0.1 | 2.1 | 0.3 |
| 1980 | 3.6 | 2.6 | 2.8 | 5.0 | 6.2 | 5.8 | 1.8 | 0.6 | 0.3 | 0.4 | 0.0 | 0.2 | 2.4 | 0.2 |
| 1981 | 1.0 | 1.3 | 1.7 | 2.4 | 5.3 | 5.0 | 1.4 | 0.8 | 0.8 | 0.4 | 0.0 | 0.0 | 1.7 | 0.3 |
| 1982 | 1.3 | 1.7 | 4.4 | 3.5 | 3.2 | 5.0 | 2.8 | 1.4 | 0.9 | 0.3 | 0.0 | 0.1 | 2.2 | 0.3 |
| 1983 | 2.7 | 4.0 | 2.8 | 2.7 | 2.6 | 5.0 | 3.3 | 1.4 | 0.6 | 0.2 | 0.1 | . | 2.3 | 0.3 |
| 1984 | 2.0 | 1.7 | 2.7 | 3.2 | 3.2 | 3.2 | 2.3 | 0.9 | 0.6 | 0.2 | 0.1 | . | 1.8 | 0.3 |
| 1985 | 0.8 | 2.0 | 2.8 | 3.1 | 4.1 | 3.5 | 1.7 | 0.7 | 0.6 | 0.2 | 0.1 | 0.0 | 1.8 | 0.3 |
| 1986 | 1.1 | 3.0 | 2.6 | 2.6 | 2.3 | 3.1 | 2.0 | 0.5 | 0.4 | 0.3 | 0.1 | 0.1 | 1.7 | 0.3 |
| 1987 | 1.4 | 1.6 | 2.7 | 2.9 | 4.5 | 3.3 | 1.9 | 1.3 | 0.7 | 0.2 | 0.1 | 0.0 | 2.0 | 0.3 |
| 1988 | 3.3 | 4.2 | 4.4 | 5.3 | 4.9 | 3.1 | 2.0 | 1.2 | 0.6 | 0.2 | 0.0 | 0.0 | 2.2 | 0.2 |
| 1989 | 1.9 | 2.1 | 3.4 | 2.3 | 3.3 | 4.2 | 1.6 | 0.9 | 0.5 | 0.2 | 0.1 | 0.0 | 1.7 | 0.3 |
| 1990 | 1.4 | 3.3 | 3.7 | 5.0 | 5.2 | 5.3 | 2.8 | 1.1 | 1.0 | 0.5 | 0.3 | 0.0 | 2.5 | 0.2 |
| 1991 | 3.3 | 6.0 | 4.0 | 4.7 | 6.5 | 6.3 | 2.1 | 0.9 | 0.5 | 0.2 | 0.1 | . | 2.9 | 0.2 |
| 1992 | 5.1 | 2.1 | 1.9 | 1.9 | 2.2 | 2.5 | 1.2 | 0.3 | 0.3 | 0.1 | 0.0 | 0.1 | 1.4 | 0.3 |
| 1993 | 3.0 | 2.8 | 2.5 | 3.9 | 3.5 | 4.0 | 1.5 | 0.7 | 0.4 | 0.1 | 0.2 | . | 1.8 | 0.3 |
| 1994 | 5.6 | 3.3 | 4.0 | 4.3 | 4.1 | 3.4 | 0.9 | 0.3 | 0.1 | 0.1 | 0.0 | 0.0 | 2.1 | 0.2 |
| 1995 | 1.8 | 2.0 | 2.8 | 2.4 | 2.4 | 1.6 | 0.7 | 0.2 | 0.2 | 0.1 | 0.1 | 0.0 | 1.2 | 0.4 |
| 1996 | 3.4 | 1.2 | 2.1 | 2.1 | 2.2 | 1.6 | 0.7 | 0.6 | 0.2 | 0.0 | 0.0 | 0.0 | 1.2 | 0.4 |
| 1997 | 1.4 | 1.7 | 1.6 | 1.7 | 2.2 | 2.9 | 0.9 | 0.6 | 0.3 | 0.2 | 0.0 | 0.1 | 1.1 | 0.4 |
| 1998 | 3.3 | 2.8 | 2.2 | 1.3 | 1.8 | 4.5 | 1.2 | 0.6 | 0.3 | 0.1 | 0.0 | 0.0 | 1.4 | 0.3 |
| 1999 | 0.7 | 1.3 | 1.2 | 2.0 | 1.7 | 2.1 | 1.0 | 0.6 | 0.2 | 0.1 | 0.0 | 0.0 | 0.9 | 0.4 |
| 2000 | 1.9 | 3.2 | 2.4 | 1.9 | 2.1 | 1.3 | 0.6 | 0.2 | 0.2 | 0.1 | 0.0 | 0.0 | 1.0 | 0.4 |
| 2001 | 0.5 | 1.0 | 1.3 | 1.2 | 1.4 | 2.2 | 0.7 | 0.2 | 0.3 | 0.0 | 0.1 | 0.0 | 0.7 | 0.4 |
| 2002 | 0.6 | 1.7 | 1.3 | 1.3 | 1.8 | 1.8 | 0.8 | 0.2 | 0.2 | 0.0 | 0.0 | . | 0.8 | 0.4 |
| 2003 | 1.1 | 0.7 | 0.8 | 1.0 | 1.9 | 1.4 | 0.5 | 0.2 | 0.2 | 0.0 | . | 0.0 | 0.6 | 0.4 |
| 2004 | 0.8 | 2.6 | 1.7 | 1.2 | 1.3 | 2.3 | 0.7 | 0.3 | 0.2 | 0.1 | 0.0 | . | 0.9 | 0.4 |
| 2005 | 2.3 | 2.2 | 2.3 | 1.4 | 1.4 | 1.7 | 0.8 | 0.3 | 0.7 | 0.0 | 0.0 | 0.0 | 1.1 | 0.4 |
| 2006 | 1.5 | 2.4 | 2.3 | 2.8 | 3.3 | 2.2 | 0.8 | 0.2 | 0.3 | 0.1 | 0.1 | 0.0 | 1.3 | 0.4 |
| 2007 | 1.5 | 1.6 | 1.3 | 1.1 | 2.2 | 2.8 | 1.0 | 0.4 | 0.4 | 0.1 | . | . | 1.0 | 0.4 |
| 2008 | 0.9 | 1.9 | 1.5 | 1.0 | 1.5 | 1.5 | 0.7 | 0.4 | 0.1 | 0.0 | . | 0.0 | 0.8 | 0.5 |
| 2009 | 1.1 | 1.5 | 1.4 | 1.4 | 1.8 | 2.1 | 0.8 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.9 | 0.4 |
| 2010 | 0.7 | 0.5 | 1.0 | 1.3 | 1.1 | 1.6 | 0.4 | 0.3 | 0.3 | 0.0 | 0.1 | 0.0 | 0.6 | 0.5 |
| 2011 | 1.1 | 1.1 | 1.5 | 1.6 | 1.4 | 1.8 | 0.8 | 0.5 | 0.4 | 0.1 | 0.0 | 0.0 | 0.9 | 0.4 |
| 2012 | 1.6 | 2.1 | 1.5 | 1.0 | 0.7 | 1.0 | 0.3 | 0.1 | 0.2 | 0.1 | 0.0 | . | 0.7 | 0.4 |
| 2013 | 1.0 | 1.3 | 1.0 | 0.5 | 0.8 | 1.4 | 0.7 | 0.1 | 0.2 | . | 0.0 | . | 0.7 | 0.5 |
| 2014 | 1.4 | 0.6 | 2.1 | 1.2 | 0.7 | 0.9 | 0.6 | 0.5 | 0.3 | 0.1 | 0.0 | . | 0.7 | 0.5 |
| 2015 | 0.8 | 2.0 | 1.3 | 1.6 | 1.6 | 1.2 | 0.5 | 0.1 | 0.1 | 0.0 | . | . | 0.7 | 0.4 |
| 2016 | 0.7 | 1.3 | 0.5 | 0.7 | 1.2 | 1.1 | 0.7 | 0.3 | 0.3 | 0.1 | 0.0 | . | 0.6 | 0.5 |
| 2017 | 0.4 | 0.7 | 1.1 | 0.7 | 0.7 | 0.7 | 0.5 | 0.0 | 0.2 | 0.0 | . | . | 0.4 | 0.6 |
| 2018 | 0.3 | 1.3 | 1.6 | 0.8 | 0.9 | 1.2 | 0.6 | 0.0 | 0.2 | 0.1 | 0.0 | 0.0 | 0.6 | 0.5 |
| est | 1.6 | 2.0 | 2.1 | 2.0 | 2.4 | 2.6 | 1.2 | 0.6 | 0.4 | 0.1 | 0.1 | 0.0 | | |
| CV | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 | 0.6 | 0.6 | 0.8 | 0.8 | 0.9 | | |

Table 4: Catch-per-unit-effort of young-of-the-year blue crab *Callinectes sapidus*. Abundance indices are the delta-lognormal mean of pre-recruit crabs per ton from the LDWF fishery-independent marine trawl survey, 1967-2018. Young-of-the-year crabs are ≥25mm and <125mm carapace width and will not grow to legal size during the survey year. Shaded areas represent the maximum of the monthly-cpue distributions.

| Catch-per-unit- effort (young-of-the-year) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sept** | **Oct** | **Nov** | **Dec** | **est** | **CV** |
| **1967** | . | . | . | . | . | . | 0.1 | 0.5 | 0.6 | 0.9 | 0.3 | 0.7 | 0.4 | 0.6 |
| **1968** | . | . | . | . | . | . | 0.3 | 0.4 | 0.8 | 1.5 | 1.0 | 1.2 | 0.4 | 0.5 |
| **1969** | . | . | . | . | . | . | 0.7 | 0.3 | 0.5 | 2.2 | 1.5 | 2.0 | 0.2 | 0.5 |
| **1970** | . | . | . | . | . | . | 0.5 | 0.1 | 0.9 | 1.0 | 2.3 | 1.6 | 0.5 | 0.4 |
| **1971** | . | . | . | . | . | . | 0.6 | 0.5 | 0.5 | 1.0 | 2.1 | 3.2 | 0.6 | 0.4 |
| **1972** | . | . | . | . | . | . | 0.5 | 0.4 | 0.4 | 0.7 | 1.4 | 1.8 | 0.4 | 0.4 |
| **1973** | . | . | . | . | . | . | 0.6 | 0.5 | 0.7 | 1.1 | 1.0 | 1.6 | 0.4 | 0.4 |
| **1974** | . | . | . | . | . | . | 0.2 | 0.4 | 0.4 | 0.7 | 0.7 | 1.5 | 0.2 | 0.6 |
| **1975** | . | . | . | . | . | . | 0.2 | 0.5 | 0.4 | 0.9 | 0.8 | 0.4 | 0.2 | 0.5 |
| **1976** | . | . | . | . | . | . | 0.4 | 0.1 | 0.3 | 0.4 | 0.7 | 1.6 | 0.3 | 0.4 |
| **1977** | . | . | . | . | . | . | 0.1 | 0.3 | 0.2 | 0.9 | 1.9 | 1.2 | 0.3 | 0.5 |
| **1978** | . | . | . | . | . | . | 0.4 | 0.3 | 0.8 | 0.7 | 0.9 | 1.8 | 0.4 | 0.6 |
| **1979** | . | . | . | . | . | . | 1.1 | 0.8 | 2.5 | 1.9 | 1.6 | 2.0 | 0.8 | 0.4 |
| **1980** | . | . | . | . | . | . | 0.8 | 0.6 | 0.9 | 1.5 | 1.2 | 2.1 | 0.5 | 0.4 |
| **1981** | . | . | . | . | . | . | 0.5 | 0.5 | 0.9 | 1.5 | 0.5 | 1.3 | 0.4 | 0.4 |
| **1982** | . | . | . | . | . | . | 1.5 | 1.1 | 1.5 | 1.9 | 2.5 | 2.3 | 0.9 | 0.3 |
| **1983** | . | . | . | . | . | . | 1.3 | 0.8 | 0.9 | 1.9 | 0.9 | 1.9 | 0.5 | 0.4 |
| **1984** | . | . | . | . | . | . | 0.7 | 0.8 | 1.3 | 1.5 | 1.7 | 1.9 | 0.5 | 0.4 |
| **1985** | . | . | . | . | . | . | 0.6 | 0.6 | 1.7 | 1.5 | 2.0 | 1.3 | 0.5 | 0.4 |
| **1986** | . | . | . | . | . | . | 0.8 | 0.4 | 0.8 | 1.7 | 1.0 | 4.0 | 0.5 | 0.4 |
| **1987** | . | . | . | . | . | . | 0.7 | 1.4 | 1.5 | 1.4 | 0.8 | 2.8 | 0.6 | 0.3 |
| **1988** | . | . | . | . | . | . | 0.6 | 0.7 | 1.0 | 0.8 | 1.1 | 0.3 | 0.4 | 0.5 |
| **1989** | . | . | . | . | . | . | 0.6 | 0.5 | 1.4 | 1.8 | 0.9 | 1.9 | 0.5 | 0.4 |
| **1990** | . | . | . | . | . | . | 1.4 | 0.7 | 1.7 | 2.3 | 1.9 | 2.9 | 0.8 | 0.3 |
| **1991** | . | . | . | . | . | . | 0.5 | 0.4 | 1.5 | 1.2 | 0.7 | 1.5 | 0.4 | 0.4 |
| **1992** | . | . | . | . | . | . | 1.5 | 0.6 | 1.0 | 0.7 | 0.6 | 1.2 | 0.4 | 0.4 |
| **1993** | . | . | . | . | . | . | 1.7 | 0.8 | 1.7 | 1.5 | 3.4 | 2.4 | 0.8 | 0.3 |
| **1994** | . | . | . | . | . | . | 0.8 | 0.7 | 0.7 | 1.4 | 3.3 | 1.7 | 0.5 | 0.4 |
| **1995** | . | . | . | . | . | . | 0.7 | 0.3 | 0.9 | 1.2 | 2.0 | 1.8 | 0.4 | 0.4 |
| **1996** | . | . | . | . | . | . | 1.0 | 0.6 | 0.7 | 0.6 | 1.8 | 1.7 | 0.4 | 0.4 |
| **1997** | . | . | . | . | . | . | 0.7 | 1.2 | 1.7 | 2.6 | 2.4 | 2.1 | 0.9 | 0.3 |
| **1998** | . | . | . | . | . | . | 0.6 | 0.7 | 0.6 | 0.8 | 0.6 | 0.8 | 0.3 | 0.5 |
| **1999** | . | . | . | . | . | . | 0.4 | 1.0 | 1.3 | 1.1 | 0.6 | 1.4 | 0.5 | 0.3 |
| **2000** | . | . | . | . | . | . | 0.3 | 0.5 | 0.8 | 0.6 | 0.8 | 1.2 | 0.3 | 0.4 |
| **2001** | . | . | . | . | . | . | 0.4 | 0.4 | 0.9 | 0.6 | 0.7 | 1.0 | 0.3 | 0.5 |
| **2002** | . | . | . | . | . | . | 0.4 | 0.4 | 0.4 | 0.7 | 1.1 | 0.5 | 0.3 | 0.5 |
| **2003** | . | . | . | . | . | . | 0.6 | 0.4 | 0.7 | 0.4 | 0.9 | 1.4 | 0.3 | 0.4 |
| **2004** | . | . | . | . | . | . | 0.7 | 0.6 | 0.8 | 0.9 | 1.5 | 2.0 | 0.5 | 0.4 |
| **2005** | . | . | . | . | . | . | 0.6 | 0.2 | 1.1 | 0.5 | 1.1 | 1.2 | 0.3 | 0.5 |
| **2006** | . | . | . | . | . | . | 0.4 | 0.2 | 0.3 | 0.4 | 0.5 | 0.5 | 0.2 | 0.6 |
| **2007** | . | . | . | . | . | . | 0.5 | 0.3 | 0.3 | 0.5 | 0.7 | 0.7 | 0.2 | 0.6 |
| **2008** | . | . | . | . | . | . | 0.6 | 0.6 | 0.4 | 0.4 | 0.5 | 0.6 | 0.2 | 0.6 |
| **2009** | . | . | . | . | . | . | 0.3 | 0.3 | 0.4 | 0.6 | 0.5 | 0.8 | 0.2 | 0.6 |
| **2010** | . | . | . | . | . | . | 0.4 | 0.2 | 0.3 | 0.2 | 0.6 | 0.3 | 0.2 | 0.6 |
| **2011** | . | . | . | . | . | . | 0.3 | 0.3 | 0.5 | 0.3 | 0.7 | 1.5 | 0.2 | 0.4 |
| **2012** | . | . | . | . | . | . | 0.2 | 0.2 | 0.7 | 0.2 | 0.2 | 0.4 | 0.1 | 0.6 |
| **2013** | . | . | . | . | . | . | 0.6 | 0.3 | 0.7 | 0.3 | 0.9 | 0.6 | 0.2 | 0.5 |
| **2014** | . | . | . | . | . | . | 0.6 | 0.7 | 0.9 | 0.6 | 0.3 | 0.4 | 0.3 | 0.5 |
| **2015** | . | . | . | . | . | . | 0.4 | 0.4 | 0.5 | 0.3 | 0.4 | 0.4 | 0.2 | 0.6 |
| **2016** | . | . | . | . | . | . | 0.8 | 0.3 | 0.5 | 0.4 | 0.3 | 0.8 | 0.3 | 0.5 |
| **2017** | . | . | . | . | . | . | 0.3 | 0.3 | 0.3 | 0.5 | 0.5 | 0.3 | 0.2 | 0.7 |
| **2018** | . | . | . | . | . | . | 0.4 | 0.0 | 0.3 | 0.5 | 0.7 | 0.6 | 0.2 | 0.6 |
| **est** | . | . | . | . | . | . | 0.6 | 0.5 | 0.8 | 1.0 | 1.0 | 1.2 | | |
| **CV** | . | . | . | . | . | . | 0.4 | 0.5 | 0.4 | 0.4 | 0.4 | 0.3 | | |

Table 5: Gompertz growth parameters of blue crab *Callinectes sapidus* from West et al. (2011). Sizes are carapace-widths in mm.

| | *Gompertz parameters* | | | |
|---|---|---|---|---|
| | *Jan-Apr* | *May-Aug* | *Sept-Dec* | *non-seasonal* |
| $CW_{\infty}$ | *164.8* | *175.9* | *174.8* | *174.5* |
| $\alpha$ | *-4.9* | *-4.6* | *-19.8* | *-5.5* |
| $\beta$ | *-3.5* | *-2.6* | *-4.4* | *-3* |

Table 6: Size-at-capture matrix of Louisiana blue crab *Callinectes sapidus* used to identify crabs that will not recruit to the fishery during the survey year. Cells represent carapace-widths at capture in mm from the LDWF fishery independent trawl survey. Crabs not fully-selected by the survey gear (<25mm) are not shown (i.e., blank cells). Month of capture represents samples from the trawl survey. Month of hatch represents monthly cohorts. Cells above the diagonal represent size-at-capture of the current year-class. Cells below the diagonal are size-at-capture of the previous year-class. The shaded area represents cohorts that will not recruit to the fishery during the survey year. Carapace widths in bold represent the maximum size-at-capture of crabs that will not recruit to the fishery during the survey year. Seasonal size-at-age (Jan-Apr, May-Aug, and Sept-Dec) is estimated from Gompertz growth models.

| | | ***Month of Capture*** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ***Jan*** | ***Feb*** | ***Mar*** | ***Apr*** | ***May*** | ***Jun*** | ***Jul*** | ***Aug*** | ***Sept*** | ***Oct*** | ***Nov*** | ***Dec*** |
| ***Month of Hatch*** | ***Jan*** | | | | *29* | *45* | *63* | *80* | *96* | *110* | *122* | *132* | *140* |
| | ***Feb*** | *140* | | | | *29* | *45* | *63* | *80* | *96* | *110* | *122* | *132* |
| | ***Mar*** | *132* | *140* | | | | *29* | ***45*** | ***63*** | ***80*** | ***96*** | ***110*** | ***122*** |
| | ***Apr*** | *122* | *132* | *140* | | | | *29* | *45* | *63* | *80* | *96* | *110* |
| | ***May*** | *85* | *98* | *110* | *120* | | | | | *31* | *44* | *57* | *71* |
| | ***Jun*** | *71* | *85* | *98* | *110* | *120* | | | | | *31* | *44* | *57* |
| | ***Jul*** | *57* | *71* | *85* | *98* | *110* | *120* | | | | | *31* | *44* |
| | ***Aug*** | *44* | *57* | *71* | *85* | *98* | *110* | *120* | | | | | *31* |
| | ***Sept*** | | | *28* | *50* | *73* | *95* | *115* | *131* | | | | |
| | ***Oct*** | | | | *28* | *50* | *73* | *95* | *115* | *131* | | | |
| | ***Nov*** | | | | | *28* | *50* | *73* | *95* | *115* | *131* | | |
| | ***Dec*** | | | | | | *28* | *50* | *73* | *95* | *115* | *131* | |

Table 7: FAO proposed guideline for indices of productivity for exploited aquatic species. Parameter values are taken from West et al. (2011) and GDAR1.

| ***Parameter*** | ***Productivity*** | | | ***Species*** | |
|---|---|---|---|---|---|
| | ***Low*** | ***Medium*** | ***High*** | *Blue Crab* | ***Score*** |
| ***M*** | *<0.2* | *0.2 - 0.5* | *>0.5* | ***1.0*** | *3* |
| ***K*** | *<0.15* | *0.15 - 0.33* | *>0.33* | ***1.9*** | *3* |
| $t_{mat}$ | *>8* | *3.3 - 8* | *<3.3* | ***1*** | *3* |
| $t_{max}$ | *>25* | *14 - 25* | *<14* | ***3*** | *3* |
| ***Examples*** | *orange roughy, many sharks* | *cod, hake* | *sardine, anchovy* | ***Blue Crab Productivity Score = 3.0 (high)*** | |

Table 8: Annual mean weights (pounds) of juvenile and adult blue crabs captured from the LDWF fishery-independent marine trawl survey, 1968-2018. Adult crabs are≥125mm carapace width. Juveniles are crabs ≥25mm and <125mm carapace width.

| | ***Mean Weight (lbs)*** | |
|---|---|---|
| ***Year*** | *Adults* | *Juveniles* |
| *1968* | *0.40* | *0.05* |
| *1969* | *0.42* | *0.05* |
| *1970* | *0.41* | *0.06* |
| *1971* | *0.41* | *0.05* |
| *1972* | *0.41* | *0.05* |
| *1973* | *0.42* | *0.06* |
| *1974* | *0.42* | *0.06* |
| *1975* | *0.40* | *0.05* |
| *1976* | *0.44* | *0.05* |
| *1977* | *0.42* | *0.04* |
| *1978* | *0.42* | *0.05* |
| *1979* | *0.42* | *0.05* |
| *1980* | *0.42* | *0.04* |
| *1981* | *0.39* | *0.06* |
| *1982* | *0.39* | *0.05* |
| *1983* | *0.38* | *0.05* |
| *1984* | *0.40* | *0.06* |
| *1985* | *0.40* | *0.06* |
| *1986* | *0.38* | *0.05* |
| *1987* | *0.37* | *0.06* |
| *1988* | *0.40* | *0.05* |
| *1989* | *0.38* | *0.05* |
| *1990* | *0.38* | *0.05* |
| *1991* | *0.39* | *0.05* |
| *1992* | *0.39* | *0.04* |
| *1993* | *0.39* | *0.03* |
| *1994* | *0.40* | *0.03* |
| *1995* | *0.39* | *0.03* |
| *1996* | *0.40* | *0.03* |
| *1997* | *0.39* | *0.03* |
| *1998* | *0.40* | *0.03* |
| *1999* | *0.39* | *0.03* |
| *2000* | *0.42* | *0.03* |
| *2001* | *0.44* | *0.03* |
| *2002* | *0.42* | *0.04* |
| *2003* | *0.46* | *0.03* |
| *2004* | *0.45* | *0.03* |
| *2005* | *0.45* | *0.03* |
| *2006* | *0.44* | *0.04* |
| *2007* | *0.42* | *0.04* |
| *2008* | *0.44* | *0.03* |
| *2009* | *0.44* | *0.05* |
| *2010* | *0.43* | *0.04* |
| *2011* | *0.46* | *0.04* |
| *2012* | *0.46* | *0.03* |
| *2013* | *0.48* | *0.03* |
| *2014* | *0.47* | *0.03* |
| *2015* | *0.46* | *0.02* |
| *2016* | *0.45* | *0.04* |
| *2017* | *0.46* | *0.04* |

Table 9: Catch-per-unit-effort of blue crab *Callinectes sapidus*. Adult, juvenile, and young-of-the-year abundance indices are derived as the delta-lognormal mean catch-per-tow from the LDWF fishery-independent marine trawl survey, 1967-2018. The juvenile abundance index $r_y$ used in the catch-survey model is derived as the sum of young-of-the-year cpue in year and juvenile cpue in year+1. The shaded cells represent values not used as model inputs.

| | *Catch-per-unit-effort (crabs per tow)* | | | *Model inputs* | |
|---|---|---|---|---|---|
| ***Year*** | *Adults* | *Juveniles* | *Young-of-the-year* | $n_y$ | $r_y$ |
| 1967 | 0.87 | 0.97 | 0.38 | | |
| 1968 | 0.74 | 1.28 | 0.40 | 0.74 | 1.66 |
| 1969 | 0.66 | 1.64 | 0.22 | 0.66 | 2.03 |
| 1970 | 1.12 | 1.24 | 0.49 | 1.12 | 1.46 |
| 1971 | 1.08 | 1.52 | 0.64 | 1.08 | 2.01 |
| 1972 | 0.88 | 1.63 | 0.43 | 0.88 | 2.27 |
| 1973 | 0.93 | 1.65 | 0.45 | 0.93 | 2.08 |
| 1974 | 1.04 | 1.71 | 0.19 | 1.04 | 2.16 |
| 1975 | 0.78 | 1.28 | 0.23 | 0.78 | 1.46 |
| 1976 | 0.45 | 0.67 | 0.31 | 0.45 | 0.90 |
| 1977 | 0.37 | 0.78 | 0.30 | 0.37 | 1.09 |
| 1978 | 0.53 | 0.98 | 0.39 | 0.53 | 1.28 |
| 1979 | 0.75 | 2.14 | 0.79 | 0.75 | 2.52 |
| 1980 | 1.01 | 2.35 | 0.51 | 1.01 | 3.14 |
| 1981 | 0.88 | 1.74 | 0.39 | 0.88 | 2.25 |
| 1982 | 0.63 | 2.17 | 0.86 | 0.63 | 2.55 |
| 1983 | 0.63 | 2.27 | 0.55 | 0.63 | 3.14 |
| 1984 | 0.86 | 1.83 | 0.52 | 0.86 | 2.38 |
| 1985 | 0.79 | 1.80 | 0.55 | 0.79 | 2.32 |
| 1986 | 0.75 | 1.65 | 0.46 | 0.75 | 2.20 |
| 1987 | 0.57 | 1.97 | 0.56 | 0.57 | 2.44 |
| 1988 | 0.50 | 2.24 | 0.38 | 0.50 | 2.79 |
| 1989 | 0.41 | 1.75 | 0.48 | 0.41 | 2.12 |
| 1990 | 0.84 | 2.53 | 0.78 | 0.84 | 3.01 |
| 1991 | 0.70 | 2.86 | 0.41 | 0.70 | 3.64 |
| 1992 | 0.32 | 1.38 | 0.40 | 0.32 | 1.79 |
| 1993 | 0.38 | 1.84 | 0.80 | 0.38 | 2.24 |
| 1994 | 0.27 | 2.07 | 0.53 | 0.27 | 2.87 |
| 1995 | 0.14 | 1.18 | 0.44 | 0.14 | 1.71 |
| 1996 | 0.19 | 1.16 | 0.42 | 0.19 | 1.61 |
| 1997 | 0.27 | 1.13 | 0.87 | 0.27 | 1.54 |
| 1998 | 0.30 | 1.38 | 0.34 | 0.30 | 2.25 |
| 1999 | 0.32 | 0.93 | 0.46 | 0.32 | 1.27 |
| 2000 | 0.30 | 1.03 | 0.32 | 0.30 | 1.49 |
| 2001 | 0.21 | 0.72 | 0.33 | 0.21 | 1.04 |
| 2002 | 0.33 | 0.81 | 0.27 | 0.33 | 1.14 |
| 2003 | 0.19 | 0.64 | 0.33 | 0.19 | 0.91 |
| 2004 | 0.24 | 0.90 | 0.50 | 0.24 | 1.22 |
| 2005 | 0.54 | 1.10 | 0.32 | 0.54 | 1.60 |
| 2006 | 1.06 | 1.29 | 0.19 | 1.06 | 1.61 |
| 2007 | 0.51 | 1.00 | 0.24 | 0.51 | 1.19 |
| 2008 | 0.40 | 0.79 | 0.25 | 0.40 | 1.03 |
| 2009 | 0.53 | 0.93 | 0.21 | 0.53 | 1.18 |
| 2010 | 0.31 | 0.60 | 0.16 | 0.31 | 0.81 |
| 2011 | 0.50 | 0.94 | 0.25 | 0.50 | 1.10 |
| 2012 | 0.25 | 0.66 | 0.14 | 0.25 | 0.90 |
| 2013 | 0.17 | 0.71 | 0.18 | 0.17 | 0.84 |
| 2014 | 0.29 | 0.68 | 0.25 | 0.29 | 0.85 |
| 2015 | 0.16 | 0.74 | 0.20 | 0.16 | 0.99 |
| 2016 | 0.33 | 0.61 | 0.28 | 0.33 | 0.82 |
| 2017 | 0.29 | 0.45 | 0.16 | 0.29 | 0.73 |
| 2018 | 0.51 | 0.61 | 0.17 | 0.51 | 0.76 |

Table 10: Assessment model inputs and resulting estimates for the Louisiana blue crab *Callinectes sapidus* stock, 1968-2018. Descriptions of model inputs are: $M$ = constant instantaneous natural mortality rate, $C_y$ = harvest (as individuals), $r_y$ = juvenile cpue, $n_y$ = adult cpue, $s_r$ = relative selectivity of juveniles to adult crabs in the survey gear. Descriptions of model estimates are: $\hat{q}_n$ = predicted catchability of adult crabs to the survey gear, $\hat{r}_y$ = predicted juvenile cpue, $\hat{n}_y$ = predicted adult cpue, $n_y$ = calculated adult cpue (i.e., from process error), $R_y$ = juvenile abundance, $N_y$ = adult abundance, $Z_y$ = instantaneous total mortality rate, $u_y$ = exploitation rate, $F_y$ = instantaneous fishing mortality rate. CPUE is derived as the delta-lognormal mean catch per tow from the LDWF fishery-independent trawl survey. Juveniles are crabs ≥25mm and <125mm carapace width. Adult crabs are ≥125mm carapace width. Abundance units are millions of individuals. Biomass units are millions of pounds.

| ***Model inputs*** $M = 1.0$ | | | | | ***Model estimates*** $\hat{q}_n = 0.00453$ | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Year*** | $C_y$ | $r_y$ | $n_y$ | $s_r$ | $\hat{r}_y$ | $\hat{n}_y$ | $n_y$ | $R_y$ | $N_y$ | $Z_y$ | $u_y$ | $F_y$ | $R_y$ Biomass | $N_y$ Biomass |
| *1968* | *24.85* | *1.66* | *0.74* | *1.00* | *1.57* | *0.72* | *0.00* | *346.63* | *159.58* | *1.16* | *0.05* | *0.08* | *18.82* | *64.40* |
| *1969* | *28.80* | *2.03* | *0.66* | *1.00* | *2.18* | *0.72* | *0.78* | *480.29* | *159.03* | *0.99* | *0.05* | *0.07* | *25.33* | *67.26* |
| *1970* | *26.31* | *1.46* | *1.12* | *1.00* | *1.54* | *1.07* | *0.99* | *340.41* | *236.73* | *0.99* | *0.05* | *0.07* | *20.22* | *96.87* |
| *1971* | *31.24* | *2.01* | *1.08* | *1.00* | *1.93* | *0.97* | *0.89* | *425.31* | *214.08* | *1.14* | *0.05* | *0.08* | *19.44* | *87.67* |
| *1972* | *38.76* | *2.27* | *0.88* | *1.00* | *2.18* | *0.92* | *0.98* | *480.12* | *203.61* | *1.15* | *0.06* | *0.10* | *22.55* | *83.19* |
| *1973* | *58.23* | *2.08* | *0.93* | *1.00* | *2.09* | *0.98* | *1.03* | *460.56* | *216.19* | *1.15* | *0.09* | *0.14* | *26.18* | *89.97* |
| *1974* | *51.16* | *2.16* | *1.04* | *1.00* | *1.95* | *0.98* | *0.97* | *429.64* | *215.18* | *1.28* | *0.08* | *0.14* | *26.71* | *91.15* |
| *1975* | *45.33* | *1.46* | *0.78* | *1.00* | *1.27* | *0.82* | *0.93* | *281.10* | *179.99* | *1.37* | *0.10* | *0.18* | *14.87* | *71.48* |
| *1976* | *36.17* | *0.90* | *0.45* | *1.00* | *0.86* | *0.53* | *0.64* | *190.46* | *117.54* | *1.26* | *0.12* | *0.21* | *9.46* | *51.91* |
| *1977* | *40.49* | *1.09* | *0.37* | *1.00* | *1.18* | *0.39* | *0.41* | *259.90* | *87.09* | *1.13* | *0.12* | *0.19* | *11.30* | *36.48* |
| *1978* | *37.87* | *1.28* | *0.53* | *1.00* | *1.41* | *0.51* | *0.47* | *310.54* | *112.11* | *1.05* | *0.09* | *0.14* | *16.06* | *46.85* |
| *1979* | *53.75* | *2.52* | *0.75* | *1.00* | *2.46* | *0.67* | *0.60* | *542.82* | *148.00* | *1.17* | *0.08* | *0.13* | *29.79* | *61.67* |
| *1980* | *45.80* | *3.14* | *1.01* | *1.00* | *2.66* | *0.98* | *1.00* | *587.19* | *215.35* | *1.30* | *0.06* | *0.10* | *24.17* | *89.78* |
| *1981* | *43.89* | *2.25* | *0.88* | *1.00* | *1.89* | *0.99* | *1.21* | *417.35* | *217.77* | *1.35* | *0.07* | *0.13* | *23.82* | *84.59* |
| *1982* | *46.12* | *2.55* | *0.63* | *1.00* | *2.13* | *0.74* | *0.94* | *470.31* | *163.98* | *1.34* | *0.07* | *0.13* | *22.63* | *64.52* |
| *1983* | *53.96* | *3.14* | *0.63* | *1.00* | *2.73* | *0.75* | *0.93* | *602.44* | *165.97* | *1.28* | *0.07* | *0.12* | *30.58* | *63.36* |
| *1984* | *77.45* | *2.38* | *0.86* | *1.00* | *2.17* | *0.97* | *1.13* | *478.07* | *213.87* | *1.31* | *0.11* | *0.20* | *28.10* | *85.88* |
| *1985* | *78.79* | *2.32* | *0.79* | *1.00* | *2.11* | *0.84* | *0.94* | *465.44* | *186.21* | *1.33* | *0.12* | *0.22* | *25.95* | *74.07* |
| *1986* | *86.64* | *2.20* | *0.75* | *1.00* | *1.89* | *0.78* | *0.87* | *417.48* | *172.56* | *1.44* | *0.15* | *0.28* | *21.95* | *66.11* |
| *1987* | *148.31* | *2.44* | *0.57* | *1.00* | *2.10* | *0.63* | *0.75* | *462.45* | *139.99* | *1.64* | *0.25* | *0.50* | *25.85* | *51.88* |
| *1988* | *140.69* | *2.79* | *0.50* | *1.00* | *2.17* | *0.53* | *0.60* | *479.06* | *117.23* | *1.68* | *0.24* | *0.49* | *21.62* | *46.85* |
| *1989* | *93.32* | *2.12* | *0.41* | *1.00* | *2.20* | *0.50* | *0.61* | *485.64* | *110.68* | *1.27* | *0.16* | *0.28* | *22.59* | *41.58* |
| *1990* | *107.26* | *3.01* | *0.84* | *1.00* | *2.46* | *0.76* | *0.74* | *542.52* | *168.21* | *1.48* | *0.15* | *0.29* | *27.31* | *64.03* |
| *1991* | *137.95* | *3.64* | *0.70* | *1.00* | *2.26* | *0.73* | *0.89* | *497.51* | *161.24* | *1.84* | *0.21* | *0.46* | *25.65* | *62.70* |
| *1992* | *138.42* | *1.79* | *0.32* | *1.00* | *1.64* | *0.48* | *0.72* | *361.68* | *104.90* | *1.73* | *0.30* | *0.62* | *14.35* | *41.17* |
| *1993* | *122.40* | *2.24* | *0.38* | *1.00* | *1.56* | *0.37* | *0.40* | *345.03* | *82.62* | *1.87* | *0.29* | *0.63* | *11.14* | *32.49* |
| *1994* | *95.96* | *2.87* | *0.27* | *1.00* | *1.39* | *0.30* | *0.38* | *307.27* | *65.62* | *2.06* | *0.26* | *0.61* | *9.20* | *26.33* |
| *1995* | *99.14* | *1.71* | *0.14* | *1.00* | *1.25* | *0.22* | *0.36* | *275.74* | *47.68* | *1.89* | *0.31* | *0.68* | *9.59* | *18.64* |
| *1996* | *105.51* | *1.61* | *0.19* | *1.00* | *1.40* | *0.22* | *0.27* | *309.03* | *49.04* | *1.75* | *0.29* | *0.62* | *9.73* | *19.47* |
| *1997* | *115.48* | *1.54* | *0.27* | *1.00* | *1.43* | *0.28* | *0.31* | *315.27* | *62.44* | *1.75* | *0.31* | *0.65* | *10.56* | *24.66* |
| *1998* | *114.56* | *2.25* | *0.30* | *1.00* | *1.77* | *0.30* | *0.31* | *389.96* | *65.81* | *1.70* | *0.25* | *0.52* | *13.63* | *26.23* |
| *1999* | *123.28* | *1.27* | *0.32* | *1.00* | *1.31* | *0.38* | *0.45* | *288.14* | *83.22* | *1.78* | *0.33* | *0.71* | *9.35* | *32.85* |
| *2000* | *127.27* | *1.49* | *0.30* | *1.00* | *1.32* | *0.28* | *0.28* | *291.89* | *62.83* | *1.95* | *0.36* | *0.82* | *9.42* | *26.66* |
| *2001* | *100.07* | *1.04* | *0.21* | *1.00* | *1.25* | *0.23* | *0.24* | *274.72* | *50.27* | *1.60* | *0.31* | *0.62* | *8.20* | *21.87* |
| *2002* | *124.22* | *1.14* | *0.33* | *1.00* | *1.17* | *0.30* | *0.27* | *258.28* | *65.43* | *1.99* | *0.38* | *0.88* | *9.34* | *27.49* |
| *2003* | *109.95* | *0.91* | *0.19* | *1.00* | *1.17* | *0.20* | *0.20* | *257.02* | *44.30* | *1.81* | *0.36* | *0.79* | *7.64* | *20.18* |
| *2004* | *103.22* | *1.22* | *0.24* | *1.00* | *1.62* | *0.22* | *0.20* | *356.30* | *49.54* | *1.36* | *0.25* | *0.47* | *9.42* | *22.22* |
| *2005* | *87.64* | *1.60* | *0.54* | *1.00* | *2.03* | *0.47* | *0.39* | *448.21* | *104.20* | *1.08* | *0.16* | *0.26* | *12.02* | *47.31* |
| *2006* | *126.87* | *1.61* | *1.06* | *1.00* | *1.59* | *0.85* | *0.68* | *349.98* | *186.97* | *1.51* | *0.24* | *0.46* | *14.01* | *82.24* |
| *2007* | *115.70* | *1.19* | *0.51* | *1.00* | *1.33* | *0.54* | *0.55* | *293.07* | *119.07* | *1.54* | *0.28* | *0.55* | *11.24* | *49.70* |
| *2008* | *105.92* | *1.03* | *0.40* | *1.00* | *1.38* | *0.40* | *0.37* | *304.70* | *88.65* | *1.38* | *0.27* | *0.50* | *10.47* | *39.16* |
| *2009* | *130.40* | *1.18* | *0.53* | *1.00* | *1.33* | *0.45* | *0.36* | *292.78* | *99.34* | *1.72* | *0.33* | *0.70* | *13.38* | *43.82* |
| *2010* | *75.22* | *0.81* | *0.31* | *1.00* | *1.09* | *0.32* | *0.30* | *240.71* | *70.02* | *1.28* | *0.24* | *0.43* | *9.79* | *30.07* |
| *2011* | *100.65* | *1.10* | *0.50* | *1.00* | *1.08* | *0.39* | *0.31* | *238.65* | *86.61* | *1.72* | *0.31* | *0.65* | *10.63* | *39.56* |
| *2012* | *104.49* | *0.90* | *0.25* | *1.00* | *0.98* | *0.26* | *0.27* | *215.22* | *58.02* | *1.96* | *0.38* | *0.87* | *6.18* | *26.94* |
| *2013* | *85.28* | *0.84* | *0.17* | *1.00* | *1.08* | *0.17* | *0.17* | *237.18* | *38.52* | *1.57* | *0.31* | *0.61* | *7.86* | *18.54* |
| *2014* | *95.73* | *0.85* | *0.29* | *1.00* | *0.89* | *0.26* | *0.23* | *195.85* | *57.10* | *1.96* | *0.38* | *0.86* | *6.55* | *27.01* |
| *2015* | *94.78* | *0.99* | *0.16* | *1.00* | *1.27* | *0.16* | *0.16* | *280.33* | *35.73* | *1.54* | *0.30* | *0.588* | *6.96* | *16.34* |
| *2016* | *94.09* | *0.82* | *0.33* | *1.00* | *1.05* | *0.31* | *0.27* | *232.07* | *67.71* | *1.57* | *0.31* | *0.62* | *8.18* | *30.70* |
| *2017* | *100.07* | *0.73* | *0.29* | *1.00* | *1.21* | *0.28* | *0.24* | *266.65* | *62.39* | *1.38* | *0.30* | *0.56* | *10.45* | *28.79* |
| *2018* | *94.81* | *0.76* | *0.51* | *1.00* | *--* | *0.37* | *0.27* | *168.65* | *82.66* | *--* | *0.38* | *--* | *6.42* | *39.90* |

Table 11: Derivation and management reference point estimates for the Louisiana blue crab *Callinectes sapidus* stock. Fishing mortality units are $\text{years}^{-1}$. Biomass units are millions of pounds.

| ***Management Benchmarks*** | | |
|---|---|---|
| ***Parameters*** | *Derivation* | *Estimates* |
| $SPR_{limit}$ | *Equations [17,19] and* $SSB_{limit}$ | *21.0%* |
| $SSB_{limit}$ | *Geometric mean of 3 lowest biomasses (1968-2009)* | *19.4* |
| $F_{limit}$ | *Equations [17,19] and* $SPR_{limit}$ | *0.928* |
| $SPR_{target}$ | *Equations [17,19] and* $SSB_{target}$ | *31.5%* |
| $SSB_{target}$ | $SSB_{limit} \times 1.5$ | *29.1* |
| $F_{target}$ | *Equations [17,19] and* $SPR_{target}$ | *0.696* |

## *11. Figures*

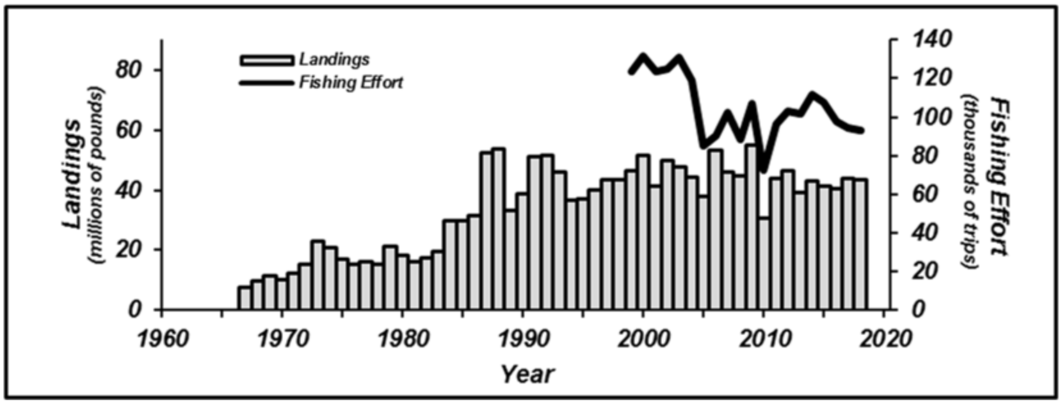


Figure 1: Commercial hard crab landings and fishing effort for Louisiana blue crab *Callinectes sapidus*. Landings, 1967-1998, are taken from NMFS statistical records. Landings and fishing effort, 1999-2018, are taken from the LDWF Trip Ticket Program. Landings are millions of pounds. Fishing effort is thousands of trap fisher trips.

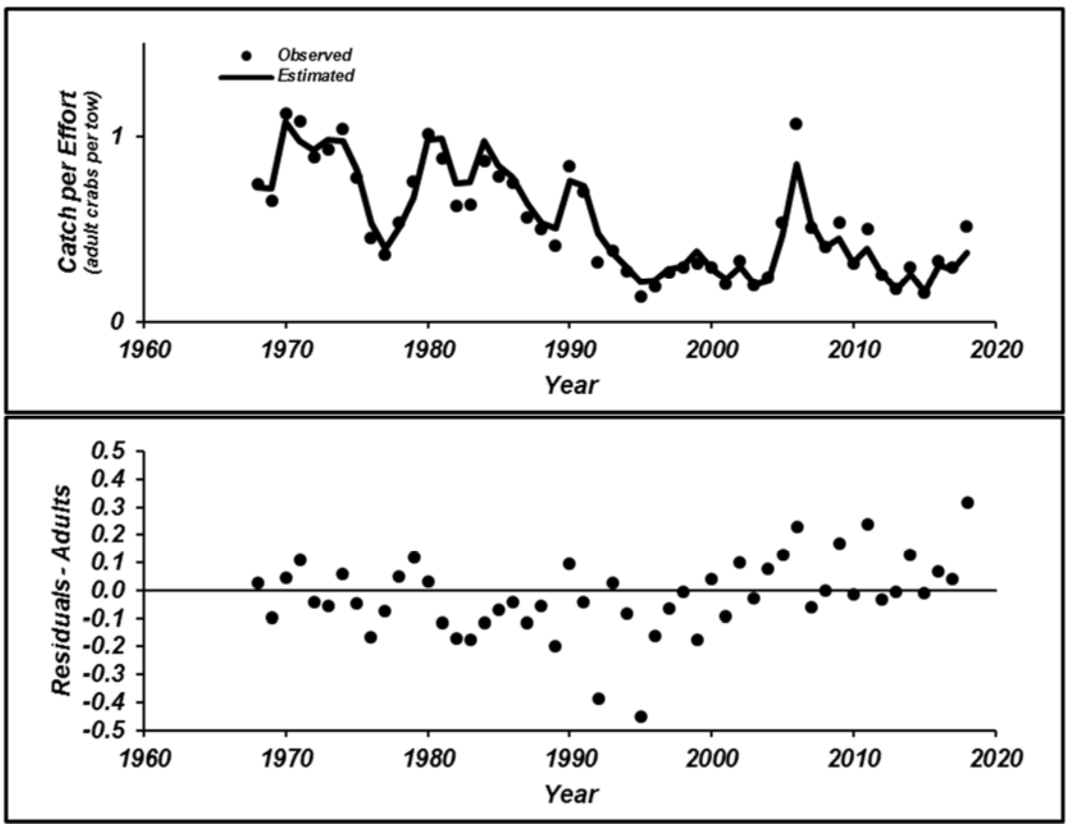


Figure 2: Catch-per-unit-effort of adult Louisiana blue crab *Callinectes sapidus*. The predicted index is derived from lognormal **observation error** of the catch-survey model. The observed index is the delta-lognormal mean catch-per-tow from the LDWF fishery-independent trawl survey, 1968-2018. Bottom graphic depicts lognormal residuals. Adult crabs are ≥125mm carapace-width.

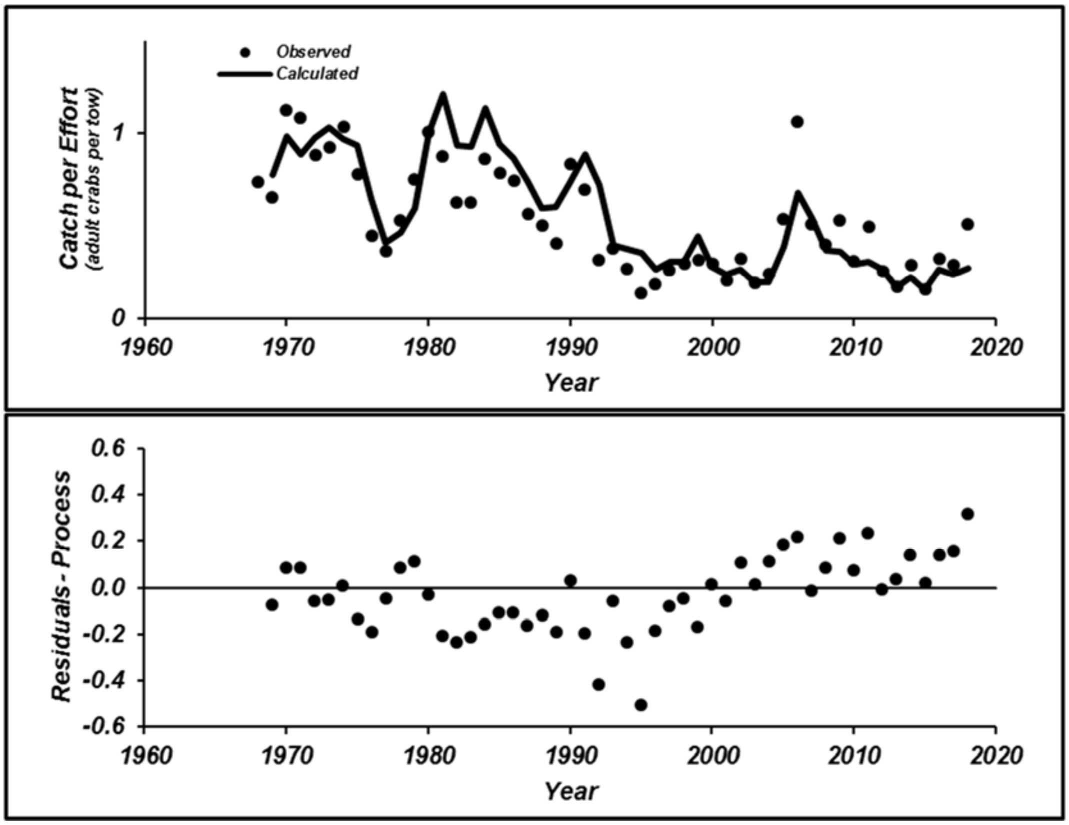


Figure 3: Catch-per-unit-effort of adult Louisiana blue crab *Callinectes sapidus.* The calculated index is derived from lognormal **process error** of the catch-survey model. The observed index is the delta-lognormal mean catch-per-tow from the LDWF fishery-independent trawl survey, 1968-2018. Bottom graphic depicts lognormal residuals. Adult crabs are ≥125mm carapace-width.

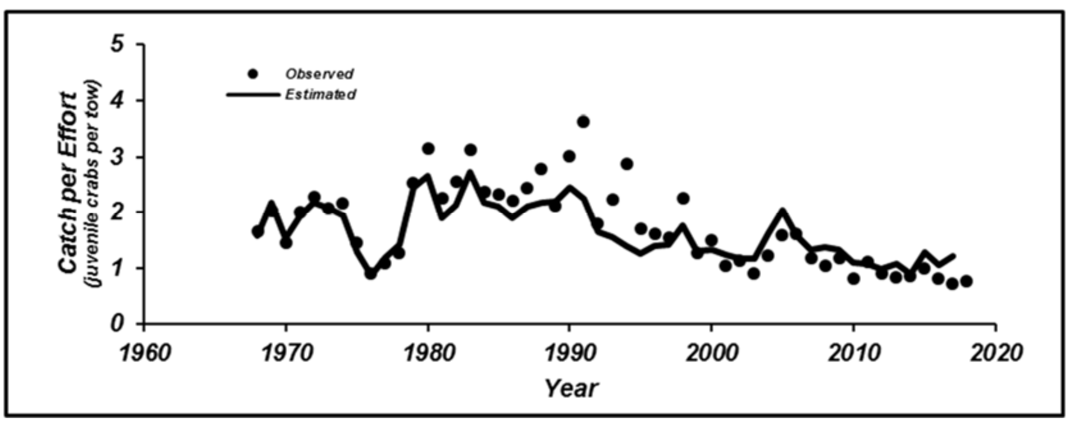


Figure 4: Catch-per-unit-effort of juvenile Louisiana blue crab *Callinectes sapidus*. The predicted index is derived from lognormal observation error of the catch-survey model. The observed index is the delta-lognormal mean catch-per-tow from the LDWF fishery-independent trawl survey, 1968-2018. Bottom graphic depicts lognormal residuals. Juveniles are crabs ≥25mm and <125mm carapace-width.

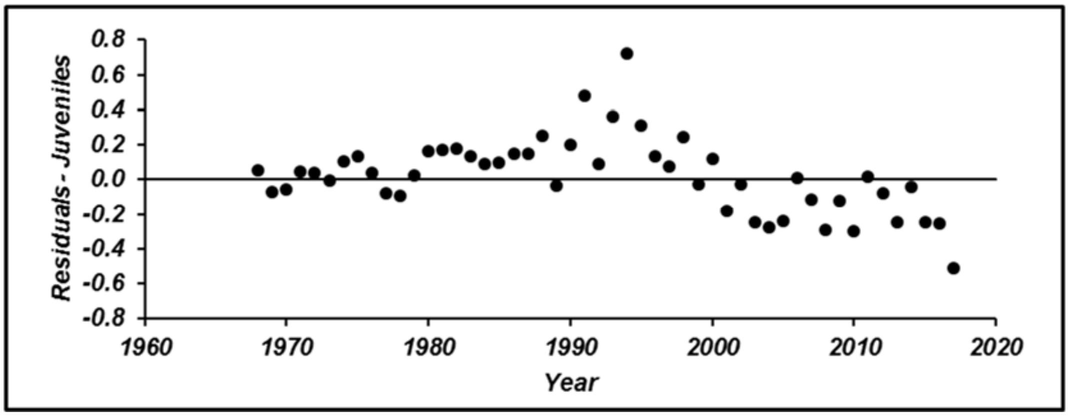


Figure 4 (continued):

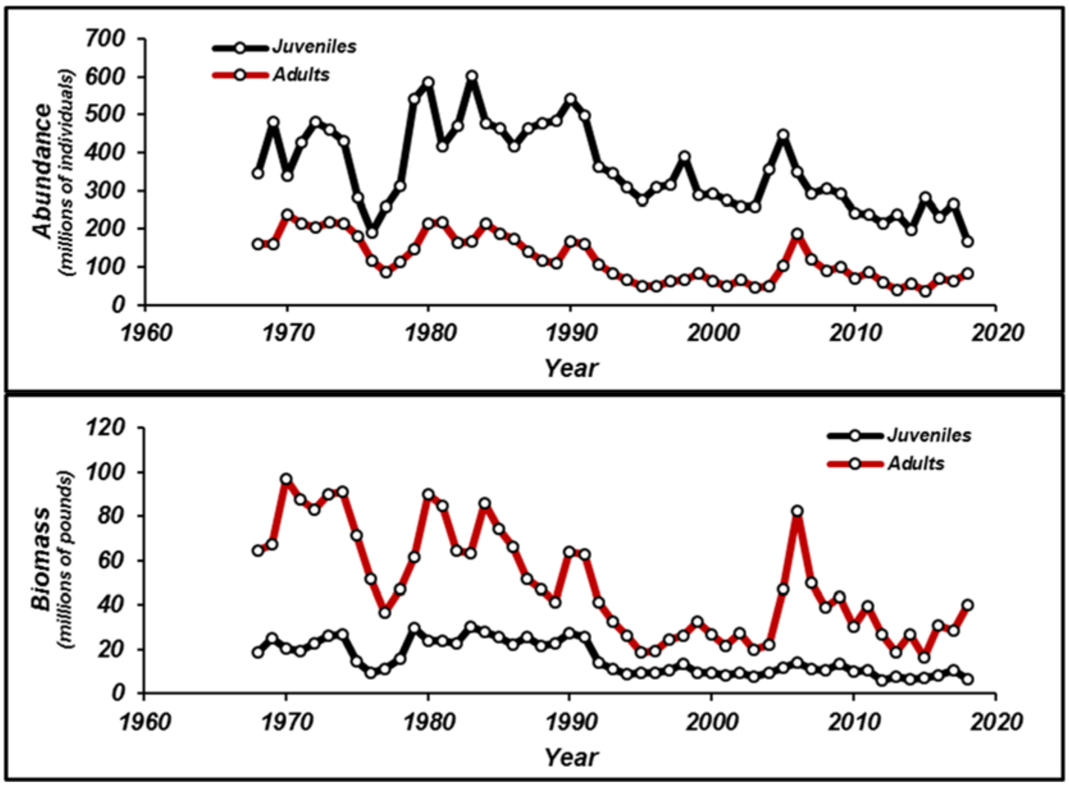


Figure 5: Abundance (top graphic) and biomass estimates (bottom graphic) of Louisiana blue crab *Callinectes sapidus* derived from the catch-survey model. Abundance units are millions of individuals. Biomass units are millions of pounds. Juveniles are crabs ≥25mm and <125mm carapace width. Adult crabs are ≥125mm carapace width.

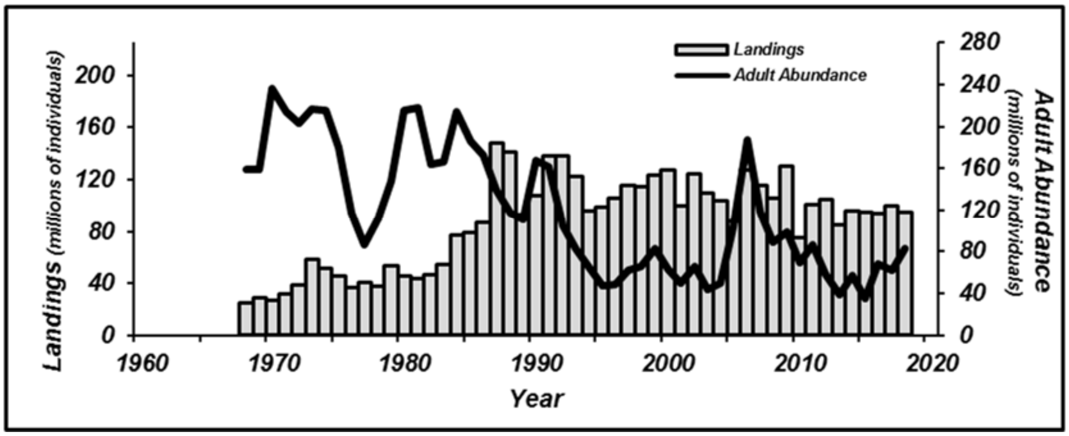


Figure 6: Estimated adult abundance and observed harvest of Louisiana blue crab *Callinectes sapidus*. Abundance is estimated from the catch-survey model. Commercial hard crab landings are expanded by 5% to approximate for recreational harvest. Units are millions of individuals.

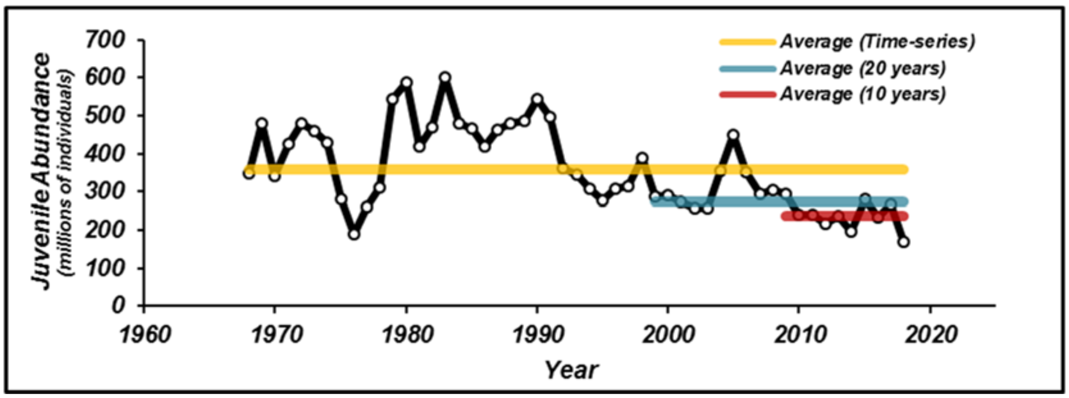


Figure 7: Juvenile abundance estimates of Louisiana blue crab *Callinectes sapidus* derived from the catch-survey model. Units are millions of individuals. Juveniles are crabs ≥25mm and <125mm carapace width. The yellow horizontal is the average juvenile abundance across the time-series. The blue and red horizontals are the most recent 20 and 10 year averages.

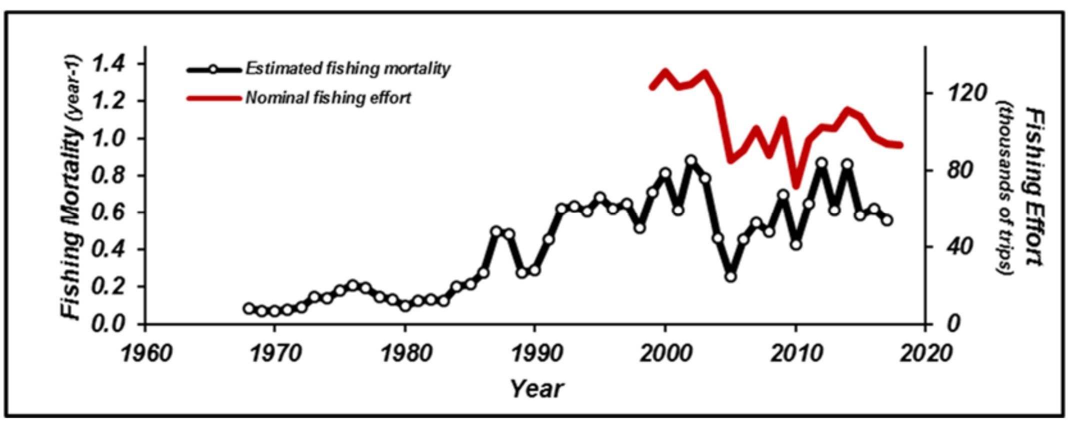


Figure 8: Estimated fishing mortality and nominal fishing effort for Louisiana blue crab *Callinectes sapidus*. Fishing mortality, 1968-2017, is estimated from the catch-survey model. Fishing effort, 1999-2018, is thousands of trap fisher trips per year taken from the LDWF Trip Ticket Program. Fishing effort is not used in the assessment model, but is presented here to validate trends in fishing mortality estimates.

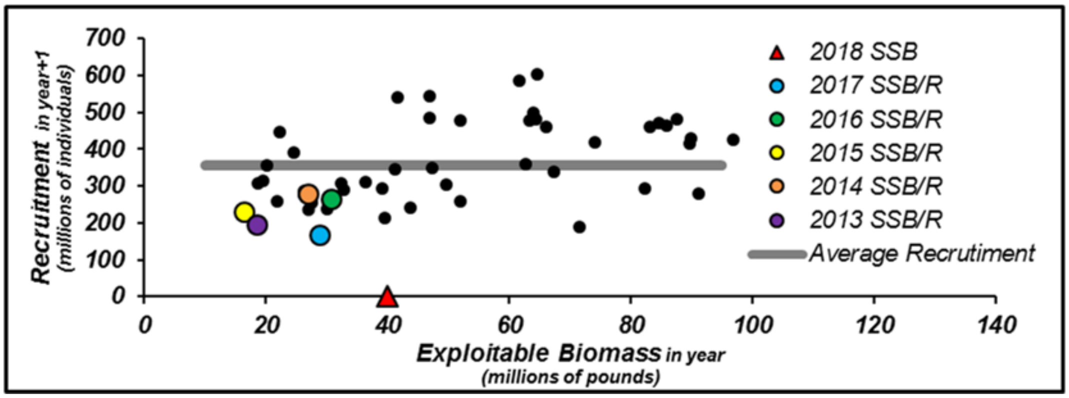


Figure 9: Exploitable biomass and subsequent recruitment of Louisiana blue crab *Callinectes sapidus*. Estimates are derived from the catch-survey model. Recruits (juveniles) are crabs ≥25mm and <125mm carapace width. Adult crabs are ≥125mm carapace width. Abundance units are millions of individuals. Biomass units are millions of pounds. The 5 most recent data pairs and the 2018 exploitable biomass estimate are identified.

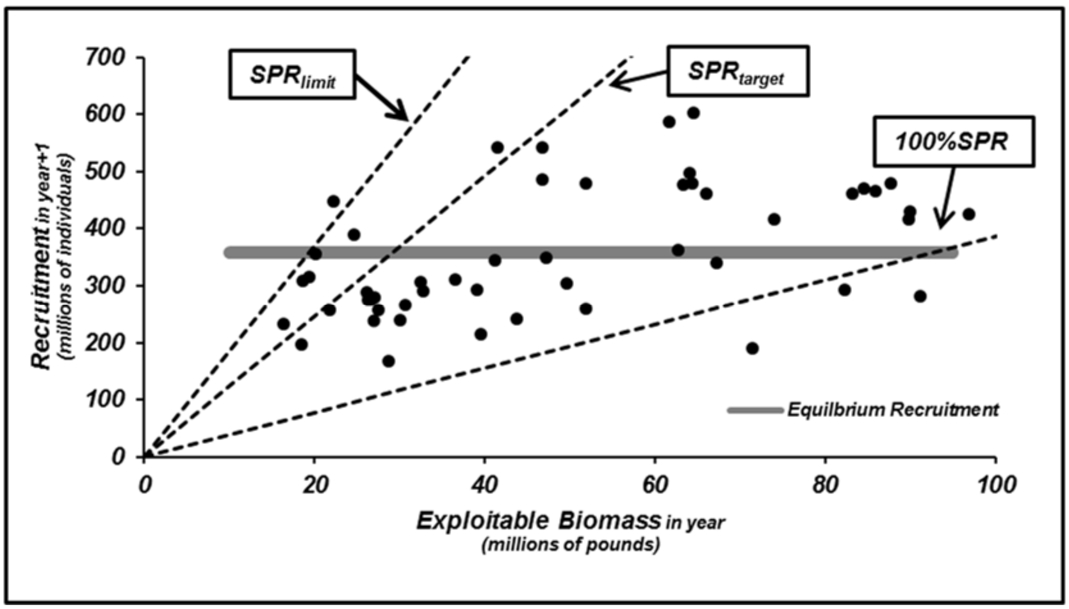


Figure 10: Equilibrium recruitment and the fished and unfished estimates of recruitment per spawner (represented by the slopes of the diagonal lines) corresponding with 21.0, 31.5, and 100% SPR. Exploitable biomass and recruitment of Louisiana blue crab *Callinectes sapidus* are derived from the catch-survey model. Recruits (juveniles) are crabs ≥25mm and <125mm carapace width. Adult (exploitable) crabs are ≥125mm carapace width. Abundance units are millions of individuals. Biomass units are millions of pounds.

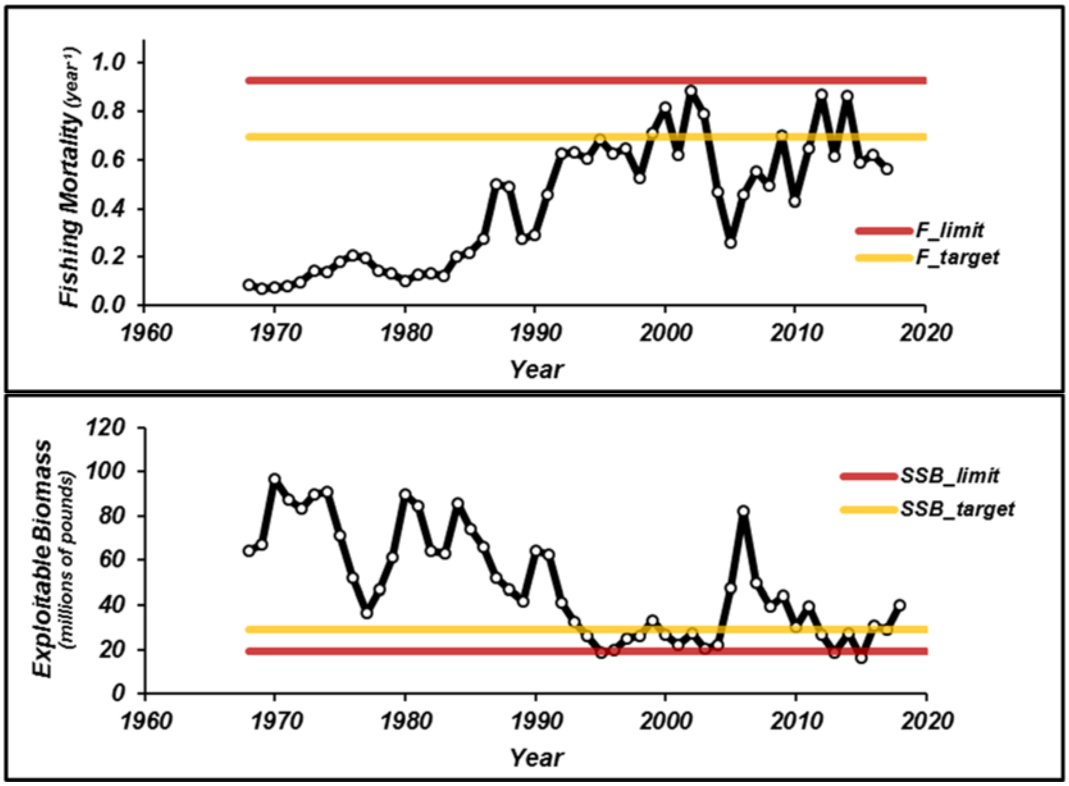


Figure 11: Time-series of catch-survey model fishing mortality rates and exploitable biomass estimates relative to management benchmarks.

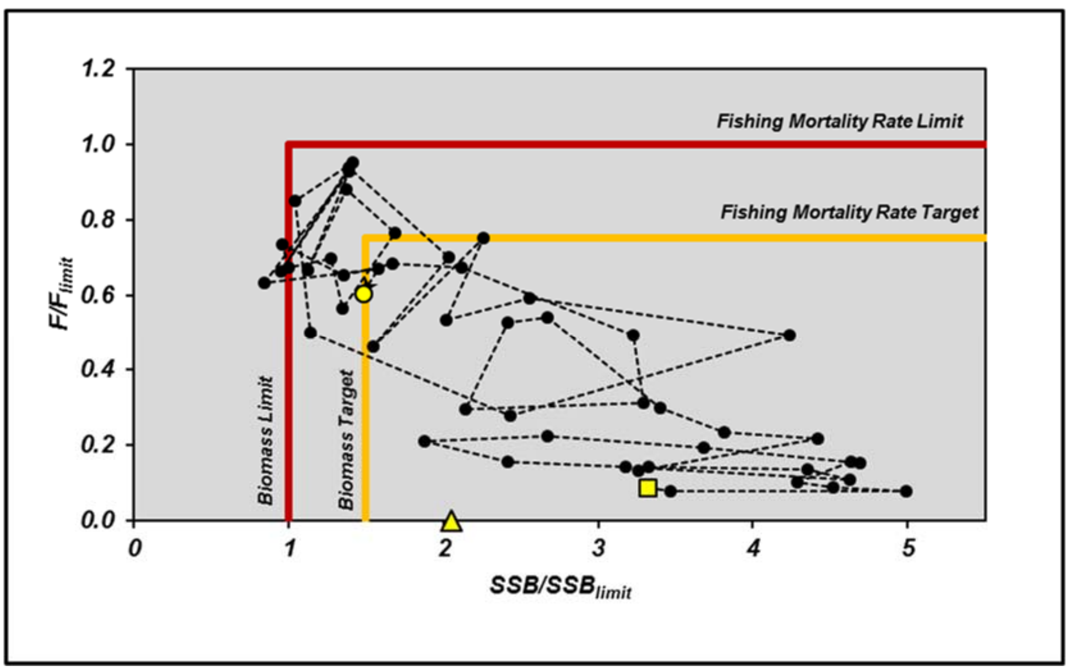


Figure 12: Ratios of annual fishing mortality rates and exploitable biomass estimates to $F_{limit}$ and $SSB_{limit}$. Exploitable biomass and instantaneous fishing mortality are estimated from the catch-survey model. The biomass limit and target are represented by the solid vertical lines. The fishing mortality rate limit and target are represented by the solid horizontal lines. The square represents the first year of data pairs and the circle represents the last. The triangle represents the 2018 exploitable biomass estimate.