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South Atlantic Red Porgy Commercial Hook-and-Line Discard Mortality Estimates Based on Observer Data

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Introduction

SEDAR 1 (2002) recommended a South Atlantic red porgy commercial hook-and-line total discard mortality estimate of 35% based on group input at the data workshop and research by Collins (1996). The 35% discard mortality estimate from Collins (1996) is based on 24-hour cage survival at 46 to 54 m, therefore, does not include depredation. A recent study in the Gulf of Mexico by Bohaboy et al. (2019) found large pelagic predators were estimated to account for 83% of red snapper discard mortality. In addition, the study by Collins (1996) only included red porgy that were able to resubmerge, thus the 35% does not account for immediate mortality. A literature review and at-sea observer data were used to investigate updating the South Atlantic red porgy discard mortality estimates for SEDAR 60. Fishery-dependent catch information collected by the National Marine Fisheries Service (NMFS) Southeast Fishery Science Center (SEFSC) Galveston Lab Reef Fish Observer Program (RFOP) on board commercial vessels in the Gulf of Mexico from July 2006 through December 2017 (accessed April 30, 2018) using standardized data protocols (NMFS, 2018) were used since no mandatory at-sea observer program is currently in place in the South Atlantic. Similar to other studies, the RFOP currently determines immediate discard mortality through surface observations of individual fish after discard (Patterson et al., 2002; Stephen and Harris, 2010). Short-term survival was assumed if the fish was able to descend rapidly or slowly and immediate mortality was classified when the fish floated on the surface or floated on the surface then slowly descended (not swimming). Although submergence ability as a proxy for discard mortality is problematic since it does not account for any long-term effects (delayed mortality), similar studies have shown that when other factors, such as hook trauma or barotrauma, are included, it can be used as a reasonably accurate method for inferring total discard mortality rates (Patterson et al., 2002; Rudershausen et al., 2014).

Methods

For the Gulf of Mexico RFOP, each year vessels were randomly selected quarterly to carry an observer. Sampling effort was stratified by season and gear in the eastern and western Gulf based on annually updated vessel logbook data (Scott-Denton et al., 2011). Beginning in February 2009, increased observer coverage levels were directed at the bottom longline fishery in the eastern Gulf of Mexico due to concerns regarding sea turtle interactions. Additionally, in 2011, increased funding allowed enhanced coverage of both the vertical line and bottom longline fisheries through 2014. Because of these actions, observer coverage levels did not remain consistent throughout the years (1% to 6% based on the number of days at sea), but varied depending on funding levels. Despite these variations in coverage levels, catch data were collected from vessels using multiple gear types across broad spatial and temporal scales. For this study, only red porgy discarded by vessels using hook-and-line (vertical line) gear were included.

Fishery observers on reef fish vessels assigned one of the following dispositions to each fish captured by the vessel: kept, used for bait, discarded alive, discarded dead, discarded unknown if dead or alive, and unknown if kept or discarded. For discarded fish, the disposition determination of alive or dead was based on surface observation of individual fish. If the fish rapidly or slowly descended, even with barotraumatic stress indicators, it was recorded as alive. It was considered dead if it floated on the surface or floated on the surface then slowly descended (not swimming). Some fish were recorded with an unknown discarded disposition due to the difficulty of observing discards attributed to poor lighting, high seas, or other factors. In this study, only individual fish that were discarded as either alive or dead were used to examine immediate discard mortality. Individual fish recorded as dead upon arrival were included in the analyses since the goal was to examine total discard mortality.

Onboard reef fish vessels, observers also assign a condition of capture for each individual fish based on external indicators of barotrauma. Research has shown that external indicators of barotraumatic stress will likely have an implication for the survival of the discarded fish (Rudershausen et al., 2007; Rudershausen et al., 2014; Sauls, 2014). The condition categories were assigned as follows: normal appearance, everted stomach (protrusion from the buccal cavity), exopthalmia (eyes bulging out of the socket), both everted stomach and exopthalmia, dead on arrival, damaged by predators, and unknown. These condition categories attempt to quantify the level of barotraumatic stress on the fish based on expansion of the swim bladder. The expansion of the swim bladder can force the stomach and/or eyes out of the body cavity. Observers also recorded if the fish was vented (air bladder punctured) prior to release; however, no distinction on the quality of the observed technique was recorded. Bottom depths were recorded in feet using fishing vessel equipment, typically depth sounders, and a fishing depth was estimated by monitoring gear deployment at each fishing site. All depths were converted to meters for the analyses.

A logistic regression model was fit to determine if fishing depth, season as a proxy for water temperature, or venting affected the immediate mortality observed. Stepwise backwards selection removed non-significant ($P > 0.05$) covariates using the likelihood ratio χ^2 P-Value to determine significance at each step. The initial model fit to the binary response of immediate discard mortality (alive or dead) was modeled as:

$$Logit(Y_i) = \alpha + \beta Depth_i + \beta Season_i + \beta Vented_i$$

where α is the intercept and β are the estimated model coefficients, depth of capture, astronomical season (e.g. winter is from 21 December through 21 March), and whether venting occurred. For the significant variables remaining in the model, the predicted odd ratios with profile likelihood 95% confidence intervals were calculated using the 'confint' function in R. For each final model, the overall χ^2 significance compared to an intercept only model, percent of deviance explained, and area under the receiver operating characteristic curve (AUC) were also reported. The AUC is a measure of overall model predictive accuracy, with 0.5 considered random and 1.0 a perfect fit (Agresti, 2013). A Hosmer-Lemeshow test statistic was used to assess the goodness of fit for the final logistic regression model (Agresti, 2013). The predicted immediate mortality probabilities with 95% confidence intervals were plotted for each significant variable. The predicted immediate mortality probabilities use the median for continuous variables and the most common factor for categorical variables. The logistic regression model was also used to estimate a range of predicted immediate mortalities using depths from South Atlantic fisheries. Analyses were performed using R statistical software (version 3.4.2; R Core Team 2017).

Results

There were 1,309 red porgy with a discard disposition of either alive or dead captured by hook-and-line gear recorded by the RFOP from July 2006 through 2017 (Table 1). The RFOP immediate discard mortality rate based on the surface estimates was 23.2% with a 95% confidence interval of 21.0 – 25.6% (Wilson score interval with continuity correction). Red porgy assigned a dead disposition category were on average captured at a deeper depth, exhibited a higher percentage of barotraumatic stress indicators, and had a smaller percentage of fish vented compared to fish recorded as released alive. For the condition categories indicating barotraumatic stress, the majority of captures (>93%) did not exhibit any signs of barotrauma (Table 2). When barotrauma occurred, stomach eversion was the most common category observed. The majority of red porgy discards observed by the RFOP (83%) were captured between 30 m and 70 m (Figure 1). The RFOP mean depth of capture (54.3 m) for red porgy was similar to the mean depth (50.1 m) recorded by hook-and-lines trips ($n = 3,683$ trips) in the South Atlantic landing red porgy from 2015 to 2017 in the commercial trip logbook (SEFSC Coastal Logbook, accessed May 31, 2018). Similar depths support RFOP data as representative of the South Atlantic hook-and-line commercial fishery.

Both depth and venting were significant variables in predicting immediate mortality for red porgy (Table 3). Season was removed as a non-significant ($P = 0.21$) variable during model fitting. The final logistic regression model was significant ($P < 0.001$), but only explained 1.5% of the deviance. The AUC value of 0.59 was low indicating poor predictive accuracy and additionally the model failed the Hosmer-Lemeshow goodness-of-fit test ($P < 0.05$). For the significant variables in the model, the predicted immediate discard mortality increased with capture depth and air bladder venting had a positive effect, decreasing predicted mortality (Figure 2).

The RFOP logistic model was fit to depths from the commercial trip logbook (SEFSC Coastal Logbook, accessed May 31, 2018) for hook-and-line trips that landed red porgy in the South Atlantic from 2015 through 2017 (Figure 3). A weighted mean of the predicted immediate mortalities based on the pounds landed per trip resulted in a predicted immediate mortality of 20.9% for fish vented and 35.2% for fish not vented. The RFOP logistic model was also fit to depths from the Southeast Region Headboat Survey (SRHS) eLog program (SRHS eLog file accessed August 30, 2019) from trips that captured a red porgy from 2014 through 2018 (Figure 4). A weighted mean of the predicted immediate mortalities based on the number of fish released results in a predicted immediate mortality of 16.8% for fish vented and 28.4% for fish not vented.

Discussion

The SEDAR 1 Update (2012) continued to recommend a commercial discard mortality rate for red porgy of 35% based on the previous assessment, but also discussed that higher rates, such as the 82% as reported by Stephen and Harris (2010), may be more appropriate. A study of red porgy survival by Overton et al. (2008) found >93% of lip hooked red porgy survived using cages (48 h) to assess long-term mortality, however, the total discard mortality rate was estimated to be 37.5% when both immediate and long-term mortality rates were included. An early study by Collins (1996) estimated a low immediate (surface) discard mortality of 6% and a 35% delayed mortality rate at 24-hours using cages for red porgy captured between 46 m to 54 m. Another study by Rudershausen et al. (2007) using data collected by two commercial vessels off North Carolina in 2005, found an immediate discard mortality rate of 14% using a similar methodology to the RFOP. In addition, the research by Rudershausen et al. (2007) used Monte Carlo simulation models to estimate delayed mortality using a barotrauma and hooking locations. Using these simulations, a delayed mortality estimate of 26% was estimated for red porgy. The red porgy immediate discard mortality estimates by Overton et al. (2008), Rudershausen et al. (2007), and the RFOP are lower than the results by Stephen and Harris (2010) that estimated an immediate discard mortality rate of 82% for red porgy from sampling aboard a commercial South Atlantic vessel fishing between 20 m and 80 m. It should be noted that the study by Stephen and Harris (2010) was limited to one vessel and neither circle hook nor dehooking devices were required in the South Atlantic commercial fishery in 2004.

Based on observer data from the Gulf of Mexico commercial fishery, a range of total discard mortality estimates were proposed for the commercial and recreational sectors. In addition to immediate mortality, delayed mortality rates were estimated from literature and depredation mortality rates were proposed at the SEDAR 60 workshop. Depredation mortality rates from 5 to 10% were estimated for both sectors based on panelist input at the workshop. For both sectors, the effects of delayed and depredation mortality are conditional on surviving immediate mortality. The total commercial hook-and-line mortality estimate ranged from 45 to 64% with a proposed midpoint value of 53% (Table 4). The commercial immediate mortality estimates are the weighted logistic predictions from the SEFSC logbook with the midpoint value (25%) assuming the majority of red porgy are being vented. The delayed mortality lower bounds of 26% is based on Rudershausen et al. (2007) and the upper bounds of 35% is based on 24-hour cage survival at 46 to 54 m from Collins (1996). The total recreational hook-and-line mortality estimate ranged from 27 to 53% with a proposed midpoint value of 41% (Table 5). The recreational immediate mortality estimates are the weighted logistic predictions from the SRHS eLog data with the midpoint value assuming 50% of red porgy are being vented. The delayed mortality lower bounds of 8% is based on 24-hour cage survival at 36 m from Collins (1996) and the upper bounds of 26% is based on Rudershausen et al. (2007).

Many stressors, such as hooking trauma, barotrauma, handling time, and temperature (Campbell et al., 2014; Curtis et al., 2015; Jarvis and Lowe, 2008) can affect both immediate and delayed discard mortality rates. In conclusion, it should be noted again that the RFOP mortality estimates for red porgy discarded in the commercial Gulf of Mexico fishery may differ from the South Atlantic due to differences in gears used, depth of capture, water temperatures, or differences in other variables not specified that could affect discard mortality. The reliability of this analysis is dependent upon the accuracy of the underlying data and input assumptions.

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Table 1. The total number of red porgy hook-and-line captures with an alive or dead disposition with the mean depth of capture (S.D.), percent exhibiting signs of external barotrauma, and percent vented prior to release recorded by the RFOP from July 2006 through December 2017.

Disposition Category	Number Observed	Mean Depth (m)	External Barotrauma	Vented
Alive	1,005	53.1 (24.2)	4.7 %	34.7%
Dead	304	58.2 (25.2)	15.3%	31.5%
Total	1,309	54.3 (24.5)	6.9%	34.1%

Source: SEFSC RFOP (May 2018)

Table 2. The number red porgy hook-and-line captures for each condition category by disposition recorded by the RFOP from July 2006 through December 2017.

Condition Category	Alive	Dead	Total
Normal	946	216	1,162
Stomach Eversion (SE)	46	36	82
Exopthalmia	1	1	2
Both SE and Exopthalmia	0	2	2
Dead on Arrival	0	47	47
Unknown	12	2	14

Source: SEFSC RFOP (May 2018)

Table 3. Logistic regression model odds ratios with profile likelihood 95% confidence intervals and the likelihood ratio χ^2 P-Value for the intercept, depth (m), whether the fish was vented prior to release compared to not vented, and season. Significant variables are denoted by an asterisk.

Variable	**Odds Ratio**	**χ^2 Significance**
Intercept	0.20 (0.14, 0.27)	—
Depth (m)	1.01 (1.00, 1.02)	0.003*
Vented (True)	0.59 (0.44, 0.80)	< 0.001*
Season		0.21

Table 4. Red porgy commercial hook-and-line total discard mortality estimates based on a range of immediate, delayed, and depredation mortality values.

Immediate Mortality	**Delayed Mortality**	**Depredation Mortality**	**Total Discard Mortality**
20%	26%	5%	45%
25%	30%	7.5%	53%
35%	35%	10%	64%

Table 5. Red porgy recreational hook-and-line total discard mortality estimates based on a range of immediate, delayed, and depredation mortality values.

Immediate Mortality	**Delayed Mortality**	**Depredation Mortality**	**Total Discard Mortality**
16%	8%	5%	27%
22%	17%	7.5%	41%
28%	26%	10%	53%

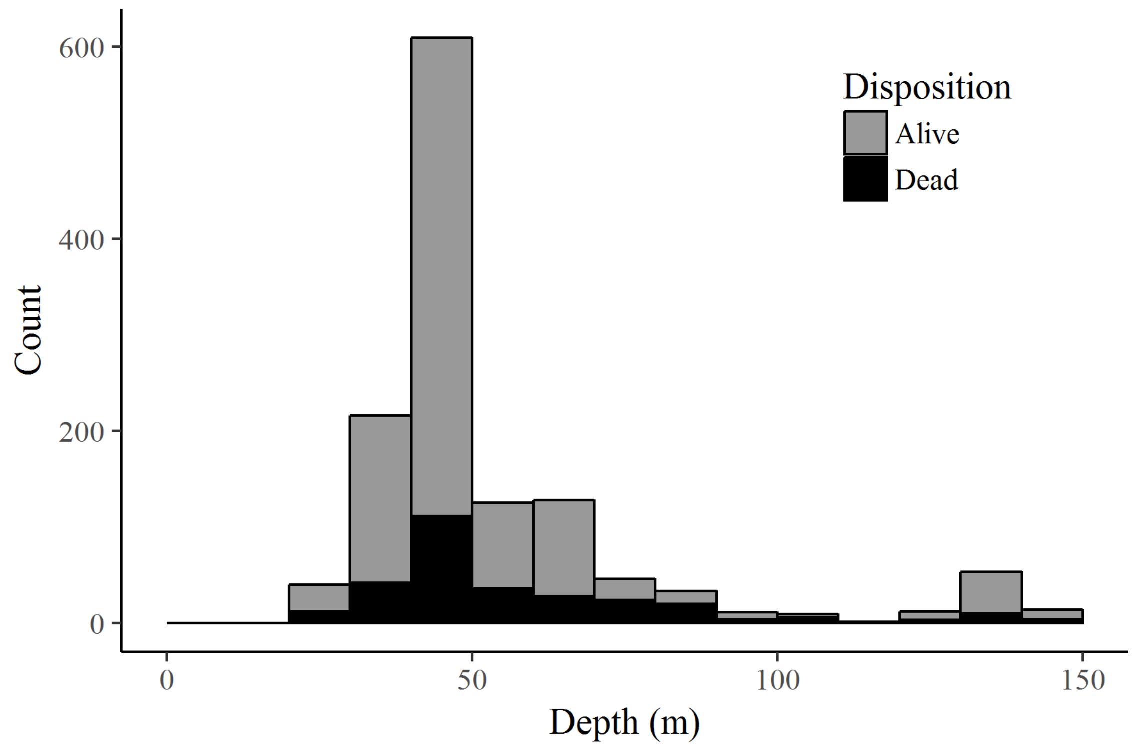

Figure 1. Histogram of capture depths for red porgy discarded by vessels using hook-and-line gear observed by the RFOP from July 2006 through December 2017.
Source: SEFSC RFOP (May 2018).

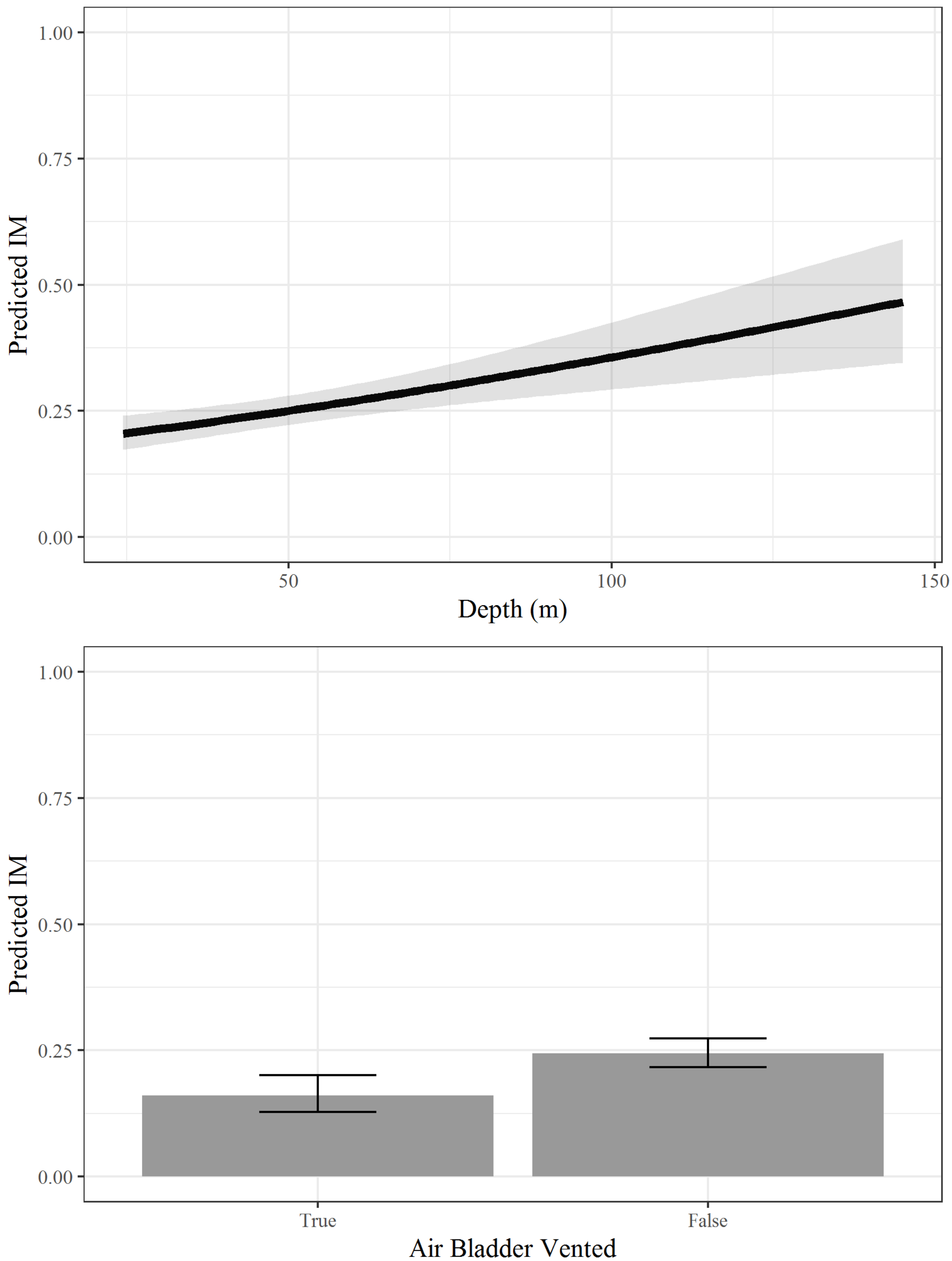

Figure 2. The predicted immediate mortality (IM) logistic regression probabilities with 95% confidence intervals for depth and whether the fish was vented prior to release based on RFOP data from July 2006 through December 2017.
Source: SEFSC RFOP (May 2018).

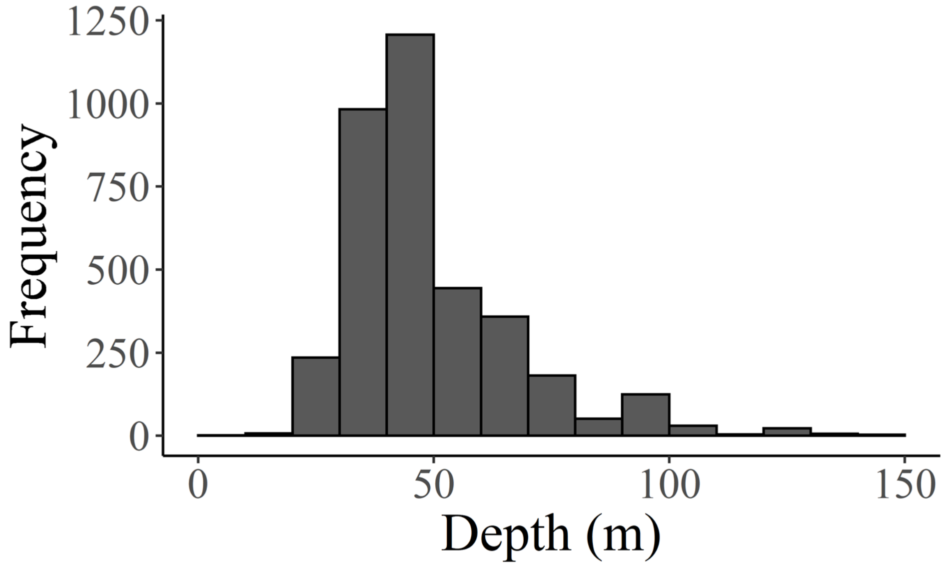

Figure 3. Histogram of depths for South Atlantic commercial hook-and-line trips landing red porgy from 2015 through 2017.
Source: SEFSC Coastal Logbook (May 2018).

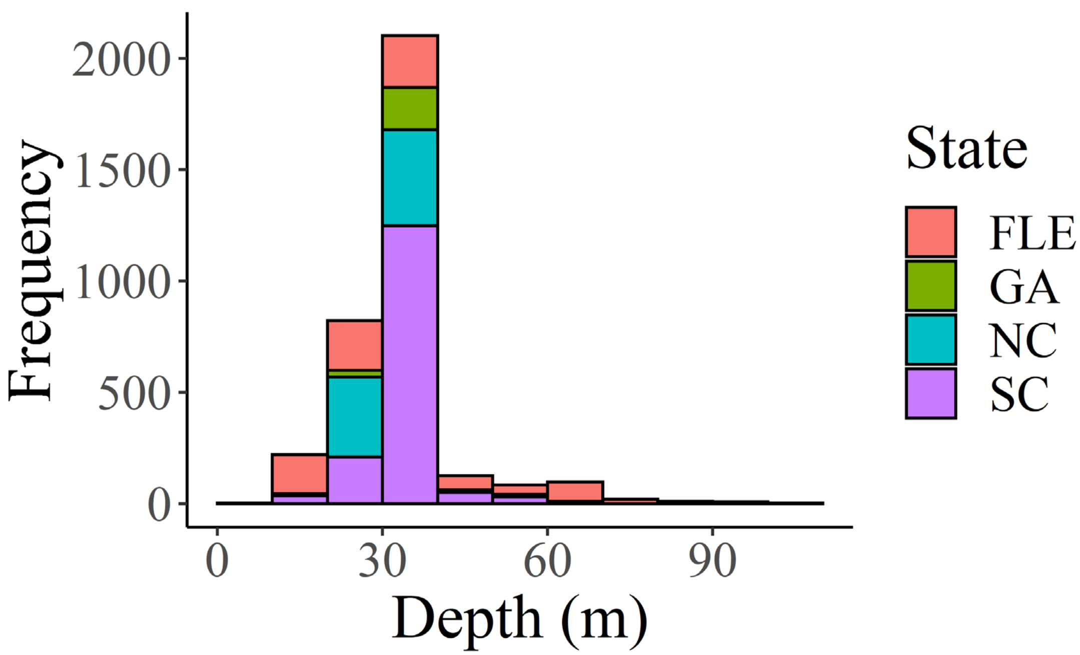

Figure 4. Histogram of primary depths fished by state for South Atlantic headboat trips capturing a red porgy from 2014 through 2018.
Source: SRHS eLog File (August 2019).