Red Snapper Fishery-Independent Index of Abundance and Age/Length Compositions in US South Atlantic Waters Based on a Chevron Video Trap Survey (2010-2024)

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MARMAP/SEAMAP-SA Reef Fish Survey Technical Report #2025-06

Abstract

This report presents a summary of the trap-collected Red Snapper from fishery-independent monitoring in the US South Atlantic region from three monitoring programs (MARMAP, SEAMAP-SA, and SEFIS, known collectively as SERFS). Specifically, it presents annual nominal abundance of Red Snapper, *Lutjanus campechanus*, in chevron video traps from 2010 to 2024. Also included are annual abundance estimates for chevron video trap catches over this same time period that are standardized by a zero-inflated negative binomial model (ZINB) to account for the effects of potential covariates on these estimates. The ZINB model produced relative abundance estimates which show a generally increasing trend from 2010 to 2019 with a stabilization of the abundance after that time. Corresponding age and length compositions from the video trap catches are displayed for informational purposes.

Background

The Marine Resources Monitoring, Assessment, and Prediction program (MARMAP) has conducted fishery-independent monitoring of reef fish species on the continental shelf and shelf edge between Cape Hatteras, North Carolina, and St. Lucie Inlet, Florida, for over 40 years. Starting in 1990, the chevron trap has been the primary gear deployed to allow for analyses of long-term changes in relative abundance, age compositions, length frequencies, and other information regarding reef fish species on live-bottom and/or hard-bottom habitats. In 2009, the Southeast Area Monitoring and Assessment Program - South Atlantic (SEAMAP-SA) provided funding to assist with the expansion of the geographical sampling coverage of the MARMAP fishery-independent chevron trap survey. Again in 2010, with the formation of the Southeast Fishery-Independent Survey (SEFIS), additional funds were provided to, among other things, expand the geographic coverage and sampling intensity of the MARMAP fishery-independent chevron trap survey and consistently add video cameras to each trap, thus making the gear the chevron-video trap (CVT). Collectively, we now refer to these three surveys' combined reef fish monitoring efforts from 2010 to present as the Southeast Reef Fish Survey (SERFS). This spatial expansion better encompassed the core geographical range of Red Snapper in the Atlantic waters off the southeastern United States compared to the earlier time. For this reason, consistent with SEDAR41 decisions, only 2010-2024 index values are presented here, though the chevron (video) trap survey has been ongoing since 1990. A recent publication exploring the differences between indices produced using the MARMAP historical spatial footprint and using the SERFS combined footprint has added weight to the decision to begin the time series in 2010 (Vecchio et al. 2023).

Objective

This report presents a standardized relative abundance index of Red Snapper physically captured in chevron traps by the SERFS survey during the years 2010-2024. The standardized index accounts for annual sampling distribution shifts with respect to covariates that affect catch of Red Snapper in chevron video traps. Also provided are distributions of annual age and length compositions of Red Snapper captured by chevron video traps. This information is critical to informing the selectivity pattern at age of Red Snapper by chevron video traps. Data presented in this report are based on the combined SERFS database accessed on February 14, 2025.

Methods

Survey Design and Gear

(see Smart et al. 2015 for full description)

Sampling area

- Cape Hatteras, NC, to St. Lucie Inlet, FL

Sampling season

- Mid-April to mid-September

Survey Design

- Simple random sample survey design
  - Annually, randomly selected stations from a CVT universe of confirmed live-bottom and/or hard-bottom habitat stations
  - No two stations are randomly selected that are closer than 200 m from each other
    - Geographic stratification is not used, but total geographic distribution of sampled stations is taken into consideration when making within-season plans to ensure coverage of the entire sampling region
- CVTs deployed on suspected hard-bottom in a given year (reconnaissance) are evaluated based on video evidence of bottom type for inclusion in the sampling universe in subsequent years
  - If added to the known habitat universe, data from the reconnaissance deployment is included in index development

Sampling Gear – Chevron Video Traps

(see Collins 1990 and MARMAP 2009 for more detailed descriptions)

- Arrowhead shaped, with a total interior volume of 0.91 m^3
- Constructed of 35 x 35 mm square mesh plastic-coated wire with a single entrance funnel (“horse neck”)
- Baited with a combination of whole or cut clupeids (*Brevoortia* or *Alosa* spp., family Clupeidae), most often *Brevoortia* spp.
  - Four whole clupeids on each of four stringers suspended within the CVT
  - Approximately 8 clupeids placed loose in the CVT
- Soak time of approximately 90 minutes
- Daylight hours

Oceanographic Data

- Hydrographic data collected via CTD during soaking of a “set” (typically 6 CVTs, but may be less) of CVTs deployed at the same time and same reef patch
  - Bottom temperature (°C) is defined as the temperature of the deepest recording within 5 m of the bottom

Data Filtering/Inclusion (provided to allow for reproduction of this data set from the SERFS database)
CVT catch data (Gear = 324) were limited to:

- Projects conducting monitoring sampling
  - P05 – MARMAP
  - T59 – SEAMAP-SA
  - T60 – SEFIS
- Reef fish monitoring samples
  - Data source ≠ "Tag-MARMAP" – represents special historic MARMAP cruises that were used to tag various species of fish
    - Because standard sampling procedures were not consistently used (e.g. not all fish were measured for length frequency) these samples are excluded from index development
- CVTs that fished properly (i.e., appropriate catch IDs)
  - 0 – no catch
  - 1 – catch with finfish
  - 2 – catch without finfish
  - 8 - Species catch subsampled for Length Frequency
- CVTs on hard-bottom habitat (i.e., appropriate station types)
  - Included all station types except for reconnaissance and experimental
- CVTs with soak times that were neither extremely short nor long which often indicates an issue with the deployment not captured elsewhere (included 45-150 minutes)
  - SERFS targets a soak time of 90 minutes for all CVT deployments
- Excluded any CVTs missing covariate information
- Excluded all CVTs sampled prior to 2010

Standardized Index Model Formulation

<u>Model Basics</u>

- Response variable
  - Abundance per CVT
- Offset term
  - Soak time
- Independent variables
  - Year
  - Covariates
    - 4 covariates explored
      - Depth – Continuous variable
      - Latitude (^{o}N) - Continuous variable
      - Bottom temperature (^{o}C) - Continuous variable
      - Day of year (DOY) - Continuous variable
    - Modelled with polynomials
      - Maximum allowed polynomial order set using preliminary generalized additive models (GAMs)

        - Limited polynomial to maximum of fourth order for biological relevance
    - Due to widely differing scales, the covariates were centered and scaled
        - Centered – subtract covariate mean
        - Scaled – divided centered values by their standard deviation prior to the GAMs
- Model structure – Zero-inflated negative binomial, and zero-inflated Poisson model structures were explored
    - Mixture model for both zero-inflated error structures
    - Two parts to the model, with Bayesian Information Criteria (BIC) used to select the best model from each of the 2 zero-inflated error distributions
        - Presence/absence (binomial sub-model)
        - Catch (count sub-model)
    - Sub-models optimized using a two-step approach due to computational demands
        - Count sub-model was optimized with all covariates removed from the zero-inflation sub-model
        - Binomial sub-model was optimized using fixed count sub-model covariates obtained in previous step
        - Allows for different covariates to be included in the two sub-models
    - Final model was selected amongst the best models from each of the error distributions using BIC
- Annual year effect coefficients of variation (CVs) and standard errors (SE) computed using bootstrapping
    - 4,960 bootstraps
- Software used
    - R (Version 4.4.3; R Development Core Team 2025)

Length Composition

- All fish per CVT were measured for maximum total length (TL) in cm

Age Composition

- Ageing methods – sagittal otoliths were removed from Red Snapper to serve as the ageing structure
    - Ages presented here are calendar age based on increment counts with an estimated increment formation on August 1 (SEDAR 41)
    - Only fish caught in CVTs were included in the age compositions
    - Selection of fish retained for aging was complete (100% retained)

Results

Sampling area

- General increase in sampling intensity (# of annual CVT deployments) through time (Fig. 1)
- CVT sampling depths range from 14 to 115 m (Table 1 and Fig. 2)

Sampling season

- Mid-April through Mid-October (Table 1 and Fig. 2)

Data Filtering/Inclusion

- Included video traps (n = 19,743; Table 2)

Standardized Index Model Formulation

Model Basics

- Independent variables
  - Covariates (Inclusion and polynomial order in sub-models available Table 3)
    - The effect on positive catches, both raw and modelled was determined (Figs. 3 and 4)
    - Depth, latitude, temperature, and day of year were included in the final model (Table 3 and Fig. 4)
- Model structure
  - Final model selected was ZINB (Table 3)
    - Selected over non-zero inflated models due to high proportion of zero counts (Fig. 5)
- Coefficients of variation (CVs) and variances stabilized within the 4,960 bootstraps (Fig. 6)
- Annual standardized and normalized (relative to the long-term mean) abundance index values for Red Snapper, including CVs showed trends from 2010 to 2024 (Table 2 and Fig. 7)

Length Composition

- All measured fish were included in the length compositions
- Lengths presented here are TL in 10 mm bins centered around the integer
  - Meristic conversions from fork length (FL) when needed were calculated in cm using this equation developed from the SERFS database

    $TL=1.079*FL+0.155$, $r^2 = 0.999$, n = 9,324 (Glasgow et al. 2020)
- Length compositions were produced for CVTs (Fig. 8)

Age Composition

- Calendar ages caught by CVTs in 2010-2024 (Fig. 9)

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Table 1. Sampling summary table for the SERFS fishery-independent chevron video trap (CVT) survey. The average and range of all the covariates by year are listed.

	Depth (m)		Latitude (°N)		Temperature (°C)		Day of Year	
Year	**Avg**	**Range**	**Avg**	**Range**	**Avg**	**Range**	**Avg**	**Range**
2010	38.6	14-92	31.3	27.3-34.6	22.2	12.3-29.4	220.9	124-300
2011	40.7	14-93	30.9	27.2-34.5	21.6	14.8-28.8	208.5	139-299
2012	40.8	15-106	31.9	27.2-35.0	22.1	12.9-27.8	194.2	115-284
2013	38.3	15-110	31.3	27.2-35.0	22.0	12.4-28.1	196.1	114-277
2014	39.3	15-110	31.9	27.2-35.0	23.3	16.1-29.3	191.4	113-294
2015	39.3	16-110	31.9	27.3-35.0	22.6	13.6-28.5	186.0	111-295
2016	40.9	17-115	32.1	27.2-35.0	23.8	15.5-29.3	216.4	125-300
2017	40.6	15-114	32.0	27.2-35.0	22.6	14.8-28.2	186.3	116-272
2018	40.3	16-114	32.0	27.2-35.0	22.5	13.6-28.3	175.8	115-277
2019	40.2	16-113	32.0	27.2-35.0	23.3	15-29.5	183.9	120-268
2020	-	-	-	-	-	-	-	-
2021	38.2	16-110	31.8	27.2-35.0	23.3	16.5-28.1	190.5	118-273
2022	38.9	17-113	32.0	27.2-35.0	23.2	14.6-32.5	194.3	116-270
2023	40.1	15-110	31.7	27.2-35.0	24.1	15.8-28.5	200.3	136-284
2024	38.8	15-102	31.6	27.2-35.0	23.3	13.8-29.6	194.5	106-277

Table 2. The annual summary of data informative to abundance index development and the results of the standardization. The data includes total number of collections per year, the number of positive collections for Red Snapper, the proportion of those positive collections in relation to the included collections, and the total number of Red Snapper caught. The results show the normalized nominal and standardized catch abundance of Red Snapper from the SERFS fishery-independent chevron video trap survey which meet criteria to be included in the standardization process. The zero-inflated negative binomial (ZINB) standardized catch also includes a coefficient of variation (CV) calculated from a bootstrapping procedure.

					Nominal Abundance	ZINB Standardized Abundance	
Year	Included Collections	Positive Collections	Proportion Positive	Total Fish	Normalized	Normalized	CV
2010	737	65	0.09	152	0.28	0.23	0.18
2011	731	67	0.09	118	0.22	0.25	0.18
2012	1174	145	0.12	410	0.48	0.48	0.13
2013	1360	140	0.1	367	0.37	0.36	0.15
2014	1472	150	0.1	614	0.57	0.63	0.13
2015	1463	159	0.11	905	0.85	0.92	0.13
2016	1484	213	0.14	1075	0.99	1.22	0.11
2017	1541	245	0.16	1499	1.33	1.35	0.11
2018	1736	275	0.16	1925	1.52	1.7	0.10
2019	1663	287	0.17	1675	1.38	1.23	0.08
2020	-	-	-	-	-	-	-
2021	1882	367	0.195	1962	1.43	1.46	0.09
2022	1648	316	0.1917	1756	1.46	1.59	0.08
2023	1516	277	0.1827	1774	1.6	1.24	0.10
2024	1336	269	0.2013	1491	1.53	1.35	0.10

Table 3. Model error structure comparison, including covariates that were included and their polynomial level for both the count and binomial sub-models. Polynomial values of "0" indicate that the covariate was not included in the final model. The best-fit model (ZINB) was chosen based on Bayesian Information Criteria (BIC).

	Count Sub-model					Binomial Sub-model				
Model Error Structure	Year	Lat	Depth	Temp	DOY	Lat	Depth	Temp	DOY	BIC
Zero-Inflated Negative Binomial	1	4	4	1	1	4	4	0	0	27597
Zero-Inflated Poisson	1	4	2	3	4	4	4	1	1	43101

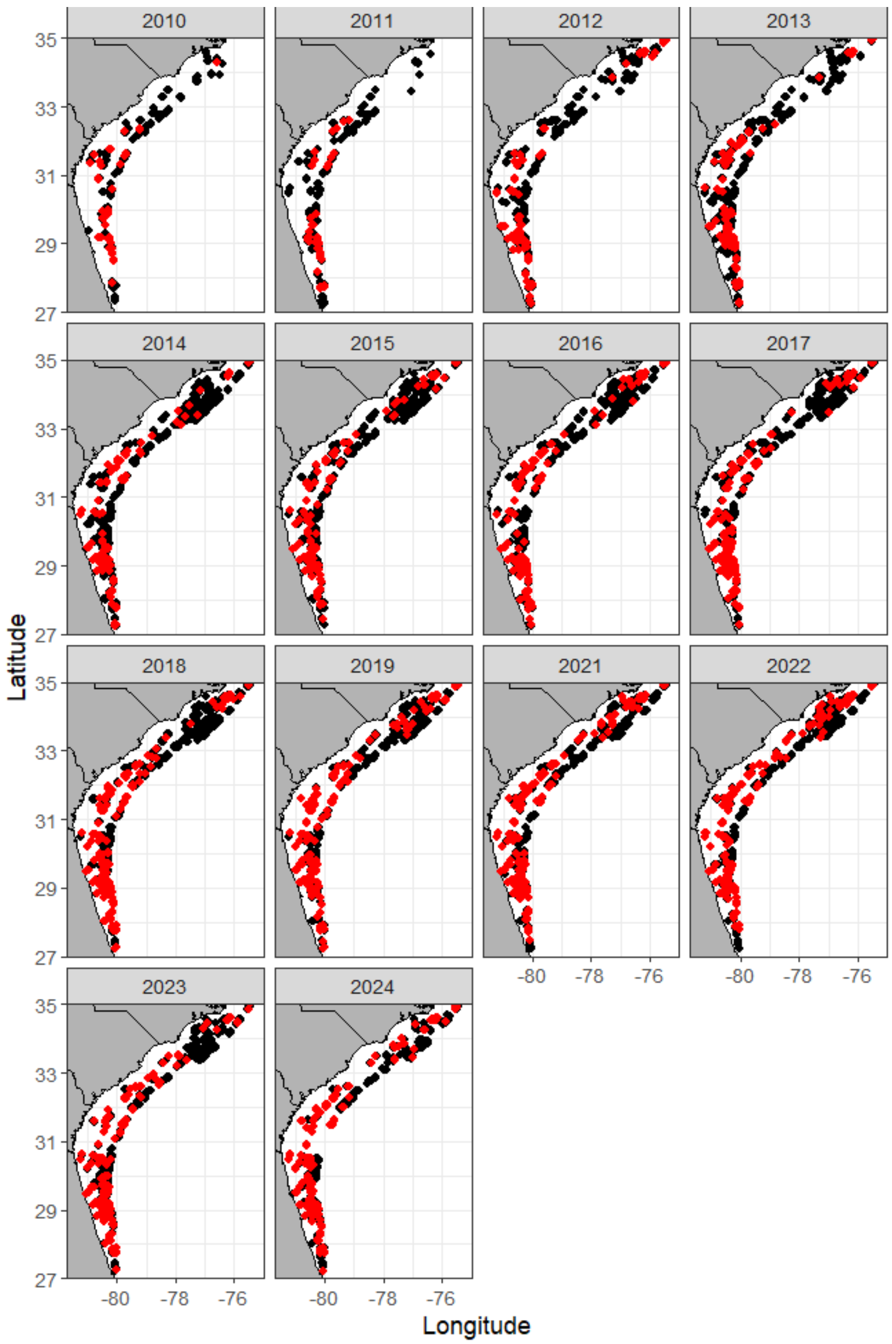

Figure 1. Sampling distribution of all collections by year of the SERFS fishery-independent chevron video trap (CVT) survey. Red circles indicate positive collections for Red Snapper, while black circles represent no catch of Red Snapper.

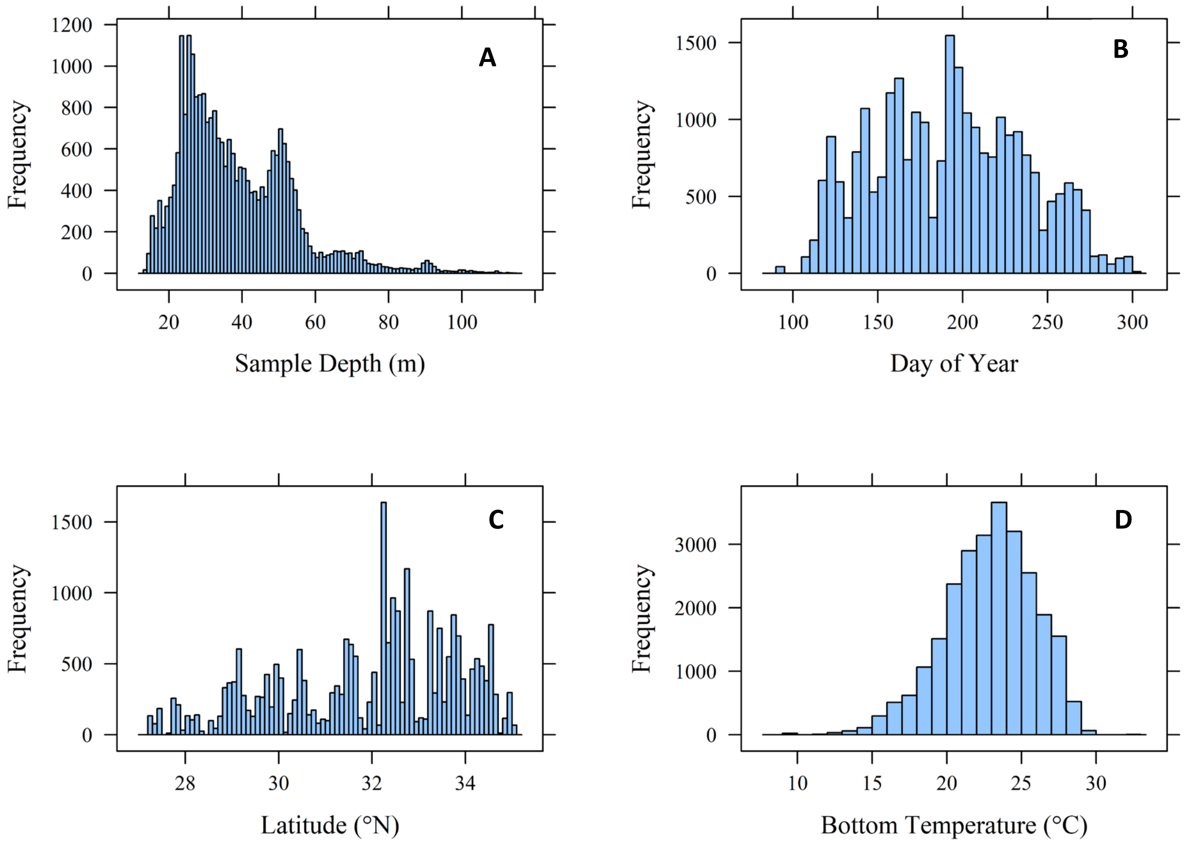

Figure 2. Sample distribution of covariate data from SERFS fishery-independent CVT survey collections over the period 2010-2024. depth (A), day of year (B), latitude (C), and bottom temperature (D).

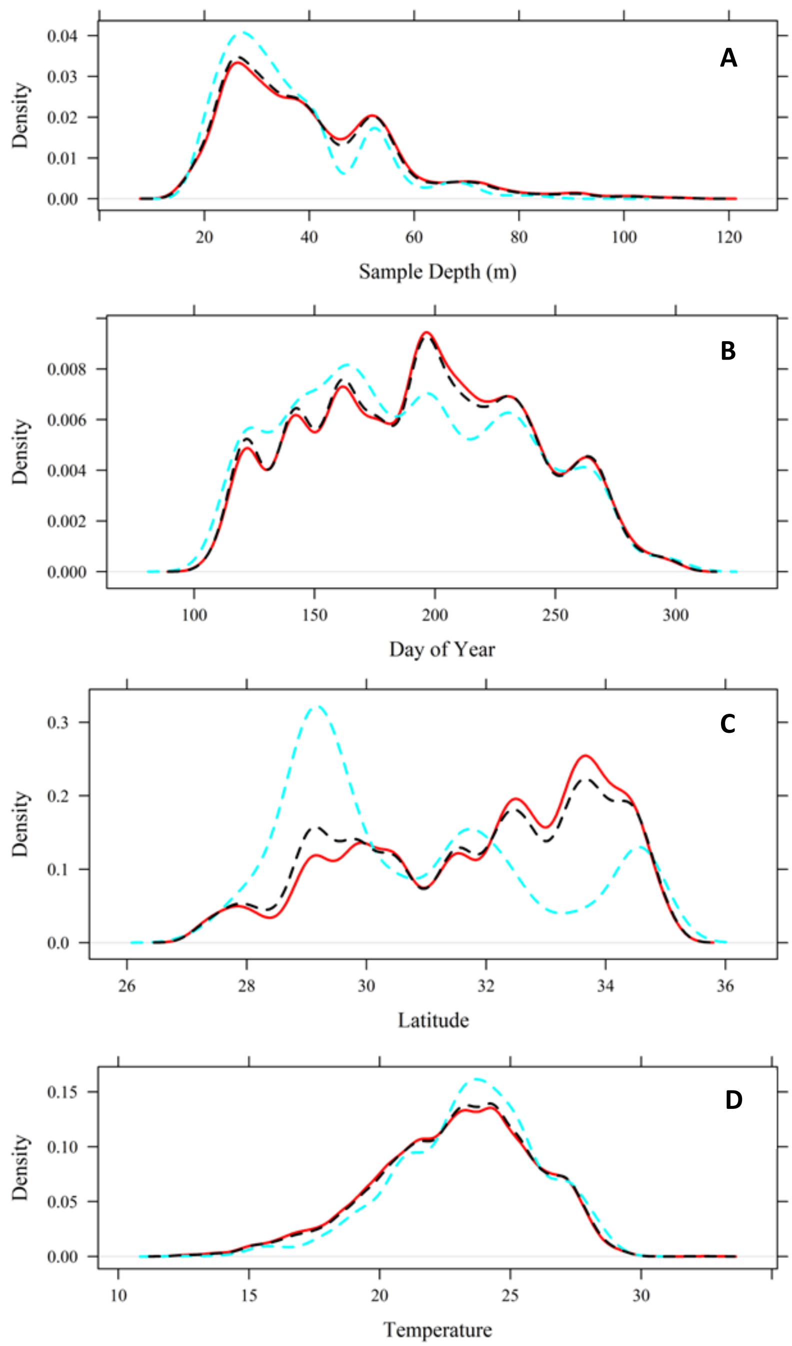

Figure 3. Sample distribution of catch abundance of Red Snapper and effects by covariate on positive (blue dashed line) and zero (red line) catches relative to all included sampling (black dashed line). depth (A), day of year (B), latitude (C), and bottom temperature (D).

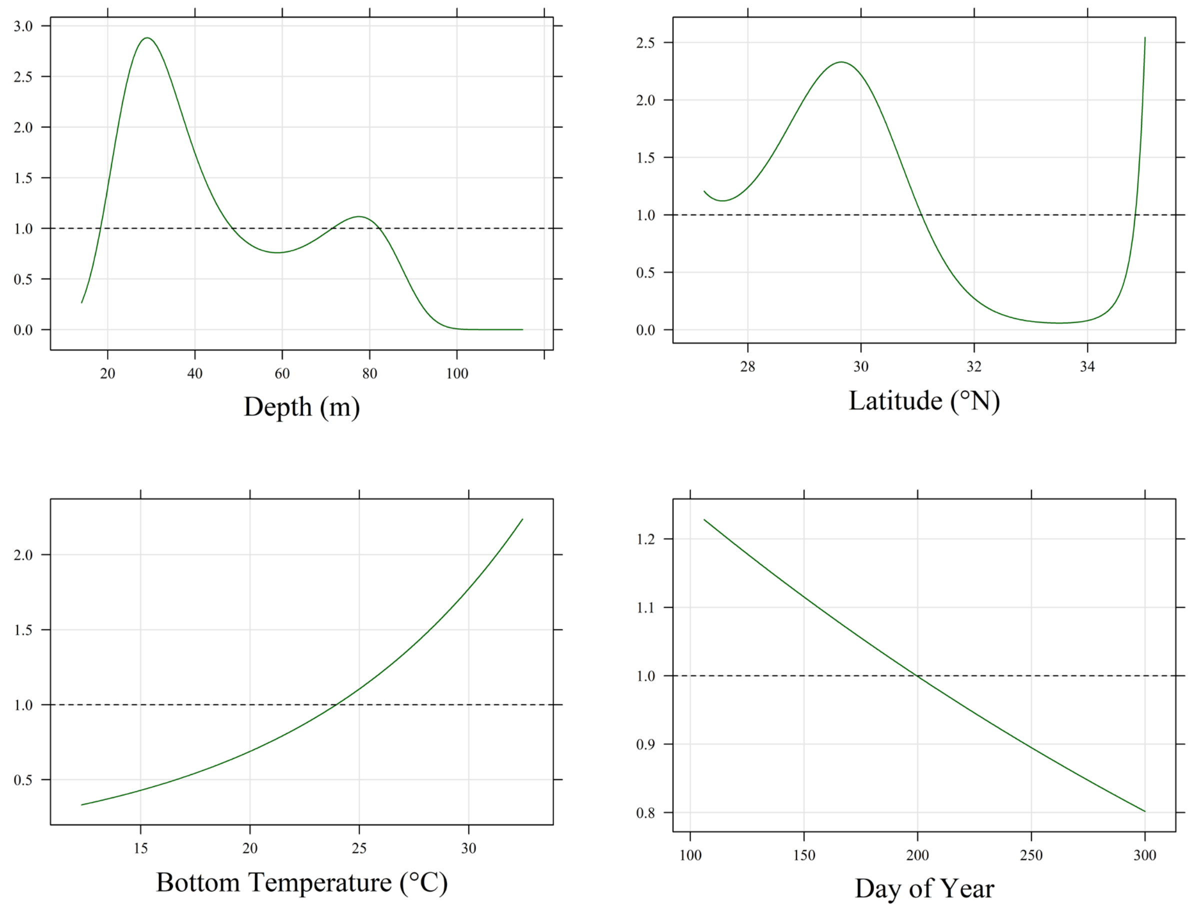

Figure 4. Modelled final covariate effects on catch of Red Snapper from the ZINB standardization.

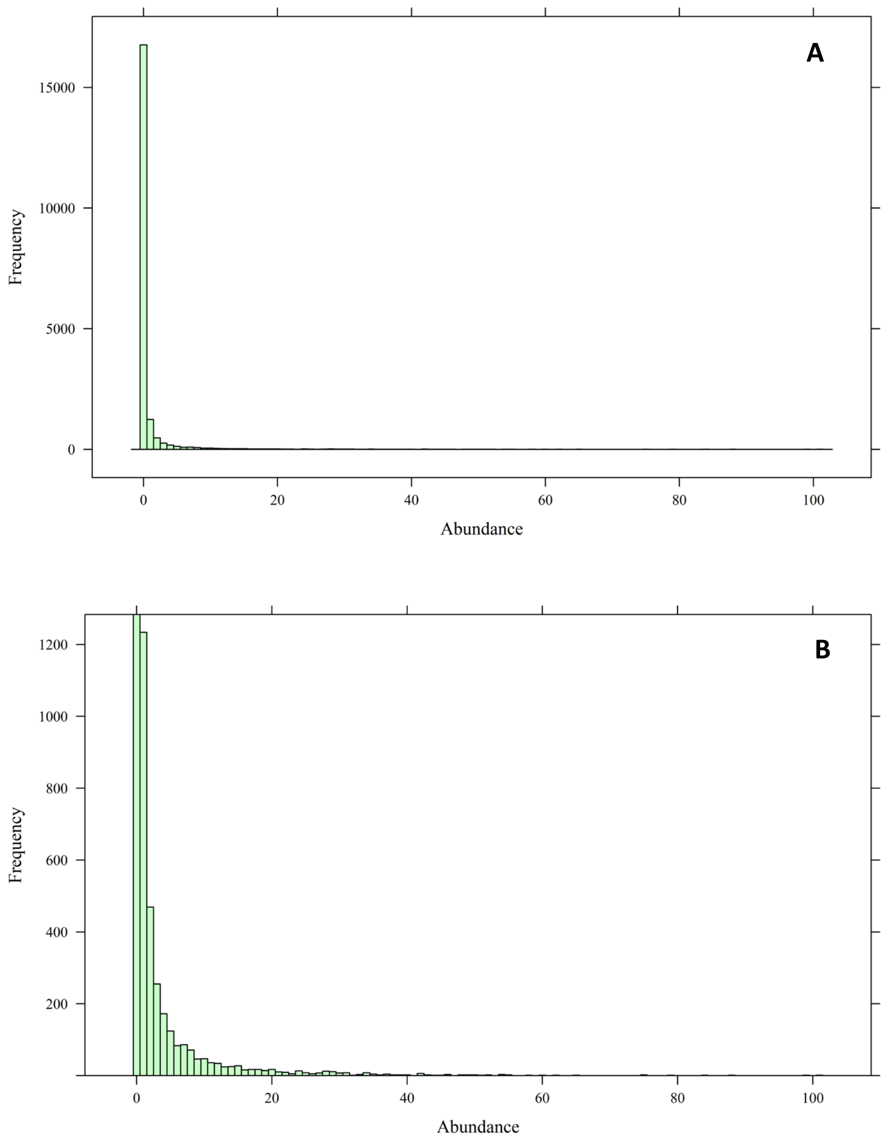

Figure 5. Count distribution of Red Snapper catch from SERFS fishery-independent CVT survey showing full range of the distribution (A) and a truncated y-axis (B) to better show positive catches.

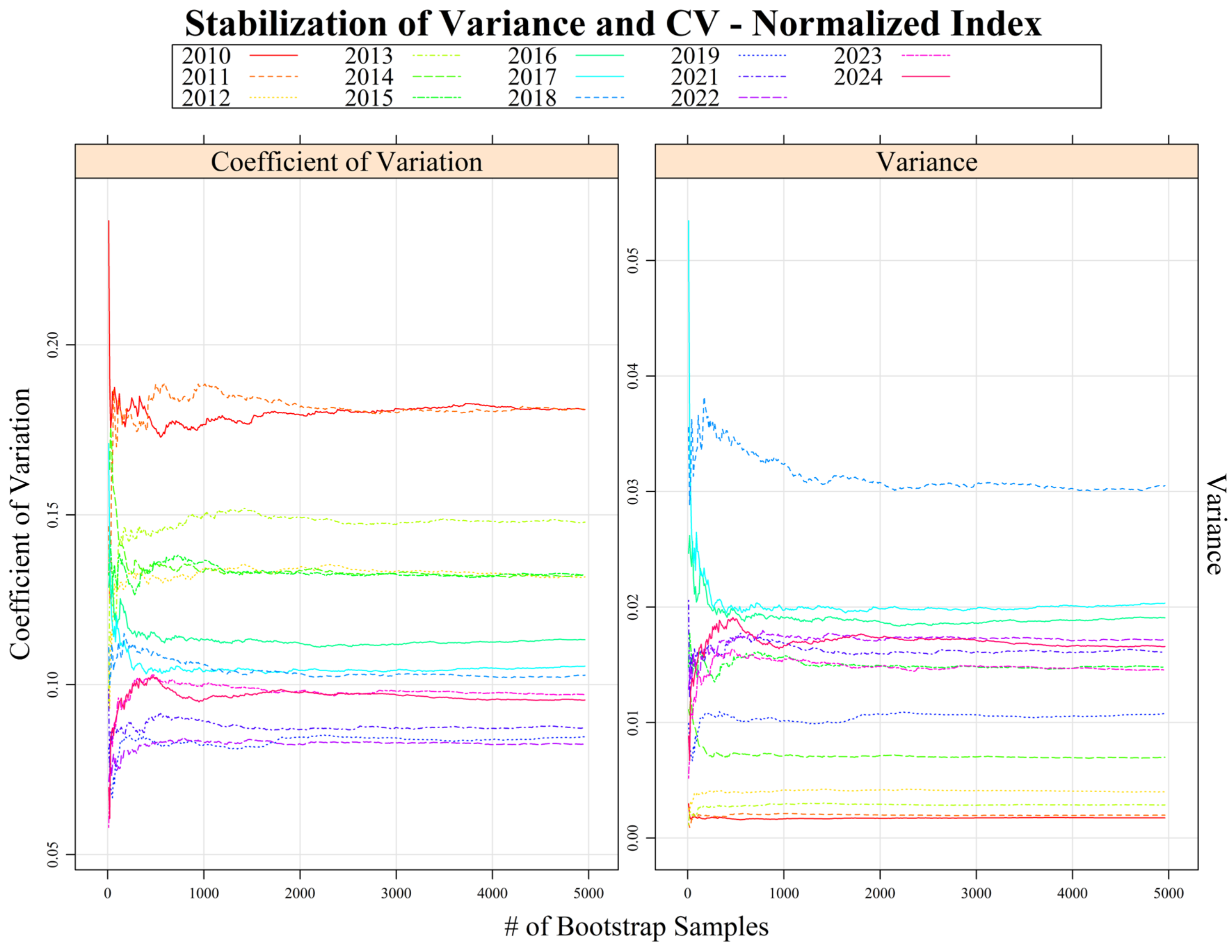

Figure 6. Stability of coefficient of variation and variance by bootstrap run during fishery-independent CVT index development.

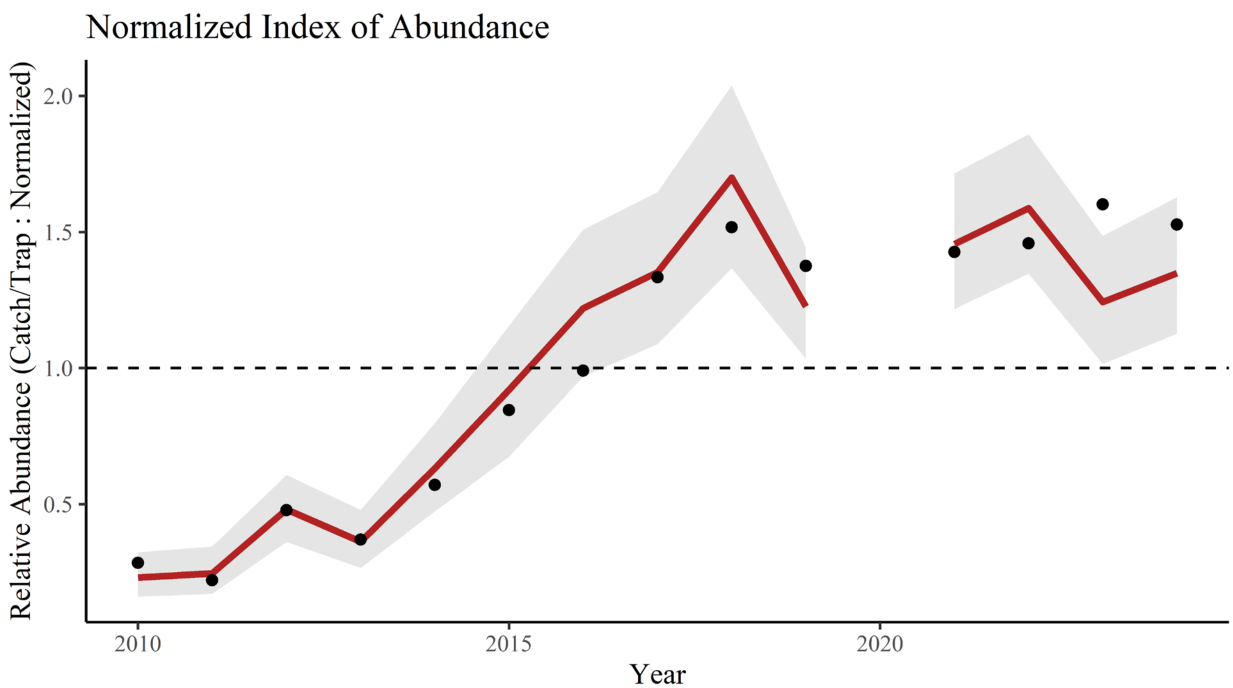

Figure 7. Normalized and standardized abundance index (solid line) with 2.5% and 97.5% confidence intervals (gray) and the nominal index (black dots) for Red Snapper in the SERFS fishery-independent CVT survey.

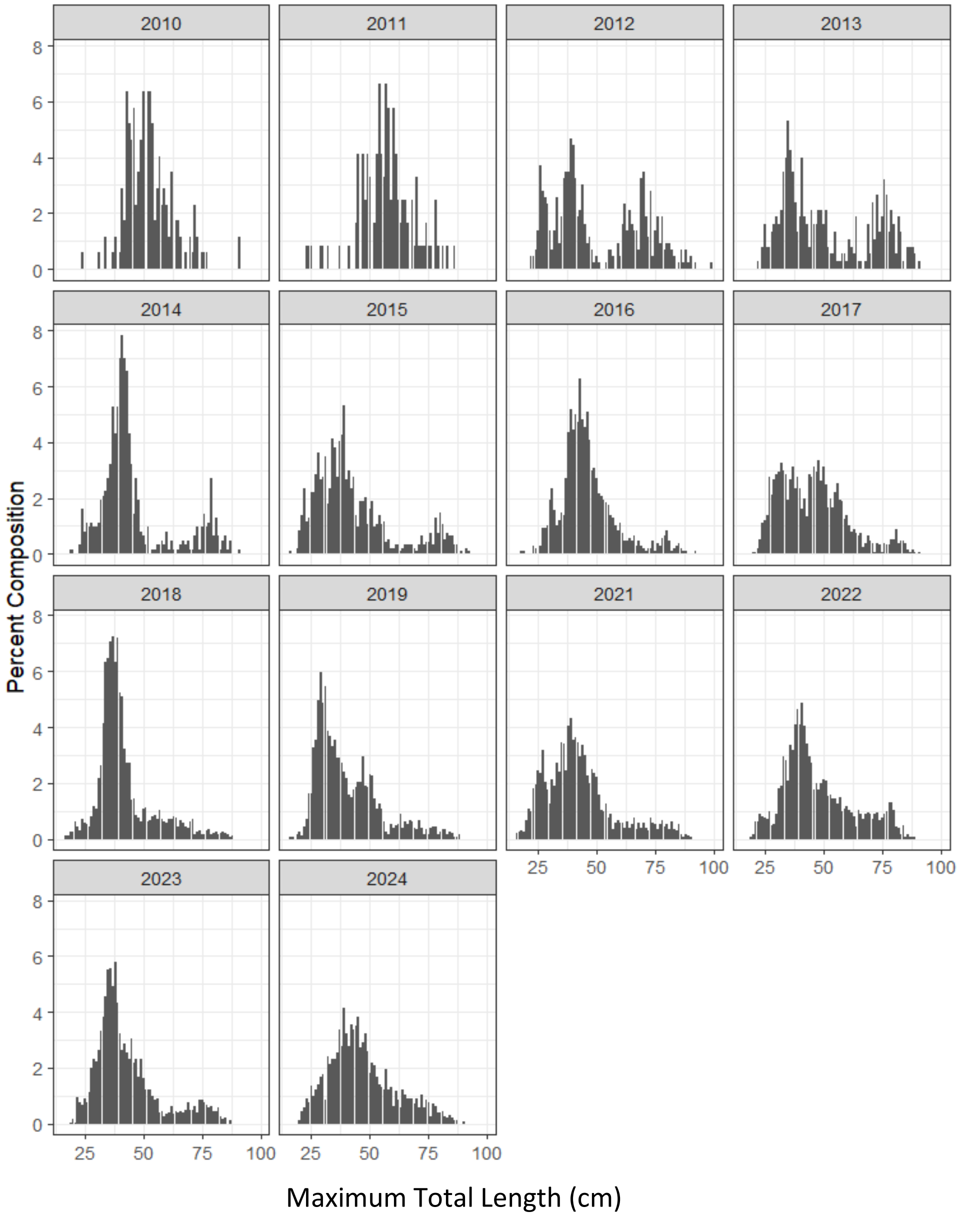

Figure 8. Percent composition of Red Snapper by 1-cm total length (TL) bin by capture year.

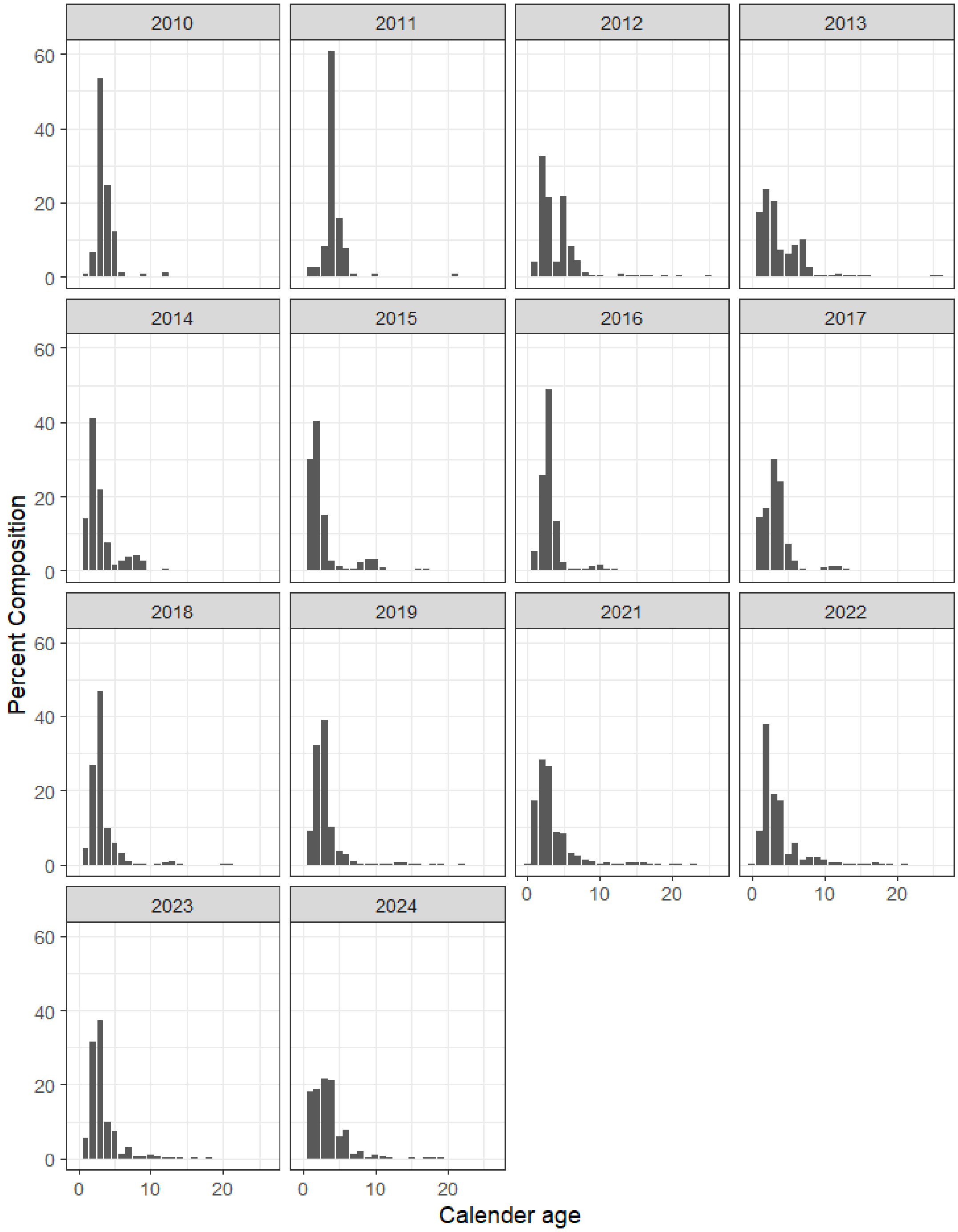

Figure 9. Percent composition of Red Snapper by calendar age by capture year.