Black Sea Bass Fishery-Independent Index of Abundance and Age/Length Compositions in US South Atlantic Waters Based on a Chevron Trap Survey (1990-2021)

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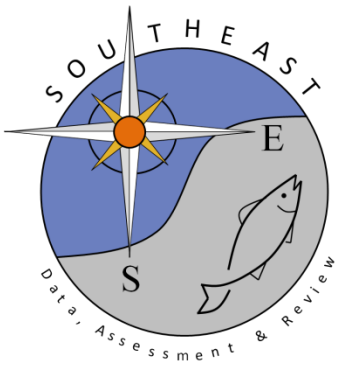

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Abstract

Fishery-independent measures of catch and effort with standard gear types and the deployment strategies are valuable for monitoring the status of stocks, interpreting fisheries landings data, performing stock assessments, and developing regulations for managing fish resources. This report presents a summary of the fishery-independent monitoring of Black Sea Bass in the US South Atlantic region and includes data from three monitoring programs (MARMAP, SEAMAP-SA, and SEFIS, known collectively as SERFS). Specifically, it presents annual nominal catch per unit effort (CPUE) of Black Sea Bass, *Centropristis striata*, in chevron traps from 1990 to 2021. Also included are annual CPUE estimates for chevron trap catches over this same 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 standardized CPUE estimates which show a continued decline since 2012 and with the most recent year being the lowest in the time series..

Background

The Marine Resources Monitoring, Assessment, and Prediction program (MARMAP) has conducted fishery-independent research on reef fish species of the continental shelf and shelf edge between Cape Hatteras, North Carolina, and St. Lucie Inlet, Florida, for over 40 years. Although the MARMAP program has used various gear types and methods of deployment since its inception, 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 2008, with a first field season in 2009, the Southeast Area Monitoring and Assessment Program, South Atlantic Region (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 geographical coverage and sampling intensity of the MARMAP fishery-independent chevron trap survey. Collectively, we now refer to these three surveys combined reef fish monitoring efforts from 2010 to present as the Southeast Reef Fish Survey (SERFS).

Objective

This report presents a standardized relative abundance index of Black Sea Bass derived from the MARMAP/SERFS chevron trap survey during the years 1990-2021, apart from 2020 during which COVID-19 prevented standard MARMAP sampling from occurring and therefore data are not available for that year. The standardized index accounts for annual sampling distribution shifts with respect to covariates that affect catch of Black Sea Bass in chevron traps. Also provided are annual age and length compositions of Black Sea Bass captured by chevron trap. This information is critical at informing the selectivity pattern at age of Black Sea Bass by chevron traps and characterizing the demographics of the catch. Data presented in this report are based on the combined SERFS database accessed on August 5, 2022.

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

- May through September
  - Limited earlier (mid-April) and later (mid-October) sampling in some years

Survey Design

- Simple random sample survey design
  - Annually, randomly selected stations from a chevron trap 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
    - Minimum distance is typically closer to 400 m
- Traps deployed on suspected live-bottom and/or hard-bottom each year (reconnaissance) are evaluated based on catch and/or video or photographic evidence of bottom type for inclusion in the universe in subsequent years
  - If added to the known habitat universe, data from the reconnaissance deployment is included in index development

Sampling Gear – Chevron 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 whole and/or cut clupeids (*Brevoortia* or *Alosa* spp., family Clupeidae), with *Brevoortia* spp. most often used
  - Four whole clupeids on each of four stringers suspended within the trap
  - Approximately 8 clupeids placed loose in the trap
- Soak time of approximately 90 minutes
- Daylight hours

Oceanographic Data

- Hydrographic data collected via CTD during soaking of a "set" (typically 6 traps, but may be less) of chevron traps deployed at the same time and same reef patch
  - Bottom temperature (^oC) is defined as the temperature of the deepest recording within 5 m of the bottom

Data Filtering/Inclusion

Chevron trap data (Gear = 324) were limited to:

- Projects conducting monitoring efforts
  - 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
- Traps 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
- Traps on live-bottom and/or hard-bottom habitat (i.e., appropriate station types)
    - Random –randomly-selected live-bottom stations
    - NonRandom – non-randomly sampled live-bottom station (haphazard or opportunistic sample)
    - ReconConv – reconnaissance deployments that were subsequently converted into live-bottom chevron trap stations
    - Null – traps for which there is no station code value
        - Use of station codes is new, with MARMAP historically using only the catch ID (see above) to indicate randomly selected stations
    - Monitoring - Station whose sampling selection (random, nonrandom) is not known, but is part of overall station universe
- Traps 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 chevron trap deployments
- Excluded any chevron trap samples missing covariate information
- Excluded all traps sampled prior to 1990

Standardized Index Model Formulation

<u>Model Basics</u>

- Response variable
    - Catch per trap
- Offset term
    - Soak time
- Dependent 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, zero-inflated Poisson, negative binomial, and Poisson error distributions 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
    - Bayesian Information Criteria (BIC) also used to select the best model from the negative binomial and Poisson error distribution models
    - Final model was selected amongst the best models from each of the 4 error distributions using BIC
- Annual year effect coefficients of variation (CVs) and standard errors (SE) computed using bootstrapping
    - 5,000 bootstraps
- Software used
    - R (Version 3.6.3; R Development Core Team 2020)

Age Composition

- Aging methods – sagittal otoliths were removed from Black Sea Bass to serve as the aging structure
    - Ages presented here are calendar age based on increment counts with an estimated increment formation on May 1
    - Prior to 2008, selection of fish retained for aging were sub-sampled based on length bins. To correct age compositions prior to 2008, we corrected the number of fish in each age bin based on the abundance and length frequency in each trap according to the method developed for SEDAR 25 Black Sea Bass (Ballenger et al., 2011)
    - From 2008 and on, only fish caught in chevron traps that had age samples taken were included in the age compositions. Selection of fish retained for aging was randomly sub-sampled.

Results

Sampling area

- General increase in sampling intensity (# of annual chevron trap deployments) through time (Table 1 and Figure 1)
- Gradual shift regarding the spatial density of samples through time (Table 1 and Figure 1)
    - More dense geographic coverage in southern and northern latitudes in later years
- Chevron trap sampling depths range from 13 to 115 m (Table 1 and Figure 2)
    - Generally less than 100 m

Sampling season

- May through September (Table 1 and Figure 2)

Data Filtering/Inclusion

- Included traps (n = 21,106; Table 1)

Standardized Index Model Formulation

Model Basics

- Dependent variables
    - Covariates (Inclusion and polynomial order in sub-models available Table 2)
        - The effect on positive catches, both raw and modelled was determined (Figures 2 and 3)
        - Depth, latitude, temperature, and day of year were included in the final model (Figure 4)
- Model structure
    - Final model selected was ZINB (Table 2)
        - Selected over non-zero inflated models due to high proportion of zero counts (Figure 5)
- Coefficients of variation (CVs) and variances stabilized within the 5,000 bootstraps (Figure 6)
- Annual standardized and normalized (relative to the long-term mean) index values for Black Sea Bass, including CVs showed trends from 1990-2021 (Table 3 and Figure 7)

Length and Age Composition

- Length compositions (Table 4)
- Calendar ages caught by chevron traps in 1990-2021 (Tables 5 and 6). Sampling did not occur in 2020 due to COVID-19.

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Table 1. Sampling summary table for the MARMAP/SERFS fishery-independent chevron trap survey. Provided are the average and range of all the covariates by year.

		Depth (m)		Latitude (°N)		Temperature (°C)		Day of Year	
Year	Included Collections	Avg	Range	Avg	Range	Avg	Range	Avg	Range
1990	310	34	17-93	32.5	30.4-33.8	22	18.2-27.8	150	114-222
1991	259	34.3	17-95	32.6	30.8-34.6	24.9	15.9-27.5	216	163-268
1992	286	34	17-62	32.8	30.4-34.3	21.3	15.3-24.5	155	92-227
1993	380	34.9	16-94	32.4	30.4-34.3	22.8	17.7-28.5	176	131-226
1994	340	39.4	16-93	32.3	30.7-33.8	22.7	18.2-26.9	174	130-300
1995	336	33.4	16-60	32.1	29.9-33.7	24.6	20.1-28.3	199	124-299
1996	323	36.9	14-100	32.5	30.0-34.3	22.1	15.6-27.0	185	121-261
1997	345	39.2	15-97	32.2	27.9-34.6	22.8	15.0-28.0	194	126-273
1998	373	38.8	14-92	32	27.4-34.6	21.5	9.5-28.6	176	126-231
1999	213	35.8	15-59	31.9	27.3-34.6	23	17.9-28.8	201	153-272
2000	272	35.2	15-91	32.2	29.0-34.3	24	18.5-28.5	202	138-294
2001	231	38.3	14-91	32.3	27.9-34.3	23.6	16.0-29.2	204	144-298
2002	225	38.4	13-94	31.8	27.9-34.0	24	15.2-28.3	205	169-268
2003	206	40.7	16-92	32	27.4-34.3	18.8	13.4-25.1	203	155-266
2004	259	40.8	14-91	32.2	30.0-34.0	20.8	16.7-25.8	176	127-303
2005	278	38.9	16-69	32	27.3-34.3	23	18.0-28.5	192	124-273
2006	281	38.7	15-94	32.2	27.3-34.4	22.4	15.0-26.7	203	158-272
2007	317	38.5	15-92	32.1	27.3-34.3	23.2	15.3-28.9	202	142-268
2008	277	39	15-92	32.1	27.3-34.6	21.8	15.2-27.2	195	127-275
2009	404	36.3	14-91	32.2	27.3-34.6	22.6	15.4-27.2	203	127-282
2010	732	38.6	14-92	31.3	27.3-34.6	22.2	12.3-29.4	222	125-301
2011	731	40.7	14-93	30.9	27.2-34.5	21.6	14.8-28.8	210	140-300
2012	1174	40.8	15-106	31.9	27.2-35.0	22.1	12.9-27.8	195	116-285
2013	1358	38.3	15-110	31.3	27.2-35.0	22	12.4-28.1	197	115-278
2014	1473	39.3	15-110	31.9	27.2-35.0	23.3	16.1-29.3	192	114-295
2015	1464	39.3	16-110	31.9	27.3-35.0	22.6	13.6-28.5	187	112-296
2016	1485	40.9	17-115	32.1	27.2-35.0	23.8	15.5-29.3	217	126-301
2017	1541	40.5	15-114	32	27.2-35.0	22.6	14.8-28.2	187	117-273
2018	1736	40.3	16-114	32	27.2-35.0	22.5	13.6-28.3	177	116-278
2019	1665	40.2	16-113	32	27.2-35.0	23.3	15.0-29.5	185	121-269
2020	-	-	-	-	-	-	-	-	-
2021	1832	38.3	16-110	31.8	27.2-35.0	23.3	17.9-28.1	191	119-274

Table 2. 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. Negative binomial and Poisson models only had the count sub-model. The best model (highlighted) 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	4	0	4	4	4	3	84958
Negative Binomial	1	4	4	4	0	—	—	—	—	89845
Zero-Inflated Poisson	1	4	4	4	4	4	4	4	3	231794
Poisson	1	4	4	4	4	—	—	—	—	334875

Table 3. The annual summary of data informative to index development and the results of the standardization. The data includes number of collections included in index development, the number of positive collections for Black Sea Bass, the proportion of those positive collections in relation to the included collections, the total number of Black Sea Bass caught, and these totals for the survey. The results show the normalized nominal and standardized chevron trap catch of Black Sea Bass from the MARMAP/SERFS fishery-independent chevron 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	Proportion Positive	Total Fish	Normalized	Normalized	CV
1990	310	190	0.61	5609	1.63	1.21	0.08
1991	259	154	0.59	3897	1.36	1.08	0.08
1992	286	178	0.62	4171	1.32	0.95	0.09
1993	380	193	0.51	3208	0.76	0.67	0.09
1994	340	139	0.41	3223	0.86	0.85	0.09
1995	336	163	0.49	3164	0.85	0.63	0.08
1996	323	164	0.51	3291	0.92	0.75	0.1
1997	345	157	0.46	4108	1.08	0.95	0.11
1998	373	168	0.45	4197	1.02	0.98	0.08
1999	213	96	0.45	4338	1.84	1.9	0.14
2000	272	110	0.4	4401	1.46	1.14	0.11
2001	231	86	0.37	3807	1.49	1.48	0.15
2002	225	77	0.34	2141	0.86	0.75	0.14
2003	206	58	0.28	1585	0.7	0.66	0.13
2004	259	86	0.33	3364	1.17	1.37	0.14
2005	278	101	0.36	2980	0.97	0.97	0.12
2006	281	112	0.4	2941	0.95	1.02	0.13
2007	317	96	0.3	2561	0.73	0.72	0.14
2008	277	97	0.35	2348	0.77	0.87	0.11
2009	404	162	0.4	3771	0.84	0.58	0.11
2010	732	336	0.46	9194	1.13	1.61	0.12
2011	731	403	0.55	14736	1.82	2.23	0.08
2012	1174	678	0.58	18967	1.46	1.66	0.05
2013	1358	766	0.56	22366	1.49	1.52	0.05
2014	1473	705	0.48	15603	0.96	1.28	0.06
2015	1464	651	0.44	13046	0.8	0.91	0.06
2016	1485	537	0.36	7624	0.46	0.71	0.07
2017	1541	547	0.35	7472	0.44	0.57	0.07
2018	1736	567	0.33	7636	0.4	0.49	0.07
2019	1665	496	0.3	5789	0.31	0.34	0.07
2020	-	-	-	-	-	-	-
2021	1832	371	0.2	3247	0.16	0.16	0.08

Table 4. Length composition of Black Sea Bass collected by the SERFS chevron rap survey from 1990-2021. Lengths are total length in cm (measured or rounded to the nearest 1-cm bin) and composition is in percent of fish in each 1-cm bin for each year. Sampling did not occur in 2020 due to COVID-19. Total fish caught and deployments are summarized by year.

Year	4	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	Deployments	Fish
1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.18	0.86	2.64	5.17	10.54	14.33	14.10	11.98	8.68	5.95	4.56	2.98	3.20	2.20	2.22	2.23	1.79	1.37	1.18	1.15	0.66	0.52	0.40	0.31	0.25	0.13	0.15	0.09	0.03	0.01	0.01	0.03	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	363	6771
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.05	0.71	2.70	6.53	13.45	15.49	14.15	9.94	9.14	6.75	4.12	2.53	3.00	2.48	2.17	1.73	1.27	0.88	0.73	0.63	0.56	0.34	0.24	0.07	0.15	0.02	0.02	0.02	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	268	4105
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.81	2.06	5.16	10.16	12.26	12.19	11.16	9.41	7.82	5.94	3.79	4.39	2.23	2.49	2.76	1.24	1.05	1.05	1.03	0.90	0.45	0.41	0.21	0.13	0.26	0.19	0.11	0.09	0.04	0.09	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	322	4667
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.31	1.41	3.60	8.90	10.39	10.11	11.55	10.14	9.41	7.66	4.56	5.18	4.28	2.65	2.11	2.08	1.63	0.93	0.79	0.56	0.56	0.42	0.11	0.00	0.08	0.17	0.03	0.08	0.03	0.03	0.06	0.03	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	351	3551
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.45	1.08	2.43	5.68	10.51	13.07	12.83	9.90	7.87	6.55	4.86	3.86	4.12	2.96	3.49	2.72	1.85	1.27	0.98	1.32	0.55	0.34	0.24	0.29	0.24	0.13	0.16	0.05	0.03	0.05	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	341	3787
1995	0.00	0.00	0.00	0.00	0.03	0.00	0.03	0.00	0.23	2.14	5.00	7.46	10.36	12.73	11.83	11.08	8.53	5.50	5.03	3.15	3.10	2.72	2.37	2.11	1.79	1.39	0.90	0.81	0.64	0.52	0.20	0.09	0.09	0.06	0.03	0.00	0.06	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	251	3457
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.11	0.64	1.22	4.58	8.50	10.83	11.83	11.97	10.83	9.05	6.04	4.92	4.08	2.99	2.81	2.04	1.99	1.93	0.98	0.53	0.53	0.48	0.21	0.16	0.21	0.13	0.16	0.13	0.00	0.03	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	461	3777
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.05	0.21	0.86	3.12	7.56	10.89	9.07	9.53	9.14	9.44	7.96	7.96	5.09	3.42	2.75	2.71	2.10	1.50	1.46	1.32	1.20	0.76	0.69	0.49	0.25	0.16	0.14	0.09	0.05	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	357	4324
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.23	1.87	5.74	8.28	9.41	11.70	11.47	9.78	7.72	7.31	5.97	4.39	3.31	2.59	2.13	1.60	1.46	1.39	0.74	0.65	0.53	0.46	0.42	0.28	0.23	0.09	0.02	0.05	0.07	0.05	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	369	4324
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.54	2.01	4.69	9.19	14.12	13.41	12.22	9.04	7.16	6.13	4.02	3.01	2.91	2.39	2.05	2.13	1.55	1.03	0.71	0.65	0.42	0.21	0.08	0.15	0.00	0.06	0.02	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	247	4779
2000	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.02	0.04	0.31	1.74	3.77	6.71	11.00	13.75	13.23	10.00	8.04	5.80	4.82	4.14	3.62	3.05	2.42	1.77	1.77	1.07	0.94	0.54	0.59	0.33	0.11	0.22	0.07	0.04	0.02	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	288	4589
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.64	2.72	6.08	7.76	7.53	9.21	10.51	12.50	9.78	8.95	5.94	4.17	4.00	2.27	2.06	1.35	1.21	1.11	0.95	0.33	0.31	0.14	0.17	0.14	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	245	4225
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.57	2.00	4.54	7.86	12.94	13.15	12.08	9.76	7.40	6.75	5.11	4.47	3.47	2.93	1.82	1.43	1.00	0.96	0.57	0.36	0.21	0.14	0.18	0.00	0.07	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	240	2798
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	2.48	5.01	9.04	9.92	12.89	12.62	9.20	9.42	7.05	4.79	3.42	3.09	3.09	1.76	1.05	1.98	0.99	0.88	0.33	0.28	0.11	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	215	1815
2004	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.47	1.52	4.89	5.92	6.83	6.99	7.11	8.18	9.64	10.20	8.72	6.52	4.67	3.29	2.45	2.30	2.34	1.95	1.58	0.93	0.95	0.64	0.56	0.31	0.33	0.16	0.10	0.10	0.08	0.06	0.04	0.06	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00	274	5136
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.25	0.90	2.56	5.86	8.67	10.55	10.03	10.76	10.63	9.55	7.49	5.22	3.99	2.81	2.11	2.11	1.99	1.69	1.06	0.51	0.28	0.30	0.15	0.10	0.10	0.03	0.08	0.00	0.03	0.07	0.00	0.02	0.00	0.00	0.00	0.03	0.00	0.02	0.00	0.00	379	6021
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.11	0.47	1.78	3.85	7.25	11.41	14.55	11.90	8.73	7.17	6.68	4.99	5.14	3.60	4.22	2.91	1.97	1.28	0.77	0.36	0.24	0.06	0.11	0.09	0.04	0.15	0.06	0.00	0.04	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	331	4673
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.06	0.15	0.43	1.65	3.55	8.27	9.19	10.59	11.11	10.41	8.21	7.78	6.95	4.19	3.64	2.69	2.76	2.05	1.84	1.59	0.92	0.73	0.40	0.49	0.00	0.06	0.03	0.12	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00	302	3266
2008	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.03	0.00	0.25	1.14	4.02	7.44	9.49	10.09	10.16	9.05	8.77	7.78	6.71	5.03	4.15	2.94	3.35	2.44	2.18	1.65	1.01	0.85	0.54	0.41	0.09	0.06	0.06	0.06	0.03	0.03	0.03	0.03	0.00	0.00	0.00	0.00	0.03	0.00	0.03	0.00	0.00	0.00	297	3160
2009	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.12	0.32	1.53	3.38	6.12	5.53	7.11	7.77	9.50	9.21	8.71	7.11	6.29	6.12	4.37	4.27	3.31	2.67	1.80	1.48	0.96	0.72	0.42	0.44	0.25	0.10	0.12	0.10	0.02	0.07	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	310	4052
2010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.09	0.39	1.09	2.13	3.86	5.07	6.25	7.10	8.30	9.26	8.89	8.06	7.61	6.63	5.51	4.79	3.26	2.81	2.46	2.05	1.42	1.12	0.70	0.34	0.36	0.18	0.08	0.04	0.05	0.02	0.03	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	764	11305
2011	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.08	0.32	0.70	1.94	3.85	5.21	6.65	7.14	7.78	7.12	7.39	7.27	6.53	6.23	5.19	4.61	3.86	3.71	3.22	2.61	2.33	1.75	1.27	0.94	0.72	0.61	0.36	0.23	0.13	0.10	0.06	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	903	18223
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.12	0.63	1.69	3.23	4.46	5.39	6.04	7.16	7.61	7.57	7.53	7.38	6.67	5.62	4.89	4.22	3.55	3.03	2.77	2.40	1.78	1.55	1.13	1.00	0.72	0.53	0.38	0.24	0.21	0.14	0.13	0.05	0.02	0.04	0.01	0.02	0.01	0.00	0.01	0.00	1273	20378
2013	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.15	0.62	1.31	2.80	4.54	6.28	7.90	8.11	7.87	8.04	7.49	6.57	5.63	5.39	4.75	3.93	3.43	2.89	2.57	2.23	1.76	1.39	1.07	0.89	0.70	0.46	0.43	0.25	0.20	0.14	0.06	0.04	0.02	0.02	0.01	0.00	0.00	0.01	0.00	0.00	1155	23005
2014	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.03	0.03	0.07	0.16	0.41	1.50	3.33	6.12	7.56	8.03	8.22	8.40	8.52	7.74	6.59	6.00	4.91	4.17	3.68	3.02	2.23	2.02	1.63	1.43	1.13	0.77	0.62	0.49	0.33	0.23	0.22	0.14	0.09	0.06	0.03	0.01	0.02	0.01	0.00	0.00	0.01	0.01	0.00	931	15772
2015	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.05	0.12	0.53	1.80	3.87	5.90	7.27	7.73	8.02	7.96	8.23	8.03	6.97	6.09	4.93	4.16	3.54	2.97	2.56	2.17	1.78	1.38	1.08	0.87	0.56	0.44	0.31	0.20	0.14	0.10	0.11	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	1148	14082
2016	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.00	0.16	0.40	0.92	2.68	4.73	6.40	7.40	8.07	8.51	8.68	7.96	6.40	6.40	5.09	4.73	3.89	3.05	2.74	2.52	1.86	1.75	1.38	1.14	0.80	0.58	0.52	0.43	0.27	0.16	0.09	0.13	0.04	0.04	0.03	0.00	0.01	0.00	0.01	0.00	0.00	0.00	793	7734
2017	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.03	0.08	0.38	1.01	2.55	4.05	5.03	6.68	7.55	7.81	8.16	7.73	7.95	7.42	6.52	4.78	4.04	3.31	2.70	2.20	2.07	1.60	1.36	1.18	0.98	0.75	0.64	0.38	0.33	0.22	0.14	0.14	0.07	0.09	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	818	7633
2018	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.08	0.04	0.31	0.84	2.50	4.57	5.61	7.31	8.12	8.46	7.61	7.84	7.79	5.79	5.76	4.59	3.79	3.28	2.77	2.67	2.13	1.75	1.56	1.11	0.98	0.88	0.54	0.39	0.29	0.22	0.14	0.09	0.05	0.05	0.03	0.04	0.00	0.00	0.00	0.01	0.00	0.01	889	7651
2019	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.02	0.41	0.86	1.86	3.54	5.52	6.42	8.33	7.95	8.60	8.72	8.03	6.86	6.07	5.01	4.20	3.77	2.84	2.29	1.81	1.63	1.17	0.93	0.81	0.69	0.52	0.22	0.40	0.21	0.09	0.07	0.03	0.05	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.00	692	5813
2020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2021	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.14	0.33	1.20	2.62	4.58	6.25	6.95	7.98	8.60	9.04	8.12	6.73	6.22	6.53	5.72	4.24	3.04	2.65	1.67	2.07	1.26	1.09	0.98	0.61	0.39	0.33	0.28	0.14	0.06	0.06	0.06	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	422	3583

Table 5. Annual age composition by calendar age of Black Sea Bass caught in the MARMAP/SERFS fishery-independent chevron trap survey. This value is in number of fish processed in 2008-2021 and estimated numbers of fish based on length frequency in 1990-2007 by that increment count per year. Sampling did not occur in 2020 due to COVID-19. Total fish caught and deployments are summarized by year.

Year	0	1	2	3	4	5	6	7	8	9	10	Deployments	Fish
1990	0	417	2421	2391	976	349	132	68	4	3	1	363	6762
1991	0	517	1893	1130	340	126	27	23	11	0	0	268	4067
1992	0	163	2211	1333	558	255	46	20	8	0	3	322	4597
1993	0	726	1919	1434	273	128	42	18	5	0	1	351	4546
1994	0	323	1632	940	825	166	53	14	9	0	1	341	3963
1995	1	390	1914	650	291	156	26	2	0	2	0	251	3432
1996	0	125	1116	1907	368	129	50	15	5	5	0	461	3720
1997	7	704	1549	1107	773	100	26	6	0	0	0	357	4272
1998	0	597	1784	1215	480	211	23	8	4	0	0	369	4322
1999	0	224	1955	1932	383	95	33	13	0	0	0	247	4635
2000	1	258	1151	2150	783	141	38	26	7	0	0	288	4555
2001	0	431	1265	1060	892	346	29	3	3	0	0	245	4029
2002	0	150	1240	751	355	229	21	5	5	0	0	240	2756
2003	0	77	491	732	244	87	25	14	1	0	0	215	1671
2004	0	452	1441	1641	871	661	124	64	11	0	0	274	5265
2005	0	331	1837	1529	1192	667	134	46	9	2	0	379	5747
2006	0	106	1347	1522	966	373	122	57	3	0	1	331	4497
2007	0	206	1172	961	570	226	30	27	4	3	0	302	3199
2008	0	28	214	248	123	64	24	5	2	1	1	106	710
2009	1	78	246	248	112	30	12	10	3	0	0	126	740
2010	1	98	616	950	434	133	28	22	6	0	0	274	2288
2011	0	177	1303	1253	597	185	35	9	8	0	1	327	3568
2012	1	112	1303	2140	876	275	72	34	8	1	0	459	4822
2013	0	143	737	1103	820	212	63	17	2	1	0	458	3098
2014	0	44	521	634	642	327	56	8	1	0	0	395	2233
2015	0	24	576	989	602	377	115	18	4	0	0	493	2705
2016	0	18	221	642	379	172	63	19	1	0	1	399	1516
2017	0	79	272	504	655	207	63	37	8	0	0	388	1825
2018	0	79	523	448	422	260	65	29	14	2	0	411	1842
2019	0	60	464	501	199	153	38	14	2	1	1	350	1433
2020	-	-	-	-	-	-	-	-	-	-	-	-	-
2021	1	36	194	226	146	59	7	3	0	1	0	247	673

Table 6. Annual age composition by calendar age of Black Sea Bass caught in the MARMAP/SERFS fishery-independent chevron trap survey. This value is in percentage of fish processed in 2008-2021 and estimated numbers of fish based on length frequency in 1990-2007 by that increment count per year. Sampling did not occur in 2020 due to COVID-19. Total fish caught and deployments are summarized by year.

Year	0	1	2	3	4	5	6	7	8	9	10	Deployments	Fish
1990	0.00	6.17	35.80	35.36	14.43	5.16	1.95	1.01	0.06	0.04	0.01	363	6762
1991	0.00	12.71	46.55	27.78	8.36	3.10	0.66	0.57	0.27	0.00	0.00	268	4067
1992	0.00	3.55	48.10	29.00	12.14	5.55	1.00	0.44	0.17	0.00	0.07	322	4597
1993	0.00	15.97	42.21	31.54	6.01	2.82	0.92	0.40	0.11	0.00	0.02	351	4546
1994	0.00	8.15	41.18	23.72	20.82	4.19	1.34	0.35	0.23	0.00	0.03	341	3963
1995	0.03	11.36	55.77	18.94	8.48	4.55	0.76	0.06	0.00	0.06	0.00	251	3432
1996	0.00	3.36	30.00	51.26	9.89	3.47	1.34	0.40	0.13	0.13	0.00	461	3720
1997	0.16	16.48	36.26	25.91	18.09	2.34	0.61	0.14	0.00	0.00	0.00	357	4272
1998	0.00	13.81	41.28	28.11	11.11	4.88	0.53	0.19	0.09	0.00	0.00	369	4322
1999	0.00	4.83	42.18	41.68	8.26	2.05	0.71	0.28	0.00	0.00	0.00	247	4635
2000	0.02	5.66	25.27	47.20	17.19	3.10	0.83	0.57	0.15	0.00	0.00	288	4555
2001	0.00	10.70	31.40	26.31	22.14	8.59	0.72	0.07	0.07	0.00	0.00	245	4029
2002	0.00	5.44	44.99	27.25	12.88	8.31	0.76	0.18	0.18	0.00	0.00	240	2756
2003	0.00	4.61	29.38	43.81	14.60	5.21	1.50	0.84	0.06	0.00	0.00	215	1671
2004	0.00	8.58	27.37	31.17	16.54	12.55	2.36	1.22	0.21	0.00	0.00	274	5265
2005	0.00	5.76	31.96	26.61	20.74	11.61	2.33	0.80	0.16	0.03	0.00	379	5747
2006	0.00	2.36	29.95	33.84	21.48	8.29	2.71	1.27	0.07	0.00	0.02	331	4497
2007	0.00	6.44	36.64	30.04	17.82	7.06	0.94	0.84	0.13	0.09	0.00	302	3199
2008	0.00	3.94	30.14	34.93	17.32	9.01	3.38	0.70	0.28	0.14	0.14	106	710
2009	0.14	10.54	33.24	33.51	15.14	4.05	1.62	1.35	0.41	0.00	0.00	126	740
2010	0.04	4.28	26.92	41.52	18.97	5.81	1.22	0.96	0.26	0.00	0.00	274	2288
2011	0.00	4.96	36.52	35.12	16.73	5.18	0.98	0.25	0.22	0.00	0.03	327	3568
2012	0.02	2.32	27.02	44.38	18.17	5.70	1.49	0.71	0.17	0.02	0.00	459	4822
2013	0.00	4.62	23.79	35.60	26.47	6.84	2.03	0.55	0.06	0.03	0.00	458	3098
2014	0.00	1.97	23.33	28.39	28.75	14.64	2.51	0.36	0.04	0.00	0.00	395	2233
2015	0.00	0.89	21.29	36.56	22.26	13.94	4.25	0.67	0.15	0.00	0.00	493	2705
2016	0.00	1.19	14.58	42.35	25.00	11.35	4.16	1.25	0.07	0.00	0.07	399	1516
2017	0.00	4.33	14.90	27.62	35.89	11.34	3.45	2.03	0.44	0.00	0.00	388	1825
2018	0.00	4.29	28.39	24.32	22.91	14.12	3.53	1.57	0.76	0.11	0.00	411	1842
2019	0.00	4.19	32.38	34.96	13.89	10.68	2.65	0.98	0.14	0.07	0.07	350	1433
2020	-	-	-	-	-	-	-	-	-	-	-	-	-
2021	0.15	5.35	28.83	33.58	21.69	8.77	1.04	0.45	0.00	0.15	0.00	247	673

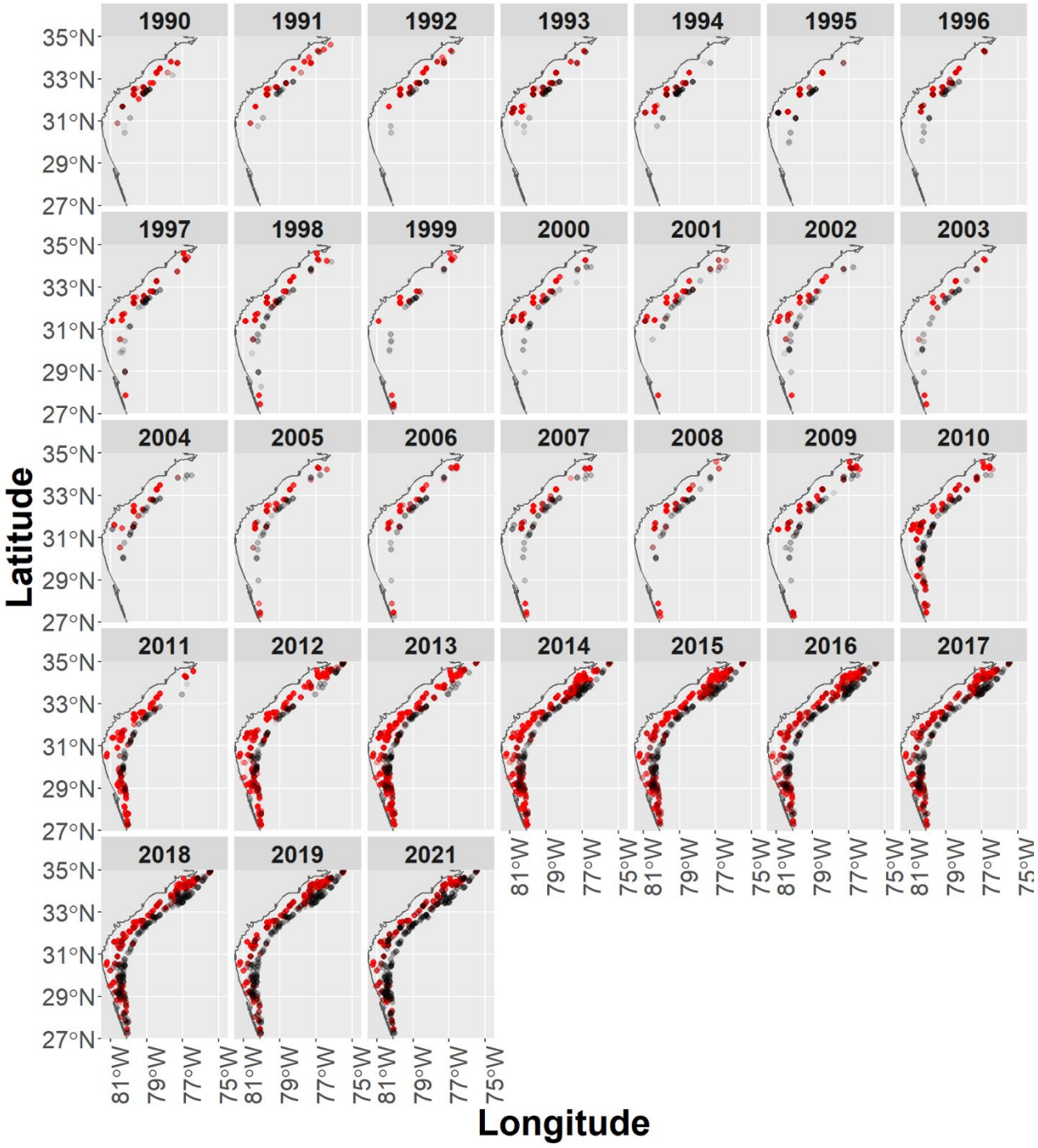


Figure 1. Sampling distribution of all collections by year of the MARMAP/SERFS fishery-independent chevron trap survey. Red circles indicate positive collections for Black Sea Bass, while black circles represent no catch of Black Sea Bass.

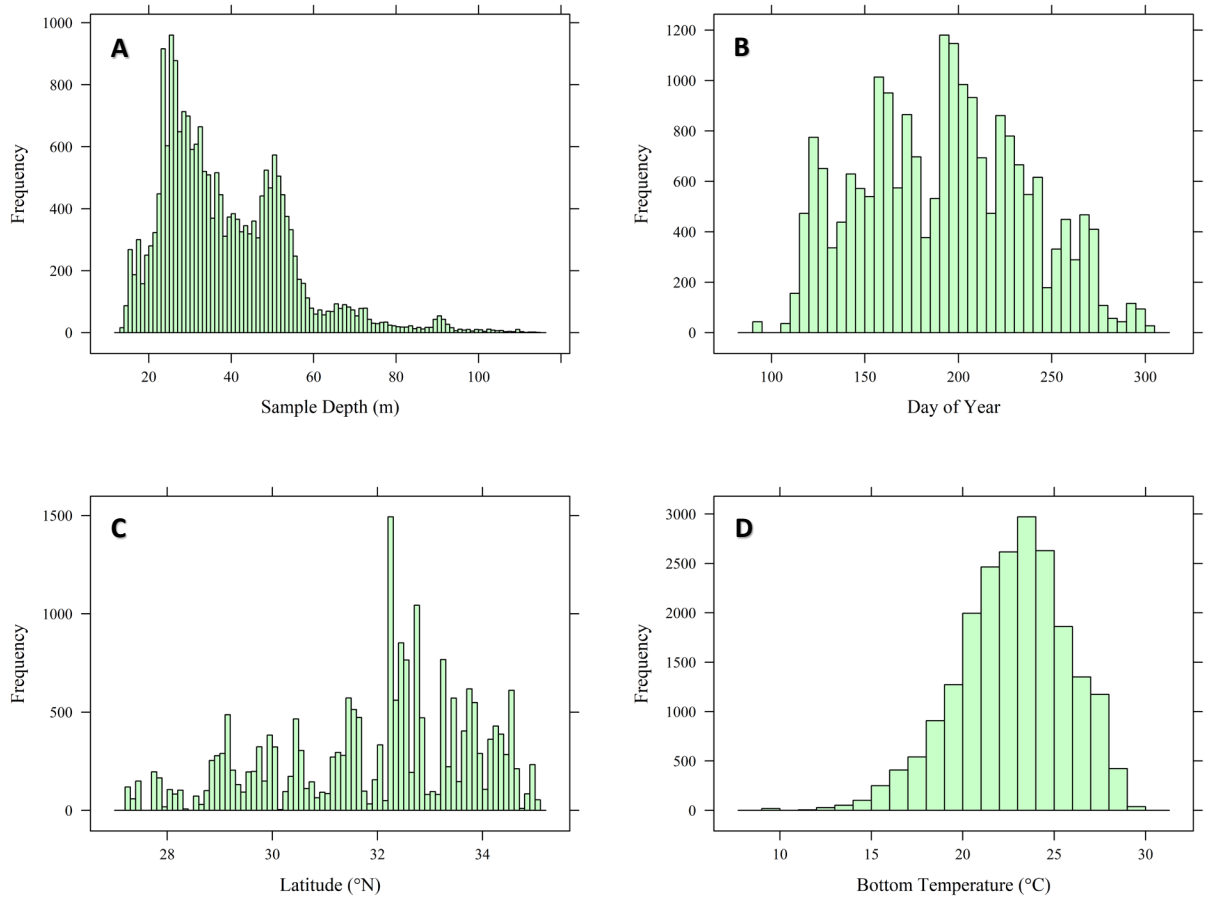


Figure 2. Sample distribution of covariate data from MARMAP/SERFS fishery-independent chevron trap survey collections for depth (A), day of year (B), latitude (C), and bottom temperature (D).

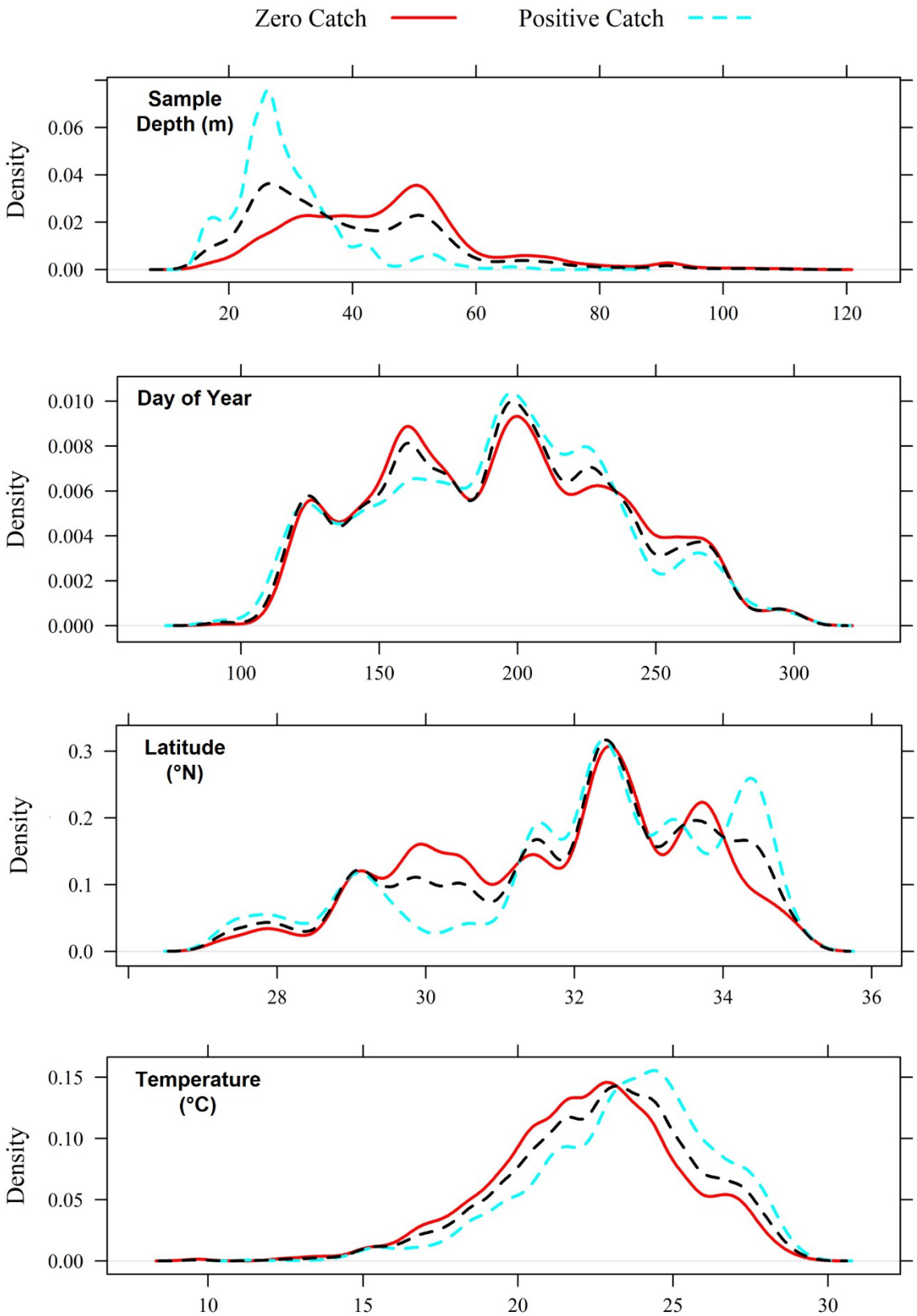


Figure 3. Sample distribution of catch of Black Sea Bass and effects by covariate on positive and zero catches.

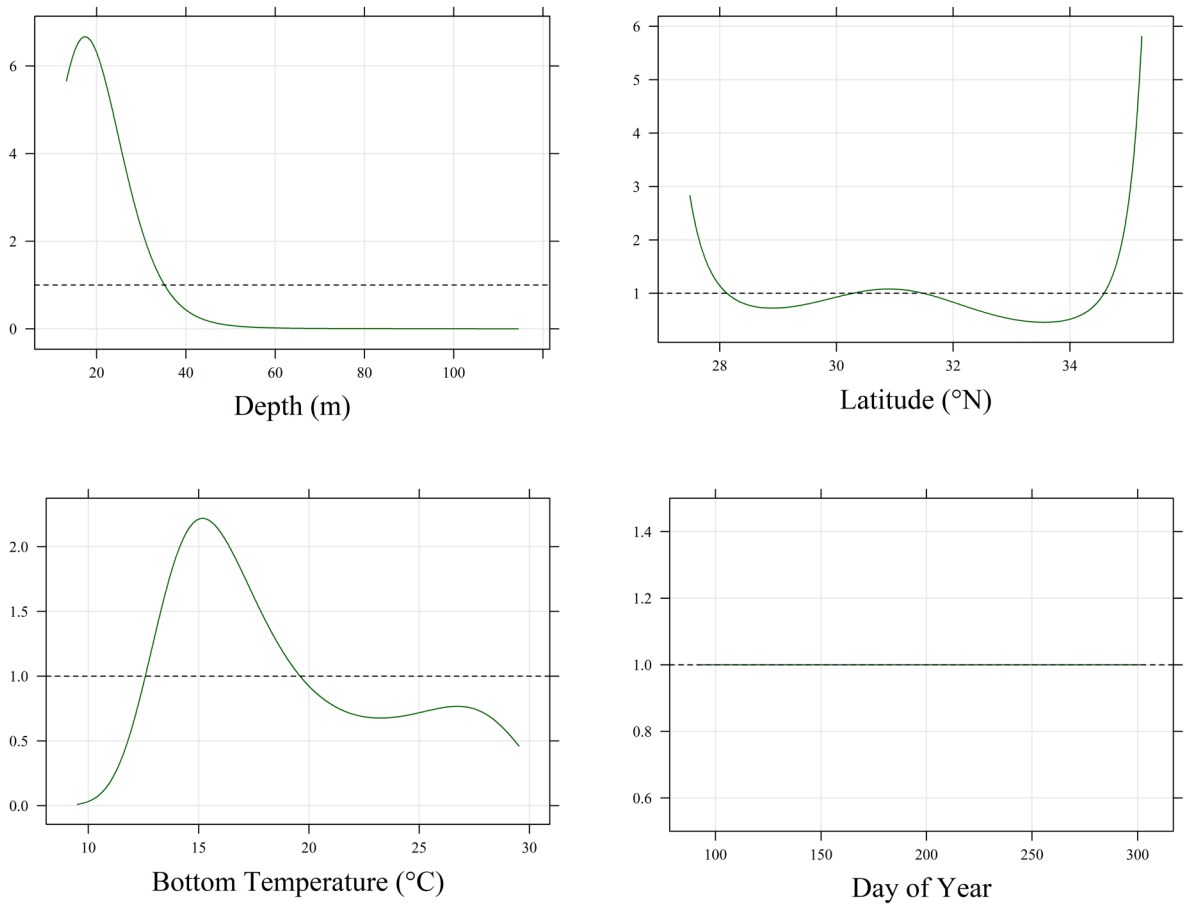
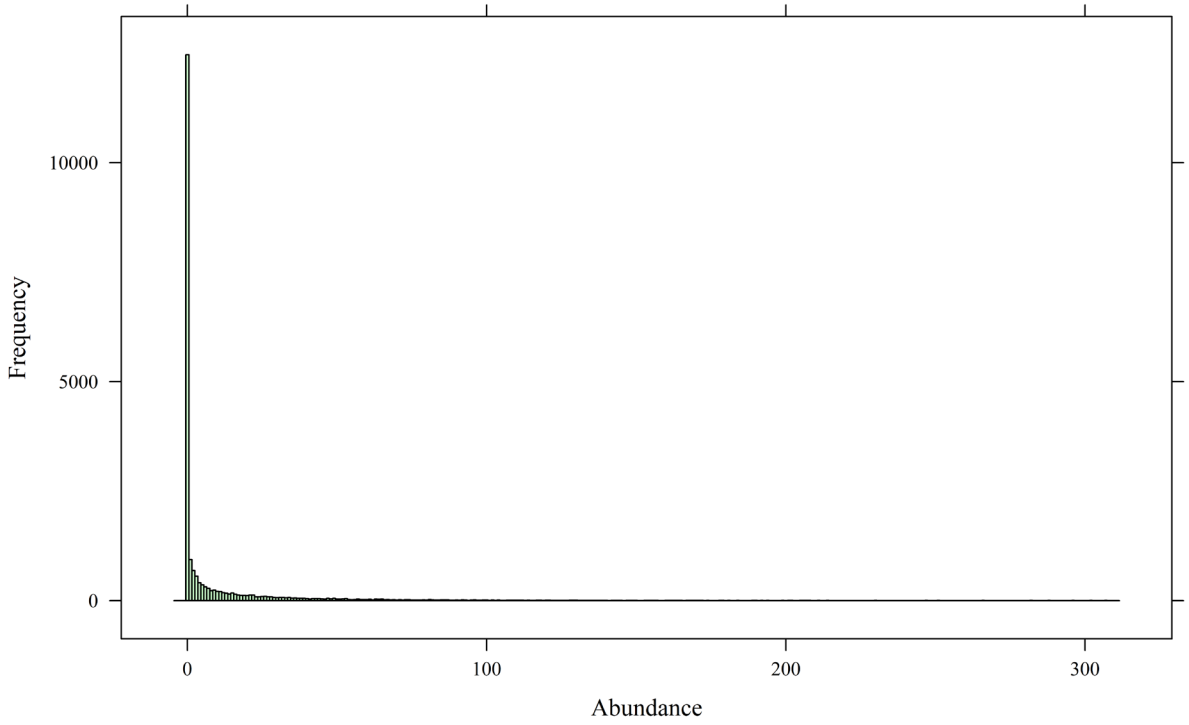


Figure 4. Modelled final covariate effects on catch of Black Sea Bass in the count submodel from the ZINB standardization. Day of year was not included in the final count submodel.



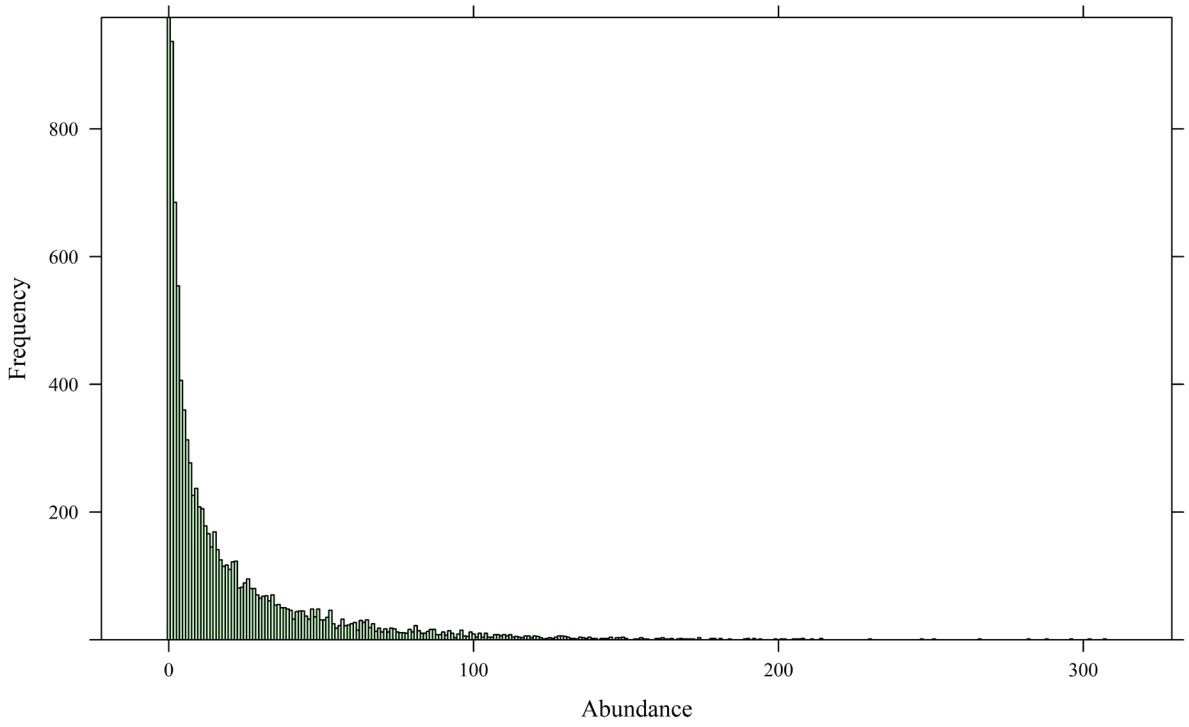


Figure 5. Count distribution of Black Sea Bass catch from MARMAP/SERFS fishery-independent chevron trap survey showing full range of the distribution (A) and a truncated y-axis (B) to better show positive catches.

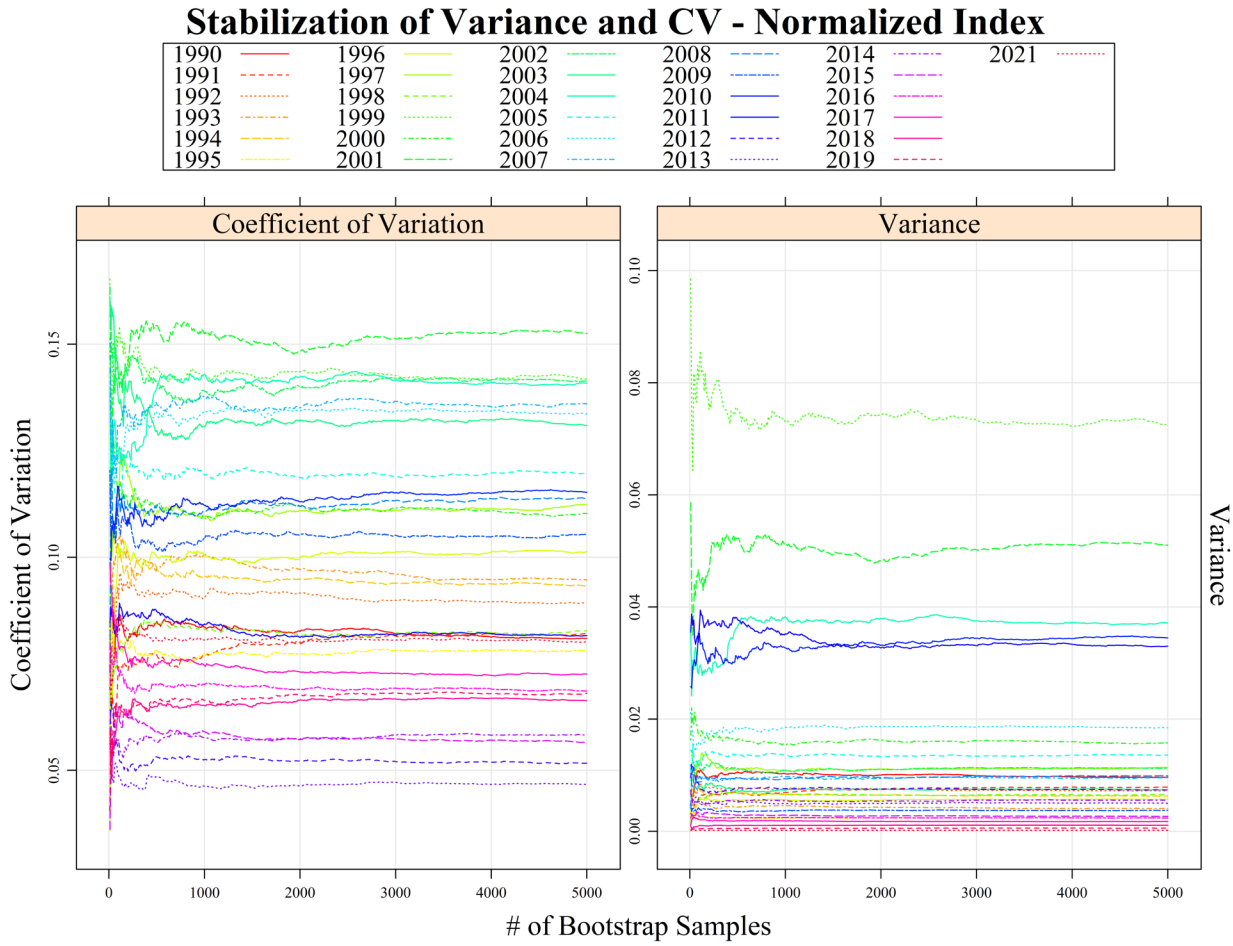


Figure 6. Stability of coefficient of variation and variance by bootstrap run during fishery-independent chevron video trap survey index development.

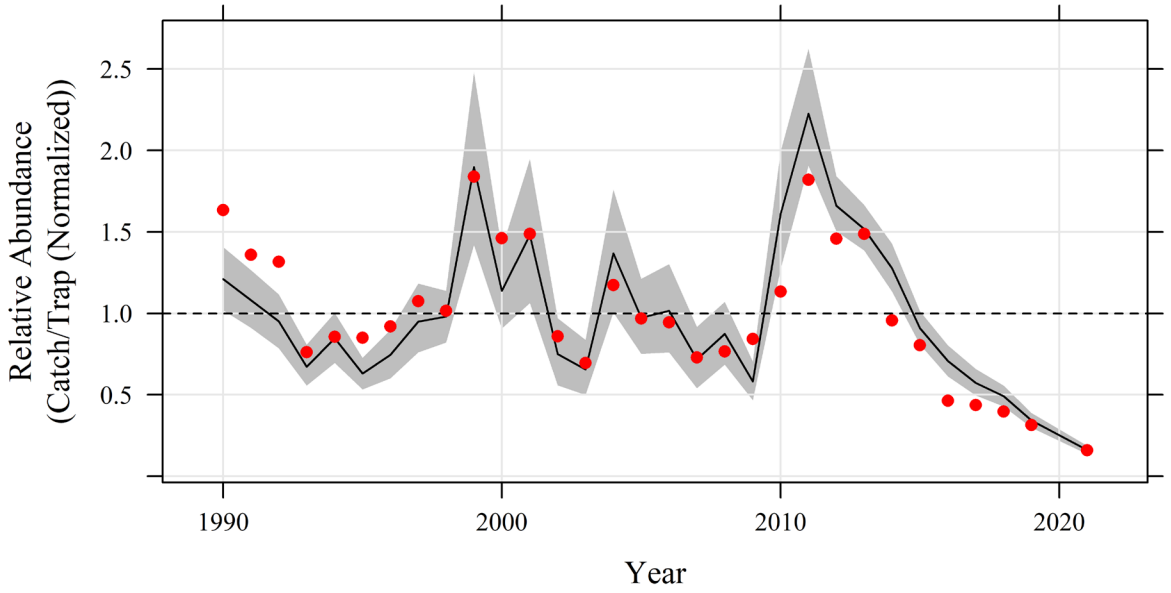


Figure 7. Normalized and standardized index (solid line) with 2.5% and 97.5% confidence intervals (gray) and the nominal index (red dots) for Black Sea Bass in the MARMAP/SERFS fishery-independent chevron trap survey.