Golden Tilefish Fishery-Independent Index of Abundance in US South Atlantic Waters Based on a SCDNR Bottom Longline Survey (1996-2016)

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MARMAP/SEAMAP-SA Reef Fish Survey Technical Report 2020-05

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 Golden Tilefish in the US South Atlantic region. Specifically, it presents annual nominal catch per unit effort (CPUE) of Golden Tilefish, *Lopholatilus chamaeleonticeps*, with bottom longline gear (LBLL) from 1996 to 2016. Also included are annual CPUE estimates for LBLL catches over this same time period that are standardized by a delta-general linearized model (delta-GLM) to account for the effects of potential covariates on these estimates. The delta-GLM produced standardized CPUE estimates were variable and there were large gaps in data due to funding considerations, including no data from the most recent years (2017 and 2018). Previous assessments pooled nominal catch data by multiple years to address low sample size.

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. The overall mission of MARMAP has been to determine the distribution, relative abundance, and critical habitat of economically and ecologically important reef fishes between Cape Hatteras, NC, and St. Lucie Inlet, FL. MARMAP has historically used a variety of gears to sample reef fishes, but the focus of this paper is on 'long' bottom longlining (LBLL) conducted intermittently since 1982 to sample deepwater members of the snapper-grouper complex, most notably Golden Tilefish, *Lopholatilus chamaeleonticeps*. This gear has also been referred to as horizontal bottom longline previously and has been conducted in standardized blocks in water depths from 160 to 300 m from South Carolina to central Florida between the months of May and September.

Objective

This report presents a standardized relative abundance index of Golden Tilefish derived from the SCDNR LBLL survey during the years 1996-2016. The standardized index accounts for annual sampling distribution shifts with respect to covariates that affect catch of Golden Tilefish by LBLL. Also provided are annual age compositions of Golden Tilefish captured by LBLL and nominal indices that are annual and binned by four-year time periods. This information is critical at informing the selectivity pattern at age of Golden Tilefish by LBLL. Data presented in this report are based on the combined SERFS database accessed on September 8, 2020.

Methods

Survey Design and Gear

(see MARMAP 2009 and Smart et al. 2015 for full description)

Sampling area

- SC to Central FL
    - Focus mainly on southern SC and northern GA

Sampling season

- May through September
- Sampling years
    - 1996-2016
        - Samples prior to 1996 were excluded on the basis of differing gear and site selection

Survey Design

- Fixed sampling blocks (Figure 1)
    - 17 blocks in total
        - Soft bottom habitat (sand or mud)
        - Typically focused on 15 blocks from SC and GA
        - Area of blocks is between 50 and 65 km^2
    - Goal is 2 LBLL deployments within each block per year
        - Minimum distance between two deployments is 200 m from each other
        - Exact location of deployments within blocks are determined by weather conditions and current direction/speed
    - Collections considered for the index were deployed at depths between 168 and 265 m (Table 1)

Sampling Gear – Long Bottom Longline

(see MARMAP 2009 and Smart et al. 2015 for more detailed descriptions)

- 1,525 m long 3.2 mm galvanized steel cable
    - Buoyed to surface on one end and weighted to bottom
- 100 gangions per set
    - 0.5 m of 90 kg monofilament
    - Non-offset circle hook (15/0)
- Baited with whole squid
- Soak time of approximately 90 minutes
- Daylight hours

Oceanographic Data

- Hydrographic data collected via CTD during soaking of gear or dataloggers attached to the mainline
    - Bottom temperature (°C) is defined as the temperature of the deepest recording within 5 m of the bottom

Data Filtering/Inclusion

Long bottom longline data (Gear = 087) were limited to:

- Projects conducting monitoring efforts
    - P05 – MARMAP
    - T59 – SEAMAP-SA
- Monitoring samples
- LBLL 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
- Within sampling blocks
- Soak times that were neither extremely short nor long which often indicates an issue with the deployment or retrieval not captured elsewhere (included 45-150 minutes)
    - MARMAP/SEAMAP-SA targets a soak time of 90 minutes for all LBLL deployments
- Excluded any LBLL samples missing covariate information
    - This included all 2003-2006 samples which did not have associated bottom temperatures
- Excluded all LBLL sampled prior to 1996

Nominal Index Formulation

Index Basics

- CPUE = average catch per longline hour
- Exclusions due to missing covariates (as stated above) were included for nominal index calculations
    - Other exclusions listed above, still apply
- Samples obtained from Florida in 1999 and 2000 were excluded because no standardization methods could be performed and for continuity with the previous assessment
- Due to sample size concerns during SEDAR25, multiple iterations were compiled to examine binning of years (Bacheler et al. 2011)
    - Annual and 4-year bin nominal indices were explored

Standardized Index Model Formulation

Model Basics

- Response variable
    - Catch per longline hour
- Dependent variables
    - Year
    - Covariates
        - 4 covariates explored
            - Depth – discrete variable

        - Ranged across full length of historic catches of Golden Tilefish (170-269 m)
        - Bins: <= 220 m and > 220 m
      - Latitude (°N) - discrete variable
        - Bins: Integer of latitude
      - Bottom temperature (°C) - discrete variable
        - Bins: <= 12° C and > 12° C
      - Season - discrete variable
        - Bins: Spring (March – June) and Summer (July – September)
- Model structure – Delta-Generalized Linear Model (Delta-GLM)
  - Two parts to the model, with Akaike Information Criteria (AIC) used to select the best model from each of the 2 models with different error structures using a backward stepwise selection process for covariates
    - Presence/absence (binomial sub-model)
      - Bernoulli distribution
    - Catch (count sub-model)
      - Examined gamma and lognormal distributions
  - Sub-models optimized using a two-step approach due to computational demands
    - 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 AIC
- The index was normalized by dividing the annual standardized CPUE by the mean standardized CPUE for the time series
- Annual year effect coefficients of variation (CVs) and standard errors (SE) computed using a jackknifing approach
- Software used
  - R (Version 3.1.0; R Development Core Team 2014)

Age Composition

- Aging methods – sagittal otoliths were removed from Golden Tilefish to serve as the aging structure
  - Ages presented here are increment count because edge types could not be distinguished accurately
  - Ageing procedures followed standard MARMAP/SEAMAP-SA ageing procedures (see Smart et al. 2015)
  - Only fish caught on LBLL that had age samples taken were included in the age compositions
    - No sub-sampling occurred

Results

<u>Sampling area</u>

- Relatively consistent sampling by time of year during years in which sampling took place (Table 1 and Fig. 2)
- Multiple breaks in the time series that are more common in recent years due to funding (Table 1)

Sampling season

- May through September, but the majority of years was August and September (Table 1)

Data Filtering/Inclusion

- Included LBLL deployments (Tables 2-4)
    - Nominal n = 332
    - Standardized n=250

Standardized Index Model Formulation

Model Basics

- Dependent variables
    - Covariates
        - Binomial sub-model: Depth and temperature included (Figs. 3 and 4)
        - Catch sub-model: Temperature included (Fig. 5)
- Model structure
    - Final model error structure selected for catch sub-model was gamma
        - For diagnostics, see figures 3-6
- Annual standardized and normalized (relative to the long-term mean) index values for Golden Tilefish, including CVs showed trends from 1996-2016 (Table 2 and Figure 7)

Age Composition

- Increment count caught by LBLL in 1996-2016 (Tables 5 and 6)

Nominal Index Formulation

Index Basics

- Annual and four-year binned index values for Golden Tilefish, including standard deviations and ranges of CPUE from 1996-2016 (Tables 3 and 4)

References

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

	Depth		Latitude		Temperature		Day of Year	
Year	**Avg**	**Range**	**Avg**	**Range**	**Avg**	**Range**	**Avg**	**Range**
1996	204.3	172-240	32.14	32-33	12.3	8.2-16	7/12	5/1-9/19
1997	208.1	185-235	32.11	32-33	13	11.6-14.8	8/16	8/12-8/20
1998	197.5	173-234	32	32-32	14.5	11-16.6	5/28	5/19-6/25
1999	211.7	181-258	31.79	28-33	9.9	8.2-14.2	8/28	7/20-9/9
2000	204.3	177-228	32	32-32	14.5	12.5-15.8	8/21	8/9-9/20
2001	209	181-231	32	32-32	11.3	10.4-12.6	8/29	8/28-8/30
2002	202	184-232	32	32-32	11.4	10.4-12.4	7/17	7/17-7/18
2003	220.6	168-251	31.9	31-32	-	-	9/23	9/22-9/25
2004	193.6	183-209	32.0	31-32	-	-	9/30	9/30-9/30
2005	211.6	175-250	31.9	31-32	-	-	9/20	9/20-9/22
2006	200.7	176-218	32.0	31-32	-	-	9/26	9/26-9/27
2007	213.6	180-240	32	32-32	11.7	8.3-15.3	8/23	6/28-9/25
2008	-	-	-	-	-	-	-	-
2009	216.9	179-244	31.91	31-33	13	8.4-16.8	9/1	8/15-9/24
2010	228.4	183-261	32.03	31-33	13.4	8.4-17.1	8/19	8/10-9/15
2011	233.7	216-265	32.04	31-33	9.2	8.2-10.9	9/12	8/29-9/28
2012	-	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-	-
2014	-	-	-	-	-	-	-	-
2015	218.9	182-250	31.92	31-33	9.9	7.3-14.3	8/27	8/18-9/16
2016	235.9	208-258	32.19	32-33	9.8	8-12.8	9/16	8/23-9/29
2017	-	-	-	-	-	-	-	-
2018	-	-	-	-	-	-	-	-

Table 2. The annual summary of data informative to standardized index development and the results of the standardization. The data includes number of included sets in index development, the proportion of positive collections in relation to the included collections, and the totals for the survey. The results show the standardized LBLL catch of Golden Tilefish from the MARMAP/SEAMAP-SA fishery-independent LBLL survey which meet criteria to be included in the standardization process. The standardized CPUE and the standardized CPUE normalized to the mean of the time series are presented and also included is a coefficient of variation (CV) calculated from a jackknifing procedure.

Year	# sets	Proportion positive	CPUE (catch*hr^{-1})	Normalized CPUE (catch*hr^{-1})	CV
1996	14	0.21	1.50	0.62	0.57
1997	19	0.53	4.09	1.69	0.39
1998	8	0.50	2.69	1.11	0.57
1999	24	0.63	4.69	1.94	0.32
2000	7	0.57	1.82	0.76	0.38
2001	12	0.67	3.71	1.54	0.36
2002	-	-	-	-	-
2003	-	-	-	-	-
2004	-	-	-	-	-
2005	-	-	-	-	-
2006	-	-	-	-	-
2007	22	0.23	0.71	0.29	0.40
2008	-	-	-	-	-
2009	32	0.59	4.97	2.06	0.23
2010	39	0.59	1.48	0.61	0.24
2011	27	0.59	2.52	1.04	0.36
2012	-	-	-	-	-
2013	-	-	-	-	-
2014	-	-	-	-	-
2015	25	0.20	0.29	0.12	0.56
2016	21	0.29	0.49	0.20	0.52
2017	-	-	-	-	-
2018	-	-	-	-	-
Total	**250**				

Table 3. The annual summary of data informative to a nominal index and the results. The data includes number of collections included in index development, number of Tilefish caught, the proportion of positive collections in relation to the included collections, and the totals for the survey. The results show the mean LBLL catch of Golden Tilefish from the MARMAP/SEAMAP-SA fishery-independent LBLL survey, the standard deviation, as well as the minimum and maximum CPUE by year.

Year	# sets	# tilefish caught	Proportion positive	Mean CPUE (catch*hr^{-1})	Std dev	Minimum CPUE (catch*hr^{-1})	Maximum CPUE (catch*hr^{-1})
1996	17	48	0.24	1.44	3.15	0.00	11.61
1997	20	120	0.55	3.71	5.07	0.00	15.35
1998	8	25	0.50	2.16	2.92	0.00	7.02
1999	25	123	0.60	2.81	4.09	0.00	15.15
2000	8	19	0.50	1.31	1.72	0.00	4.53
2001	13	48	0.62	2.21	2.77	0.00	9.03
2002	18	18	0.44	0.60	1.00	0.00	3.26
2003	13	5	0.23	0.27	0.56	0.00	1.82
2004	5	0	0.00	0.00	0.00	0.00	0.00
2005	16	41	0.44	1.41	2.07	0.00	5.45
2006	7	5	0.29	0.45	0.95	0.00	2.55
2007	22	34	0.23	0.93	1.79	0.00	5.33
2008	-	-	-	-	-	-	-
2009	36	208	0.58	3.72	5.43	0.00	19.79
2010	39	125	0.59	2.01	2.62	0.00	9.36
2011	27	124	0.56	2.18	2.90	0.00	9.31
2012	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-
2014	-	-	-	-	-	-	-
2015	34	8	0.15	0.15	0.43	0.00	1.98
2016	24	19	0.29	0.51	0.93	0.00	3.30
2017	-	-	-	-	-	-	-
2018	-	-	-	-	-	-	-
Totals	**332**	**970**					

Table 4. The four-year binned summary of data informative to a nominal index binned by four-year periods and the results. The data includes number of collections included in index development, number of Tilefish caught, the proportion of positive collections in relation to the included collections, and the totals for the survey. The results show the mean LBLL catch of Golden Tilefish from the MARMAP/SEAMAP-SA fishery-independent LBLL survey, the standard deviation, as well as the minimum and maximum CPUE by four-year bin. No sampling was done after 2016.

Year	# sets	# tilefish caught	Proportion positive	Mean CPUE (catch*hr^{-1})	Std dev	Minimum CPUE (catch*hr^{-1})	Maximum CPUE (catch*hr^{-1})
1996-1999	70	316	0.49	2.66	4.10	0.00	15.35
2000-2003	52	90	0.44	1.03	1.79	0.00	9.03
2004-2007	50	80	0.28	0.92	1.73	0.00	5.45
2009-2012	102	457	0.58	2.66	3.95	0.00	19.79
2013-2016	58	27	0.21	0.30	0.70	0.00	3.30
Totals	**332**	**970**					

Table 5. Annual age composition by increment count of Golden Tilefish caught in the MARMAP/SEAMAP-SA fishery-independent LBLL survey. This value is in numbers of fish processed in 1996-2018. Total fish caught and positive deployments are summarized by year.

Increments	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	9	8	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
5	7	26	0	6	0	1	1	0	0	4	1	0	0	10	2	0	0	0	0	0	0	0	0
6	8	29	5	17	0	0	1	1	0	10	0	0	0	29	8	4	0	0	0	1	0	0	0
7	9	12	6	44	5	2	4	1	0	6	2	6	0	39	12	9	0	0	0	0	1	0	0
8	6	13	6	39	6	8	8	1	0	4	0	7	0	45	30	15	0	0	0	0	1	0	0
9	1	11	5	22	1	6	6	2	0	7	1	10	0	29	20	23	0	0	0	0	1	0	0
10	0	11	1	7	2	13	3	0	0	6	1	1	0	24	22	29	0	0	0	0	5	0	0
11	1	7	1	13	2	8	1	0	0	3	0	5	0	14	7	16	0	0	0	1	5	0	0
12	0	2	1	4	1	6	0	0	0	0	0	3	0	6	13	10	0	0	0	2	3	0	0
13	0	0	0	4	2	1	1	0	0	1	0	0	0	2	3	10	0	0	0	2	3	0	0
14	0	0	0	0	0	1	0	0	0	0	0	0	0	1	5	5	0	0	0	1	2	0	0
15	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2	3	0	0	0	1	0	0	0
16	0	0	0	0	0	2	0	0	0	0	0	0	0	2	3	3	0	0	0	0	1	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	2	0	0	0	0	3	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Fish	**44**	**120**	**25**	**156**	**19**	**48**	**25**	**5**	**0**	**42**	**5**	**33**	**0**	**206**	**128**	**130**	**0**	**0**	**0**	**8**	**25**	**0**	**0**
Deployments	**4**	**11**	**4**	**19**	**4**	**8**	**9**	**3**	**0**	**7**	**2**	**5**	**0**	**21**	**24**	**17**	**0**	**0**	**0**	**5**	**9**	**0**	**0**

Table 6. Annual age composition by increment count of Golden Tilefish caught in the MARMAP/SEAMAP-SA fishery-independent LBLL survey. This value is in proportion of fish processed in 1996-2018. Total fish caught and positive deployments are summarized by year.

Increments	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
2	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0.05	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0.2	0.07	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0.16	0.22	0	0.04	0	0.02	0.04	0	0	0.1	0.2	0	0	0.05	0.02	0	0	0	0	0	0	0	0
6	0.18	0.24	0.2	0.11	0	0	0.04	0.2	0	0.24	0	0	0	0.14	0.06	0.03	0	0	0	0.13	0	0	0
7	0.2	0.1	0.24	0.28	0.26	0.04	0.16	0.2	0	0.14	0.4	0.18	0	0.19	0.09	0.07	0	0	0	0	0.04	0	0
8	0.14	0.11	0.24	0.25	0.32	0.17	0.32	0.2	0	0.1	0	0.21	0	0.22	0.23	0.12	0	0	0	0	0.04	0	0
9	0.02	0.09	0.2	0.14	0.05	0.13	0.24	0.4	0	0.17	0.2	0.3	0	0.14	0.16	0.18	0	0	0	0	0.04	0	0
10	0	0.09	0.04	0.04	0.11	0.27	0.12	0	0	0.14	0.2	0.03	0	0.12	0.17	0.22	0	0	0	0	0.2	0	0
11	0.02	0.06	0.04	0.08	0.11	0.17	0.04	0	0	0.07	0	0.15	0	0.07	0.05	0.12	0	0	0	0.13	0.2	0	0
12	0	0.02	0.04	0.03	0.05	0.13	0	0	0	0	0	0.09	0	0.03	0.1	0.08	0	0	0	0.25	0.12	0	0
13	0	0	0	0.03	0.11	0.02	0.04	0	0	0.02	0	0	0	0.01	0.02	0.08	0	0	0	0.25	0.12	0	0
14	0	0	0	0	0	0.02	0	0	0	0	0	0	0	0	0.04	0.04	0	0	0	0.13	0.08	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0.03	0	0	0.02	0.02	0	0	0	0.13	0	0	0
16	0	0	0	0	0	0.04	0	0	0	0	0	0	0	0.01	0.02	0.02	0	0	0	0	0.04	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0.02	0	0	0	0	0.12	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0	0	0	0	0	0	0
Fish	**44**	**120**	**25**	**156**	**19**	**48**	**25**	**5**	**0**	**42**	**5**	**33**	**0**	**206**	**128**	**130**	**0**	**0**	**0**	**8**	**25**	**0**	**0**
Deployments	**4**	**11**	**4**	**19**	**4**	**8**	**9**	**3**	**0**	**7**	**2**	**5**	**0**	**21**	**24**	**17**	**0**	**0**	**0**	**5**	**9**	**0**	**0**

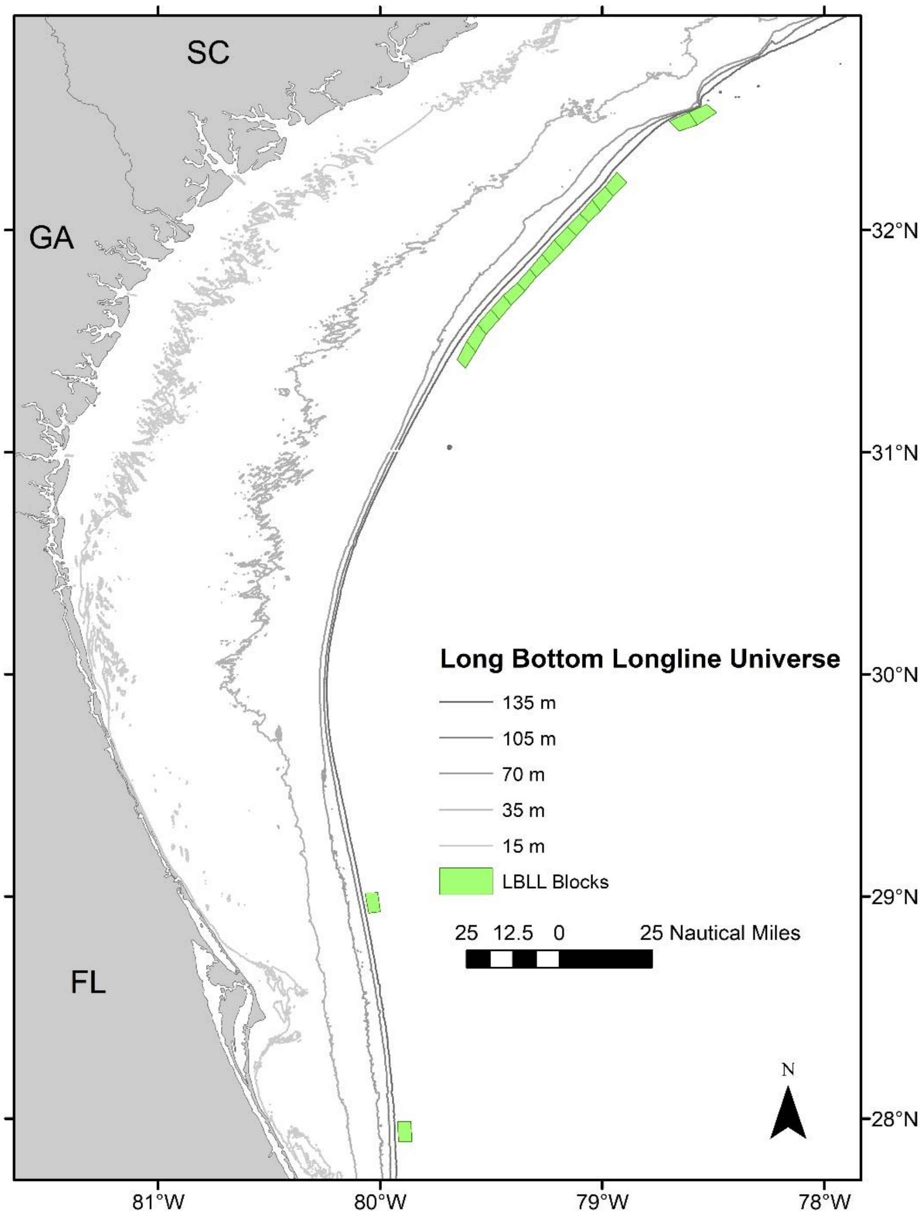

Figure 1. Sampling universe of the MARMAP/SEAMAP-SA fishery-independent LBLL survey. Green blocks represent fixed locations within which the goal is two LBLL deployments per year.

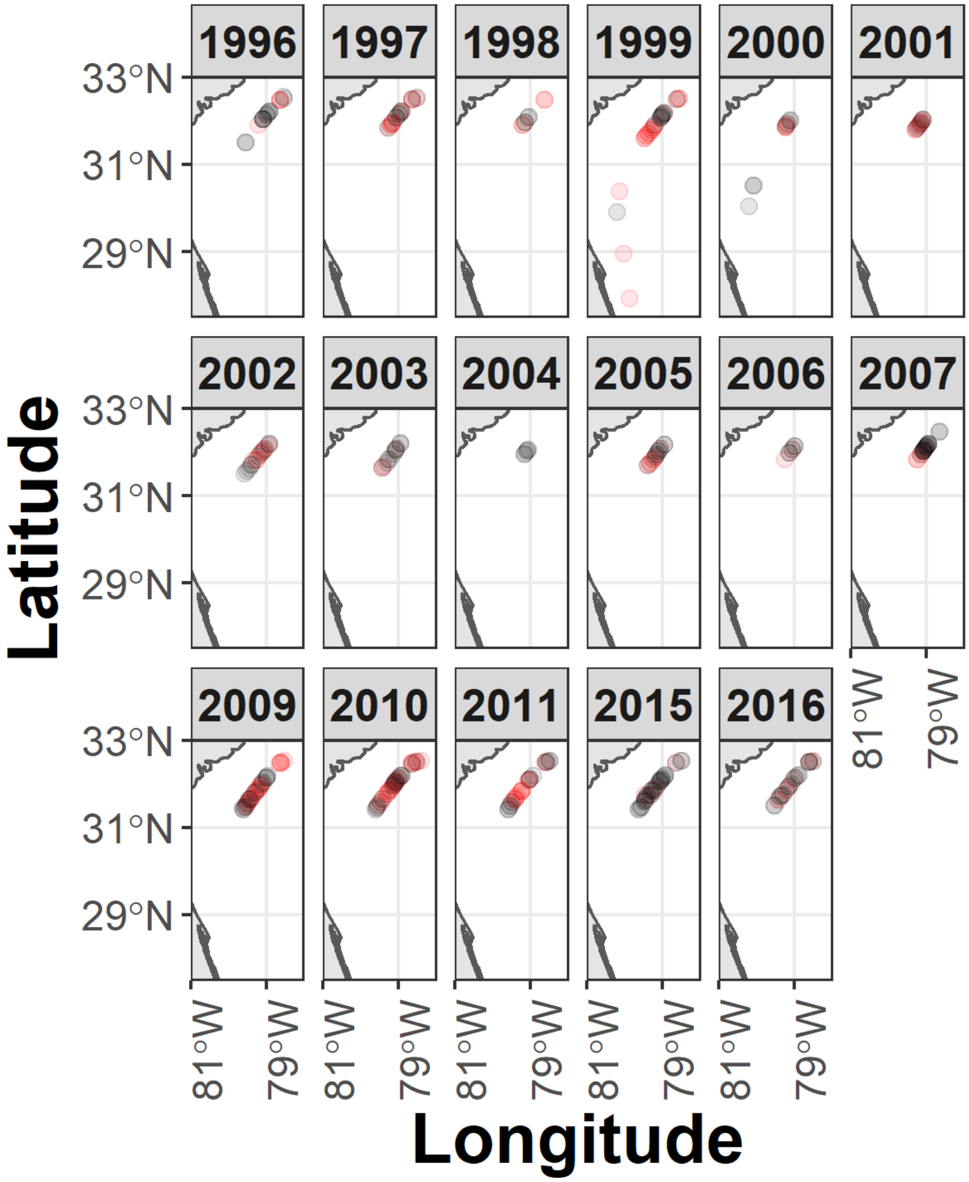

Figure 2. Sampling distribution of all collections by year of the MARMAP/SEAMAP-SA fishery-independent LBLL survey. Red circles indicate positive collections for Golden Tilefish, while black circles represent no catch of Golden Tilefish. No sampling was done after 2016.

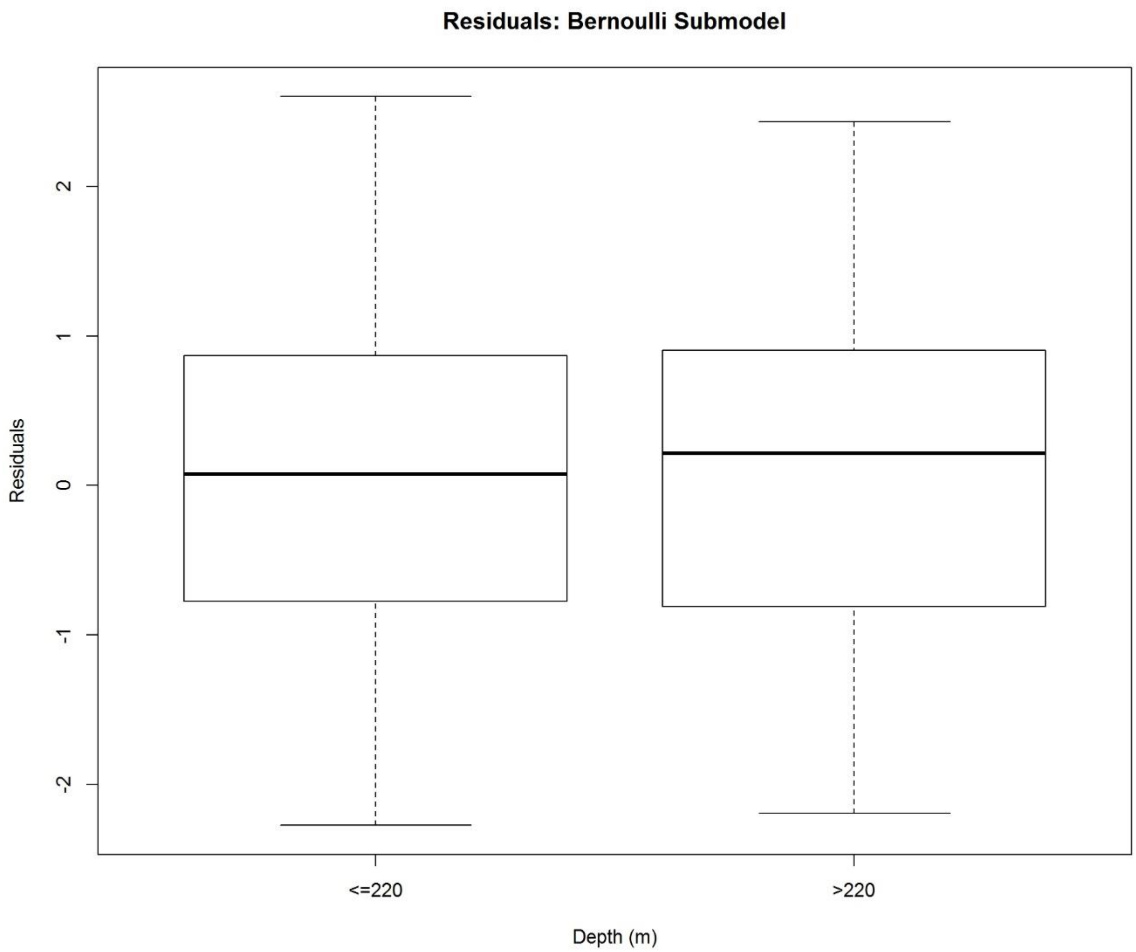

Figure 3. Residual plot for the covariate depth in the binomial sub-model of the delta-GLM standardized index of Golden Tilefish caught in the MARMAP/SEAMAP-SA fishery-independent LBLL survey. Depth was separated into a shallow (<= 220 m) and a deep (> 220 m) bin.

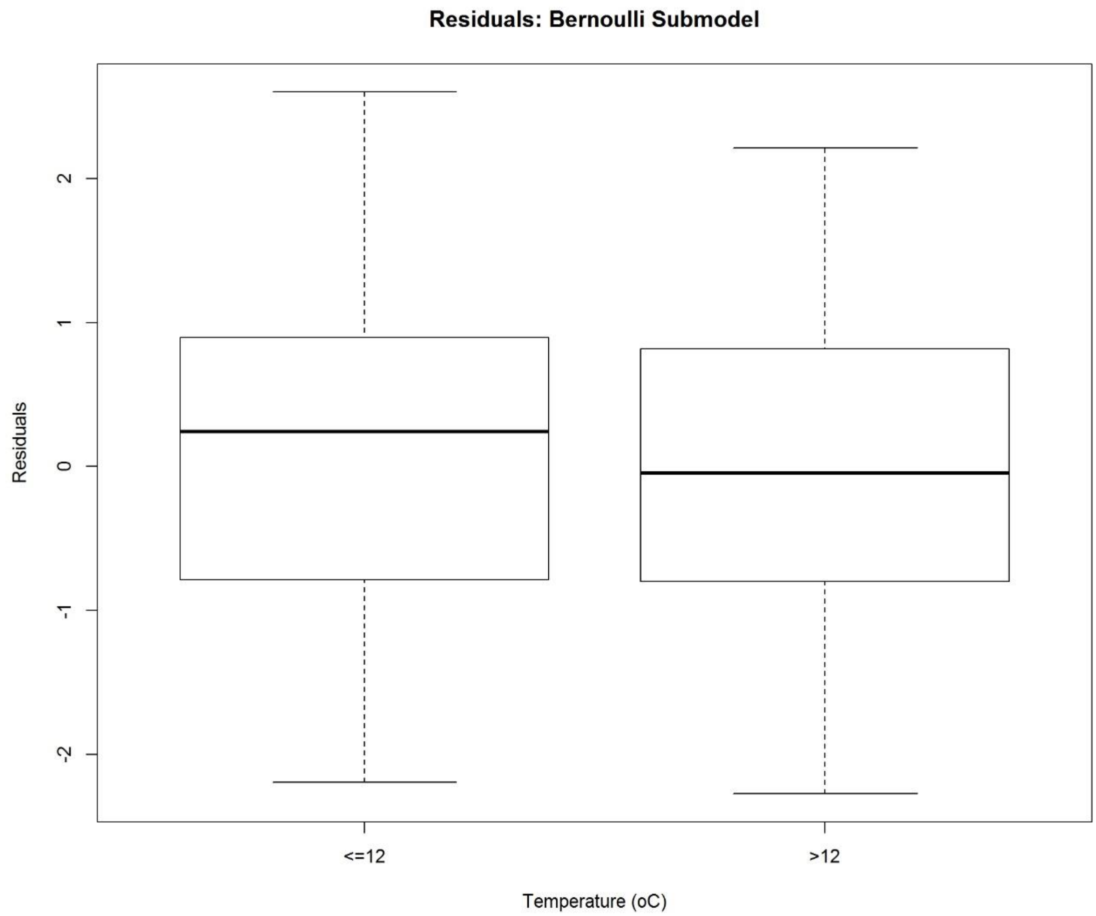

Figure 4. Residual plot for the covariate temperature in the binomial sub-model of the delta-GLM standardized index of Golden Tilefish caught in the MARMAP/SEAMAP-SA fishery-independent LBLL survey. Temperature was separated into two bins (<= 12° C and > 12° C).

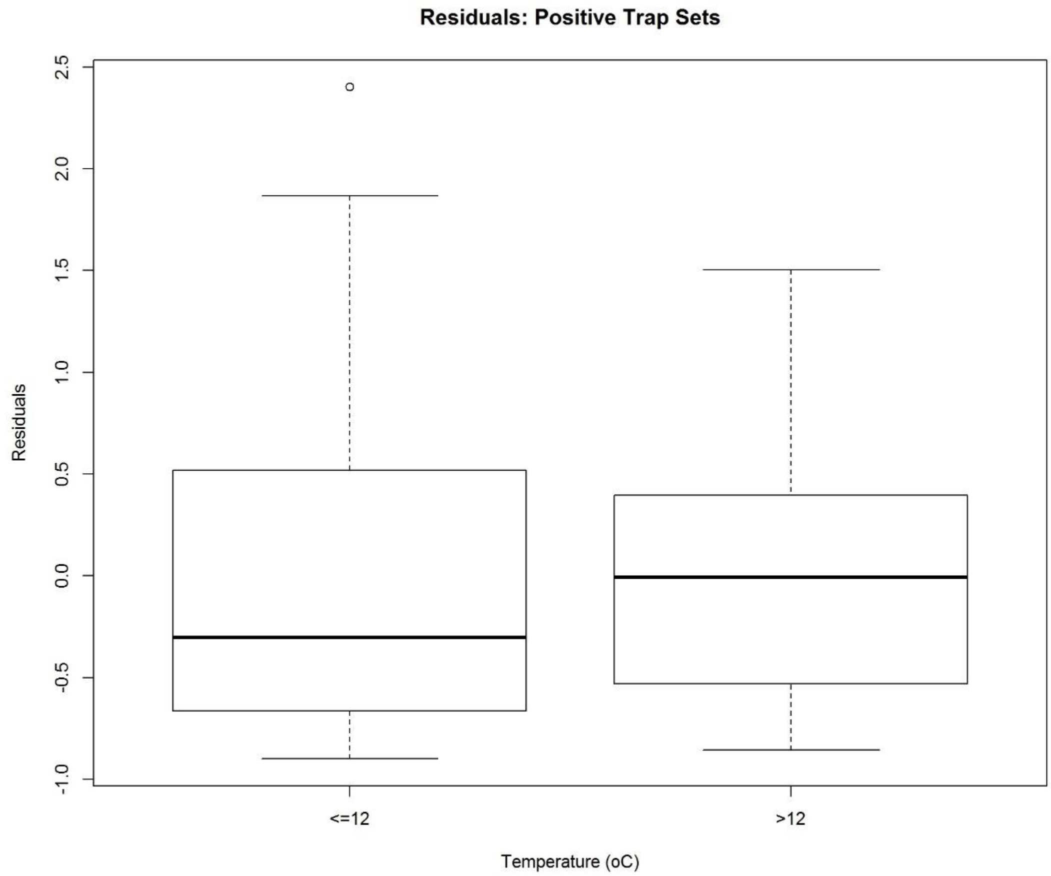

Figure 5. Residual plot for the covariate temperature in the count (positive) sub-model of the delta-GLM standardized index of Golden Tilefish caught in the MARMAP/SEAMAP-SA fishery-independent LBLL survey. Temperature was separated into two bins (<= 12° C and > 12° C).

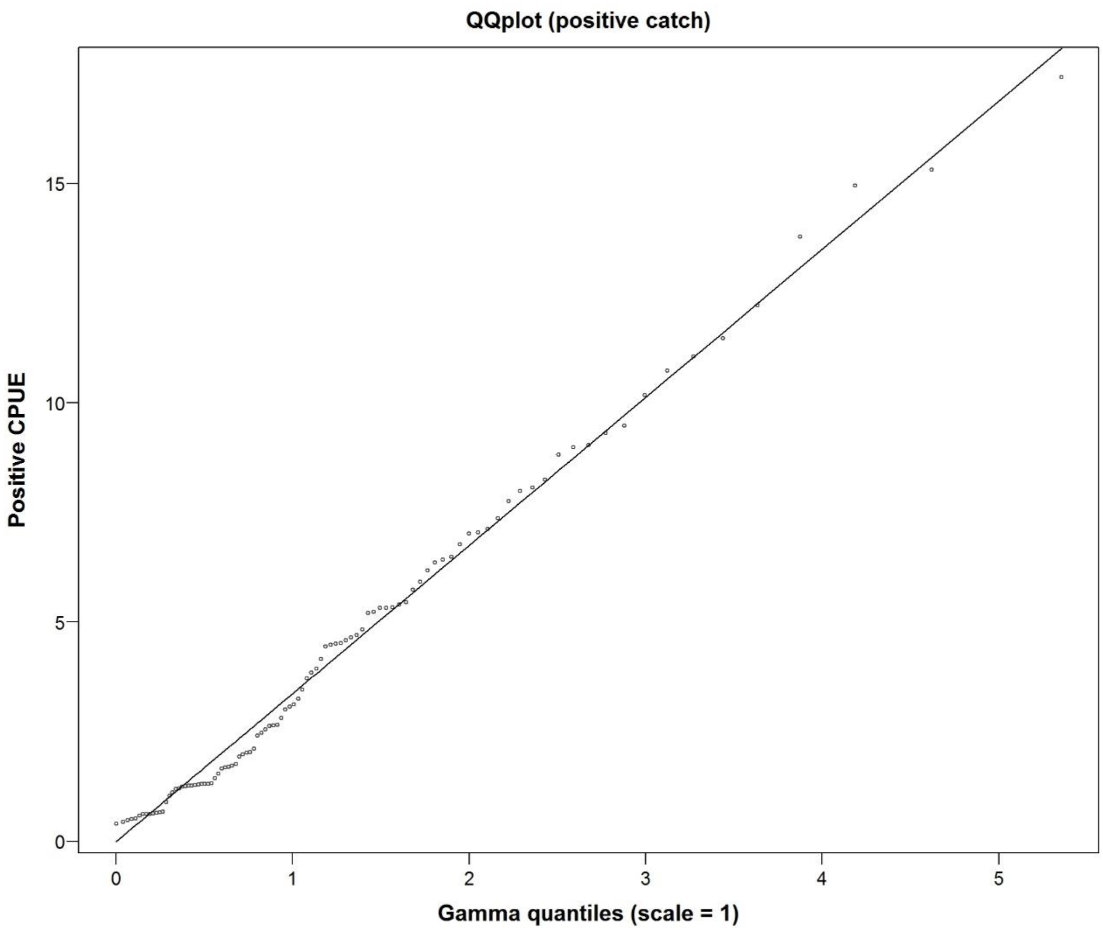

Figure 6. Quantile-Quantile plot for the count (positive) sub-model of the Delta-GLM standardized MARMAP/SEAMAP-SA fishery-independent LBLL survey. The gamma distribution was used for this sub-model.

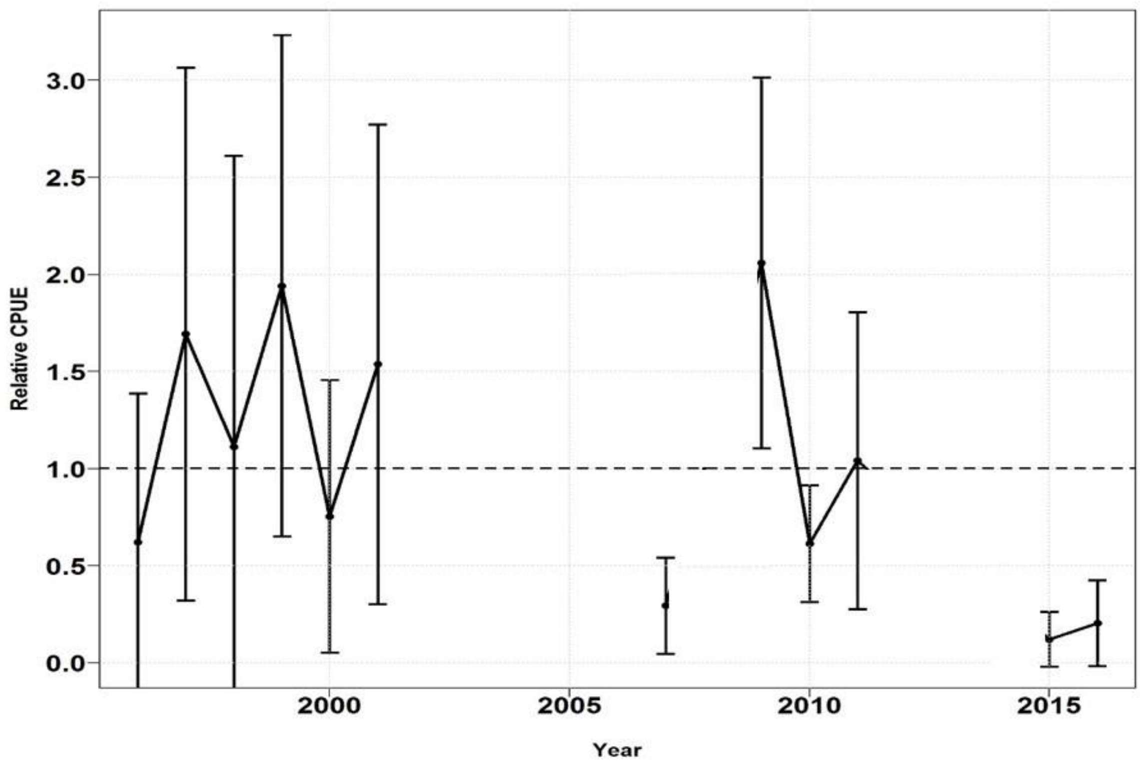

Figure 7. Normalized and standardized index (solid line) with 2.5% and 97.5% confidence intervals (bars) for Golden Tilefish in the MARMAP/SEAMAP-SA fishery-independent LBLL survey based on a jackknifing procedure.