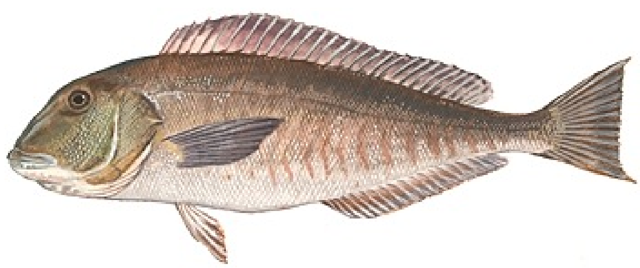
Atlantic Blueline Tilefish Assessment Report Addendum 1: Data Limited Methods (DLM) South of Cape Hatteras

SEDAR Operational Assessment



Southeast Fisheries Science Center

National Marine Fisheries Service

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Following the SEDAR 50 benchmark assessment, the analytical team applied an age-aggregated surplus production model (AAPM) using ASPIC software (Version 7.03; Prager 2015) as the primary assessment model for the southern region and applied data limited methods (DLM) using the R package `DLMtool` (Carruthers et al. 2022) for the northern region, for the SEDAR 92 operational assessment (SEDAR 2025). Following the April 2025 South Atlantic SSC meeting, the SAFMC requested that the DLM analysis also be run for the southern region. This report documents the `DLMtool` analysis for the Atlantic South of Cape Hatteras, complementing documentation in the SEDAR 92 Report (SEDAR 2025).

1 Methods

1.1 Data Sources

Data sources supplied to `DLMtool` included a time series of removals (i.e. landings plus dead discards), length compositions, and life history parameters.

1.2 Removals

The removals time series available for the `DLMtool` analysis was identical to what was supplied to the AAPM. The development of this time series was described in detail in section 4.1.1.3 of the SEDAR 92 report (SEDAR 2025). The removals series included commercial and recreational landings and dead discards in whole weight (1000 lb).

As noted in SEDAR 50, large increases in landings of Atlantic blueline tilefish north of Cape Hatteras occurred after 2005 (Figure 1). These removals have generally remained at higher levels through the terminal year of the current assessment (2023). Initially most of this increase occurred in North Carolina, but there has been an increase in Mid-Atlantic removals in recent years. While commercial landings were the primary source of removals in the Atlantic through 2005, increases since 2006 are predominantly due to recreational landings (Figure 2). Dead discards have remained a fairly small percentage of removals. Focusing on the southern region, most removals have occurred in Florida (Figure 3) with an increasing proportion of recreational landings in recent years, often exceeding the commercial landings since 2009 (Figure 4).

Time series of landings and dead discards for the southern region are provided in Table 1. To develop the catch (`Cat`) input, total removals (Table 1) were truncated to a long period of recent, fairly stable removals from 1987 – 2023. This excluded an early period when the fishery was developing (pre-1981) and a period of high commercial landings in Florida (1981-1986). The MPs used in the current assessment do not incorporate time series trends in catch. Rather the `Cat` input is used to compute mean and CV of catch over different time periods, and some MPs also use the most recent year of catch. Average catch (`AvC` = 131574 lb) and the CV of catch (`CV_Cat` = 0.5) are `DLMtool` inputs which were also computed from the `Cat` series.

1.3 Length compositions

Updated length data (fork length, FL) from the commercial longline fleet were provided for SEDAR 92 through 2023. Length data was filtered to include only fish from the area south of Cape Hatteras. Length compositions were developed in 30-mm bins over the range 270–1110 mm (labeled at bin center). All lengths below and above the minimum and maximum bins were pooled in the first and last bins, respectively (Figure 6, 7). These lengths were also combined across all years to build an aggregate length frequency distribution to compute two additional DLMtool inputs: the length of fish in the first length mode (`Lc` = 533 mm) and the mean length of fish larger than

Lc (Lbar = 619 mm; Figure 8). Length at full selection (LFS) was set equal to Lc. Note that in the version of DLMtool used in SEDAR 50 Lbar and Lc were computed inside some functions and were not supplied by the user. In DLMtool (version 6.0.6) Lbar and Lc inputs are specified as time series, but the MPs employed here do not use the entire time series or model interannual variability in length, thus a single value was repeated for all years in the input.

1.4 Life history

Life history inputs described in this section are identical to values used in the DLMtool analysis north of Cape Hatteras (SEDAR 2025). Most of the data sets used to develop these inputs included fish from north and south of Cape Hatteras, so they are equally appropriate for either region.

For several life history inputs, values in SEDAR 92 were the same as in SEDAR 50. A Beverton-Holt steepness parameter estimate and CV (h = steep = 0.836; CV_h = CV_steep = 0.24) were based on a meta-analysis of marine demersal teleost fishes (Shertzer and Conn 2012). Weight-length equation parameters ($W = aL^b$; a = wla = 0.0000178 and b = wlb = 2.94) and associated CVs (CV_a = CV_wla = 0.08 and CV_b = CV_wlb = 0.004) and length at 50% maturity (L_{50} = L50 = 305) were based on data for blueline tilefish provided during SEDAR 50. Maximum age ($t_{\max}$ = MaxAge = 40) was based on golden tilefish, and the natural mortality estimate was computed as a function of t_{max} following Then et al. (2014) (M = Mort = $4.899 * 40^{-0.916} = 0.17$). The CV associated with M (CV_M = CV_Mort = 0.24) was computed in SEDAR 50 as the value associated with a normal distribution, with a mean of 0.17 and 97.5 percentile at 0.25, which was an upper estimate for M. The upper estimate of M was associated with a minimum estimate of t_{max} of 26 years. This minimum estimate of t_{max} was identified by the SEDAR 50 Data Workshop Life History Working Group based on the bomb radio-carbon study of blueline tilefish conducted by SCDNR staff (SEDAR 2017, section II 2.4).

The SEDAR 92 Life History Topical Working Group (LH TWG) identified a new set of Von Bertalanffy growth parameter estimates for the current assessment, estimated from SCDNR length and age data for blueline tilefish (Bubley 2024) (L_∞ = vbLinf = 679.01, K = vbK = 0.16, t_0 = vbt0 = -6.16) and associated CVs ($CV_{L\infty}$ = CV_vbLinf = 0.014, CV_K = CV_vbK = 0.141, CV_{t0} = CV_vbt0 = -0.19). These values were similar to those developed from a meta-analysis in SEDAR 50, with the exception of t_0.

1.5 Model Configuration and Equations

All available inputs were entered into the appropriate slots in a DLMtool Data object. The Data object was then supplied to the MSEtool::TAC function to run a set of methods referred to as MPs (management procedures) which compute stochastic distributions of total allowable catch (TAC) advice. The MSEtool (Hordyk et al. 2023) R package was designed to be compatible with DLMtool for conducting management strategy evaluations using the openMSE framework (Hordyk et al. 2021). By default, the TAC function will run a checkMP step to check the Data object to determine which of the available MPs can be run. When running this checkMP step, DLMtool is not identifying which MPs are appropriate to apply. It is simply checking that the necessary data inputs for each MP are available in the Data object and determining if it is possible to run them. Expert judgement must be used to determine which of the possible methods is appropriate. For the SEDAR 92 operational assessment, the selection of MPs was based on the expert judgement of the SEDAR 50 assessment panel. Each of the MPs was run 1000 times, and each run randomly drew values of certain input data types (e.g. M, L_{50}) from a statistical distribution (usually normal). The variance of these distributions was determined by user specified coefficients of variation (CV). Note that the Lc and Lbar inputs are fixed. For each MP, the function output does not return a single base estimate, but rather a distribution of TACs to serve as proxies for MSY.

Five MPs applied in SEDAR 50 were considered appropriate for use here. A sixth, `SPMSY`, was applied in SEDAR 50 but was not ultimately used for management. This MP assumes that the catch time series is proportional to abundance then applies a Schaefer surplus production model (see DLMtool help file for `SPMSY`). This assumption is not considered valid for blueline tilefish south of Cape Hatteras which have been managed with annual catch limits since 2012 (SEDAR 2025). Therefore, `SPMSY` was not included in the current analysis.

The data inputs required by each MP are presented in Table 2 with `DLMtool` descriptions of each data input in Table 3. These methods are listed by their `DLMtool` abbreviations and briefly described below:

- `AvC`: Average catch over the entire the catch time series. The MP resamples a lognormal distribution with mean equal to the mean catch (`AvC` slot) and fixed standard deviation of 0.2, which is hard coded into the MP.

- `CC1`: Average catch over the most recent `yrsmth` = 5 years of the catch time series (C_{ave}; computed internally from `Cat`). The MP resamples a truncated lognormal distribution with a mean equal to C_{ave} and a standard deviation equal to `CV_Cat`/(`yrsmth`$^{0.5}$)

- `CC4`: 70% of average catch over the most recent `yrsmth` = 5 years of the catch time series (C_{ave}; computed internally from `Cat`). Identical to the `CC1` MP but the TAC estimates are multiplied by 0.7.

- `Fdem_ML`: Demographic F_{MSY} method that uses length frequency data in a calculation that estimates recent Z:

  $$Z = K(Linf - Lbar)/(Lbar - Lc) \tag{1}$$

  where K and $Linf$ are parameters of a Von Bertalanffy growth model, Lc is the length at full vulnerability to fishing, and $Lbar$ is the mean length of fish greater than Lc. The method was developed by Beverton and Holt (1956) to be applied to a population at equilibrium and has been reprinted in later works (e.g. Hilborn and Walters 1992; Gedamke and Hoenig 2006). The MP then subtracts M to estimate F_{recent} and then estimates B_{current} as the most recent year of catch (`Cat`) divided by 1-exp(-F_{recent}). Then using the life history data, it applies the Euler-Lotka equation (Gotelli 2008, Chap. 3) and solves for r. Then calculates $r/2 = F_{\mathrm{MSY}}$. This estimate of F_{MSY} is then multiplied by B_{current} to estimate a TAC.

- `YPR_ML`: Estimates B_{current} with the same method as described above for Fdem_ML. This method then conducts a yield-per-recruit analysis to determine the value of F at which the slope of the $YPR = f(F)$ curve is 10% of the slope of this curve at the origin; this value, termed $F_{0.1}$, is used as the F_{MSY} proxy. This F_{MSY} proxy is then multiplied by B_{current} to estimate a TAC.

2 Results

Distributions of TACs from `DLMtool` analysis south of Cape Hatteras are plotted in Figure 9. Quantiles and standard errors of these distributions for each MP are summarized in Table 4. The median TAC from the average catch MP (`AvC`) was 133 klb, while the median TAC for the recent average catch MP `CC1` was 115 klb. The median TAC for the `CC4` MP was 79 klb which is about 70% of `CC1`. The two mean length (ML) methods (`Fdem_ML` and `YPR_ML`) produced TAC distributions with medians of $457 - 761$ klb, which is about $3 - 10$ times as high as median TACs for catch-based methods.

3 Discussion

To put these TAC estimates into context, removals of blueline tilefish south of Cape Hatteras have only exceeded 450 klb in the three highest historical years ($1982-1984$), during a period of high commercial landings in Florida, before federal regulations were in place. According to the current regulatory history (SEDAR 2025), the first regulations in place for blueline tilefish were daily retention limits for recreational fishers in 1994, as part of the aggregate grouper bag limit. Annual catch limits (ACL) were first put in place on the commercial fleet in 2012 with an ACL of 344 klb for the SAFMC region. During the period $1987-2011$ between high Florida landings and the start of commercial regulations the average annual removals south of Cape Hatteras was 116 klb and did not exceed 250 klb. By comparison, the MSY estimate from the age-aggregated production model ensemble for blueline tilefish was 247 klb, and 216 and 278 klb for the separate handline and longline models (SEDAR 2025). For comparison with a related species with a similar historical pattern of exploitation in the SAFMC region, MSY for the South Atlantic stock of tilefish (*Lopholatilus chamaeleonticeps*) was recently estimated at 545 klb, with average removals from $1987-2022$ at about 500 klb (SEDAR 2024). So comparison with catches and MSY estimates for blueline tilefish, the TAC estimates from the ML MPs are rather high, while the catch-based TACs match the catches, as expected.

When `DLMtool` was recently applied north of Cape Hatteras in SEDAR 92, the ML methods were not recommended for management, for several reasons. They produced extremely high TAC estimates (13,000 - 16,000 klb), which were 10-20 times as high as the highest observed catches in that region, and were therefore considered unreasonable. Further investigation of the computations with the the ML methods in that region showed that internal estimates of total mortality (Z) were usually lower than the estimate of natural mortality (M) resulting in negative estimates of fishing mortality (F), which is impossible. The TAC distributions from these methods were also extremely wide to the point of being uninformative. In addition, these methods assume that the population is at equilbrium, which was likely violated given the catch history north of Cape Hatteras, where catches have increased substantially in recent decades. The use of Equation 1 for estimating Z is strongly discouraged if the population is not at equilibrium Hilborn and Walters (1992).

In the current analysis for the area south of Cape Hatteras, although the TAC distributions are still high, the medians are within the range of historic landings. However the standard errors (SE) are 2-3 times the medians, indicating that the estimates are highly uncertain (Table 4). By comparison the SE of MSY from the ASPIC model for this stock was about 0.25 times the median (SEDAR 2025, ; Table 4 of the SEDAR 92 report). The main problem with the ML methods in the north was that the input life history values internally produced negative estimates of current F (SEDAR 2025). But this was not the case for the south. Substituting life history values into Eq. 1 yields a plausible result:

$Z = 0.16(679.01 - 592)/(592 - 532) = 0.23$

and

$Z - M = F = 0.23 - 0.17 = 0.06$

About 14% of stochastic runs still result in negative F estimates, but these are filtered out internally, leaving a truncated distribution of F. The results of the ML MPs are included in this report for further consideration.

The difference in the results between the north and the south for the ML methods was almost entirely due to the difference in L_{bar}, because the other life history inputs were identical and the L_c estimate was nearly identical. The ML methods are very sensitive to L_{bar} which is provided as a fixed input. The only other important values in the ML method calculations which differed between the north and the south were last year of catch and the CV of catch. The estimation of F_{MSY} proxies was almost entirely dependent on the life history inputs, which did not differ between regions, thus the internal F_{MSY} estimates would be nearly identical.

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5 Tables

Table 1. Observed time series of removals (L = landings, D = dead discards) by fleet (c = commercial, r = recreational), and summed across fleets (Total), south of Cape Hatteras. All values are in units of 1000 lb whole weight.

Year	L_c	L_r	D_c	D_r	Total
1958	0.191	0.000	0.000	0.000	0.191
1959	0.099	0.000	0.000	0.000	0.099
1960	0.000	0.000	0.000	0.000	0.000
1961	0.000	0.000	0.000	0.000	0.000
1962	0.734	0.000	0.000	0.000	0.734
1963	0.727	0.000	0.000	0.000	0.727
1964	0.107	0.000	0.000	0.000	0.107
1965	5.520	0.000	0.000	0.000	5.520
1966	1.032	0.000	0.000	0.000	1.032
1967	2.431	0.000	0.000	0.000	2.431
1968	1.134	0.000	0.000	0.000	1.134
1969	0.802	0.000	0.000	0.000	0.802
1970	2.164	0.000	0.000	0.000	2.164
1971	4.307	0.000	0.000	0.000	4.307
1972	2.552	0.000	0.000	0.000	2.552
1973	10.974	0.000	0.000	0.000	10.974
1974	25.949	0.000	0.000	0.000	25.949
1975	44.836	0.000	0.000	0.000	44.836
1976	44.382	0.000	0.000	0.000	44.382
1977	30.911	0.000	0.000	0.000	30.911
1978	71.084	0.000	0.000	0.000	71.084
1979	58.622	0.000	0.000	0.000	58.622
1980	144.486	0.000	0.000	0.000	144.486
1981	410.068	7.256	0.000	0.000	417.324
1982	1057.417	37.086	0.000	0.000	1094.503
1983	539.528	13.404	0.000	0.000	552.932
1984	409.166	77.582	0.000	0.000	486.748
1985	315.644	2.596	0.000	0.000	318.240
1986	243.436	2.179	0.000	0.000	245.615
1987	115.375	4.705	0.000	0.000	120.080
1988	91.432	1.201	0.000	0.000	92.633
1989	96.977	0.432	0.000	0.000	97.409
1990	138.129	0.757	0.000	0.000	138.886
1991	181.123	0.802	0.000	15.356	197.281
1992	204.080	2.782	0.000	1.946	208.808
1993	176.976	21.996	1.633	0.000	200.605
1994	147.191	0.146	1.776	0.000	149.113
1995	140.052	12.308	1.825	0.000	154.185
1996	111.085	11.676	1.816	0.000	124.577
1997	161.408	0.350	2.238	0.000	163.996

Table 1. (continued)

Year	L_c	L_r	D_c	D_r	Total
1998	88.411	0.259	1.755	0.023	90.448
1999	82.743	1.880	1.522	4.082	90.227
2000	91.954	0.323	1.032	0.085	93.394
2001	107.186	1.054	1.353	0.000	109.593
2002	84.858	9.483	1.268	1.424	97.033
2003	75.236	52.319	1.298	12.764	141.617
2004	57.859	17.489	1.245	0.199	76.793
2005	58.493	7.949	1.254	10.844	78.540
2006	65.885	14.341	1.366	0.002	81.595
2007	41.964	13.157	1.621	0.764	57.506
2008	35.374	31.511	1.329	0.009	68.223
2009	47.440	56.420	1.790	6.193	111.843
2010	65.418	76.913	1.388	0.067	143.786
2011	9.151	9.949	0.923	0.034	20.058
2012	23.068	134.967	1.015	1.158	160.207
2013	70.280	336.345	1.305	14.850	422.781
2014	90.098	77.934	1.091	20.558	189.681
2015	51.633	57.956	0.642	16.089	126.320
2016	56.907	42.425	1.271	6.219	106.822
2017	67.144	112.374	1.460	21.058	202.036
2018	66.146	89.900	1.542	4.065	161.653
2019	62.536	45.563	1.392	0.007	109.498
2020	48.799	114.045	1.288	4.635	168.768
2021	40.852	45.807	1.135	5.228	93.022
2022	38.693	38.819	1.466	0.525	79.503
2023	35.648	102.755	0.879	0.433	139.715

Table 2. Data inputs required by each DLMtool management procedure (MP). Row names represent the names of DLMtool Data object slots. Column names represent the names of DLMtool MPS. Descriptions of each input are provided in Table 3

	AvC	CC1	CC4	Fdem_ML	YPR_ML
Cat	X	X	X	X	X
CV_Cat		X	X	X	X
CV_LFS					X
CV_Mort				X	X
CV_steep				X	
CV_vbK				X	X
CV_vbLinf				X	X
CV_vbt0				X	X
L50				X	
Lbar				X	X
Lc				X	X
LFS					X
LHYear	X	X	X		
MaxAge				X	X
Mort				X	X
steep				X	
vbK				X	X
vbLinf				X	X
vbt0				X	X
wla				X	
wlb				X	
Year	X	X	X		

Table 3. Descriptions of slots in DLMtool Data objects used by MPs applied in the current analysis. Reprinted from MSEtool::DataDescription table for slots used in the MPs selected.

Slot	Description
Cat	Total annual catches. Matrix of nsim rows and nyears columns. Non-negative real numbers
CV_Cat	Coefficient of variation in annual catches. Matrix nsim rows and either 1 or nyear columns. Positive real numbers. Note: built-in MPs use only the first value of CV_Cat for all years.
CV_LFS	Coefficient of variation in length at full selection. Vector nsim long. Positive real numbers
CV_Mort	Coefficient of variation in natural mortality rate. Vector nsim long. Positive real numbers
CV_steep	Coefficient of variation in steepness. Vector nsim long. Positive real numbers
CV_vbK	Coefficient of variation in the von Bertalanffy K parameter. Vector nsim long. Positive real numbers
CV_vbLinf	Coefficient of variation in maximum length. Vector nsim long. Positive real numbers
CV_vbt0	Coefficient of variation in age at length zero. Vector nsim long. Positive real numbers
L50	Length at 50 percent maturity. Vector nsim long. Positive real numbers
Lbar	Mean length of catches over Lc. Matrix of nsim rows and nyears columns. Positive real numbers
Lc	Modal length of catches. Matrix of nsim rows and nyears columns. Positive real numbers
LFS	Shortest length at full selection. Vector nsim long. Positive real numbers
LHYear	The last historical year of the simulation (before projection). Single value. Positive integer
MaxAge	Maximum age. Vector nsim long. Positive integer
Mort	Natural mortality rate. Vector nsim long. Positive real numbers
steep	Steepness of stock-recruitment relationship. Vector nsim long. Value in the range of one-fifth to 1
vbK	The von Bertalanffy growth coefficient K. Vector nsim long. Positive real numbers
vbLinf	Maximum length. Vector nsim long. Positive real numbers
vbt0	Theoretical age at length zero. Vector nsim long. Non-positive real numbers
wla	Weight-Length parameter alpha. Vector nsim long. Positive real numbers
wlb	Weight-Length parameter beta. Vector nsim long. Positive real numbers
Year	Years that corresponding to catch and relative abundance data. Vector nyears long. Positive integer

Table 4. Quantiles (%) and standard error (SE) of TAC (total allowable catch) distributions from all `DLMtool` *management procedures applied south of Cape Hatteras. Column names AvC, CC1, CC4, Fdem_ML, and YPR_ML are abbreviations for management procedures defined in the main text. Quantity indicates either a percentile or the TAC distribution or its standard error.*

Quantity	AvC	CC1	CC4	Fdem_ML	YPR_ML
2.5%	92	76	53	46	105
5%	97	80	55	85	134
10%	105	87	60	152	161
25%	116	99	68	350	260
50%	133	115	79	761	457
75%	152	134	93	1485	858
90%	174	155	108	2666	2024
95%	187	172	117	4084	3238
97.5%	200	185	125	5500	4878
SE	28	28	19	1472	1836

6 Figures

Figure 1. Removals in the Atlantic by aggregated area, from the southern SAFMC boundary (near Key West) north through the Mid-Atlantic. Removals include commercial and recreational landings and dead discards. They are aggregated here into the smallest common areas that most of the removals could be aggregated into. The proportion of total removals for all years combined, from each area, is presented in the legend in parentheses next to the name of the area.

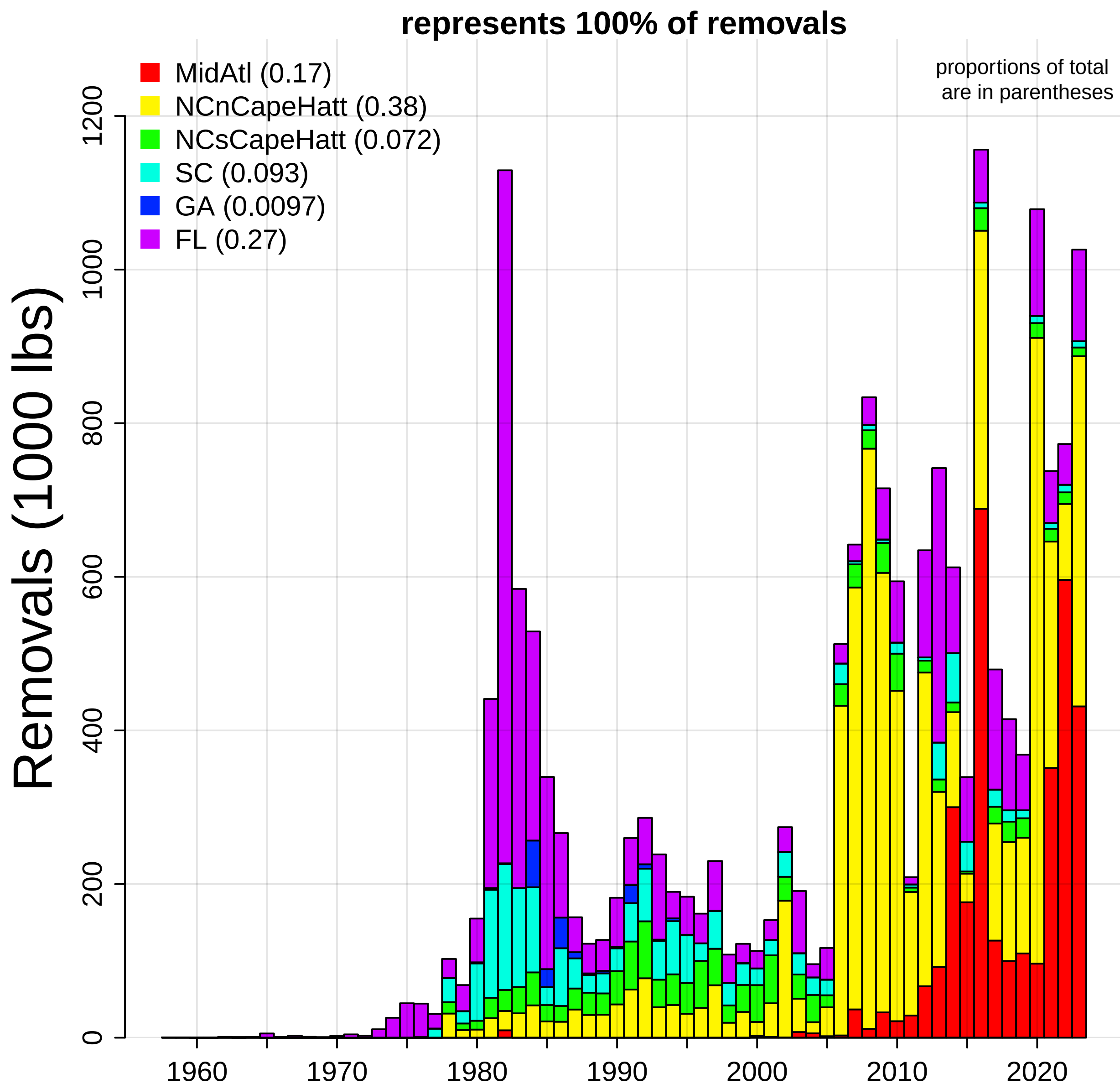

Figure 2. Removals in the Atlantic by fleet, from the southern SAFMC boundary (near Key West) north through the Mid-Atlantic. The proportion of total removals for all years combined, from each area, is presented in the legend in parentheses next to the name of the area. Land = landings, Disc = dead discards, Com = commercial, Rec = recreational.

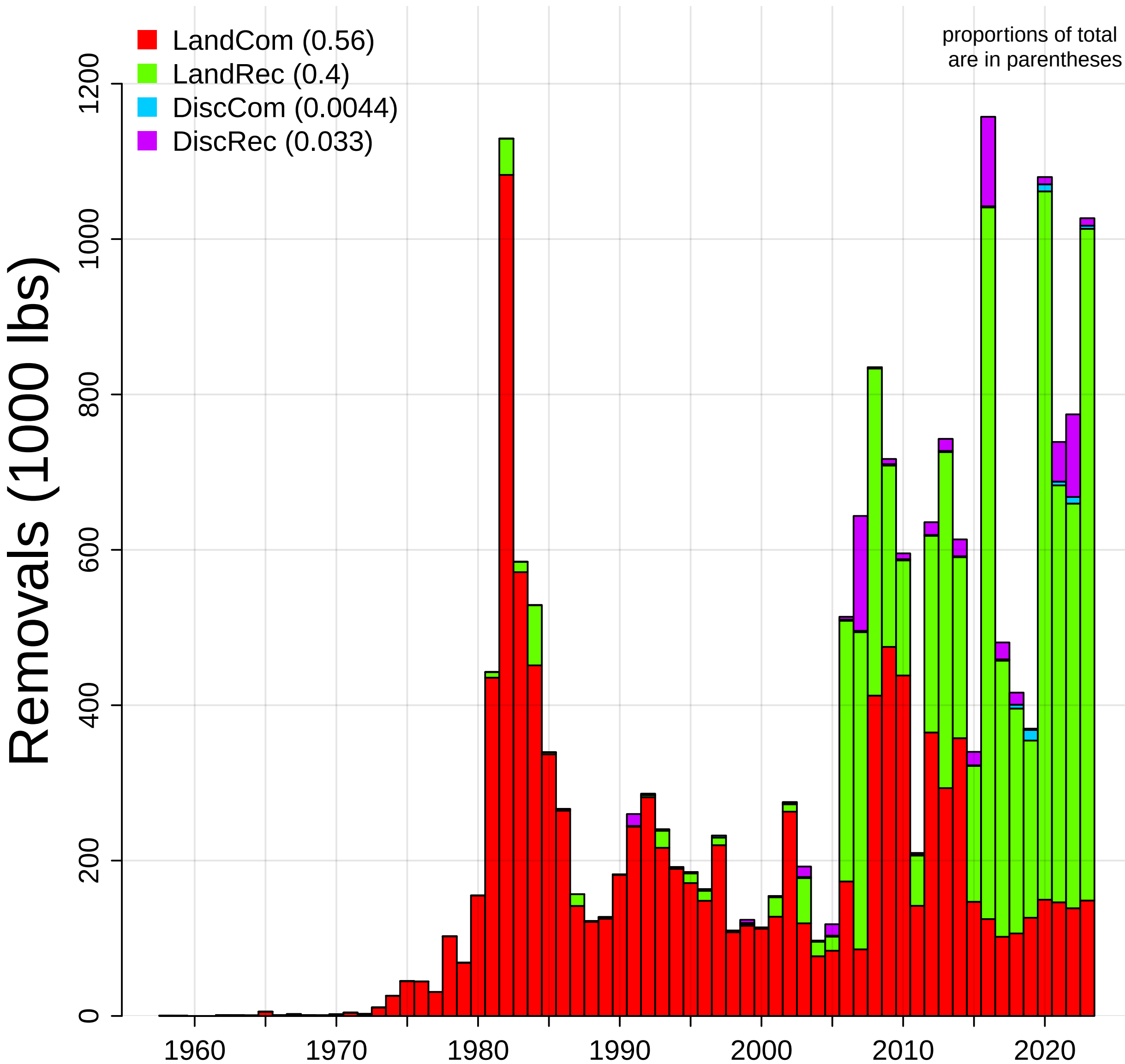

Figure 3. Removals from Cape Hatteras south to the southern SAFMC boundary (near Key West), by aggregated area. Removals include commercial and recreational landings and dead discards. They are aggregated here into the smallest common areas that most of the removals could be aggregated into. A small proportion of the removals (1%) could not be traced to one of these areas, thus the plot represents 99% of removals. The proportion of total removals for all years combined, from each area, is presented in the legend in parentheses next to the name of the area.

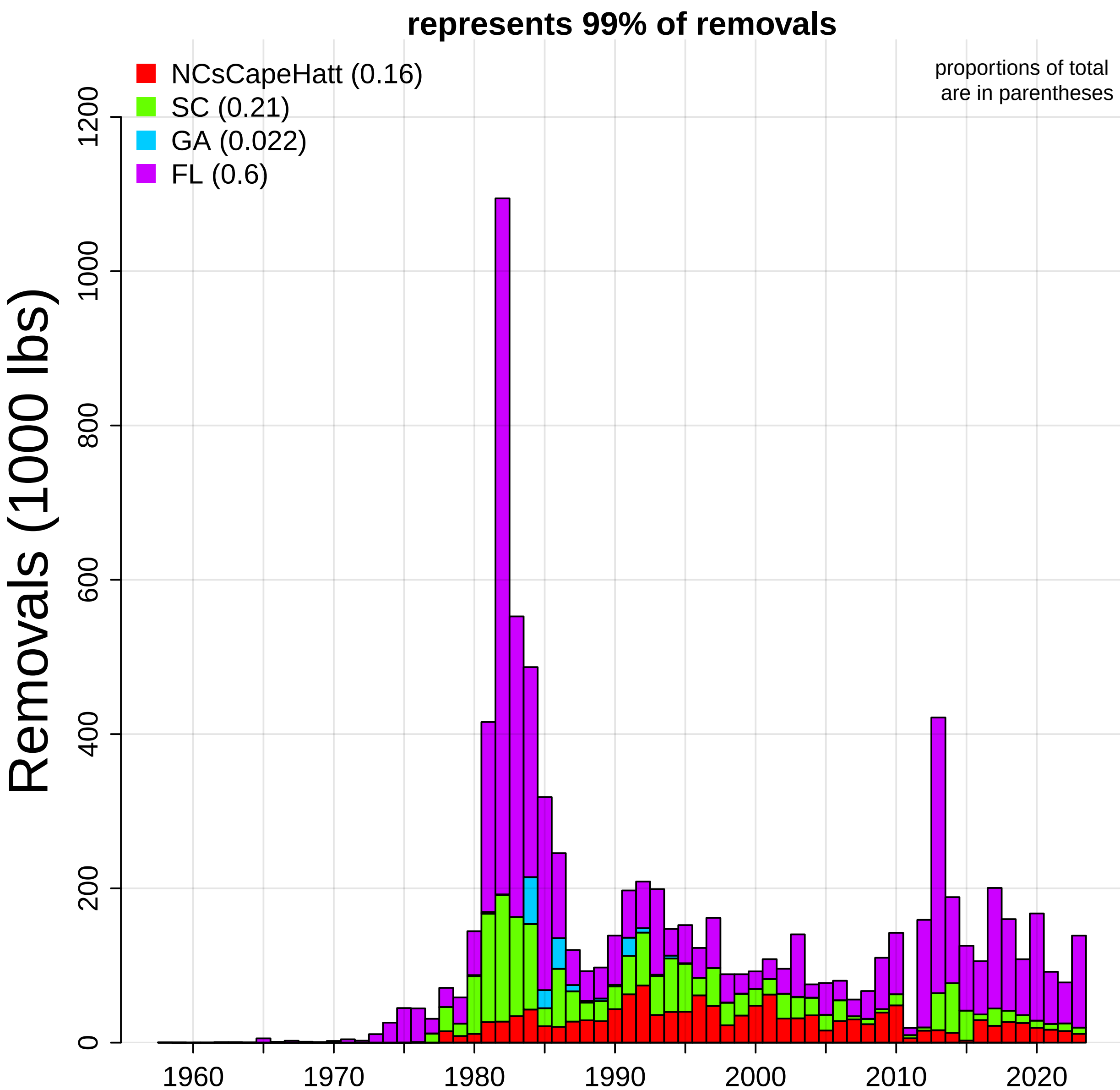

Figure 4. Removals south of Cape Hatteras, by fleet. The proportion of total removals for all years combined, from each area, is presented in the legend in parentheses next to the name of the area. Land = landings, Disc = dead discards, Com = commercial, Rec = recreational.

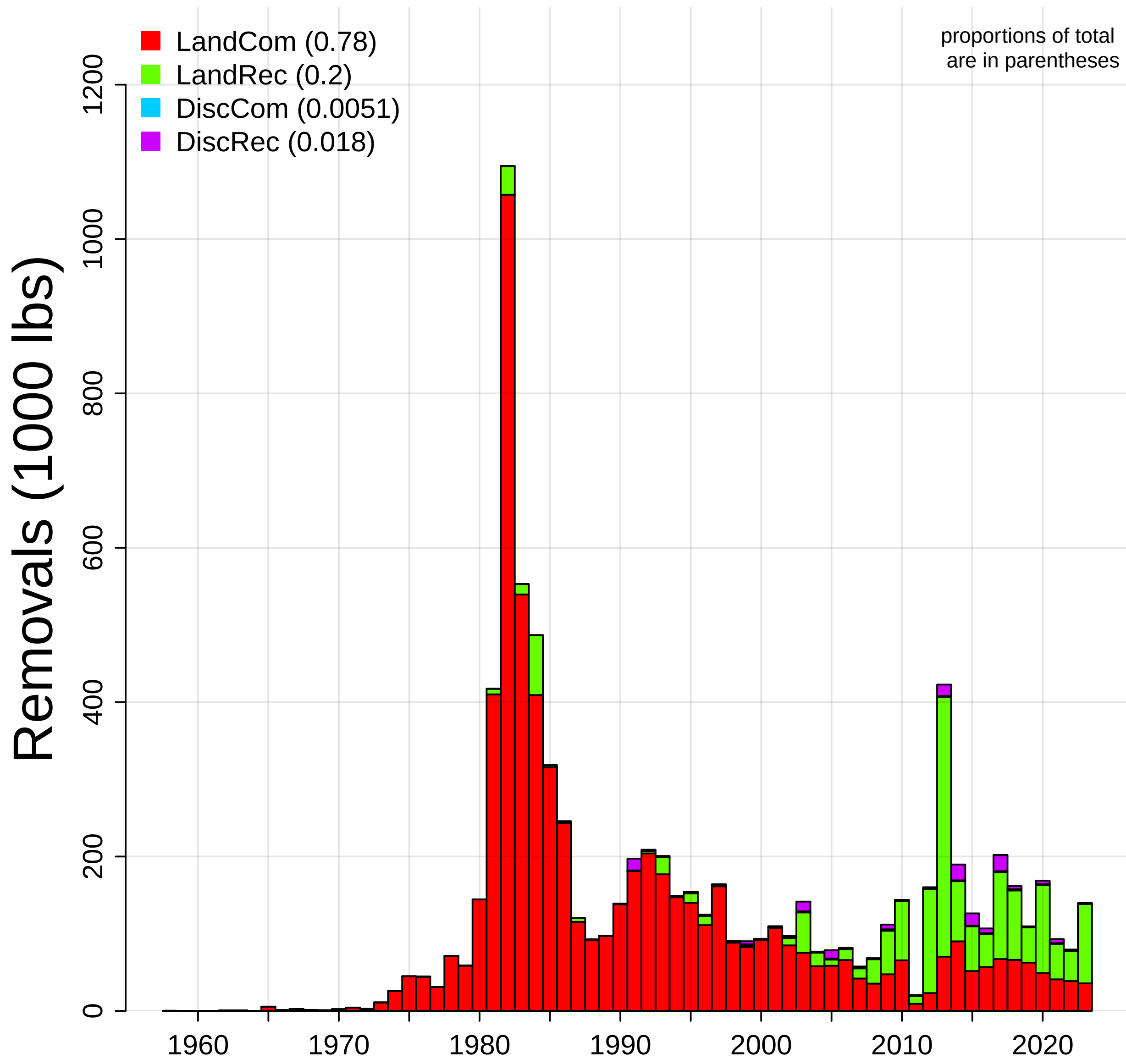

Figure 5. Catch time series south of Cape Hatteras DLM analysis. The figure shows the entire time series available and the portion of the time series used in analysis.

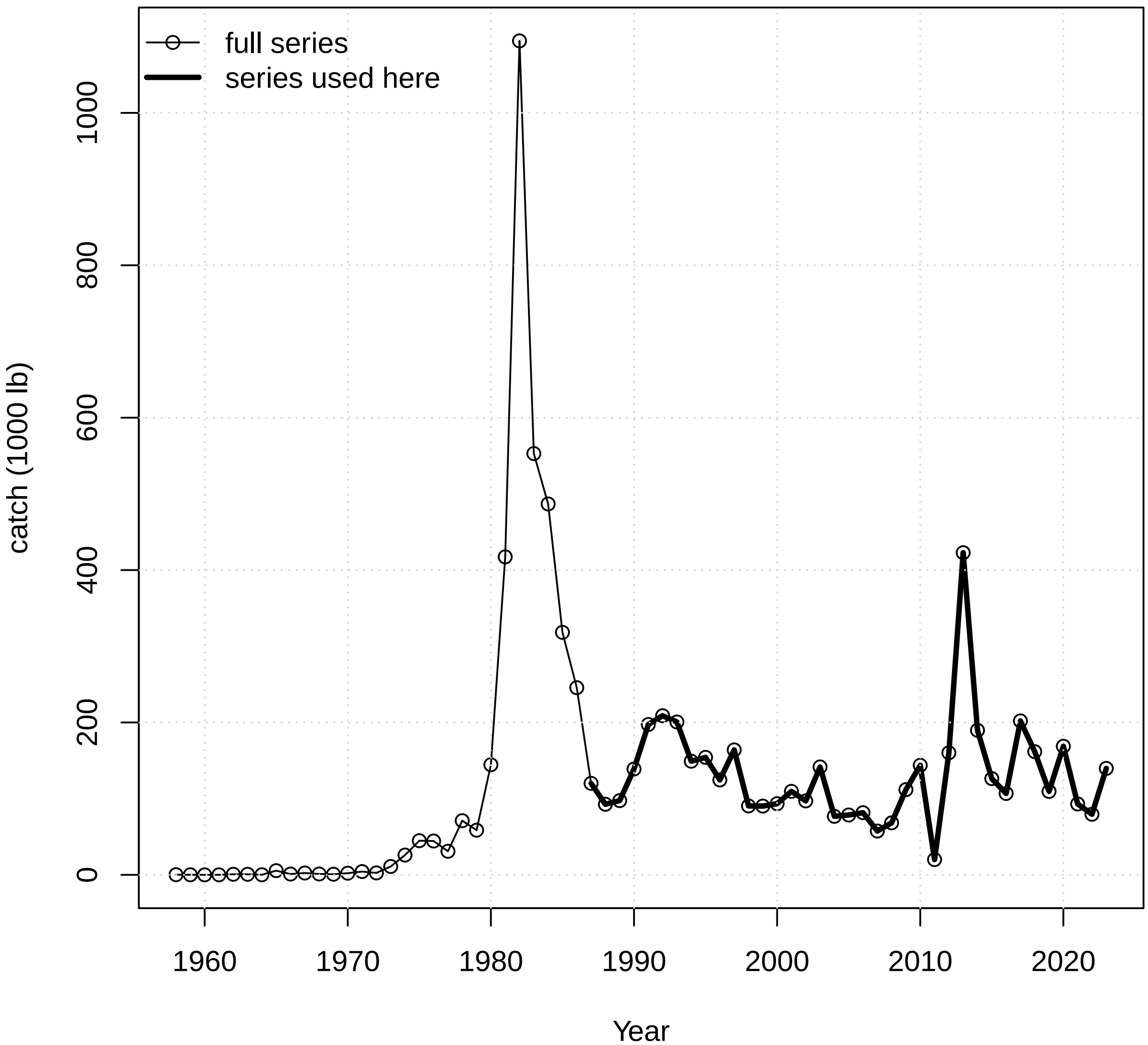

Figure 6. Stacked barplot of annual commercial longline length composition data used in south of Cape Hatteras DLM analysis. Numbers above each bar represent the annual number of fish length measuremnts.

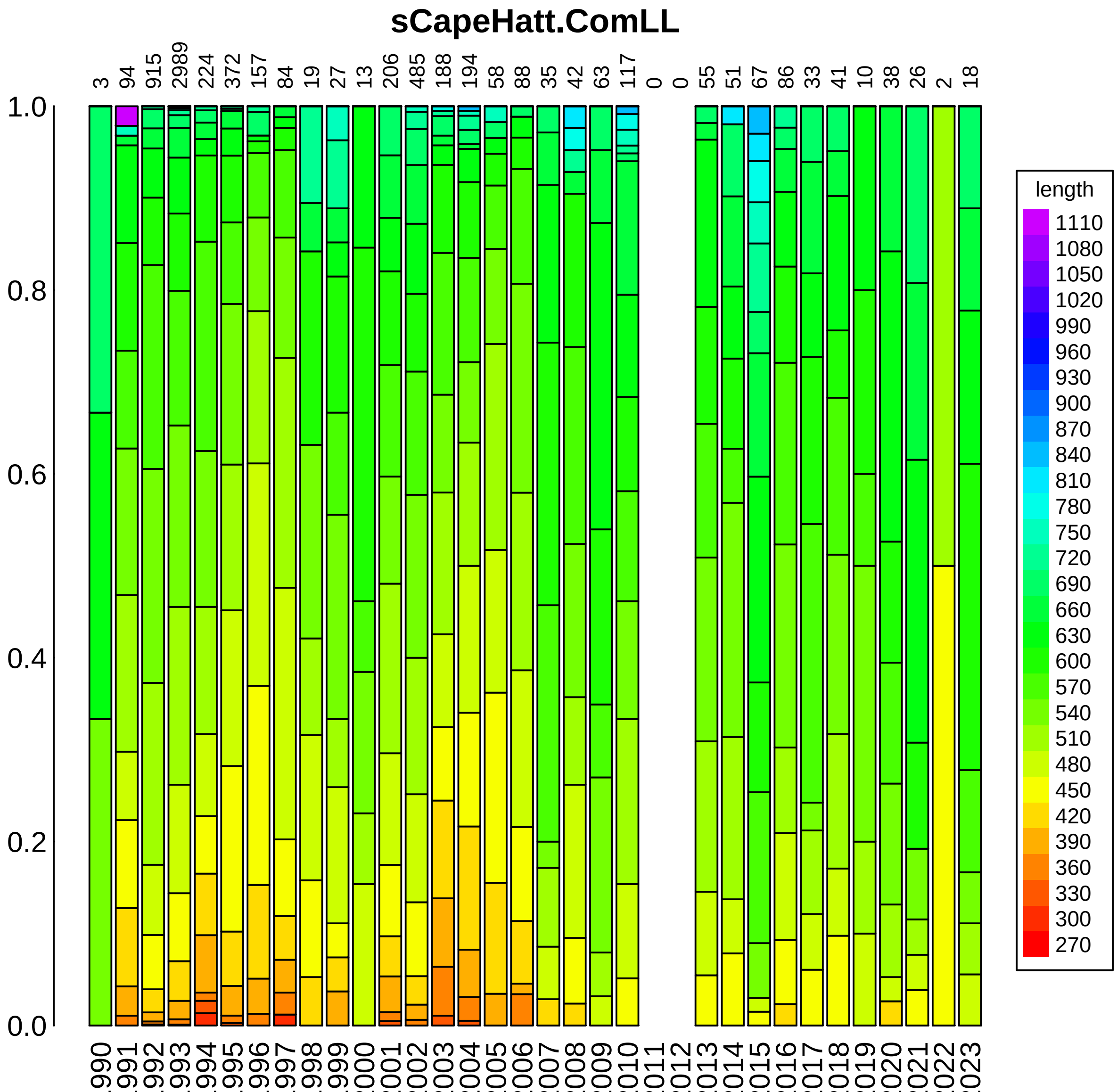

Figure 7. Frequency histograms of annual commercial longline length (mm) composition data used in south of Cape Hatteras DLM analysis. n1 = number of trips, n2 = number of fish.

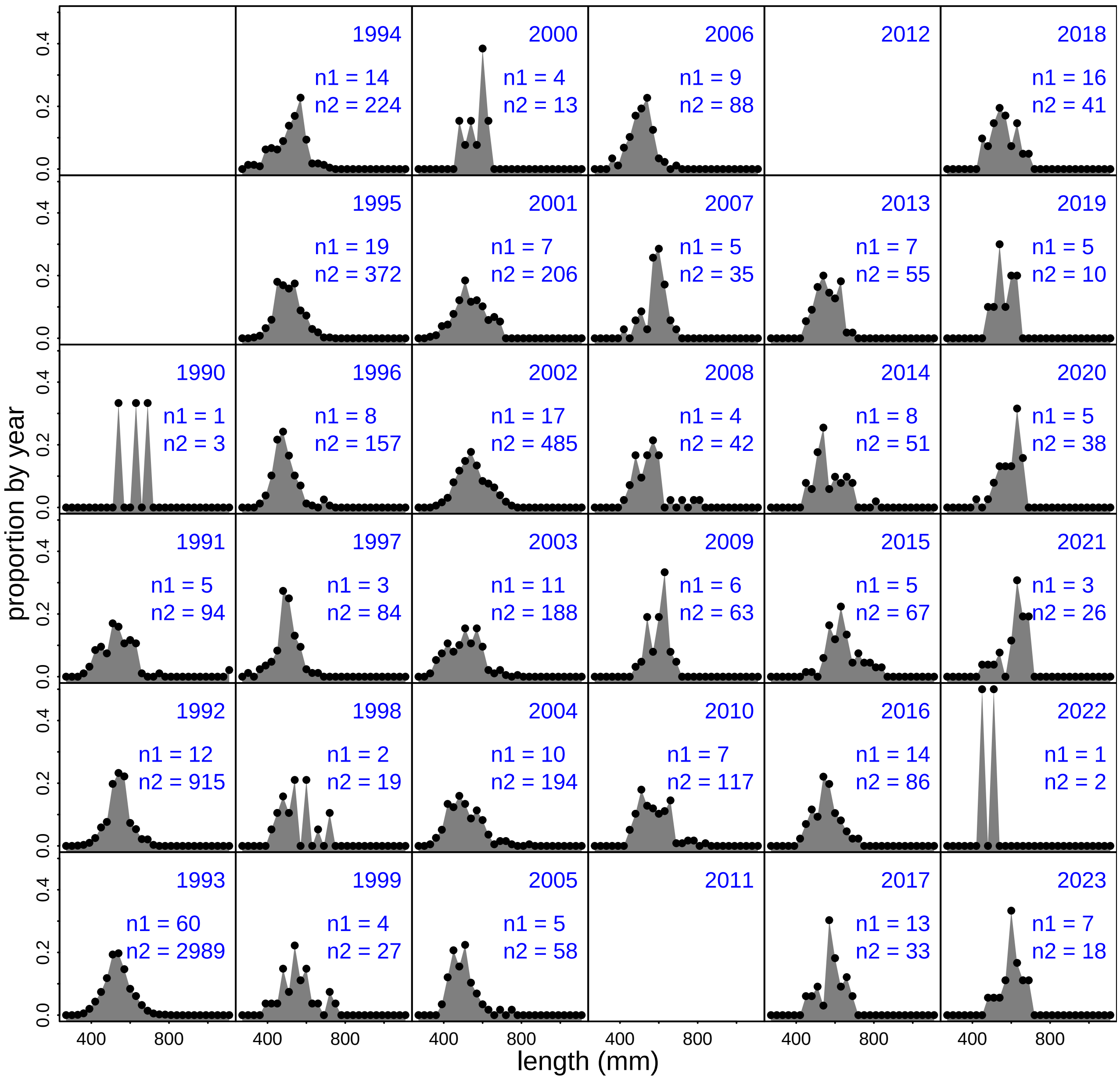

Figure 8. Aggregate commercial longline length composition data used in south of Cape Hatteras DLM analysis to compute the length of fish in the first length mode (Lc; indicated with an arrow) and the mean length of fish larger than Lc (Lbar; dashed vertical line). Green points indicate the peaks of length modes identified with a kernel density function.

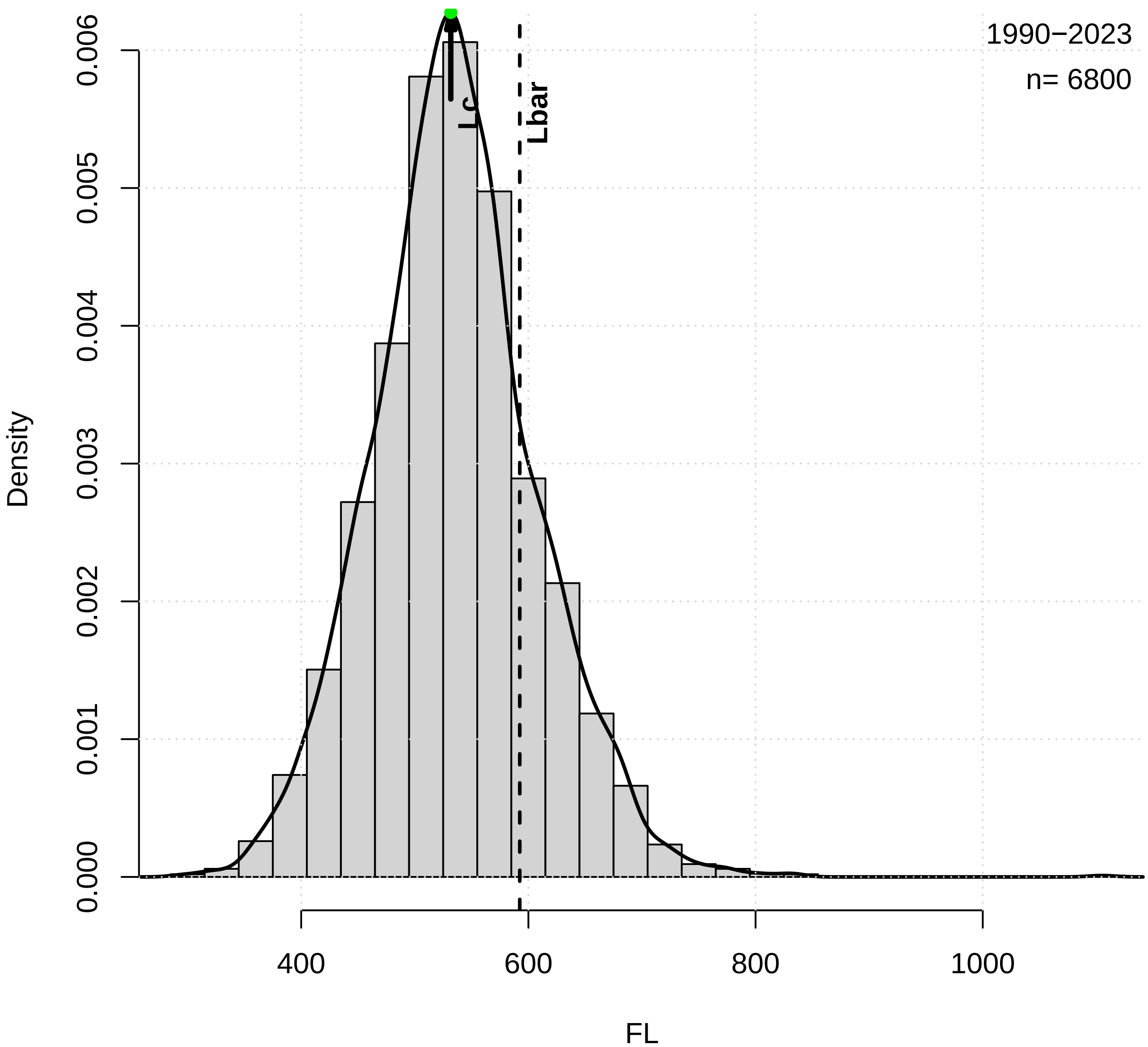

Figure 9. Kernel density estimates of TAC distributions from south of Cape Hatteras DLM analysis for all methods applied. Abbreviations for management procedures are indicated in the legend and show the color of the corresponding line. Densities are standardized to a maximimum of one, to improve visual comparison. Note that density lines for Fdem_ML and YPR_ML extend far beyond the plot range.