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DATA-MINING OF SHORTFIN MAKO SHARK (*ISURUS OXYRINCHUS*) LENGTHS OF NORTH AND SOUTH ATLANTIC STOCKS FROM THE SPANISH SURFACE LONGLINE FLEET FROM THE PERIOD 1993-2023

[1] J. Fernández-Costa, P. Pérez-Casal, and A. Ramos-Cartelle

SUMMARY

*This paper summarizes the length data of the shortfin mako shark (*Isurus oxyrinchus*) carried out between 1993 and 2023 for the North and South Atlantic stocks. The data-mining was carried out through an intense compilation of records from samples on board commercial trips, experimental and tagging surveys as well as through sampling during landings.*

RÉSUMÉ

*Ce document résume les données de longueur du requin-taupe bleu (*Isurus oxyrinchus*) enregistrées entre 1993 et 2023 pour les stocks de l'Atlantique Nord et Sud. L'exploration des données a été réalisée au moyen d'une compilation intensive des registres d'échantillons prélevés lors des sorties commerciales, de prospections expérimentales et de marquage, ainsi qu'à travers l'échantillonnage menée pendant les débarquements.*

RESUMEN

*El documento resume los datos de talla del marrajo dientuso (*Isurus oxyrinchus*) registrados entre los años 1993-2023 para los stocks norte y sur del Atlántico. La minería de datos fue realizada mediante una intensa recopilación de registros de muestreos a bordo de buques comerciales, en campañas experimentales y de marcado, así como mediante registros en desembarcos.*

KEYWORDS

Shortfin mako shark, length data, sex-ratio

[1] Instituto Español de Oceanografía, CSIC, P.O. Box 130, 15080 A Coruña (Spain)
Email: tunidos.corunha@ieo.csic.es
http://www.co.ieo.es/tunidos

1. Introduction

The shortfin mako *Isurus oxyrinchus* is a large pelagic and highly migratory shark species distributed circumglobally in tropical, and temperate waters with a preference range described between 17º-22ºC (Compagno 2001). Horizontal migrations of Atlantic shortfin mako have been described from conventional tagging-recapture information recorded since the 1960s (Kolher *et al.* 2002, Anon. 2017). Recent studies with satellite tagging provided important information on movements pattern and habitat use for large pelagic sharks such as the shortfin mako shark. The shortfin mako spent most of the time in temperate waters above 90m depth but can undertook dives down to 900m (Abascal *et al.* 2011, Santos *et al.* 2021, Vaudo *et al*. 2017).

The shortfin mako shark was the second most important bycatch of shark species in the Spanish surface longline fleet since 1970s (Mejuto 1985, 2007). Before the entered in force the ICCAT recommendations on the conservation for the North (Rec 17-08, 19-06 and 21-09) and the South (Rec 22-11) Atlantic stocks of shortfin mako, been one of the most valuable shark species for its high quality of meat in the Atlantic Ocean, the shortfin mako shark was frequently landed in commercial fisheries mainly as bycatch of swordfish and tuna longliners, and even in the case of coastal gillnets and artisanal fisheries (García-Cortés *et al.* 2021, Mejuto *et al.* 2009, Santos *et al.* 2021).

The main objective of this paper is to provide length information of the Spanish surface longline fleet recovered from different scientific sources as a contribution to the 2025 shortfin mako shark stock assessment. The present paper includes sizes data previously analyzed and provided in Garcia-Cortés *et al.* 2021, updating the series for the most recent years. These size distributions can be used on the models in the next stock assessment.

The authors of the present document have decided to contribute to the ICCAT database by making available these size data under those conditions already stablished by the authors with ICCAT.

2. Material and methods

A collaborative effort was undertaken to collect and analyze data on the length and sex information of shortfin mako sharks caught by the Spanish surface longline fleet in the Atlantic between 1993 and 2023. The data were collected on board and in port by scientific samplers working on the SWOATL project of the Spanish Institute of Oceanography.

Information on the length was recorded for each specimen. Other information related to sex, the month/quarter and the geographical position (considering 5x5 degree grids) was also collected and recorded when it was feasible. The observations were allocated into the North and South Atlantic stocks (separated by 5º N) for descriptive and analytical purposes.

Specimens were measured at straight fork length (FL) in cm and grouped into five-cm length classes. Sex was identified according to the presence or absence of claspers and recorded when possible, otherwise they were classified as unknown (Unk).

The aim was to assess the inter-annual size distribution by stock and sex. The sex-ratio was obtained as the percentage of females present with regard to the total number sexed individuals and plotted by each 5ºx5º square.

3. Results and discussion

A total of 21,427 length observations (FL in cm) of *Isurus oxyrinchus* were recovered from different scientific sources of information for the period between 1993 and 2023; 8,391 observations for the Northern stock and 13,036 for the Southern stock. **Table 1** summarizes the number of observations and the number of individuals by sex, the mean length and standard deviation, during the period 1993-2023 for Northern and Southern Atlantic stocks.

Tables 2 and **3** show the number of observations available sexes combined (females, males, and unknown) with descriptive statistics (minimum, maximum, mean length, the standard deviations and CVs) by stock and year. For the North Atlantic stock, the length range recorded was between 50 and 330 cm, with a mean length of 141.48 cm (Std. dev = 30.87), being mean lengths of 138.48 cm (Std. dev = 30.40) and 141.66 cm (Std. dev = 29.43) for females and males, respectively. A length range between 60 and 320 cm, with a mean length of 148.19 cm (Std. dev = 35.84), was found for the South stock with mean lengths of 144.93 cm (Std. dev = 35.17) and 149.68 cm (Std. dev = 36.03) for females and males, respectively.

The data analyzed were somewhat unbalanced between the two stocks in terms of number of observations with more data collected in the south stock. For the years 2020 and 2023, only a few data were available.

Figure 1 shows the size frequency distribution combined (females, males and unknown) and by sex for the Northern and Southern stocks. There were differences in the size distribution of both stocks, with an apparent bimodal size distribution in the case of the southern stock. **Figure 2** shows the boxplot with the size distribution of the shortfin mako size categorized by sex for stock. The median size (the middle bar) and the inter-quartile range (the box) were somewhat higher in the South stock than in the North stock with small differences in the case of males and females but with larger differences for the median value in the case of unknown individuals.

The length frequency distributions between stocks may be comparable in terms of the different proportions of each stock observed. However, they are not really comparable in terms of biological importance or gear selectivity given that they measure availability rather than anything else. The Spanish fleet operates mainly in the temperate waters of the northern stock and in the warmer tropical and sub-tropical waters of the southern stock, so the length frequency distribution is likely to represent individuals at different life stages in each stock.

The results obtained in this study represent the length frequency distributions of the Spanish longline fleet and caution should be taken to extrapolate these results to other fleets.

The global sex-ratio obtained for the total Atlantic was 50% of females. For the North and South stocks, it was 49% and 50% of females, respectively. **Figure 3** shows the sex-ratio by 5ºx5º square for the Atlantic Ocean. There was some apparent spatial variability in the sex ratios suggesting a sexual segregation, showing a presence of more males in the temperate regions, and more females in the north-east of the tropical area at least in this set of data of the Spanish surface longline fleet (García-Cortés *et al.* 2021).

Figures 4 and **5** are a representation of the total size distributions by year for each stock.

It is important to note that the present results are based on the information available and that the distribution may vary depending on factors such the habitat, the spatial-temporal distribution and the available prey populations in a particular year or region.

Acknowledgments

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Table 1. Number of observations and total number of individuals of *Isurus oxyrinchus* by sex (N_Female: female, N_Male: male, and N_Unk: unknown), FL Mean: mean length in straight FL in cm and the standard deviation (Std.dev) for the period 1993-2023 obtained in the North and South Atlantic stocks.

	N	N_Female	N_Male	N_Unk	Mean (FL cm)	Std. Dev
North stock	8391	2790	2926	2675	141.48	30.87
South stock	13036	6273	6168	595	148.19	35.84

Table 2. Number of *Isurus oxyrinchus* individuals sampled during the period 1993-2023 in the North Atlantic stock. Most representative statistics are presented for each year (N: number of sampled fish, FL Max: maximum length (FL cm), FL Min: minimum length (FL cm), FL Mean: arithmetic mean of the length (FL cm), Std. dev: standard deviation and CV: coefficient of variation).

Year	N	FL Max	FL Min	FL Mean	Std.dev	CV
1993	25	190	110	152.40	20.47	13.43
1994	0	N/A	N/A	N/A	N/A	N/A
1995	0	N/A	N/A	N/A	N/A	N/A
1996	0	N/A	N/A	N/A	N/A	N/A
1997	34	200	60	131.32	42.16	32.11
1998	36	240	155	190.14	19.10	10.05
1999	92	270	80	148.32	27.15	18.30
2000	199	255	65	141.26	37.22	26.35
2001	295	285	95	149.54	37.47	25.05
2002	120	280	90	147.04	23.66	16.09
2003	396	315	75	151.24	33.46	22.13
2004	307	295	60	158.36	25.34	16.00
2005	229	195	80	117.36	24.46	20.84
2006	905	295	60	127.66	25.06	19.63
2007	371	190	80	132.94	17.74	13.34
2008	145	250	80	150.28	27.64	18.39
2009	669	280	85	156.12	31.51	20.18
2010	518	300	90	148.60	33.03	22.23
2011	445	300	90	147.60	34.35	23.27
2012	76	285	105	182.50	31.81	17.43
2013	29	170	105	139.14	21.30	15.31
2014	777	285	75	136.85	28.90	21.12
2015	1290	330	80	134.84	26.25	19.47
2016	767	295	50	140.38	28.39	20.22
2017	363	260	85	138.03	29.74	21.54
2018	200	230	95	136.28	25.28	18.55
2019	76	225	130	160.99	20.17	12.53
2020	7	275	145	182.86	43.77	23.93
2021	0	N/A	N/A	N/A	N/A	N/A
2022	0	N/A	N/A	N/A	N/A	N/A
2023	20	175	100	133.75	24.27	18.15

Table 3. Number of *Isurus oxyrinchus* individuals sampled during the period 1993-2023 in the South Atlantic stock. Most representative statistics are presented for each year (N: number of sampled fish, FL Max: maximum length (FL cm), FL Min: minimum length (FL cm), FL Mean: arithmetic mean of the length (FL cm), Std. dev: standard deviation and CV: coefficient of variation).

Year	N	FL Max	FL Min	FL Mean	Std. Dev	CV
1993	331	310	85	183.22	31.51	17.20
1994	519	295	80	173.29	26.21	15.13
1995	621	285	70	167.87	29.13	18.04
1996	1192	275	95	165.39	30.28	18.31
1997	341	275	80	182.71	30.46	16.67
1998	188	295	95	177.50	35.41	19.95
1999	168	320	85	181.85	39.14	21.53
2000	40	270	130	171.50	29.57	17.24
2001	34	220	100	167.65	26.41	15.75
2002	568	295	70	142.60	32.09	22.50
2003	6178	285	60	125.39	20.26	16.16
2004	181	270	90	168.29	30.21	17.95
2005	204	265	90	175.59	27.31	15.55
2006	163	310	90	182.02	31.66	17.39
2007	29	265	75	160.52	52.63	32.79
2008	21	225	60	125.71	54.64	43.46
2009	20	190	125	152.25	17.58	11.55
2010	12	215	160	178.75	16.53	9.25
2011	605	305	80	148.28	35.05	23.64
2012	62	320	65	184.68	44.37	24.03
2013	134	260	95	190.86	28.94	15.16
2014	138	250	110	176.92	29.92	16.91
2015	296	285	75	170.10	28.43	16.71
2016	47	275	155	184.26	29.06	15.77
2017	243	260	60	176.58	32.19	18.23
2018	212	315	85	193.28	33.92	17.55
2019	0	N/A	N/A	N/A	N/A	N/A
2020	0	N/A	N/A	N/A	N/A	N/A
2021	400	310	80	172.45	35.10	20.35
2022	89	260	80	156.80	45.47	29.00
2023	0	N/A	N/A	N/A	N/A	N/A

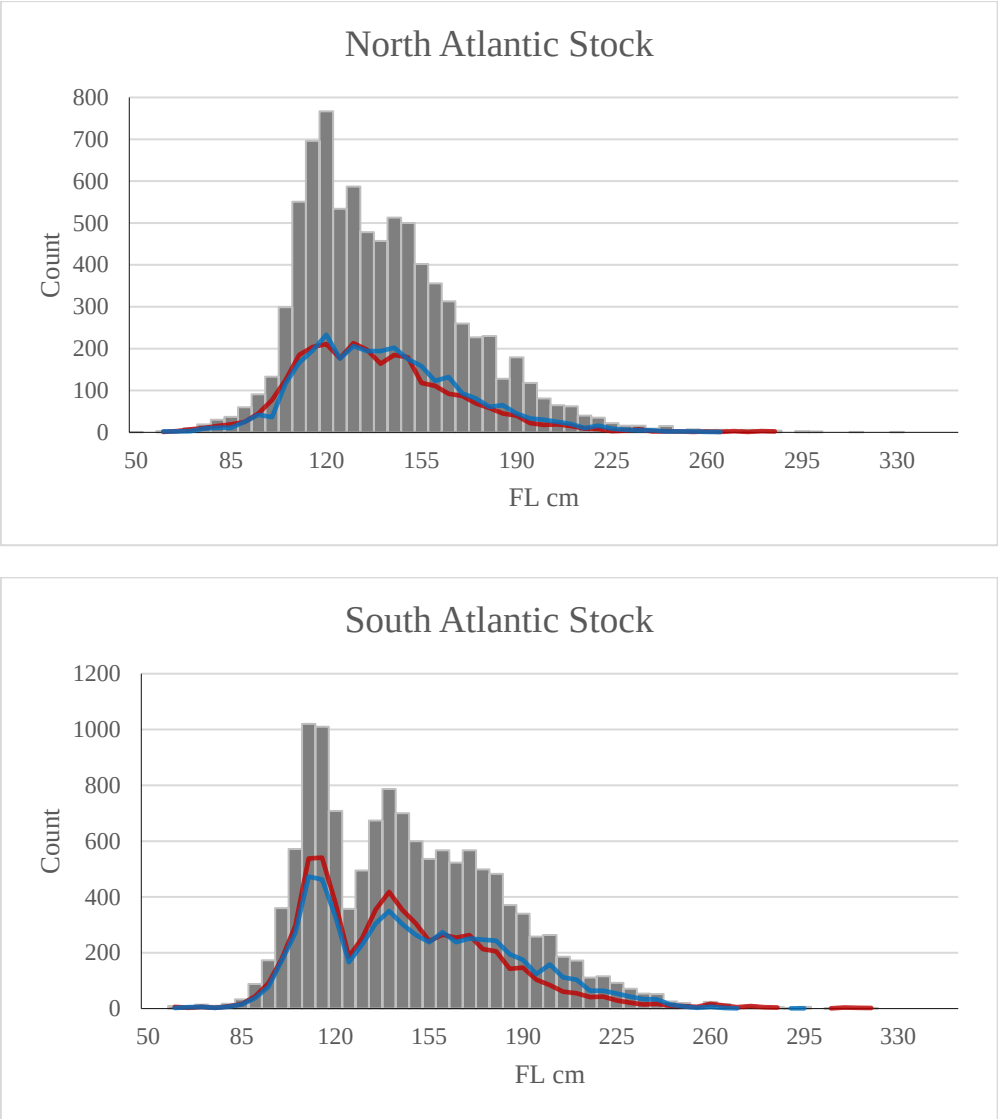

Figure 1. Length-frequency distribution (FL cm) of the *Isurus oxyrinchus* sex-combined and by sex (red line: female, blue line: male) from each Atlantic stock for the period 1993-2023.

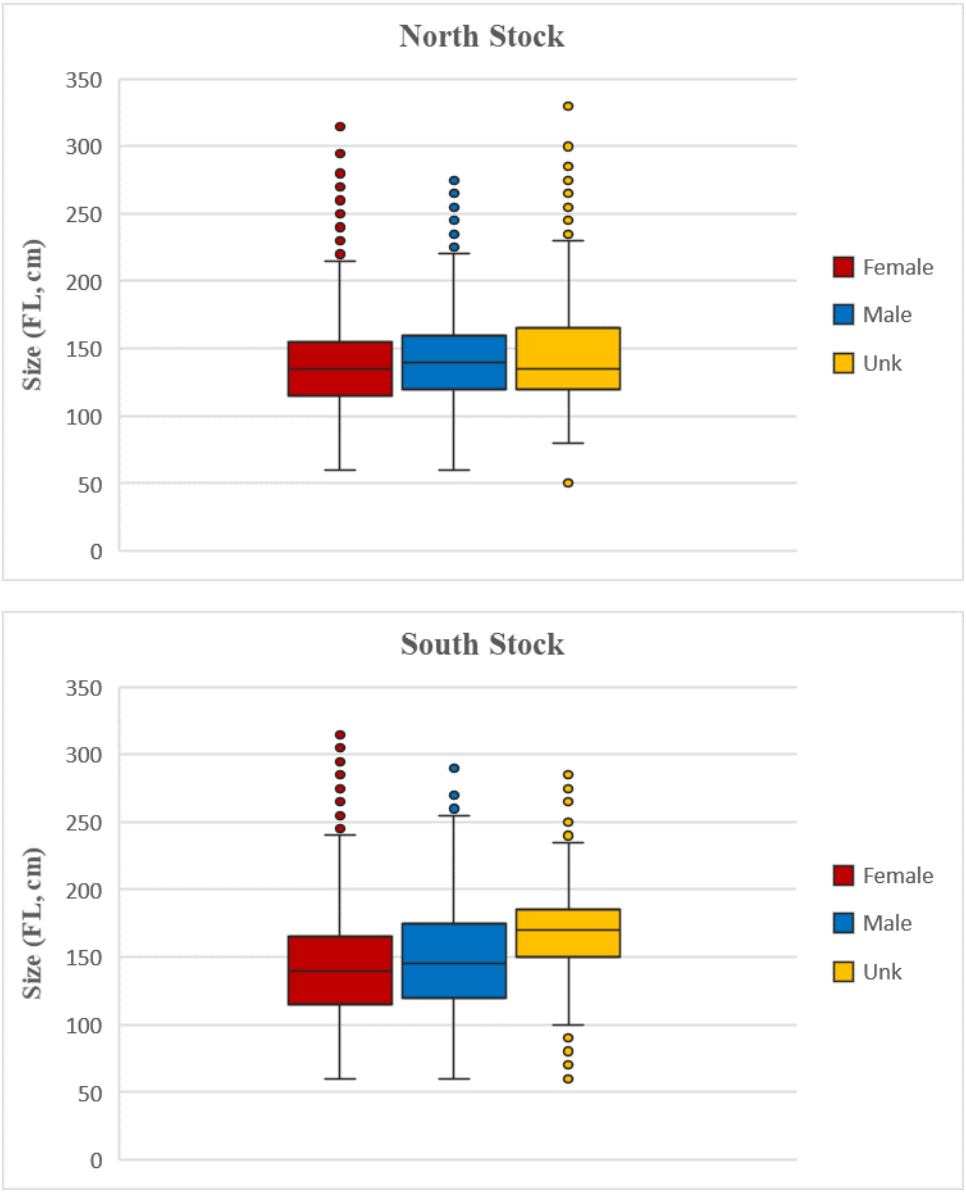

Figure 2. Boxplot with the length distribution (FL cm) of the *Isurus oxyrinchus* categorized by sex from each Atlantic stock for the period 1993-2023.

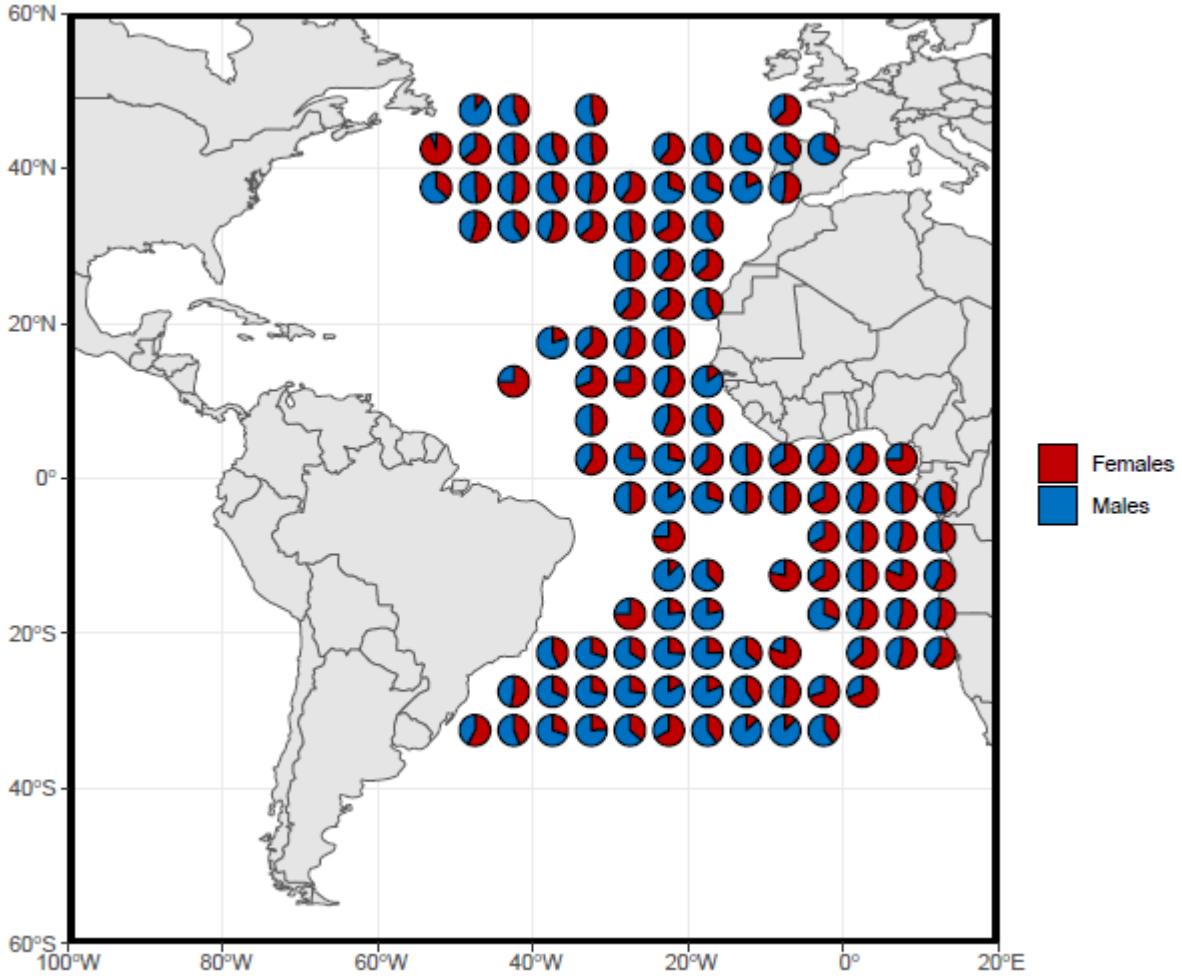

Figure 3. Sex-ratio of the *Isurus oxyrinchus* by 5ºx5º square in the Atlantic Ocean for years combined.

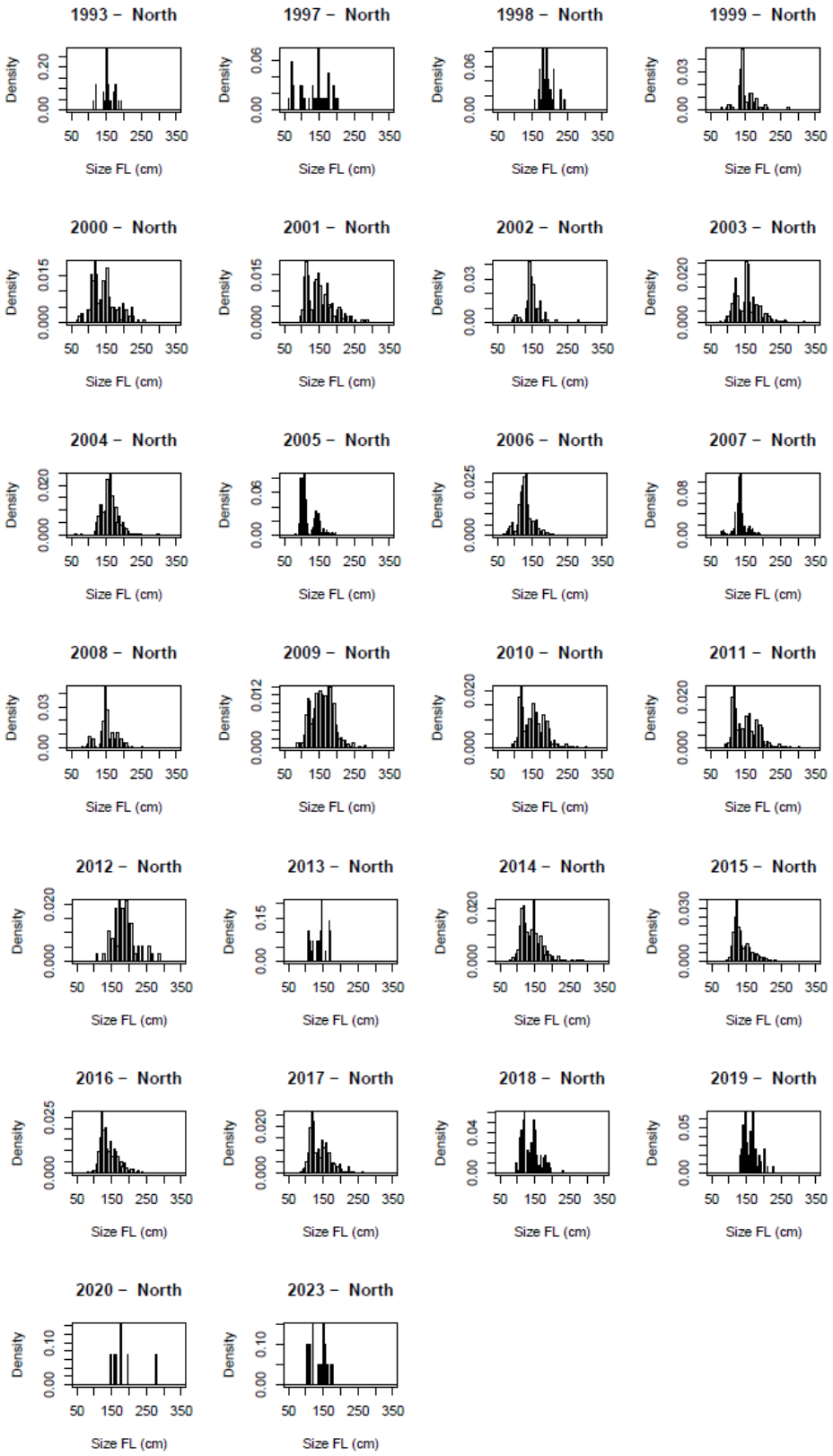

Figure 4. Total length distribution (FL cm) of the *Isurus oxyrinchus* by year (1993-2023) for the North Atlantic stock. Non-sampling years have been omitted.

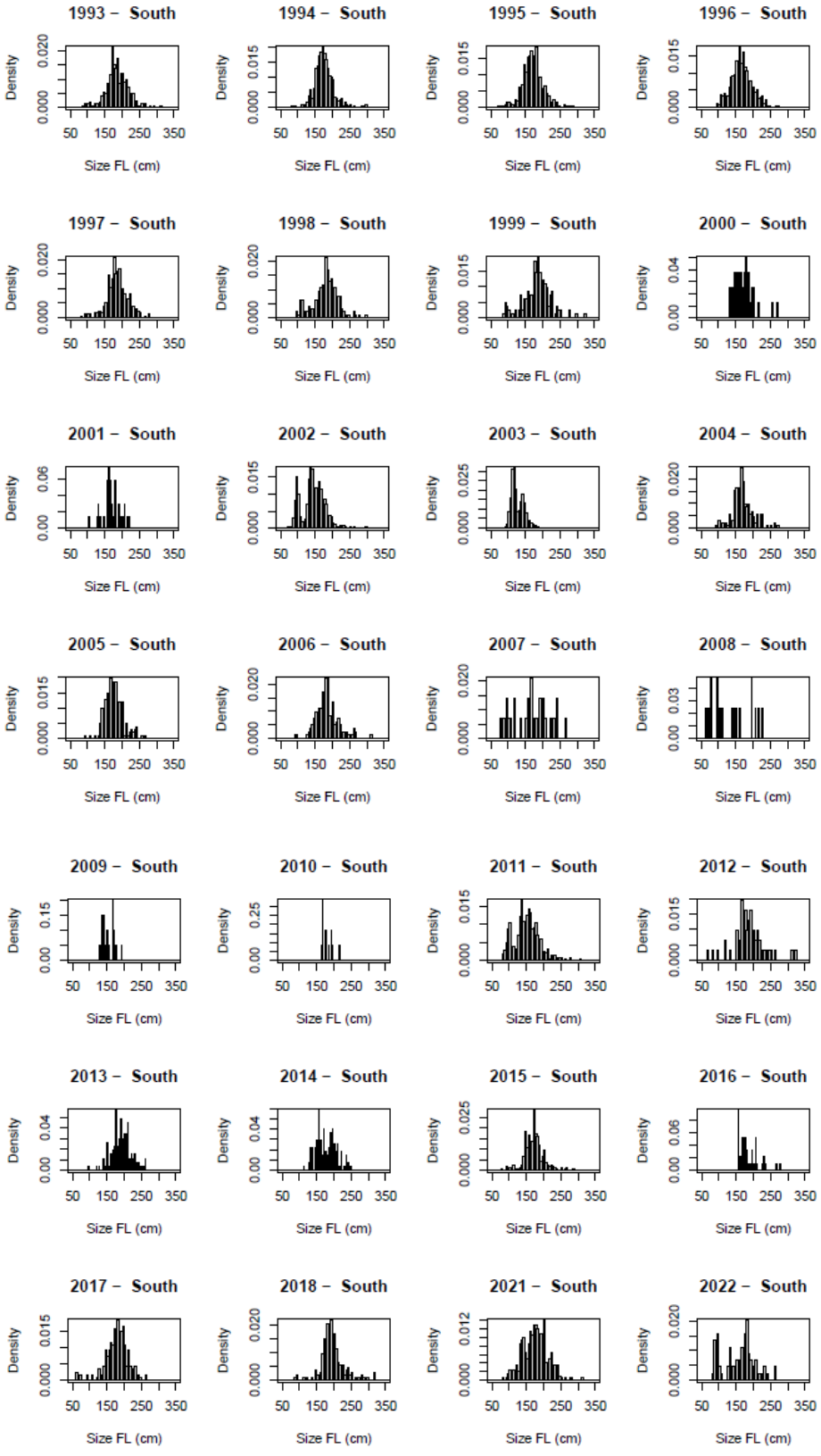

Figure 5. Total length distribution (FL cm) of the *Isurus oxyrinchus* by year (1993-2023) for South Atlantic stock. Non-sampling years have been omitted.