SEDAR

Southeast Data, Assessment, and Review

SEDAR 65

HMS Blacktip Shark

SECTION II: Data Workshop Report

January 2020

SEDAR
4055 Faber Place Drive, Suite 201 North Charleston, SC 29405

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1. Introduction

1.1 Workshop Time and Place

The SEDAR 65 Data Workshop meeting was held October 29 – November 1, 2019 in Charleston South Carolina. Three data webinars were held prior to the workshop on May 28th, June 20th, and September 10th. An additional webinar was held post the Data workshop on December 5th, 2019.

1.2 Terms of Reference

1. Define the unit stock for the SEDAR 65 stock assessment as from the northern extent of the stock to the east coast of Florida at the mainland at 25°20.4' N. lat., proceeding due east (the northern Miami-Dade County line).
   a. The potential for population substructure within that stock unit may be examined, if feasible.
   b. If feasible, document if the range of the stock has changed in recent years (e.g., moved further north) compared to historical norms.
2. Review, discuss, and tabulate available life history information.
   a. Evaluate age, growth, natural mortality, and reproductive characteristics.
   b. Provide appropriate models to describe population growth, maturation, and fecundity by age, sex, and/or length as applicable.
   c. Evaluate the adequacy of available life history information for conducting stock assessments and recommend life history information for use in population modeling.
   d. Evaluate and discuss the sources of uncertainty and error, and data limitations (such as temporal and spatial coverage) for each data source. Provide estimates or ranges of uncertainty for all life history information.
3. Recommend discard mortality rates.
   a. Review available research and published literature.
   b. Provide estimates of discard mortality rate by fishery, gear type, depth, and other strata as feasible or appropriate.
   c. Include thorough rationale for recommended discard mortality rates.
   d. Provide estimates of uncertainty around recommended discard mortality rates.
4. Provide measures of relative population abundance that are appropriate for stock assessment.
   a. Consider and discuss all available and relevant fishery-dependent and -independent data sources. Document all programs evaluated; address program objectives, methods, coverage, sampling intensity, and other relevant characteristics.
   b. Provide maps of fishery and survey coverage.
   c. Develop fishery and survey CPUE indices by appropriate strata (e.g., age or size, and fishery) and include measures of precision and accuracy.
   d. Develop fishery and survey CPUE length compositions by appropriate strata (e.g., age or size, and fishery) and include both the number of individuals measured as well as relevant alternative measures of effective sample size (i.e., alternative measures of sampling effort

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such as the number of trips, hauls, sets, baskets of gear, etc. that were sampled for length measurements).

e. Discuss the degree to which available indices and length compositions adequately represent fishery and population conditions.

f. Recommend which data sources adequately and reliably represent population abundance for use in assessment modeling.

g. Provide appropriate measures of uncertainty for the abundance indices to be used in stock assessment models.

h. Rank the available indices with regard to their reliability and suitability for use in assessment modeling.

5. Provide commercial catch statistics across all fisheries, including both landings and discards in both pounds and number.

   a. Evaluate and discuss the adequacy of available data for accurately characterizing harvest and discard by fishery sector or gear.

   b. Provide length distributions for both landings and discards if available and include both the number of individuals measured as well as relevant alternative measures of effective sample size (i.e., alternative measures of sampling effort such as the number of trips, hauls, sets, baskets of gear, etc. that were sampled for length measurements).

   c. Discuss the degree to which available length distributions adequately represent commercial fishery conditions.

   d. Provide estimates of uncertainty around each set of landings and discard estimates if available.

6. Provide recreational catch statistics, including both landings and discards in both pounds and number.

   a. Evaluate and discuss the adequacy of available data (including species id) for accurately characterizing harvest and discard by species and types of recreational fishing.

   b. Provide length distributions for both landings and discards if available and include both the number of individuals measured as well as relevant alternative measures of effective sample size (i.e., alternative measures of sampling effort such as the number of trips, hauls, sets, baskets of gear, etc. that were sampled for length measurements).

   c. Discuss the degree to which available length distributions adequately represent recreational fishery conditions.

   d. Provide estimates of uncertainty around each set of landings and discard estimates.

7. Identify and describe ecosystem, climate, species interactions, habitat considerations, and/or episodic events that would be reasonably expected to affect population dynamics.

8. Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment. If possible, include specific guidance on sampling intensity (number of samples including age and length structures) and appropriate strata and coverage.

9. Prepare the Data Workshop report providing complete documentation of workshop actions and decisions in accordance with project schedule deadlines (Section II of the SEDAR assessment report).

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1.3 List of Participants

Participants	Affiliation
Panelists	
Dean Courtney	NMFS
Enric Cortes	NMFS
William Driggers	NMFS
Heather Moncrief - cox	NMFS
Xinsheng Zhang	NMFS
Andrea Kroetz	NMFS
John Carlson	NMFS
Eric Hoffmayer	NMFS
Adam Pollack	NMFS
Alyssa Mathers	NMFS
Heather Baertlein	NMFS
Bryan Frazier	SCDNR
James Gelsleichter	UNF
Robert Hueter	MOTE
Steve Kajiura	FAU
Rob Latour	VIMS
John Mohan	TAMU
Staff	
Kathleen Howington	SEDAR
Cierra Graham	SAFMC
Clifford Hutt	NMFS/HMS
Julie Neer	SEDAR
Workshop Observers	
Rusty Hudson	ASA
Kaitlyn O'Brien	VIMS
Liz Vinyard	SCDNR
Ashley Galloway	SCDNR
Michelle Passeritti	U of SC
Steve Durkee	NMFS
Webinar Participants	
Vivian Matter	NMFS
Kevin McCarthy	NMFS
Lisa Natanson	NMFS
Carolyn Belcher	NMFS
Elizabeth Babcock	RSMAS
Cami McCandless	NMFS

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Webinar Observers

Delisse Ortiz	NMFS
Guy Dubeck	NMFS
Ian Miller	NMFS
Jackie Wilson	NMFS
Steve Durkee	NMFS
Tobey Curtis	NMFS
Karyl Brewster-Geisz	NMFS

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1.4 List of Data Workshop Working Papers

Documents prepared for the SEDAR 65 Data workshop			
Document #	**Title**	**Author**	**Date Received**
SEDAR65-DW01	Reproductive parameters for blacktip sharks (Carcharhinus limbatus) from the western North Atlantic Ocean	Natanson et. al.	10/9/19 Revised: 10/29/19, 11/5/19 , 11/22/19
SEDAR65-DW02	Age and growth parameters for blacktip sharks, Carcharhinus limbatus, in the western North Atlantic Ocean	Deacy and Moncrief-Cox	10/8/19
SEDAR65-DW03	Bycatch estimates of blacktip shark in the south Atlantic coastal gillnet fishery	Carlson et. al.	9/25/19
SEDAR65-DW04	Bycatch estimates of blacktip shark in the shark bottom longline fishery	Carlson et. al.	9/25/19
SEDAR65-DW05	Size composition and indices of relative abundance of the Atlantic blacktip shark (Carcharhinus limbatus) in coastal Virginia waters	Latour et. al.	10/4/19 Revised: 10/23/19
SEDAR65-DW06	Mark/recapture data for blacktip sharks, Carcharhinus limbatus, in U.S. Atlantic from the NOAA Fisheries Cooperative Shark Tagging Program	Cami McCandless	12/5/19
SEDAR65-DW07	Standardized catch rates of blacktip sharks, Carcharhinus limbatus, caught during the South Carolina Department of Natural Resources, Cooperative Atlantic States Shark Pupping and Nursery long-gillnet survey	Cami McCandless and Bryan Frazier	11/29/19 Revised: 12/31/19
SEDAR65-DW08	Standardized catch rates of blacktip sharks, Carcharhinus limbatus, from the NOAA Cooperative Atlantic States Shark Pupping and Nursery longline survey using generalized linear mixed models	Cami McCandless, Bryan Frazier, James Gelsleichter, and Carolyn Belcher	11/29/19

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SEDAR65-DW09	Standardized catch rates of blacktip sharks, *Carcharhinus limbatus*, from the NOAA Cooperative Atlantic States Shark Pupping and Nursery longline survey	Cami McCandless and Lisa Natanson	11/29/19
SEDAR65-DW10	Standardized recruitment index for blacktip sharks caught during the South Carolina Department of Natural Resources, Cooperative Atlantic States Shark Pupping and Nursery short-gillnet survey	Bryan Frazier and Cami McCandless	11/29/19
SEDAR65-DW11	Standardized catch rates of blacktip sharks, *Carcharhinus limbatus*, from the South Carolina Department of Natural Resources red drum and Southeast Area Monitoring and Assessment Program longline surveys	Cami McCandless and Bryan Frazier	11/29/19
SEDAR65-DW12	Standardized catch rates of blacktip sharks, Carcharhinus limbatus, from the Georgia Department of Natural Resources, Southeast Area Monitoring and Assessment Program longline survey	Cami McCandless, Donna McDowell and Carolyn Belcher	11/29/19 Modified: 12/5/19
SEDAR65-DW13	Standardized catch rates of blacktip sharks (Carcharhinus limbatus) from the South Carolina Department of Natural Resources drumline survey	Bryan S. Frazier, Adam G. Pollack	11/26/19
SEDAR65-DW14	Estimation of blacktip shark, *Carcharhinus limbatus*, discards in the northeast gillnet fishery using data collected by the NOAA Northeast Fisheries Observer Program	Cami McCandless, Joe Mello, and Kathy Sosebee	12/5/19
SEDAR65-DW15	Distribution and Length Data for Blacktip Sharks Captured on the NOAA/NMFS/SEFSC/MSLABS Bottom Longline Survey in the Western North Atlantic Ocean	Adam G. Pollack, William B. Driggers III, David S. Hanisko[2] and G. Walter Ingram, Jr.	10/29/19
SEDAR65-DW16	An index of abundance from the Marine Recreational Information Program data	Babcock	10/8/19
SEDAR65-DW17	Catch rates of blacktip sharks (Carcharhinus limbatus) in US Atlantic Ocean from the Shark Bottom Longline Observer Program, 1994-2018	Carlson et.al.	10/4/19

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Reference Documents			
SEDAR65-RD01	SEDAR64-RD-12 Model-estimated conversion factors for calibrating Coastal Household Telephone Survey (CHTS) charter boat catch and effort estimates with For Hire Survey (FHS) estimates in the Atlantic and Gulf of Mexico with application to red grouper and greater amberjack	Dettloff and Matter	10/1/19
SEDAR65-DW18	Stress response and post-release mortality of blacktip sharks (*Carcharhinus limbatus*) captured in shore-based and charter boat-based recreational fisheries Stress response and post-release mortality of blacktip sharks (*Carcharhinus limbatus*) captured in shore-based and charter boat-based recreational fisheries.	Frazier	10/25/19
SEDAR65-DW19	Preliminary catches of blacktip sharks in the U.S. Atlantic ocean	Cortes	10/24/19
SEDAR65-DW20	An Updated Literature Review of Post-release Live-discard Mortality Rate Estimates in Sharks for use in SEDAR 65	Dean Courtney and Alyssa Mathers	11/1/19 Revised: 12/4/19
SEDAR65-DW21	Estimating Post-Release Mortality And Capture Stress Of Blacktip Sharks In The Gulf Of Mexico Recreational Fishery	John Mohan	12/6/19

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2. Life History

2.1 Life History Work Group Participants

William Driggers, Leader……...NMFS Pascagoula
Bethany Deacy, *not present*…….…..LDWF
Bryan Frazier……...SCDNR
Jim Gelsleichter……...…….……..…UNF
Eric Hoffmayer…….....NMFS Pascagoula
Steve Kajiura…….……FAU
John Mohan……TAMUG
Heather Moncrief-Cox…….……NMFS Panama City
Lisa Natanson, *not present*…….. NMFS Narragansett

2.2 Summary of Life History Documents

SEDAR65-DW-01: Reproductive parameters for blacktip sharks (*Carcharhinus limbatus*) from the western North Atlantic Ocean.
Lisa J. Natanson, Bethany M. Deacy, Heather E. Moncrief-Cox and William B. Driggers III
Reproductive parameters for blacktip sharks off the east coast of the United States in the western North Atlantic Ocean were estimated using data from the SEFSC Shark Bottom Longline Observer Program and the NEFSC and SEFSC Bottom Longline surveys. Sharks examined ranged in size from 80-178 cm FL for females and 71-158 cm FL for males. Median FL_{50} at maturity was 115.15 cm for males, 123.05 cm for females, and 117.48 cm for sexes combined. Median Age_{50} at maturity was 5.34 years for males, 6.69 years for females, and 5.78 years for sexes combined. Brood size from 87 females ranged from 1 to 7 with a mean of 4.09 (±0.13 SD). There was a significant but weak relationship between maternal age/length and brood size.

SEDAR65-DW-02: Age and growth parameters for blacktip sharks, *Carcharhinus limbatus*, in the western North Atlantic Ocean.
Bethany M. Deacy and Heather E. Moncrief-Cox
Through fishery-dependent and -independent sources, a total of 547 blacktip sharks were collected off the east coast of the United States between 2006 and 2018, which were used to generate age and growth parameters for this species. Three-parameter von Bertalanffy growth curves were produced for females (n=269) males (n=278), and both sexes combined. Results of these growth curves showed a difference between sexes (females: L_∞ = 166.23 ± 2.47 cm FL, k = 0.16 ± 0.01, t_0 = -2.59 ± 0.16; males: L_∞ = 145.03 ± 1.82 cm FL, k = 0.23 ± 0.02, t_0 = -1.97 ± 0.16). Maximum ages observed were 17.5 years and 13.5 years, for females and males, respectively. A long-term recapture that validates annual band deposition in this species up to 13 years of age is discussed.

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SEDAR65-DW-06: Mark recapture data for blacktip sharks, *Carcharhinus limbatus*, in the U.S. Atlantic from the NOAA Cooperative Shark Tagging Program.
Camilla T. McCandless
Mark/recapture information from the NOAA Cooperative Shark Tagging Program covering the period from 1965 through 2018 were summarized for blacktip sharks, *Carcharhinus limbatus*, tagged in the U.S. Atlantic. Seasonal distribution of combined tagging and recapture events for all life stages (young of the year, juvenile, adult) of blacktip sharks included waters off Florida and the U.S. Virgin Islands in all seasons. Shark tagging and recapture events for all life stages remained in these waters in the winter, extended north up to New Jersey in the spring and summer, and reduced back down to North Carolina in the fall. Out of 12,912 tagging events along the U.S. Atlantic (60%) and Gulf of Mexico (40%), there was no movement between the two regions and limited exchange (2 fish) between the Atlantic and the Caribbean.

SEDAR65-DW-15: Distribution and Length Data for Blacktip Sharks Captured on the NOAA/NMFS/SEFSC/MSLABS Bottom Longline Survey in the Western North Atlantic Ocean.
Adam G. Pollack, William B. Driggers III, David S. Hanisko and G. Walter Ingram, Jr.
Measurements from 825 females, ranging in size from 51.0-158.0 cm fork length, and 730 males, ranging in size from 47.6 to 158.0 cm FL, were used to generate length-length and length-weight conversions. Precaudal length, fork length, natural total length and stretched total length were measured from the tip of the snout to the anterior margin of the precaudal pit, the caudal notch, the tip of the upper lobe of the caudal fin while in a "natural" position and the tip of the upper lobe of the caudal fin while fully extended along the axis of the body, respectively. All length measures were taken on a straight line along the axis of the body to the nearest millimeter. All length measures were converted to centimeters before analyses. Any sharks with estimated lengths and/or weights were omitted from analyses.

2.3 Life history Information Summary and Consensus

2.3.1 Stock definition datasets and decisions

Efforts were made to contact curators of known tagging databases to determine if any blacktip sharks were documented to move between waters off the US east coast and the Gulf of Mexico. Similarly, persons actively using advanced tagging technologies were contacted. No records of movements between the two areas were found (e.g. SEDAR65-DW-06, Moncrief-Cox, pers. comm., Hueter, pers. comm.).

The Indices Group requested that the Life History Group determine the northern extent of the range of blacktip sharks off the east coast. The northern range of blacktip sharks in the western Atlantic was previously identified as Cape Hatteras, NC, with individuals found north of that area considered rare strays (Bigelow & Schroeder 1948). However, recent telemetry data have revealed that blacktip sharks regularly migrate as far north as the southern coast of Long Island, NY. These data come from sharks instrumented with acoustic transmitters off St Helena Sound, SC (Frazier, unpublished) and Palm Beach, FL (Bowers and Kajiura, unpublished). At least 7% of adult sharks instrumented in St Helena Sound, SC and 43% of adult male blacktip sharks tagged in Palm Beach, FL have been subsequently detected off Long Island, NY in the summer months. Individuals have been demonstrated to repeatedly migrate from Palm Beach, FL to Long Island, NY over multiple years. The repeated migration of a sizeable proportion of

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the population indicates that the sharks are not merely straying that far north. Their regular seasonal detection suggests that the northern range for this species extends to at least Long Island, NY.

Decision: Tagging studies show no movement of blacktip sharks between water off the US east coast and the Gulf of Mexico.

Decision: Blacktip sharks range from southern Florida to at least New York off the US east coast.

2.3.2 Age and Growth Datasets and Decisions

Age and growth data were presented by Deacy and Moncrief-Cox (SEDAR65-DW-02) based on growth band counts from 269 females and 278 males. Vertebrae were collected from fishery-dependent and independent sources at locations ranging from 24 56.60ºN to 37 11.00ºN latitude. Aged sharks ranged in size from 46.8-178.0 cm FL for females and 41.0-165.0 cm FL for males. The maximum observed ages for females was 17.5 years, which was two years older than reported for females in the same area by Carlson et al. (2006). The maximum observed age for males was 13.5 years, in agreement with Carlson et al. (2006). Von Bertalanffy growth models (VBGF) were generated individually for each sex and for sexes combined. Resulting VBGF parameter estimates were similar to those of Carlson et al. (2006). As referenced in Deacy and Moncrief-Cox (SEDAR65-DW-02), a vertebral sample from a known age male shark was used for validation of growth band periodicity.

Decision: Use sex-specific growth model parameters and a maximum age of 17.5 years from SEDAR65-DW-02.

2.3.3 Reproduction Datasets and Decisions

Reproductive parameters for blacktip sharks in the western Atlantic were estimated using data from the SEFSC Shark Bottom Longline Observer Program and the NEFSC Bottom Longline Survey to calculate size and age at median maturity, mean brood size, and the relationships between maternal length/age and brood size. Data from 283 male (range 71-158 cm FL) and 247 female (range 80-178 cm FL) blacktip sharks were used to calculate reproductive parameters. Median FL_{50} at maturity was 115.15 cm FL for males, 123.05 cm FL for females, and 117.34 cm FL for sexes combined. Data from 242 male (87-153 cm FL) and 182 female (80-178 cm FL) with direct age estimates and reproductive conditions were used to obtain median age at maturity. Median Age_{50} at maturity was 5.34 years for males, 6.69 years for females, and 5.78 years for sexes combined. Brood size from 87 females ranged from 1 to 7 with a mean of 4.09 (±0.13 SD). There were weak but significant relationships between maternal length/age and brood size. The biennial reproductive cycle of females suggested by Castro (1996) was supported by recently conducted hormonal analyses (J. Gelsleichter, pers, comm). Additionally, recent observations of a late May/June time of parturition (B. Frazier, pers. comm.) were consistent with past reports by Castro (1996) and Ulrich et al. (2007).

Decision: Use reproductive parameters presented in SEDAR65-DW-01.

Decision: Use maturity ogives presented in SEDAR65-DW-01.

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2.4 Tables

Table 1 Summary of Recommended Life History Parameters

Growth parameters	Female / Male / Sexes combined	Reference
L_∞ (cm)	166.23 (2.47)/ 145.03 (1.82) / 159.30 (1.87)	SEDAR65-DW-02
k	0.16 (0.01) / 0.23 (0.02) / 0.17 (0.01)	SEDAR65-DW-02
t_o (years)	-2.59 (0.16) / -1.97 0.16) / -2.51 (0.13)	SEDAR65-DW-02
Maximum observed age (years)	17.5 / 13.5	SEDAR65-DW-02
Sample size	269 / 278 / 547	SEDAR65-DW-02
Length-weight relationships		
PCL (cm)	PCL = 1.92990 + 0.885043*FL	SEDAR65-DW-15
NTL (cm)	NTL = 4.89349 + 1.15734*FL	SEDAR65-DW-15
STL (cm)	STL = 9.00754 + 1.16776*FL	SEDAR65-DW-15
Wt (kg)	$Wt = (4.63x10^{-6})FL^{3.21575}$	SEDAR65-DW-15
Age at 50% maturity		
Female	t_{mat}= 6.69 years a = -12.07 (2.52) b = 1.80 (0.35)	SEDAR65-DW-01
Male	t_{mat}= 5.34 years a = -9.09 (1.72) b = 1.70 (0.29)	SEDAR65-DW-01
Size at 50% maturity		
Female	FL_{mat}= 123.05 cm FL a = -30.09 (4.66) b = 0.24 (0.04)	SEDAR65-DW-01
Male	FL_{mat}= 115.15 cm FL a =-31.41 (5.34) b = 0.27 (0.04)	SEDAR65-DW-01
Reproductive cycle	Biennial	Castro 1996, Gelscleichter pers. comm.
Fecundity	4.09 (SD = 0.13) pups per brood	SEDAR65-DW-01
Maternal age/fecundity relationship	Brood size = -0.04078 + 0.38445*Age	SEDAR65-DW-01
Maternal size/fecundity relationship	Brood size = -5.82556+0.06857*FL	SEDAR65-DW-01
Gestation	11 months	Castro 1996, Ulrich et al. 2007
Pupping month	late May / June	Castro 1996, Ulrich et al. 2007, Frazier pers. comm.

Values in parentheses represent standard error unless otherwise noted.

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Table 2. Proportion of mature blacktip sharks (*Carcharhinus limbatus*) in 5 cm size classes by sex.

Fork length (cm)	Sexes Combined	Females	Males
40	0.00	0.00	0.00
45	0.00	0.00	0.00
50	0.00	0.00	0.00
55	0.00	0.00	0.00
60	0.00	0.00	0.00
65	0.00	0.00	0.00
70	0.00	0.00	0.00
75	0.00	0.00	0.00
80	0.00	0.00	0.00
85	0.00	0.00	0.00
90	0.00	0.00	0.00
95	0.01	0.00	0.00
100	0.02	0.00	0.02
105	0.06	0.01	0.06
110	0.16	0.04	0.20
115	0.37	0.12	0.49
120	0.65	0.32	0.79
125	0.85	0.62	0.94
130	0.95	0.85	0.98
135	0.98	0.95	1.00
140	0.99	0.98	1.00
145	1.00	1.00	1.00
150	1.00	1.00	1.00
155	1.00	1.00	1.00
160	1.00	1.00	1.00
165	1.00	1.00	1.00
170	1.00	1.00	1.00
175	1.00	1.00	1.00
180	1.00	1.00	1.00

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Table 3. Proportion of mature blacktip sharks (*Carcharhinus limbatus*) in 1 year age classes by sex.

Age (years)	Sexes Combined	Females	Males
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.02	0.00	0.02
4	0.07	0.01	0.09
5	0.24	0.05	0.36
6	0.58	0.22	0.75
7	0.86	0.64	0.94
8	0.96	0.91	0.99
9	0.99	0.98	1.00
10	1.00	1.00	1.00
11	1.00	1.00	1.00
12	1.00	1.00	1.00
13	1.00	1.00	1.00
14	1.00	1.00	1.00
15	1.00	1.00	1.00
16	1.00	1.00	1.00
17	1.00	1.00	1.00

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2.5 Literature cited

Bigelow, H.B., and W.C. Schroeder. (1948) Sharks. *In*: Tee-Van, J., Breder, C.M., Hildebrand, S.F., Parr, A.E., & Schroeder, W.C. (Eds), Fishes of the Western North Atlantic. Part One. Lancelets, Cyclostomes, Sharks. Sears Foundation for Marine Research, Yale University, New Haven, 576 pp.

Carlson, J.K., J.A. Sulikowski, and I.E. Baremore. 2006. Do differences in life history exist for blacktip sharks, *Carcharhinus limbatus*, from the United States South Atlantic Bight and Eastern Gulf of Mexico? Environmental Biology of Fishes 77:279-292.

Castro, J. I. 1996. Biology of the Blacktip Shark, *Carcharhinus limbatus*, off the southeastern United States. Bulletin of Marine Science 59:508–522.

Ulrich, G.F, C.M. Jones. W.B. Driggers III, J.M. Drymon, D. Oakley and C. Riley. 2007. Habitat utilization, relative abundance, and seasonality of sharks in the estuarine and nearshore waters of South Carolina. American Fisheries Society Symposium 50:125-139

2.6 Research Recommendations:

1. Increase sampling intensity throughout range, particularly at depths less than 20 m.
2. Investigate sex- and life stage-specific movements of blacktip sharks to determine if migratory behaviors change based on maturity or reproductive condition.
3. Animals should be tagged throughout their range, including the northern extent of the population range off New York, to gain a more complete understanding of migratory and residency patterns.
4. Identify environmental conditions (e.g. dissolved oxygen, temperature, salinity, etc.) and ecological factors (e.g. prey abundance, community structure, etc.) that correlate with migration, movement patterns, and preferred habitats. This will allow prediction of future range changes based on habitat suitability models.
5. Identification of population structure based on genetic information or other intrinsic natural markers/tracers.

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3. Catches

3.1 Catches Workgroup Participants

Enric Cortés, Leader…….....NMFS Panama City
Heather Baertlein, co-Leader. ……NMFS HMS Division
Robert Hueter ……...…….……Mote Marine Laboratory
Cliff Hutt…….NMFS HMS Division
Alyssa Mathers……. NMFS Panama City
Vivian Matter, *not present*…….. NMFS Miami
Xinsheng Zhang.……..… NMFS Panama City

3.2 List of Working and Reference Papers

Documents Prepared for the Assessment Process		
SEDAR 65-DW-03	Bycatch estimates of blacktip shark in the south Atlantic coastal gillnet fishery	John Carlson, Alyssa Mathers and Kevin McCarthy
SEDAR 65-DW-04	Bycatch estimates of blacktip shark in the shark bottom longline fishery	John Carlson, Alyssa Mathers Heather Moncrief-Cox and Kevin McCarthy
SEDAR 65-DW-14	Estimation of blacktip shark, *Carcharhinus limbatus*, discards in the northeast gillnet fishery using data collected by the NOAA Northeast Fisheries Observer Program	Camilla T. McCandless, Joseph J. Mello, and Katherine A. Sosebee
SEDAR 65-DW-18	Stress response and post-release mortality of blacktip sharks (*Carcharhinus limbatus*) captured in shore-based and charter boat-based recreational fisheries	D. Nick Weber, Bryan S. Frazier, Nicholas M. Whitney, James Gelsleichter, Gorka Sancho
SEDAR 65-DW-19	SEDAR 65-DW19: Preliminary catches of blacktip sharks in the U.S. Atlantic ocean	Enric Cortés and Heather Baertlein
SEDAR 65-DW-20	An updated literature review of post-release live-discard mortality rate estimates in sharks for use in SEDAR 65	Dean Courtney amd Alyssa Mathers

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Reference Documents		
SEDAR 65-RD-01	Model-estimated conversion factors for calibrating Coastal Household (SEDAR 64 – RD-12)	K. Dettloff and V. Matter
SEDAR 65-RD-02	Sample size sensitivity analysis for calculating MRIP weight estimates (SEDAR 67-WP-06)	K. Dettloff and V. Matter
SEDAR 65-RD-04	Updated Post-release Live-discard Mortality Rate and Range of Uncertainty Developed for Blacktip Sharks Captured in Hook and Line Recreational Fisheries for use in the SEDAR	Dean Courtney

3.3 Relevant Terms of Reference

Term of Reference 3

Recommend discard mortality rates. a) Review available research and published literature. b) Provide estimates of discard mortality rate by fishery, gear type, depth, and other strata as feasible or appropriate. c) Include thorough rationale for recommended discard mortality rates. d) Provide estimates of uncertainty around recommended discard mortality rates.

Term of Reference 5

Provide commercial catch statistics across all fisheries, including both landings and discards in both pounds and number. a) Evaluate and discuss the adequacy of available data for accurately characterizing harvest and discard by fishery sector or gear. b) Provide length distributions for both landings and discards if available and include both the number of individuals measured as well as relevant alternative measures of effective sample size (i.e., alternative measures of sampling effort such as the number of trips, hauls, sets, baskets of gear, etc. that were sampled for length measurements). c) Discuss the degree to which available length distributions adequately represent commercial fishery conditions. d) Provide estimates of uncertainty around each set of landings and discard estimates if available.

Term of Reference 6

Provide recreational catch statistics, including both landings and discards in both pounds and number. a) Evaluate and discuss the adequacy of available data (including species id) for accurately characterizing harvest and discard by species and types of recreational fishing. b). Provide length distributions for both landings and discards if available and include both the number of individuals measured as well as relevant alternative measures of effective sample size (i.e., alternative measures of sampling effort such as the number of trips, hauls, sets, baskets of gear, etc. that were sampled for length measurements). c) Discuss the degree to which available length distributions adequately represent recreational fishery conditions. d) Provide estimates of uncertainty around each set of landings and discard estimates.

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Term of Reference 8

Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment. If possible, include specific guidance on sampling intensity (number of samples including age and length structures) and appropriate strata and coverage.

3.4 Data Review

3.4.1 Review of working papers

SEDAR 65 – DW-03: Bycatch estimates of blacktip shark in the south Atlantic coastal gillnet fishery.
J Carlson, A Mathers, and K McCarthy

This document presents U.S. south Atlantic blacktip shark discards (in numbers of fish, dead or alive) from the commercial gillnet fishery from 1998–2018. Also included are discard rates, number of observed trips, discard rate standard errors, and number of logbook trips reporting effort.

The authors followed the approach of Garrison (2007) by employing a simple ratio estimator to represent bycatch rates. An estimate of uncertainty in these estimates was derived from bootstrap resampling of the calculated CPUE data set. Estimates were derived separately for sharks discarded dead and sharks discarded alive as reported by the on-board observer. Total bycatch by year for the fishery was estimated by multiplying the derived bootstrap CPUE estimates by the total number of reported sets for the US South Atlantic. Total effort data reflects all gillnet trip reports received by the Coastal Fisheries Logbook Program (hereafter Logbook Program) in the southeast United States. Calculated US south Atlantic blacktip shark discards (in numbers of fish, dead or alive) from the commercial gillnet fishery are provided. In all the estimates, data was pooled without considering strata due to the sparse nature of the bycatch events.

SEDAR 65 - DW-04: Bycatch estimates of blacktip shark in the shark bottom longline fishery**.**
J Carlson, A Mathers and K McCarthy

This document presents calculated blacktip shark dead discards (in numbers of sharks) from the commercial shark bottom longline fishery (1993–2018) and the shark research fishery (2008–2018). Also included are calculated blacktip shark live discards (in numbers of sharks) from the same sources.

The authors followed the approach of Garrison (2007) by employing a simple ratio estimator to represent bycatch rates. An estimate of uncertainty in these estimates was derived from bootstrap resampling of the calculated CPUE data set. Estimates were derived separately for sharks discarded dead and sharks discarded alive as reported by the on-board observer. Estimates of dead and live discards were reported separately for the shark research fishery and the shark

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bottom longline fishery. As vessels in the shark research fishery are monitored 100%, no extrapolations of the dead discards were needed. Total discards were calculated as the product of observer reported yearly mean dead and live discard rates by hook and the yearly total fishing effort (bottom longline hooks) reported to the coastal logbook program. Calculated blacktip shark dead discards (in numbers of sharks) from commercial shark bottom longline fishery and the shark research fishery are provided. Calculated blacktip shark live discards (in numbers of sharks) from the commercial shark bottom longline fishery and the shark research fishery are provided. In all the estimates, data was pooled without considering strata due to the sparse nature of the bycatch events.

SEDAR 65 - DW-14: Estimation of blacktip shark, *Carcharhinus limbatus*, discards in the northeast gillnet fishery using data collected by the NOAA Northeast Fisheries Observer Program.
C. McCandless, J. Mello and K. Sosebee

This document presents dead and live discards of blacktip sharks, *Carcharhinus limbatus*, from the Northeast Region's Mid-Atlantic sink-gillnet fishing fleet. Discards were estimated in numbers and weight. The authors followed the approach of ratio-estimators based on the methodology described in Rago et al. (2005), updated in Wigley et al, (2007). The derived ratio estimators from the Northeast Fisheries Observer Program data were applied to the dealer landings data for estimation of blacktip shark discards from the Northeast Region's Mid-Atlantic sink-gillnet fishing fleet from 1995 to 2018. In addition, back-calculated live and dead discard estimates based on average discard rates (1995-2018) and total annual landings were provided. The estimated live discards are very small, except for 1998-2002, and the estimated dead discards are very small, except for 1998 and 1999.

SEDAR 65-DW-18: Stress response and post-release mortality of blacktip sharks (*Carcharhinus limbatus*) captured in shore-based and charter boat-based recreational fisheries.
D. Nick Weber, Bryan S. Frazier, Nicholas M. Whitney, James Gelsleichter, Gorka Sancho

This document estimated post-release mortality rates for blacktip sharks captured on rod-and-reel by shore-based and charter boat-based fishermen using acoustic transmitters (n = 81). Additionally, 24 individuals were double-tagged with pop-off satellite archival tags (PSATs) to validate the survivorship results obtained from the acoustic transmitters. The stress response associated with both recreational capture methods was quantified using numerous blood chemistry parameters. Overall, 18.5% of blacktip sharks died post-release (17.1% shore-based; 20.0% charter boat-based). The survivorship results inferred from acoustic transmitters were consistent with results inferred from PSATs, validating our use of acoustic transmitters to assess PRM in blacktip sharks. Fight time (i.e. time on the line) had a significant effect on blood pH, lactate, hematocrit, potassium, and glucose for sharks caught from shore, but only on lactate for sharks caught from charter boats. Fifty percent of foul-hooked sharks (i.e. sharks hooked anywhere but the jaw) died post-release.

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SEDAR 65-DW-19: Preliminary catches of blacktip sharks in the U.S. Atlantic Ocean
E Cortes and H Baertlein

Commercial landings, commercial discard estimates, and recreational catch estimates of blacktip sharks in the U.S. Atlantic coast for 1981-2018 are presented in this document. Information on the geographical distribution of both commercial landings and recreational catches is also included. Gear-specific information of commercial landings and fishing mode and fishing area of recreational catches are summarized. Length composition information from recreational sources is also presented.

SEDAR65-DW20: An updated literature review of post-release live-discard mortality rate estimates in sharks for use in SEDAR 65
D. Courtney and A. Mathers

This working paper summarizes literature reviewed for estimates of delayed discard mortality rates (M_D) in sharks, and identifies those available for blacktip sharks (*Carcharhinus limbatus*). Estimates of immediate (i.e. at-vessel) discard-mortality rates (M_A) are also identified. Previous SEDAR HMS shark Assessment Process (AP) and Data Workshop (DW) post-release live-discard mortality (PRLDM) rate decisions are provided.

3.4.2 Commercial Catch Datasets and Decisions

Commercial landings

An additional 14 years of commercial landings data were available since the last Atlantic blacktip shark assessment (SEDAR 11; NMFS 2006) (**Table 1** and **Table 2; Figure 1** and **Figure 2**). U.S. commercial landings in weight (pounds dressed weight; lb dw) were thus available for the period 1981-2018. These data were gathered from different sources over the time series. As in SEDAR 11, landings for 1981-1985 were assumed to be equal to the average for 1986-1988. The 1986-1990 landings were a legacy data set from the 1996 Large Coastal Shark Stock Evaluation Workshop (NMFS 1996), which included shark landings from longlines and gillnets for the Florida East coast, Georgia and South Carolina, and North Carolina (see Appendix 3 of the 1996 SEW). Specifically, the members of the catch subgroup at that workshop compiled a table that represented the available data, observations and/or perceptions on the proportion of large coastal shark landings represented by sandbar and blacktip sharks. Sources of this legacy data included observer data and observations of biologists and fin dealers. Available data were often applied across un-sampled years when the general perceptions of the fishery supported this. Gillnet landings estimates for Large Coastal sharks in North Carolina were prorated by the North Carolina Division of Marine Fisheries. These estimates of the North Carolina data set reflect the exclusion of all sharks other than the Large Coastal species from the North Carolina database, wherever possible.

Commercial landings for 1991-2012 come from the Atlantic portion of the FINS database (Atlantic Coastal Cooperative Statistics Program [ACCSP]). No data from the FINS database

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(Gulf Fisheries Information Network [GulfFIN]) representing the Gulf of Mexico region were included. Landings for 2013-2018 come from the NOAA Fisheries Highly Migratory Species commercial landings (eDealer) database.

Commercial landings of U.S. Atlantic blacktip shark by gear from the ACCSP for 1991-2018 were dominated by longlines (56%) and gillnets (33%) (**Table 3, Figure 3**). The remaining 11% included a combined "other gears" consisting of a "not coded" category (6%), hook and line (4%), and an assortment of other gears that contributed minimally. Based on this characterization of landings by gear type, commercial landings were split into three categories: longlines, gillnets, and other gears.

Blacktip landings by state were dominated by Florida (63.3%), North Carolina (16.7%), New Jersey (6.5%), Virginia (6.3%), and South Carolina (4.3%), with Florida consistently dominating through time. Most landings thus corresponded to the southeast region (**Table 4, Figure 4**).

Commercial landings were also calculated in numbers to satisfy ToR 5. They were calculated by dividing annual landings in weight (lb dw) by average weights (lb dw) from the Southeast Gillnet Observer Program (GNOP) and the Reef Fish and Shark Bottom Longline Observer Programs (collectively referred to as BLLOP hereforth) as appropriate. All weights from the GNOP and BLLOP were predicted from fork length measurements taken by observers in gillnet and longline fisheries, respectively, using a weight-length regression. Average weights were available for 1999-2018 from the GNOP and for 1993-2018 from the BLLOP. For the GNOP, the average weight for 1986-1998 was taken as the average for the first 5 years of data (1999-2003); for the BLLOP, the average weight for 1986-1992 came from Parrack (1990).

Discussion and decisions

Based on input from the commercial shark fishing industry, it was clarified that the market in the early 1980s was inconsistent with the landings calculated for 1981–1985 because there was very little shark fishing effort in those years. To account for the low shark fishing effort, it was proposed that landings for 1981 and 1982 be set to zero and landings for 1983–1985 assumed to linearly increase to the average for 1986-1988.

It was also proposed that the "other gears" series be back-calculated to 1983 for consistency with the longline and gillnet series. Because some of the records contained in the other gears series under the "not coded" category were rather high in 1991 and 1992, it was proposed that the values for 1986-1990 be computed as the mean for the entire time series (1991-2018)

Decision: Set the 1981 and 1982 landings to 0.

Decision: Assume a linear increase of landings in 1983-1985 from 0 in 1982 to the mean of 1986-1988 to represent growing market for shark products. Apply this increase to the three fleets considered (longlines, gillnets, and other gears)

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Decision: Reconstruct the other gears series to start also in 1983, setting 1986-1990 values equal to the mean of the entire time series (1991-2018)

Commercial dead discards

Working papers SEDAR65-DW-03 and SEDAR65-DW-04 provided estimates of dead discards of Atlantic blacktip sharks for the gillnet fishery and longline fishery for the southeast region, respectively, based on observer reports and commercial logbook data.

After the Data Workshop, Working Paper SEDAR65-DW-14 was submitted on December 5, 2019. This document provided estimates of live and dead discards in the northeast gillnet fishery based on observer reports from the Northeast Fishery Observer Program and Vessel Trip Report (VTR) landings data. After reviewing the document, the Panel expressed concern about the magnitude of the discard estimates in weight when compared to those in numbers, which may have been caused by mis-identification issues. The Panel then asked the authors to include landings data in the paper and to address mis-identification problems. In response, the authors re-ran the analyses 1) excluding all discards from observed trips that had high numbers of small (<40 cm FL, the known size at birth) blacktip sharks reported as these fish were likely misidentified, and 2) using the dealer data instead of VTR data due to the discrepancy between the VTR and dealer data in the early years (after the initiation of mandatory reporting). The final updated paper, which also included a correction in the computation of the variance, was submitted on December 10, 2019.

Discussion and decisions

Estimates of dead discards were produced for 1993-2018 for longlines and 1999-2018 for gillnets for the southeast region, and 1995-2018 for gillnets in the northeast region. For consistency with the landings, which started in 1983, it was also proposed that the longline and gillnet dead discards be back-calculated to 1983 using the mean for the entire time series. For the northeast gillnet fishery, the average discard ratios across all years were applied to the annual total landings.

It was brought up that the ratio method used for these three papers that provided discard estimates was a reasonable approach. However, pooling all data without considering strata due to the sparse nature of the bycatch events is a limitation of the bycatch estimates, although the northeast gillnet estimates used quarters as strata and improved temporal resolution. However, the estimated northeast gillnet discards are very inconsistent, with multiple years without any discards. The Panel expressed concern for the large annual and interannual variability/uncertainty in the bycatch estimates. The Panel thus recommended during the Data Workshop that the authors work with the assessment team during the assessment process to explore ways to address these concerns. Furthermore, after reviewing the discard estimates for the northeast gillnet fishery during the SEDAR 65 post Data Workshop webinar on December 5, 2019, the Panel recommended that all these three estimates of (dead and live) discards not be

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included in the base run, but instead be considered in the uncertainty analysis (i.e., alternative states of nature).

Recommendations for continuing work:

- Use running average to smooth annual bycatch estimates

- Use multi-year-block average bycatch estimates to replace annual bycatch estimates. The defined multi-year-block should be consistent with major management changes.

- Use multi-year-block average estimated CPUEs, but using censored annual logbook data or dealer landing data to estimate bycatch. In this case, the interannual variability of bycatch estimates is driven by interannual variability in effort from the logbook data, or in landing data from dealers.

Decision: Back-calculate dead discards to 1983 for longlines and gillnets using the mean for the entire time series (1993 – 2018 for southeast longlines; 1999-2018 for southeast gillnets; 1995-2018 for northeast gillnets)

Decision: Do not include the three estimates of dead discards (southeast longline, southeast gillnet, and northeast gillnet) in the base run. Include all three estimates of dead discards in a sensitivity run.

Commercial post-release live discard mortality

Working papers SEDAR65-DW-03 and SEDAR65-DW-04 also provided estimates of Atlantic blacktip sharks released alive in the gillnet and longline fisheries for the southeast region, based on observer reports and commercial logbook data.

See the "Commercial dead discards" section above for a description and treatment of the discard estimates (both dead and live) provided in document SEDAR65-DW-14.

Discussion and decisions

Preliminary estimates of live post-release mortality (the proportion of sharks released alive that die) was accounted for in commercial gears by multiplying estimated blacktip sharks released alive in gillnets and longlines (SEDAR65-DW-03 and SEDAR65-DW04) by a post-release mortality rate of 0.31 derived for gillnets, as described in Hueter et al.(2006) and summarized below, and 0.097 derived for hook and line (taken as a proxy for bottom longline gear; Whitney et al. 2017). However, new estimates of post-release mortality rates became available at the workshop for bottom longline fisheries (SEDAR65-RD06). Specifically, a rate of 44.2% (±8.3% 95% CIs) was proposed (N. Whitney pers. com. to B. Frazier) as described in SEDAR65-RD06 and summarized below.

Previous SEDAR panels (SEDAR29) adopted 31% as the best estimate of the post-release live-discard mortality rate for Gulf of Mexico blacktip sharks captured in gillnet fisheries (SEDAR65-DW20, their Table 4) obtained from juvenile blacktip sharks captured with research gillnets (Hueter

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et al. 2006). The same approach was adopted by the Panel here. In addition, 95% CIs for gillnet fisheries were calculated by the Panel using methods and data available in Hueter *et al.* (2006). Release and recapture data for blacktip sharks captured in research gillnets and summarized by their condition at release was obtained from Hueter *et al.* (2006, their Table 3):

Condition	Tagged	Recaptured	Ratio
1	928	58	0.0625
2	939	39	0.0415
3	666	24	0.0360
4	365	4	0.0110

The relative survival (Beta^) of tagged blacktip sharks released in conditions 2–4 was estimated relative to that of blacktip sharks released in condition 1 as the ratio of recapture rates using equation (10) in Hueter et al (2006); lower and upper 95% CIs were obtained using equation (11) in Hueter *et al.* (2006) adapted from Hueter *et al.* (2006, their Table 4):

	Beta^	LCI	UCI
Ratio of ratios (condition 2: condition 1)	0.6645	0.4474	0.9870
Ratio of ratios (condition 3: condition 1)	0.5766	0.3621	0.9181
Ratio of ratios (condition 4: condition 1)	0.1753	0.0641	0.4795

Hueter *et al.* (2006) obtained estimates of absolute post-release mortality by assuming all sharks in condition 1 survived the catch–tag–release event. Using this approach 31% (898 of 2,898) of blacktip sharks released from gillnets are estimated to have died (adapted from Hueter *et al.* (2006, their Table 5):

Condition	Number tagged	Survival rate	Death rate	Number dying	Percent dying (PRLDM)
1	928	1	0	0	
2	939	0.66	0.34	319.26	
3	666	0.58	0.42	279.72	
4	365	0.18	0.82	299.30	
Total	2898			898.28	31%

Lower and upper 95% CIs (alpha = 0.05) for cryptic post-release mortality of blacktip sharks released from gill nets were calculated by the Panel using the same approach (Adapted from Hueter *et al.* 2006, their Tables 4, and 5):

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Condition	Number tagged	Survival rate LCI	Death rate UCI	Number dying UCI	Percent dying UCI (PRLDM)
1	928	1	0	0	
2	939	0.45	0.55	516.45	
3	666	0.36	0.64	426.24	
4	365	0.06	0.94	343.1	
Total	2898			1285.79	44.4%

Condition	Number tagged	Survival rate UCI	Death rate LCI	Number dying LCI	Percent dying LCI (PRLDM)
1	928	1	0	0	
2	939	0.99	0.01	9.39	
3	666	0.92	0.08	53.28	
4	365	0.48	0.52	189.80	
Total	2898			252.47	8.7%

Because all sharks in condition 1 are assumed to survive (death rate =0), this approach may underestimate the total post-release mortality. Similarly, a previous literature review developed for Gulf of Mexico blacktip sharks during SEDAR 29 (Courtney 2012) suggested that the best estimate of the post-release live-discard mortality rate of blacktip sharks captured in gillnets, 31%, obtained from juvenile blacktip sharks captured with research gillnets Hueter *et al*. (2006), may need to be adjusted upward to reflect the relative difference in the at-vessel gillnet mortality rate observed for juvenile blacktips captured with research gillnets (38%) (Hueter and Manire, 1994) relative to that of sub-adult blacktips captured in scientifically monitored commercial gillnets (90%) (Thorpe and Frierson, 2009). However, the Panel discussed that the new approach developed here to calculate 95% CIs was the preferred approach for developing the range of uncertainty for blacktip shark post-release mortality in gillnet fisheries because it was based on data available from the original publication, which resulted in a relatively wide range of uncertainty.

A new estimate of acute post-release mortality rates for coastal sharks caught in the Florida commercial shark demersal longline fishery, 44.2% ±8.3% (±95% CI), was presented and discussed by the Panel for use in SEDAR 65 demersal longline fisheries (SEDAR65-RD06). The estimate was based on a large sample size (N = 95) of physically recovered acceleration data loggers (ADLs) released on blacktip sharks captured near Madeira Beach, FL, and Key West, FL. At both study sites, specific fishing locations and practices were directed by commercial longline captains to ensure methods were consistent with typical commercial fishing practices. Post-release mortality rates were calculated as the percentage of blacktip sharks that died post-release out of the number of tags recovered. Mortality was identified from recovered tag data as a lack of movement and a constant depth, assumed to be associated with a negatively buoyant shark on the bottom.

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Accelerometer deployments, all shark species tagged in the study, lasted between 0.7 and 205 h (mean 20.9 ± 18.7 h). Ninety one % of mortalities, all tagged sharks in the study, occurred within 5 h of release, and all mortalities occurred within 12 h of release.

The 95% confidence interval obtained for post-release mortality estimates in demersal longlines (SEDAR65-RD06) was based on methods in Goodyear (2002) which was not available for the Panel to review. Consequently, the Panel re-calculated 95% CIs for demersal longlines during the meeting using a binomial distribution with 95 releases and 42 mortalities, and obtained a slightly wider range of uncertainty (34.0 % to 54.8%). The binomial 95% CI calculations were later verified in R version 3.3.2 (R Development Core Team, 2016) using the library "binom" (Dorai-Raj 2014): binom.confint(x = 42, n = 95, method = "exact").

Decision: Back-calculate live discards to 1983 for longlines and gillnets using the mean for the entire time series (1993 – 2018 for southeast longlines; 1999-2018 for southeast gillnets; 1995-2018 for northeast gillnets)

Decision: Do not include the three estimates of live discards (southeast longline, southeast gillnet, and northeast gillnet) in the base run. Include all three estimates of live discards in a sensitivity run.

Decision: Use a post-release live discard mortality rate of 31% for commercial gillnets (with a 95% CI of 8.7%-44.4%) and 44.2% for bottom longlines (with a binomial 95% CI of 34.0%-54.8%)

	Estimate	Lower 95% CL	Upper 95% CL
Gillnet	31%	8.7%	44.4%
Demersal Longline	44.2%	34.0%	54.8%

Commercial length compositions

The only data sources for lengths of commercially caught sharks are the observer programs (BLLOP and GNOP in this case). Length composition information from these programs will be provided separately.

3.4.3 Recreational Catch Datasets and Decisions

Recreational catches of Atlantic blacktip sharks, computed as the sum of estimates from the Marine Recreational Information Program (MRIP) and the Southeast Region Headboat Survey (SRHS), were available for 1981-2018. The MRIP estimates include Access Point Angler Intercept Survey (APAIS) and Fishing Effort Survey (FES) calibrations. Annual recreational catch estimates of blacktip sharks in the Atlantic were computed as the sum of type A (number of fish killed or kept

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seen by the interviewer), type B1 (number of fish killed or kept reported to the interviewer by the angler), and type B2 (number of fish released alive reported by the fisher) estimated to have died (by initially applying a post-release mortality rate of 0.097 from Whitney et al. (2017). Type B2 estimates for SRHS became available in 2004. Catches are reported in both numbers and weight for types A and B1, but only in numbers for type B2. Annual weight estimates for type B2 were computed by multiplying B2 catches in numbers by an average weight obtained by dividing AB1 catch in weight by catch in numbers.

The overwhelming majority of Atlantic blacktip shark catches were reported in MRIP. Catches showed a generally decreasing trend from 1981 to 2018, punctuated by several peaks, most notably in 1985, 1990, 1997, and 2004 (for A, B1, and B2), and in 1993, 2009, and 2015 (for B2 only) (**Table 1, Table 2**).

By fishing mode, most AB1 Atlantic blacktip shark catches were from shore (49%) and by private boats (45%), with charter boats and headboats contributing very little (**Figure 5**). By fishing area, most blacktip catches occurred less than 3 miles from shore (44%) and in inshore waters (42%), with the remaining 14% of catches in waters over three miles from shore (**Figure 6**). Most of the catches were in the southeast region, with Florida-East coast (50%), South Carolina (31%), and Georgia (13%) accounting for 94% of all blacktips (**Figure 7**).

Discussion and decisions

Concern was expressed over the inter-annual variability and high uncertainty of the recreational dataset for both AB1 and B2 catches. In particular, a peak in B2 catches was noted in 2009 based on two records from wave 3 (May-June) in inshore waters of South Carolina, which resulted in unusually high estimates of 404,126 and 1,925,555 sharks. Additional research revealed that this high estimate was generated from 5 interviews all intercepted on the same day at the same pier in Beaufort County, SC. The anglers interviewed reported releasing 3, 4, 4, 8, and 8 blacktip sharks, respectively. The interaction of the FES and APAIS calibration effects on the shore effort estimates appear to have resulted in these unusually high releases. Based on this information, the Group decided that smoothing this 2009 value by setting it equal to the geometric mean of the three preceding and three ensuing years was warranted.

In addition to the peak in B2 catches in 2009, there remained concern about the various peaks in the recreational estimates in general. It was proposed to run a three-year moving average (based either on the arithmetic or geometric mean) to smooth the series while preserving the average trend. These transformations resulted in means for the entire time series (1981-2018) of 29,026 and 23,474 sharks for the arithmetic mean and geometric mean moving average series, respectively (compared to 28,743 for the untransformed series), or a 1% increase and 18% decrease, respectively, with respect to the untransformed series. Furthermore all the annual values in the transformed series fell between the 95% CIs (**Table 5, Table 6; Figure 8, Figure 9, Figure 10**).

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Decision: Smooth the 2009 B2 catch value by setting it equal to the geometric mean of the 3 preceding and ensuing years

Decision: Remove peaks in AB1s and B2s by running a 3-year moving average (based on the arithmetic mean)

Recreational post-release live discard mortality

Based on document SEDAR65-DW-18, a post-release mortality rate of 18.5% was proposed (average of 17.1% for shore-based fishing and 20.0% for charter boats). This more recent rate was considered to have improved previous research and was therefore adopted. The need to provide estimates of uncertainty for these estimates was also noted and a proposal to use a binomial distribution to generate them presented and approved.

Post release mortality (PRM) rates were estimated for blacktip sharks captured and released alive on rod-and-reel by shore-based (n = 41) and charter boat-based (n=40) fishermen using acoustic transmitters (total n = 81). Blacktip sharks were caught with rod-and-reel by participating recreational anglers from the shore (i.e. beach) and onboard charter fishing boats in the coastal waters of South Carolina and Florida. All fishing from charter boats was conducted by the clients who hired the charter, and thus a wide range of angler experience was sampled. Anglers used their personal fishing equipment, which varied in size and strength, and no input was provided by the authors on the fishing equipment (e.g. rod and reel type/size, hook type/size) or capture techniques. Survivorship was assessed by passively monitoring sharks following release and examining movements of sharks among fixed acoustic receivers deployed along the eastern coast of the U.S. as part of both the Atlantic Cooperative Telemetry (ACT) and the Florida Atlantic Coast Telemetry (FACT) Networks. Sharks that were detected multiple times by an acoustic receiver more than 10 days post-release were considered to have survived the capture event (and any associated tag ingestion during predation events, typically regurgitated within around 5 days of ingestion). Additionally, a subset of acoustically tagged individuals from shore-based (n = 12) and charter boat-based (n = 12) fishing were double-tagged with pop-off satellite archival tags (PSATs, total n = 24) to validate the survivorship results obtained from the acoustic transmitters. The survivorship results inferred from acoustic transmitters were consistent with results inferred from PSATs, Fifteen sharks (n = 7 shore-based; n = 8 charter boat-based) died within 10 days of being released by recreational anglers, resulting in post-release mortality rates of 17.1% (shore-based) and 20.0% (charter boat-based).

The Panel calculated 95% CIs for the recreational fishery during the meeting using a binomial distribution with 81 releases and 15 mortalities, and obtained a PRM rate for recreational fisheries of 18.5 and a range of uncertainty from 10.8 % to 28.7%. The binomial 95% CI calculations were later verified in R version 3.3.2 (R Development Core Team, 2016) using the library “binom” (Dorai-Raj 2014): binom.confint(x = 15, n = 81, method = "exact").

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The new estimate of post-release mortality obtained for blacktip sharks captured in recreational fisheries in the coastal waters of South Carolina and Florida is consistent with an updated estimate from the Gulf of Mexico recreational fisheries where 22 tags with conclusive data resulted in 5 mortalities and a PRM estimate of 22.7% with a 95% binomial CI of 7.8-45.4% (pers. comm. John Mohan; also see SEDAR65-RD04, their Appendix B).

Decision: Use overall post-release mortality rate of 18.5% for hook and line recreational fisheries (with a binomial 95% CI of 10.8%-28.7%)

	Estimate	Lower 95% CI	Upper 95% CI
Recreational	18.5%	10.8%	28.7%

Using the new estimate of post-release mortality of 18.5% resulted in almost a doubling (90% increase) of animals released alive assumed to have died compared to the numbers obtained using the previous estimate of 9.7%. In absolute terms, this translated to an increase from 991,810 mortalities to 1,891,596 mortalities during the entire time series (1981-2018).

Recreational length compositions

Lengths were available from the MRIP and the SRHS. Length-frequency distributions showed that mostly immature individuals are caught as determined by comparing to the median sizes at maturity for males and females (115 cm FL and 123 cm FL, respectively; SEDAR 65-DW-01). The mean fork length from MRIP (75.4 cm) was not significantly smaller than that from SRHS (78.0 cm) (Welch two sample t-test data: $t = 0.8582$, $df = 141.58$, $P = 0.3922$; **Figure 11**). There were, however, highly significant differences in the size of blacktip sharks caught by fishing mode (ANOVA: $F = 7.05$, $df = 3$, $P = 0.00011$), with blacktips caught from shore being significantly smaller than those caught by private boats, charter boats, or headboats (Multiple comparison test of means for unbalanced data: contrasts fit: Shore – Cbt, $P < 0.001$; Shore – Hbt, $P < 0.00797$; Shore – Pri, $P < 0.00802$; **Figure 12**). Similarly, there were highly significant differences in the size of blacktip sharks caught by fishing area (ANOVA: $F = 11.99$, $df = 3$, $P = 1.07E-07$), with blacktips caught inshore being significantly smaller than those caught in the ocean (≤ 3 miles), ocean (> 3 miles), or in headboats (Multiple comparison test of means for unbalanced data: contrasts fit: Inshore – Hbt, $P < 0.0272$; Inshore – Ocean (≤ 3 mi), $P < 0.001$; Inshore – Ocean (>3 mi), $P < 0.0014$; **Figure 13**). No significant differences in the size of blacktip sharks by state were found (ANOVA: $F = 1.462$, $df = 7$, $P = 0.177$; **Figure 14**).

A study conducted by the South Carolina Department of Natural Resources (SCDNR) was presented at the Workshop that included ten shore-based shark angling groups (consisting of 2–10 members) who were requested to keep logbooks for one year to log effort, gear, species, bait, water temperature, length, sex, and fishing location. A total of six logbooks were recorded. As part of this study, 166 lengths of blacktip sharks measured in SC and FL were made available. Inclusion of these

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lengths gave a picture of the size composition of the catches of blacktip sharks caught from shore different from that provided by MRIP. Shore-based animals recorded in these logbooks were mostly mature (vs. immature in the MRIP database). The Group argued that these new lengths should be included as they provide evidence that larger blacktips can also be caught from shore, likely from beaches, by anglers targeting large blacktips, whereas the samples provided by MRIP are typically collected at piers or docks and are likely from anglers targeting other species but catching smaller blacktips (**Figure 15**).

Decision: Include Atlantic blacktip shark lengths from the SCDNR study (n=166)

3.5 Research recommendations

- Increase public education outreach activities for species identification in the recreational fishery. This is important because the fishery has become largely recreational, there are no species identification training workshops for recreational fishers, and it is difficult to distinguish blacktip from spinner sharks, especially as juveniles, by non-trained individuals.

- Improve the MRIP process to filter biased sampling that leads to unreal, extreme fluctuations in catch data for sharks, through a QA step that is applied with an objective, non-arbitrary procedure.

3.6 Literature Cited

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3.7 Tables

Table 1. Catches of blacktip sharks in the U.S. Atlantic in weight (lb dressed). B2 dead were obtained as the annual B2 live release estimates multiplied by the overall post-release mortality rate, 18.5%, assumed for hook and line recreational fisheries.

Year	Unreported commercial catches	Bottom longlines	Gillnets	Other gears	Recreational catches (A+B1)	Recreational catches (B2 dead)	Total
1981					47092	595924	643016
1982					569953	96652	666606
1983		117654	156572	13927	82381	93535	464070
1984		235309	313144	27854	199303	206718	982328
1985		352963	469716	41781	762918	30328	1657706
1986		546144	352931	41781	297951	97588	1336395
1987		175361	632155	41781	57384	9835	916516
1988	95172	337384	424063	41781	72175	14942	985517
1989	80892	370196	359204	41781	103798	15608	971479
1990		283349	375659	41781	85675	13931	800395
1991		212125	354837	491096	442506	28386	1528949
1992		756923	87757	234581	178352	379223	1636836
1993		807599	335794	99764	129048	79936	1452141
1994		396013	20022	33314	254666	1184496	1888511
1995		573084	62577	41805	96245	97286	870996
1996		231129	404648	24586	347566	166697	1174626
1997		123687	112990	11594	134772	109794	492836
1998		117429	68892	9432	357963	299781	853496
1999		128348	83778	9297	386373	166531	774327
2000		188258	96767	7682	184545	439377	916629
2001		109355	156606	5082	137276	620594	1028913
2002		200569	270521	13940	70650	408989	964669
2003		225246	235939	12878	87192	221422	782676
2004		97734	176299	11657	42494	801983	1130166
2005		107426	109778	5810	978424	1296155	2497593
2006		117754	219294	4751	69958	296926	708683
2007		30858	48869	2155	146318	299452	527652
2008		118901	159135	4434	61241	1197343	1541053
2009		171886	30113	38086	24669	303174	567929
2010		164057	89956	17814	44388	324191	640406
2011		143771	38845	7655	24290	165085	379646
2012		106103	68209	40171	40389	136353	391226
2013		156418	81966	25843	18874	406311	689412
2014		206387	65028	10592	15749	528133	825889
2015		193274	36023	528	38481	758443	1026749
2016		175635	70933	1907	47534	125576	421585
2017		175775	42433	1753	13739	189677	423378
2018		93515	29955	1661	6648	395902	527681

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Table 2. Catches of blacktip sharks in the U.S. Atlantic in numbers. B2 dead were obtained as the annual B2 live release estimates multiplied by the overall post-release mortality rate, 18.5%, assumed for hook and line recreational fisheries.

Year	Unreported commercial catches	Bottom longlines	Gillnets	Other gears	Recreational catches (A+B1)	Recreational catches (B2 dead)	Total
1981					6827	86395	93223
1982					57164	9694	66858
1983		4902	3568	580	33139	37626	79816
1984		9805	7137	1161	28894	29969	76966
1985		14707	10705	1741	137138	5452	169743
1986		22756	8044	1741	19913	6522	58975
1987		7307	14407	1741	40660	7202	71317
1988	3966	14058	9665	1741	21595	4479	55503
1989	3371	15425	8187	1741	27132	4623	60478
1990		11806	8562	1741	12135	2020	36263
1991		8839	8087	20462	96461	6364	140213
1992		31538	2000	9774	30414	65396	139123
1993		24636	7653	3043	25395	16092	76819
1994		18735	456	1576	30597	143805	195169
1995		24573	1426	1793	21950	22609	72351
1996		9060	9222	964	62069	29799	111115
1997		4050	2575	380	30336	25885	63226
1998		3600	1570	289	113397	96371	215227
1999		4090	2350	296	49380	21457	77574
2000		5743	3798	234	26758	63700	100233
2001		3255	2557	151	19283	89953	115199
2002		7043	5740	490	9466	59294	82033
2003		7525	4730	430	31811	81591	126088
2004		3297	4417	393	5986	116216	130310
2005		3877	2647	210	87462	115873	210068
2006		4569	5625	184	10280	43048	63706
2007		1419	11462	99	17576	43394	73951
2008		3726	6349	139	7168	173580	190962
2009		4528	1128	1003	2792	43953	53405
2010		4583	3145	498	2283	47000	57509
2011		5625	2031	299	2055	23934	33944
2012		4195	3899	1588	5846	19768	35296
2013		5446	5119	900	2727	58906	73098
2014		8356	3492	429	2278	76567	91122
2015		6181	3075	17	5306	109957	124536
2016		5942	1264	65	6520	18206	31996
2017		6797	6583	68	1527	27499	42474
2018		2863	1948	51	500	57397	62759

Table 3. Commercial landings (lb dw) by gear type, ACCSP (1991-2018).

Gear type	Weight (lb dw)	Percent
BY HAND, DIVING GEAR	44	4.0E-06
DIP NETS	43	3.9E-06
DREDGE	817	7.5E-05
FYKE NETS	1	1.3E-07
GILL NETS	3599256	0.33
HAND LINE	14476	1.3E-03
HAUL SEINES	4653	4.3E-04
HOOK AND LINE	383591	0.04
LONG LINES	6111466	0.56
NOT CODED	641689	0.06
OTHER FIXED NETS	160	1.5E-05
OTHER GEARS	5660	5.2E-04
OTHER SEINES	1768	1.6E-04
OTHER TRAWLS	61475	5.6E-03
OTTER TRAWLS	26231	2.4E-03
POTS AND TRAPS	384	3.5E-05
POUND NETS	387	3.6E-05
PURSE SEINE	223	2.1E-05
SPEARS	270	2.5E-05
TRAMMEL NETS	6093	5.6E-04
TROLL LINES	22634	2.1E-03
	10881321	1
GILL NETS + LONGLINES		0.89

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Table 4. Commercial landings (lb dw) by state, ACCSP (1991-2018).

State	Weight (lb dw)	Percent
CT	12	1.07E-06
FL	6892785	0.6335
GA	207094	0.0190
MA	580	5.33E-05
MD	100988	0.0093
NC	1812974	0.1666
NJ	704663	0.0648
NY	2936	0.0003
RI	113	1.04E-05
SC	469940	0.0432
VA	689107	0.0633
	10881191	1
	Northeast	0.07
	Southeast	0.93

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Table 5. Catches of blacktip sharks in the U.S. Atlantic in weight (lb dressed) after smoothing the recreational series with a three-year moving average (arithmetic mean). B2 dead were obtained as the annual B2 live release estimates multiplied by the overall post-release mortality rate, 18.5%, assumed for hook and line recreational fisheries.

Year	Unreported commercial catches	Bottom longlines	Gillnets	Other gears	Recreational catches (A+B1)	Recreational catches (B2 dead)	Total
1981					233142	262037	495179
1982					233142	262037	495179
1983		117654	156572	13927	283879	132302	704335
1984		235309	313144	27854	348201	110194	1034701
1985		352963	469716	41781	420057	111545	1396062
1986		546144	352931	41781	372751	45917	1359524
1987		175361	632155	41781	142503	40788	1032589
1988	95172	337384	424063	41781	77785	13462	989647
1989	80892	370196	359204	41781	87216	14827	954116
1990		283349	375659	41781	210659	19308	930757
1991		212125	354837	491096	235511	140513	1434082
1992		756923	87757	234581	249969	162515	1491745
1993		807599	335794	99764	187355	547885	1978397
1994		396013	20022	33314	159986	453906	1063241
1995		573084	62577	41805	232826	482826	1393117
1996		231129	404648	24586	192861	124592	977816
1997		123687	112990	11594	280100	192091	720461
1998		117429	68892	9432	293036	192035	680824
1999		128348	83778	9297	309627	301896	832946
2000		188258	96767	7682	236065	408834	937606
2001		109355	156606	5082	130824	489653	891519
2002		200569	270521	13940	98373	417002	1000404
2003		225246	235939	12878	66779	477464	1018306
2004		97734	176299	11657	369370	773187	1428246
2005		107426	109778	5810	363625	798355	1384994
2006		117754	219294	4751	398233	630844	1370876
2007		30858	48869	2155	92505	597907	772295
2008		118901	159135	4434	77409	633329	993208
2009		171886	30113	38086	43433	641576	925094
2010		164057	89956	17814	31116	297490	600433
2011		143771	38845	7655	36356	208543	435170
2012		106103	68209	40171	27851	235916	478251
2013		156418	81966	25843	25004	356932	646163
2014		206387	65028	10592	24368	564296	870671
2015		193274	36023	528	33921	470717	734464
2016		175635	70933	1907	33252	357899	639625
2017		175775	42433	1753	22640	237052	479653
2018		93515	29955	1661	22640	237052	384823

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Table 6. Catches of blacktip sharks in the U.S. Atlantic in numbers after smoothing the recreational series with a three-year moving average (arithmetic mean). B2 dead were obtained as the annual B2 live release estimates multiplied by the overall post-release mortality rate, 18.5%, assumed for hook and line recreational fisheries.

Year	Unreported commercial catches	Bottom longlines	Gillnets	Other gears	Recreational catches (A+B1)	Recreational catches (B2 dead)	Total
1981					32377	44572	76948
1982					32377	44572	76948
1983		4902	3568	0	39732	25763	73966
1984		9805	7137	1161	66390	24349	108841
1985		14707	10705	1741	61982	13981	103116
1986		22756	8044	1741	65904	6392	104836
1987		7307	14407	1741	27389	6068	56912
1988	3966	14058	9665	1741	29796	5435	64659
1989	3371	15425	8187	1741	20287	3707	52717
1990		11806	8562	1741	45243	4335	71687
1991		8839	8087	20462	46337	24593	108318
1992		31538	2000	9774	50757	29284	123353
1993		24636	7653	3043	28802	75098	139232
1994		18735	456	1576	25981	60835	107583
1995		24573	1426	1793	38205	65404	131401
1996		9060	9222	964	38119	26098	83463
1997		4050	2575	380	68601	50685	126291
1998		3600	1570	289	64371	47905	117734
1999		4090	2350	296	63178	60509	130424
2000		5743	3798	234	31807	58370	99953
2001		3255	2557	151	18503	70982	95448
2002		7043	5740	490	20187	76946	110406
2003		7525	4730	430	15755	85700	114140
2004		3297	4417	393	41753	104560	154421
2005		3877	2647	210	34576	91712	133022
2006		4569	5625	184	38439	67438	116256
2007		1419	11462	99	11675	86674	111329
2008		3726	6349	139	9179	91809	111202
2009		4528	1128	1003	4081	93011	103752
2010		4583	3145	498	2377	43129	53731
2011		5625	2031	299	3395	30234	41584
2012		4195	3899	1588	3542	34202	47427
2013		5446	5119	900	3617	51747	66830
2014		8356	3492	429	3437	81810	97524
2015		6181	3075	17	4701	68243	82218
2016		5942	1264	65	4451	51887	63609
2017		6797	6583	68	2849	34367	50664
2018		2863	1948	51	2849	34367	42078

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3.8 Figures

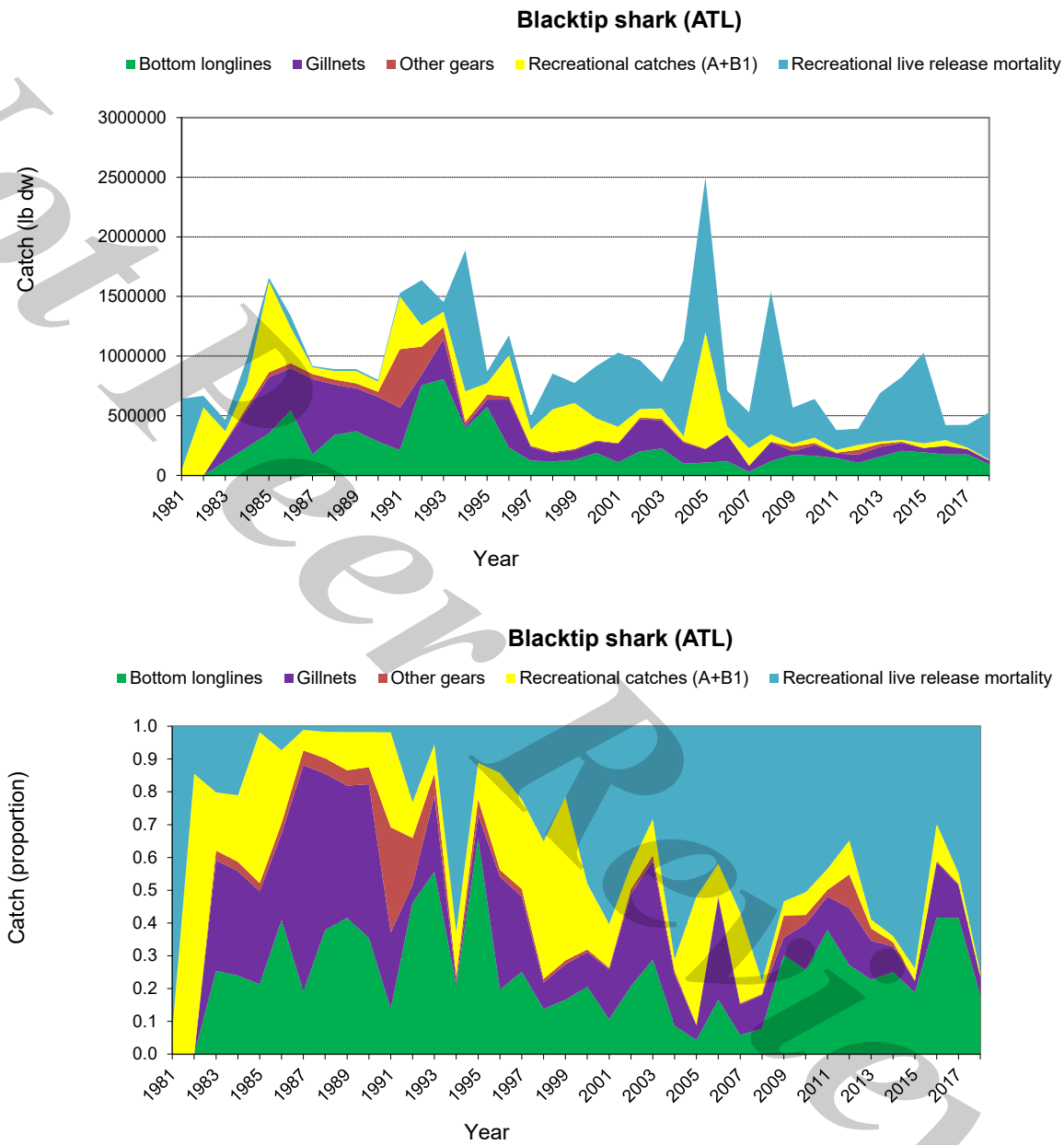

Figure 1. Commercial and recreational catches of Atlantic blacktip sharks in weight (lb dw), 1981-2018. Top panel: stacked catches by year; bottom panel: proportions by year.

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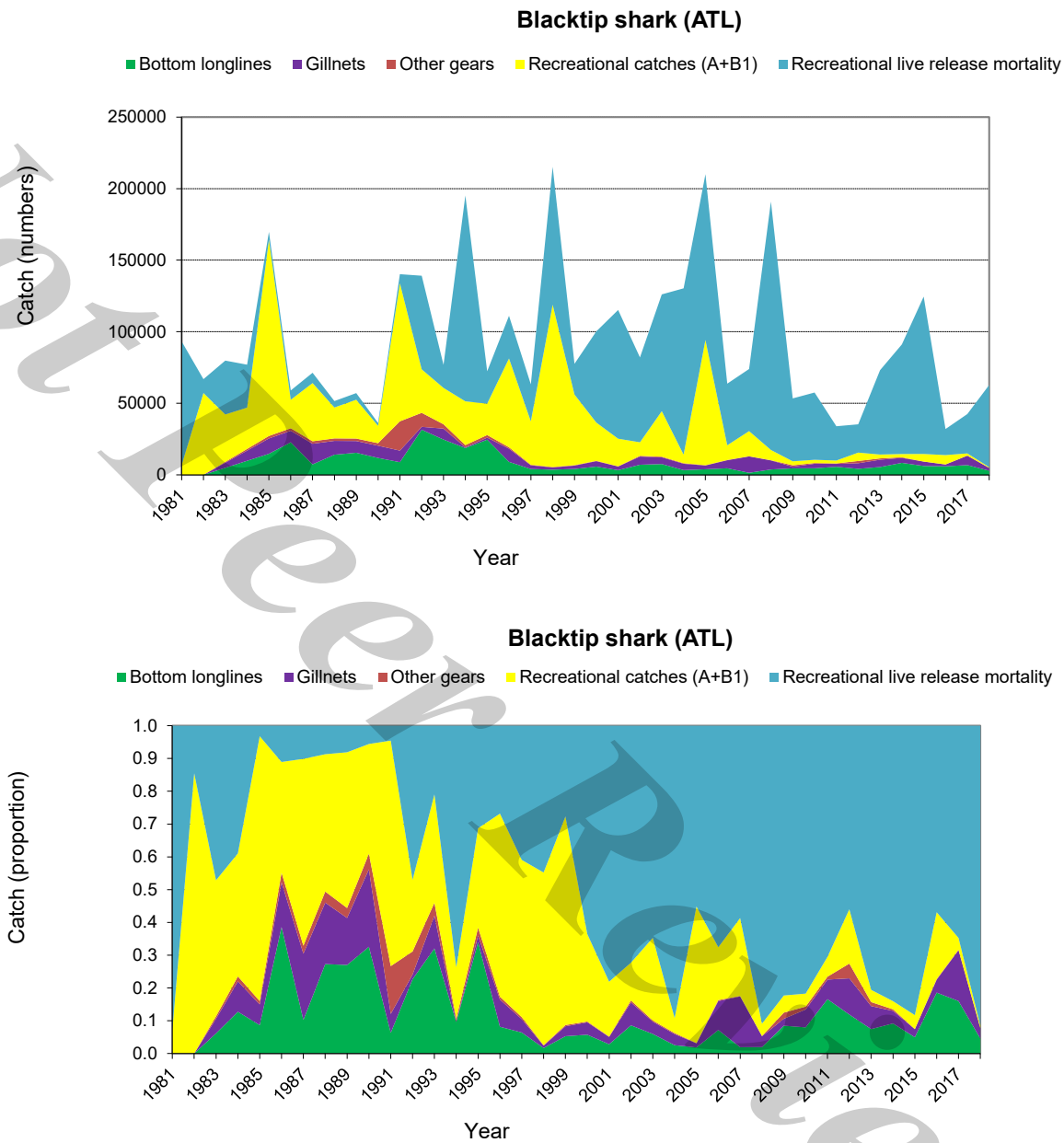

Figure 2. Commercial and recreational catches of Atlantic blacktip sharks in numbers, 1981-2018. Top panel: stacked catches by year; bottom panel: proportions by year.

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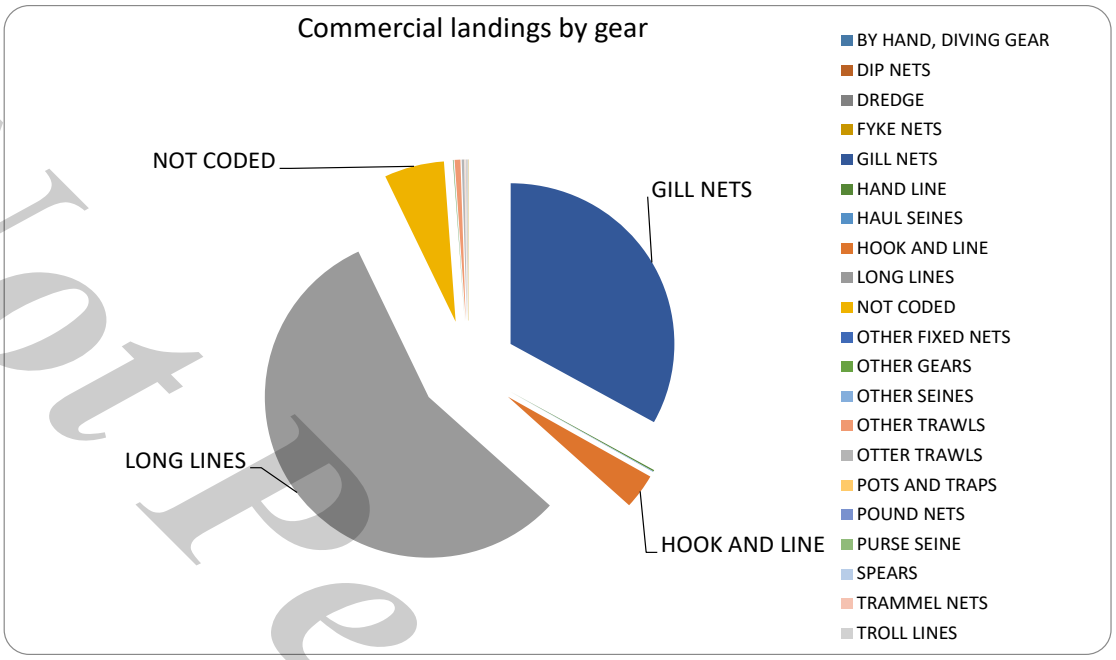

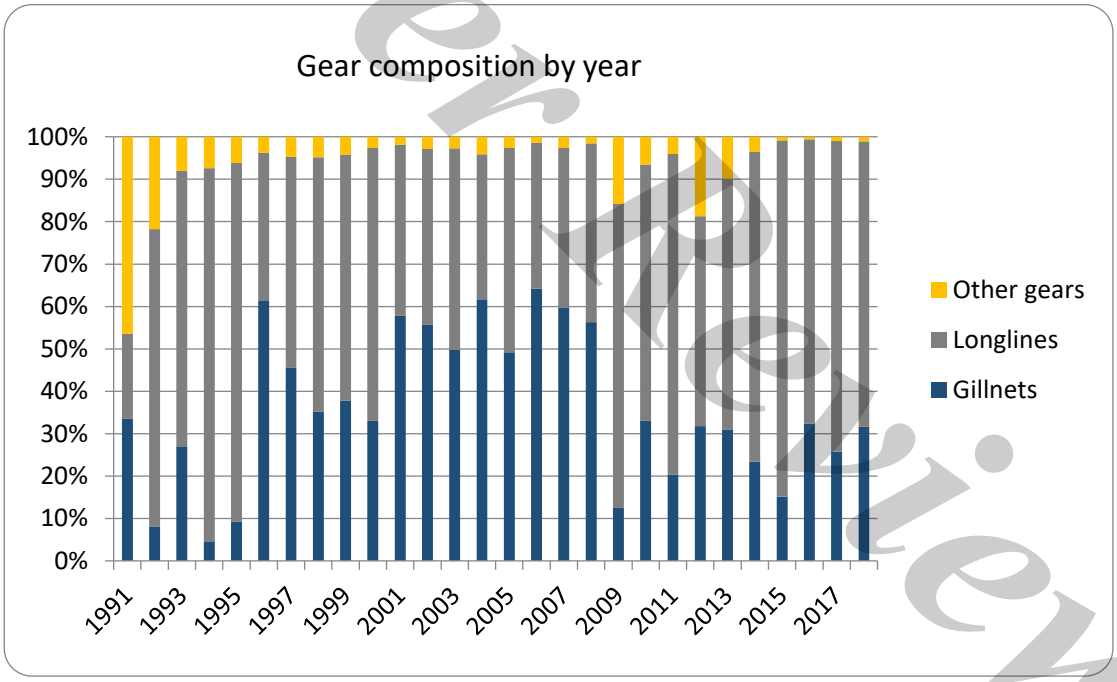

Figure 3. Commercial landings (lb dw) by gear type from the ACCSP for 1991-2018. Top panel: relative contribution for the entire time period; bottom panel: annual composition of the main gears by year.

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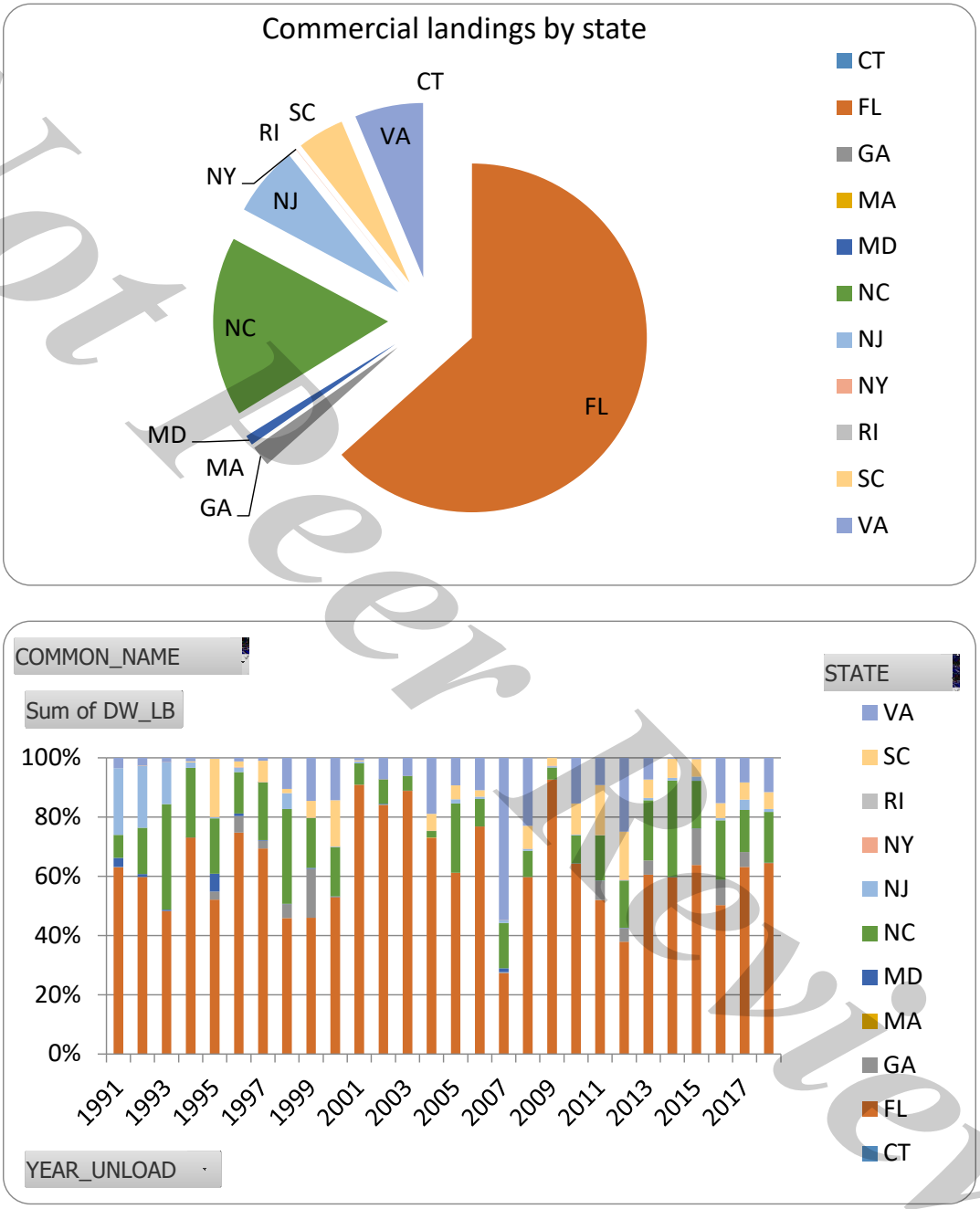

Figure 4. Commercial landings (lb dw) by state from the ACCSP for 1991-2018. Top panel: relative contribution for the entire time period; bottom panel: annual composition of the main gears by year

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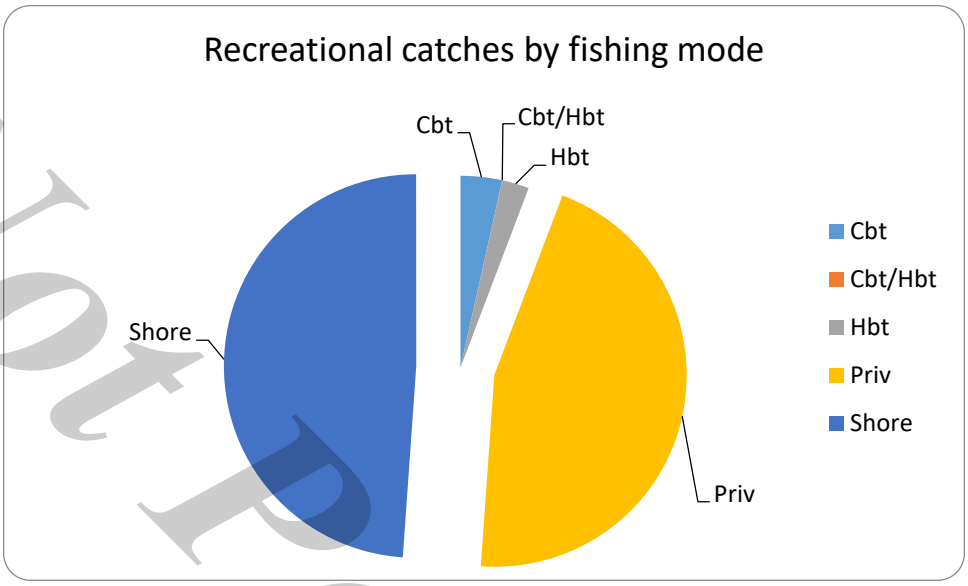

Figure 5. Recreational catches (AB1, numbers) of Atlantic blacktip sharks by fishing mode, 1981–-2018. Shore=fishing from shore; Private= private boats; Hbt=headboats; Cbt=charterboats.

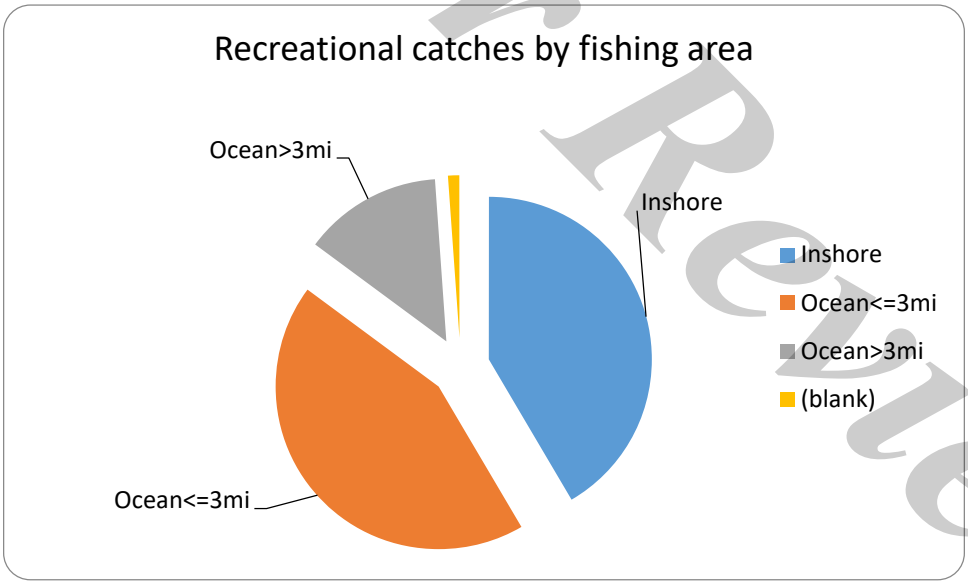

Figure 6. Recreational catches (AB1, numbers) of Atlantic blacktip sharks by fishing area, 1981-2018. Note: "Blank" indicates catches reported in the SRHS.

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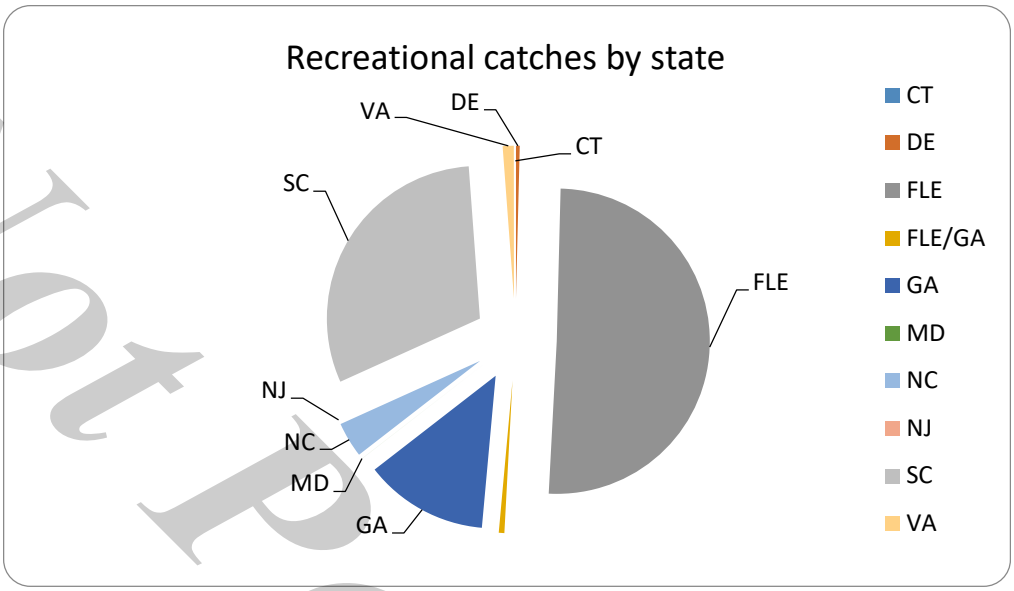

Figure 7. Recreational catches (AB1, numbers) of Atlantic blacktip sharks by state, 1981-2018.

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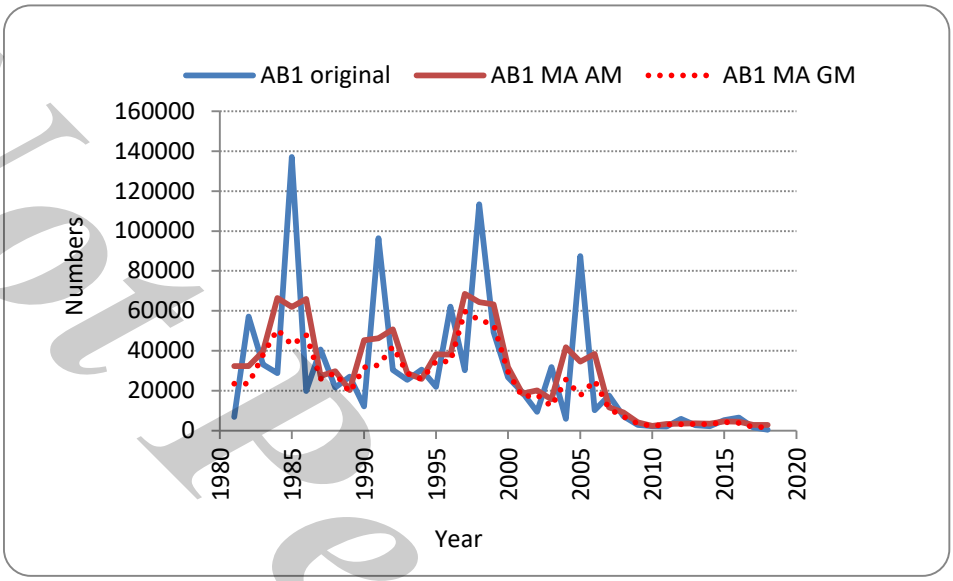

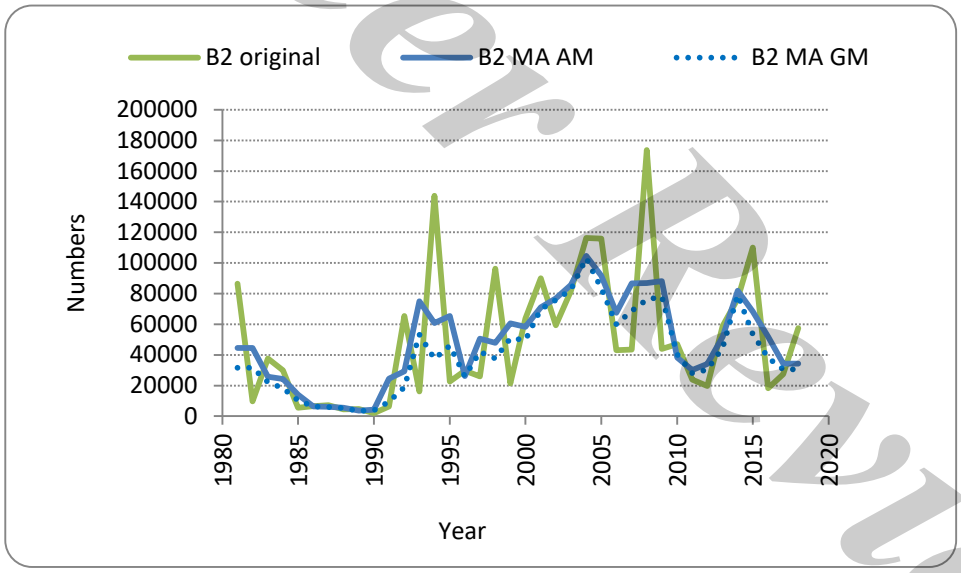

Figure 8. Recreational AB1 (top) and B2 (bottom) catches of Atlantic blacktip sharks in numbers, 1981-2018, comparing the original data, a 3-year moving average based on the arithmetic mean (MA AM), and a 3-year moving average based on the geometric mean (MA GM).

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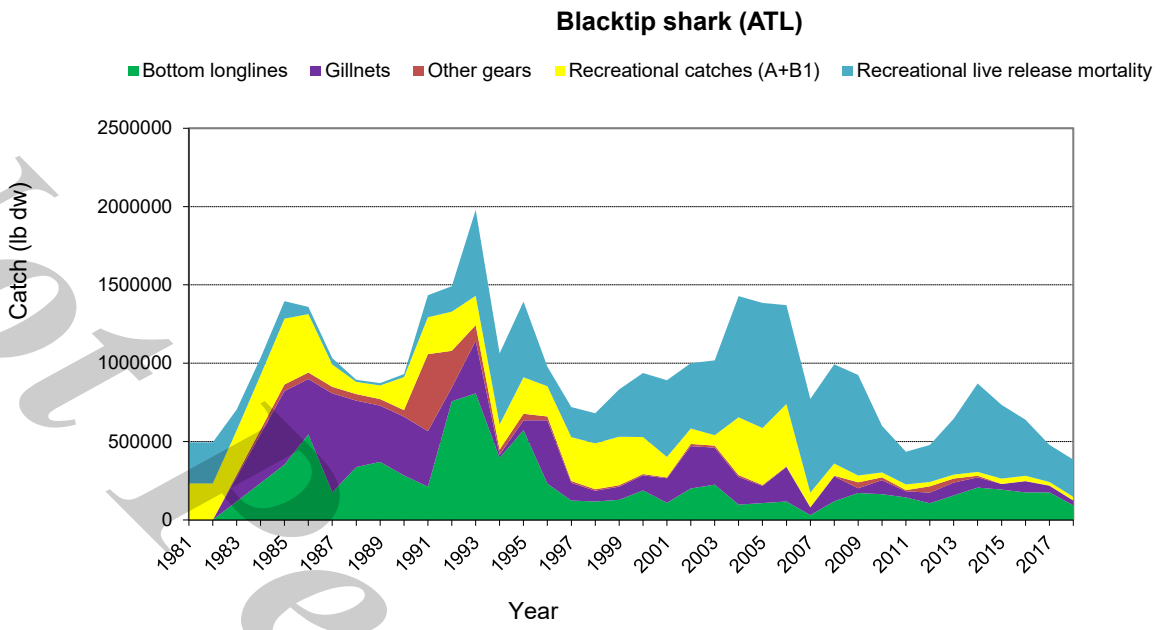

Figure 9. Commercial and recreational catches of Atlantic blacktip sharks in weight (lb dw), 1981-2018, with the recreational catches smoothed with a 3-year moving average (arithmetic mean).

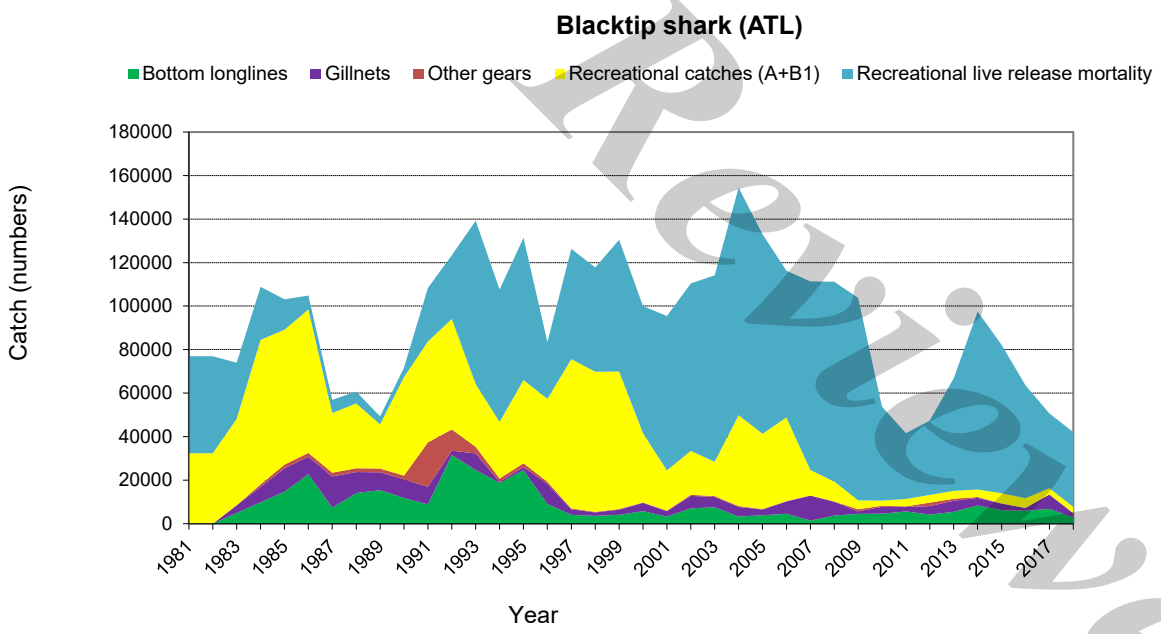

Figure 10. Commercial and recreational catches of Atlantic blacktip sharks in numbers, 1981-2018, with the recreational catches smoothed with a 3-year moving average (arithmetic mean).

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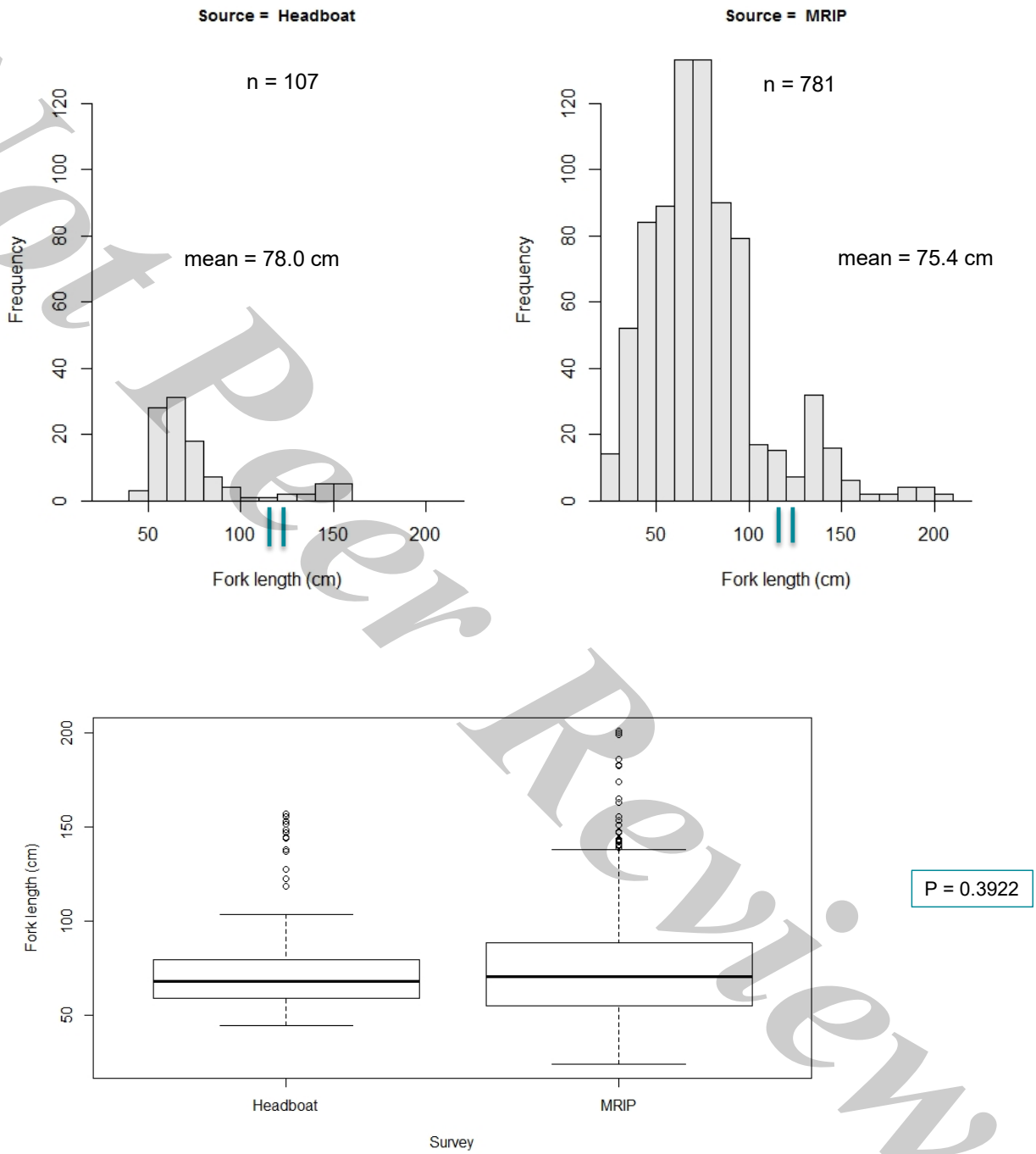

Figure 11. Length-frequency histograms of Atlantic blacktip sharks from the MRIP and SRHS surveys (top panel) and boxplot of fork length by survey (bottom panel). Vertical bars in the top panel denote median length at maturity for males (115 cm FL) and females (123 cm FL), respectively.

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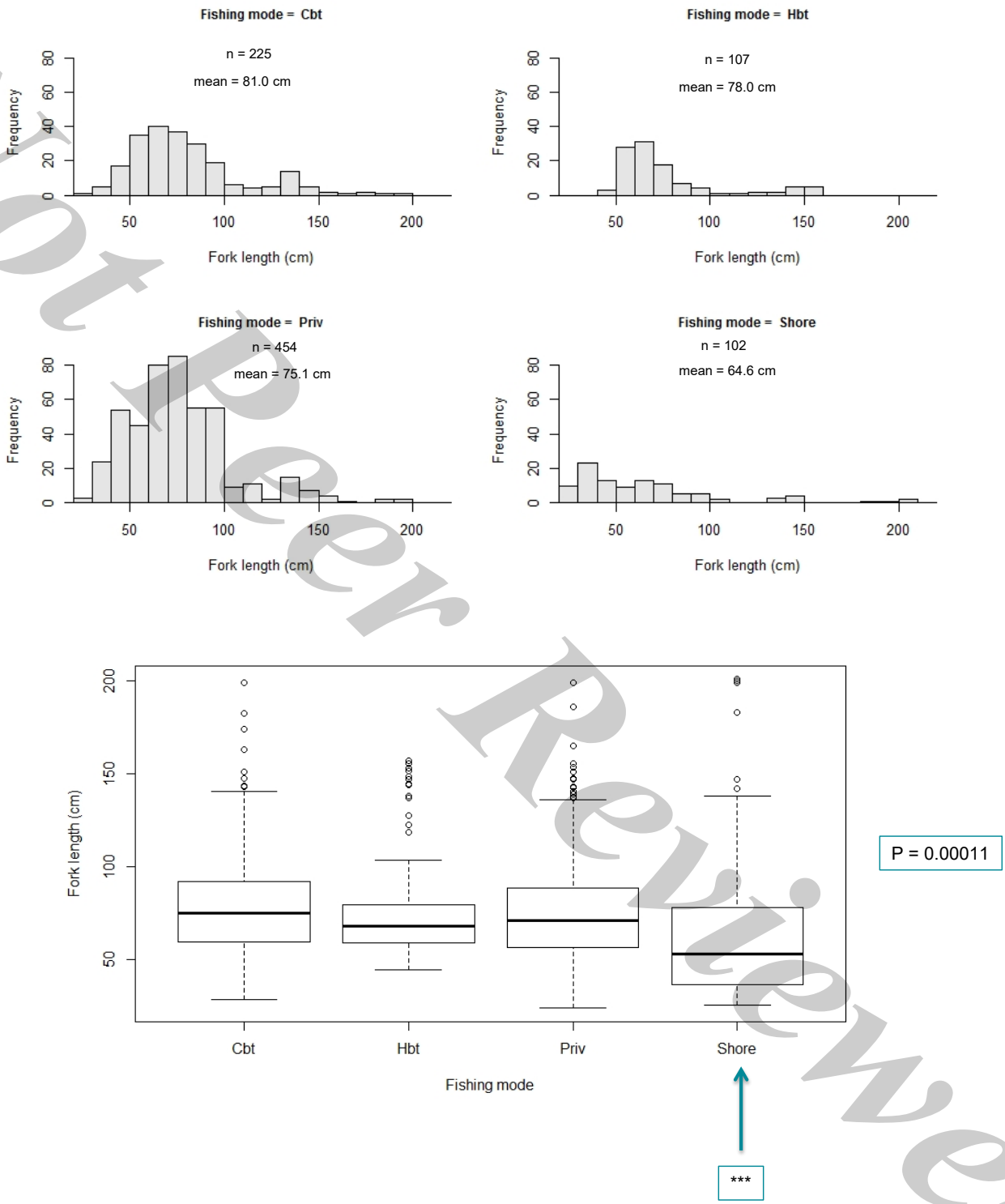

Figure 12. Length-frequency histograms of Atlantic blacktip sharks from the MRIP and SRHS surveys by fishing mode (top panel) and boxplot of fork length by fishing mode (bottom panel).

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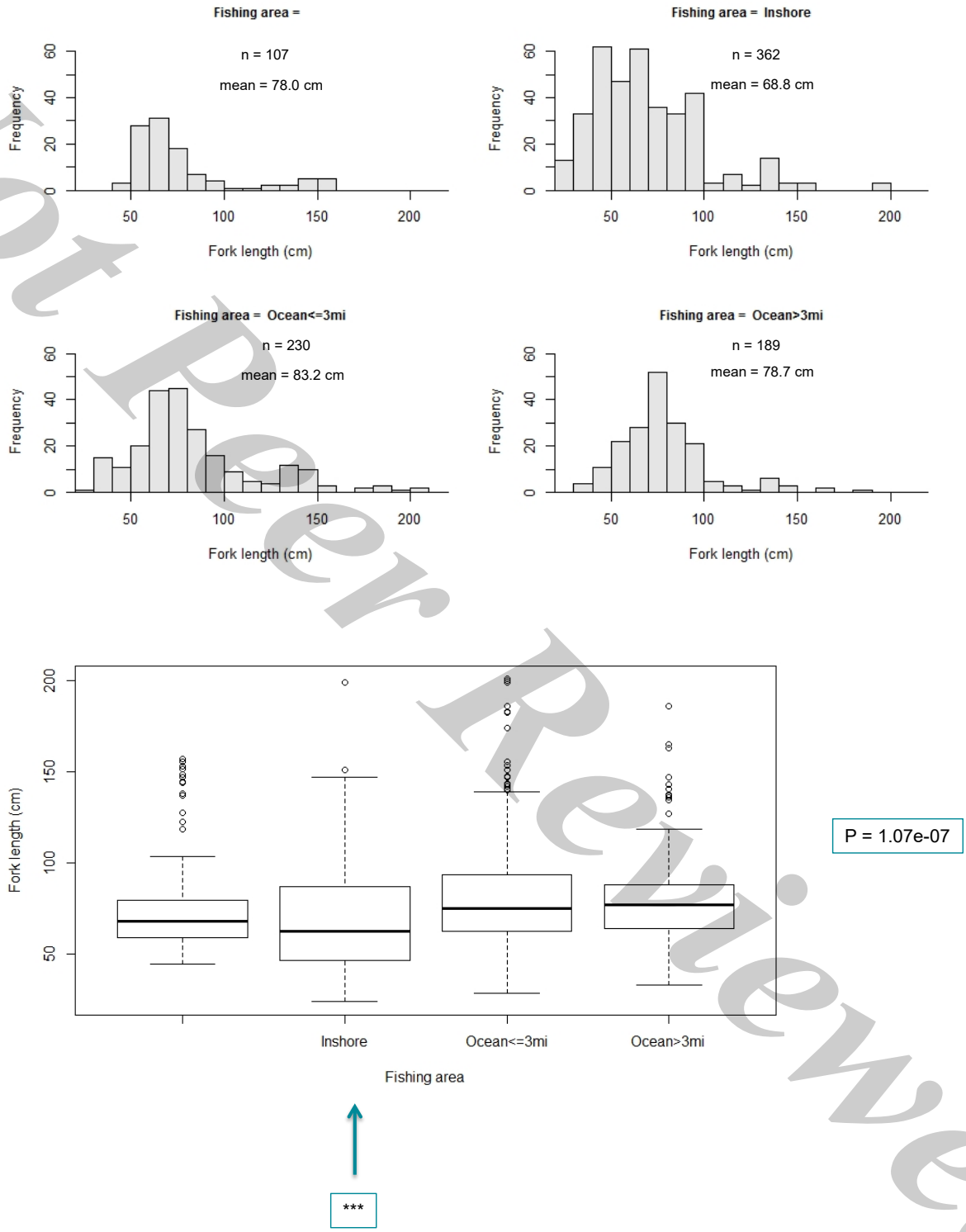

Figure 13. Length-frequency histograms of Atlantic blacktip sharks from the MRIP and SRHS surveys by fishing area (top panel) and boxplot of fork length by fishing area (bottom panel). Blank fishing area denotes lengths form the SRHS.

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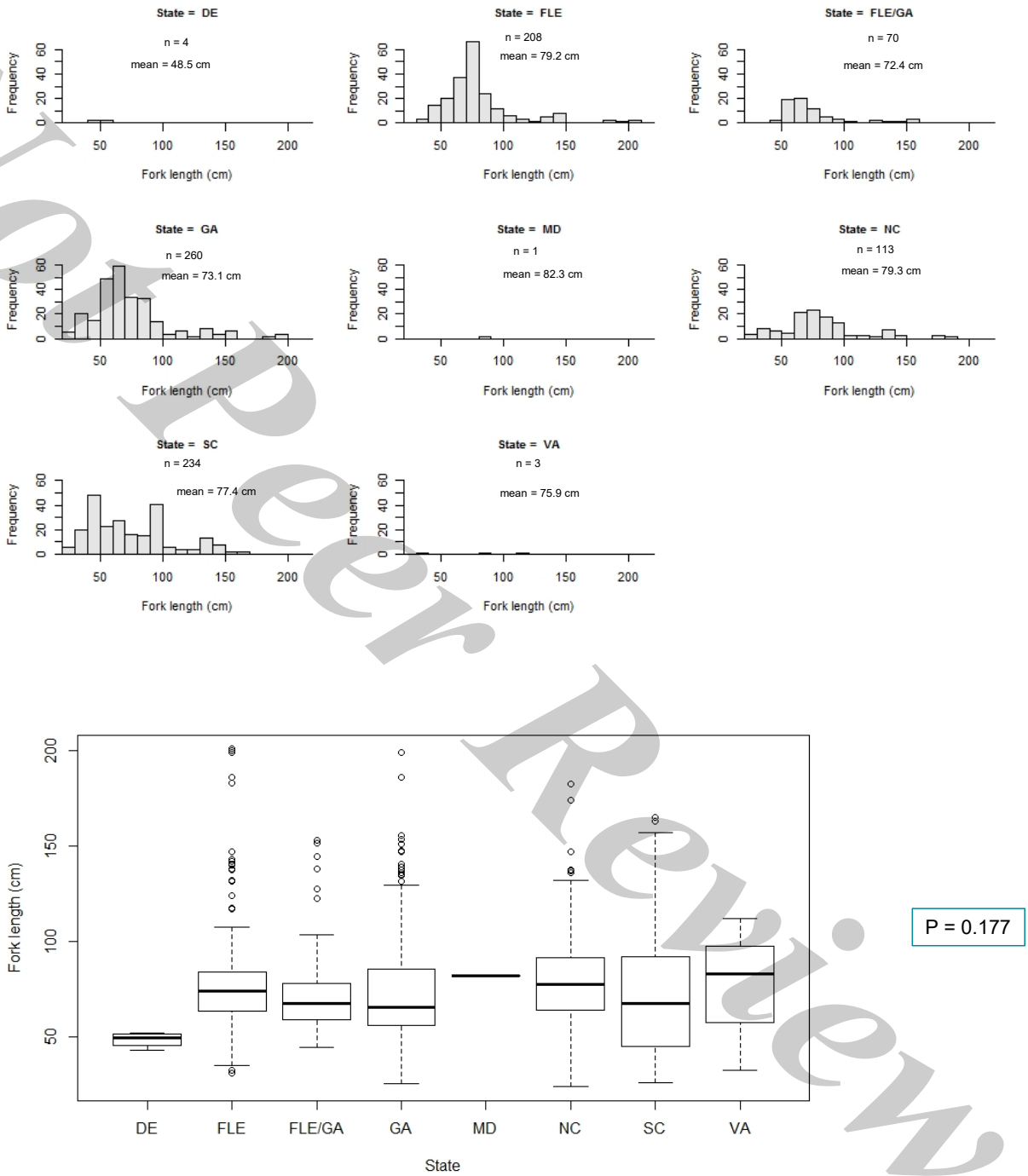

Figure 14. Length-frequency histograms of Atlantic blacktip sharks from the MRIP and SRHS surveys by state (top panel) and boxplot of fork length by state (bottom panel).

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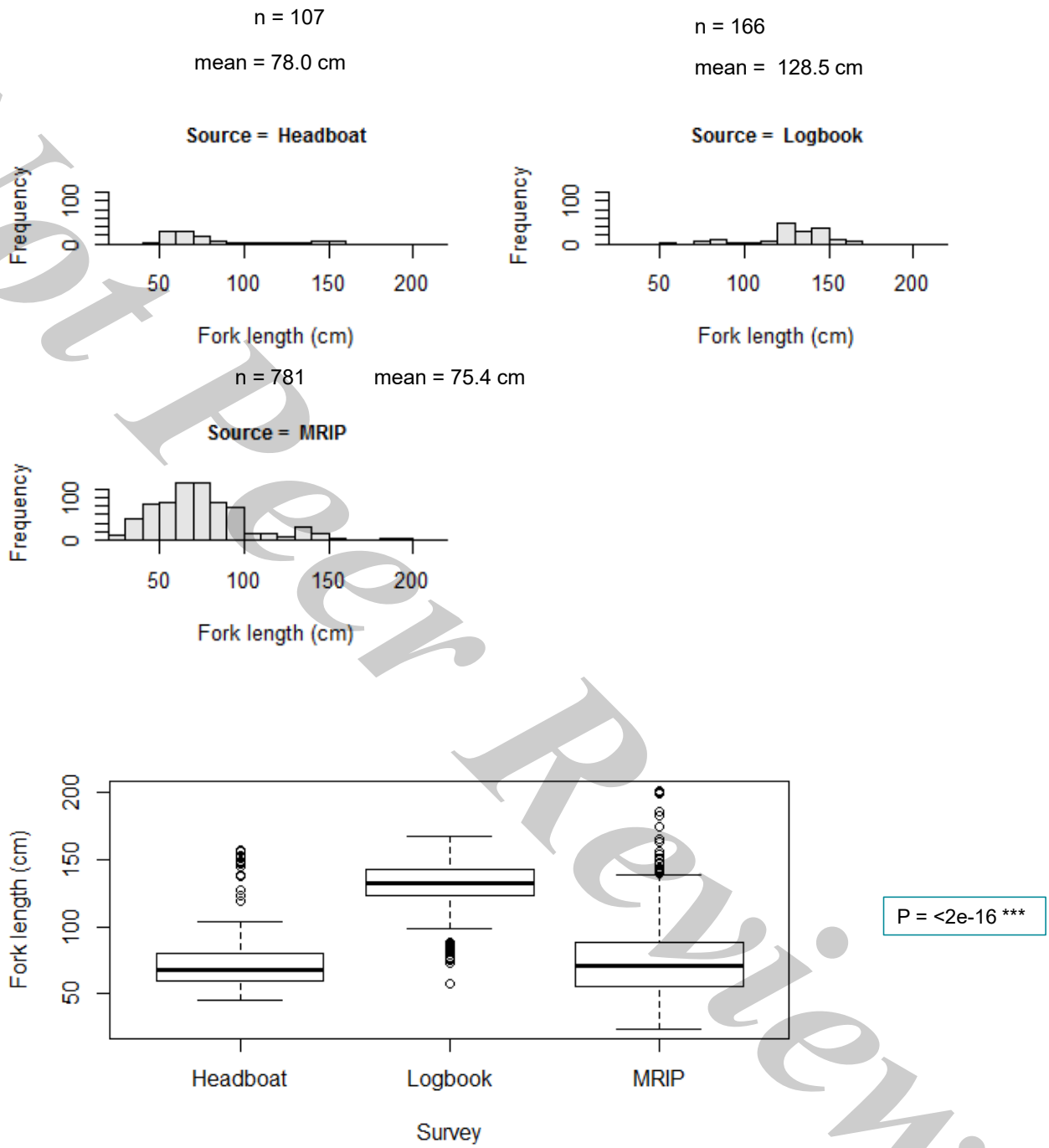

Figure 15. Length-frequency histograms of Atlantic blacktip sharks from the MRIP and SRHS surveys, with the added logbook survey from SCDNR (top panel) and boxplot of fork length by survey (bottom panel). Vertical bars in the top panel denote median length at maturity for males (115 cm FL) and females (123 cm FL), respectively.

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4. Indices of Population Abundance

4.1 Overview

Twelve (12) indices of abundance were considered for use in the assessment models. Indices were constructed using both fishery independent and dependent data. The Working Group (referred to as "Group" henceforth) assessed the appropriateness of each time series by modifying guidelines developed by the International Commission for the Conservation of Atlantic Tunas (ICCAT) Scientific Committee on Research and Statistics (SCRS; ICCAT Doc. No. SCI-033 / 2012). In almost all data series, regardless of whether the data was fishery dependent or independent, the data were standardized using a form of the generalized linear model (Aitchison, 1955). Elements considered for each data series ranged from the statistical diagnostics of the analysis to the temporal and spatial coverage of the index (Table 1). The Group also used a flowchart developed by ICCAT in its decision making process. In previous SEDARs for sharks, the indices working group ranked indices on a scale of 1-5 as a means of relative weight for the stock assessment. The Group discussed that there is likely little difference among several of the categorical designations and decided to drop that method and to either simply recommend the retention of the index or recommend it be not utilized for the assessment. While all indices reviewed were judged to be appropriately constructed, in some cases revisions were recommended.

4.2 Workgroup Participants

John Carlson, Leader……NOAA Fisheries Service- Panama City, FL
Cami McCandless, *not present at workshop*……NOAA Fisheries Service, Narragansett, RI
Bryan Frazier…….....South Carolina Department of Natural Resources
Robert J Latour…….....Virginia Institute of Marine Science
Adam Pollack……NOAA Fisheries Service- Pascagoula, MS
Kaitlyn O'Brien...…….……Virginia Institute of Marine Science
Andrea Kroetz……...……...NOAA Fisheries Service- Panama City, FL
James Gelsleichter…….....University of North Florida
Dean Courtney……NOAA Fisheries Service- Panama City, FL

4.3 Review of Indices

4.3.1 Fishery Dependent indices

Marine Recreational Information Program Data (SEDAR65-DW16)

The Marine Recreational Information Program (MRIP) catch data set was used to derive a standardized index of abundance for Atlantic blacktip sharks using delta-lognormal generalized linear mixed models. The Group noted that this is a stock wide survey that was fully analyzed with the diagnostics and characterization of uncertainty fully acceptable. However, as the author noted, the fraction of the catch of carcharhinid sharks identified to species in the MRIP data has declined over the last 30 years, as more sharks have been released alive rather than landed. While this is a success from a management perspective, the trip interceptor cannot identify the

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species. Thus, this index is likely to be biased. Moreover, the Group also noted that identification of blacktip sharks especially as it relates to spinner shark would be biased.

Decision: The Group thus recommended that this index not be utilized.

SEFSC Shark Bottom Longline Observer Program (SEDAR65-DW-17).
Observations by at-sea observers of the shark-directed bottom longline fishery in the Atlantic Ocean and Gulf of Mexico have been conducted since 1994 (e.g. Morgan et al. 2009, Mathers et al. 2018 and references therein). A previous stock assessment for Atlantic blacktip shark utilized data from this fishery as an index of abundance and as an input to the stock assessment model (SEDAR21). A combined data set was developed based on observer programs from Morgan et al. (2009) and Mathers et al. (2018). Following the definition of the South Atlantic from the Office of Sustainable Fisheries, Highly Migratory Species Management Division, data were excluded from the Gulf of Mexico. Historically, vessels in this fishery primarily targeted sandbar shark. With the introduction of the shark research fishery in 2008, vessels outside the research fishery were not permitted to target or land sandbar sharks. This change in management regulations likely influences the time series of abundance for sharks such that vessels fishing in the research fishery should be modeled separately from those outside the research fishery. Therefore, two indices of abundance were created from this data series; 1994-2007 for all vessels and 2008-2018 for vessels in the research fishery. While observations of vessels outside the research fishery were made from 2008-2018, the low sample size in some years precluded including those data, as the model would have difficulty converging. The time series covers a broad area (North Carolina to Florida) over a long temporal period (1993-2018). Data was standardized using the Delta-Generalized Linear Mixed Model approach, which is common in fisheries.

Decision: The Group determined that despite the series being noisy due to observational error, the series should be retained for use in the stock assessment.

4.3.2 Fishery Independent Indices

Virginia Shark Monitoring and Assessment Program (SEDAR65-DW05)

The Virginia Shark Monitoring and Assessment Program (VASMAP), which is based out of the Virginia Institute of Marine Science (VIMS), has been sampling shark populations in the coastal waters of Virginia since 1974 using standardized fisheries-independent longline gear. Data have been incorporated into stock assessments conducted by NOAA Fisheries for shark populations in the Atlantic, and are used by the Atlantic States Marine Fisheries Commission (ASMFC) and the Virginia Marine Resources Commission (VMRC) in their respective shark management policies. The Group noted that although the series is limited spatially, it is based on 6 fixed stations in offshore waters of Chesapeake Bay and captures blacktip sharks as they migrate north in spring and in fall when returning south. The series is the longest temporally. However, in early years due to funding and logistics, many years are missing or suffer from small sample size.

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Decision: The Group thus recommended three alternate time series for this data be developed and potentially utilized in the stock assessment: 1) including the entire time series regardless of sample size (1974-2018), 2) truncated to match the year when the catch series begins (1981-2018), and 3) the time series which would be considered to be the most robust in regards to sampling (1990-2018).

NOAA Fisheries-Southeast Fisheries Science Center-Mississippi Laboratory Bottom Longline Survey (SEDAR65-DW15)

The National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) Southeast Fisheries Science Center (SEFSC) Mississippi Laboratories (MSLABS) has conducted standardized bottom longline surveys in the Gulf of Mexico (GOM), Caribbean, and western North Atlantic Ocean since 1995. Data from the NOAA/NMFS/SEFSC/MSLABS Bottom Longline Survey were examined to determine the feasibility of constructing an index of relative abundance for blacktip sharks captured in the western North Atlantic Ocean. Despite good spatial and temporal coverage, both the authors of the study and the Group noted that there were not sufficient numbers of blacktip sharks caught in the survey to produce a reliable index of relative abundance (n=45). This was largely due to the timing of the survey, which occurs when most blacktip sharks are either in areas further north or in shallow waters inaccessible by the NOAA vessel**.**

Decision: The Group did not recommend this series for use in the assessment.

NOAA Fisheries-Northeast Fisheries Science Center- Bottom Longline Survey (SEDAR65-DW09)

The Northeast Fisheries Science Center (NEFSC) coastal shark bottom longline survey is conducted by the Apex Predators Program. The primary objective of this survey is to conduct a standardized, systematic survey of the shark populations off the US Atlantic coast to provide unbiased indices of the relative abundance for species occurring in the waters from Florida to the Mid-Atlantic. Data from this survey were used to examine the trends in relative abundance of blacktip sharks in the waters off the east coast of the United States. The majority (72%) of the catch consisted of mature males and the proportion of sets with positive catch (at least one blacktip shark caught) was 26%. Catch per unit effort (CPUE) in number of sharks per 100 hook hours was examined for each year of the bottom longline survey: 1996, 1998, 2001, 2004, 2007, 2009, 2012, 2015, and 2018. The CPUE was standardized using generalized linear models in a two-step delta-lognormal approach that models the proportion of positive catch with a binomial error distribution separately from the positive catch, which is modeled using a lognormal distribution. The standardized CPUE results from the NEFSC longline survey show an

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increasing trend in blacktip shark relative abundance across survey years from 1996 to 2018. This survey has been used in previous assessments for sandbar and dusky sharks (SEDAR21-DW-28) and the updates to these assessments. Review of the initial analysis indicated that the CVs in later years may be biased low. Additional analyses were requested and incorporation of an additional variable corrected the problem.

Decision: The Group recommended this series be retained for use in the assessment.

South Carolina Department of Natural Resources SEAMAP Longline Survey (SEDAR65-DW11)

The South Carolina Department of Natural Resources (SCDNR) Southeast Area Monitoring and Assessment Program (SEAMAP) multispecies survey started in 2007 as a replacement for the prior SCDNR red drum longline survey. This survey was developed to increase the geographical and seasonal coverage of the prior survey and move it from a fixed-station to a random-stratified multispecies survey. Thirty sites are randomly selected from a predetermined list of sites (40-100 sites/strata) during each sampling period (2- month periods: March/April, May/June, July/August, September/October, and November/December). Each of four strata (Winyah Bay, Charleston Harbor, St. Helena Sound and Port Royal Sound) is sampled once during each time period. The catch per unit effort (CPUE) from the SCDNR SEAMAP longline survey was used to examine blacktip shark relative abundance in South Carolina's estuarine and nearshore waters. The CPUE was standardized using generalized linear models in a two-step delta-lognormal approach that models the proportion of positive catch with a binomial error distribution separately from the positive catch, which is modeled using a lognormal distribution. The standardized CPUE results from the SCDNR SEAMAP longline survey indicate a variable but slight increasing trend overall in blacktip shark relative abundance across survey years from 2007 to 2018 with a notable peak in 2013. This peak was also seen in the SCDNR long-gillnet survey (SEDAR65-WP-07) and, not as pronounced, in the COASTSPAN longline survey (SEDAR65-WP-08). The Group noted that the survey suffers from limited spatial coverage but has good temporal coverage. The survey is also based on a stratified random design located within the core of the species range. This survey was previously used in stock assessments for Atlantic sharpnose sharks (SEDAR34-WP36) and the sandbar shark update (SEDAR 54).

Decision: The Group recommended that this series be retained for use in the assessment.

South Carolina Department of Natural Resources Drumline Survey (SEDAR 65 – DW21)

The SCDNR drumline survey has been conducted since 2013 and is currently an ongoing program. It uses an index station protocol to sample for large coastal sharks in estuarine waters as well as sounds in SC. Sampling typically occurs from April through November. Data from

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this survey were used to look at trends in relative abundance for mature blacktip sharks. A binomial model was developed using the drumline data because of the use of a single hook fished on each line. Year and month were retained in the final model. Nominal and standardized presence/absence results from this survey indicate a stable or slightly increasing population across the survey timeframe. The Group discussed the fact that this time series is not very long temporally. However, the survey samples mostly large juveniles and adults with a high proportion positive of catches.

Decision: As there are few series that sample this portion of the population exclusively, the Group recommended the series be retained.

South Carolina Department of Natural Resources Red Drum Survey (SEDAR65-DW11)

The South Carolina Department of Natural Resources (SCDNR) conducts a long-term monitoring program for adult red drum, *Sciaenops ocellatus,* in the coastal waters of South Carolina and regularly has shark bycatch. A fixed-station longline survey was conducted from 1994 to 2006 before being modified to the aforementioned multispecies random stratified survey. Catch per unit effort (CPUE) in number of sharks per 100 hook hours was used to examine blacktip shark relative abundance. The proportion of SCDNR red drum survey sets with positive catch (at least one blacktip shark caught) was 13%. The CPUE was standardized using generalized linear models in a two-step delta-lognormal approach that models the proportion of positive catch with a binomial error distribution separately from the positive catch, which is modeled using a lognormal distribution. The standardized CPUE results from the SCDNR red drum longline survey indicate a variable but slight decreasing trend overall in blacktip shark relative abundance across survey years from 1996 to 2006. This survey was previously used in stock assessments for sandbar and blacknose sharks (SEDAR21-WP-30) and Atlantic sharpnose sharks (SEDAR34-WP-36). While the series is not designed for sharks, blacktip sharks comprise a good proportion of the catch and the series is long term.

Decision: The Group recommended that this series be retained for use in the assessment.

Georgia Department of Natural Resources SEAMAP Longline Survey (SEDAR65-DW12)

In 2006 a pilot study to work out the logistics of a Georgia Department of Natural Resources (GADNR) Southeast Area Monitoring and Assessment Program (SEAMAP) longline survey was conducted. The objectives of this survey are to develop a state specific sampling protocol that provides a fisheries independent index of abundance for adult red drum, to sample adult red drum and develop information on catch per unit effort (CPUE) and size, to collect migratory and stock identification data on adult red drum, to evaluate age composition and reproductive status

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of red drum <90 cm total length, and to disseminate accomplishments and results to the Atlantic States Marine Fisheries Commission (ASMFC) and the National Marine Fisheries Service (NMFS) for inclusion in stock assessment efforts. The GADNR SEAMAP survey gear also targets multiple coastal shark species. The survey design was finalized and sampling began in 2007. This survey has been previously used in stock assessments for Atlantic sharpnose shark when combined with the SCDNR SEAMAP survey and details on the combined index are available in the addendum to SEDAR34-WP-34 and SEDAR34-WP-36.

Differences in bait and hook type were found to have a significant effect on blacktip shark catches, but could not be accounted for in the model since the differences did not overlap within years. The CPUE was standardized using generalized linear models in a two-step delta-lognormal approach that models the proportion of positive catch with a binomial error distribution separately from the positive catch, which is modeled using a lognormal distribution. The resulting relative abundance has an overall decreasing trend due to the high first year and is likely influenced by the change in bait and hook type. The highest estimate is in 2007, the only year when both mixed bait sets and mixed hook sets were used. Following this year there is a variable but overall increasing trend from 2008 to 2015 when the bait and hook type are held constant (squid bait, mixed hooks). There is another dip in 2016 when small hooks are removed but mixed baits are returned. The trend increases again for the remainder of the time series while the mixed baits and large hooks are held constant from 2016 to 2018. Running the analyses again without 2007 produces an overall increasing trend but retains the variability.

Decision: Because of the variability in methods and their influence on the abundance trend, the Group recommended this series not be retained for use in the stock assessment.

COASTSPAN Longline (SEDAR65-DW08)

In an effort to examine the use of South Carolina's, Georgia's and northern Florida's estuarine and nearshore waters as nursery areas for coastal shark species, personnel from the South Carolina Department of Natural Resources (SCDNR), Georgia Department of Natural Resources (GADNR), and the University of North Florida (UNF) in collaboration with the National Marine Fisheries Service's (NMFS) Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) survey began sampling for sharks using longline and/or gillnet methods in several of their state's estuaries and nearshore waters. Sampling in South Carolina and, on a very limited basis, in Georgia began in 1998 by SCDNR and Savannah State University, respectively. GADNR took over Georgia sampling in 2000 and UNF began sampling in northern Florida in 2008. Exploratory sampling in the early years and a shift in spatial coverage in later years limit the start of the time series to 2005. The CPUE (sharks per 100 hook hours) was standardized using a two-step delta-lognormal approach that models the proportion of positive catch with a

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binomial error distribution separately from the positive catch, which is modeled using a lognormal distribution. The standardized indices of abundance from the COASTSPAN longline survey show a slight decreasing trend overall in both total and YOY (young-of-the-year) blacktip shark relative abundance across survey years with notable peaks in 2008 and 2013. A peak in 2013 was also seen in the SCDNR Southeast Area Monitoring Program (SEAMAP) longline survey (SEDAR65-WP-11) and the COASTSPAN long-gillnet survey (SEDAR65-WP-07). This survey has been previously used in stock assessments for Atlantic sharpnose shark, bonnethead and sandbar shark (SEDAR34-WP-37, SEDAR21-WP-30).

Decision: The Group evaluated the time series and, due to the temporal and spatial coverage, decided that it should be recommended for use. After consulting with the lead stock assessment analyst, the Group also recommended the series be split into Age 0 sharks only and all life stages combined. The Age 0 sharks time series will be used as a recruitment index for the stock assessment. The Group noted that both the Age 0 and juvenile time series should not be included in a model at the same time because they are based on the same data set.

COASTSPAN Long and Short Gillnet (SEDAR65-DW07 and SEDAR65-DW10)

In an effort to examine the use of South Carolina's estuarine waters as nursery areas for coastal shark species, the South Carolina Department of Natural Resources (SCDNR) Marine Resources Division, in collaboration with the National Marine Fisheries Service's (NMFS) Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) Survey began sampling for sharks using gillnet methods (230 m x 3 m net with 10.3 cm stretched mesh) in several estuaries within South Carolina since 1998. A small gillnet survey (45 m x 3 m with 10.3 cm stretched mesh) was added in 2006 to supplement large gillnet sampling and facilitate sampling in areas too small for the large gillnet. For both gillnet surveys the catch per unit effort (CPUE) in number of sharks per net hour was used to examine blacktip shark trends in abundance. The gillnets are set on station and inspected (hauled) multiple times and re-set to reduce bycatch before the final haulback. For the small gillnet each of these hauls is modeled separately. During long gillnet sets, once the end set gillnet anchor is deployed sometimes the net is immediately retrieved at the start set anchor to begin inspecting the net, resulting in records with short soak times (<5 minutes). To avoid unreasonably high catch rates due to these short soak times with the long gillnets, all sets conducted consecutively at the same station were grouped and the combined catch and soak times were considered a single set. The CPUEs were standardized using delta-lognormal generalized linear models. Standardized CPUE results from the COASTSPAN short-gillnet survey from 2006-2018 indicate a slight increasing trend overall in YOY blacktip shark relative abundance during the survey years with notable peaks in 2007 and 2012. The

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standardized CPUE results from the COASTSPAN long-gillnet survey from 2001-2018 also indicate a slight increasing trend overall for all life stages and YOY blacktip shark relative abundance across survey years with a notable peak in 2013. This peak was also seen in the SCDNR Southeast Area Monitoring Program (SEAMAP) longline survey (SEDAR65-WP-11) and, not as pronounced, in the COASTSPAN longline survey (SEDAR65-WP-08). These surveys have been used previously in the assessments for Atlantic sharpnose and bonnethead sharks (SEDAR34-WP-36). Although the series is limited spatially and based on a fixed station sampling design, the time series is located within the core of the species range.

Decision: The Group recommended this series be retained for use in the assessment.

4.4 Research Recommendations

1. Explore the utility of combining multiple indices into one index using the Bayesian hierarchical model (Conn, 2009) or other similar methodology. The data series that could potentially be combined are:
    - For Age 0
        - Coastspan Longline, Coastspan Gillnet Short Net, Coastspan Gillnet Long Net
    - For All Ages
        - NEFSC Bottom Longline, Shark Bottom Longline Observer, Virginia Institute of Marine Science, SEAMAP Longline, SCDNR Red Drum Longline
2. Investigate alternate methods in future assessments for standardizing indices of abundances outside the Delta-Lognormal method (Lo et al. 1992).
3. Explore the utility of standardized age-0 indices as recruitment indices in the stock assessment model.

4.5 Literature Cited

Aitchison, J. (1955). On the distribution of a positive random variable having a discrete probability mass at the origin. Journal of the American Statistical Association 50: 901-908.

Conn, P.B. (2009). Hierarchical analysis of multiple noisy abundance indices. Canadian Journal of Fisheries and Aquatic Sciences, 67:108-120.

Lo, N.C.H., Jacobson, L.D. and Squire, J.L. (1992). Indices of relative abundance from fish spotter data based on delta-lognormal models. Canadian Journal of Fisheries and Aquatic Sciences 49:2515-2526.

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4.6 Tables

Table 1. Elements used to evaluate the adequacy and retention of CPUE series as an input to the stock assessment model.

ELEMENT	DESCRIPTION	ACTIONS AND REASONING
1	Diagnostics	Apply defendable model validations (i.e., Q-Q plots, residuals, etc.) and consider overdispersion
2	Appropriateness of data exclusions and classifications (e.g., to identify targeted trips).	How were trips identified and was this a shark directed survey
3	Geographical coverage	How does the series compare with the range of the stock (i.e. Miami , FL to Long Island, NY)
4	Catch fraction	Change to mean proportion positives through time series
5	Length of time series relative to the history of exploitation.	The length of catch series for assessment is 1981-2018. For inclusion, survey must be established for minimum of 10 years but consideration will be given to shorter time series if they satisfy other important criteria
6	Are other indices available for the same time period?	Evaluate and pick best survey or combine them at the data level (if methods are similar)
7	Does the index standardization account for known factors that influence catchability/selectivity?	Is there an attempt to account for catchability and are the appropriate factors being considered
8	Are there conflicts between the catch history and the CPUE response?	Does the trend follow the expected performance based on management
9	Is the interannual variability outside biologically plausible bounds	Look at interannual variability: Is the trend of increase biologically plausible?
10	Are biologically implausible interannual deviations severe?	Covariates appropriate or accurate, change in design or stations appropriate
11	Assessment of data quality and adequacy of data for standardization purposes (e.g., sampling design, sample size, factors considered)	Are the covariates appropriate that were used in standardizing the data?
12	Is this CPUE time series continuous?	If not continuous, were there big changes in survey?
13	Characterization of Index uncertainty	Method of characterization (e.g., bootstrap, delta method), magnitude of uncertainty (e.g., CV)

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Table 2. Indices recommended by the Indices Working Group, including the corresponding SEDAR document number and index type (fishery independent or dependent).

Index Name	SEDAR Document Number	Index Type
SEFSC Shark Bottom Longline Observer Program	SEDAR65-DW-17	Dependent
Virginia Shark Monitoring and Assessment Program	SEDAR65-DW05	Independent
NOAA Fisheries-Northeast Fisheries Science Center-Bottom Longline Survey	SEDAR65-DW09	Independent
South Carolina Department of Natural Resources SEAMAP Longline Survey	SEDAR65-DW11	Independent
South Carolina Department of Natural Resources Drumline Survey	SEDAR 65 – DW21	Independent
South Carolina Department of Natural Resources Red Drum Survey	SEDAR65-DW11	Independent
COASTSPAN Longline	SEDAR65-DW08	Independent
COASTSPAN Long and Short Gillnet	SEDAR65-DW07 and SEDAR65-DW10	Independent

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Table 3. Recommended indices of abundance including index name and SEDAR document number. CV is the coefficient of variation for the annual index value.

Year	Shark Bottom Longline Fishery	CV	Shark Research Fishery	CV	VIMS (Original)	CV	VIMS (Catch Series)	CV	VIMS (Robust Series)	CV
1974					0.7469	0.7437				
1975					1.1763	0.5683				
1976										
1977										
1978										
1979										
1980					0.0943	0.7123				
1981					0.0504	0.8973	0.0500	0.5708		
1982										
1983					0.1169	1.2217	0.1145	0.9001		
1984										
1985										
1986										
1987					0.1604	1.0616	0.1555	0.9388		
1988					0.1707	1.0215	0.1567	1.1678		
1989										
1990					0.0266	1.3347	0.0273	0.7614	0.0260	0.7673
1991					0.0124	1.8805	0.0125	0.7852	0.0120	0.7901
1992					0.0216	1.3499	0.0219	0.7791	0.0211	0.7844
1993										
1994	19.4100	0.7100								
1995	46.0500	0.4400			0.0611	1.0088	0.0599	1.0097	0.0580	1.0125
1996	28.0300	0.4900			0.0371	1.0039	0.0370	1.0058	0.0354	1.0083
1997	2.5800	0.9300			0.0711	0.7561	0.0701	0.6663	0.0691	0.6719
1998	34.6300	0.5800			0.0045	0.4682	0.0045	1.0100	0.0043	1.0122
1999	93.8700	0.3500			0.2107	0.5608	0.2188	0.4473	0.2177	0.4551
2000	132.3400	0.4300			0.0109	0.9634	0.0105	1.0123	0.0104	1.0139
2001	46.5700	0.5100			0.0320	1.2198	0.0321	0.5688	0.0310	0.5757
2002	190.2100	0.2600			0.1087	0.6660	0.1062	0.5768	0.1016	0.5839
2003	18.2900	0.6400								
2004	52.6000	0.4000			0.0401	0.8875	0.0396	0.6480	0.0383	0.6539
2005	106.5800	0.4600								
2006	91.3500	0.5400			0.0660	0.7513	0.0635	0.5736	0.0632	0.5805
2007	27.4800	0.6800			0.0440	0.8838	0.0436	0.6490	0.0422	0.6553
2008			94.6000	0.5800	0.2774	0.4119	0.2787	0.3208	0.2771	0.3282
2009			108.4100	0.3500	0.0926	1.0833	0.0897	0.6293	0.0861	0.6401
2010			69.9500	0.2600	0.0842	0.7442	0.0835	0.5156	0.0820	0.5228
2011			74.7700	0.2600	0.0497	1.0076	0.0511	0.7615	0.0512	0.7667
2012			176.6500	0.4200	0.0328	1.0677	0.0322	0.6537	0.0309	0.6608
2013			100.0900	0.5100	0.2257	0.5884	0.2209	0.5254	0.2235	0.5330
2014			213.3700	0.2400	0.0760	0.8985	0.0763	0.3929	0.0744	0.4006
2015			144.8000	0.3000	0.0279	0.9791	0.0285	0.4818	0.0279	0.4876
2016			124.3600	0.3700	0.0844	0.6713	0.0843	0.2961	0.0825	0.3038
2017			266.4400	0.3200	0.0944	0.6746	0.0945	0.4609	0.0921	0.4681
2018			42.1300	0.5000	0.1238	0.6438	0.1230	0.3593	0.1212	0.3670

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Table 3. Cont.: Recommended indices of abundance including index name and SEDAR document number. CV is the coefficient of variation for the annual index value.

Year	NMFS-NEFSC Bottom Longline	CV	SCDNR SEAMAP LL	CV	SCDNR Red Drum Survey	CV	SCDNR Drumline Survey	CV	Coastspan Longline (All ages)	CV
1974										
1975										
1976										
1977										
1978										
1979										
1980										
1981										
1982										
1983										
1984										
1985										
1986										
1987										
1988										
1989										
1990										
1991										
1992										
1993										
1994										
1995										
1996	0.0032	1.0173			1.2274	0.6400				
1997					1.2726	0.6040				
1998	0.0315	0.4825			0.4577	0.6102				
1999					0.3944	0.8652				
2000					1.3585	0.4409				
2001	0.0131	0.5612			0.3487	1.2696				
2002					0.5890	0.7197				
2003					1.0194	0.5536				
2004	0.0310	0.4841			0.4589	0.7920				
2005					0.3098	0.9044			3.0231	0.2860
2006					1.3158	0.4324			1.5217	0.3796
2007	0.0008	1.9006	1.7214	0.3529					1.2054	0.5417
2008			0.8375	0.5103					3.4409	0.3795
2009	0.0263	0.6062	1.2200	0.3571					1.9428	0.2760
2010			0.8986	0.2888					2.0045	0.2486
2011			1.5343	0.2856					1.6024	0.2641
2012	0.1218	0.3836	1.5427	0.2560					2.6903	0.2341
2013			2.7065	0.2112			0.1655	0.2253	3.6962	0.2047
2014			1.7660	0.2006			0.2058	0.1612	1.9738	0.2960
2015	0.1485	0.3513	1.9826	0.2068			0.1741	0.1799	1.4657	0.2989
2016			0.9741	0.2685			0.1359	0.1803	1.7694	0.2462
2017			1.1241	0.2341			0.1854	0.1654	1.5851	0.2819
2018	0.3183	0.2468	1.4639	0.2194			0.2067	0.1860	1.0245	0.3064

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Table 3. Cont.: Recommended indices of abundance including index name and SEDAR document number. CV is the coefficient of variation for the annual index value.

Year	Coastspan Longline (Age 0)	CV	Coastspan Gillnet Long Net (All age)	CV	Coastspan Gillnet Long Net (Age 0)	CV	Coastspan Gillnet Short Net (Age 0)	CV
1974								
1975								
1976								
1977								
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								
2001			0.7976	0.2830	0.7001	0.3356		
2002			0.3089	0.4301	0.2226	0.6537		
2003			0.9009	0.3185	0.8146	0.3725		
2004			0.1496	1.1760	0.1451	1.3325		
2005	2.8189	0.3037	0.8355	0.4021	0.9064	0.4633		
2006	1.4128	0.4026	1.1390	0.3691	1.0225	0.3704	0.4978	0.4516
2007	1.2135	0.5519	0.4859	0.4220	0.4904	0.5854	1.4930	0.5187
2008	2.8834	0.3891	0.5520	0.4518	0.5644	0.5376	0.3010	1.1630
2009	1.8817	0.3067	1.0722	0.3632	0.7493	0.4790	0.3086	1.1235
2010	1.7531	0.2862	1.0557	0.4180	0.6152	0.5843	0.5651	0.4762
2011	1.5969	0.2827	0.7263	0.4749	0.2755	0.7552	0.6010	0.4853
2012	2.6555	0.2460	0.9271	0.7757	0.8465	0.9029	1.0683	0.2875
2013	3.4398	0.2168	3.6840	0.3590	3.8455	0.4166	0.8272	0.4261
2014	1.8919	0.3177	1.2765	0.4608	0.8915	0.5349	0.2497	0.6939
2015	0.8971	0.3923	0.7070	0.3013	0.4001	0.5242	0.5397	0.4586
2016	1.6699	0.2699	0.6067	0.5169	0.1181	0.8992	0.2959	0.5259
2017	1.6069	0.2941	1.3203	0.4210	1.3561	0.4949	0.6881	0.4061
2018	1.0313	0.3190	1.4201	0.3151	0.9674	0.4563	1.2167	0.3111

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4.7 Figures

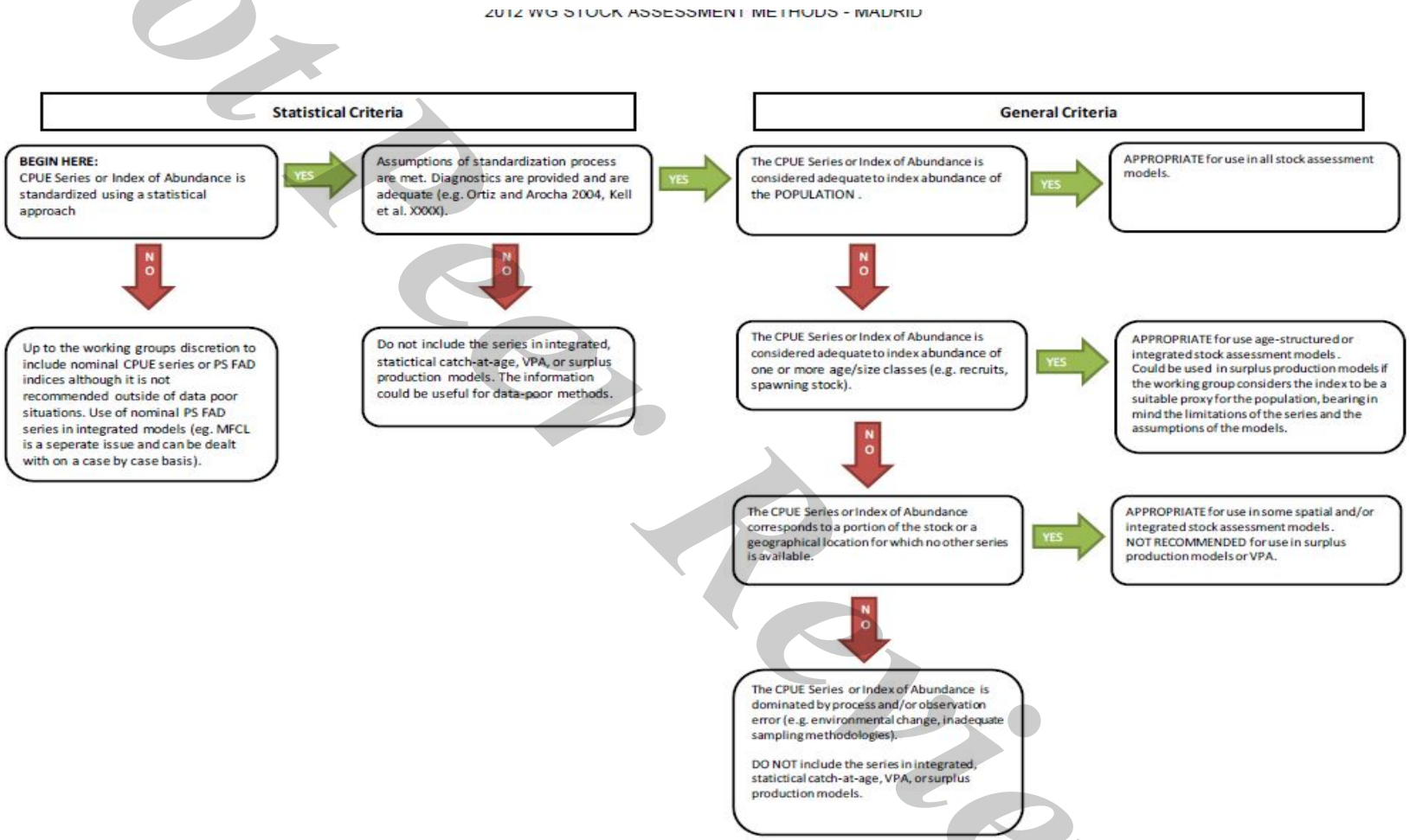

Figure 1. A flowchart to facilitate the appropriate application of CPUE series to stock assessment models used by ICCAT.

Figure 1. Flowchart developed by ICCAT and used as a method to evaluate indices of abundance as an input to the stock assessment model

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Figure 2. Approximate linear coverage of specific abundance indices for Atlantic blacktip shark.

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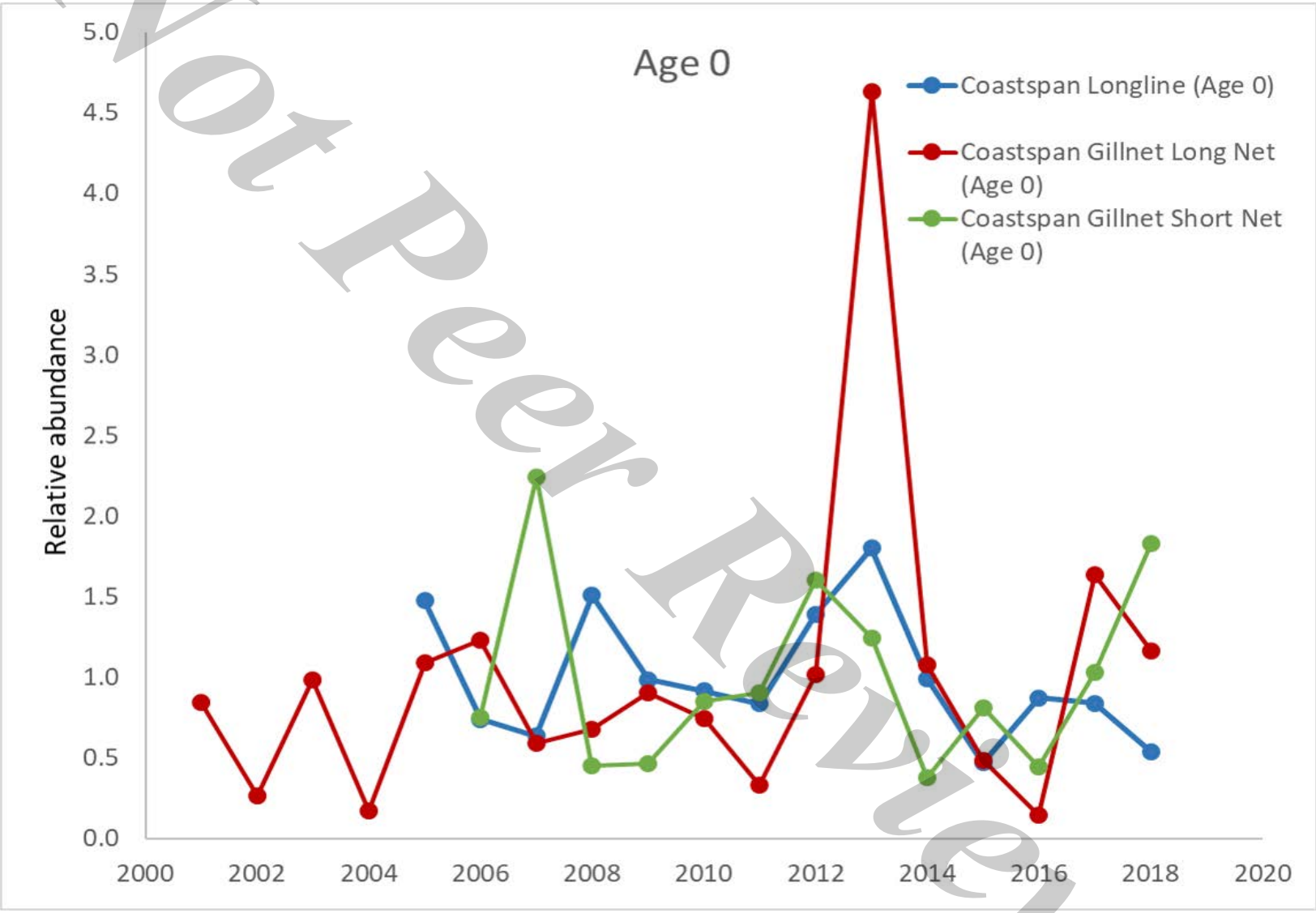

Figure 3. Plot of mean annual values of relative abundance for each time series recommended for the Atlantic Ocean stock of Age 0 blacktip shark by the Indices Working Group. For each index, values were converted to a common scale for plotting purposes by dividing mean annual values for a time series by the average of all mean annual values for that specific time series.

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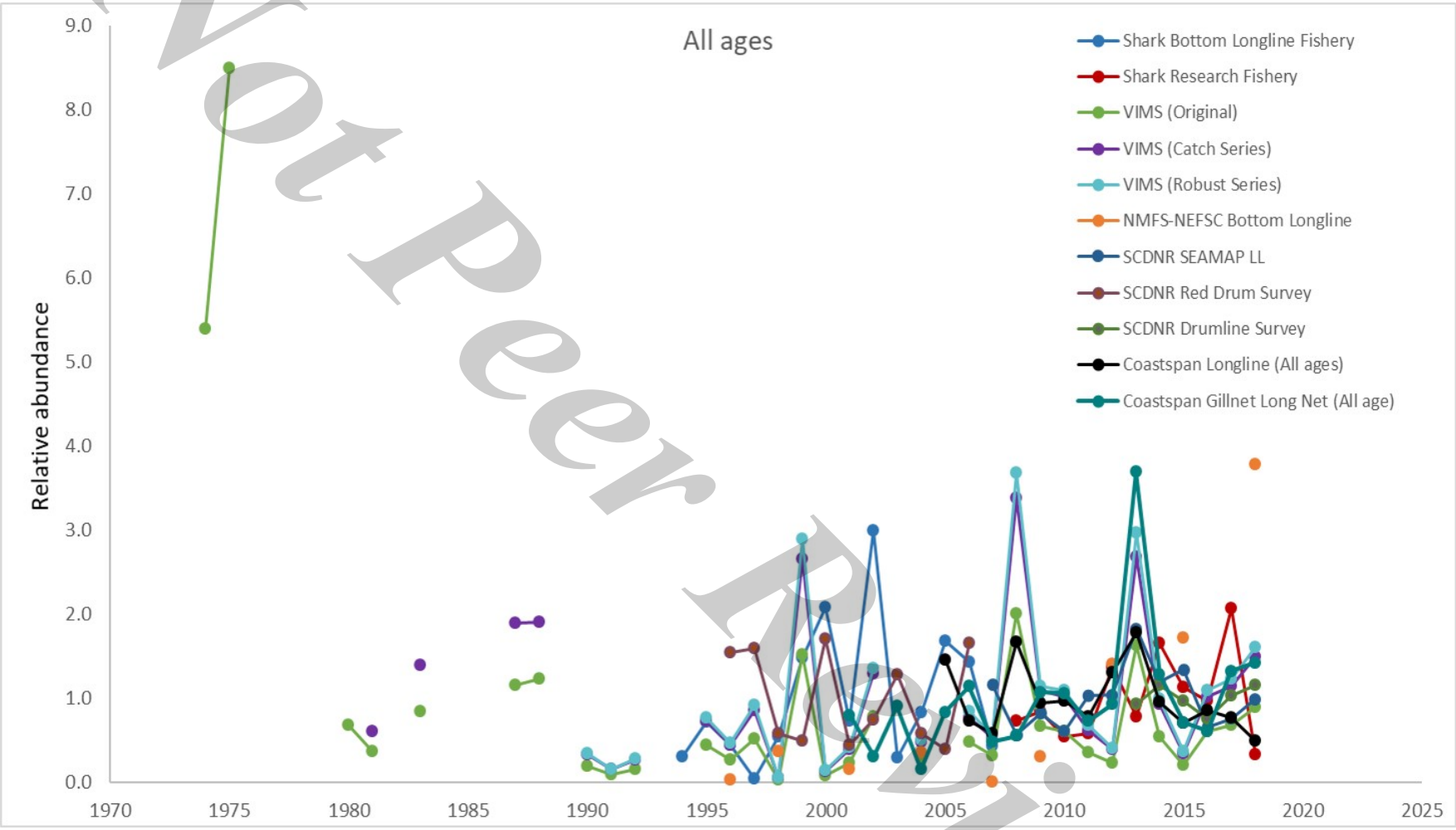

Figure 4. Plot of mean annual values of relative abundance for each time series recommended for the Atlantic Ocean stock for all ages of blacktip shark by the Indices Working Group. For each index, values were converted to a common scale for plotting purposes by dividing mean annual values for a time series by the average of all mean annual values for that specific time series

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5. TOR # 7 Ecological Factors Affecting Blacktip Sharks

Assessment Term of Reference 7 requires the SEDAR group to "Identify and describe ecosystem, climate, species interactions, habitat considerations, and/or episodic events that would be reasonably expected to affect population dynamics." As highly migratory, long-lived marine fishes with protracted life histories, sharks can be impacted by a wide range of ecological factors and changes in their environments. The panel discussed specific ecological factors with the potential to affect population dynamics of Atlantic blacktip sharks and constructed the following list, not in order of priority or impact:

- Changes in blacktip shark prey and predator abundance and trophic interactions
- Temperature changes in blacktip habitat and how those affect prey/predator distribution and the sharks themselves, including the sharks' range, migration, and reproductive biology
- Habitat alterations such as beach renourishment and dredging that affect quality and availability of habitat critical to blacktip shark life stages
- Environmental contaminants from anthropogenic pollutants, currently a low risk factor for blacktip sharks but with the potential to have a greater effect on shark health and population status
- Harmful algal blooms, hypoxia, and other human-influenced ecological disruptions that impact blacktip shark habitat
- Hurricanes and other large weather events that cause disturbances in blacktip shark habitat
- Changes in patterns of discarded bycatch from trawlers in areas where previously blacktip sharks would aggregate near the boats

Ideally, an ecosystem-based management approach would take all these various factors into consideration to assure sustainability of the Atlantic blacktip shark stock. To achieve that goal, and to improve the stock assessment process for this shark, the group recommends the following research recommendations, not in rank order:

- Quantify seasonal and spatial distribution of prey for Atlantic blacktip sharks, and use stomach contents analysis to determine the relative importance of different forage fish species in the diet. This is important in the New York Bight area where blacktip sharks were not previously abundant and are now exploiting resources that have not been previously subjected to this level of exploitation. It might also be important in the southern end of their range because, although anglers state that blacktip sharks are following baitfish down the coast, the peak in baitfish abundance occurs a few months before the blacktip sharks arrive off south Florida.
- Model the effects of changing stock distribution, due to ecological factors, on the results of fixed-station, fisheries-independent surveys for stock assessment. In general such surveys assume that changes in relative abundance are a result of changing stock size, rather than shifts in range and distribution as a result of ecological change. Modeling how ecological factors affect stock distribution allows for better quantification of stock abundance as measured by fixed-station surveys.
- Conduct research on ecological changes in blacktip shark inshore nursery areas on the U.S. Atlantic coast and how those changes have affected recruitment.
- Assess the levels of environmental contaminants in blacktip sharks and how those affect the sharks' physiology and reproductive success.
- Study the response of blacktip sharks to harmful algal blooms and how those phenomena affect the status of the Atlantic stock of these sharks.

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6. Appendix 1 Length Frequency

Materials and Methods

Length composition data for Atlantic blacktip sharks were available from both fishery-dependent and fishery-independent surveys from 1974-2019 (n=17, Table 1). Data were recorded by fisheries research biologists, scientific observers, and recreational fishermen (e.g., logbook data). Length data used in analyses from fishery-dependent surveys were sourced from the Marine Recreational Information Program (MRIP), Southeast Region Head Boat Survey (SRHS), South Carolina Department of Natural Resources (SCDNR) shore-based fishing logbook data, Southeast Fisheries Science Center (SEFSC) Panama City Laboratory Shark Bottom Longline Observer Program (SBLOP), SEFSC Panama City Gillnet Observer Program (GNOP), and the University of Florida longline program (i.e., bottom longline program before it was taken over by SEFSC-SBLOP). Length data from fishery-independent surveys were sourced from the Virginia Shark Monitoring and Assessment Program (VASMAP), SEFSC Mississippi Lab bottom longline, Northeast Fishery Science Center (NEFSC) longline, Southeast Area Monitoring and Assessment Program (SEAMAP) Longline from Georgia-University of North Florida, SCDNR-SEAMAP longline, SCDNR drumline, SCDNR red drum longline, Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) longline, COASTSPAN gillnet, Florida Atlantic University (FAU) drumline/longline, and SCDNR small gillnet survey.

Data on Atlantic blacktip shark size, sex, capture location, and date were recorded for each specimen. For analyses purposes, data were restricted to the western Atlantic. Fork length (FL) measurements in centimeters (cm) were used to create length compositions and data were filtered to include only true measurements (i.e., no estimated measurements). Length data were omitted from analyses if it exceeded biologically plausible measurements for this species; age-0 length is reported to be around 40 cm FL and maximum size was around 180 cm FL (S65-DW02). Data were binned into size classes of 5 cm FL increments and subset by sex. Data matrices were then created for each sex to include the proportion of animals in each size bin per year for input into Stock Synthesis. Length-frequency compositions histograms were created for males, females, and combined sexes of Atlantic blacktip shark. Age at 50% maturity was indicated by vertical bars and was designated as 123.05 cm FL for females and 115.15 cm FL for males. Each survey used in this report was analyzed separately.

Results

A total of 10,945 records of Atlantic blacktip shark specimens were considered within the scope of this study in the years of 1974-2019. Fishery-dependent surveys contributed 6,585 specimens and fishery-independent surveys contributed 4,360 specimens (Table 1). Atlantic blacktip sharks ranged in size from 40 cm FL to 180 cm FL, covering a wide range of the species' size range from young-of-the-year to adult sharks. Variability in the size distribution and numbers of recorded specimens was present among the different surveys (Table 1). Length-frequency histograms indicate a wide range of sizess for blacktip sharks captured in each survey (Figure 1).

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6.1 Tables

Table 1. Fishery-dependent and fishery-independent surveys that were used to create length compositions for Atlantic blacktip sharks.

Data Source	Year	Sample Size
Fishery Dependent		
Marine Recreational Information Program (MRIP)	1981-2018	781
Southeast Region Head Boat Survey (SRHS)	1989-2018	107
South Carolina Department of Natural Resources (SCDNR) Shore Fishing	2013-2018	166
Southeast Fisheries Science Center (SEFSC) Panama City Lab Shark Bottom Longline Observer Program (SBLOP)	2005-2018	3,708
Southeast Fisheries Science Center (SEFSC) Panama City Lab Gillnet Observer Program (GNOP)	1999-2018	124
University of Florida Shark Bottom Longline Observer Program[1]	1994-2005	1,699
	Total	**6, 585**
Fishery Independent		
Virginia Shark Monitoring and Assessment Program (VASMAP)	1974-2018	324
Southeast Fisheries Science Center (SEFSC) Mississippi Laboratory Bottom Longline	1996-2018	19
Northeast Fisheries Science Center (NEFSC) Bottom Longline	1996-2018	638
Southeast Area Monitoring and Assessment Program (SEAMAP) Longline (Georgia-University of North Florida)	2007-2018	218
South Carolina Department of Natural Resources (SCDNR) SEAMAP Longline	2007-2018	1,032
South Carolina Department of Natural Resources (SCDNR) Drumline	2013-2019	302
South Carolina Department of Natural Resources (SCDNR) Red Drum longline	1994-2008	301
Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) Longline	1999-2019	641
Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) Gillnet	1999-2019	487
Florida Atlantic University Drumline/Longline	2014-2019	123
South Carolina Department of Natural Resources (SCDNR) Small Gillnet Survey	2006-2019	275
	Total	**4, 360**

[1] From 1994-2005, the shark bottom longline observer program was administered by the Florida Museum of Natural History at the University of Florida

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6.2 Figures

Figure 1. Length-frequency distributions of Atlantic blacktip sharks from fishery-dependent and fishery-independent surveys. Red vertical lines indicate 50% maturity for females (123 cm FL) and blue vertical lines indicate 50% maturity for males (115 cm FL).

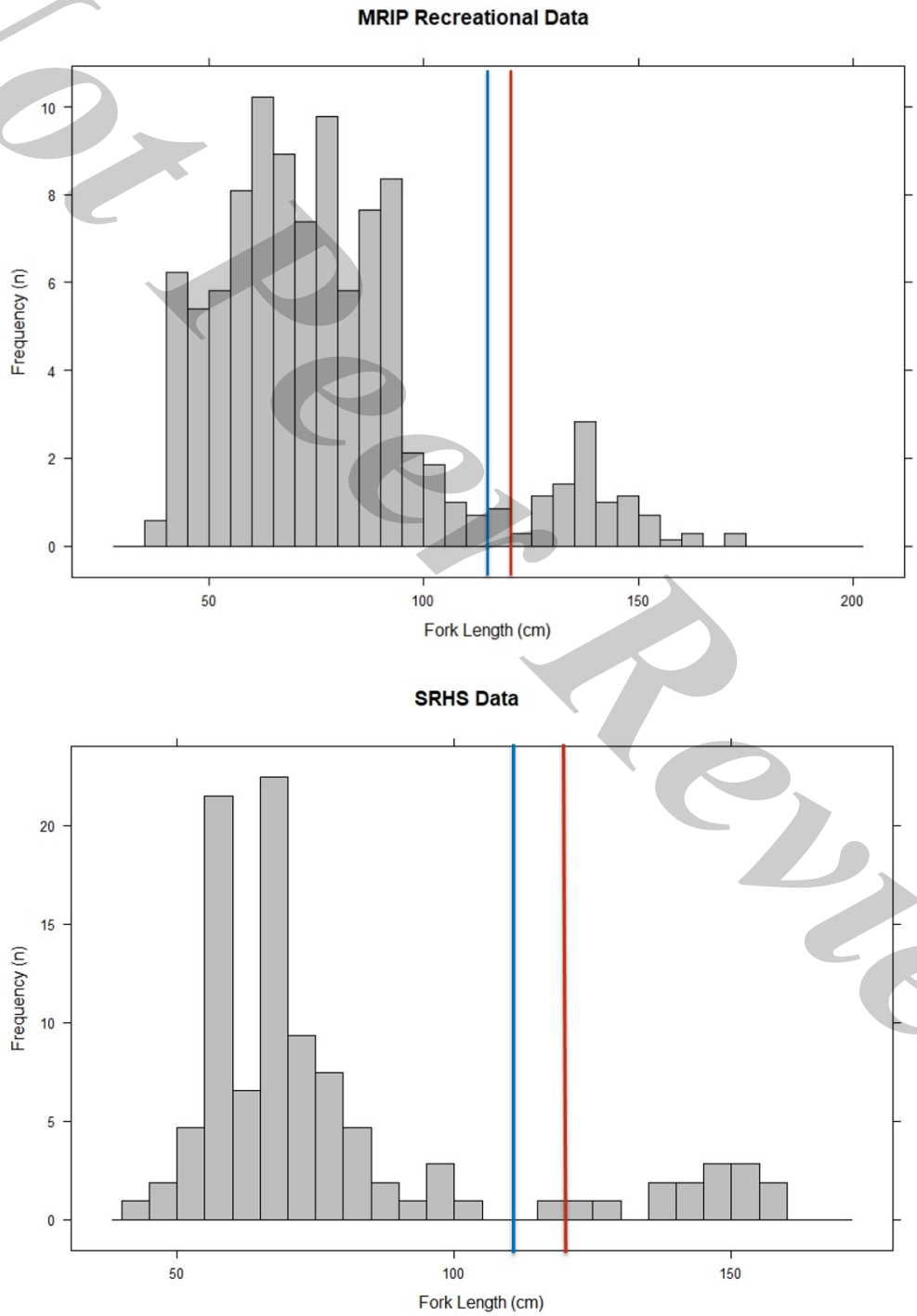

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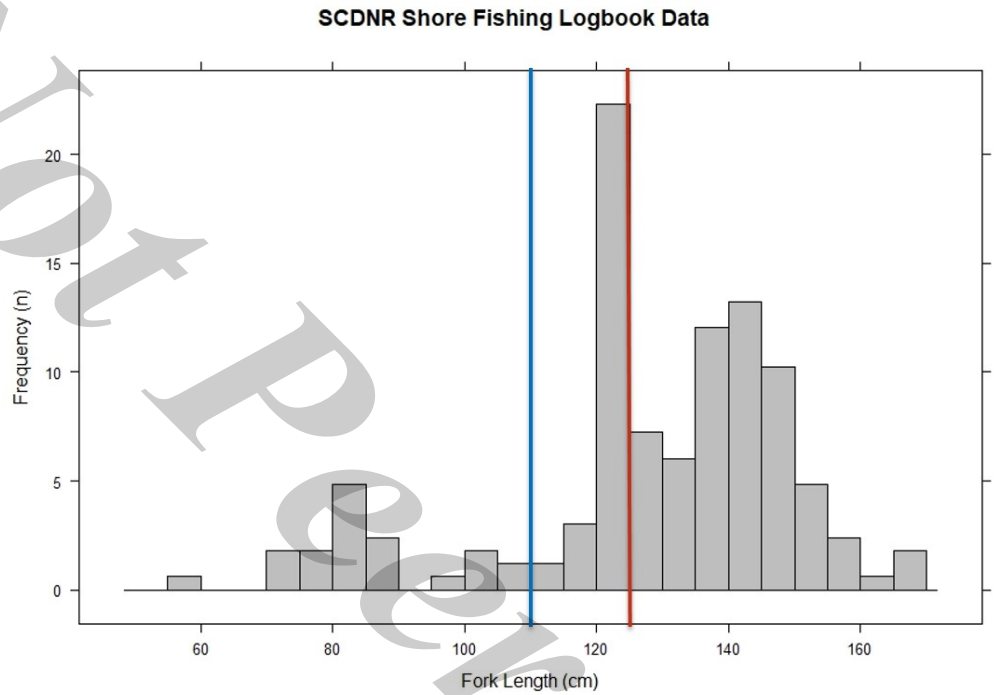
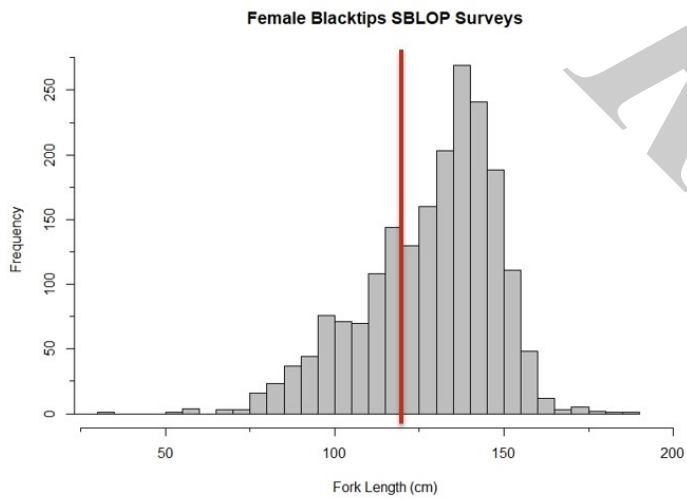
Figure 1 Continued:. Length-frequency distributions of Atlantic blacktip sharks from fishery-dependent and fishery-independent surveys. Red vertical lines indicate 50% maturity for females (123 cm FL) and blue vertical lines indicate 50% maturity for males (115 cm FL).





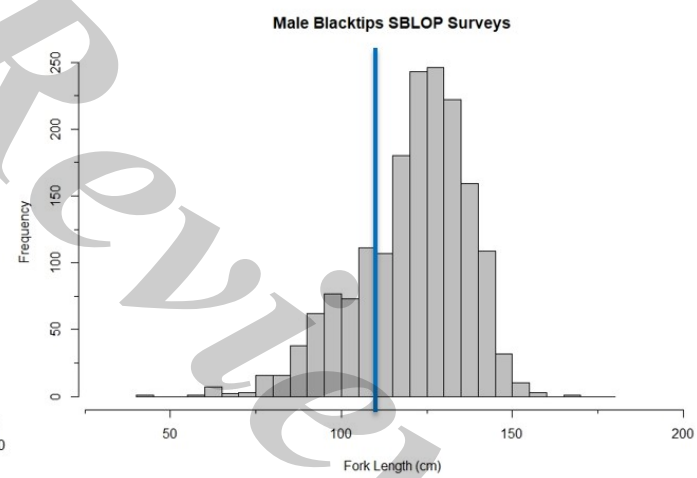


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Figure 1 Continued:. Length-frequency distributions of Atlantic blacktip sharks from fishery-dependent and fishery-independent surveys. Red vertical lines indicate 50% maturity for females (123 cm FL) and blue vertical lines indicate 50% maturity for males (115 cm FL).

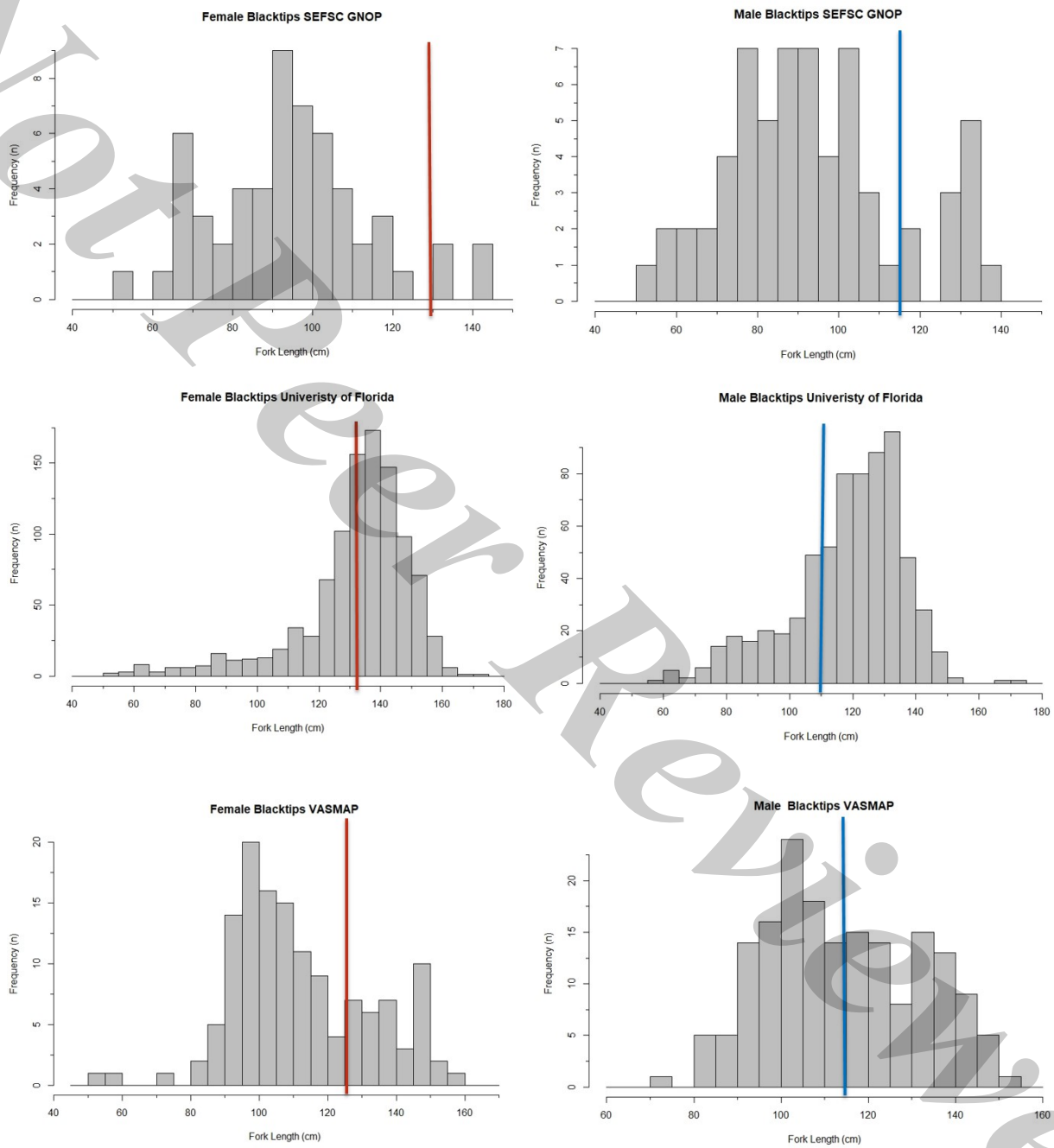

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Figure 1 Continued:. Length-frequency distributions of Atlantic blacktip sharks from fishery-dependent and fishery-independent surveys. Red vertical lines indicate 50% maturity for females (123 cm FL) and blue vertical lines indicate 50% maturity for males (115 cm FL).

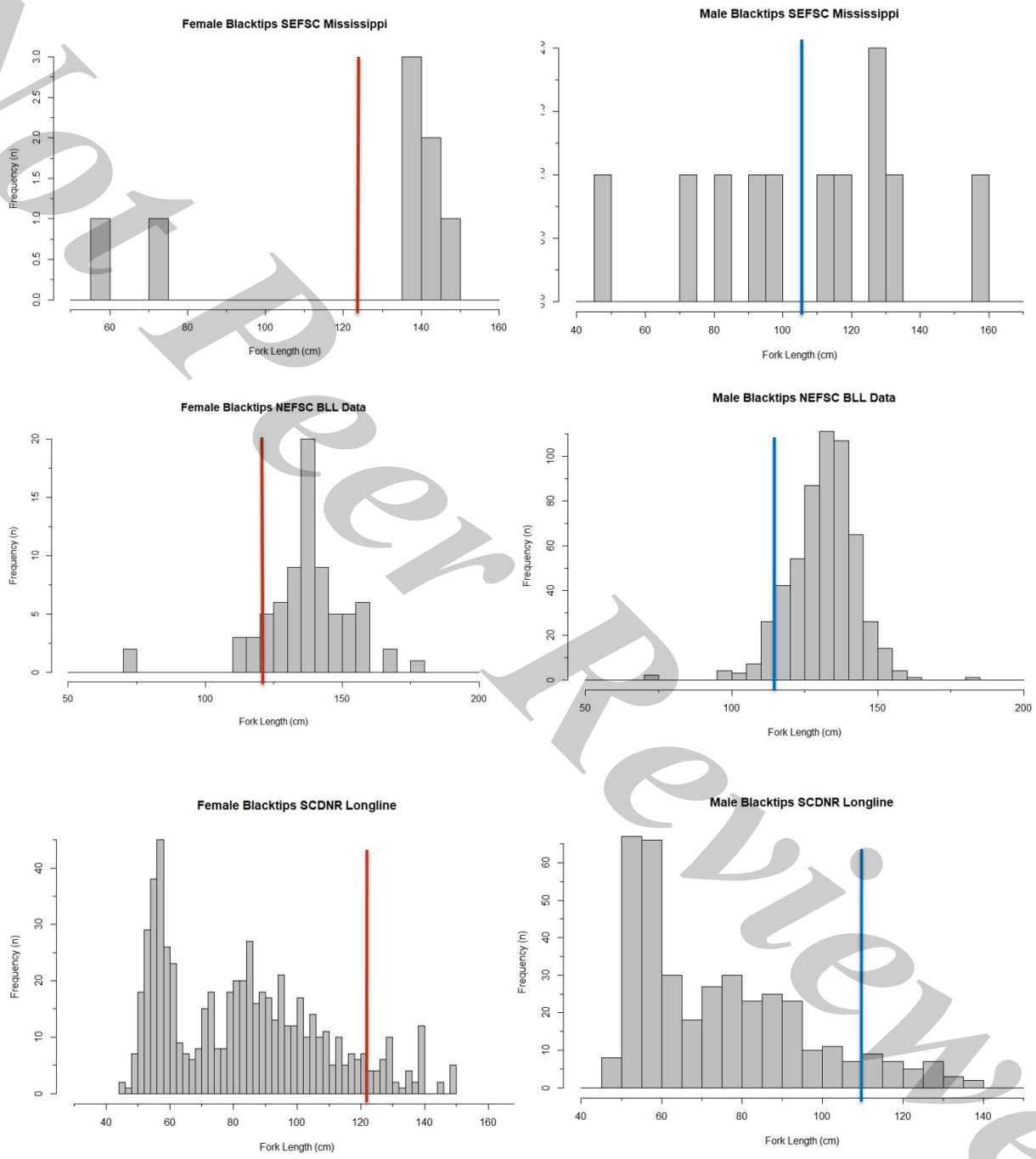

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Figure 1 Continued:. Length-frequency distributions of Atlantic blacktip sharks from fishery-dependent and fishery-independent surveys. Red vertical lines indicate 50% maturity for females (123 cm FL) and blue vertical lines indicate 50% maturity for males (115 cm FL).

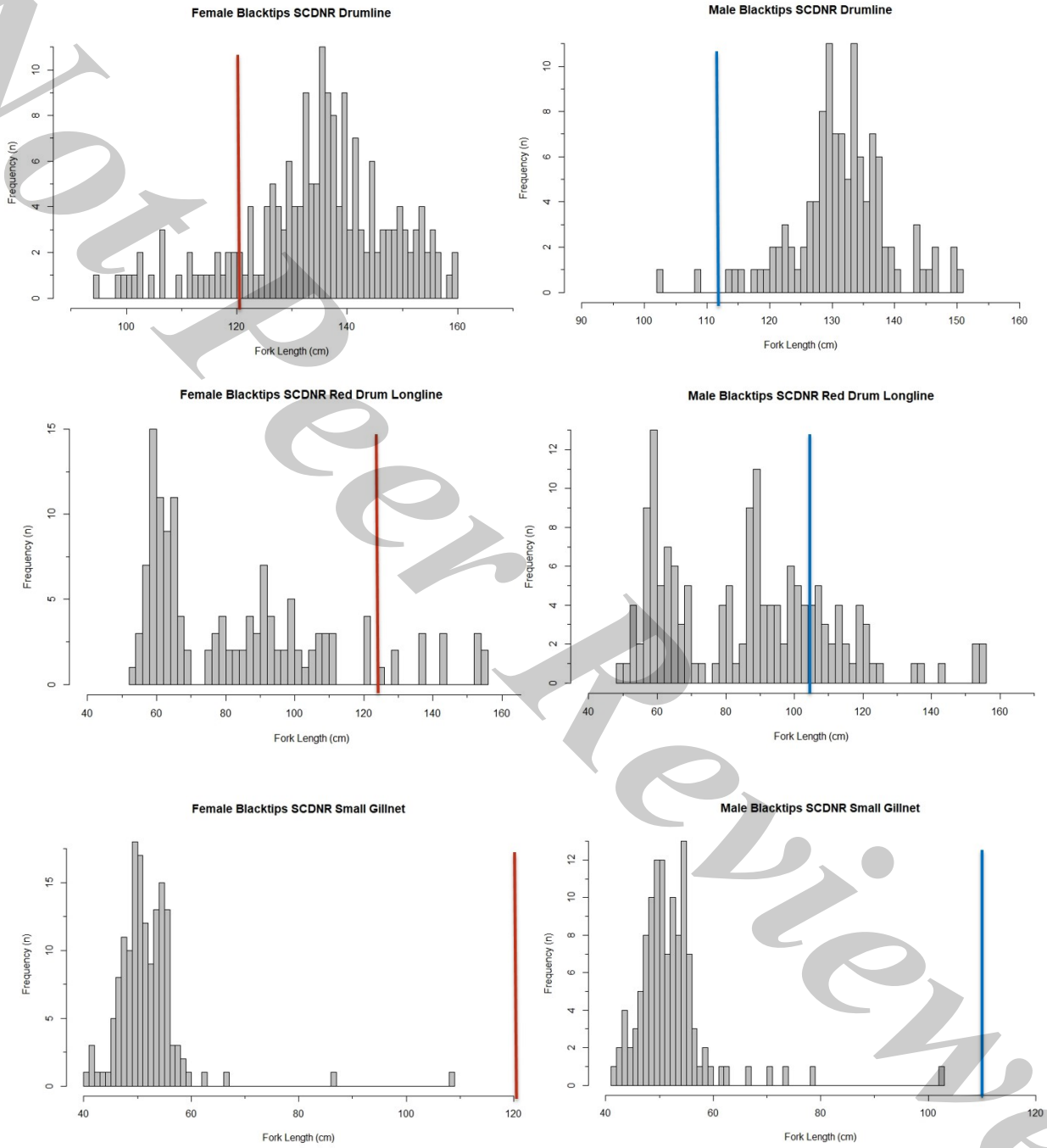

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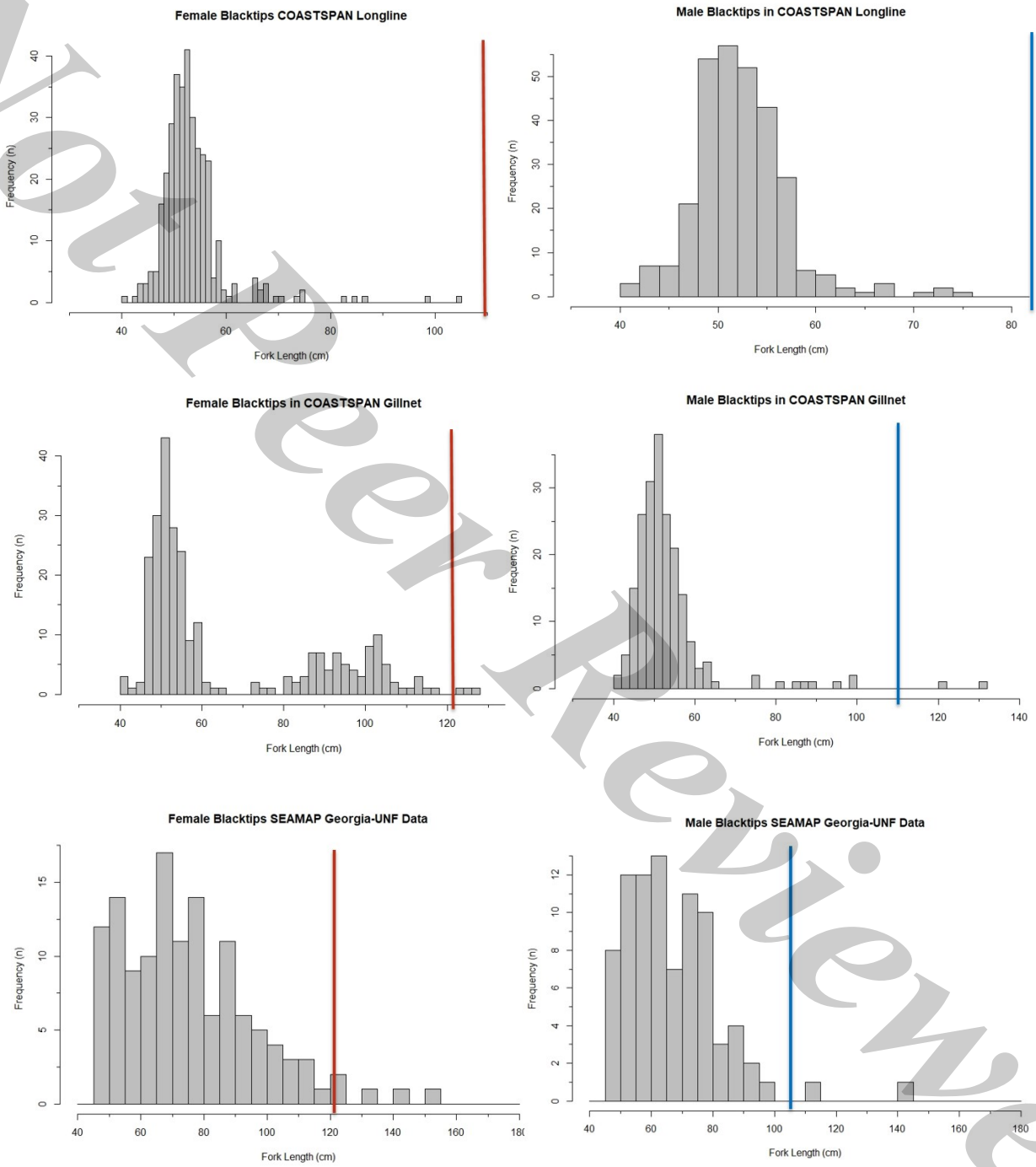
Figure 1 Continued:. Length-frequency distributions of Atlantic blacktip sharks from fishery-dependent and fishery-independent surveys. Red vertical lines indicate 50% maturity for females (123 cm FL) and blue vertical lines indicate 50% maturity for males (115 cm FL).



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