# SEDAR

Southeast Data, Assessment, and Review

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SEDAR 77

# HMS Hammerhead Sharks

Data Workshop Final Report

**April 2022**

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 77 Data Workshop meeting was held December 13-17, 2021 via webinar. Three data webinars were held prior to the workshop on September 23, October 20th and November 9th, 2021. Two additional webinars were held post the Data workshop on January 13 and January 31, 2022.

## 1.2 Terms of Reference

1. Definition of assessment unit stock will be developed through the Hammerhead Sharks Stock ID process and will be added to TORs once that process is complete.
2. Review, discuss, and tabulate available life history information for each stock being assessed.
    a. Evaluate age, growth, natural mortality, and reproductive characteristics
    b. Provide appropriate models to describe population- and area-specific (if warranted) growth, maturation, and fecundity by age, sex, 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, where applicable.
3. Provide measures of population relative abundance that are appropriate for these stock assessments.
    a. Consider all available and relevant fishery-dependent and fishery-independent data sources
    b. Document all programs evaluated; address program objectives, methods, coverage, sampling intensity, and other relevant characteristics.
    c. Provide maps of fishery-dependent and fishery independent survey coverage.
    d. Develop fishery and survey CPUE indices by appropriate strata (e.g., age, size, area, and fishery) and include measures of precision and accuracy.
    e. Document pros and cons of available indices regarding their ability to represent abundance.
        i. Consider potential species identification issues between hammerhead shark species and, if present, whether the issue was adequately addressed during index development.
    *f.* Categorize the available indices into Recommended and Not Recommended; provide justifications for the categorization.
    g. For recommended indices, document any known or suspected spatial or temporal patterns not accounted for by standardization.
    h. Provide appropriate measures of uncertainty for the abundance indices to be used in stock assessment models.
4. Provide commercial catch statistics for each stock being assessed, including landings, dead discards, live discards, and potential post-release mortality in both weight and number. Consider species identification issues between hammerhead shark species and correct for these instances as appropriate.
    a. Evaluate and discuss the adequacy of available data for accurately characterizing

landings and discards by fishery sector or gear.
   b. Provide length and age distributions for both landings and discards if feasible.
   c. Provide maps of fishery effort and harvest by fishery sector or gear.
   d. Provide estimates of uncertainty around each set of commercial landings (if possible) and discard estimates.
   e. Provide estimates of discard mortality rate by gear.
5. Provide recreational catch statistics for each stock being assessed, including landings, dead discards, live discards, and potential post-release mortality in both weight and number. Consider species identification issues between hammerhead shark species and correct for these instances as appropriate.
   a. Evaluate and discuss the adequacy of available data for accurately characterizing landings and discards by fishery sector or gear.
   b. Provide length and age distributions for both landings and discards if feasible.
   c. Provide maps of fishery effort and harvest by fishery sector or gear.
   d. Provide estimates of uncertainty around each set of recreational landings and discard estimates.
   e. Provide estimates of discard mortality rate by gear.
6. Identify and describe ecosystem, climate, species interactions, habitat considerations, and/or episodic events that would be reasonably expected to affect population dynamics.
   a. Report and summarize species that frequently co-occur or are associated with hammerhead sharks from survey data, if possible.
   b. Report and summarize species envelopes used for CPUE standardization, i.e. minimum and maximum values of environmental boundaries (e.g. depth, temperature, substrate, relief).
   c. Review and summarize available diet composition with respect to ontogeny, seasonality, and habitat, where available.
7. Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment. Include specific guidance on sampling intensity (number of length samples) and appropriate strata and coverage.
8. Prepare a Data Workshop report providing complete documentation of workshop actions and decisions in accordance with project schedule deadlines.

### 1.3 List of Participants

| Participants | Affiliation |
|---|---|
| **Assessment Development Team (ADT)** | |
| Rob Latour | Virginia Institute of Marine Science College of William and Mary |
| Beth Babcock | RSMAS U. Of Miami |
| John Carlson | HMS |
| Trey Driggers | SEFSC Mississippi Laboratory |
| **Panelists** | |
| Eric Hoffmayer | SEFSC Mississippi laboratory |
| Enric Cortes | SEFSC Panama City laboratory |
| Xinsheng Zhang | SEFSC Panama City laboratory |
| Dean Courtney | SEFSC Panama City laboratory |
| Xinsheng Zhang | SEFSC Panama City laboratory |
| Heather Baertlein | HMS |
| Alyssa Mathers | SEFSC Panama City laboratory |
| Andrea Kroetz | SEFSC Panama City laboratory |
| Cliff Hutt | HMS |
| Adam Pollack | SEFSC Mississippi laboratory |
| Cami McCandless | NEFSC Narragansett Laboratory |
| Heather Moncrief-Cox | SEFSC Panama City Laboratory |
| Michelle Passerotti | NEFSC Narragansett Laboratory |
| David Wells | Department of Biology Texas A&M University |
| David Portnoy | Department of Biology Texas A&M University |
| Bryan Frazier | SC Department of Natural Resources |
| R. Dean Grubbs | Florida State University Coastal and Marine Laboratory |
| Marcus Drymon | Mississippi State |
| Bradley Wetherbee | University of Rhode Island |
| Mahmood Shivji | NOVA Southeastern University - Halmos College of Natural Sciences and Oceanography |
| Russell Hudson | Directed Shark Fisheries, Inc. |
| Neil Hammerschlag | RSMAS U. Of Miami |
| Juan Carlos Perez-Jimenez | El Colegio de la Frontera Sur (ECOSUR) |
| Demian Chapman | Florida International University |
| James Gelsleichter | University of North Florida |
| Mark Sampson | Recreational fisherman |
| **STAFF** | |
| Kathleen Howington | SEDAR |
| Cindy Chaya | SAFMC |
| Julie Neer | SEDAR |
| Suzanna Thomas | SAFMC |
| Karyl Brewster-Geisz | HMS Management |

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|---|---|
| Margaret Miller | NMFS |
| Adam Brame | NMFS |

**Appointed Data providers**

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|---|---|
| Vivian Matter | SEFSC Miami |
| Kevin McCarthy | SEFSC Miami |
| Larry Beerkircher | SEFSC Miami |
| Graciela Garcia-Moliner | CMFC |
| Hannah Medd | Shark conservancy |
| Jayne Gardiner | New College |
| Max lee | MOTE |

**Other**

| | |
|---|---|
| Simon Gulak | Sea Leucas LLC |
| Bradley Smith | NMFS |
| Carole Neidig | MOTE |
| Cassandra Scott | |
| Chip Collier | SAFMC |
| Dalyan Lopez | CFMC |
| Delisse Ortiz | NMFS |
| Derek Kraft | NMFS |
| Genevieve Patrick | MOTE |
| Ian Miller | NMFS |
| Kesley Banks | Texas A&M |
| Leann Bosarge | GMFMC |
| Liajay Riviera | CFMC |
| Sascha Cushner | NMFS |
| Steve Durkee | NMFS |
| Tobey Curtis | NMFS |
| Kristin Hannah | NMFS |
| Matthew Streich | Texas A&M |
| Dan Crear | NMFS |
| Daniel Roberts | Water Interface EM |

### 1.4 Document List

| Document # | Title | Authors | Received |
|---|---|---|---|
| **Documents Prepared for SEDAR 77 Data process** | | | |
| SEDAR77-DW01 | Hammerhead Shark Catches from Bottom Longline and Pelagic Longline Surveys conducted by Mississippi Laboratories | Adam G. Pollack and David S. Hanisko | 9/7/2021 |
| SEDAR77-DW02 | Report on spatial movements of great and scalloped hammerhead sharks in the US Atlantic and Gulf of Mexico using Satellite tags | Neil Hammerschlag | 9/8/2021 |
| SEDAR77-DW03 | Morphometric conversions for great hammerhead *Sphyrna mokarran* and scalloped hammerhead *Sphyrna lewini* from the western North Atlantic Ocean and Gulf of Mexico | Lisa J. Natanson, Camilla T. McCandless William B. Driggers III, Eric R. Hoffmayer, Bryan S. Frazier, Carolyn N. Belcher, James Gelsleichter, Michelle S. Passerotti | 11/8/2021 |
| SEDAR77-DW04 | Preliminary catches of hammerhead sharks in the U.S. Atlantic, Gulf of Mexico, and Caribbean | Enric Cortes | 11/28/2021 |
| SEDAR77-DW05 | Hammerhead Shark (*Sphyrna spp.*) Electronic Monitoring Data Review from the Gulf of Mexico Bottom Longline Reef Fish Fishery | Max Lee, B.S., Genevieve Patrick, M.S., Carole Neidig, M.S., and Ryan Schloesser, Ph.D. | 11/17/2021 |
| SEDAR77-DW06 | Size distribution and trends in relative abundance of scalloped hammerheads (*Sphyrna lewini*) in the northern Gulf of Mexico, 2006-2021 | M. B. Jargowsky, S. P. Powers, and J. M. Drymon | 11/29/2021 Revised: 12/16/21 |
| SEDAR77-DW07 | Post-release mortality and behavior of sharks in shore-based recreational fisheries using citizen scientists and low-cost tags | John A. Mohan , R.J. David Wells, Marcus Drymon, Gregory Stunz, and Matthew Streich | 11/29/2021 Revised: 12/16/21 |
| SEDAR77-DW08 | Standardized abundance indices for scalloped hammerhead shark from the Pelagic Longline Observer Program, 1992-2019 | John K. Carlson, Sasha Cushner, and Lawrence Beerkircher | 11/28/2021 |

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| SEDAR77-DW09 | Stress physiology of scalloped and great hammerhead sharks from a bottom longline fishery | Bianca K. Prohaska, Heather Marshall, R. Dean Grubbs, Bryan S. Frazier, John J. Morris, Alyssa Andres, Karissa Lear, Robert E Hueter, Bryan A Keller, Nicholas M Whitney | 11/29/2021 |
| SEDAR77-DW10 | Stress physiology of scalloped and great hammerhead sharks from a bottom longline fishery: Supplemental Tables | Bianca K. Prohaska, Heather Marshall, R. Dean Grubbs, Bryan S. Frazier, John J. Morris, Alyssa Andres, Karissa Lear, Robert E Hueter, Bryan A Keller, Nicholas M Whitney | 11/29/2021 |
| SEDAR77-DW11 | Age and growth of the great hammerhead, *Sphyrna mokarran*, in the western North Atlantic Ocean. | William B. Driggers III, Christian M. Jones, Kristin M. Hannan, Andrew Piercy, and Bryan S. Frazier | 11/29/2021 |
| SEDAR77-DW12 | Standardized abundance indices from scalloped and great hammerhead from the Shark Bottom Longline Observer Program, 1994-2019 | John K. Carlson and Alyssa N. Mathers | 11/30/2021 |
| SEDAR77-DW13 | Standardized Abundance Indices for Scalloped Hammerhead from the Southeast Coastal Gillnet Fishery | John Carlson and Alyssa Mathers | 11/30/2021 |
| SEDAR77-DW14 | Standardized Abundance Indices for Great Hammerhead from the Florida State University Longline Survey | John Carlson and R. Dean Grubbs | 11/30/2021 |

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| SEDAR77-DW15 | Standardized Abundance Index for Great Hammerhead from the Rosenstiel School of Marine and Atmospheric Science Drumline Survey | John Carlson, Neil Hammerschlag and Robert J. Latour | 11/30/2021 Revised: 2/9/2022 |
| SEDAR77-DW16 | Relative abundance index for young-of-the-year scalloped hammerhead shark based on a fishery-independent gillnet survey off Texas, 1982-2019 | John K. Carlson and Mark Fisher | 12/1/2021 |
| SEDAR77-DW17 | Relative abundance index for young-of-the-year scalloped hammerhead shark from the northeastern Gulf of Mexico | John K. Carlson, Jill Hendon, Jeremy Higgs, Dana M. Bethea, Bethany Deacy, Heather Moncrief-Cox, and Andrea Kroetz | 12/1/2021 |
| SEDAR77-DW18 | Reproductive parameters of great hammerhead sharks (*Sphyrna mokarran*) and scalloped hammerhead sharks (*Sphyrna lewini*) from the western North Atlantic Ocean | Heather E. Moncrief-Cox, Kristin M. Hannan, Michelle S. Passerotti, William B. Driggers III and Bryan S. Frazier | 12/1/2021 |
| SEDAR77-DW19 | Age and growth of scalloped (*Sphyrna lewini*) and Carolina (*Sphyrna gilberti*) hammerheads in the western North Atlantic Ocean | Bryan S. Frazier, Ashley S. Galloway, Lisa J. Natanson, Andrew N. Piercy, and William B. Driggers III | 12/2/2021 |
| SEDAR77-DW20 | Bycatch estimates of scalloped and great hammerhead shark in the shark bottom longline fishery | John Carlson, Alyssa Mathers, Heather Moncrief-Cox, Kevin McCarthy | 12/8/2021 |

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| SEDAR77-DW21 | Bycatch Estimates of Scalloped and Great Hammerhead Shark in the Southeast Coastal Gillnet Fishery | John Carlson, Alyssa Mathers and Kevin McCarthy | 12/8/2021 |
| SEDAR77-DW22 | Report on the post-release mortality rates of great hammerhead sharks *Sphyrna mokarran* in the recreational, catch and release, shore-based fishery in Florida, USA. | Hannah B. Medd and Jill L. Brooks | 12/6/2021 |
| SEDAR77-DW23 | Relative abundance of scalloped hammerhead*, Sphyrna lewini*, and Carolina hammerhead, *Sphyrna gilberti*, along the southern U.S east coast. | David S, Portnoy, Amanda M. Barker, and Bryan S. Frazier | 12/8/2021 |
| SEDAR77-DW24 | Scalloped and Great Hammerheads Abundance Indices from NMFS Bottom Longline Surveys in the Northern Gulf of Mexico and Western North Atlantic | Adam G. Pollack and David S. Hanisko | 12/9/2021 |
| SEDAR77-DW25 | Standardized Catch Rates Of Great Hammerheads (*Sphyrna Mokarran*) Collected During Bottom Longline Surveys In Coastal Waters Of The Northern Gulf Of Mexico, 2006-2019 | Eric Hoffmayer, Adam Pollack, Jill Hendon, Marcus Drymon, and Sean Powers | 12/10/21 |
| SEDAR77-DW26 | An Updated Literature Review of Post-Release Live-Discard Mortality Rate Estimates in Sharks for use in SEDAR 77 | Dean Courtney, Alyssa Mathers, and Andrea Kroetz | 12/13/21 |
| SEDAR77-DW27 | Estimation of scalloped and smooth hammerhead discards in the northeast gillnet fishery using data collected by the NOAA Northeast Fisheries Observer Program | Camilla T. McCandless and Joseph J. Mello | 1/24/22 Revised: 1/29/2022 |

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| SEDAR77-DW28 | Standardized index of abundance for scalloped hammerhead sharks from the NOAA Northeast Fisheries Science Center coastal shark bottom longline survey | Camilla T. McCandless and Lisa J. Natanson. | 1/7/22 |
| SEDAR77-DW29 | Standardized indices of abundance for scalloped hammerhead sharks from the South Carolina Department of Natural Resources red drum and Southeast Area Monitoring and Assessment Program longline surveys | Camilla T. McCandless and Bryan S. Frazier | 1/7/22 |
| SEDAR77-DW30 | Standardized index of abundance for scalloped hammerhead sharks from the South Carolina Department of Natural Resources, Cooperative Atlantic States Shark Pupping and Nursery long-gillnet survey | Camilla T. McCandless, Bryan S. Frazier, James Gelsleichter, and Carolyn N. Belcher. | 1/7/22 |
| SEDAR77-DW31 | Standardized index of abundance for scalloped hammerhead sharks from the South Carolina Department of Natural Resources, Cooperative Atlantic States Shark Pupping and Nursery long-gillnet survey | Camilla T. McCandless and Bryan S. Frazier | 1/7/22 |
| SEDAR77-DW32 | Standardized index of abundance for scalloped hammerhead sharks from the South Carolina Department of Natural Resources, Cooperative Atlantic States Shark Pupping and Nursery short-gillnet survey | Camilla T. McCandless and Bryan S. Frazier | 1/7/22 |
| SEDAR77-DW33 | Standardized index of abundance for scalloped hammerhead sharks from the University of North Carolina shark longline survey south of Shakleford Banks | Camilla T. McCandless and Joel Fodrie | 1/7/22 |
| SEDAR77-DW34 | Movement and post-release mortality data for great hammerheads, *Sphyrna mokarran*, tagged during research bottom longline surveys in the northern Gulf of Mexico from 2012-2014 | Eric R. Hoffmayer, Jill M. Hendon, Jennifer A. McKinney, Brett Falterman, William B. Driggers III | 12/16/21 |

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| SEDAR77-DW35 | Hammerhead post-release mortality data summary for SEDAR | N.M. Whitney, K.O. Lear, H.M. Marshall, J. Morris, A.M. Andres, C.F. White, T. Driggers, B. Prohaska, J. Gelsleichter, B. Frazier, R.D. Grubbs | 12/17/2021 |
| SEDAR77-DW36 | Report on post-release mortality of scalloped hammerhead, *Sphyrna lewini*, and great hammerhead, *Sphyrna mokarran* | Jayne M. Gardiner, Tonya R. Wiley, Jorge Brenner | 1/24/2022 |
| SEDAR77-DW37 | Revised bycatch estimates of scalloped and great hammerhead shark in the shark bottom longline fishery | Xinsheng Zhang, John Carlson, Enric Cortés, Elizabeth Babcock, Robert Latour | 1/31/22 |
| SEDAR77-DW38 | Revised Bycatch Estimates of Scalloped and Great Hammerhead Shark in the Southeast Coastal Gillnet Fishery | Xinsheng Zhang, John Carlson, Enric Cortés, Elizabeth Babcock, Robert Latour | 1/31/22 |
| Document # | Title | Authors | Received |
| **Reference Documents for the SEDAR 77 Data process** | | | |
| SEDAR77-RD26 | Age and growth of the great hammerhead shark, Sphyrna mokarran, in the north-western Atlantic Ocean and Gulf of Mexico | Andrew N. Piercy, John K. Carlson and Michelle S. Passerotti | 9/8/2021 |
| SEDAR77-RD27 | Status Review Report: Great Hammerhead Shark *(Sphyrna mokarran)* | Margaret Miller, John Carlson, LeAnn Hogan, and Donald Kobayashi | 9/8/2021 |
| SEDAR77-RD28 | Hammerhead Sharks of the Northwest Atlantic and Gulf of Mexico (2014 – 2020) | Lisa Clarke, Librarian, NOAA Central Library | 9/8/2021 |

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| SEDAR77-RD29 | Age validation of great hammerhead shark (*Sphyrna mokarran*), determined by bomb radiocarbon analysis | Michelle S. Passerotti<br>John K. Carlson<br>Andrew N. Piercy<br>Steven E. Campana | 9/8/2021 |
| SEDAR77-RD30 | Age and growth of the smooth hammerhead, Sphyrna zygaena, in the Atlantic Ocean: comparison with other hammerhead species | Daniela Rosa, Rui Coelho, Joana Fernandez-Carvalho & Miguel N. Santos | 9/8/2021 |
| SEDAR77-RD31 | Status Review Report:<br>Scalloped Hammerhead Shark (*Sphyrna lewini*) | Margaret H. Miller, Dr. John Carlson, Peter Cooper, Dr. Donald Kobayashi, Marta Nammack, and Jackie Wilson | 9/8/2021 |
| SEDAR77-RD32 | Age and growth of the scalloped hammerhead shark, *Sphyrna lewini*, in the north-west Atlantic Ocean and Gulf of Mexico | Andrew N. Piercy, John K. Carlson, James A. Sulikowski and George H. Burgess | 9/8/2021 |
| SEDAR77-RD33 | Scalloped hammerhead shark (Sphyrna lewini)<br>2014-2019 | Trevor Riley, Head of Public Services, NOAA Central Library | 9/8/2021 |
| SEDAR77-RD34 | The biology and conservation status of the large hammerhead shark complex: the great, scalloped, and smooth hammerheads | Austin J. Gallagher and A. Peter Klimley | 9/8/2021 |
| SEDAR77-RD35 | Hooking mortality of scalloped hammerhead Sphyrna lewini and great hammerhead Sphyrna mokarran sharks caught on bottom longlines | SJB Gulak, AJ de Ron Santiago & JK Carlson | 9/8/2021 |
| SEDAR77-RD36 | ENDANGERED SPECIES ACT STATUS REVIEW REPORT<br>Smooth Hammerhead Shark (*Sphyrna zygaena*) | M.H. Miller | 9/8/2021 |
| SEDAR77-RD37 | Scalloped Hammerhead Shark *(Sphyrna lewini)* 5-Year Review: Summary and Evaluation | National Marine Fisheries Service Office of Protected Resources<br>Silver Spring, MD | 9/8/2021 |

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| SEDAR77-RD38 | Periodicity of the growth-band formation in vertebrae of juvenile scalloped hammerhead shark *Sphyrna lewini* from the Mexican Pacific Ocean | C. Coiraton,\| J. Tovar-Ávila, K. C. Garcés-García, J. A. Rodríguez-Madrigal, R. Gallegos-Camacho, D. A. Chávez-Arrenquín, F. Amezcua | 9/8/2021 |
| SEDAR77-RD39 | Range extension of the Endangered great hammerhead shark *Sphyrna mokarran* in the Northwest Atlantic: preliminary data and significance for conservation | Neil Hammerschlag, Austin J. Gallagher, Dominique M. Lazarre, and Curt Slonim | 9/8/2021 |
| SEDAR77-RD40 | Identification of a nursery area for the critically endangered hammerhead shark (Sphyrna lewini) amid intense fisheries in the southern Gulf of Mexico | Gabriela Alejandra Cuevas-Gómez, Juan Carlos Pérez-Jiménez, Iván Méndez-Loeza, Maribel Carrera-Fernández, and José Leonardo Castillo-Géniz | 9/8/2021 |
| SEDAR77-RD41 | SEDAR65-RD20 - An Updated Literature Review of Post-release Live-discard Mortality Rate Estimates in Sharks for use in SEDAR 65 | Dean Courtney and Alyssa Mathers | 9/23/2021 |
| SEDAR77-RD42 | Physiological stress response, reflex impairment, and survival of five sympatric shark species following experimental capture and release | A. J. Gallagher, J. E. Serafy, S. J. Cooke, N. Hammerschlag, | 9/23/2021 |
| SEDAR77-RD43 | Integrating reflexes with physiological measures to evaluate coastal shark stress response to capture | J. M. Jerome, A. J. Gallagher, S. J. Cooke, and N. Hammerschlag | 9/23/2021 |
| SEDAR77-RD44 | SEDAR29-WP17- A preliminary review of post-release live-discard mortality estimates for sharks. | Dean Courtney | 12/14/21 |
| SEDAR77-RD45 | SEDAR34-WP08- A preliminary review of post-release live-discard mortality rate estimates in sharks for use in SEDAR 34 | Dean Courtney | 12/14/21 |

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| SEDAR77-RD46 | SEDAR39-DW21 - A preliminary review of post-release live-discard mortality rate estimates in sharks for use in SEDAR 39. | Dean Courtney | 12/14/21 |
| SEDAR77-RD47 | 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 29-Update | Dean Courtney | 12/14/2021 |
| SEDAR77-RD48 | Meta-analysis of post-release fishing mortality in apex predatory pelagic sharks and white marlin | Michael K. Musyl and Eric L. Gilman | 1/31/2022 |

## 2. Life History

Life History Workgroup participants

| | |
|---|---|
| William Driggers, Co-Leader | National Marine Fisheries Service, Pascagoula, MS |
| Bryan Frazier, Co-leader | South Carolina Department of Natural Resources |
| Jim Gelsleichter | University of North Florida |
| Kristin Hannan | National Marine Fisheries Service, Pascagoula, MS |
| Heather Moncrief-Cox | National Marine Fisheries Service, Panama City, FL |
| Michelle Passerotti | National Marine Fisheries Service, Narragansett, RI |
| David Portnoy | Texas A&M University, Corpus Christi, TX |

### 2.1 Summary of Life History Documents

SEDAR77-DW03: Morphometric conversions for great hammerhead *Sphyrna mokarran* and scalloped hammerhead *Sphyrna lewini* from the western North Atlantic Ocean and Gulf of Mexico.
*Lisa J. Natanson, Camilla T. McCandless, William B. Driggers III, Eric R. Hoffmayer, Bryan S. Frazier, Carolyn N. Belcher, James Gelsleichter, and Michelle S. Passerotti*

Morphometric conversion equations were presented for great and scalloped hammerheads collected from United States waters of the western North Atlantic Ocean. Equations were given for each species relating fork length (FL), pre-caudal length, total length, stretched total length and whole weight. These data were derived from measurements of sharks sampled during research activities from 1961-2018. All FL – length relationships were pooled across sexes whereas FL – weight relationships were calculated separately for each sex and for sexes combined.

SEDAR77-DW11: Age and growth of the great hammerhead, *Sphyrna mokarran*, in the western North Atlantic Ocean.
*William B. Driggers III, Christian M. Jones, Kristin M. Hannan, Andrew Piercy, and Bryan S. Frazier*

Vertebrae were collected from 388 great hammerheads off the east coast of the United States and within the northern Gulf of Mexico, including 204 females, 179 males and five individuals of unknown sex, to assess the age and growth of the species. Female sharks ranged in size from 42-357 cm FL and males ranged in size from 40-297 cm FL. As the current study was an update to growth models presented by Piercy et al. (2010), we employed the identical standard ageing methods described in that study with the exception that no stain (i.e., crystal violet) was used to elucidate growth bands as bands were readily visible in non-stained vertebra.

Three parameter von Bertalanffy growth models were fitted to age and length data from both sexes and sexes combined using parameters reported by Piercy et al. (2010) as initial estimates. As expected, females ($L_\infty$ = 323.9 mm FL, $k$ = 0.11, $t_o$ = -2.06 years) had a higher asymptotic length and lower growth constant than males ($L_\infty$ = 249.4 mm FL, $k$ = 0.20, $t_o$ = -1.37 years) and there was a significant difference among VBGF parameter estimates between the sexes ($\chi^2$ = 113.21, p < 0.01). The maximum observed ages for females and males were 35 years and 38 years, respectively. These maximum observed ages were lower than those found by Piercy et al. (2010) who reported maximum observed ages of 44 years for females and 42 years for males.

SEDAR77-DW18: Reproductive parameters of great hammerhead sharks (*Sphyrna mokarran*) and scalloped hammerhead sharks (*Sphyrna lewini*) from the western North Atlantic Ocean.
*Heather E. Moncrief-Cox, Kristin M. Hannan, Michelle S. Passerotti, William B. Driggers III and Bryan S. Frazier*

Maturity at length and at age was evaluated for great and scalloped hammerheads from the east coast of the United States (hereafter Atlantic) and Gulf of Mexico. Binomial maturity data were fit to length and age maturity ogives using generalized linear models with a logit link, following the methods of Natanson et al. (2019). Ages for great hammerheads were provided by Driggers et al. (SEDAR77-DW11) and scalloped hammerhead age data were provided by Frazier et al. (SEDAR77-DW19).

Maturity data were available for 751 great hammerheads, of which 86 had associated ages. Most individuals evaluated were captured in the Gulf Mexico ($n$ = 617 and $n$ = 55 for length and age data, respectively). Males ranged in size from 50.0 – 298.0 cm FL, with the median length at maturity ($L_{50}$) being 200.56 cm FL ($L_{50}$ $SE$ = 1.63, $a$ = -19.144, $b$ = 0.095) for both regions combined. Minimum and maximum observed sizes for females in the Atlantic and Gulf of Mexico were 48.0 cm and 360.0 cm FL, respectively, with $L_{50}$ estimated to be 206.83 cm FL ($L_{50}$ $SE$ = 2.89; $a$ = -21.286, $b$ = 0.103). The age at which 50% of males were mature ($A_{50}$) for both regions combined was 7.8 years ($A_{50}$ $SE$ = 0.49, $a$ = -8.876, $b$ = 1.137), and 8.1 years for females ($A_{50}$ $SE$ = 0.70, $a$ = -7.569, $b$ = 0.937); however, additional age data are needed to improve confidence in these values.

A total of 1,537 scalloped hammerheads had maturity status information available to evaluate median length at maturity, with fork lengths ranging from 27.0 – 289.0 cm FL. Age information was available for 459 individuals from the Atlantic and 174 from the Gulf of Mexico. Due to the presence of Carolina hammerheads and Carolina-scalloped hammerhead hybrids in the Atlantic, the regions were analyzed separately. In the Atlantic, male $L_{50}$ and $A_{50}$ were 158.31 cm FL ($L_{50}$ $SE$ = 1.99, $a$ = -21.937, $b$ = 0.139) and 12.4 years ($A_{50}$ $SE$ = 0.44, $a$ = -7.670, $b$ = 0.619), respectively. In the Gulf of Mexico, $L_{50}$ was estimated at 142.94 cm ($L_{50}$ $SE$ = 1.55, $a$ = -17.544, $b$ = 0.123) and $A_{50}$ was 8.6 years ($A_{50}$ $SE$ = 0.57, $a$ = -8.080, $b$ = 2.84). There was a significant difference in both $L_{50}$ and $A_{50}$ for males between the regions ($p$ < 0.001 in both analyses). Females in the Atlantic had $L_{50}$ estimated at 187.54 cm FL ($L_{50}$ $SE$ = 3.13, $a$ = -45.626, $b$ = 0.243), and $A_{50}$ was 16.2 years ($A_{50}$ $SE$ = 0.78, $a$ = -11.652, $b$ = 0.721). Within the Gulf of Mexico, 50% of females matured at 176.50 cm FL ($L_{50}$ $SE$ = 16.80, $a$ = -4941.910, $b$ = 28.000) and 13.9 years ($A_{50}$ $SE$ = 6797.88, $a$ = -55.677, $b$ = 4.009). Females did not show a significant difference between regions, possibly due to the low sample size in the Atlantic ($n$ = 8).

SEDAR77-DW19: Age and growth of scalloped (*Sphyrna lewini*) and Carolina (*Sphyrna gilberti*) hammerheads in the western North Atlantic Ocean.
*Bryan S. Frazier, Ashley S. Galloway, Lisa J. Natanson, Andrew N. Piercy, and William B. Driggers III*

*Scalloped hammerhead*

Vertebrae from scalloped hammerheads were collected from a variety of fishery dependent and independent sources, including archived samples used by Piercy et al. (2007). Because Carolina and scalloped hammerheads are sympatric in at least a portion of their known ranges (i.e., off the east coast) and are indistinguishable relying solely on their external morphologies, fin clips were taken when possible and samples were identified to species level using genomic techniques (Barker et al. 2021). As fin clips were not available for archived specimens, we could not determine if Carolina hammerhead samples were present. Despite extensive sampling, the Carolina hammerhead has not been detected in the Gulf of Mexico but is known to occur along the U.S. east coast (hereafter, Atlantic) (Barker et al. 2021). Therefore, samples from the Atlantic were assumed to include both scalloped and Carolina hammerheads while samples from the Gulf of Mexico were assumed to be solely scalloped hammerheads. Standard techniques were used to section vertebrae and estimate ages and were similar to those used by Piercy et al. (2010).

Atlantic and Gulf of Mexico combined

A total of 1,026 vertebrae were available for analysis. Of these, 403 were females (27-245 cm FL range), and 623 were males (27.6-287 cm FL). Three parameter von Bertalanffy growth models were fit to females, males, and sexes combined. Model results indicate females ($L_\infty$ = 229.2 cm FL, $k$ = 0.086, $t_o$ = -2.35 years) and males ($L_\infty$ = 230.1 cm FL, $k$ = 0.092, $t_o$ = -2.17 years) had similar estimates of average asymptotic length and growth coefficient, although there was a significant difference among VBGF parameter estimates between the sexes ($\chi^2$ = 19.00, $p < 0.001$). However, it should be noted samples from presumed mature females were lacking compared to those available for males. Maximum estimated ages were 29.5 for females, and 39.5 for males. Previous age and growth work by Piercy et al. (2007) found maximum estimated ages of 30.5 for both sexes. Region-specific growth models were significantly different ($\chi^2$ = 48.15, $p < 0.001$) with scalloped hammerheads in the Atlantic reaching a larger asymptotic length and lower growth constant compared to individuals from the Gulf of Mexico.

Gulf of Mexico

A total of 291 vertebrae from scalloped hammerheads collected in the Gulf of Mexico were available for age analysis. Vertebrae from 107 females and 184 males were available for growth modeling. Female sharks ranged in size from 30-235 cm FL and males ranged in size from 35-223 cm FL. Sample sizes were lower for the Gulf of Mexico compared to the Atlantic and samples of mature female scalloped hammerheads were limited. Three parameter von Bertalanffy growth models were fit to length and age data for females, males, and sexes combined. Model results indicate females ($L_\infty$ = 234.5 cm FL, $k$ = 0.084, $t_o$ = -2.41 years) had a higher asymptotic length and lower growth constant than males ($L_\infty$ = 210.5 cm FL, $k$ = 0.122, $t_o$ = -1.82 years). Maximum estimated ages were 24.5 for females, and 37.5 for males.

Vertebral sample were available for 708 scalloped hammerheads from the Atlantic, of which 285 were females and 423 were males. Female sharks ranged in size from 27-245 cm FL and males ranged in size from 28-287 cm FL. Three parameter von Bertalanffy growth models were fit to sex-specific and combined sexes length and age data. Model results indicated females ($L_\infty$ = 225.8 cm FL, $k$ = 0.089, $t_o$ = -2.29 years) had a lower asymptotic length and slightly higher growth constant than males ($L_\infty$ = 242.1 cm FL, $k$ = 0.081, $t_o$ = -2.33 years) and there was a significant difference

among VBGF parameter estimates between the sexes ($X^2$ = 19.00, $p < 0.001$). Maximum estimated ages were 29.5 for females, and 39.5 for males.
*Carolina hammerhead*

A total of 76 vertebrae were available for construction of growth curves for Carolina hammerheads (all from the Atlantic). Unfortunately, insufficient samples were available to generate robust estimates of growth in this species. Further, all but one of the vertebral samples from genetically verified Carolina hammerheads were from individuals 4 years of age or less.

## 2.2 Life History Information Summary and Consensus

### 2.2.1 Age and Growth Datasets and Decisions

*Scalloped hammerhead*

Age estimates for 1,026 scalloped hammerheads (403 females and 623 males) were used to generate region and sex-specific growth curves as well as growth curves for combined regions and sexes. Age estimates reported in Frazier et al. (SEDAR77-DW19) were considered accurate and reliable as between reader agreement was high (70.8%) and 92.8% of age estimates were within ± 1 band. This conclusion was supported by a low inter-reader index of average percentage error (5.5%) and coefficient of variation (7.6%). Three parameter von Bertalanffy growth models were fit to age and length data for female, male, and combined sexes age for the combined Atlantic and Gulf of Mexico areas. While results indicated females and males had similar asymptotic length and growth coefficient estimates, there was a significant difference among VBGF parameter estimates between the sexes ($\chi^2$ = 19.00, $p < 0.001$). Further, region-specific (i.e. Atlantic vs. Gulf of Mexico) growth models were significantly different ($\chi^2$ = 48.15, $p < 0.001$) with scalloped hammerheads in the Atlantic reaching a larger asymptotic length and lower growth constant compared to individuals from the Gulf of Mexico. The regional differences in growth coupled with the inclusion of an unknown number of samples from the cryptic Carolina hammerhead among Atlantic samples led the Life History Group to agree that region-specific growth model parameter estimates should be used for scalloped hammerheads.

When comparing region and sex-specific growth models, there was no significant difference in the growth of females between regions ($\chi^2$ = 1.02, $p$ = 0.796) while VBGF parameter estimates were significantly different between regions for males ($\chi^2$ = 48.15, $p < 0.001$). Frazier et al. (SEDAR77-DW19) suggested that VBGF parameter estimates for the Gulf of Mexico were based on the inclusion of a limited number of samples from large, mature females and thus possibly do not reflect true population parameters in this region. Regardless, the Life History Group concluded that these are the best available estimates of sex and region-specific growth for the species. Among all vertebral samples aged, the oldest observed individual in the Atlantic was a 39.5 year old male while the oldest individual collected from the Gulf of Mexico was a 37.5 year old male: the previous maximum observed age for the species was 30.5 years. This individual was 9 years older than the oldest aged specimen from Piercy et al. (2007).

**Decision: Use region and sex-specific growth model parameters estimates and a maximum age of 39.5 years for both regions as presented in SEDAR77-DW19.**

*Carolina hammerhead*

Limited life history data were available for the Carolina hammerhead. Frazier et al. (SEDAR77-DW19) produced a growth model using the available data, however, there was a paucity of large juvenile and adult samples. Therefore, the Life History Working Group had no confidence that model results were representative of Carolina hammerhead population life history.

**Decision: Combine Carolina hammerhead age and growth samples with Atlantic scalloped hammerhead samples to produce sex-specific growth models containing both species.**

*Great hammerhead*

Age and growth information was presented by Driggers et al. (SEDAR77-DW-11) based on analyses of vertebral centra from 388 great hammerheads collected from fishery dependent and independent sources in United States waters of the western North Atlantic Ocean. Included among these samples were 92 vertebrae included in the growth model presented by Piercy et al. (2010); however, not all samples utilized by Piercy et al. (2010) were available for reanalysis. Sharks aged by Driggers et al. (SEDAR77-DW-11) ranged in size from 42-357 cm FL and 40-297 cm FL for females and males, respectively. Based on high between-reader agreement (84% of counts in agreement, 96% of counts within one year, 100% of counts within 2 years), and low inter-reader index of average percentage error (0.92%) and coefficient of variation (1.30%), ages were considered accurate and reliable. Three parameter von Bertalanffy growth models were generated and models for females and males were significantly different from one another. The maximum observed ages by Driggers et al. (SEDAR77-DW-11) for females and males were 35 years and 38 years, respectively. These maximum observed ages were lower than those found by Piercy et al. (2010) who reported maximum observed ages of 44 years for females and 42 years for males. Based on direct observation and bomb radiocarbon analysis, Passerotti et al. (2010) validated an age of 42 years for a great hammerhead collected off the east coast of the United States.

**Decision: Use sex-specific growth model parameters from SEDAR77-DW-11 and a maximum age of 42 years from Passerotti et al. (2010).**

*Smooth hammerhead*

No age and growth information or data for smooth hammerheads were available for the US waters of the western North Atlantic Ocean. Therefore, the Life History Working Group reviewed the available literature to determine the most appropriate age and growth data to use for smooth hammerheads. After review, von Bertalanffy parameters from Rosa et al. (2017) were deemed most appropriate as this study contained samples from the northern and southern hemispheres in the Atlantic Ocean.

**Decision: Use sex-specific growth model parameters and maximum ages from Rosa et al. (2017).**

### 2.2.2 Reproduction Datasets and Decisions

*Scalloped hammerhead*

Age and size at maturity ogives for scalloped hammerheads were presented in SEDAR77-DW18. These were based on data collected from fishery dependent and independent sources, including the SEFSC, NEFSC, South Carolina Department of Natural Resources, Mote Marine Laboratory, University of Florida, Dauphin Island Sea Lab, and the Gulf of Mexico Shark Pupping and Nursery Project. The resulting region and sex-specific ogives were based on a robust sample size and larger sample size than previously available.

**Decision: Use region-specific age and size at maturity ogives reported for scalloped hammerheads in SEDAR77-DW18 and summarized in Table 1 and maturity schedules listed in Tables 5 and 6.**

Despite the common occurrence and frequent capture of scalloped hammerheads, surprisingly few studies have examined their reproductive biology in United States waters of the western North Atlantic Ocean with none being notable or examining the species in detail. Based on the concurrent presence of vitellogenic ovarian follicles and developing embryos, Castro (2009) demonstrated that scalloped hammerheads off the southeastern United States have an annual reproductive cycle. This finding is in agreement with other studies examining the reproductive cycle of the species in other regions (e.g., Hazin et al., 2001; Torres-Huerta et al., 2008). The Life History Group determined the mean fecundity of scalloped hammerheads to be 18 pups per brood (S.D. = 7.67) based on data obtained from various unpublished sources (NEFSC, SEFSC, SCDNR, Florida State University, University of Florida). Based on these data, and in agreement with Hazin et al. (2001), there was no relationship between maternal length and brood size. The gestation period of scalloped hammerheads is considered to be 10-11 months based on a limited number of observations reported in Castro (2011); an estimate similar to gestation times suggested in other parts of the species' range (e.g., Branstetter, 1987; Chen et al., 1988; Stevens and Lyle, 1989; Hazin et al., 2001). Parturition in the southeastern United States occurs during May through June (Ulrich et al. 2007). Data from 351 individuals with an open umbilicus collected in South Carolina waters during May and June indicated that the mean size at birth for scalloped hammerheads is 352 mm FL (S.D. = 31.8).

**Decision: Use reproductive characteristics summarized above and in Tables 1.**

*Carolina hammerhead*

Because the Carolina hammerhead was only recently described (i.e., 2013) and that, externally, it is morphologically indistinguishable from the scalloped hammerhead, there has been very limited targeted sampling of the species and almost nothing is known about its basic biology. The only aspect of the species' reproductive biology that are known are that parturition occurs during June and the mean size at birth is 315.3 mm FL (S.D. = 18.5 )(B. Frazier, unpublished data). What limited information that is available for Carolina hammerheads is summarized in Table 2.

**Decision: Insufficient data to describe the basic reproductive biology of the Carolina hammerhead.**

*Great hammerhead*

Age and size at maturity ogives were presented in SEDAR77-DW18 and based on length and maturity data taken from 751 individuals collected by a number of sources, including the SEFSC, NEFSC, Florida State University, Gulf Coast Research Laboratory and the University of Florida. The resulting sex-specific ogives were based on a robust sample size and larger sample size than previously available.

**Decision: Use sex-specific age and size at maturity ogives reported for great hammerheads in SEDAR77-DW18 and summarized in Table 3. and maturity schedules listed in Tables 7 and 8.**

Stevens and Lyle (1989) examined the reproductive system of great hammerheads collected off northern Australia and noted the lack of ovarian activity in pregnant females. Thus, they concluded the species reproduces on a biennial cycle. This finding was supported by Castro (2011), who reported observing females nearing parturition with inactive ovaries. Fecundity data were very limited in the primary literature, therefore, the Life History Group compiled information from all available published records (e.g., Springer, 1938, 1940; Baughman and Springer, 1950; Clark and von Schmidt, 1965; Dodrill, 1977; Castro, 2011) and supplemented those data with unpublished records from the NEFSC and E. Hoffmayer. The mean brood size of great hammerheads was determined to be 30.93 pups per brood (S.D. = 10.74). Gestation was determined to be 11-12 months by Cadenat and Blache (1981), Stevens and Lyle (1989) and Castro (2011) based primarily on the development of embryos and comparisons of months associated with mating times and presence of postpartum females. Parturition occurs in late spring/ early summer (Clark and von Schmidt, 1965) off the west coast of Florida. As location of pupping grounds are currently unknown for great hammerheads in the western North Atlantic Ocean, the Life History Group determined the time of parturition observed off western Florida was likely representative of what occurs in the western North Atlantic in general. There was a significant relationship between maternal length and brood size (provided in Table 3) based on data reported in Springer (1938), Clark and von Schmidt (1965), Dodrill (1977) and Castro (2011) in addition to unpublished data from the NEFSC and E. Hoffmayer. Piercy et al. (2010) reported that the size at birth for great hammerheads is 50 cm FL; a size similar to the range of sizes (46-54 cm FL) of free swimming, presumed neonates observed in South Corlina waters (B. Frazier, unpublished data).

**Decision: Use reproductive characteristics summarized above and in Table 3.**

*Smooth hammerhead*

No new data related to the reproductive biology of smooth hammerheads were presented or available from fisheries dependent or independent sources in the western North Atlantic Ocean. Therefore, the Life History Group relied on published information to determine which of the available data were most appropriate to describe the reproductive biology of the species in United States waters of the western North Atlantic Ocean. Size at 50% maturity for females (200 cm FL) and males (193.7 cm FL) were obtained from Nava Nava and Marquez-Farias (2014), who examined

1,041 individuals collected in the Gulf of California from 1995-2000. Unfortunately, no *a* and *b* parameter estimates were reported for the presented ogives and age at maturity was not assessed. To provide an estimate for age at 50% maturity we back transformed the age at the reported sizes at 50% maturity reported by Nava Nava and Marquez-Farias (2014) for females and males, which were 10.5 years and 10.4, respectively, using the VBGF parameter estimates provided by Rosa et al. (2017).

There are very limited data available to describe the basic reproductive biology of the smooth hammerhead and, as a result, the Life History Group had to rely on information from a number of published sources, most based on studies conducted outside of the western North Atlantic Ocean. Based on the examination of 21 gravid females collected from a commercial longline fishery operating in the Gulf of Guinea, Castro and Mejuto (1995) reported that the mean brood size for smooth hammerheads is 33.5, which was consistent with the brood size range of 29-37 reported by Bigelow and Schroeder (1948) and 20-50 reported by Ebert and Stehmann (2013). The only information the Life History Group could locate regarding the reproductive periodicity for female smooth hammerheads was Castro (2011) who reports having examined two gravid females with inactive ovaries indicating these females were reproducing on a biennial cycle. Castro (2011) also stated that he observed no appendiculae on the umbilical cords of these gravid females. This is consistent with a biennial cycle among placentally viviparous sharks within the order Carcharhiniformes as species with an exclusively annual reproductive cycle have appendiculae present on their umbilical cords (e.g. Atlantic sharpnose sharks (*Rhizoprionodon terraenovae*), bonnetheads (*Sphyrna tiburo*) and scalloped hammerheads). A gestation time of 10-11 months was suggested by White et al. (2006), however, there was no supporting information. No relationship between maternal length and fecundity was available. The size at birth for smooth hammerheads is 50.3 cm FL based on conversion of the reported TL at birth of 55 cm TL from Coelho et al. (2011) and Rosa et al. (2017).

**Decision: Use reproductive characteristics described above and summarized in Table 4.**

## 2.3 Research recommendations:

- Increase data and sample collection in all forms necessary for informing age related parameters for all hammerhead species, with particular attention to Carolina and smooth hammerheads of both sexes and female scalloped hammerheads.
- Investigate alternative methods for non-lethal estimation of age and/or maturity status (e.g., epigenetic ageing). Conduct age validation studies on scalloped hammerheads to reduce uncertainty in band counting methodology.
- Increased reproductive sampling for all species throughout their range, especially with regard to brood size, gestation period, and reproductive cycle.
- Improve standardization of reproductive measurements and sampling techniques across research groups to facilitate better estimates of reproductive parameters.
- Increase genetic surveillance of scalloped and Carolina hammerheads in the Atlantic in order to further delineate species-specific life history traits and important habitats
- Continued genetic monitoring of Carolina and scalloped hammerheads within nurseries to track the relative abundance of the two species.

- Determine life-stage specific movement patterns and habitat utilization for all hammerhead species using electronic tagging, with particular attention to identifying pupping areas for great and smooth hammerheads.
- Assess stock structure and movement between Caribbean and U.S. waters for scalloped and great hammerheads.
- Identify species-specific abiotic characteristics driving distributions and how environmental changes could impact the life history and distribution of hammerheads in the western North Atlantic Ocean.

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## 2.4 Tables

**Table 1** Summary of life history parameters for scalloped hammerheads (*Sphyrna lewini*) in the western North Atlantic Ocean.

| Life History Workgroup | Region | Summary of scalloped hammerhead biological inputs for 2022 assessment | Reference |
|---|---|---|---|
| Growth parameters | | Female / Male / Combined | |
| $L_\infty$ (cm FL) | Combined | 229.2 (5.44)/ 230.1 (2.77)/ 232.2 (2.47) | SEDAR77-DW-19 |
| *k* | Combined | 0.086 (0.005)/ 0.092 (0.003)/ 0.088 (0.002) | SEDAR77-DW-19 |
| $t_o$ (years) | Combined | -2.352 (0.11)/ -2.166 (0.10)/ -2.262 (0.07) | SEDAR77-DW-19 |
| Maximum observed age (years) | Combined | 29.5 / 39.5 | SEDAR77-DW-19 |
| Sample size | Combined | 403 / 623 / 1026 | SEDAR77-DW-19 |
| $L_\infty$ (cm FL) | GOM | 234.5 (12.89)/ 210.5 (3.90)/ 216.0 (3.61) | SEDAR77-DW-19 |
| *k* | GOM | 0.084 (0.009)(/ 0.122 (0.008)/ 0.108 (0.005) | SEDAR77-DW-19 |
| $t_o$ (years) | GOM | -2.407 (0.17)/ -1.818 (0.18)/ -1.998 (0.13) | SEDAR77-DW-19 |
| Maximum observed age (years) | GOM | 24.5 / 37.5 | SEDAR77-DW-19 |
| Sample size | GOM | 107 / 184 / 291 | SEDAR77-DW-19 |
| $L_\infty$ (cm FL) | Atlantic | 225.8 (6.33)/ 242.1 (3.65)/ 241.0 (3.28) | SEDAR77-DW-19 |
| *K* | Atlantic | 0.089 (0.006)/ 0.081 (0.003)/ 0.080 (0.003) | SEDAR77-DW-19 |
| $t_o$ (years) | Atlantic | -2.29 (0.14)/ -2.33 (0.11)/ -2.38 (0.09) | SEDAR77-DW-19 |
| Maximum observed age (years) | Atlantic | 29.5/ 39.5* | SEDAR77-DW-19 |
| Sample size | Atlantic | 285 / 423 / 708 | SEDAR77-DW-19 |
| Length-weight relationships | | | |
| PCL in cm | | PCL= (0.909)FL-0.265 | SEDAR77-DW03 |
| TL in cm | | TL = (1.281)FL+0.218 | SEDAR77-DW03 |
| STL in cm | | STL = (1.305)FL+0.596 | SEDAR77-DW03 |
| WT in kg Combined | | $WT=(1.161e\text{-}5)FL^{2.988}$ | SEDAR77-DW03 |
| WT in kg Female | | $WT=(5.774e\text{-}6)FL^{3.128}$ | SEDAR77-DW03 |
| WT in kg Male | | $WT=(1.778e\text{-}5)FL^{2.905}$ | SEDAR77-DW03 |
| Age at 50% maturity ogive | | | |
| Female (n =220) | Combined | $t_{mat}$ = 16.11 years<br>*a* = -11.979 (3.80), *b* = 0.744 (0.24) | SEDAR77-DW18 |
| Male (n= 413) | Combined | $t_{mat}$ = 11.31 years<br>*a* = -6.317 (0.82), *b* = 0.559 (0.07) | SEDAR77-DW18 |
| Size at 50% maturity ogive | | | |
| Female (n= 473) | Combined | $FL_{mat}$ = 183.93 cm FL<br>*a* = -35.342 (10.57), *b* = 0.192 (0.06) | SEDAR77-DW18 |
| Male (n= 1064) | Combined | $FL_{mat}$ = 147.48 cm FL<br>*a* = -16.127 (1.30), *b* = 0.109 (0.01) | SEDAR77-DW18 |
| Age at 50% maturity ogive | | | |
| Female (n= 56) | GOM | $t_{mat}$ = 13.89 years<br>*a* = -55.677 (62741.45), *b* = 4.009 (4967.34) | SEDAR77-DW18 |
| Male (n= 118 | GOM | $t_{mat}$ = 8.60 years<br>*a* = -8.08 (2.84), *b* = 0.94 (0.32) | SEDAR77-DW18 |
| Size at 50% maturity ogive | | | |
| Female (n= 289) | GOM | $FL_{mat}$ = 176.50 cm FL<br>*a* = -4941.9 (166040.49), *b* = 28.0 (940.67) | SEDAR77-DW18 |
| Male (n= 656) | GOM | $FL_{mat}$ = 142.94 cm FL<br>*a* = -17.544 (1.81), *b* = 0.123 (0.01) | SEDAR77-DW18 |
| Age at 50% maturity ogive | | | |
| Female (n= 164) | Atlantic | $t_{mat}$ = 16.16 years<br>*a* = -11.652 (3.84), *b* = 0.721 (0.25) | SEDAR77-DW18 |
| Male (n= 295) | Atlantic | $t_{mat}$ = 12.39 years<br>*a* = -7.670 (1.31), *b* = 0.619 (0.10) | SEDAR77-DW18 |
| Size at 50% maturity ogive | | | |
| Female (n= 184) | Atlantic | $FL_{mat}$ = 187.54 cm FL<br>*a* = -45.626 (19.93), *b* = 0.243 (0.10) | SEDAR77-DW18 |
| Male (n= 408) | Atlantic | $FL_{mat}$ = 158.31 cm FL<br>*a* = -21.937 (3.24), *b* = 0.139 (0.042) | SEDAR77-DW18 |
| Reproductive cycle | | Annual | Castro 2009 |
| Fecundity | | 18 (SD = 7.67); range 7-30 (n=11) | NMFS unpublished, Castro 2011 |
| Size at birth | | 352.0 m FL (S.D. = 31.8) (n = 351) | Frazier, unpublished |
| Gestation | | 10-12 months | Castro 2011 |
| Pupping month | | May – June | Ulrich et al. 2007 |
| Fecundity-maternal size relationship | | No relationship | NFMS unpublished, Castro 2011 |

*Recommended use of male maximum age for species

*All values in parentheses are standard error unless indicated otherwise

**Table 2.** Summary of life history parameters for Carolina hammerheads (*Sphyrna gilberti*) in the western North Atlantic Ocean.

| Life History Workgroup | Summary of Carolina hammerhead biological inputs for 2022 assessment | Reference |
|---|---|---|
| Growth parameters | Combined | |
| $L_\infty$ (cm FL) | 192* | SEDAR77-DW19 |
| $k$ | 0.21* | SEDAR77-DW19 |
| $t_o$ (years) | -0.99* | SEDAR77-DW19 |
| Maximum observed age (years) | 21.5* | SEDAR77-DW19 |
| Sample size | 78 | SEDAR77-DW19 |
| Length-weight relationships** | | |
| PCL in cm | PCL= (0.909)FL-0.265 | SEDAR77-DW03 |
| TL in cm | TL = (1.281)FL+0.218 | SEDAR77-DW03 |
| STL in cm | STL = (1.305)FL+0.596 | SEDAR77-DW03 |
| WT in kg Combined | $WT=(1.161e\text{-}5)FL^{2.988}$ | SEDAR77-DW03 |
| WT in kg Males | $WT=(5.774e\text{-}6)FL^{3.128}$ | SEDAR77-DW03 |
| WT in kg Females | $WT=(1.778e\text{-}5)FL^{2.905}$ | SEDAR77-DW03 |
| Age at 50% maturity ogive | | |
| Female | Unknown | |
| Male | Unknown | |
| Size at 50% maturity ogive | | |
| Female | Unknown | |
| Male | Unknown | |
| Reproductive cycle | | |
| Fecundity | Unknown | |
| Size at birth | 315.3 mm FL (S.D. = 18.5) | Frazier, unpublished |
| Gestation | | |
| Pupping month | June | Frazier, unpublished |
| Fecundity-maternal size relationship | Unknown | |

*Limited samples did not yield robust growth curves
**Recommended use of length-weight relationships from scalloped hammerhead

**Table 3.** Summary of life history parameters for great hammerheads (*Sphyrna mokarran*) in the western North Atlantic Ocean.

| Life History Workgroup | Summary of great hammerhead biological inputs for 2022 assessment | Reference |
|---|---|---|
| Growth parameters | Female / Male / Combined | |
| $L_\infty$ (cm FL) | 323.9 (7.49)/ 249.4 (3.36)/ 283.8 (3.96) | SEDAR77-DW11 |
| $k$ | 0.11 (0.011)/ 0.20 (0.010)/ 0.15 (0.010) | SEDAR77-DW11 |
| $t_o$ (years) | -2.06 (0.20)/ -1.37 (0.14)/ -1.72 (0.14) | SEDAR77-DW11 |
| Maximum observed age (years) | 35 / 38 / 42* | SEDAR77-DW11, *recommended per SEDAR77-RD29 |
| Sample size | 204 / 179 / 388 | SEDAR77-DW11 |
| Length-weight relationships | | |
| PCL in cm | PCL= (0.895)FL+1.652 | SEDAR77-DW03 |
| TL in cm | TL = (1.226)FL+9.139 | SEDAR77-DW03 |
| STL in cm | STL = (1.227)FL+14.13 | SEDAR77-DW03 |
| WT in kg Combined | $WT=(1.691e\text{-}5)FL^{2.912}$ | SEDAR77-DW03 |
| WT in kg Female | $WT=(9.275e\text{-}6)FL^{3.028}$ | SEDAR77-DW03 |
| WT in kg Male | $WT=(2.482e\text{-}5)FL^{2.836}$ | SEDAR77-DW03 |
| Age at 50% maturity ogive | | |
| Female (n= 34) | $t_{mat}$ = 8.1 years<br>*a* = -7.569 (2.67), *b* = 0.937 (0.32) | SEDAR77-DW18 |
| Male (n= 52) | $t_{mat}$ = 7.8 years<br>*a* = -8.876 (2.61), *b* = 1.137 (0.34) | SEDAR77-DW18 |
| Size at 50% maturity ogive | | |
| Female (n= 273) | $FL_{mat}$ = 206.83 cm FL<br>*a* = -21.286 (3.53), *b* = 0.103 (0.02) | SEDAR77-DW18 |
| Male (n= 478) | $FL_{mat}$ = 200.56 cm FL<br>*a* = -19.144 (1.89), *b* = 0.095 (0.01) | SEDAR77-DW18 |
| Reproductive cycle | Biennial | Stevens and Lyle 1989, Cortes et al. 2015 |
| Fecundity | 30.93 (SD = 10.74), range 13-56 | Springer 1938, Springer 1940, Baughman and Springer, 1950, Clark and von Schmidt, 1965, Dodrill 1977, Castro 2011, NEFSC unpublished data, Hoffmayer unpublished data |
| Size at birth | 500 mm FL | Piercy et al. 2010, Frazier unpublished |
| Gestation | 11-12 months | Cadenat and Blache 1981,Stevens and Lyle 1989, Castro 2011 |
| Pupping month | late spring/summer | Clark and von Schmidt 1965 |
| Fecundity-maternal size relationship | Brood size = -67.9565 + 0.345301*FL, ($p < 0.01$, $r^2 = 0.90$) | Springer 1938, Baughman and Springer 1950, Clark and von Schmidt 1965, Dodrill 1977, Castro 2011, NEFSC unpublished data, Hoffmayer unpublished data |

*All values in parentheses are standard error unless indicated otherwise

**Table 4.** Summary of life history parameters for smooth hammerheads (*Sphyrna zygaena*) in the western North Atlantic Ocean.

| Life History Workgroup | Summary of smooth hammerhead biological inputs for 2022 assessment | Reference |
|---|---|---|
| Growth parameters | Female / Male / Combined | |
| $L_\infty$ (cm FL) | 293.9 / 284.6 / 288.2 | Rosa et al. 2017 |
| *k* | 0.09 / 0.09 / 0.09 | Rosa et al. 2017 |
| $L_0$ (cm) | 52.7 / 52.2 / 52.4 | Rosa et al. 2017 |
| Maximum observed age (years) | 25 / 24 / 25 | Rosa et al. 2017 |
| Sample size | 287 | Rosa et al. 2017 |
| Length-weight relationships | | |
| FL in cm | TL = 12.72 + 0.84 FL | Coelho et al. 2011* |
| WT in kg Combined | $WT=(2.00e\text{-}6)FL^{3.329}$ | Coelho (IPMA) unpublished data |
| Age at 50% maturity ogive | | |
| Female | $t_{mat}$ = 10.5 years | Nava Nava and Marquez-Farias (2014)** |
| Male | $t_{mat}$ = 10.4 years | |
| Size at 50% maturity ogive | | |
| Female | $FL_{mat}$ = 200 cm FL | Nava Nava and Marquez-Farias 2014 |
| Male | $FL_{mat}$ = 193.7 cm FL | Nava Nava and Marquez-Farias 2014 |
| Reproductive cycle | Biennial | Castro, 2011 |
| Fecundity | 33.5 | Bigelow and Schroder, 1948, Castro and Mejuto 1995 |
| Size at birth | 50.3 cm FL | Coelho et al. 2011, Rosa et al. 2017. |
| Gestation | 10-11 months | White et al. 2006 |
| Pupping month | summer (January-March, NSW Australia) | Stevens 1984 |
| Fecundity-maternal size relationship | | |

* Relationship misstated in publication as FL=12.72+0.84*TL. This results in FL>TL.

**Estimates at age at 50% maturity based on length at 50% maturity transformed using recommended von Bertalanffy growth parameters from Rosa et al. 2017.

**Table 5.** Proportion of mature scalloped hammerheads (*Sphyrna lewini*) in 5 cm size classes by sex and region.

| | Sexes combined | | | Females | | | Males | | |
|---|---|---|---|---|---|---|---|---|---|
| Fork length (cm) | Areas combined | Gulf of Mexico | Atlantic | Areas combined | Gulf of Mexico | Atlantic | Areas combined | Gulf of Mexico | Atlantic |
| 25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 35 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 45 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 55 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 60 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 65 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 70 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 75 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 85 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 95 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 100 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 |
| 105 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 |
| 110 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.02 | 0.00 |
| 115 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.03 | 0.00 |
| 120 | 0.03 | 0.03 | 0.01 | 0.00 | 0.00 | 0.00 | 0.05 | 0.06 | 0.01 |
| 125 | 0.04 | 0.05 | 0.01 | 0.00 | 0.00 | 0.00 | 0.08 | 0.10 | 0.01 |
| 130 | 0.07 | 0.08 | 0.02 | 0.00 | 0.00 | 0.00 | 0.12 | 0.17 | 0.02 |
| 135 | 0.11 | 0.14 | 0.03 | 0.00 | 0.00 | 0.00 | 0.20 | 0.28 | 0.04 |
| 140 | 0.17 | 0.22 | 0.05 | 0.00 | 0.00 | 0.00 | 0.30 | 0.42 | 0.08 |
| 145 | 0.25 | 0.34 | 0.09 | 0.00 | 0.00 | 0.00 | 0.42 | 0.57 | 0.14 |
| 150 | 0.35 | 0.49 | 0.16 | 0.00 | 0.00 | 0.00 | 0.56 | 0.71 | 0.25 |
| 155 | 0.48 | 0.63 | 0.26 | 0.00 | 0.00 | 0.00 | 0.68 | 0.82 | 0.40 |
| 160 | 0.60 | 0.76 | 0.39 | 0.01 | 0.00 | 0.00 | 0.79 | 0.89 | 0.58 |
| 165 | 0.71 | 0.85 | 0.53 | 0.03 | 0.00 | 0.00 | 0.87 | 0.94 | 0.73 |
| 170 | 0.80 | 0.91 | 0.68 | 0.06 | 0.00 | 0.01 | 0.92 | 0.97 | 0.84 |
| 175 | 0.87 | 0.95 | 0.79 | 0.15 | 0.00 | 0.04 | 0.95 | 0.98 | 0.92 |
| 180 | 0.92 | 0.97 | 0.87 | 0.31 | 1.00 | 0.13 | 0.97 | 0.99 | 0.96 |
| 185 | 0.95 | 0.98 | 0.93 | 0.54 | 1.00 | 0.34 | 0.98 | 0.99 | 0.98 |
| 190 | 0.97 | 0.99 | 0.96 | 0.76 | 1.00 | 0.63 | 0.99 | 1.00 | 0.99 |
| 195 | 0.98 | 1.00 | 0.98 | 0.89 | 1.00 | 0.85 | 0.99 | 1.00 | 0.99 |
| 200 | 0.99 | 1.00 | 0.99 | 0.96 | 1.00 | 0.95 | 1.00 | 1.00 | 1.00 |
| 205 | 0.99 | 1.00 | 0.99 | 0.98 | - | 0.99 | 1.00 | 1.00 | 1.00 |
| 210 | 1.00 | 1.00 | 1.00 | 0.99 | - | 1.00 | 1.00 | 1.00 | 1.00 |
| 215 | 1.00 | 1.00 | 1.00 | 1.00 | - | 1.00 | 1.00 | 1.00 | 1.00 |
| 220 | 1.00 | 1.00 | 1.00 | 1.00 | - | 1.00 | 1.00 | 1.00 | 1.00 |
| 225 | 1.00 | 1.00 | 1.00 | 1.00 | - | 1.00 | 1.00 | 1.00 | 1.00 |
| 230 | 1.00 | 1.00 | 1.00 | 1.00 | - | 1.00 | 1.00 | 1.00 | 1.00 |
| 235 | 1.00 | 1.00 | 1.00 | 1.00 | - | 1.00 | 1.00 | 1.00 | 1.00 |
| 240 | 1.00 | 1.00 | 1.00 | 1.00 | - | 1.00 | 1.00 | 1.00 | 1.00 |
| 245 | 1.00 | 1.00 | 1.00 | 1.00 | - | 1.00 | 1.00 | 1.00 | 1.00 |
| 250 | 1.00 | 1.00 | 1.00 | 1.00 | - | 1.00 | 1.00 | 1.00 | 1.00 |
| 255 | 1.00 | 1.00 | 1.00 | 1.00 | - | 1.00 | 1.00 | 1.00 | 1.00 |
| 260 | 1.00 | 1.00 | 1.00 | 1.00 | - | 1.00 | 1.00 | 1.00 | 1.00 |
| 265 | 1.00 | 1.00 | 1.00 | 1.00 | - | 1.00 | 1.00 | 1.00 | 1.00 |
| 270 | 1.00 | 1.00 | 1.00 | 1.00 | - | 1.00 | 1.00 | 1.00 | 1.00 |
| 275 | 1.00 | 1.00 | 1.00 | 1.00 | - | 1.00 | 1.00 | 1.00 | 1.00 |
| 280 | 1.00 | 1.00 | 1.00 | 1.00 | - | 1.00 | 1.00 | 1.00 | 1.00 |
| 285 | 1.00 | 1.00 | 1.00 | 1.00 | - | 1.00 | 1.00 | 1.00 | 1.00 |
| 290 | 1.00 | 1.00 | 1.00 | 1.00 | - | 1.00 | 1.00 | 1.00 | 1.00 |
| 295 | 1.00 | 1.00 | 1.00 | 1.00 | - | 1.00 | 1.00 | 1.00 | 1.00 |
| 300 | 1.00 | 1.00 | 1.00 | 1.00 | - | 1.00 | 1.00 | 1.00 | 1.00 |

**Table 6.** Proportion of mature scalloped hammerheads (*Sphyrna lewini*) in 1 year age classes by sex.

| | Sexes Combined | | | Females | | | Males | | |
|---|---|---|---|---|---|---|---|---|---|
| Age (years) | Areas combined | Gulf of Mexico | Atlantic | Areas combined | Gulf of Mexico | Atlantic | Areas combined | Gulf of Mexico | Atlantic |
| 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.08 | 0.00 |
| 3 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.61 | 0.00 |
| 4 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.96 | 0.01 |
| 5 | 0.02 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 | 0.03 | 1.00 | 0.01 |
| 6 | 0.03 | 0.05 | 0.01 | 0.00 | 0.00 | 0.00 | 0.05 | 1.00 | 0.02 |
| 7 | 0.06 | 0.12 | 0.03 | 0.00 | 0.00 | 0.00 | 0.08 | 1.00 | 0.03 |
| 8 | 0.09 | 0.28 | 0.05 | 0.00 | 0.00 | 0.00 | 0.14 | 1.00 | 0.06 |
| 9 | 0.15 | 0.52 | 0.08 | 0.01 | 0.00 | 0.01 | 0.22 | 1.00 | 0.11 |
| 10 | 0.23 | 0.75 | 0.13 | 0.01 | 0.00 | 0.01 | 0.33 | 1.00 | 0.19 |
| 11 | 0.34 | 0.89 | 0.21 | 0.02 | 0.00 | 0.02 | 0.46 | 1.00 | 0.30 |
| 12 | 0.46 | 0.96 | 0.33 | 0.05 | 0.00 | 0.05 | 0.60 | 1.00 | 0.44 |
| 13 | 0.59 | 0.98 | 0.47 | 0.09 | 0.03 | 0.09 | 0.72 | 1.00 | 0.59 |
| 14 | 0.71 | 0.99 | 0.61 | 0.17 | 0.61 | 0.17 | 0.82 | 1.00 | 0.73 |
| 15 | 0.81 | 1.00 | 0.73 | 0.31 | 0.99 | 0.30 | 0.89 | 1.00 | 0.83 |
| 16 | 0.88 | 1.00 | 0.83 | 0.48 | 1.00 | 0.47 | 0.93 | 1.00 | 0.90 |
| 17 | 0.92 | 1.00 | 0.90 | 0.66 | 1.00 | 0.65 | 0.96 | 1.00 | 0.95 |
| 18 | 0.95 | 1.00 | 0.94 | 0.80 | 1.00 | 0.79 | 0.98 | 1.00 | 0.97 |
| 19 | 0.97 | 1.00 | 0.97 | 0.90 | 1.00 | 0.89 | 0.99 | 1.00 | 0.98 |
| 20 | 0.98 | 1.00 | 0.98 | 0.95 | 1.00 | 0.94 | 0.99 | 1.00 | 0.99 |
| 21 | 0.99 | 1.00 | 0.99 | 0.97 | 1.00 | 0.97 | 1.00 | 1.00 | 1.00 |
| 22 | 0.99 | 1.00 | 0.99 | 0.99 | 1.00 | 0.99 | 1.00 | 1.00 | 1.00 |
| 23 | 1.00 | 1.00 | 1.00 | 0.99 | 1.00 | 0.99 | 1.00 | 1.00 | 1.00 |
| 24 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 25 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 26 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 27 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 28 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 29 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 30 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 31 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 32 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 33 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 34 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 35 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 36 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 37 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 38 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 39 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 40 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

**Table 7.** Proportion of mature great hammerheads (*Sphyrna mokarran*) 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 | 0.00 | 0.00 | 0.00 |
| 100 | 0.00 | 0.00 | 0.00 |
| 105 | 0.00 | 0.00 | 0.00 |
| 110 | 0.00 | 0.00 | 0.00 |
| 115 | 0.00 | 0.00 | 0.00 |
| 120 | 0.00 | 0.00 | 0.00 |
| 125 | 0.00 | 0.00 | 0.00 |
| 130 | 0.00 | 0.00 | 0.00 |
| 135 | 0.00 | 0.00 | 0.00 |
| 140 | 0.00 | 0.00 | 0.00 |
| 145 | 0.01 | 0.00 | 0.00 |
| 150 | 0.01 | 0.00 | 0.01 |
| 155 | 0.02 | 0.00 | 0.01 |
| 160 | 0.03 | 0.01 | 0.02 |
| 165 | 0.04 | 0.01 | 0.03 |
| 170 | 0.07 | 0.02 | 0.05 |
| 175 | 0.11 | 0.04 | 0.07 |
| 180 | 0.16 | 0.06 | 0.11 |
| 185 | 0.24 | 0.10 | 0.17 |
| 190 | 0.35 | 0.15 | 0.25 |
| 195 | 0.47 | 0.23 | 0.35 |
| 200 | 0.59 | 0.33 | 0.46 |
| 205 | 0.70 | 0.46 | 0.58 |
| 210 | 0.80 | 0.59 | 0.69 |
| 215 | 0.87 | 0.70 | 0.78 |
| 220 | 0.91 | 0.80 | 0.85 |
| 225 | 0.95 | 0.87 | 0.90 |
| 230 | 0.97 | 0.92 | 0.94 |
| 235 | 0.98 | 0.95 | 0.96 |
| 240 | 0.99 | 0.97 | 0.97 |
| 245 | 0.99 | 0.98 | 0.98 |
| 250 | 1.00 | 0.99 | 0.99 |
| 255 | 1.00 | 0.99 | 0.99 |
| 260 | 1.00 | 1.00 | 1.00 |
| 265 | 1.00 | 1.00 | 1.00 |
| 270 | 1.00 | 1.00 | 1.00 |
| 275 | 1.00 | 1.00 | 1.00 |
| 280 | 1.00 | 1.00 | 1.00 |
| 285 | 1.00 | 1.00 | 1.00 |
| 290 | 1.00 | 1.00 | 1.00 |
| 295 | 1.00 | 1.00 | 1.00 |
| 300 | 1.00 | 1.00 | 1.00 |
| 305 | 1.00 | 1.00 | 1.00 |
| 310 | 1.00 | 1.00 | 1.00 |
| 315 | 1.00 | 1.00 | 1.00 |
| 320 | 1.00 | 1.00 | 1.00 |
| 325 | 1.00 | 1.00 | 1.00 |
| 330 | 1.00 | 1.00 | 1.00 |
| 335 | 1.00 | 1.00 | 1.00 |
| 340 | 1.00 | 1.00 | 1.00 |
| 345 | 1.00 | 1.00 | 1.00 |
| 350 | 1.00 | 1.00 | 1.00 |
| 355 | 1.00 | 1.00 | 1.00 |
| 360 | 1.00 | 1.00 | 1.00 |

**Table 8.** Proportion of mature great hammerheads (*Sphyrna mokarran*) in 1 year age classes by sex.

| Age (years) | Sexes Combined | Females | Males |
|---|---|---|---|
| 0 | 0.00 | 0.00 | 0.00 |
| 1 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 |
| 3 | 0.01 | 0.01 | 0.00 |
| 4 | 0.02 | 0.02 | 0.01 |
| 5 | 0.05 | 0.05 | 0.04 |
| 6 | 0.12 | 0.12 | 0.11 |
| 7 | 0.28 | 0.27 | 0.29 |
| 8 | 0.53 | 0.48 | 0.55 |
| 9 | 0.76 | 0.70 | 0.80 |
| 10 | 0.90 | 0.86 | 0.92 |
| 11 | 0.96 | 0.94 | 0.97 |
| 12 | 0.99 | 0.98 | 0.99 |
| 13 | 1.00 | 0.99 | 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 |
| 18 | 1.00 | 1.00 | 1.00 |
| 19 | 1.00 | 1.00 | 1.00 |
| 20 | 1.00 | 1.00 | 1.00 |
| 21 | 1.00 | 1.00 | 1.00 |
| 22 | 1.00 | 1.00 | 1.00 |
| 23 | 1.00 | 1.00 | 1.00 |
| 24 | 1.00 | 1.00 | 1.00 |
| 25 | 1.00 | 1.00 | 1.00 |
| 26 | 1.00 | 1.00 | 1.00 |
| 27 | 1.00 | 1.00 | 1.00 |
| 28 | 1.00 | 1.00 | 1.00 |
| 29 | 1.00 | 1.00 | 1.00 |
| 30 | 1.00 | 1.00 | 1.00 |
| 31 | 1.00 | 1.00 | 1.00 |
| 32 | 1.00 | 1.00 | 1.00 |
| 33 | 1.00 | 1.00 | 1.00 |
| 34 | 1.00 | 1.00 | 1.00 |
| 35 | 1.00 | 1.00 | 1.00 |
| 36 | 1.00 | 1.00 | 1.00 |
| 37 | 1.00 | 1.00 | 1.00 |
| 38 | 1.00 | 1.00 | 1.00 |
| 39 | 1.00 | 1.00 | 1.00 |
| 40 | 1.00 | 1.00 | 1.00 |
| 41 | 1.00 | 1.00 | 1.00 |
| 42 | 1.00 | 1.00 | 1.00 |

## 3. Catches

**Catches Panel**

Heather Baertlein, co-Leader.………… .…………………………….………NMFS HMS Division
Enric Cortés, Leader………………………………………………………....NMFS Panama City
Cliff Hutt…………………………………………………………………...….NMFS HMS Division
Alyssa Mathers……………………………………………………………… NMFS Panama City
Vivian Matter, *not present*……………………………………………………….. NMFS Miami
Xinsheng Zhang, Commercial Bycatch Leader.………………….….….…… NMFS Panama City

**Ad-hoc working group on Post-Release Live Discard Mortality (PRLDM)**

*SEDAR Pool members:*

Banks, Kesley……………………………………………………….....… Texas A&M University
Courtney, Dean, Ad-Hoc WG Leader…….……………………………………..NMFS Panama City
Drymon, Marcus……………………………………………...………Mississippi State University
Frazier, Bryan…………………………………………………………………...…South Carolina DNR
Gardiner, Jayne………………………………………………….….....New College of Florida
Gelsleichter, Jim……………………………………………………………………....UNF
Grubbs, Dean…………………………………………………………………………..FSU
Hammerschlag, Neil………………………………………………...………RSMAS, U. of Miami
Hoffmayer, Eric……………………………………………...……………NMFS Pascagoula
Hutt, Cliff…………………………………………………..…………….NMFS HMS Division
Medd, Hannah……………………………………………………American Shark Conservancy
Wells, David……………………………..………………...…………Texas A&M University
.
*Working paper or data providers who participated in PRLDM ad-hoc WG discussions but were not part of SEDAR pool:*

Gulak, Simon…………………………………………………………..………Mar Alliance
Whitney, Nick…………………………………………………………New England Aquarium

***List of Working and Reference Papers***

| Documents Prepared for the Data Workshop Process | | |
|---|---|---|
| | | |
| SEDAR77-DW4 | Preliminary catches of hammerhead sharks in the U.S. Atlantic, Gulf of Mexico, and Caribbean | Enric Cortés and Heather Baertlein |
| SEDAR77-DW7 | Preliminary post-release mortality estimates for the shore-based recreational shark fishery in Texas | John A. Mohan , R. J. David Wells, Marcus Drymon, Gregory Stunz, and Matthew Streich |
| SEDAR77-DW9 | Stress physiology of scalloped and great hammerhead sharks from a bottom longline fishery | Bianca K. Prohaska, Heather Marshall, R. Dean Grubbs, Bryan S. Frazier, John J. Morris, Alyssa Andres, Karissa Lear, Robert E. Hueter, Bryan A. Keller, and Nicholas M. Whitney |
| SEDAR77-DW10 | Stress physiology of scalloped and great hammerhead sharks from a bottom longline fishery: Supplemental Tables | Bianca K. Prohaska, Heather Marshall, R. Dean Grubbs, Bryan S. Frazier, John J. Morris, Alyssa Andres, Karissa Lear, Robert E. Hueter, Bryan A. Keller, and Nicholas M Whitney |
| SEDAR77-DW20 | Bycatch estimates of scalloped and great hammerhead shark in the shark bottom longline fishery | John Carlson, Alyssa Mathers, Heather Moncrief-Cox, and Kevin McCarthy |
| SEDAR77-DW21 | Bycatch estimates of scalloped and great hammerhead shark in the southeast coastal gillnet fishery | John Carlson, Alyssa Mathers, and Kevin McCarthy |
| SEDAR77-DW22 | Report on the post-release mortality rates of great hammerhead sharks *Sphyrna mokarran* in the recreational, catch and release, shore-based fishery in Florida, USA | Hannah B. Medd and Jill L. Brooks |
| SEDAR77-DW26 | An updated literature review of post-release live-discard mortality rate estimates in sharks for use in SEDAR 77 | Dean Courtney, Alyssa Mathers, and Andrea Kroetz |
| SEDAR77-DW27 | Estimation of scalloped and smooth hammerhead discards in the northeast gillnet | Camilla T. McCandless and Joseph J. Mello |

| | | |
|---|---|---|
| | fishery using data collected by the NOAA Northeast Fisheries Observer Program | |
| SEDAR77-DW34 | Movement and post-release mortality data for great hammerheads, *Sphyrna mokarran*, tagged during research bottom longline surveys in the northern Gulf of Mexico from 2012-2014 | Eric Hoffmayer, Jill Hendon, Jennifer McKinney, Brett Falterman, and William B. Driggers III |
| SEDAR77-DW35 | Hammerhead post-release mortality data summary for SEDAR | N. M. Whitney, K. O. Lear, H. M. Marshall, J. Morris, A. M. Andres, C. F. White, T. Driggers, B. Prohaska, J. Gelsleichter, B. Frazier, and R. D. Grubbs |
| SEDAR77-DW36 | Report on post-release mortality of scalloped hammerhead, *Sphyrna lewini*, and great hammerhead, *Sphyrna mokarran* | Jayne M. Gardiner, Tonya R. Wiley, and Jorge Brenner |
| SEDAR77-DW37 | Revised bycatch estimates of scalloped and great hammerhead shark in the shark bottom longline fishery | Xinsheng Zhang, John Carlson, Enric Cortés, Elizabeth Babcock, and Robert Latour |
| SEDAR77-DW38 | Revised bycatch estimates of scalloped and great hammerhead shark in the southeast coastal gillnet fishery | Xinsheng Zhang, John Carlson, Enric Cortés, Elizabeth Babcock, and Robert Latour |
| **Reference Documents** | | |
| SEDAR77-RD20 | Double tagging clarifies post-release fate of great hammerheads (*Sphyrna mokarran*) | J. M. Drymon and R. J. D. Wells |
| SEDAR77-RD35 | Hooking mortality of scalloped hammerhead *Sphyrna lewini* and great hammerhead *Sphyrna mokarran* sharks caught on bottom longlines | S. J. B. Gulak, A. J. de Ron Santiago, and J. K. Carlson |
| SEDAR77-RD41 | An updated literature review of post-release live-discard mortality rate estimates in sharks for use in SEDAR 65 | Dean Courtney and Alyssa Mathers |
| SEDAR77-RD42 | Physiological stress response, reflex impairment, and survival of five sympatric shark species following experimental capture and release | A. J. Gallagher, J. E. Serafy, S. J. Cooke, and N. Hammerschlag |
| SEDAR77-RD43 | Integrating reflexes with physiological measures to evaluate coastal shark stress response to capture | J. M. Jerome, A. J. Gallagher, S. J. Cooke, and N. Hammerschlag |
| SEDAR77-RD44 | SEDAR29-WP17- A preliminary review of post-release live-discard mortality estimates for sharks | Dean Courtney |

| | | |
|---|---|---|
| SEDAR77-RD45 | SEDAR34-WP08- A preliminary review of post-release live-discard mortality rate estimates in sharks for use in SEDAR 34 | Dean Courtney |
| SEDAR77-RD46 | SEDAR39-DW21 - A preliminary review of post-release live-discard mortality rate estimates in sharks for use in SEDAR 39 | Dean Courtney |
| SEDAR77-RD47 | 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 29-Update | Dean Courtney |
| SEDAR77-RD48 | Meta-analysis of post-release fishing mortality in apex predatory pelagic sharks and white marlin | Michael K. Musyl and Eric L. Gilman |

## RELEVANT TERMS OF REFERENCE

***Term of Reference 4***

*Provide commercial catch statistics for each stock being assessed, including landings, dead discards, live discards, and potential post-release mortality in both weight and number. Consider species identification issues among hammerhead shark species and correct for these instances as appropriate.*

*a. Evaluate and discuss the adequacy of available data for accurately characterizing landings and discards by fishery sector or gear.*

*b. Provide length and age distributions for both landings and discards if feasible.*

*c. Provide maps of fishery effort and harvest by fishery sector or gear.*

*d. Provide estimates of uncertainty around each set of commercial landings (if possible) and discard estimates.*

*e. Provide estimates of discard mortality rate by gear.*

***Term of Reference 5***

*Provide recreational catch statistics for each stock being assessed, including landings, dead discards, live discards, and potential post-release mortality in both weight and number. Consider species identification issues among hammerhead shark species and correct for these instances as appropriate.*

*a. Evaluate and discuss the adequacy of available data for accurately characterizing landings and discards by fishery sector or gear.*

*b. Provide length and age distributions for both landings and discards if feasible.*

*c. Provide maps of fishery effort and harvest by fishery sector or gear.*

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

*e. Provide estimates of discard mortality rate by gear.*

**Term of Reference 7**

*Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment. Include specific guidance on sampling intensity (number of length samples) and appropriate strata and coverage.*

**Term of Reference 8**

*Prepare a Data Workshop report providing complete documentation of workshop actions and decisions in accordance with project schedule deadlines.*

## 3.1 Data Review - Catch Statistics

### 3.1.1 Commercial catches

Review of working papers

**SEDAR77-DW4:** Preliminary catches of hammerhead sharks in the U.S. Atlantic, Gulf of Mexico, and Caribbean
*E. Cortes and H. Baertlein*

This document presents commercial landings and recreational catch estimates of hammerhead sharks (*Sphyrna lewini, S. mokarran, S. zygaena, and Sphyrna* spp.) along the U.S. Atlantic and Gulf of Mexico coasts for 1981-2020. Commercial dead discards from the pelagic longline fishery are also presented along with Mexican landings from the Gulf of Mexico and available landings from Puerto Rico and the U.S. Virgin Islands. Information on the geographical distribution of both commercial landings and recreational catches is presented along with gear-specific information of commercial landings and information on recreational catches by fishing mode and fishing area. Length composition information from recreational sources is also presented.

**SEDAR77-DW7:** Preliminary post-release mortality estimates for the shore-based recreational shark fishery in Texas
*J.A. Mohan, R.J. David Wells, M. Drymon, G. Stunz, and M. Streich*

Recreational shark fishing has become increasingly popular in recent decades, especially shore-based fishing that has provided access to a broad demographic of anglers. Catch and release (CR) shark fishing has become best practice to limit deleterious effects on overall stocks, but species-specific stress levels and post-release mortality in shore-based fisheries are unclear. Advances in electronic tagging technology, including acceleration data loggers (ADLs) and pop-up satellite archival transmitting tags (PSATs), now provide unprecedented insight into fine scale (e.g. seconds to minutes with ADLs) and long term (e.g. daily to monthly with PSAT) behavior of sharks post-release. Using electronic tags, researchers have demonstrated that the physical and physiological stress inflicted upon sharks caught and released contributes directly to post-release mortality (PRM), which can occur immediately or as a result of cumulative sub-lethal effects causing fitness losses over time. Currently, PRM estimates from boat-based shark fisheries are primarily used to inform management strategies and research into the contribution of shore-based shark fishing to overall PRM rates is lacking. This project cooperatively engaged recreational shore-based shark anglers to deploy ADLs and PSATs on blacktip, bull, tiger and scalloped hammerhead sharks to estimate post-release behavior and mortality rates. These species vary in physiological sensitivity to capture from highly sensitive (hammerhead species) to less sensitive (tiger) and ensures increased tag deployment rates in unpredictable but diverse catches to explore species specific mortality rates. The objectives of the study were: 1) Characterize both fine and broad-scale post-release behavior and mortality of beach-caught sharks in Texas using ADLs and PSATs deployed by experienced recreational fishermen; 2) Compare behavioral capture responses among diverse shark species with variable capture-sensitivities (blacktip, bull, tiger, and scalloped hammerhead sharks) and seasonal environmental variables; 3) Host both pre- and post-tagging shark angler workshops to train anglers in shark identification, disseminate tagging results and discuss how results can be applied to shark conservation efforts. Sharks were captured by recreational shore-based anglers from August 2018 to October 2021. For each captured shark, fight time, handling time, and biological metrics including length and sex were recorded, and release condition was scored as good, fair, poor, or dead.

Of the 21 PSATs deployed, 5 PSAT tags were recovered by researchers and provided high-resolution data for temperature, light level, and depth: 4 sharks survived and 1 shark experienced mortality 1.25 hours after release. Eleven tags transmitted limited data, but the data were sufficient to determine shark status based on high-resolution depth data for the final 5 days of deployment and daily summaries for minimum and maximum depths, temperature, and light levels: 8 sharks survived, and 3 sharks exhibited mortality immediately. One tag on a shark that experienced mortality less than 10 min after release returned light level, depth, and temperature data that were sufficient to determine the shark was ingested by a predator. Five tags did not transmit any data after deployment and thus we cannot determine the post-release fate of those sharks. Post release mortality rates across all the PSAT tags was 25% (4/16). ADLs were deployed on 20 different sharks and were recovered for analysis: 14 sharks survived, 2 sharks exhibited mortality immediately, and 4 sharks displayed mortality from 45 min to 5 hours post release. Post-release mortality across all the ADL tags was 30% (6/20). A total of 20 bull sharks were caught and tagged: 2 sharks experienced mortality, 14 sharks survived, and 4 tags did not transmit data. The mortality rate for bull sharks was therefore found to be 12.5% (2/16). A total of 13 blacktip sharks were caught and tagged: 5 sharks exhibited mortality, 6 sharks survived, and 2 tags did not transmit any data. The mortality rate for blacktip sharks was estimated to be 45.5% (5/11). **Although scalloped hammerheads were originally targeted, 2 great hammerheads were caught and tagged: 1 experienced immediate mortality and was ingested and 1 experienced delayed mortality five days after release. The mortality rate for great hammerheads was estimated at 100% (2/2) if both mortalities can be attributed to the capture event, or 50% if the delayed mortality five days post release is considered a natural mortality**. A total of 4 tiger sharks were caught and tagged and all survived, suggesting 0% mortality. However, one tiger shark exhibited mortality 41 days after tagging that was categorized as a natural mortality and not due to capture stress.

Understanding how fishing mortality rates may differ between shore-based and boat-based recreational fleets and across different species is essential for accurately assigning gear type and mortality estimates in stock assessment models. Angler outreach and education was achieved by PIs attending the Sharkathon shore-based fishing tournament in October 2021, reaching hundreds of participating anglers, even though 2020 survey ambitions were delayed due to COVID19. Follow-up angler surveys will occur in 2022 to generate reference data on angler attitude and response to research results. In summary, this collaborative project combined cooperative angler citizen scientists and advanced electronic tags to provide an empirically derived post-release mortality rate estimate across different species in a recreational shore-based fishery for use in management protocols.

**SEDAR77-DW9:** Stress physiology of scalloped and great hammerhead sharks from a bottom longline fishery
*B.K. Prohaska, H. Marshall, R.D. Grubbs, B.S. Frazier, J.J. Morris, A. Andres, K. Lear, R.E. Hueter, B.A. Keller, and N.M. Whitney*

The scalloped hammerhead *Sphyrna lewini* and the great hammerhead *Sphyrna mokarran* are large, coastal to semi-oceanic shark species common to waters of the U.S. east coast where they are regularly taken in commercial and recreational fisheries, particularly the bottom longline fishery. High rates of hooking mortality and low rates of population growth are believed to have caused severe declines in the U.S. Atlantic populations of these species. The objective of this study was to determine the physiological stress induced by bottom longline capture in both *S. lewini* and *S. mokarran*. Physiological stress was quantified using the blood biochemical indicators glucose, lactate, pH, hematocrit, sodium, potassium, calcium, chloride, and magnesium, which have been demonstrated to indicate physiological stress in elasmobranchs. Each shark captured was assigned a condition factor, which was compared with the stress parameters and time on hook to quantify stress induced by different longline hook times. The physiological stress parameters lactate and pH were found to scale negatively with hook time and condition factor in both species. For both species, possible predictors of mortality include hook time, lactate, potassium, and pH. These data will be useful for estimating post-release mortality of *S. mokarran* from measurements taken at the time of capture and the physiological stress response to longline capture in both species to the Atlantic bottom longline fishery.

**SEDAR77-DW20**: Bycatch estimates of scalloped and great hammerhead shark in the shark bottom longline fishery.
*J. Carlson, A. Mathers, H. Moncrief-Cox, and K. McCarthy*

This document presents calculated scalloped and great hammerhead shark dead and live discards (in numbers of sharks) from the commercial shark bottom longline fishery (1993–2019) and the shark research fishery (2008–2019). 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 of dead and live discards were reported separately for the shark research fishery and the shark bottom longline fishery. As vessels in the shark research fishery are monitored 100%, no extrapolations of the dead discards were needed.

**SEDAR77-DW21:** Bycatch estimates of scalloped and great hammerhead shark in the southeast coastal gillnet fishery
*J. Carlson, A. Mathers, and K. McCarthy*

This document presents calculated scalloped and great hammerhead shark dead and live discards (in numbers of sharks) from the commercial gillnet fishery from 1998–2019. 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. Total discards were calculated as the product of observer reported yearly mean dead and live discard rates by set and the yearly total fishing effort (gillnet sets) reported to the coastal logbook program.

**SEDAR77-DW22:** Report on the post-release mortality rates of great hammerhead sharks *Sphyrna mokarran* in the recreational, catch and release, shore-based fishery in Florida, USA.
*H.B. Medd and J.L. Brooks*

Great hammerhead sharks (*Sphyrna mokarran)* are targeted by recreational anglers along the coast of Florida. We estimated the post-release mortality rates for those great hammerhead sharks captured by rod and reel shore-based recreational anglers using short-term, pop-off satellite archival tags (PSATs). All sharks were tagged within the normal release procedures by anglers, and the handling time was not extended to collect other data. One of 13 sharks with reporting tags (7.7%) died post-release.

**SEDAR77-DW26:** An updated literature review of post-release live-discard mortality rate estimates in sharks for use in SEDAR 77
*D. Courtney, A. Mathers, and A. Kroetz*

This working paper summarizes a literature database reviewed for post-release live-discard mortality (PRLDM) rates in sharks. The literature database was reviewed for estimates of delayed discard-mortality rates (MD) and immediate (i.e. at-vessel or acute) discard-mortality rates (MA) for hammerhead sharks (Sphyrnidae). Previous SEDAR Assessment Process (AP) and Data Workshop (DW) PRLDM rate decisions for sharks were also summarized.

**SEDAR77-DW27:** Estimation of scalloped and smooth hammerhead discards in the northeast gillnet fishery using data collected by the NOAA Northeast Fisheries Observer Program
*C.T. McCandless and J.J. Mello*

Dead and live discards of scalloped and smooth hammerhead sharks from the Northeast Region's Mid-Atlantic sink-gillnet fishing fleet were estimated in numbers and weight using data collected by the Northeast Fisheries Observer Program from 1995 to 2019 and were back-calculated to 1981. Block averaging of the discard rates was also used to create estimates in numbers of individuals and weight. Additionally, based on panel recommendations considering all bycatch data available for use during this assessment, discard estimates for the northeast gillnet fishery were created using the grand mean of the discard ratios.

**SEDAR77-DW34:** Movement and post-release mortality data for great hammerheads, *Sphyrna mokarran*, tagged during research bottom longline surveys in the northern Gulf of Mexico from 2012-2014
*E.R. Hoffmayer, J.M. Hendon, J.A. McKinney, B. Falterman, and W.B. Driggers III*

Great hammerheads, *Sphyrna mokarran*, were targeted using 1.8 km bottom longline with 100 3m gangions baited with Atlantic mackerel, *Scomber scomber* set in northern Gulf of Mexico waters from 9 – 366m. The bottom longlines were soaked for one hour and retrieved, and sharks were identified, measured, weighed and then tagged and released. Nine great hammerheads (male n=1: 155 cm FL; female n=8: 85.5-214 cm FL) were fitted with smart position and temperature transmitting (SPOT) tags. Four SPOT tags (range 19 to 101 days, mean: 53.3 ± 20.0 days) reported data with five of the tags not transmitting data to the satellite after the tags were deployed, suggesting those sharks succumbed to the capture stress. All surviving four great hammerheads remained in relatively coastal, nearshore waters with only two locations occurring in waters deeper than 50m. Two of the sharks remained in the general localized area where they were tagged, whereas the other two sharks moved across the Mississippi River Delta from MS to LA and vice versa. The post-release mortality rate was estimated to be 55.5% with a 95% binomial confidence interval of 21.2 to 86.3%.

**SEDAR77-DW35:** Hammerhead post-release mortality data summary for SEDAR

*N.M. Whitney, K.O. Lear, H.M. Marshall, J. Morris, A.M. Andres, C.F. White, T. Driggers, B. Prohaska, J. Gelsleichter, B. Frazier, and R.D. Grubbs*

Between 2014 and 2019 Scalloped and Great Hammerhead sharks (*Sphyrna lewini* and *Sphyrna mokarran*) were tagged with a combination of acceleration data-loggers (ADLs; model G6A+, Cefas, Inc., Lowestoft UK) and Pop-up Satellite Archival Tags (PSATs; model PSATLIFE, Lotek, Ontario, CAN) to determine their post-release survival from commercial longline fisheries. Sharks were caught on longlines in collaboration with commercial fishermen in the Gulf of Mexico near Madeira Beach, FL, Naples, FL, and Galveston, TX, and in Florida Bay near Key West, FL. In most cases (excluding sets fished near Galveston, TX), hook timers were deployed on the gangions with each hook, so that the actual time each shark was hooked before capture was known. Relatively short soak times were used in order to land live animals for tagging, with the result that the majority of hook times are under three hours.

**SEDAR77-DW36:** Report on post-release mortality of scalloped hammerhead, *Sphyrna lewini*, and great hammerhead, *Sphyrna mokarran*

*J.M. Gardiner, T.R. Wiley, and J. Brenner*

This was a data summary and there was no abstract available.

**SEDAR77-DW37:** Revised bycatch estimates of scalloped and great hammerhead shark in the shark bottom longline fishery

*X. Zhang, J.Carlson, E. Cortés, E. Babcock, and R. Latour*

This document details the use of the delta-lognormal method (Pennington, 1983) to calculate discard rates to produce discard estimates and associated uncertainty to use in the SEDAR 77 assessment of hammerhead sharks. The ratio method was used in SEDAR77-DW20 to calculate discard estimates and associated uncertainty. However, the estimated standard deviations (or CVs) obtained through bootstrap resampling reported in SEDAR77-DW20 are extremely high. The panel recommended to use the delta-lognormal method as an alternative method to estimate dead discards and live discards with the same data sets. The discard estimates from the delta-lognormal are similar to those of the ratio method, but the estimated standard deviations (or CVs) from the delta-lognormal method are much smaller than the ratio method and are within a very reasonable range. Consequently, the panel recommended to use discard estimates and associated uncertainty estimates from the delta-lognormal method in the SEDAR 77 stock assessment. Given the very small number of sets in which a non-zero bycatch was observed (positive sets), the panel recommended to use the grand mean of discard rates based on the pooled observed sets for all years and the annual logbook effort to produce annual discard estimates. With this recommendation, the trend of the discard estimates is solely driven by the logbook effort. The estimated discard estimates, upper 95% CI and lower 95% CI were recommended to be used in the base, and high and low catch scenarios, respectively.

**SEDAR77-DW38:** Revised Bycatch Estimates of Scalloped and Great Hammerhead Shark in the Southeast Coastal Gillnet Fishery
*X. Zhang, , J. Carlson, E. Cortés, E. Babcock, and R. Latour*

This document details the use of the delta-lognormal method (Pennington, 1983) to calculate discard rates to produce discard estimates and associated uncertainty from US southeast commercial gillnet fishery to use in the SEDAR 77 assessment of hammerhead sharks. The ratio method was used in SEDAR77-DW21 to calculate discard estimates and associated uncertainty. However, the estimated standard deviations (or CVs) obtained through bootstrap resampling reported in SEDAR77-DW21 are extremely high. The panel recommended to use the delta-lognormal method as an alternative method to estimate dead discards and live discards with the same data sets. The discard estimates from the delta-lognormal are similar to those of the ratio method, but the estimated standard deviations (or CVs) from the delta-lognormal method are much smaller than the ratio method and are within a very reasonable range. Consequently, the panel recommended to use discard estimates and associated uncertainty estimates from the delta-lognormal method in the SEDAR 77 stock assessment. Given the very small number of sets in which a non-zero bycatch was observed (positive sets), the panel recommended to use the grand mean of discard rates based on the pooled observed sets for all years and the annual logbook effort to produce annual discard estimates. With this recommendation, the trend of the discard estimates is solely driven by the logbook effort. The estimated discard estimates, upper 95% CI and lower 95% CI were recommended to be used in the base and high and low catch scenarios, respectively.

### 3.1.2 Commercial Datasets and Decisions

Commercial landings

U.S. commercial landings in weight (lb dw) were available for the period 1991-2020. These data were gathered from two different sources over the time series. Commercial landings for 1991-2013 come from the FINS database, which includes Atlantic Coastal Cooperative Statistics Program (ACCSP) and Gulf Fisheries Information Network (GulfFIN) landings, from the Atlantic and Gulf of Mexico regions, respectively. Landings for 2014-2020 come from the NOAA Fisheries Highly Migratory Species commercial landings (eDealer) database.

In addition to the above databases, landings for Puerto Rico and the U.S. Virgin Islands were also gathered from the Accumulated Landings System (ALS) database for 1987-2011 and the Caribbean Commercial Vessel Logbook database for 2012-2020. Mexican landings of hammerhead sharks in the Gulf of Mexico were reconstructed based on a near-census of landings at fishing camps in the states of Tamaulipas, Veracruz, Tabasco, and Campeche conducted during approximately one year from November 1993 to December 1994 (see section below).

Reported landings of unclassified sharks were apportioned to scalloped, great, smooth, and unclassified hammerheads based on year, state, gear, and area fished whenever possible; year, state and gear; year and state; or only state depending on data availability. Unclassified hammerheads were then apportioned to the different species (scalloped, great, or smooth hammerhead) based on the proportions of these three species in the FINS database during 1991-2020 (the average proportion for the entire period was used because proportions fluctuated widely from year to year and some years had no observations). For gear-specific landings, unclassified hammerheads were apportioned to the different species based on the average proportions of the three species in the main gears (bottom longlines, gillnets, and lines) during the same period.

Commercial landings in numbers were calculated by dividing annual landings in weight (lb dw) by average weights (lb dw) obtained from the Southeast Gillnet Observer Program (GNOP) and the Reef Fish and Shark Bottom Longline Observer Programs (collectively referred to as BLLOP henceforth) 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 weight-length regressions given in SEDAR77-DW03. Since there were no observations of sharks caught on hook and line/hand line fisheries, average weights for hook and line/hand line gears were assumed equal to those from the bottom longline fishery. Since the native form of commercial catches is weight (lb dw, with lb dw = lb whole weight/1.39) it is more appropriate to use catch in weight in models where catches can be entered either in numbers or in weight (e.g., Stock Synthesis).

Scalloped hammerhead, all regions—Total commercial landings of scalloped hammerheads (with added pelagic longline dead discards; see section below) peaked during the early to mid-1990s and decreased thereafter generally remaining below 100,000 pounds dressed weight (lb dw) after 1996 (**Figure 1**).

Commercial landings by gear from FINS for 1991-2020 (accounting only for unclassified sharks apportioned to be scalloped hammerheads) were dominated by longlines (60%) and gillnets (26%), with hook & line accounting for 10% of the total (**Figure 2, top**). The relative importance of longlines and gillnets alternated through time but was generally higher for longlines (**Figure 2, bottom**).

Landings by state were dominated by Florida (62%; 29% on the west coast, 33% on the east coast), followed by North Carolina (21%) and Louisiana (13%) (**Figure 3, top**), with Florida dominating through time during most of 1991-2015 and North Carolina and Louisiana becoming more important thereafter (**Figure 3, bottom**).

Average weights were available for 2002-2020 from the GNOP and for 1993-2020 from the BLLOP. For the GNOP, the average weight for 1981-2001 was taken as the mean for the entire time series of data (2002-2020); for the BLLOP, the average weight for 1981-1992 was taken as the average for the entire time series of data (1993-2020) owing to high interannual variability in average weights in both cases. Individual weights were obtained from individual fork lengths using the sex-specific weight-to-length regressions given in SEDAR77-DW03.

Scalloped hammerhead GOM—Total commercial landings of scalloped hammerheads in the Gulf of Mexico (with added pelagic longline dead discards; see section below) were rather choppy throughout the time series but never exceeded 41,000 lb dw (**Figure 4**).

Commercial landings by gear from FINS for 1991-2020 (accounting only for unclassified sharks apportioned to be GOM scalloped hammerheads) were dominated by longlines (76%) and hand lines (23%), with gillnets accounting for less than 1% (**Figure 5, top**). Longlines were the dominant gear in all years except for 2018 and 2020 when hand lines had a higher contribution (**Figure 5, bottom**).

Landings by state were dominated by Florida (66%), followed by Louisiana (30%) and Alabama to a lesser extent (4%) (**Figure 6, top**), with Florida dominating throughout the entire time series with the exception of higher landings in Louisiana in 2018 and 2020 (**Figure 6, bottom**).

Average weights were available for 2002-2020 from the GNOP and for 1994-2020 from the BLLOP. For the GNOP, the average weight for 1981-2001 was taken as the mean for the entire time series of data (2002-2020); for the BLLOP, the average weight for 1981-1993 was taken as the average for the entire time series of data (1994-2020) owing to high interannual variability in average weights in both cases. Individual weights were obtained from individual fork lengths using the sex-specific weight-to-length regressions given in SEDAR77-DW03 (for GOM and ATL combined).

Scalloped hammerhead ATL— Total commercial landings of scalloped hammerheads (with added pelagic longline dead discards; see section below) peaked during the early to mid-1990s and decreased thereafter generally remaining below 100,000 pounds dressed weight (lb dw) after 1996 (**Figure 7**).

Commercial landings by gear from FINS for 1991-2020 (accounting only for unclassified sharks apportioned to be ATL scalloped hammerheads) were almost equally represented by longlines (46%) and gillnets (47%), with hook and line accounting for the remaining 7% (**Figure 8, top**). Longlines and gillnets alternated in importance throughout the time series (**Figure 8, bottom**).
Landings by state were dominated by Florida (59%) and North Carolina (39%) (**Figure 9, top**), with Florida being the main state of landings in most years up to 2015 after which North Carolina became the main sate of landings (**Figure 9, bottom**).

Average weights were available for 2002-2020 from the GNOP and for 1993-2020 from the BLLOP. For the GNOP, the average weight for 1981-2001 was taken as the mean for the entire time series of data (2002-2020); for the BLLOP, the average weight for 1981-1992 was taken as the average for the entire time series of data (1993-2020) owing to high interannual variability in average weights in both cases. Individual weights were obtained from individual fork lengths using the sex-specific weight-to-length regressions given in SEDAR77-DW03 (for GOM and ATL combined).

Great hammerhead—Total commercial landings of great hammerheads (with added pelagic longline dead discards; see section below) peaked at over 550,000 lb dw in 1994, but rapidly decreased thereafter remaining under 90,000 lb dw since 1997 (**Figure 10**).

Commercial landings by gear from FINS for 1991-2020 (accounting only for unclassified sharks apportioned to be great hammerheads) were dominated by longlines (57%), followed by gillnets (42%), with hook and line making up the remaining 1% (**Figure 11, top**). The relative importance of longlines and gillnets varied slightly through time (**Figure 11, bottom**).

Landings by state were dominated by Florida (50%; 42% on the west coast, 8% on the east coast), closely followed by North Carolina (40%), with some landings from Alabama (7%) (**Figure 12, top**). Alabama accounted for all landings in 2005-2011 and Florida and North Carolina consistently dominated the landings since 2012 (**Figure 12, bottom**).

Average weights were only available for 2002, 2003, and 2020 from the GNOP and for 1993-2020 from the BLLOP. For the GNOP, the average weight for all remaining years was taken as the average of the three available years (2002, 2003, 2020); for the BLLOP, the average weight for 1981-1992 was taken as the average for the entire time series of data (1993-2020) owing to high interannual variability in average weights. Individual weights were obtained from individual fork lengths using the sex-specific weight-to-length regressions given in SEDAR77-DW03.

Smooth hammerhead—Total commercial landings of smooth hammerheads (with added pelagic longline dead discards; see section below) were of small magnitude and never exceeded 10,000 lb dw during the entire time series (**Figure 13**).

Almost half of all commercial landings from FINS for 1991-2020 (accounting only for unclassified sharks apportioned to be smooth hammerheads) were not identified to gear, gillnets made up the majority of the identified gears (41%), followed by longlines (5%) (**Figure 14, top**). The majority of unidentified gear occurred in 2009 and 2010, after which gillnets were generally the most dominant gear (**Figure 14, bottom**).

All landings occurred in the Atlantic, with New York (52%), Virginia (23%), and North Carolina (18%) being the main states of landing (**Figure 15, top**). New York landings dominated in 2009-2011, Virginia landings in 2012, and North Carolina landings in 2013-2014 and since 2016 (**Figure 15, bottom**).

There were very few available average weights: for 2009 and 2010 from the GNOP and for 1994, 1995, 1997, 2000, 2002, 2005, 2008, 2010, and 2018 from the BLLOP, but sample sizes were very low for most years. For the GNOP, the average weight for all remaining years was taken as the average of the two available years (2009-2010); for the BLLOP, the average weight for 1981-1993 and all other years without samples was taken as the average of the years with samples (1994, 1995, 1997, 2000, 2002, 2005, 2008, 2010, and 2018). Individual weights were obtained from individual fork lengths using a weight-to-length regression for sexes combined given in Coelho et al. (2011).

Carolina hammerhead—There were no commercial landings identified as Carolina hammerheads, but an unknown portion of the scalloped hammerhead landings in the Atlantic could be attributed to this cryptic species.

*Discussion and decisions*

Although recreational catch statistics are available since 1981, commercial landings by species only start in 1991. Based on previous input from the commercial shark fishing industry provided for SEDAR 65, there was very little commercial shark fishing effort in the early 1980s so it was proposed that to reconstruct the commercial landings series back to 1981, a linear decrease from the average of the first three years of data (1991-1993) be assumed from 1990 back to 1981. This back-calculation methodology should also be applied to the discard series available.

***Decision:*** ***Assume a linear increase of landings from 0 in 1981 to 90% of the mean of 1991-1993 in 1990 to represent growing market for shark products. Apply this increase to the three fleets considered for each stock (longlines, gillnets, and hook and line/unknown gear)***

***Commercial dead and live discards***

Working papers SEDAR77-DW20 and SEDAR77-DW21 provided estimates of dead and live discards of scalloped and great hammerheads for the bottom longline fishery and the gillnet fishery for the southeast region, respectively, based on observer reports and commercial logbook data. Working Paper SEDAR77-DW27 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. SEDAR77-DW20 and SEDAR77-DW21 were replaced by SEDAR77-DW37 and SEDAR77-DW38 after the data workshop for the bottom longline fishery and the gillnet fishery for the southeast region, respectively.

*Discussion and decisions*

Estimates of dead and live discards were generated for 1993-2019 for longlines and 1998-2019 for gillnets for the southeast region, and 1995-2019 for gillnets in the northeast region. For consistency with the landings, which started in 1981, it was also proposed that the longline and gillnet dead and live discards be back-calculated to 1981.

The Group discussed that the ratio method used to estimate discards in the three working papers was a reasonable approach, but that the estimated standard deviations (or CVs) obtained from bootstrapping were extremely high in working papers SEDAR77-DW20 and SEDAR77-DW21. It was decided to form a small bycatch working group to use an alternative discard estimation method based on the delta-lognormal approach (Pennington, 1983) using the same data sets with the expectation that this alternative method can provide reasonable estimated standard deviations (or CVs).

The delta-lognormal method (Pennington, 1983) assumes a lognormal distribution of the positive bycatch rate observations. Effectively, the estimates are constructed as a product of the proportion of successful occurrences of an event and the average rate at which the event occurs for those successful events. The variance is a function of the variability of the positive bycatch rates as well the number of successful and unsuccessful sets. The delta estimator is more appropriate than the simple ratio estimate because catch rates are generally log-normally distributed and bycatch events (i.e., positive sets) are rare. The unit of effort in this analysis is the number of hooks (bottom longlines) or sets (gillnets). Due to small number of sets in which a non-zero bycatch of the species group was observed (positive sets), observed sets are pooled by each observed year and all observed years, respectively. The annual mean discard rate is based on the pooled observed sets for each observed year. The grand mean discard rate is based on the pooled observed sets for all observed years.

When number of sets in which a non-zero bycatch was observed (positive sets) is greater than 1, the mean discard rate, *C*, is calculated as:

$$C = \frac{m}{n} e^{L} G_m\left(\frac{s^2}{2}\right) \tag{1}$$

$m$ is number of sets in which a non-zero bycatch was observed (positive sets),
$n$ is total number of sets observed,
$L$ is the mean of the log-transformed number of animals taken per 1000 hooks (bottom longlines) or per set (gillnets) for the positive sets,
$s^2$ is the variance of the log-transformed number of animals taken per 1000 hooks (bottom longlines) or per set (gillnets) for the positive sets, and
$G_m(\frac{1}{2}s^2)$ is the cumulative probability function from the Poisson distribution given as:

$$G_m\left(\frac{1}{2}s^2\right) = 1 + \frac{m-1}{m}\left(\frac{1}{2}s^2\right) + \sum_{j=2}^{\infty} \frac{(m-1)^{2j-1}}{m^j (m+1)(m+3)\ldots(m+2j-3)} \text{x} \frac{\left(\frac{1}{2}s^2\right)^j}{j!} \tag{2}$$

The series was computed numerically over *j* terms until meeting a convergence criterion of a change in the function value of < 0.001 with additional terms (j). The variance of the delta estimator is:

$$\text{var}(C) = \frac{m}{n}\left(e^{2L}\right)\left[\frac{m}{n} G_m^2\left(\frac{s^2}{2}\right) - \frac{m-1}{n-1} G_m\left(\frac{m-2}{m-1} s^2\right)\right] \tag{3}$$

When number of sets in which a non-zero bycatch was observed (positive sets) is equal to 1, the mean discard rate reduces to the simple mean rate where:

$$C = \frac{e^{L}}{n} \tag{4}$$

and the variance of the delta estimator is:

$$\text{var}(C) = (\frac{e^L}{n})^2 \quad (5)$$

When number of sets in which a non-zero bycatch was observed (positive sets) is equal to 0, the mean discard is:

$$C = 0 \quad (6)$$

and the variance of the delta estimator is:

$$\text{var}(C) = 0 \quad (7)$$

When number of sets in which a non-zero bycatch was observed (positive sets) is greater than or equal to 1, the coefficient of variation for the mean discard rate is taken as:

$$CV = \frac{\sqrt{\text{var}(C)}}{C} \quad (8)$$

The *C* calculated above gives either the annual mean or the grand mean number of animals caught per 1000 hooks (bottom longlines) or per set (gillnets) for the observed sets. To estimate annual discards, *N*, these rates are multiplied by the annual total number of logbook hooks (in thousands, bottom longlines) or logbook sets (gillnets). With an assumption of effort (*number of logbook hooks or logbook sets*) being a known constant, the coefficient of variation for the annual (or grand) mean discard rate is the same as the coefficient of variation for the annual discards. Approximate 95% confidence intervals (95% CI) were calculated assuming a log-normal distribution of annual discards as *Nk* and *N/k* for the upper and lower confidence bounds respectively where:

$$k = e^{\left[1.96\sqrt{\ln(1+\text{CV}^2)}\right]} \quad (9)$$

The discard estimates from the delta-lognormal method are similar to those of the ratio method, but the estimated standard deviations (or CVs) from the delta-lognormal method are much smaller than those from the ratio method and are within a very reasonable range. Consequently, the panel recommended to use discard estimates and associated uncertainty estimates from the delta-lognormal method (Pennington, 1983) in the SEDAR 77 stock assessment. The panel recommended to include the number of reported logbook hooks/sets, number of observed hooks/sets, number of observed positive hooks/sets, and number of animals caught in the Tables if they are available. Given the very small number of sets in which a non-zero bycatch was observed (positive sets), the panel recommended to use the grand mean of discard rates based on the pooled observed sets for all years and the annual logbook effort to produce annual discard estimates. With this recommendation, the trend of the discard estimates is solely driven by the logbook effort. The estimated discard estimates, upper 95% CI and lower 95% CI were recommended to be used in the base, and high and low catch scenarios, respectively. The discard estimates from the delta-lognormal method were presented in working papers SEDAR77-DW37 and SEDAR77-DW38 after the data workshop for the bottom longline fishery and the gillnet fishery for the southeast region, respectively.

***<u>Decision:</u> Include the number of reported logbook hooks/sets, number of observed hooks/sets, number of observed positive hooks/sets, and number of animals caught in the Tables if they are available.***

***<u>Decision:</u> Back-calculate dead and live discards to 1981 for the southeast bottom longlines and southeast gillnets (1993 – 2019 for southeast bottom longlines; 1998-2019 for southeast gillnets). Assume a linear increase in discards from 0 in 1981 to 90% of the mean of the entire time series in the year preceding the first year of bycatch estimates for southeast bottom longlines and southeast gillnets to parallel the approach used for back-calculating landings.***

***<u>Decision</u>: Back-calculate dead and live discards to 1981 for northeast gillnets. The average discard ratio for the entire time series (1995-2019 for northeast gillnets) across all strata (grand mean) for live and dead discards by number and weight were applied to the annual total landings for the Mid-Atlantic statistical areas identified in the dealer database for northeast gillnets.***

***<u>Decision:</u> Use the delta-lognormal method to replace the ratio method for southeast bottom longline and southeast gillnet discard estimates.***

***<u>Decision:</u> Include the dead and live discard estimates obtained with the delta-lognormal method and the grand mean CPUE in the base run for southeast bottom longline and southeast gillnet; include the dead and live discard estimates obtained with the ratio method and the grand mean CPUE in the base run for northeast gillnet. Use the estimated lower 95%CI and upper 95%CI in low and high catch sensitivity scenarios, respectively.***

*<u>Shark bottom longline for areas combined</u>*

<u>Great hammerhead</u> — Yearly calculated dead discards of great hammerhead sharks for the shark bottom longline fishery were a couple of hundred during 1993 to the mid-2000s and less than 50 after 2006 (**Table 1**). Yearly observed dead discards of great hammerhead sharks for the shark research bottom longline fishery (2008-2019) were small and were less than 10 after 2011 (**Table 2**). Yearly calculated live discards of great hammerhead sharks for the shark bottom longline fishery were a couple of hundred during 1993 to the mid-2000s and less than 100 after 2006 (**Table 3**). Yearly observed live discards of great hammerhead sharks for the shark research bottom longline fishery (2008-2019) were less than 30 (**Table 4**).

<u>Scalloped hammerhead</u> — Yearly calculated dead discards of scalloped hammerhead sharks for the shark bottom longline fishery were generally a few hundred during 1993 to the mid-2000s except for a peak in 1996 and were about 100 after 2007 (**Table 5**). Yearly observed dead discards of scalloped hammerhead sharks for the shark research bottom longline fishery (2008-2019) were small and were less than 10 after 2011 (**Table 6**). Yearly calculated live discards of scalloped hammerhead sharks for the shark bottom

longline fishery were a few hundred during 1993 to the mid-2000s except for a peak in 1996 and were about 100 after 2006 (**Table 7**). Yearly observed live discards of scalloped hammerhead sharks for the shark research bottom longline fishery (2008-2019) were less than 50 (**Table 8**).

*Shark bottom longline for the Atlantic*

Scalloped hammerhead — Yearly calculated dead discards of scalloped hammerhead sharks for the shark bottom longline fishery were generally a couple of hundred during 1993 to the mid-2000s and below 100 after 2006 (**Table 9**). Yearly observed dead discards of scalloped hammerhead sharks for the shark research bottom longline fishery (2008-2019) were small and were less than 5 after 2011 (**Table 10**). Yearly calculated live discards of scalloped hammerhead sharks for the shark bottom longline fishery were generally a couple of hundred during 1993 to the mid-2000s and less than 100 after 2006 (**Table 11**). Yearly observed live discards of scalloped hammerhead sharks for the shark research bottom longline fishery (2008-2019) were less than 20 (**Table 12**).

*Shark bottom longline for the Gulf of Mexico*

Scalloped hammerhead — Yearly calculated dead discards of scalloped hammerhead sharks for the shark bottom longline fishery were generally a couple of hundred during 1993 to the mid-2000s with peaks in 1995 and 1996 and were less than 100 after 2007 (**Table 13**). Yearly observed dead discards of scalloped hammerhead sharks for the shark research bottom longline fishery (2008-2019) were small and were less than 10 after 2011 (**Table 14**). Yearly calculated live discards of scalloped hammerhead sharks for the shark bottom longline fishery were a couple of hundred during 1993 to the mid-2000s with peaks in 1995 and 1996 and were less than 100 after 2006 (**Table 15**). Yearly observed live discards of scalloped hammerhead sharks for the shark research bottom longline fishery (2008-2019) were less than 30 (**Table 16**).

*US southeast commercial gillnet for areas combined*

Great hammerhead — Yearly calculated dead discards of great hammerhead sharks for the US southeast commercial gillnet fishery (1998-2019) ranged from 28 to 77 (**Table 17**). Yearly calculated live discards of great hammerhead sharks for the US southeast commercial gillnet fishery (1998-2019) ranged from 4 to 10 (**Table 18**).

Scalloped hammerhead — Yearly calculated dead discards of scalloped hammerhead sharks for the US southeast commercial gillnet fishery (1998-2019) ranged from 183 to 504 (**Table 19**). Yearly calculated live discards of scalloped hammerhead sharks for the US southeast commercial gillnet fishery (1998-2019) ranged from 75 to 208 (**Table 20**).

*US southeast commercial gillnet for the Atlantic*

Scalloped hammerhead — Yearly calculated dead discards of scalloped hammerhead sharks for the US southeast commercial gillnet fishery (1998-2019) ranged from 173 to 459 (**Table 21**). Yearly calculated live discards of scalloped hammerhead sharks for the US southeast commercial gillnet fishery (1998-2019) ranged from 75 to 200 (**Table 22**).

*US southeast commercial gillnet for the Gulf of Mexico*

Scalloped hammerhead — Yearly calculated dead discards of scalloped hammerhead sharks for the US southeast commercial gillnet fishery (1998-2019) ranged from 9 to 120 (**Table 23**). Yearly calculated live discards of scalloped hammerhead sharks for the US southeast commercial gillnet fishery (1998-2019) ranged from 1 to 12 (**Table 24**).

*US northeast commercial gillnet for the Mid-Atlantic*

Scalloped hammerhead — Yearly back-calculated dead discards of scalloped hammerhead sharks for the US northeast commercial gillnet fishery (1981-1994) ranged from 4 to 110 and
yearly calculated dead discards of scalloped hammerhead sharks for the US northeast commercial gillnet fishery (1995-2019) ranged from 70 to 618 (**Table 25**). Yearly back-calculated live discards of scalloped hammerhead sharks for the US northeast commercial gillnet fishery (1981-1994) ranged from 3 to 86 and yearly calculated dead discards of scalloped hammerhead sharks for the US northeast commercial gillnet fishery (1995-2019) ranged from 55 to 483 (**Table 25**).

Smooth hammerhead — Yearly back-calculated dead discards of smooth hammerhead sharks for the US northeast commercial gillnet fishery (1981-1994) ranged from 4 to 111 and
yearly calculated dead discards of smooth hammerhead sharks for the US northeast commercial gillnet fishery (1995-2019) ranged from 71 to 628 (**Table 26**). Yearly back-calculated live discards of smooth hammerhead sharks for the US northeast commercial gillnet fishery (1981-1994) ranged from 2 to 58 and yearly calculated dead discards of smooth hammerhead sharks for the US northeast commercial gillnet fishery (1995-2019) ranged from 37 to 328 (**Table 26**).

## Commercial post-release live discard mortality

*Discussion and decisions*

*SEDAR77-DW09 and SEDAR77-DW10*

The Post-release delayed mortality (PRLDM) Ad-hoc Working Group discussed SEDAR77-DW09 and SEDAR77-DW10 (Prohaska et al. 2021a, 2021b), which provided evidence from the evaluation of blood biochemical indicators and capture condition that scalloped and great hammerheads captured with bottom longlines and on the hook for longer than about 3 hr are likely to be in either poor condition or dead at release. SEDAR77-DW09 and SEDAR77-DW10 evaluated the physiological stress induced by bottom longline capture for scalloped and great hammerheads. Each captured shark was assigned a capture condition factor at release, which was compared with physiological stress quantified using the blood biochemical indicators and with time on hook to quantify stress induced by different longline hook times. SEDAR77-DW09 and SEDAR77-DW10 indicated that after about 3 hr of hook time, there were no scalloped hammerhead assigned to either excellent, good, or fair condition at release (**Figure 16**). SEDAR77-DW09 and SEDAR77-DW10 indicated that after about 2 hr of hook time, there were no great hammerhead assigned to either excellent, good, or fair capture condition at release (**Figure 16**). SEDAR77-DW09 and SEDAR77-DW10 indicated that scalloped and great hammerheads released in fair condition had lactate levels of about 6 and 12 mmol $l^{-1}$, respectively, which corresponded to about 80 and 100 minutes of time on the hook, respectively (**Figure 17**). SEDAR77-DW09 and SEDAR77-DW10 indicated that lactate levels of scalloped and great hammerheads released in poor condition were about 12 and 19 mmol $l^{-1}$, respectively, which corresponded to about 180 and 200 minutes of time on the hook, respectively (**Figure 18**).

*SEDAR77-RD35*

The PRLDM Ad-hoc Working Group discussed SEDAR77-RD35 (Gulak et al. 2015; Simon Gulak, Pers. Comm. December 14, 2022), which provided evidence from fisheries research conducted employing hook timers on contracted commercial bottom-longline vessels in the U.S. Highly Migratory Species Shark Research Fishery to determine that the proportion of total number captured by hour for scalloped and great hammerheads on the hook <= 3 hr was 33.54 and 33.80%, respectively (**Tables 27 and 28**).

*SEDAR77-RD20, SEDAR77-RD42, SEDAR77-DW34, and SEDAR77-DW35*

The PRLDM Ad-hoc Working Group discussed SEDAR77-RD20 (Drymon and Wells 2017), SEDAR77-RD42 (Gallagher et al. 2014), SEDAR77-DW34 (Hoffmayer et al. 2021), and SEDAR77-DW35 (Whitney et al. 2021), which provided evidence from electronically tagged sharks to estimate PRLDM of great hammerheads captured on drumline and bottom longline gear soaked for between about 1 – 3 hr that ranged from 0 % (N tagged = 3, n dead post-release = 0) to 56% (N tagged = 9, n dead post-release = 5) with a pooled estimate of 45% (N tagged = 60, n dead post-release = 27; **Table 29**). The PRLDM Ad-hoc Working Group also discussed that SEDAR77-DW35 (Whitney et al. 2021) provided evidence from electronically tagged sharks to estimate PRLDM of scalloped hammerheads captured on bottom longline gear soaked for between about 1 – 3 hr (post-release mortality = 8% obtained from N tagged = 25 and n dead post-release = 2; **Table 29**).

The PRLDM Ad-hoc Working Group discussed using the proportion of total number captured by hour for scalloped hammerheads on bottom longline hook-timers for <=3 hr and > 3 hr to compute the PRLDM rate for scalloped hammerheads captured in commercial bottom longline gear. The estimate of PRLDM rate obtained from electronically tagged scalloped hammerheads captured on bottom longlines with hook or soak times about 1 – 3 hr (8%; **Table 29**) was applied to the proportion of scalloped hammerheads on hook-timers for <=3 hr (33.54%, n = 55; **Tables 27 and 30**). The PRLDM Ad-hoc Working Group discussed that the PRLDM rate of scalloped hammerheads on hook timers > 3hr (66.46%, n = 109; **Tables 27 and 30**) was assumed to be 100% because live scalloped hammerheads were likely to be in poor condition at release and unlikely to survive post-release. The PRLDM mortality rate calculated for scalloped hammerheads released from commercial bottom longline gear using this approach was 69.15% (**Table 30**).

***Decision:*** ***Use a PRLDM mortality rate of 69.15% as the best estimate of PRLDM for scalloped hammerheads released alive from commercial bottom longline gear.***

A binomial confidence interval was used to calculate a range of uncertainty for PRLDM in a recent SEDAR blacktip shark stock assessment (NMFS 2020). Consequently, the PRLDM Ad-hoc Working Group also discussed using a binomial 95% confidence interval (CI, 0.0098 – 0.2603) calculated in R version 4.0.5 (R Development Core Team, 2021) with the library "binom" (Dorai-Raj 2014): binom.confint(x = 2, n = 25, method = "exact") as the minimum and maximum estimate of PRLDM obtained from electronic tag data for scalloped hammerheads captured on bottom longline gear soaked for between about 1 – 3 hr. Applying this range of uncertainty obtained from the binomial CI to the equations in **Table 30** resulted in a 95% CI of 66.79 – 75.19% PRLDM for scalloped hammerheads captured on bottom longline gear.

***Decision:*** ***Use a 95% CI of 66.79 – 75.19% PRLDM as the minimum and maximum estimate of PRLDM for scalloped hammerheads released alive from commercial bottom longline gear.***

Similarly, the PRLDM Ad-hoc Working Group discussed using proportions of great hammerheads on bottom longline hook-timers for <=3 hr and > 3hr to compute the PRLDM for great hammerheads captured in commercial bottom longline gear. The estimate of PRLDM rate obtained from electronically tagged great hammerheads captured on drumlines and bottom longlines with soak times about 1 – 3 hr (45%; **Table 29**) was applied to the proportion of great hammerheads on hook-timers for <=3 hr (33.80%, n = 24; **Tables 28 and 31**). The PRLDM Ad-hoc Working Group discussed that the PRLDM rate of great hammerheads on hook timers > 3hr (66.20%, n = 47; **Tables 28 and 31**) was assumed to be 100% because live great hammerheads were likely to be in poor condition at release and unlikely to survive post-release. The PRLDM rate calculated for great hammerheads released from commercial bottom longline gear using this approach was 81.41% (**Table 31**).

***Decision:*** ***Use a PRLDM rate of 81.41% for great hammerheads released alive from commercial bottom longline gear.***

Similarly, the PRLDM Ad-hoc Working Group discussed using a binomial 95% confidence interval (CI, 0.3212 – 0.5839) calculated in R version 4.0.5 (R Development Core Team, 2021) with the library "binom" (Dorai-Raj 2014): binom.confint(x = 27, n = 60, method = "exact") as the minimum and maximum estimate of PRLDM obtained from electronic tag data for great hammerheads captured on bottom longline gear soaked for between about 1 – 3 hr. Applying this range of uncertainty obtained from the binomial CI to the equations in **Table 31** resulted in a 95% CI of 77.05 – 85.93% PRLDM for great hammerheads captured on bottom longline gear.

***<u>Decision:</u> Use a 95% CI of 77.05 – 85.93% PRLDM as the minimum and maximum estimate of PRLDM for great hammerheads released alive from commercial bottom longline gear.***

Other methods have also been used to obtain a 95% confidence interval for post-release mortality estimates for demersal longlines (Whitney 2019 citing methods in Goodyear 2002), however these methods were not reviewed by the PRLDM Ad-hoc Working Group during the data process workshops.

The PRLDM Ad-hoc Working Group discussed that PRLDM rates obtained for hammerheads captured with bottom longline gear may also be the best available estimates of PRLDM for hammerheads captured in commercial gillnet gear.

***<u>Decision:</u> Use PRLDM rates obtained for hammerheads captured with bottom longline gear as the best available estimates of PRLDM for hammerheads captured in commercial gillnet gear.***

The PRLDM Ad-hoc Working Group discussed that smooth and scalloped hammerheads are physiologically more similar than smooth and great hammerheads. Consequently, the PRLDM Ad-hoc Working Group discussed that PRLDM rates obtained for scalloped hammerheads captured with bottom longline gear may be the best available estimates of PRLDM for smooth hammerheads captured with both bottom longline gear and commercial gillnet gear.

***<u>Decision:</u> Use PRLDM rates obtained for scalloped hammerheads captured with bottom longline gear as the best available estimates of PRLDM for smooth hammerheads captured with both bottom longline gear and commercial gillnet gear.***

### <u>Commercial length compositions</u>

The data sources for lengths of commercially caught sharks are the observer programs (BLLOP, GNOP, NEFOP, and PLLOP in this case). Length composition information from these programs is provided in the length composition section of this DW report.

### <u>Mexican landings</u>

An intensive monitoring of the artisanal shark fisheries in the coastal waters of the Mexican Gulf of Mexico was carried out from November 1993 to December 1994 with the aim of characterizing the shark fisheries prosecuted in the region (Castillo et al., 1998). Twelve of the most important fishing ports from the States of Tamaulipas, Veracruz, Tabasco and Campeche were sampled on a daily basis (**Figure 19**). The shark fishing operations of 901 artisanal boats were monitored. Most of the sampled boats (97%) were small boats ("pangas") with fiberglass and wood hulls, 7.5–10.0 m long and 1.0–2.5 m wide, with an outboard motor and an operational range of 1–3 days, whereas the remaining 3% were larger boats with hulls of wood and metal, > 10 m long and >2.6 m wide, with an inboard motor and an operational range of 4–15 days. The two types of boats combined accounted for 9964 trips, with Campeche having the highest number of boats, fishing trips, and shark landings overall. Biological information collected included length, sex, and reproductive stage of individual animals. It must be noted that in some of the sites visited sampling was not systematic throughout the year owing to logistic and funding issues.

The Castillo et al. (1998) study thus provided a snapshot of the landings, sex, and lengths of sharks captured in four of the six Mexican states in the GOM for one year spanning 1993-1994. Based on this information it was possible to reconstruct the catches of the different hammerhead shark species using the following procedure. First, the proportion that hammerhead shark species made up of the total sharks landed was computed for each of the four states sampled (**Figure 20**). Second, for each species of hammerhead represented in the landings (i.e., scalloped and great hammerhead) length-frequency distributions (cm TL) by sex by state were computed (**Figures 21, 22**) and the proportion of landings of sharks <150 cm TL were assigned to a "*cazones*" category and those >=150 cm TL to a "*tiburones*" category. These two categories are those reported in the Mexican official fishery statistics from the Comisión Nacional de Acuacultura y Pesca (Conapesca) available for the period 1976-2019 (J.L. Castillo, pers. comm. to Enric Cortés). We then calculated the percentage of "cazones" and "tiburones" for sexes combined as a weighted average (by sample size for each sex) for each state (**Figures 21, 22**). Third, for each species, we took the landings of "cazones" and "tiburones" reported for each state by Conapesca (**Table 32**) and multiplied it by the proportion that scalloped and great hammerhead make up of the entire catches (step 1) and by the proportion of "cazones" and "tiburones" attributed to each species (step 2) to obtain the total estimated number of hammerheads of each species caught in each state (**Table 33**; **Figure 23**). This assumed that the species composition of the landings observed in 1993-1994 remained the same throughout the entire time series. Fourth, these total estimated landings could further be disaggregated into gear-specific landings for each state by assigning landings to three major gear types (longlines, nets, and hook and line) based on gear composition observed by state. Gear-specific landings by state were then added to provide total landings by gear type (**Table 34**; **Figures 24, 25**).

An additional source of information on Mexican shark landings was also examined in SEDAR77-DW04. This sample, based in part on Pérez-Jiménez and Méndez-Loeza (2015), monitored the small-scale artisanal shark gillnet fishery in the states of Tabasco and Campeche during 2011-2016. However, the proportion that hammerhead shark species (scalloped and great hammerheads) made up of the total sharks landed was only available for the state of Campeche and therefore it was decided not to use this source of data.

Discussion ensued about these sources of Mexican landings. It was noted that while the Castillo et al. (1998) study was almost a census, reconstruction of catches for the 1981-2019 period assumed that the species composition had remained the same throughout this time period. Since there was no additional information available to determine whether/how species composition may have changed through time and that the entire reconstructed series was based on a single year of data, the Panel decided that Mexican landings should be used only in a high catch sensitivity scenario. It was also noted that the U.S. has no management authority in Mexico and therefore inclusion of this series in the base run could be problematic.

***<u>Decision:</u> Include the reconstructed Mexican landings based on one year of data from Castillo et al. (1998) in a high catch sensitivity scenario only; exclude from the base run.***

Puerto Rico/U.S. Virgin Islands landings

There were no commercial landings of hammerhead sharks from Puerto Rico (PR) or the U.S. Virgin Islands (USVI) reported in the FINS or eDealer databases. The Caribbean Commercial Vessel Logbook database included some reports, but of very small magnitude. For scalloped hammerhead in PR, weights ranged from 14 to 116 lb dw during 2012-2020 and in the USVI, weights were less than 1 lb dw. For great hammerhead in PR, weights ranged from 81 to 676 lb dw during 2012-2020, and in the USVI, from 57 to 662 lb dw. Additional information obtained from the Accumulated Landings System (ALS) database showed that most sharks in PR are reported as unclassified and those reported as "hammerhead" never exceeded 80 lb whole weight (ww) in any year during 1987-2011. **Figure 26** shows the landings of scalloped and great hammerheads after apportioning the unclassified sharks to the different hammerhead species and then apportioning the unclassified hammerheads to scalloped or great hammerhead. Scalloped hammerhead landings ranged from 31 to 323 lb dw during 1987-2011 and great hammerhead landings ranged from 261 to 2,694 lb dw during the same period.

These low reported landings reflect the fact that few longliners dock and offload in PR ports and that they do not fish in more coastal waters (R. Espinoza, Conservación Conciencia, pers. comm. to Enric Cortés). As part of a Shark Research and Conservation Program Conservación Conciencia has been conducting fishery-dependent surveys at fishing ports and villages from 2019 to 2021 as well as fishery-independent surveys since 2017 with the aim to characterize Puerto Rico's shark fishery through a marine conservation agreement with PR fishers who report and provide details on their catch. Scalloped hammerheads were the second most observed species during fishery-dependent surveys conducted from February 2019-August 2021 (n = 46; all immature) and only 10 (90% immature) great hammerheads were observed. While this information may become important in future stock assessments, there are currently no data/estimates of coastal shark landings in PR that could be used to raise these observations to total estimates of hammerhead sharks landed.

The Panel noted the small magnitude of the PR/USVI landings available, that inclusion of potentially available hammerhead catch data from the rest of Caribbean nations was outside the scope of this assessment and should be addressed in the future through a Regional Fisheries Management Organization (RFMO) such as the WECAFC (Western Central Atlantic Fishery Commission), and that the current assessment represented a good-faith effort to include catches from U.S. territories (and Mexico) only.

***Decision:* Although the magnitude is almost insignificant, do not include Puerto Rico and U.S. Virgin Islands landings in the base run; include them only in a high catch sensitivity scenario**

Pelagic longline dead discards and live post-release mortality

Dead discard estimates of scalloped, great, and smooth hammerhead sharks in the pelagic longline fishery for the period 1987-2020 (based on the Pelagic Longline Observer Program and fishing effort reported in pelagic longline logbooks) were obtained from the International Commission for the Conservation of Atlantic Tunas (ICCAT) Task 1 statistics (**Figures 1, 4, 7, 10, and 13**). Estimates of animals released alive were not available. To convert weights into numbers, weights in tons ww were first converted to weights in lb dw by applying a conversion ratio of 2.02 (ww = 2.02 dw) and then obtaining average weights from fork lengths reported in the Pelagic Longline Observer Program for 1992-2017. Average weight for all remaining years was taken as the average for the entire time series of data available (1992-2017). Individual weights were obtained from individual fork lengths using the sex-specific weight-to-length regressions given in SEDAR77-DW03. Unclassified hammerheads were apportioned to the different species based on the proportions of the three species for years with data or based on the average proportions for the entire period in the years for which there were no species-specific data. Years with no data at all (i.e., 2002-2006) were set equal to the mean unclassified hammerheads for the entire period multiplied by the average proportion of the three species for the entire period.

It was noted that the dead discard estimates from the pelagic longline fishery are available in the ICCAT Task I database and should thus be used, but that no estimates of live release discards have been generated to date.

***Decision:*** ***There are no uncertainty estimates associated with published ICCAT pelagic longline dead discards and no live discard estimates. CVs are calculated by area/quarter but not overall, and are not included in the Task 1 data reported to ICCAT. The DW panel recommended using ICCAT pelagic longline dead discards in the base run (and low catch and high catch scenarios).***

***Decision:*** ***Assume a linear increase in discards from 0 in 1981 to 83.4% of the mean of the entire time series in the year preceding the first year of bycatch estimates (1987) to parallel the approach used for back-calculating landings and other commercial discard series***

### 3.1.3 Recreational Catch Datasets and Decisions

Recreational catches

Recreational catches of hammerhead sharks reported herein are the sum of estimates from the Marine Recreational Information Program (MRIP), the Southeast Region Headboat Survey (SRHS) operated by the SEFSC Beaufort Laboratory, and the Texas Parks and Wildlife Department (TPWD) Survey. There were no hammerhead sharks reported from the Louisiana Creel survey and only insignificant amounts in the Large Pelagic Survey (LPS). The MRIP estimates include Access Point Angler Intercept Survey (APAIS) and Fishing Effort Survey (FES) calibrations. Annual recreational catch estimates of hammerhead sharks were computed as the sum of type A (number of fish killed or kept 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 from post-release live-discard mortality. MRIP catches are reported in both numbers and weight for types A and B1, but only in numbers for type B2. SRHS catch estimates for types A and B1 are also provided in both numbers and weight, but B2 estimates are not available. TPWD catch estimates for types A and B1 are only provided in numbers and B2 estimates are not available. Annual weight estimates for MRIP type B2 were computed by multiplying B2 catches in numbers by an average weight obtained from MRIP AB1 catches. Since the native form of recreational catches is numbers, it is more appropriate to use catch in numbers in models where catches can be entered either in numbers or in weight (e.g., Stock Synthesis).

To account for sharks identified only as Sphyrnidae or *Sphyrna* spp., unclassified sphyrnid sharks were initially allocated to each of the three hammerhead species (*S. lewini*, *S. mokarran* or *S. zygaena*) based on the annual contribution of these three species and the bonnethead shark (*Sphyrna tiburo*) to the sphyrnid shark catch. On average throughout the time series (1981-2020) bonnethead, scalloped hammerhead, great hammerhead, and smooth hammerhead sharks accounted for 82%, 7%, 9%, and 2% of sphyrnid AB1 catches and 83%, 5%, 9%, and 3% of sphyrnid B2 catches, respectively.

It was noted that it would be better to use the species composition of A catches only (observed by the interviewer) rather than AB1 or B2 catches to apportion the unclassified hammerheads into the three species. It was thus recommended to use the annual proportions based on A catches for 1981-2000, and to use the 1981-2000 average proportions of A catches for 2001-2020 to account for management measures implemented during that period.

As in other SEDARs, in initial discussions the Panel expressed concerns over the inter-annual variability and high uncertainty of the recreational catch estimates. To account for the large interannual variability in recreational catch estimates, the A+B1 and B2 catch series were smoothed using a three-year moving geometric average, as most recently done for SEDAR 65 [(NMFS 2020), while preserving the average trend. It was noted that despite smoothing the series with the three-year moving geometric average there were still some large peaks apparent. Thus, individual years with noticeable peaks were identified for each of the stocks and smoothed:

| | | Stock | | | | |
|---|---|---|---|---|---|---|
| | | Scalloped all | Scalloped GOM | Scalloped ATL | Great | Smooth |
| AB1 | Numbers | 1982, 1993 | 1984, 1985 | 1982, 1993 | 1982 | 1991 |
| | Weight | 1993 | 1984, 1985 | 1993 | 1982 | 1991 |

The individual smoothing applied is described below for each stock.

***Decision:*** ***Apportion the AB1 and B2 unclassified sphyrnid sharks as follows: 1) for 1981-2000, use annual proportions based on A catches (observed by interviewer) and 2) for 2001-2020, use average proportion during 1981-2000 based on the A catches to account for management measures implemented***

***Decision:*** ***Smooth the AB1 and B2 recreational catch series with a three-year geometric moving average***

***Decision:*** ***Smooth individual years with noticeable peaks by setting them equal to the geometric mean of the 3 preceding and ensuing years (as available)***

Recreational post-release live discard mortality

The PRLDM Ad-hoc Working Group discussed that direct estimates of PRLDM were not available for hammerheads from a review of the scientific literature reviewed in SEDAR77-DW25 (Courtney et al. 2021, their Tables A.1 and A.2). Consequently, a minimum estimate of recreational PRLDM for hammerheads was developed by the PRLDM Ad-hoc Working Group from great hammerheads captured and released alive in three directed electronic tagging studies of recreational fishing gear reported and reviewed during the SEDAR 77 Data Workshop (SEDAR77-DW07, SEDAR77-DW22, and a SEDAR 77 Data Workshop presentation) as summarized below. The PRLDM rate estimate was obtained primarily from great hammerheads captured and released alive by experienced recreational anglers targeting sharks. As a result, the PRLDM estimate obtained from these studies was assumed to represent a plausible minimum estimate of the PRLDM of all hammerheads released alive from recreational gear, which are primarily captured incidentally, as discussed below. In contrast, a best estimate of hammerhead shark recreational PRLDM was obtained during the SEDAR 77 Data Workshop from a previously published meta-analysis of pelagic shark PRLDM rates captured and released alive from multiple gear types (Musyl and Gilman 2019). It was noted during the SEDAR 77 Data Workshop that meta-analysis may provide a relatively more robust (stable) PRLDM estimate than those obtained from individual directed studies, which can fluctuate based on individual study design and sample size, as discussed below. Similarly, a maximum estimate of hammerhead shark recreational PRLDM was obtained during the SEDAR 77 Data Workshop as the 95% upper confidence interval (UCI) of pelagic shark PRLDM (Musyl and Gilman 2019).

***Decision:*** ***Use the pooled PRLDM rate of 11.8% obtained from three directed electronic tagging studies of great hammerheads released alive from recreational gear as a minimum estimate of the PRLDM rate for hammerheads captured and released alive with recreational gear.***

The PRLDM Ad-hoc Working Group discussed, and the SEDAR 77 Data Workshop panel accepted, using a pooled PRLDM rate of 11.8% obtained from great hammerheads released alive from recreational gear as a minimum estimate of the PRLDM rate of hammerheads captured and released alive with recreational gear.

| Source | Tags | PRLDM | (%) |
|---|---|---|---|
| SEDAR77-DW07 | 2 | 1 | 50.0% |
| SEDAR77-DW22 | 13 | 1 | 7.7% |
| SEDAR 77 Data Workshop Presentation[1] | 2 | 0 | 0.0% |
| Total (pooled data) | 17 | 2 | 11.8% |

[1](Bryan Frazier – Tag Data)

The PRLDM Ad-hoc Working Group noted that two of the directed studies (SEDAR77-DW07 and SEDAR77-DW22) which reported PRLDM from electronic tagging involved anglers experienced at targeting sharks, and that experienced anglers may reflect best practices associated with maximizing post-release survival (for example, reduced fight and handling time associated with heavy tackle designed to catch sharks). The PRLDM Ad-hoc Working Group also noted that the post-release mortality rate of 11.8% obtained from great hammerheads released alive from recreational gear is lower than that obtained for Atlantic blacktip sharks (18.5%; range 10.8–28.7%) during the SEDAR 65 Atlantic blacktip shark stock assessment (NMFS 2020; e.g., Courtney et al. 2021, their Table B.1) and also lower than that obtained from meta-analysis of pelagic sharks captured and released alive from longline, purse-seine and rod & reel gear combined (Musyl and Gilman 2019). Consequently, the PRLDM Ad-hoc Working Group discussed that the post-release mortality rate of 11.8% obtained from the three directed studies evaluated here may represent a plausible minimum estimate of the PRLDM rate of hammerheads captured and released alive with recreational gear.

***Decision:*** ***Use the PRLDM obtained from meta-analysis for pelagic sharks (26.8%, Musyl and Gilman 2019) as the best estimate of the PRLDM rate for hammerheads captured and released alive with recreational gear.***

***Decision:*** ***Use the 95% upper confidence interval (UCI) of PRLDM obtained from meta-analysis for pelagic sharks (36.0%, Musyl and Gilman 2019) as the maximum estimate of the PRLDM rate for hammerheads captured and released alive with recreational gear.***

The PRLDM Ad-hoc Working Group discussed the meta-analysis of pelagic shark post-release mortality rates captured and released alive from multiple gear types (Musyl and Gilman 2019) during the SEDAR 77 Data Workshop. The PRLDM Ad-hoc Working Group discussed, and the SEDAR 77 Data Workshop panel accepted, that the PRLDM rate obtained from meta-analysis (Musyl and Gilman, 2019) is likely to be more robust (stable) compared to the PRLDM estimated from the three directed studies evaluated here because of low sample size in the directed studies.

*SEDAR77-DW07*

The PRLDM Ad-hoc Working Group discussed SEDAR77-DW07 (Mohan et al. 2021), which provided evidence to estimate post release mortality from electronically tagged great hammerheads captured and released alive during Texas shore based angling. Two great hammerheads were caught, tagged, released alive, and provided electronic tag data that indicated the animal’s fate (alive or dead) after live release. One experienced immediate mortality (light level, depth, and temperature data were sufficient to determine the shark was ingested by a predator) and one survived up to 16 days following release. The mortality rate for great hammerheads obtained from these data was estimated at 50%. The study included highly experienced Texas shore-based anglers who were trained during the study in shark identification, data collection, and tag deployment. No further input was provided by investigators during the study in order to ensure the preservation of normal techniques utilized by shore-based recreational fishermen.

*SEDAR77-DW22*

The PRLDM Ad-hoc Working Group discussed SEDAR77-DW22 (Medd et al. 2021), which provided evidence to estimate post release mortality from electronically tagged great hammerheads captured and released alive during Florida shore based recreational angling. Thirteen great hammerheads were caught, tagged, released alive, and provided electronic tag data that indicated the animal's fate (alive or dead) after live release. One experienced constant depth associated with mortality. None of the pressure profiles of the other 13 tags indicated a detachment due to constant depth release. The mortality rate for great hammerheads obtained from these data was estimated at 7.7%. The anglers that caught the sharks in the tagging study were experienced (i.e., more than 1- 5 years of shark fishing) and generally used heavy gear types capable of reeling in sharks to shore relatively more quickly than would have been possible with lighter tackle.

*SEDAR 77 Data Workshop presentation (Bryan Frazier – PRLDM in South Carolina charter vessel based recreational angling)*

The PRLDM Ad-hoc Working Group discussed the SEDAR 77 Data Workshop presentation by Bryan Frazier, which provided evidence to estimate post-release mortality from electronically tagged great hammerheads captured and released alive during South Carolina charter vessel based recreational angling. Two great hammerheads were caught, tagged, released alive, and provided electronic tag data that indicated the animal's fate (alive or dead) after live release. None experienced constant depth assumed to be associated with mortality. The mortality rate for great hammerheads obtained from these data was estimated at 0%. One additional great hammerhead was tagged, but electronic tag data was not available at the Data Workshop to determine the animal's fate after live release.

A summary of the information provided during the SEDAR 77 Data Workshop presentation by Bryan Frazier is provided below and in **Figures 27** and **28**. One great hammerhead was a 245 cm fork length pregnant female (confirmed via ultrasound) captured after a 32 minute fight time and at a water temperature of 30.7° C. The shark was tagged with standard-rate X-tag on 8/24/17. The tag was shed after 122 days at liberty. An example of the temperature and depth profile is provided in **Figure 27**. The other great hammerhead was a 286 cm fork length female captured after a 47 minute fight time and at a water temperature of 29.4° C. The shark was tagged with a PSATLife tag on 6/28/17. After 9 days at liberty, the tag shed prematurely, but indicated post-release survival based on light intensity and depth data. An example of light intensity and pressure (depth) of the great hammerhead tagged with a PSATLife tag is provided in **Figure 28**.

*SEDAR 77 Data Workshop presentation (Kesley Banks - Fight and handling times in a Texas shore-based recreational shark fishery)*

The PRLDM Ad-hoc Working Group discussed the SEDAR 77 Data Workshop presentation by Kesley Banks, which summarized fight and handling times in a shore-based recreational shark fishery. It was noted that anglers generally used heavy gear, and that fight times for great hammerheads were generally longer than those for scalloped hammerhead because the size of great hammerheads was generally larger than the size of scalloped hammerheads in the shore based fishery.

A summary of the information provided during the SEDAR 77 Data Workshop presentation by Kesley Banks is provided below. The Texas Shark Rodeo (TSR) is an annual 9-month long land-based shark fishing tournament that advocates for catch-photo-release with an "emphasis on tagging and collecting data for the conservation of sharks" (texassharkrodeo.com). There is no entry fee for the tournament, with winners receiving trophies and recognition, but no monetary incentive. Anglers participating in the TSR tag and submit a photograph of their catch for it to be counted, allowing for confirmation of the species submitted. Date of capture, location, stretched total length (measured from the tip of the snout to the tip of the stretched upper caudal lobe), sex, species, and tag number, along with photographs were then submitted via online form. Although variation in recreational gear types exists amongst individual anglers, the general strategy for land-based fishing in Texas involves the use of large reels spooled with 800–1,000 m of 50-lb (22.68-kg) to 100-lb (45.36-kg) test line (monofilament or braided) with approximately 100 m of monofilament top shot of increased strength. A wire or monofilament leader, consisting of a weight and a line with a circle or J-hook ranging in size from 13/0 to 24/0, is connected to the top-shot line. The hook is baited with large sections of stingray *Rhinoptera* spp. or *Dasyatis* spp., crevalle jack *Caranx hippos*, or striped mullet *Mugil cephalus* and is either surf cast or kayaked out 100–400 m offshore. Anglers participating in the TSR span the entire Texas coast and were permitted to target sharks from shore (e.g., beach, jetty, channel), excluding piers or vessels of any type.

Beginning in 2020, time of hook, time at landing, and time at release were asked during the tournaments. This allowed for 62 hammerheads (great: n = 43, scalloped: n = 19) to be sampled for fight and handling times. Anglers typically spent longer fighting great hammerheads (mean ± SD: 30 ± 21 min) than scalloped hammerheads (5 ± 4 min). The maximum fight time was 90 minutes to land a great hammerhead and the shortest time was 1 minute for a scalloped hammerhead. Handling times were also longer for great hammerheads (5 ± 2.5 min) than scalloped hammerheads (3 ± 1.6 min) with the longest being 15 minutes for a great hammerhead and shortest at 0 minutes for a great hammerhead. Length data was also available for hammerheads from 2014 – 2021. Scalloped hammerheads were typically smaller in length than great hammerheads. The reported number of pups captured is larger for scalloped hammerheads (n = 43 smaller than 70 cm FL) than great hammerheads (n = 2 smaller than 80 cm FL), which could help explain the shorter fight and handling times for scalloped hammerheads.

*SEDAR 77 Data Workshop presentation (Cliff Hutt – Proportion of shark targeted recreational fishing trips in the MRIP data base that captured or harvested hammerheads)*

The PRLDM Ad-hoc Working Group discussed the SEDAR 77 Data Workshop presentation by Cliff Hutt, which reported the proportion of shark targeted recreational fishing trips in the MRIP data base that captured or harvested hammerheads. It was noted that the majority of trips which reported either catching or harvesting hammerheads, did not report targeting sharks.

A summary of the information provided during the SEDAR 77 Data Workshop presentation by Cliff Hutt is provided below and in **Figures 29** to **32**. The MRIP data base was queried for the number of MRIP trips: (1) targeting sharks (excluding pelagic, small coastals, and dogfish); (2) catching hammerheads, including generic hammerheads; (3) catching hammerheads identified to species; and 4) harvesting hammerheads identified to species. 17.7% of trips that reported catch of hammerheads reported targeting sharks (excluding pelagics or small coastals). 33.1% of trips that reported harvesting hammerheads reported targeting sharks (excluding pelagics or small coastals). Trips targeting sharks account for approximately 3.5% of all MRIP estimated recreational trips that reported catching sharks. The patterns of available data used to calculate these proportions has also changed over time, possibly in response to changes in management, for example limiting harvest of hammerheads (e.g., see **Figures 29 to 32**).

*SEDAR77-RD48 (Musyl and Gilman 2019)*

The PRLDM Ad-hoc Working Group discussed the published meta-analysis of pelagic shark post-release mortality rates captured and released alive from multiple gear types (Musyl and Gilman 2019) during the SEDAR 77 Data Workshop. The PRLDM Ad-hoc Working Group noted that the post-release mortality rate obtained from the published meta-analysis (Musyl and Gilman, 2019) is likely to be more robust (stable) compared to the PRLDM estimated from the three directed studies identified above because of low sample size in the directed studies. PRLDM obtained from meta-analysis for all pelagic sharks combined (33 studies) was 26.8% (Musyl and Gilman 2019, 19.3% LCI, 36.0% UCI, obtained from longline, purse-seine, rod and reel combined, Dead = 95, Tagged = 401). In comparison, PRLDM obtained from meta-analysis for scalloped hammerhead captured and released alive from purse-seine gear (One study) was 87.5% (Musyl and Gilman 2019, 26.6% LCI, 99.3% UCI, Dead = 3, Tagged = 3). The PRLDM Ad-hoc Working Group discussed that the post-release mortality rate of 26.8% obtained from meta-analysis for all pelagic sharks combined (Musyl and Gilman 2019) along with the 95% UCI (36.0%) may represent plausible robust (stable) estimates of the best available and maximum, respectively, PRLDM rate of hammerheads captured and released alive with recreational gear.

*SEDAR77-DW36*

The PRLDM Ad-hoc Working Group discussed SEDAR77-DW36 (Gardiner et al. 2022), which provided evidence of post-release mortality for great and scalloped hammerheads fitted with surgically implanted acoustic transmitters and/or satellite tags after being captured during fishery-independent surveys or directed sampling efforts using gillnet, bottom longline, or drum line gear. One great hammerhead was also incidentally captured using rod and reel gear, with light monofilament terminating in a 6/0 circle hook. Only individuals that appeared healthy and in robust condition were selected for tagging. Upon release, animal movements were tracked by arrays of passive acoustic receivers (e.g., SEDAR 77-SID05, Gardiner et al. 2021). Animals were classified as either survivals (individuals that maintained continuous movement for a period ≥ 14 days) or mortalities (individuals that ceased movement within 14 days or individuals that disappeared within a gated array after 6 months had elapsed).

Post-release outcomes were determined for scalloped and great hammerheads from multiple release locations in Florida west coast estuaries and bays adjacent to the Gulf of Mexico as described in Gardiner et al. (2022, their Tables 1 and 2) and summarized below in **Table 35**. The PRLDM Ad-hoc Working Group discussed that many of the acoustic array locations provided complete coverage across all entry/exit points (Gardiner et al. 2022), such that acoustically tagged sharks were unlikely to emigrate from the tag location undetected. Consequently, the PRLDM Ad-hoc Working Group discussed that the resulting post-release mortality rate estimates obtained from the acoustic tagging data (**Table 35**) could be useful to inform stock assessment. However, the PRLDM rates obtained from the study were not adopted for use in the current assessment because the data were not reviewed by the PRLDM Ad-hoc Working Group in detail. The PRLDM Ad-hoc Working Group discussed that the post-release mortality of the one great hammerhead incidentally captured using rod and reel gear, with light monofilament terminating in a 6/0 circle hook, was consistent with the possibility that hammerheads captured incidentally may experience higher post-release mortality rates than hammerheads captured by anglers targeting sharks, as discussed above.

*SEDAR77-SID01*

The PRLDM Ad-hoc Working Group discussed SEDAR77-SID01 (Heim et al. 2021), which provided evidence of post-release mortality for 15 great hammerhead (1 post-release mortality) and 10 scalloped hammerheads (1 post release mortality). Sharks were tagged in the Bahamas, Florida and South Carolina using various capture methods including hand line and bottom longline. The data collection for the project was still ongoing and therefore the data analysis was preliminary. The PRLDM rates obtained from the study were not adopted for use in the current assessment because the data were not reviewed by the PRLDM Ad-hoc Working Group in detail.

### Catches by species/stock

Scalloped hammerhead, all regions—The vast majority of scalloped hammerhead catches were from MRIP. Catches were highest at the beginning of the time series and showed a decreasing trend punctuated by some peaks, notably in 1982 and 1993 for the AB1 series. Upon further examination, it was found that the A estimate for 1982 was influenced by a large value of 22,010 sharks for South Carolina (Wave 3, Private, Inland), which was based on one observed trip that harvested 20 sharks, all measuring only 11 inches. Since this was unrealistic, the recommendation was to remove this SC estimate entirely. Thus, 22,010 was subtracted from the original A estimate of 39,739. The original AB1 estimate for 1993 was 60,926 sharks, including an A estimate of 5,559 sharks (east coast of FL, Wave 3, Shore, State Ocean) and a B1 estimate of 38,913 sharks (east coast of FL, W3, Shore, State Ocean). The A estimate corresponded to 1 angler reporting 1 harvested shark and the B1 estimate to 3 anglers reporting harvests of 1, 2, and 4 sharks each, all legal in 1993). Based on this the recommendation was to smooth the 1993 data point. **Figure 33** shows the recreational catches before (top) and after (bottom) smoothing the individual points and the general smoothing.

Most AB1 catches by state corresponded to the southeast region in the Atlantic with Florida-East coast (45%), Georgia (17%), and South Carolina (13%) accounting for 75% of all scalloped hammerhead catches (**Figure 34, top**). By fishing mode, most AB1 catches were from shore (48%) and by private boats (47%), with charter boats and headboats contributing very little (**Figure 34, middle**). By fishing area, most AB1 catches occurred less than 3 miles from shore (45%) and in inshore waters (37%), with the remaining catches occurring in waters over three miles from shore (9%) or less than 10 miles from shore (8%; **Figure 34, bottom**).

***Decision:*** ***Remove the South Carolina A estimate of 22,010 sharks from the original A estimate of 39,739 for the 1982 AB1 estimate in numbers; smooth the 1993 AB1 estimate (in numbers and weight) by setting it equal to the geometric mean of the 3 preceding and ensuing years***

Scalloped hammerhead GOM—The vast majority of scalloped hammerhead catches were from MRIP. Catches showed a decreasing trend punctuated by some peaks, notably in 1985 for the AB1 series. Upon further examination, it was found that of the original AB1 estimate of 27,387 sharks for 1985, 19,977 sharks corresponded to A estimates of 5,408 sharks (MS, W3, Private, Inland), 7,600 sharks (West coast of FL, W4, Private, Fed Ocean), and 4,814 sharks (MS, W4, Private, Inland). The 5,408 estimate was based on 2 anglers reporting 1 shark each, the 7,600 estimate was based on 1 angler reporting 1 shark, and the 4,814 estimate was based on 2 anglers reporting 1 shark each, and 1 angler reporting 2 sharks. Based on this the recommendation was to smooth the 1985 estimate. The 1984 AB1 estimate of 10,416 was influenced by a B1 estimate of 10,001 sharks (MS, Wave 4, Private, Fed Ocean), which was based on an extrapolation from 2 trips reporting 1 shark harvested each. Based on this the recommendation was also to smooth this estimate. **Figure 35** shows the recreational catches before (top) and after (bottom) smoothing the individual points and the general smoothing.

Most AB1 catches by state corresponded to Florida-west coast (43%), Mississippi (38%), Alabama (10%), and Texas (9%) (**Figure 36, top**). By fishing mode, most AB1 catches were from private boats (72%) and from shore (19%), with charter boats and headboats contributing the remaining 9% (**Figure 36, middle**). By fishing area, most AB1 catches occurred in waters over three miles from shore (21%) and less than 10 miles from shore (33%) with catches in less than 3 miles from shore and in inshore waters accounting for 40% of the total catches (**Figure 36, bottom**).

***Decision:*** ***Smooth the 1984 and 1985 AB1 estimates (in numbers and weight) by setting them equal to the geometric mean of the 3 preceding and ensuing years***

Scalloped hammerhead ATL—Almost all scalloped hammerhead catches were from MRIP. Catches showed a decreasing trend punctuated by some peaks, notably in 1982 and 1993 for the AB1 series. As for the scalloped hammerhead with all regions combined, the A estimate for 1982 was influenced by a large value of 22,010 sharks for SC (Wave 3, Private, Inland), which was based on one observed trip that harvested 20 sharks, all measuring only 11 inches. Since this was unrealistic, the recommendation was to remove this SC estimate entirely. Thus, 22,010 was subtracted from the original A estimate of 39,066. The original AB1 estimate for 1993 was 56,720 sharks, including an A estimate of 5,559 sharks (east coast of FL, Wave 3, Shore, State Ocean) and a B1 estimate of 38,913 sharks (east coast of FL, W3, Shore, State Ocean). The A estimate corresponded to 1 angler reporting 1 harvested shark and the B1 estimate to 3 anglers reporting harvests of 1, 2, and 4 sharks each, all legal in 1993). Based on this the recommendation was to smooth the 1993 data point. **Figure 37** shows the recreational catches before (top) and after (bottom) smoothing the individual points and the general smoothing.

Most AB1 catches by state corresponded to Florida-east coast (58%), Georgia (22%), South Carolina (17%), and North Carolina (3%) (**Figure 38, top**). By fishing mode, most AB1 catches were from shore (57%) and from private boats (39%), with charter boats contributing the remaining 4% (**Figure 38, middle**). By fishing area, most AB1 catches occurred in waters less than 3 miles from shore (55%) and in inshore waters (39%), with catches in waters over three miles from shore accounting for 6% of the total (**Figure 38, bottom**).

***Decision:* Remove the South Carolina A estimate of 22,010 sharks from the original A estimate of 39,066 for the 1982 AB1 estimate in numbers; smooth the 1993 AB1 estimates (in numbers and weight) by setting them equal to the geometric mean of the 3 preceding and ensuing years**

Great hammerhead—The vast majority of great hammerhead catches were from MRIP. Catches showed a decreasing trend punctuated by some peaks, notably in 1982 for the AB1 series. Upon further examination, it was found that of the original AB1 estimate of 105,497 sharks for 1982, 87,791 sharks corresponded to an A estimate of 19,282 sharks (LA, W3, Shore, Ocean), an A estimate of 10,865 sharks (east coast of FL, W4, Shore, Ocean), a B1 estimate of 42,876 sharks (East coast of FL, W2, Shore, Ocean), and a B1 estimate of 14,768 sharks (east coast of FL, W4, Shore, Ocean). The 19,282 estimate was based on 1 angler reporting 1 shark, the 10,865 estimate was based on 1 angler reporting 1 shark, the 42,876 estimate was based on 1 angler reporting 1 shark (which was an unusually large effort extrapolation), and the 14,768 estimate on 1 angler reporting 1 shark. Based on this the recommendation was to remove the 42,876 B1 estimate and to further smooth the 1982 estimate. **Figure 39** shows the recreational catches before (top) and after (bottom) smoothing the individual points and the general smoothing.

Most AB1 catches by state corresponded to the southeast region with Florida-east coast (53%) and Florida-west coast (34%) accounting for 87% of all great hammerhead catches, followed by Louisiana (5%), and Georgia and South Carolina (3% each) (**Figure 40, top**). By fishing mode, almost all AB1 catches were from shore (76%) and by private boats (32%), with charter boats and headboats contributing only 2% (**Figure 40, middle**). By fishing area, most AB1 catches occurred less than 3 miles from shore (48%) and in inshore waters (28%), with the remaining catches occurring in waters over three from shore (3%), less than 10 miles from shore (18%), or in waters over 10 miles from shore (3%) (**Figure 40, bottom**).

***Decision:* Remove the Florida east coast B1 estimate of 42,876 sharks from the original AB1 estimate of 105,497 for the 1982 AB1 estimate in numbers and smooth that 1982 AB1 estimate (in numbers and weight) by setting it equal to the geometric mean of the 3 ensuing years (1981 value was 0)**

Smooth hammerhead—Almost all smooth hammerhead catches were from MRIP. Catches showed a generally decreasing trend punctuated by a very large peak in 1991 for the AB1 series. Upon further examination, it was found that the A estimate for 1991 was influenced by a large value of 39,148 sharks (east coast of FL, W6, Shore, Ocean), which was based on 1 angler reporting 1 shark (an unusually large effort extrapolation). Since this was unrealistic, the recommendation was to remove this FL estimate entirely. Thus, 39,148 was subtracted from the original A estimate of 39,284. **Figure 41** shows the recreational catches before (top) and after (bottom) smoothing the individual points and the general smoothing.

Most AB1 catches by state corresponded to the southeast region with Florida-East coast (51%) and Florida-west coast (16%) accounting for 67% of all smooth hammerhead catches, followed by Georgia (17%), South Carolina (10%), and Maryland (6%) (**Figure 42, top**). By fishing mode, almost all AB1 catches were from shore (60%) and by private boats (38%), with charter boats and headboats contributing only 2% (**Figure 42, middle**). By fishing area, most AB1 catches occurred less than 3 miles from shore (53%) and in inshore waters (27%), with the remaining catches occurring in waters over three miles from shore (4%) and less than 10 miles from shore (16%) (**Figure 42, bottom**).

***Decision:*** ***Remove the Florida east coast A estimate of 39,148 sharks from the original A estimate of 39,284 for the 1991 AB1 estimate in numbers; smooth that 1991 AB1 estimate in weight by setting it equal to the geometric mean of the 3 preceding and ensuing years***

Carolina hammerhead— There were no recreational catches identified as Carolina hammerheads, but an unknown portion of the scalloped hammerhead catches in the Atlantic could be attributed to this cryptic species.

#### Recreational length compositions

Lengths available from the MRIP and the SRHS surveys were reported and analyzed in SEDAR77-DW04. See that working document for details and section on length compositions of this DW report. We only provide a synopsis by stock here.

Scalloped hammerhead, all regions—Lengths of scalloped hammerheads were available from the MRIP (cm FL; n=227) and the SRHS (mm TL; n=63). Total lengths in the SRHS were converted to fork lengths with the equation for combined sexes given in SEDAR77-DW03. Length-frequency distributions show that more immature than mature sharks are caught based on the median sizes at maturity for males and females listed in the SEDAR 77 Stock ID report (146 cm FL for males; 179 cm FL for females) (**Figure 43**).

Scalloped hammerhead GOM—Lengths of GOM scalloped hammerheads were available from the MRIP (cm FL; n=53) and the SRHS (mm TL; n=59). Total lengths in the SRHS were converted to fork lengths with the equation for combined sexes given in SEDAR77-DW03 for scalloped hammerheads (GOM and ATL combined). Length-frequency distributions show that more immature than mature sharks are caught based on the median sizes at maturity for males and females listed in the SEDAR 77 Stock ID report (142 cm FL for males; 180 cm FL for females) (**Figure 44**).

Scalloped hammerhead ATL—Lengths of ATL scalloped hammerheads were available from the MRIP (cm FL; n=174) while very few were available from the SRHS (mm TL; n=4). Total lengths in the SRHS were converted to fork lengths with the equation for combined sexes given in SEDAR77-DW03 for scalloped hammerheads (GOM and ATL combined). Length-frequency distributions show that more immature than mature sharks are caught in the MRIP based on the median sizes at maturity for males and females listed in the SEDAR 77 Stock ID report (157 cm FL for males; 178 cm FL for females) (**Figure 45).**

Great hammerhead—Lengths of great hammerheads were available from the MRIP (cm FL; n=89) while very few were available from the SRHS (mm TL; n=8). Total lengths in the SRHS were converted to fork lengths with the equation for combined sexes given in SEDAR77-DW03. Length-frequency distributions show that more immature than mature sharks are caught based on the median sizes at maturity for males and females listed in the SEDAR 77 Stock ID report (197 cm FL for males; 199 cm FL for females) **(Figure 46**).

Smooth hammerhead—Lengths of smooth hammerheads were only available from the MRIP (cm FL; n=47). The length-frequency distribution shows that most sharks caught were immature based on median sizes at maturity for males and females given in Stevens (1984) (255 cm TL for males; 265 cm TL for females; when transformed into fork lengths using the regression equation FL=12.72+0.84TL from Coelho et al. (2011) they become 227 cm FL for males and 235 cm FL for females) (**Figure 47**).

*Carolina hammerhead—* There were no recreational lengths identified as Carolina hammerheads, but an unknown portion of the scalloped hammerhead lengths in the Atlantic could be attributed to this cryptic species.

### 3.1.4 Combined commercial and recreational catches

Scalloped hammerhead, all regions—Total catches of scalloped hammerheads in weight peaked during the early 1990s and again in the early 2000s and showed a decreasing trend thereafter. Recreational catches were generally the most important, except for years with higher commercial catches in the late 1980s and mid-1990s (**Figure 48**).

**Tables 36** and **37** show commercial catches by gear, dead discard estimates from the pelagic longline (PLL) fishery, recreational catches (AB1, LPRM=Live post-release mortality=B2 dead), and total catch. Total catch was computed as the sum of recreational catches (AB1+LPRM) and the maximum of the sum of commercial catches by gear (bottom longline+gillnets+hand lines/hook and line+PLL discards) and the total combined commercial catches not disaggregated by gear, in weight (lb dw) and numbers, respectively.

Scalloped hammerhead GOM— Total catches of GOM scalloped hammerheads in weight peaked during the mid-1990s and again in the mid-2000s and showed a decreasing trend thereafter. Recreational catches were generally the most important, except for years with higher commercial catches in the mid-1990s, late 2000s, and mid-2010s (**Figure 49**).

**Tables 38** and **39** show commercial catches by gear, dead discard estimates from the pelagic longline (PLL) fishery, recreational catches (A+B1, LPRM=Live post-release mortality), and total catch. Total catch was computed as the sum of recreational catches (AB1+LPRM) and the maximum of the sum of commercial catches by gear (bottom longline+gillnets+hand lines/hook and line+PLL discards) and the total combined commercial catches not disaggregated by gear, in weight (lb dw) and numbers, respectively.

Scalloped hammerhead ATL—Total catches of ATL scalloped hammerheads in weight generally mirrored those for the scalloped hammerheads for regions combined because catches in the Atlantic accounted for the majority of scalloped hammerhead catches (**Figure 50**).

**Tables 40** and **41** show commercial catches by gear, dead discard estimates from the pelagic longline (PLL) fishery, recreational catches (AB1, LPRM=Live post-release mortality), and total catch. Total catch was computed as the sum of recreational catches (AB1+LPRM) and the maximum of the sum of commercial catches by gear (bottom longline+gillnets+hand lines/hook and line+PLL discards) and the total combined commercial catches not disaggregated by gear, in weight (lb dw) and numbers, respectively.

Great hammerhead—Total catches of great hammerheads in weight were overwhelmingly dominated by recreational catches until the late 1990s and remained at low levels thereafter. Recreational catches showed a steep decline from the early 1980s to the late 1990s (**Figure 51**).

**Tables 42** and **43** show commercial catches by gear, dead discard estimates from the pelagic longline (PLL) fishery, recreational catches (AB1, LPRM=Live post-release mortality), and total catch. Total catch was computed as the sum of recreational catches (AB1+LPRM) and the maximum of the sum of commercial catches by gear (bottom longline+gillnets+hand lines/hook and line+PLL discards) and the total combined commercial catches not disaggregated by gear, in weight (lb dw) and numbers, respectively.

Smooth hammerhead—The vast majority of catches of smooth hammerheads in weight were reported as recreational during the entire time series (**Figure 52**).

**Tables 44** and **45** show commercial catches by gear, dead discard estimates from the pelagic longline (PLL) fishery, recreational catches (AB1, LPRM=Live post-release mortality), and total catch. Total catch was computed as the sum of recreational catches (AB1+LPRM) and the maximum of the sum of commercial catches by gear (bottom longline+gillnets+unknown gear+PLL discards) and the total combined commercial catches not disaggregated by gear, in weight (lb dw) and numbers, respectively.

Carolina hammerhead—There were no commercial or recreational catches reported as Carolina hammerheads, but an unknown portion of the scalloped hammerhead catches in the Atlantic could be attributed to this cryptic species.

## 3.2 Research Recommendations

- Increase public education outreach activities for species identification in the recreational fishery. This is important because there are no species identification training workshops for recreational fishers, and it is difficult to distinguish among different species, especially 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.

- Promote that the next stock assessment of hammerhead shark species/stocks be conducted under the auspices of an RFMO (e.g., WECAFC) so that all sources of removals and abundance indices and length compositions (if available) from Caribbean nations where the species/stock is distributed can be accounted for.

- Pooling observed sets for all areas by either each observed year or all observed years without considering variance of areas and seasons, along with an assumption of effort (*number of logbook hooks*) being a known constant, may cause the actual variance of discard estimates to be underestimated. This in turn will produce a narrower confidence interval, which may have a confidence level lower than desired. The pooling methods may need to be further evaluated in the future.
- Given the very small number of sets in which a non-zero bycatch was observed (positive sets), the panel recommended to use the grand mean of discard rates based on the pooled observed sets for all years and the annual logbook effort to produce annual discard estimates. Assuming the grand mean of discard rate based on all the pooled observed sets is a constant for the entire time series, and the trend of the discard estimates is solely driven by the logbook effort, which may need to be further evaluated in the future.
- The discard estimates and associated uncertainty estimates using the delta-lognormal method (SEDAR77-DW37 and SEDAR77-DW38) are regarded as an improvement over the discard estimates and associated uncertainty estimates using the ratio method reported in SEDAR77-DW20 and SEDAR77-DW21. More discard methods should be further explored in the future.

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## 3.4 Tables

**Table 1**. Yearly calculated dead discards of great hammerhead sharks for the shark bottom longline fishery for the areas combined. Discards are reported as number of individuals. Due to small number of observed positive sets, all years of observed data are combined.

| Observed Year | Observed Sets | Positive Sets | Observed Hooks | Positive Hooks | Observed Animals | Mean CPUE (Per 1000 Hooks) | Standard Deviation | CV | Logbook Year | Logbook Hooks | Estimated Discards | Upper 95% CI | Lower 95% CI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 1993 | 1101380 | 102 | 252 | 41 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 1994 | 1941435 | 180 | 444 | 73 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 1995 | 2417653 | 224 | 553 | 91 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 1996 | 3435583 | 319 | 787 | 129 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 1997 | 1471463 | 137 | 338 | 56 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 1998 | 1579283 | 147 | 363 | 60 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 1999 | 1529138 | 142 | 350 | 58 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 2000 | 1387950 | 129 | 318 | 52 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 2001 | 1358879 | 126 | 311 | 51 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 2002 | 1662874 | 154 | 380 | 62 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 2003 | 1652615 | 153 | 378 | 62 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 2004 | 1227075 | 114 | 281 | 46 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 2005 | 1388406 | 129 | 318 | 52 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 2006 | 1579548 | 147 | 363 | 60 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 2007 | 495758 | 46 | 114 | 19 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 2008 | 258546 | 24 | 59 | 10 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 2009 | 290442 | 27 | 67 | 11 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 2010 | 230152 | 21 | 52 | 9 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 2011 | 209477 | 19 | 47 | 8 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 2012 | 193178 | 18 | 44 | 7 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 2013 | 231876 | 22 | 54 | 9 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 2014 | 329424 | 31 | 76 | 13 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 2015 | 300820 | 28 | 69 | 11 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 2016 | 187493 | 17 | 42 | 7 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 2017 | 210155 | 20 | 49 | 8 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 2018 | 196449 | 18 | 44 | 7 |
| 2005-2019 | 649 | 6 | 249305 | 1327 | 12 | 0.093 | 0.045 | 0.490 | 2019 | 130975 | 12 | 30 | 5 |

**Table 2**. Yearly observed dead discards of great hammerhead sharks from the shark research fishery for the areas combined. Discards are reported as number of individuals.

| Year | Number Observed Sets | Total Dead Discards |
|---|---|---|
| 2008 | 62 | 3 |
| 2009 | 111 | 3 |
| 2010 | 185 | 27 |
| 2011 | 236 | 37 |
| 2012 | 85 | 2 |
| 2013 | 93 | 6 |
| 2014 | 104 | 1 |
| 2015 | 99 | 1 |
| 2016 | 81 | 1 |
| 2017 | 104 | 2 |
| 2018 | 108 | 0 |
| 2019 | 100 | 3 |

**Table 3**. Yearly calculated live discards of great hammerhead sharks for the shark bottom longline fishery for the areas combined. Discards are reported as number of individuals. Due to small number of observed positive sets, all years of observed data are combined.

| Observed Year | Observed Sets | Positive Sets | Observed Hooks | Positive Hooks | Observed Animals | Mean CPUE (Per 1000 Hooks) | Standard Deviation | CV | Logbook Year | Logbook Hooks | Estimated Discards | Upper 95% CI | Lower 95% CI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 1993 | 1101380 | 155 | 289 | 83 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 1994 | 1941435 | 272 | 507 | 146 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 1995 | 2417653 | 339 | 631 | 182 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 1996 | 3435583 | 482 | 898 | 259 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 1997 | 1471463 | 206 | 384 | 111 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 1998 | 1579283 | 222 | 413 | 119 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 1999 | 1529138 | 215 | 400 | 115 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 2000 | 1387950 | 195 | 363 | 105 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 2001 | 1358879 | 191 | 356 | 103 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 2002 | 1662874 | 233 | 434 | 125 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 2003 | 1652615 | 232 | 432 | 125 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 2004 | 1227075 | 172 | 320 | 92 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 2005 | 1388406 | 195 | 363 | 105 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 2006 | 1579548 | 222 | 413 | 119 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 2007 | 495758 | 70 | 130 | 38 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 2008 | 258546 | 36 | 67 | 19 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 2009 | 290442 | 41 | 76 | 22 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 2010 | 230152 | 32 | 60 | 17 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 2011 | 209477 | 29 | 54 | 16 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 2012 | 193178 | 27 | 50 | 14 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 2013 | 231876 | 33 | 61 | 18 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 2014 | 329424 | 46 | 86 | 25 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 2015 | 300820 | 42 | 78 | 23 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 2016 | 187493 | 26 | 48 | 14 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 2017 | 210155 | 29 | 54 | 16 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 2018 | 196449 | 28 | 52 | 15 |
| 2005-2019 | 649 | 15 | 249305 | 4608 | 20 | 0.140 | 0.046 | 0.330 | 2019 | 130975 | 18 | 34 | 10 |

**Table 4**. Yearly observed live discards of great hammerhead sharks from the shark research fishery for the areas combined. Discards are reported as number of individuals.

| Year | Number Observed Sets | Total Live Discards |
|---|---|---|
| 2008 | 62 | 2 |
| 2009 | 111 | 4 |
| 2010 | 185 | 0 |
| 2011 | 236 | 8 |
| 2012 | 85 | 3 |
| 2013 | 93 | 15 |
| 2014 | 104 | 4 |
| 2015 | 99 | 12 |
| 2016 | 81 | 5 |
| 2017 | 104 | 26 |
| 2018 | 108 | 5 |
| 2019 | 100 | 14 |

**Table 5**. Yearly calculated dead discards of scalloped hammerhead sharks for the shark bottom longline fishery for the areas combined. Discards are reported as number of individuals. Due to small number of observed positive sets, all years of observed data are combined.

| Observed Year | Observed Sets | Positive Sets | Observed Hooks | Positive Hooks | Observed Animals | Mean CPUE (Per 1000 Hooks) | Standard Deviation | CV | Logbook Year | Logbook Hooks | Estimated Discards | Upper 95% CI | Lower 95% CI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 1993 | 1101380 | 362 | 615 | 213 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 1994 | 1941435 | 637 | 1083 | 375 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 1995 | 2417653 | 794 | 1349 | 467 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 1996 | 3435583 | 1128 | 1917 | 664 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 1997 | 1471463 | 483 | 821 | 284 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 1998 | 1579283 | 518 | 880 | 305 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 1999 | 1529138 | 502 | 853 | 295 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 2000 | 1387950 | 456 | 775 | 268 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 2001 | 1358879 | 446 | 758 | 262 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 2002 | 1662874 | 546 | 928 | 321 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 2003 | 1652615 | 543 | 923 | 320 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 2004 | 1227075 | 403 | 685 | 237 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 2005 | 1388406 | 456 | 775 | 268 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 2006 | 1579548 | 519 | 882 | 305 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 2007 | 495758 | 163 | 277 | 96 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 2008 | 258546 | 85 | 144 | 50 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 2009 | 290442 | 95 | 161 | 56 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 2010 | 230152 | 76 | 129 | 45 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 2011 | 209477 | 69 | 117 | 41 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 2012 | 193178 | 63 | 107 | 37 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 2013 | 231876 | 76 | 129 | 45 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 2014 | 329424 | 108 | 184 | 64 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 2015 | 300820 | 99 | 168 | 58 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 2016 | 187493 | 62 | 105 | 36 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 2017 | 210155 | 69 | 117 | 41 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 2018 | 196449 | 64 | 109 | 38 |
| 2005-2019 | 649 | 25 | 249305 | 7203 | 44 | 0.328 | 0.090 | 0.280 | 2019 | 130975 | 43 | 73 | 25 |

**Table 6**. Yearly observed dead discards of scalloped hammerhead sharks from the shark research fishery for the areas combined. Discards are reported as number of individuals.

| Year | Number Observed Sets | Total Dead Discards |
|---|---|---|
| 2008 | 62 | 1 |
| 2009 | 111 | 41 |
| 2010 | 185 | 23 |
| 2011 | 236 | 37 |
| 2012 | 85 | 6 |
| 2013 | 93 | 3 |
| 2014 | 104 | 4 |
| 2015 | 99 | 4 |
| 2016 | 81 | 6 |
| 2017 | 104 | 8 |
| 2018 | 108 | 4 |
| 2019 | 100 | 3 |

**Table 7**. Yearly calculated live discards of scalloped hammerhead sharks for the shark bottom longline fishery for the areas combined. Discards are reported as number of individuals. Due to small number of observed positive sets, all years of observed data are combined.

| Observed Year | Observed Sets | Positive Sets | Observed Hooks | Positive Hooks | Observed Animals | Mean CPUE (Per 1000 Hooks) | Standard Deviation | CV | Logbook Year | Logbook Hooks | Estimated Discards | Upper 95% CI | Lower 95% CI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 1993 | 1101380 | 347 | 670 | 180 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 1994 | 1941435 | 611 | 1179 | 317 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 1995 | 2417653 | 761 | 1468 | 394 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 1996 | 3435583 | 1081 | 2086 | 560 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 1997 | 1471463 | 463 | 893 | 240 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 1998 | 1579283 | 497 | 959 | 258 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 1999 | 1529138 | 481 | 928 | 249 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 2000 | 1387950 | 437 | 843 | 226 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 2001 | 1358879 | 428 | 826 | 222 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 2002 | 1662874 | 523 | 1009 | 271 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 2003 | 1652615 | 520 | 1003 | 269 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 2004 | 1227075 | 386 | 745 | 200 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 2005 | 1388406 | 437 | 843 | 226 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 2006 | 1579548 | 497 | 959 | 258 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 2007 | 495758 | 156 | 301 | 81 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 2008 | 258546 | 81 | 156 | 42 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 2009 | 290442 | 91 | 176 | 47 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 2010 | 230152 | 72 | 139 | 37 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 2011 | 209477 | 66 | 127 | 34 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 2012 | 193178 | 61 | 118 | 32 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 2013 | 231876 | 73 | 141 | 38 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 2014 | 329424 | 104 | 201 | 54 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 2015 | 300820 | 95 | 183 | 49 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 2016 | 187493 | 59 | 114 | 31 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 2017 | 210155 | 66 | 127 | 34 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 2018 | 196449 | 62 | 120 | 32 |
| 2005-2019 | 649 | 18 | 249305 | 5196 | 40 | 0.315 | 0.109 | 0.350 | 2019 | 130975 | 41 | 79 | 21 |

**Table 8**. Yearly observed live discards of scalloped hammerhead sharks from the shark research fishery for the areas combined. Discards are reported as number of individuals.

| Year | Number Observed Sets | Total Live Discards |
|---|---|---|
| 2008 | 62 | 2 |
| 2009 | 111 | 16 |
| 2010 | 185 | 13 |
| 2011 | 236 | 19 |
| 2012 | 85 | 5 |
| 2013 | 93 | 7 |
| 2014 | 104 | 10 |
| 2015 | 99 | 13 |
| 2016 | 81 | 23 |
| 2017 | 104 | 42 |
| 2018 | 108 | 14 |
| 2019 | 100 | 17 |

**Table 9**. Yearly calculated dead discards of scalloped hammerhead sharks for the shark bottom longline fishery for the Atlantic. Discards are reported as number of individuals. Due to small number of observed positive sets, all years of observed data are combined.

| Observed Year | Observed Sets | Positive Sets | Observed Hooks | Positive Hooks | Observed Animals | Mean CPUE (Per 1000 Hooks) | Standard Deviation | CV | Logbook Year | Logbook Hooks | Estimated Discards | Upper 95% CI | Lower 95% CI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 1993 | 373270 | 99 | 208 | 47 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 1994 | 767570 | 204 | 429 | 97 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 1995 | 293603 | 78 | 164 | 37 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 1996 | 853758 | 226 | 475 | 108 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 1997 | 393413 | 104 | 219 | 49 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 1998 | 458687 | 122 | 256 | 58 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 1999 | 420234 | 111 | 233 | 53 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 2000 | 398160 | 106 | 223 | 50 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 2001 | 432662 | 115 | 242 | 55 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 2002 | 586165 | 155 | 326 | 74 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 2003 | 586888 | 156 | 328 | 74 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 2004 | 455745 | 121 | 254 | 58 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 2005 | 386396 | 103 | 217 | 49 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 2006 | 386212 | 102 | 214 | 49 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 2007 | 207548 | 55 | 116 | 26 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 2008 | 112946 | 30 | 63 | 14 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 2009 | 252278 | 67 | 141 | 32 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 2010 | 209491 | 56 | 118 | 27 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 2011 | 150252 | 40 | 84 | 19 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 2012 | 88786 | 24 | 50 | 11 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 2013 | 126843 | 34 | 71 | 16 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 2014 | 173177 | 46 | 97 | 22 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 2015 | 155914 | 41 | 86 | 20 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 2016 | 92890 | 25 | 53 | 12 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 2017 | 97453 | 26 | 55 | 12 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 2018 | 72317 | 19 | 40 | 9 |
| 2005-2019 | 251 | 11 | 94607 | 3721 | 21 | 0.265 | 0.104 | 0.39 | 2019 | 22476 | 6 | 13 | 3 |

**Table 10**. Yearly observed dead discards of scalloped hammerhead sharks from the shark research fishery for the Atlantic. Discards are reported as number of individuals.

| Year | Number Observed Sets | Total Dead Discards |
|---|---|---|
| 2008 | 21 | 0 |
| 2009 | 40 | 0 |
| 2010 | 127 | 10 |
| 2011 | 141 | 17 |
| 2012 | 58 | 3 |
| 2013 | 47 | 1 |
| 2014 | 88 | 2 |
| 2015 | 60 | 2 |
| 2016 | 52 | 1 |
| 2017 | 49 | 1 |
| 2018 | 57 | 4 |
| 2019 | 51 | 0 |

**Table 11**. Yearly calculated live discards of scalloped hammerhead sharks for the shark bottom longline fishery for the Atlantic. Discards are reported as number of individuals. Due to small number of observed positive sets, all years of observed data are combined.

| Observed Year | Observed Sets | Positive Sets | Observed Hooks | Positive Hooks | Observed Animals | Mean CPUE (Per 1000 Hooks) | Standard Deviation | CV | Logbook Year | Logbook Hooks | Estimated Discards | Upper 95% CI | Lower 95% CI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 1993 | 373270 | 118 | 298 | 47 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 1994 | 767570 | 243 | 613 | 96 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 1995 | 293603 | 93 | 235 | 37 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 1996 | 853758 | 270 | 681 | 107 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 1997 | 393413 | 124 | 313 | 49 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 1998 | 458687 | 145 | 366 | 57 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 1999 | 420234 | 133 | 335 | 53 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 2000 | 398160 | 126 | 318 | 50 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 2001 | 432662 | 137 | 346 | 54 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 2002 | 586165 | 185 | 467 | 73 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 2003 | 586888 | 186 | 469 | 74 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 2004 | 455745 | 144 | 363 | 57 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 2005 | 386396 | 122 | 308 | 48 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 2006 | 386212 | 122 | 308 | 48 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 2007 | 207548 | 66 | 166 | 26 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 2008 | 112946 | 36 | 91 | 14 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 2009 | 252278 | 80 | 202 | 32 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 2010 | 209491 | 66 | 166 | 26 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 2011 | 150252 | 48 | 121 | 19 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 2012 | 88786 | 28 | 71 | 11 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 2013 | 126843 | 40 | 101 | 16 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 2014 | 173177 | 55 | 139 | 22 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 2015 | 155914 | 49 | 124 | 19 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 2016 | 92890 | 29 | 73 | 11 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 2017 | 97453 | 31 | 78 | 12 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 2018 | 72317 | 23 | 58 | 9 |
| 2005-2019 | 251 | 8 | 94607 | 2263 | 10 | 0.316 | 0.158 | 0.500 | 2019 | 22476 | 7 | 18 | 3 |

**Table 12**. Yearly observed live discards of scalloped hammerhead sharks from the shark research fishery for the Atlantic. Discards are reported as number of individuals.

| Year | Number Observed Sets | Total Live Discards |
|---|---|---|
| 2008 | 21 | 0 |
| 2009 | 40 | 0 |
| 2010 | 127 | 9 |
| 2011 | 141 | 4 |
| 2012 | 58 | 0 |
| 2013 | 47 | 7 |
| 2014 | 88 | 7 |
| 2015 | 60 | 6 |
| 2016 | 52 | 17 |
| 2017 | 49 | 19 |
| 2018 | 57 | 9 |
| 2019 | 51 | 1 |

**Table 13**. Yearly calculated dead discards of scalloped hammerhead sharks for the shark bottom longline fishery for the Gulf of Mexico. Discards are reported as number of individuals. Due to small number of observed positive sets, all years of observed data are combined.

| Observed Year | Observed Sets | Positive Sets | Observed Hooks | Positive Hooks | Observed Animals | Mean CPUE (Per 1000 Hooks) | Standard Deviation | CV | Logbook Year | Logbook Hooks | Estimated Discards | Upper 95% CI | Lower 95% CI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 1993 | 728110 | 267 | 525 | 136 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 1994 | 1173865 | 431 | 848 | 219 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 1995 | 2124050 | 780 | 1534 | 397 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 1996 | 2581825 | 948 | 1864 | 482 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 1997 | 1078050 | 396 | 779 | 201 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 1998 | 1120596 | 411 | 808 | 209 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 1999 | 1108904 | 407 | 800 | 207 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 2000 | 989790 | 363 | 714 | 185 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 2001 | 926217 | 340 | 669 | 173 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 2002 | 1076709 | 395 | 777 | 201 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 2003 | 1065727 | 391 | 769 | 199 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 2004 | 771330 | 283 | 557 | 144 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 2005 | 1002010 | 368 | 724 | 187 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 2006 | 1193336 | 438 | 861 | 223 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 2007 | 288210 | 106 | 208 | 54 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 2008 | 137903 | 51 | 100 | 26 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 2009 | 29846 | 11 | 22 | 6 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 2010 | 24177 | 9 | 18 | 5 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 2011 | 26370 | 10 | 20 | 5 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 2012 | 95264 | 35 | 69 | 18 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 2013 | 95401 | 35 | 69 | 18 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 2014 | 135732 | 50 | 98 | 25 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 2015 | 130594 | 48 | 94 | 24 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 2016 | 82828 | 30 | 59 | 15 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 2017 | 100869 | 37 | 73 | 19 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 2018 | 111142 | 41 | 81 | 21 |
| 2005-2019 | 398 | 14 | 154698 | 3482 | 23 | 0.367 | 0.131 | 0.360 | 2019 | 96685 | 35 | 69 | 18 |

**Table 14**. Yearly observed dead discards of scalloped hammerhead sharks from the shark research fishery for the Gulf of Mexico. Discards are reported as number of individuals.

| Year | Number Observed Sets | Total Dead Discards |
|---|---|---|
| 2008 | 41 | 1 |
| 2009 | 71 | 41 |
| 2010 | 58 | 13 |
| 2011 | 95 | 20 |
| 2012 | 27 | 3 |
| 2013 | 46 | 2 |
| 2014 | 16 | 2 |
| 2015 | 39 | 2 |
| 2016 | 29 | 5 |
| 2017 | 55 | 7 |
| 2018 | 49 | 0 |
| 2019 | 49 | 3 |

**Table 15**. Yearly calculated live discards of scalloped hammerhead sharks for the shark bottom longline fishery for the Gulf of Mexico. Discards are reported as number of individuals. Due to small number of observed positive sets, all years of observed data are combined.

| Observed Year | Observed Sets | Positive Sets | Observed Hooks | Positive Hooks | Observed Animals | Mean CPUE (Per 1000 Hooks) | Standard Deviation | CV | Logbook Year | Logbook Hooks | Estimated Discards | Upper 95% CI | Lower 95% CI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 1993 | 728110 | 224 | 514 | 98 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 1994 | 1173865 | 362 | 830 | 158 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 1995 | 2124050 | 655 | 1502 | 286 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 1996 | 2581825 | 796 | 1825 | 347 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 1997 | 1078050 | 332 | 761 | 145 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 1998 | 1120596 | 345 | 791 | 150 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 1999 | 1108904 | 342 | 784 | 149 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 2000 | 989790 | 305 | 699 | 133 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 2001 | 926217 | 285 | 653 | 124 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 2002 | 1076709 | 332 | 761 | 145 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 2003 | 1065727 | 328 | 752 | 143 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 2004 | 771330 | 238 | 546 | 104 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 2005 | 1002010 | 309 | 708 | 135 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 2006 | 1193336 | 368 | 844 | 161 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 2007 | 288210 | 89 | 204 | 39 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 2008 | 137903 | 42 | 96 | 18 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 2009 | 29846 | 9 | 21 | 4 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 2010 | 24177 | 7 | 16 | 3 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 2011 | 26370 | 8 | 18 | 3 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 2012 | 95264 | 29 | 66 | 13 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 2013 | 95401 | 29 | 66 | 13 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 2014 | 135732 | 42 | 96 | 18 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 2015 | 130594 | 40 | 92 | 17 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 2016 | 82828 | 26 | 60 | 11 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 2017 | 100869 | 31 | 71 | 14 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 2018 | 111142 | 34 | 78 | 15 |
| 2005-2019 | 398 | 10 | 154698 | 2933 | 30 | 0.308 | 0.137 | 0.440 | 2019 | 96685 | 30 | 69 | 13 |

**Table 16**. Yearly observed live discards of scalloped hammerhead sharks from the shark research fishery for the Gulf of Mexico. Discards are reported as number of individuals.

| Year | Number Observed Sets | Total Live Discards |
|---|---|---|
| 2008 | 41 | 2 |
| 2009 | 71 | 16 |
| 2010 | 58 | 4 |
| 2011 | 95 | 15 |
| 2012 | 27 | 5 |
| 2013 | 46 | 0 |
| 2014 | 16 | 3 |
| 2015 | 39 | 7 |
| 2016 | 29 | 6 |
| 2017 | 55 | 23 |
| 2018 | 49 | 5 |
| 2019 | 49 | 16 |

**Table 17**. Yearly calculated dead discards of great hammerhead sharks from the US southeast commercial gillnet fishery for the areas combined. Discards are reported as number of individuals. Due to small number of observed positive sets, all years of observed data are combined.

| Observed Year | Observed Sets | Positive Sets | Observed Animals | Mean CPUE (Per Set) | Standard Deviation | CV | Logbook Year | Logbook Sets | Estimated Discards | Upper 95% CI | Lower 95% CI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1998-2019 | 3790 | 25 | 68 | 0.018 | 0.004 | 0.250 | 1998 | 2515 | 44 | 71 | 27 |
| 1998-2019 | 3790 | 25 | 68 | 0.018 | 0.004 | 0.250 | 1999 | 2077 | 36 | 58 | 22 |
| 1998-2019 | 3790 | 25 | 68 | 0.018 | 0.004 | 0.250 | 2000 | 2097 | 37 | 60 | 23 |
| 1998-2019 | 3790 | 25 | 68 | 0.018 | 0.004 | 0.250 | 2001 | 2034 | 36 | 58 | 22 |
| 1998-2019 | 3790 | 25 | 68 | 0.018 | 0.004 | 0.250 | 2002 | 1953 | 34 | 55 | 21 |
| 1998-2019 | 3790 | 25 | 68 | 0.018 | 0.004 | 0.250 | 2003 | 1633 | 29 | 47 | 18 |
| 1998-2019 | 3790 | 25 | 68 | 0.018 | 0.004 | 0.250 | 2004 | 1602 | 28 | 45 | 17 |
| 1998-2019 | 3790 | 25 | 68 | 0.018 | 0.004 | 0.250 | 2005 | 1879 | 33 | 54 | 20 |
| 1998-2019 | 3790 | 25 | 68 | 0.018 | 0.004 | 0.250 | 2006 | 2471 | 43 | 70 | 27 |
| 1998-2019 | 3790 | 25 | 68 | 0.018 | 0.004 | 0.250 | 2007 | 3748 | 66 | 107 | 41 |
| 1998-2019 | 3790 | 25 | 68 | 0.018 | 0.004 | 0.250 | 2008 | 3756 | 66 | 107 | 41 |
| 1998-2019 | 3790 | 25 | 68 | 0.018 | 0.004 | 0.250 | 2009 | 4422 | 77 | 125 | 47 |
| 1998-2019 | 3790 | 25 | 68 | 0.018 | 0.004 | 0.250 | 2010 | 2801 | 49 | 80 | 30 |
| 1998-2019 | 3790 | 25 | 68 | 0.018 | 0.004 | 0.250 | 2011 | 3825 | 67 | 109 | 41 |
| 1998-2019 | 3790 | 25 | 68 | 0.018 | 0.004 | 0.250 | 2012 | 3773 | 66 | 107 | 41 |
| 1998-2019 | 3790 | 25 | 68 | 0.018 | 0.004 | 0.250 | 2013 | 2173 | 38 | 62 | 23 |
| 1998-2019 | 3790 | 25 | 68 | 0.018 | 0.004 | 0.250 | 2014 | 3932 | 69 | 112 | 43 |
| 1998-2019 | 3790 | 25 | 68 | 0.018 | 0.004 | 0.250 | 2015 | 3871 | 68 | 110 | 42 |
| 1998-2019 | 3790 | 25 | 68 | 0.018 | 0.004 | 0.250 | 2016 | 3221 | 56 | 91 | 35 |
| 1998-2019 | 3790 | 25 | 68 | 0.018 | 0.004 | 0.250 | 2017 | 2351 | 41 | 67 | 25 |
| 1998-2019 | 3790 | 25 | 68 | 0.018 | 0.004 | 0.250 | 2018 | 3227 | 56 | 91 | 35 |
| 1998-2019 | 3790 | 25 | 68 | 0.018 | 0.004 | 0.250 | 2019 | 3635 | 64 | 104 | 39 |

**Table 18**. Yearly calculated live discards of great hammerhead sharks from the US southeast commercial gillnet fishery for the areas combined. Discards are reported as number of individuals. Due to small number of observed positive sets, all years of observed data are combined.

| Observed Year | Observed Sets | Positive Sets | Observed Animals | Mean CPUE (Per Set) | Standard Deviation | CV | Logbook Year | Logbook Sets | Estimated Discards | Upper 95% CI | Lower 95% CI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1998-2019 | 3790 | 8 | 9 | 0.002 | 0.001 | 0.360 | 1998 | 2515 | 6 | 12 | 3 |
| 1998-2019 | 3790 | 8 | 9 | 0.002 | 0.001 | 0.360 | 1999 | 2077 | 5 | 10 | 3 |
| 1998-2019 | 3790 | 8 | 9 | 0.002 | 0.001 | 0.360 | 2000 | 2097 | 5 | 10 | 3 |
| 1998-2019 | 3790 | 8 | 9 | 0.002 | 0.001 | 0.360 | 2001 | 2034 | 5 | 10 | 3 |
| 1998-2019 | 3790 | 8 | 9 | 0.002 | 0.001 | 0.360 | 2002 | 1953 | 5 | 10 | 3 |
| 1998-2019 | 3790 | 8 | 9 | 0.002 | 0.001 | 0.360 | 2003 | 1633 | 4 | 8 | 2 |
| 1998-2019 | 3790 | 8 | 9 | 0.002 | 0.001 | 0.360 | 2004 | 1602 | 4 | 8 | 2 |
| 1998-2019 | 3790 | 8 | 9 | 0.002 | 0.001 | 0.360 | 2005 | 1879 | 4 | 8 | 2 |
| 1998-2019 | 3790 | 8 | 9 | 0.002 | 0.001 | 0.360 | 2006 | 2471 | 6 | 12 | 3 |
| 1998-2019 | 3790 | 8 | 9 | 0.002 | 0.001 | 0.360 | 2007 | 3748 | 9 | 18 | 5 |
| 1998-2019 | 3790 | 8 | 9 | 0.002 | 0.001 | 0.360 | 2008 | 3756 | 9 | 18 | 5 |
| 1998-2019 | 3790 | 8 | 9 | 0.002 | 0.001 | 0.360 | 2009 | 4422 | 10 | 20 | 5 |
| 1998-2019 | 3790 | 8 | 9 | 0.002 | 0.001 | 0.360 | 2010 | 2801 | 7 | 14 | 4 |
| 1998-2019 | 3790 | 8 | 9 | 0.002 | 0.001 | 0.360 | 2011 | 3825 | 9 | 18 | 5 |
| 1998-2019 | 3790 | 8 | 9 | 0.002 | 0.001 | 0.360 | 2012 | 3773 | 9 | 18 | 5 |
| 1998-2019 | 3790 | 8 | 9 | 0.002 | 0.001 | 0.360 | 2013 | 2173 | 5 | 10 | 3 |
| 1998-2019 | 3790 | 8 | 9 | 0.002 | 0.001 | 0.360 | 2014 | 3932 | 9 | 18 | 5 |
| 1998-2019 | 3790 | 8 | 9 | 0.002 | 0.001 | 0.360 | 2015 | 3871 | 9 | 18 | 5 |
| 1998-2019 | 3790 | 8 | 9 | 0.002 | 0.001 | 0.360 | 2016 | 3221 | 8 | 16 | 4 |
| 1998-2019 | 3790 | 8 | 9 | 0.002 | 0.001 | 0.360 | 2017 | 2351 | 6 | 12 | 3 |
| 1998-2019 | 3790 | 8 | 9 | 0.002 | 0.001 | 0.360 | 2018 | 3227 | 8 | 16 | 4 |
| 1998-2019 | 3790 | 8 | 9 | 0.002 | 0.001 | 0.360 | 2019 | 3635 | 9 | 18 | 5 |

**Table 19**. Yearly calculated dead discards of scalloped hammerhead sharks from the US southeast commercial gillnet fishery for the areas combined. Discards are reported as number of individuals. Due to small number of observed positive sets, all years of observed data are combined.

| Observed Year | Observed Sets | Positive Sets | Observed Animals | Mean CPUE (Per Set) | Standard Deviation | CV | Logbook Year | Logbook Sets | Estimated Discards | Upper 95% CI | Lower 95% CI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1998-2019 | 3790 | 115 | 558 | 0.114 | 0.017 | 0.150 | 1998 | 2515 | 287 | 386 | 213 |
| 1998-2019 | 3790 | 115 | 558 | 0.114 | 0.017 | 0.150 | 1999 | 2077 | 237 | 319 | 176 |
| 1998-2019 | 3790 | 115 | 558 | 0.114 | 0.017 | 0.150 | 2000 | 2097 | 239 | 321 | 178 |
| 1998-2019 | 3790 | 115 | 558 | 0.114 | 0.017 | 0.150 | 2001 | 2034 | 232 | 312 | 173 |
| 1998-2019 | 3790 | 115 | 558 | 0.114 | 0.017 | 0.150 | 2002 | 1953 | 223 | 300 | 166 |
| 1998-2019 | 3790 | 115 | 558 | 0.114 | 0.017 | 0.150 | 2003 | 1633 | 186 | 250 | 138 |
| 1998-2019 | 3790 | 115 | 558 | 0.114 | 0.017 | 0.150 | 2004 | 1602 | 183 | 246 | 136 |
| 1998-2019 | 3790 | 115 | 558 | 0.114 | 0.017 | 0.150 | 2005 | 1879 | 214 | 288 | 159 |
| 1998-2019 | 3790 | 115 | 558 | 0.114 | 0.017 | 0.150 | 2006 | 2471 | 282 | 379 | 210 |
| 1998-2019 | 3790 | 115 | 558 | 0.114 | 0.017 | 0.150 | 2007 | 3748 | 427 | 574 | 318 |
| 1998-2019 | 3790 | 115 | 558 | 0.114 | 0.017 | 0.150 | 2008 | 3756 | 428 | 575 | 318 |
| 1998-2019 | 3790 | 115 | 558 | 0.114 | 0.017 | 0.150 | 2009 | 4422 | 504 | 678 | 375 |
| 1998-2019 | 3790 | 115 | 558 | 0.114 | 0.017 | 0.150 | 2010 | 2801 | 319 | 429 | 237 |
| 1998-2019 | 3790 | 115 | 558 | 0.114 | 0.017 | 0.150 | 2011 | 3825 | 436 | 586 | 324 |
| 1998-2019 | 3790 | 115 | 558 | 0.114 | 0.017 | 0.150 | 2012 | 3773 | 430 | 578 | 320 |
| 1998-2019 | 3790 | 115 | 558 | 0.114 | 0.017 | 0.150 | 2013 | 2173 | 248 | 333 | 184 |
| 1998-2019 | 3790 | 115 | 558 | 0.114 | 0.017 | 0.150 | 2014 | 3932 | 448 | 602 | 333 |
| 1998-2019 | 3790 | 115 | 558 | 0.114 | 0.017 | 0.150 | 2015 | 3871 | 441 | 593 | 328 |
| 1998-2019 | 3790 | 115 | 558 | 0.114 | 0.017 | 0.150 | 2016 | 3221 | 367 | 493 | 273 |
| 1998-2019 | 3790 | 115 | 558 | 0.114 | 0.017 | 0.150 | 2017 | 2351 | 268 | 360 | 199 |
| 1998-2019 | 3790 | 115 | 558 | 0.114 | 0.017 | 0.150 | 2018 | 3227 | 368 | 495 | 274 |
| 1998-2019 | 3790 | 115 | 558 | 0.114 | 0.017 | 0.150 | 2019 | 3635 | 414 | 557 | 308 |

**Table 20**. Yearly calculated live discards of scalloped hammerhead sharks from the US southeast commercial gillnet fishery for the areas combined. Discards are reported as number of individuals. Due to small number of observed positive sets, all years of observed data are combined.

| Observed Year | Observed Sets | Positive Sets | Observed Animals | Mean CPUE (Per Set) | Standard Deviation | CV | Logbook Year | Logbook Sets | Estimated Discards | Upper 95% CI | Lower 95% CI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1998-2019 | 3790 | 106 | 194 | 0.047 | 0.005 | 0.11 | 1998 | 2515 | 118 | 147 | 95 |
| 1998-2019 | 3790 | 106 | 194 | 0.047 | 0.005 | 0.11 | 1999 | 2077 | 98 | 122 | 79 |
| 1998-2019 | 3790 | 106 | 194 | 0.047 | 0.005 | 0.11 | 2000 | 2097 | 99 | 123 | 79 |
| 1998-2019 | 3790 | 106 | 194 | 0.047 | 0.005 | 0.11 | 2001 | 2034 | 96 | 120 | 77 |
| 1998-2019 | 3790 | 106 | 194 | 0.047 | 0.005 | 0.11 | 2002 | 1953 | 92 | 115 | 74 |
| 1998-2019 | 3790 | 106 | 194 | 0.047 | 0.005 | 0.11 | 2003 | 1633 | 77 | 96 | 62 |
| 1998-2019 | 3790 | 106 | 194 | 0.047 | 0.005 | 0.11 | 2004 | 1602 | 75 | 93 | 60 |
| 1998-2019 | 3790 | 106 | 194 | 0.047 | 0.005 | 0.11 | 2005 | 1879 | 88 | 110 | 71 |
| 1998-2019 | 3790 | 106 | 194 | 0.047 | 0.005 | 0.11 | 2006 | 2471 | 116 | 145 | 93 |
| 1998-2019 | 3790 | 106 | 194 | 0.047 | 0.005 | 0.11 | 2007 | 3748 | 176 | 219 | 141 |
| 1998-2019 | 3790 | 106 | 194 | 0.047 | 0.005 | 0.11 | 2008 | 3756 | 177 | 221 | 142 |
| 1998-2019 | 3790 | 106 | 194 | 0.047 | 0.005 | 0.11 | 2009 | 4422 | 208 | 259 | 167 |
| 1998-2019 | 3790 | 106 | 194 | 0.047 | 0.005 | 0.11 | 2010 | 2801 | 132 | 164 | 106 |
| 1998-2019 | 3790 | 106 | 194 | 0.047 | 0.005 | 0.11 | 2011 | 3825 | 180 | 224 | 144 |
| 1998-2019 | 3790 | 106 | 194 | 0.047 | 0.005 | 0.11 | 2012 | 3773 | 178 | 222 | 143 |
| 1998-2019 | 3790 | 106 | 194 | 0.047 | 0.005 | 0.11 | 2013 | 2173 | 102 | 127 | 82 |
| 1998-2019 | 3790 | 106 | 194 | 0.047 | 0.005 | 0.11 | 2014 | 3932 | 185 | 230 | 148 |
| 1998-2019 | 3790 | 106 | 194 | 0.047 | 0.005 | 0.11 | 2015 | 3871 | 182 | 227 | 146 |
| 1998-2019 | 3790 | 106 | 194 | 0.047 | 0.005 | 0.11 | 2016 | 3221 | 152 | 189 | 122 |
| 1998-2019 | 3790 | 106 | 194 | 0.047 | 0.005 | 0.11 | 2017 | 2351 | 111 | 138 | 89 |
| 1998-2019 | 3790 | 106 | 194 | 0.047 | 0.005 | 0.11 | 2018 | 3227 | 152 | 189 | 122 |
| 1998-2019 | 3790 | 106 | 194 | 0.047 | 0.005 | 0.11 | 2019 | 3635 | 171 | 213 | 137 |

**Table 21**. Yearly calculated dead discards of scalloped hammerhead sharks from the US southeast commercial gillnet fishery for the Atlantic. Discards are reported as number of individuals. Due to small number of observed positive sets, all years of observed data are combined.

| Observed Year | Observed Sets | Positive Sets | Observed Animals | Mean CPUE (Per Set) | Standard Deviation | CV | Logbook Year | Logbook Sets | Estimated Discards | Upper 95% CI | Lower 95% CI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1998-2019 | 3598 | 111 | 511 | 0.112 | 0.017 | 0.15 | 1998 | 2403 | 269 | 361 | 200 |
| 1998-2019 | 3598 | 111 | 511 | 0.112 | 0.017 | 0.15 | 1999 | 1855 | 207 | 278 | 154 |
| 1998-2019 | 3598 | 111 | 511 | 0.112 | 0.017 | 0.15 | 2000 | 1945 | 218 | 293 | 162 |
| 1998-2019 | 3598 | 111 | 511 | 0.112 | 0.017 | 0.15 | 2001 | 1872 | 209 | 281 | 156 |
| 1998-2019 | 3598 | 111 | 511 | 0.112 | 0.017 | 0.15 | 2002 | 1874 | 210 | 282 | 156 |
| 1998-2019 | 3598 | 111 | 511 | 0.112 | 0.017 | 0.15 | 2003 | 1558 | 174 | 234 | 130 |
| 1998-2019 | 3598 | 111 | 511 | 0.112 | 0.017 | 0.15 | 2004 | 1547 | 173 | 232 | 129 |
| 1998-2019 | 3598 | 111 | 511 | 0.112 | 0.017 | 0.15 | 2005 | 1812 | 203 | 273 | 151 |
| 1998-2019 | 3598 | 111 | 511 | 0.112 | 0.017 | 0.15 | 2006 | 2379 | 266 | 357 | 198 |
| 1998-2019 | 3598 | 111 | 511 | 0.112 | 0.017 | 0.15 | 2007 | 3658 | 409 | 549 | 305 |
| 1998-2019 | 3598 | 111 | 511 | 0.112 | 0.017 | 0.15 | 2008 | 3602 | 403 | 541 | 300 |
| 1998-2019 | 3598 | 111 | 511 | 0.112 | 0.017 | 0.15 | 2009 | 4108 | 459 | 616 | 342 |
| 1998-2019 | 3598 | 111 | 511 | 0.112 | 0.017 | 0.15 | 2010 | 2714 | 304 | 408 | 226 |
| 1998-2019 | 3598 | 111 | 511 | 0.112 | 0.017 | 0.15 | 2011 | 3467 | 388 | 521 | 289 |
| 1998-2019 | 3598 | 111 | 511 | 0.112 | 0.017 | 0.15 | 2012 | 3540 | 396 | 532 | 295 |
| 1998-2019 | 3598 | 111 | 511 | 0.112 | 0.017 | 0.15 | 2013 | 1876 | 210 | 282 | 156 |
| 1998-2019 | 3598 | 111 | 511 | 0.112 | 0.017 | 0.15 | 2014 | 3354 | 375 | 504 | 279 |
| 1998-2019 | 3598 | 111 | 511 | 0.112 | 0.017 | 0.15 | 2015 | 3125 | 350 | 470 | 261 |
| 1998-2019 | 3598 | 111 | 511 | 0.112 | 0.017 | 0.15 | 2016 | 2851 | 319 | 428 | 238 |
| 1998-2019 | 3598 | 111 | 511 | 0.112 | 0.017 | 0.15 | 2017 | 2151 | 241 | 324 | 179 |
| 1998-2019 | 3598 | 111 | 511 | 0.112 | 0.017 | 0.15 | 2018 | 3063 | 343 | 461 | 255 |
| 1998-2019 | 3598 | 111 | 511 | 0.112 | 0.017 | 0.15 | 2019 | 3370 | 377 | 506 | 281 |

**Table 22**. Yearly calculated live discards of scalloped hammerhead sharks from the US southeast commercial gillnet fishery for the Atlantic. Discards are reported as number of individuals. Due to small number of observed positive sets, all years of observed data are combined.

| Observed Year | Observed Sets | Positive Sets | Observed Animals | Mean CPUE (Per Set) | Standard Deviation | CV | Logbook Year | Logbook Sets | Estimated Discards | Upper 95% CI | Lower 95% CI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1998-2019 | 3598 | 104 | 191 | 0.049 | 0.006 | 0.110 | 1998 | 2403 | 117 | 146 | 94 |
| 1998-2019 | 3598 | 104 | 191 | 0.049 | 0.006 | 0.110 | 1999 | 1855 | 90 | 112 | 72 |
| 1998-2019 | 3598 | 104 | 191 | 0.049 | 0.006 | 0.110 | 2000 | 1945 | 95 | 119 | 76 |
| 1998-2019 | 3598 | 104 | 191 | 0.049 | 0.006 | 0.110 | 2001 | 1872 | 91 | 114 | 73 |
| 1998-2019 | 3598 | 104 | 191 | 0.049 | 0.006 | 0.110 | 2002 | 1874 | 91 | 114 | 73 |
| 1998-2019 | 3598 | 104 | 191 | 0.049 | 0.006 | 0.110 | 2003 | 1558 | 76 | 95 | 61 |
| 1998-2019 | 3598 | 104 | 191 | 0.049 | 0.006 | 0.110 | 2004 | 1547 | 75 | 94 | 60 |
| 1998-2019 | 3598 | 104 | 191 | 0.049 | 0.006 | 0.110 | 2005 | 1812 | 88 | 110 | 70 |
| 1998-2019 | 3598 | 104 | 191 | 0.049 | 0.006 | 0.110 | 2006 | 2379 | 116 | 145 | 93 |
| 1998-2019 | 3598 | 104 | 191 | 0.049 | 0.006 | 0.110 | 2007 | 3658 | 178 | 222 | 143 |
| 1998-2019 | 3598 | 104 | 191 | 0.049 | 0.006 | 0.110 | 2008 | 3602 | 176 | 220 | 141 |
| 1998-2019 | 3598 | 104 | 191 | 0.049 | 0.006 | 0.110 | 2009 | 4108 | 200 | 250 | 160 |
| 1998-2019 | 3598 | 104 | 191 | 0.049 | 0.006 | 0.110 | 2010 | 2714 | 132 | 165 | 106 |
| 1998-2019 | 3598 | 104 | 191 | 0.049 | 0.006 | 0.110 | 2011 | 3467 | 169 | 211 | 135 |
| 1998-2019 | 3598 | 104 | 191 | 0.049 | 0.006 | 0.110 | 2012 | 3540 | 173 | 216 | 139 |
| 1998-2019 | 3598 | 104 | 191 | 0.049 | 0.006 | 0.110 | 2013 | 1876 | 91 | 114 | 73 |
| 1998-2019 | 3598 | 104 | 191 | 0.049 | 0.006 | 0.110 | 2014 | 3354 | 164 | 205 | 131 |
| 1998-2019 | 3598 | 104 | 191 | 0.049 | 0.006 | 0.110 | 2015 | 3125 | 152 | 190 | 122 |
| 1998-2019 | 3598 | 104 | 191 | 0.049 | 0.006 | 0.110 | 2016 | 2851 | 139 | 174 | 111 |
| 1998-2019 | 3598 | 104 | 191 | 0.049 | 0.006 | 0.110 | 2017 | 2151 | 105 | 131 | 84 |
| 1998-2019 | 3598 | 104 | 191 | 0.049 | 0.006 | 0.110 | 2018 | 3063 | 149 | 186 | 119 |
| 1998-2019 | 3598 | 104 | 191 | 0.049 | 0.006 | 0.110 | 2019 | 3370 | 164 | 205 | 131 |

**Table 23**. Yearly calculated dead discards of scalloped hammerhead sharks from the US southeast commercial gillnet fishery for the Gulf of Mexico. Discards are reported as number of individuals. Due to small number of observed positive sets, all years of observed data are combined.

| Observed Year | Observed Sets | Positive Sets | Observed Animals | Mean CPUE (Per Set) | Standard Deviation | CV | Logbook Year | Logbook Sets | Estimated Discards | Upper 95% CI | Lower 95% CI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1998-2019 | 192 | 4 | 47 | 0.161 | 0.131 | 0.810 | 1998 | 112 | 18 | 73 | 4 |
| 1998-2019 | 192 | 4 | 47 | 0.161 | 0.131 | 0.810 | 1999 | 222 | 36 | 146 | 9 |
| 1998-2019 | 192 | 4 | 47 | 0.161 | 0.131 | 0.810 | 2000 | 152 | 24 | 97 | 6 |
| 1998-2019 | 192 | 4 | 47 | 0.161 | 0.131 | 0.810 | 2001 | 162 | 26 | 105 | 6 |
| 1998-2019 | 192 | 4 | 47 | 0.161 | 0.131 | 0.810 | 2002 | 79 | 13 | 53 | 3 |
| 1998-2019 | 192 | 4 | 47 | 0.161 | 0.131 | 0.810 | 2003 | 75 | 12 | 49 | 3 |
| 1998-2019 | 192 | 4 | 47 | 0.161 | 0.131 | 0.810 | 2004 | 55 | 9 | 36 | 2 |
| 1998-2019 | 192 | 4 | 47 | 0.161 | 0.131 | 0.810 | 2005 | 67 | 11 | 44 | 3 |
| 1998-2019 | 192 | 4 | 47 | 0.161 | 0.131 | 0.810 | 2006 | 92 | 15 | 61 | 4 |
| 1998-2019 | 192 | 4 | 47 | 0.161 | 0.131 | 0.810 | 2007 | 90 | 14 | 57 | 3 |
| 1998-2019 | 192 | 4 | 47 | 0.161 | 0.131 | 0.810 | 2008 | 154 | 25 | 101 | 6 |
| 1998-2019 | 192 | 4 | 47 | 0.161 | 0.131 | 0.810 | 2009 | 314 | 51 | 206 | 13 |
| 1998-2019 | 192 | 4 | 47 | 0.161 | 0.131 | 0.810 | 2010 | 87 | 14 | 57 | 3 |
| 1998-2019 | 192 | 4 | 47 | 0.161 | 0.131 | 0.810 | 2011 | 358 | 58 | 234 | 14 |
| 1998-2019 | 192 | 4 | 47 | 0.161 | 0.131 | 0.810 | 2012 | 233 | 37 | 150 | 9 |
| 1998-2019 | 192 | 4 | 47 | 0.161 | 0.131 | 0.810 | 2013 | 297 | 48 | 194 | 12 |
| 1998-2019 | 192 | 4 | 47 | 0.161 | 0.131 | 0.810 | 2014 | 578 | 93 | 376 | 23 |
| 1998-2019 | 192 | 4 | 47 | 0.161 | 0.131 | 0.810 | 2015 | 746 | 120 | 485 | 30 |
| 1998-2019 | 192 | 4 | 47 | 0.161 | 0.131 | 0.810 | 2016 | 370 | 60 | 243 | 15 |
| 1998-2019 | 192 | 4 | 47 | 0.161 | 0.131 | 0.810 | 2017 | 200 | 32 | 129 | 8 |
| 1998-2019 | 192 | 4 | 47 | 0.161 | 0.131 | 0.810 | 2018 | 164 | 26 | 105 | 6 |
| 1998-2019 | 192 | 4 | 47 | 0.161 | 0.131 | 0.810 | 2019 | 265 | 43 | 174 | 11 |

**Table 24**. Yearly calculated live discards of scalloped hammerhead sharks from the US southeast commercial gillnet fishery for the Gulf of Mexico. Discards are reported as number of individuals. Due to small number of observed positive sets, all years of observed data are combined.

| Observed Year | Observed Sets | Positive Sets | Observed Animals | Mean CPUE (Per Set) | Standard Deviation | CV | Logbook Year | Logbook Sets | Estimated Discards | Upper 95% CI | Lower 95% CI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1998-2019 | 192 | 2 | 3 | 0.016 | 0.012 | 0.740 | 1998 | 112 | 2 | 7 | 1 |
| 1998-2019 | 192 | 2 | 3 | 0.016 | 0.012 | 0.740 | 1999 | 222 | 3 | 11 | 1 |
| 1998-2019 | 192 | 2 | 3 | 0.016 | 0.012 | 0.740 | 2000 | 152 | 2 | 7 | 1 |
| 1998-2019 | 192 | 2 | 3 | 0.016 | 0.012 | 0.740 | 2001 | 162 | 3 | 11 | 1 |
| 1998-2019 | 192 | 2 | 3 | 0.016 | 0.012 | 0.740 | 2002 | 79 | 1 | 4 | 0 |
| 1998-2019 | 192 | 2 | 3 | 0.016 | 0.012 | 0.740 | 2003 | 75 | 1 | 4 | 0 |
| 1998-2019 | 192 | 2 | 3 | 0.016 | 0.012 | 0.740 | 2004 | 55 | 1 | 4 | 0 |
| 1998-2019 | 192 | 2 | 3 | 0.016 | 0.012 | 0.740 | 2005 | 67 | 1 | 4 | 0 |
| 1998-2019 | 192 | 2 | 3 | 0.016 | 0.012 | 0.740 | 2006 | 92 | 1 | 4 | 0 |
| 1998-2019 | 192 | 2 | 3 | 0.016 | 0.012 | 0.740 | 2007 | 90 | 1 | 4 | 0 |
| 1998-2019 | 192 | 2 | 3 | 0.016 | 0.012 | 0.740 | 2008 | 154 | 2 | 7 | 1 |
| 1998-2019 | 192 | 2 | 3 | 0.016 | 0.012 | 0.740 | 2009 | 314 | 5 | 18 | 1 |
| 1998-2019 | 192 | 2 | 3 | 0.016 | 0.012 | 0.740 | 2010 | 87 | 1 | 4 | 0 |
| 1998-2019 | 192 | 2 | 3 | 0.016 | 0.012 | 0.740 | 2011 | 358 | 6 | 22 | 2 |
| 1998-2019 | 192 | 2 | 3 | 0.016 | 0.012 | 0.740 | 2012 | 233 | 4 | 15 | 1 |
| 1998-2019 | 192 | 2 | 3 | 0.016 | 0.012 | 0.740 | 2013 | 297 | 5 | 18 | 1 |
| 1998-2019 | 192 | 2 | 3 | 0.016 | 0.012 | 0.740 | 2014 | 578 | 9 | 33 | 2 |
| 1998-2019 | 192 | 2 | 3 | 0.016 | 0.012 | 0.740 | 2015 | 746 | 12 | 44 | 3 |
| 1998-2019 | 192 | 2 | 3 | 0.016 | 0.012 | 0.740 | 2016 | 370 | 6 | 22 | 2 |
| 1998-2019 | 192 | 2 | 3 | 0.016 | 0.012 | 0.740 | 2017 | 200 | 3 | 11 | 1 |
| 1998-2019 | 192 | 2 | 3 | 0.016 | 0.012 | 0.740 | 2018 | 164 | 3 | 11 | 1 |
| 1998-2019 | 192 | 2 | 3 | 0.016 | 0.012 | 0.740 | 2019 | 265 | 4 | 15 | 1 |

**Table 25**. Scalloped hammerhead final discard estimates from the Northeast Region's Mid-Atlantic sink-gillnet fishing fleet created using the grand mean discard ratio for use in the SEDAR 77 assessment for this species.

| | total | ave num | est num | 95% | 95% | ave wgt | est wgt (lbs) | 95% | 95% | ave num | est num | 95% | 95% | ave wgt | est wgt (lbs) | 95% | 95% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| year | landings (lbs) | live d/k | live disc | LCL | UCL | live d/k | live disc | LCL | UCL | dead d/k | dead disc | LCL | UCL | dead d/k | dead disc | LCL | UCL |
| 1981 | 952070 | 0.0000040 | 4 | 2 | 6 | 0.0002151 | 205 | 40 | 369 | 0.0000051 | 5 | 3 | 7 | 0.0003480 | 331 | 143 | 520 |
| 1982 | 800479 | 0.0000040 | 3 | 1 | 5 | 0.0002151 | 172 | 34 | 311 | 0.0000051 | 4 | 2 | 6 | 0.0003480 | 279 | 120 | 437 |
| 1983 | 1633356 | 0.0000040 | 7 | 3 | 10 | 0.0002151 | 351 | 69 | 634 | 0.0000051 | 8 | 4 | 12 | 0.0003480 | 568 | 245 | 891 |
| 1984 | 1109970 | 0.0000040 | 4 | 2 | 7 | 0.0002151 | 239 | 47 | 431 | 0.0000051 | 6 | 3 | 8 | 0.0003480 | 386 | 167 | 606 |
| 1985 | 1393009 | 0.0000040 | 6 | 2 | 9 | 0.0002151 | 300 | 59 | 540 | 0.0000051 | 7 | 4 | 10 | 0.0003480 | 485 | 209 | 760 |
| 1986 | 1665998 | 0.0000040 | 7 | 3 | 11 | 0.0002151 | 358 | 70 | 646 | 0.0000051 | 9 | 5 | 12 | 0.0003480 | 580 | 250 | 909 |
| 1987 | 2535339 | 0.0000040 | 10 | 4 | 16 | 0.0002151 | 545 | 107 | 984 | 0.0000051 | 13 | 7 | 19 | 0.0003480 | 882 | 381 | 1384 |
| 1988 | 2641003 | 0.0000040 | 11 | 4 | 17 | 0.0002151 | 568 | 111 | 1025 | 0.0000051 | 14 | 7 | 20 | 0.0003480 | 919 | 397 | 1441 |
| 1989 | 7681371 | 0.0000040 | 31 | 13 | 49 | 0.0002151 | 1652 | 324 | 2980 | 0.0000051 | 39 | 21 | 58 | 0.0003480 | 2673 | 1154 | 4192 |
| 1990 | 8883032 | 0.0000040 | 36 | 15 | 56 | 0.0002151 | 1911 | 375 | 3446 | 0.0000051 | 45 | 24 | 67 | 0.0003480 | 3091 | 1334 | 4848 |
| 1991 | 14004376 | 0.0000040 | 56 | 23 | 89 | 0.0002151 | 3012 | 591 | 5433 | 0.0000051 | 72 | 39 | 105 | 0.0003480 | 4873 | 2103 | 7643 |
| 1992 | 14803957 | 0.0000040 | 59 | 25 | 94 | 0.0002151 | 3184 | 625 | 5743 | 0.0000051 | 76 | 41 | 111 | 0.0003480 | 5151 | 2224 | 8079 |
| 1993 | 21398090 | 0.0000040 | 86 | 36 | 136 | 0.0002151 | 4602 | 903 | 8301 | 0.0000051 | 110 | 59 | 160 | 0.0003480 | 7446 | 3214 | 11678 |
| 1994 | 20856487 | 0.0000040 | 83 | 35 | 132 | 0.0002151 | 4486 | 880 | 8091 | 0.0000051 | 107 | 57 | 156 | 0.0003480 | 7257 | 3133 | 11382 |
| 1995 | 18574803 | 0.0000040 | 74 | 31 | 118 | 0.0002151 | 3995 | 784 | 7206 | 0.0000051 | 95 | 51 | 139 | 0.0003480 | 6463 | 2790 | 10137 |
| 1996 | 26013961 | 0.0000040 | 104 | 43 | 165 | 0.0002151 | 5595 | 1098 | 10092 | 0.0000051 | 133 | 72 | 195 | 0.0003480 | 9052 | 3907 | 14197 |
| 1997 | 33567487 | 0.0000040 | 134 | 56 | 213 | 0.0002151 | 7220 | 1417 | 13022 | 0.0000051 | 172 | 92 | 251 | 0.0003480 | 11680 | 5042 | 18319 |
| 1998 | 37990099 | 0.0000040 | 152 | 63 | 241 | 0.0002151 | 8171 | 1604 | 14738 | 0.0000051 | 195 | 105 | 285 | 0.0003480 | 13219 | 5706 | 20733 |
| 1999 | 35233873 | 0.0000040 | 141 | 59 | 223 | 0.0002151 | 7578 | 1487 | 13669 | 0.0000051 | 180 | 97 | 264 | 0.0003480 | 12260 | 5292 | 19228 |
| 2000 | 29740831 | 0.0000040 | 119 | 49 | 188 | 0.0002151 | 6397 | 1255 | 11538 | 0.0000051 | 152 | 82 | 223 | 0.0003480 | 10349 | 4467 | 16231 |
| 2001 | 25990262 | 0.0000040 | 104 | 43 | 165 | 0.0002151 | 5590 | 1097 | 10083 | 0.0000051 | 133 | 71 | 195 | 0.0003480 | 9044 | 3904 | 14184 |
| 2002 | 22966222 | 0.0000040 | 92 | 38 | 146 | 0.0002151 | 4940 | 970 | 8910 | 0.0000051 | 118 | 63 | 172 | 0.0003480 | 7991 | 3449 | 12533 |
| 2003 | 28133639 | 0.0000040 | 113 | 47 | 178 | 0.0002151 | 6051 | 1188 | 10914 | 0.0000051 | 144 | 77 | 211 | 0.0003480 | 9790 | 4226 | 15354 |
| 2004 | 22495571 | 0.0000040 | 90 | 37 | 143 | 0.0002151 | 4838 | 950 | 8727 | 0.0000051 | 115 | 62 | 168 | 0.0003480 | 7828 | 3379 | 12277 |
| 2005 | 20886990 | 0.0000040 | 84 | 35 | 132 | 0.0002151 | 4492 | 882 | 8103 | 0.0000051 | 107 | 57 | 156 | 0.0003480 | 7268 | 3137 | 11399 |
| 2006 | 13680048 | 0.0000040 | 55 | 23 | 87 | 0.0002151 | 2942 | 577 | 5307 | 0.0000051 | 70 | 38 | 102 | 0.0003480 | 4760 | 2055 | 7466 |
| 2007 | 25248342 | 0.0000040 | 101 | 42 | 160 | 0.0002151 | 5430 | 1066 | 9795 | 0.0000051 | 129 | 69 | 189 | 0.0003480 | 8786 | 3792 | 13779 |
| 2008 | 20668902 | 0.0000040 | 83 | 34 | 131 | 0.0002151 | 4445 | 873 | 8018 | 0.0000051 | 106 | 57 | 155 | 0.0003480 | 7192 | 3104 | 11280 |
| 2009 | 27306265 | 0.0000040 | 109 | 45 | 173 | 0.0002151 | 5873 | 1153 | 10593 | 0.0000051 | 140 | 75 | 205 | 0.0003480 | 9502 | 4101 | 14902 |
| 2010 | 14664473 | 0.0000040 | 59 | 24 | 93 | 0.0002151 | 3154 | 619 | 5689 | 0.0000051 | 75 | 40 | 110 | 0.0003480 | 5103 | 2203 | 8003 |
| 2011 | 30295460 | 0.0000040 | 121 | 50 | 192 | 0.0002151 | 6516 | 1279 | 11753 | 0.0000051 | 155 | 83 | 227 | 0.0003480 | 10542 | 4550 | 16533 |
| 2012 | 24959012 | 0.0000040 | 100 | 41 | 158 | 0.0002151 | 5368 | 1054 | 9683 | 0.0000051 | 128 | 69 | 187 | 0.0003480 | 8685 | 3749 | 13621 |
| 2013 | 23562221 | 0.0000040 | 94 | 39 | 149 | 0.0002151 | 5068 | 995 | 9141 | 0.0000051 | 121 | 65 | 176 | 0.0003480 | 8199 | 3539 | 12859 |
| 2014 | 31582469 | 0.0000040 | 126 | 53 | 200 | 0.0002151 | 6793 | 1333 | 12252 | 0.0000051 | 162 | 87 | 237 | 0.0003480 | 10990 | 4744 | 17236 |
| 2015 | 120724151 | 0.0000040 | 483 | 201 | 765 | 0.0002151 | 25965 | 5096 | 46834 | 0.0000051 | 618 | 332 | 904 | 0.0003480 | 42008 | 18132 | 65883 |
| 2016 | 19271696 | 0.0000040 | 77 | 32 | 122 | 0.0002151 | 4145 | 814 | 7476 | 0.0000051 | 99 | 53 | 144 | 0.0003480 | 6706 | 2895 | 10517 |
| 2017 | 18009161 | 0.0000040 | 72 | 30 | 114 | 0.0002151 | 3873 | 760 | 6987 | 0.0000051 | 92 | 50 | 135 | 0.0003480 | 6267 | 2705 | 9828 |
| 2018 | 16100672 | 0.0000040 | 64 | 27 | 102 | 0.0002151 | 3463 | 680 | 6246 | 0.0000051 | 82 | 44 | 121 | 0.0003480 | 5602 | 2418 | 8787 |
| 2019 | 18502297 | 0.0000040 | 74 | 31 | 117 | 0.0002151 | 3979 | 781 | 7178 | 0.0000051 | 95 | 51 | 139 | 0.0003480 | 6438 | 2779 | 10097 |

**Table 26.** Smooth hammerhead final discard estimates from the Northeast Region's Mid-Atlantic sink-gillnet fishing fleet created using the grand mean discard ratio for use in the SEDAR 77 assessment for this species.

| year | total landings (lbs) | ave num live d/k | est num live disc | 95% LCL | 95% UCL | ave wgt live d/k | est wgt (lbs) live disc | 95% LCL | 95% UCL | ave num dead d/k | est num dead disc | 95% LCL | 95% UCL | ave wgt dead d/k | est wgt (lbs) dead disc | 95% LCL | 95% UCL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 952070 | 0.0000027 | 3 | 2 | 3 | 0.0000386 | 37 | 26 | 47 | 0.0000052 | 5 | 4 | 6 | 0.0001878 | 179 | 92 | 266 |
| 1982 | 800479 | 0.0000027 | 2 | 1 | 3 | 0.0000386 | 31 | 22 | 40 | 0.0000052 | 4 | 3 | 5 | 0.0001878 | 150 | 77 | 223 |
| 1983 | 1633356 | 0.0000027 | 4 | 3 | 6 | 0.0000386 | 63 | 45 | 81 | 0.0000052 | 8 | 6 | 11 | 0.0001878 | 307 | 158 | 456 |
| 1984 | 1109970 | 0.0000027 | 3 | 2 | 4 | 0.0000386 | 43 | 31 | 55 | 0.0000052 | 6 | 4 | 7 | 0.0001878 | 208 | 107 | 310 |
| 1985 | 1393009 | 0.0000027 | 4 | 3 | 5 | 0.0000386 | 54 | 39 | 69 | 0.0000052 | 7 | 5 | 9 | 0.0001878 | 262 | 134 | 389 |
| 1986 | 1665998 | 0.0000027 | 5 | 3 | 6 | 0.0000386 | 64 | 46 | 82 | 0.0000052 | 9 | 6 | 11 | 0.0001878 | 313 | 161 | 465 |
| 1987 | 2535339 | 0.0000027 | 7 | 5 | 9 | 0.0000386 | 98 | 70 | 125 | 0.0000052 | 13 | 10 | 17 | 0.0001878 | 476 | 245 | 707 |
| 1988 | 2641003 | 0.0000027 | 7 | 5 | 9 | 0.0000386 | 102 | 73 | 131 | 0.0000052 | 14 | 10 | 17 | 0.0001878 | 496 | 255 | 737 |
| 1989 | 7681371 | 0.0000027 | 21 | 14 | 27 | 0.0000386 | 296 | 213 | 380 | 0.0000052 | 40 | 29 | 51 | 0.0001878 | 1443 | 742 | 2143 |
| 1990 | 8883032 | 0.0000027 | 24 | 17 | 32 | 0.0000386 | 343 | 246 | 439 | 0.0000052 | 46 | 34 | 59 | 0.0001878 | 1668 | 858 | 2479 |
| 1991 | 14004376 | 0.0000027 | 38 | 26 | 50 | 0.0000386 | 540 | 388 | 693 | 0.0000052 | 73 | 53 | 93 | 0.0001878 | 2630 | 1352 | 3908 |
| 1992 | 14803957 | 0.0000027 | 40 | 28 | 53 | 0.0000386 | 571 | 410 | 732 | 0.0000052 | 77 | 56 | 98 | 0.0001878 | 2780 | 1429 | 4131 |
| 1993 | 21398090 | 0.0000027 | 58 | 40 | 77 | 0.0000386 | 826 | 593 | 1059 | 0.0000052 | 111 | 81 | 141 | 0.0001878 | 4019 | 2066 | 5971 |
| 1994 | 20856487 | 0.0000027 | 57 | 39 | 75 | 0.0000386 | 805 | 578 | 1032 | 0.0000052 | 108 | 79 | 138 | 0.0001878 | 3917 | 2014 | 5820 |
| 1995 | 18574803 | 0.0000027 | 51 | 35 | 66 | 0.0000386 | 717 | 514 | 919 | 0.0000052 | 97 | 70 | 123 | 0.0001878 | 3488 | 1793 | 5183 |
| 1996 | 26013961 | 0.0000027 | 71 | 49 | 93 | 0.0000386 | 1004 | 720 | 1287 | 0.0000052 | 135 | 99 | 172 | 0.0001878 | 4885 | 2512 | 7259 |
| 1997 | 33567487 | 0.0000027 | 91 | 63 | 120 | 0.0000386 | 1295 | 930 | 1661 | 0.0000052 | 175 | 127 | 222 | 0.0001878 | 6304 | 3241 | 9367 |
| 1998 | 37990099 | 0.0000027 | 103 | 71 | 136 | 0.0000386 | 1466 | 1052 | 1879 | 0.0000052 | 198 | 144 | 251 | 0.0001878 | 7134 | 3668 | 10601 |
| 1999 | 35233873 | 0.0000027 | 96 | 66 | 126 | 0.0000386 | 1359 | 976 | 1743 | 0.0000052 | 183 | 134 | 233 | 0.0001878 | 6617 | 3402 | 9832 |
| 2000 | 29740831 | 0.0000027 | 81 | 56 | 106 | 0.0000386 | 1147 | 824 | 1471 | 0.0000052 | 155 | 113 | 197 | 0.0001878 | 5585 | 2871 | 8299 |
| 2001 | 25990262 | 0.0000027 | 71 | 49 | 93 | 0.0000386 | 1003 | 720 | 1286 | 0.0000052 | 135 | 99 | 172 | 0.0001878 | 4881 | 2509 | 7253 |
| 2002 | 22966222 | 0.0000027 | 62 | 43 | 82 | 0.0000386 | 886 | 636 | 1136 | 0.0000052 | 119 | 87 | 152 | 0.0001878 | 4313 | 2217 | 6409 |
| 2003 | 28133639 | 0.0000027 | 77 | 53 | 101 | 0.0000386 | 1085 | 779 | 1392 | 0.0000052 | 146 | 107 | 186 | 0.0001878 | 5283 | 2716 | 7851 |
| 2004 | 22495571 | 0.0000027 | 61 | 42 | 80 | 0.0000386 | 868 | 623 | 1113 | 0.0000052 | 117 | 85 | 149 | 0.0001878 | 4225 | 2172 | 6277 |
| 2005 | 20886990 | 0.0000027 | 57 | 39 | 75 | 0.0000386 | 806 | 578 | 1033 | 0.0000052 | 109 | 79 | 138 | 0.0001878 | 3923 | 2017 | 5828 |
| 2006 | 13680048 | 0.0000027 | 37 | 26 | 49 | 0.0000386 | 528 | 379 | 677 | 0.0000052 | 71 | 52 | 90 | 0.0001878 | 2569 | 1321 | 3817 |
| 2007 | 25248342 | 0.0000027 | 69 | 47 | 90 | 0.0000386 | 974 | 699 | 1249 | 0.0000052 | 131 | 96 | 167 | 0.0001878 | 4742 | 2438 | 7045 |
| 2008 | 20668902 | 0.0000027 | 56 | 39 | 74 | 0.0000386 | 797 | 572 | 1022 | 0.0000052 | 108 | 78 | 137 | 0.0001878 | 3882 | 1996 | 5768 |
| 2009 | 27306265 | 0.0000027 | 74 | 51 | 98 | 0.0000386 | 1054 | 756 | 1351 | 0.0000052 | 142 | 104 | 181 | 0.0001878 | 5128 | 2636 | 7620 |
| 2010 | 14664473 | 0.0000027 | 40 | 27 | 52 | 0.0000386 | 566 | 406 | 725 | 0.0000052 | 76 | 56 | 97 | 0.0001878 | 2754 | 1416 | 4092 |
| 2011 | 30295460 | 0.0000027 | 82 | 57 | 108 | 0.0000386 | 1169 | 839 | 1499 | 0.0000052 | 158 | 115 | 200 | 0.0001878 | 5689 | 2925 | 8454 |
| 2012 | 24959012 | 0.0000027 | 68 | 47 | 89 | 0.0000386 | 963 | 691 | 1235 | 0.0000052 | 130 | 95 | 165 | 0.0001878 | 4687 | 2410 | 6965 |
| 2013 | 23562221 | 0.0000027 | 64 | 44 | 84 | 0.0000386 | 909 | 653 | 1166 | 0.0000052 | 123 | 89 | 156 | 0.0001878 | 4425 | 2275 | 6575 |
| 2014 | 31582469 | 0.0000027 | 86 | 59 | 113 | 0.0000386 | 1219 | 875 | 1562 | 0.0000052 | 164 | 120 | 209 | 0.0001878 | 5931 | 3049 | 8813 |
| 2015 | 120724151 | 0.0000027 | 328 | 225 | 432 | 0.0000386 | 4658 | 3343 | 5972 | 0.0000052 | 628 | 458 | 798 | 0.0001878 | 22672 | 11656 | 33688 |
| 2016 | 19271696 | 0.0000027 | 52 | 36 | 69 | 0.0000386 | 744 | 534 | 953 | 0.0000052 | 100 | 73 | 127 | 0.0001878 | 3619 | 1861 | 5378 |
| 2017 | 18009161 | 0.0000027 | 49 | 34 | 64 | 0.0000386 | 695 | 499 | 891 | 0.0000052 | 94 | 68 | 119 | 0.0001878 | 3382 | 1739 | 5025 |
| 2018 | 16100672 | 0.0000027 | 44 | 30 | 58 | 0.0000386 | 621 | 446 | 796 | 0.0000052 | 84 | 61 | 106 | 0.0001878 | 3024 | 1555 | 4493 |
| 2019 | 18502297 | 0.0000027 | 50 | 35 | 66 | 0.0000386 | 714 | 512 | 915 | 0.0000052 | 96 | 70 | 122 | 0.0001878 | 3475 | 1786 | 5163 |

**Table 27.** Capture of scalloped hammerheads (n = 164) by hour during fisheries research conducted employing hook timers on contracted commercial bottom-longline vessels in the U.S. Highly Migratory Species Shark Research Fishery (Gulak et al. 2015; Simon Gulak, Pers. Comm. December 14, 2022)[1].

| Hours | Alive | Dead | Total | % Alive | % Dead | Proportion of total captured each hour | Running tally | Running proportion of total captured by hour |
|---|---|---|---|---|---|---|---|---|
| 0-1 | 14 | | 14 | 100.0% | 0.0% | 8.54% | 14 | 8.54% |
| 1-2 | 22 | 6 | 28 | 78.6% | 21.4% | 17.07% | 42 | 25.61% |
| 2-3 | 7 | 6 | 13 | 53.8% | 46.2% | 7.93% | 55 | 33.54% |
| 3-4 | 9 | 10 | 19 | 47.4% | 52.6% | 11.59% | 74 | 45.12% |
| 4-5 | 7 | 8 | 15 | 46.7% | 53.3% | 9.15% | 89 | 54.27% |
| 5-6 | 1 | 13 | 14 | 7.1% | 92.9% | 8.54% | 103 | 62.80% |
| 6-7 | 1 | 4 | 5 | 20.0% | 80.0% | 3.05% | 108 | 65.85% |
| 7-8 | 1 | 14 | 15 | 6.7% | 93.3% | 9.15% | 123 | 75.00% |
| 8-9 | | 13 | 13 | 0.0% | 100.0% | 7.93% | 136 | 82.93% |
| 9-10 | | 1 | 1 | 0.0% | 100.0% | 0.61% | 137 | 83.54% |
| 10-11 | 1 | 3 | 4 | 25.0% | 75.0% | 2.44% | 141 | 85.98% |
| 11-12 | | 6 | 6 | 0.0% | 100.0% | 3.66% | 147 | 89.63% |
| 12-13 | | 3 | 3 | 0.0% | 100.0% | 1.83% | 150 | 91.46% |
| 13-14 | | 4 | 4 | 0.0% | 100.0% | 2.44% | 154 | 93.90% |
| 14-15 | | 3 | 3 | 0.0% | 100.0% | 1.83% | 157 | 95.73% |
| 15-16 | | 1 | 1 | 0.0% | 100.0% | 0.61% | 158 | 96.34% |
| 16-17 | | 3 | 3 | 0.0% | 100.0% | 1.83% | 161 | 98.17% |
| 17-18 | | 1 | 1 | 0.0% | 100.0% | 0.61% | 162 | 98.78% |
| 18-19 | | 1 | 1 | 0.0% | 100.0% | 0.61% | 163 | 99.39% |
| 19-20 | | 1 | 1 | 0.0% | 100.0% | 0.61% | 164 | 100.00% |

[1] Data provided by Simon Gulak (Pers. Comm. December 14, 2022) were not filtered to include covariates used in the original study and, consequently, differ slightly from those presented in the original study.

**Table 28**. Capture of great hammerheads (n = 71) by hour during fisheries research conducted employing hook timers on contracted commercial bottom-longline vessels in the U.S. Highly Migratory Species Shark Research Fishery (Gulak et al. 2015; Simon Gulak, Pers. Comm. December 14, 2022)[1].

| Hours | Alive | Dead | Total | % Alive | % Dead | Proportion of total captured each hour | Running tally | Running proportion of total captured by hour |
|---|---|---|---|---|---|---|---|---|
| 0-1 | 10 | | 10 | 100.0% | 0.0% | 14.08% | 10 | 14.08% |
| 1-2 | 9 | | 9 | 100.0% | 0.0% | 12.68% | 19 | 26.76% |
| 2-3 | 4 | 1 | 5 | 80.0% | 20.0% | 7.04% | 24 | 33.80% |
| 3-4 | 5 | 3 | 8 | 62.5% | 37.5% | 11.27% | 32 | 45.07% |
| 4-5 | 2 | 5 | 7 | 28.6% | 71.4% | 9.86% | 39 | 54.93% |
| 5-6 | | 8 | 8 | 0.0% | 100.0% | 11.27% | 47 | 66.20% |
| 6-7 | 1 | 6 | 7 | 14.3% | 85.7% | 9.86% | 54 | 76.06% |
| 7-8 | | 2 | 2 | 0.0% | 100.0% | 2.82% | 56 | 78.87% |
| 8-9 | | 6 | 6 | 0.0% | 100.0% | 8.45% | 62 | 87.32% |
| 9-10 | | 1 | 1 | 0.0% | 100.0% | 1.41% | 63 | 88.73% |
| 10-11 | | 1 | 1 | 0.0% | 100.0% | 1.41% | 64 | 90.14% |
| 12-13 | | 1 | 1 | 0.0% | 100.0% | 1.41% | 65 | 91.55% |
| 14-15 | | 2 | 2 | 0.0% | 100.0% | 2.82% | 67 | 94.37% |
| 15-16 | | 1 | 1 | 0.0% | 100.0% | 1.41% | 68 | 95.77% |
| 16-17 | | 1 | 1 | 0.0% | 100.0% | 1.41% | 69 | 97.18% |
| 18-19 | | 1 | 1 | 0.0% | 100.0% | 1.41% | 70 | 98.59% |
| 19-20 | | 1 | 1 | 0.0% | 100.0% | 1.41% | 71 | 100.00% |

[1] Data provided by Simon Gulak (Pers. Comm. December 14, 2022) were not filtered to include covariates used in the original study and, consequently, differ slightly from those presented in the original study.

**Table 29**. Post release mortality of electronically tagged great and scalloped hammerheads captured on bottom longline gear (SEDAR77-RD20; SEDAR77-RD42; SEDAR77-DW34; SEDAR77-DW35).

A. Great Hammerhead

| Source | Tagged (N) | Post-release mortality (n) | Proportion (n/N) | Post-release mortality (%) |
|---|---|---|---|---|
| SEDAR77-RD20[1] | 3 | 0 | 0.00 | 0 |
| SEDAR77-RD42[2] | 28 | 13 | 0.46 | 46 |
| SEDAR77-DW34[3] | 9 | 5 | 0.56 | 56 |
| SEDAR77-DW35[4] | 20 | 9 | 0.45 | 45 |
| Pooled | 60 | 27 | 0.45 | 45 |

B. Scalloped Hammerhead

| Source | Tagged (N) | Post-release mortality (n) | Proportion (n/N) | Post-release mortality (%) |
|---|---|---|---|---|
| SEDAR77-DW35[4] | 25 | 2 | 0.08 | 8 |

[1] SEDAR77-RD20 (Drymon and Wells 2017) captured sharks in northern Gulf of Mexico with research longlines set for about one hour; Post-release mortality was estimated with double tagging from SPOT and survivorship pop-off archival transmitting tags (sPAT, Wildlife Computers).

[2] SEDAR77-RD42 (Gallagher et al. 2014) captured sharks in subtropical locations with baited drum-lines soaked for about one hour; Post-release mortality was estimated with Smart Position or Temperature Transmitting (SPOT) satellite tags (SPOTS, Wildlife Computers) reporting rates after 4 weeks.

[3] SEDAR77-DW34 (Hoffmayer et al. 2021) captured sharks in the northern Gulf of Mexico with research longlines set for about one hour; Post-release mortality was estimated with SPOT tag reporting rates (n = 4 reporting tags ranged 19 to 101 days, mean: 53.3 ± 20.0 days). Five tags did not transmit data to the satellite after the tags were deployed, suggesting those sharks succumbed to the capture stress.

[4] SEDAR77-DW35 (Whitney et al. 2021) captured sharks in the Gulf of Mexico with commercial longlines using a combination of relatively short soak times and (or) hook-timers in order to land live animals for tagging, with the result that the majority of hook times were under three hours; Post-release mortality was estimated with a combination of acceleration data-loggers (ADLs; model G6A+, Cefas, Inc., Lowestoft UK) and Pop-up Satellite Archival Tags (PSATs; model PSATLIFE, Lotek, Ontario, CAN).

**Table 30.** Post-release live-discard mortality rate calculations for scalloped hammerheads released from commercial bottom longline gear (69.15%).

| | | |
|---|---|---|
| M_A = Minimum PRLDM | 0.0800 | |
| S_A = 1 - M_A | 0.9200 | |
| Cumulative percentage on hook timers | | |
| Hook time | Scalloped | n |
| 1hr | 8.54% | 14 |
| 2hr | 25.61% | 42 |
| 3hr | 33.54% | 55 |
| Total | 100.00% | 164 |
| Proportion not at poor condition (<= 3hr) | | |
| <= 3hr | 0.3354 | 55 |
| Proportion at poor condition (> 3hr) | | |
| > 3hr | 0.6646 | 109 |
| **Proportion that survive** post-release | | Calculations |
| <= 3hr | 0.3085 | [(1-0.0800)*0.3354] |
| > 3hr | 0 | [0*0.6646] |
| Total | 0.3085 | |
| **Proportion that die** post-release | | Calculations |
| 1-Total | 0.6915 | [1-0.3085] |
| **Check proportion that die** | | Calculations |
| <= 3hr | 0.0268 | [0.0800*0.3354] |
| > 3hr | 0.6646 | [">3 hr"] |
| Total | 0.6915 | ["<=3hr" + ">3 hr"] |
| PRLDM – Scalloped hammerhead | 69.15% | |

**Table 31.** Post-release live-discard mortality rate calculations for great hammerheads released from commercial bottom longline gear (81.41%).

| | | |
|---|---|---|
| M_A = Minimum PRLDM | 0.4500 | |
| S_A = 1 - M_A | 0.5500 | |
| Cumulative percentage on hook timers | | |
| Hook time | Great | n |
| 1hr | 14.08% | 10 |
| 2hr | 26.76% | 19 |
| 3hr | 33.80% | 24 |
| Total | 100.00% | 71 |
| Proportion not at poor condition (<= 3hr) | | |
| <= 3hr | 0.3380 | 24 |
| Proportion at poor condition (> 3hr) | | |
| > 3hr | 0.6620 | 47 |
| **Proportion that survive** post-release | | Calculations |
| <= 3hr | 0.1859 | [(1-0.4500)*0.3380] |
| > 3hr | 0 | [0*0.6620] |
| Total | 0.1859 | |
| **Proportion that die** post-release | | Calculations |
| 1-Total | 0.8141 | [1-0.1859] |
| **Check proportion that die** | | Calculations |
| <= 3hr | 0.1521 | [0.4500*0.3380] |
| > 3hr | 0.6620 | [">3 hr"] |
| Total | 0.8141 | ["<=3hr" + ">3 hr"] |
| PRLDM – Great hammerhead | 81.41% | |

**Table 32**. Mexican landings of “cazones “ (sharks less than 150 cm TL) and “tiburones” (sharks greater than 150 cm TL) by state reported by the Comisión Nacional de Acuacultura y Pesca (Conapesca; tons ww).

| | Landings of cazones | | | | Landings of tiburones | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Tamaulipas | Veracruz | Tabasco | Campeche | Tamaulipas | Veracruz | Tabasco | Campeche |
| 1976 | 266 | 474 | 169 | 627 | 75 | 234 | 92 | 468 |
| 1977 | 575 | 654 | 189 | 544 | 155 | 190 | 358 | 817 |
| 1978 | 439 | 358 | 204 | 377 | 133 | 667 | 309 | 1037 |
| 1979 | 733 | 627 | 228 | 429 | 203 | 738 | 193 | 640 |
| 1980 | 889 | 706 | 274 | 491 | 371 | 1351 | 182 | 391 |
| 1981 | 2486 | 1036 | 407 | 441 | 703 | 3676 | 181 | 758 |
| 1982 | 1044 | 1309 | 392 | 847 | 286 | 3461 | 148 | 706 |
| 1983 | 1019 | 1493 | 311 | 2013 | 423 | 2719 | 374 | 1741 |
| 1984 | 1291 | 2433 | 500 | 2005 | 466 | 3133 | 397 | 1839 |
| 1985 | 1479 | 1144 | 442 | 1582 | 378 | 1239 | 414 | 1249 |
| 1986 | 1382 | 991 | 438 | 1174 | 372 | 1935 | 812 | 1754 |
| 1987 | 1583 | 777 | 467 | 1390 | 494 | 1425 | 669 | 2671 |
| 1988 | 1744 | 838 | 477 | 1363 | 631 | 2283 | 372 | 2573 |
| 1989 | 1917 | 1254 | 410 | 1128 | 573 | 1617 | 252 | 1400 |
| 1990 | 2352 | 1254 | 667 | 1209 | 666 | 1823 | 380 | 2022 |
| 1991 | 1692 | 1137 | 802 | 1003 | 551 | 1670 | 400 | 1802 |
| 1992 | 1907 | 1135 | 678 | 2414 | 622 | 1823 | 482 | 2163 |
| 1993 | 2154 | 1464 | 571 | 1745 | 593 | 1731 | 326 | 1785 |
| 1994 | 2052 | 1266 | 489 | 1273 | 707 | 1685 | 438 | 1808 |
| 1995 | 1655 | 1162 | 449 | 1115 | 1136 | 1683 | 325 | 1543 |
| 1996 | 1775 | 1355 | 515 | 1066 | 1044 | 2047 | 328 | 1637 |
| 1997 | 825 | 1739 | 331 | 489 | 697 | 2381 | 148 | 615 |
| 1998 | 1229 | 972 | 421 | 821 | 981 | 1519 | 136 | 641 |
| 1999 | 882 | 736 | 419 | 738 | 784 | 1414 | 188 | 483 |
| 2000 | 928 | 532 | 372 | 851 | 729 | 1652 | 199 | 519 |
| 2001 | 973 | 653 | 357 | 901 | 814 | 1738 | 147 | 548 |
| 2002 | 1156 | 586 | 344 | 757 | 698 | 1314 | 101 | 398 |
| 2003 | 1036 | 389 | 360 | 778 | 751 | 974 | 226 | 277 |
| 2004 | 1325 | 354 | 254 | 824 | 776 | 933 | 165 | 200 |
| 2005 | 676 | 23 | 1243 | 309 | 220 | 336 | 593 | 229 |
| 2006 | 618 | 400 | 316 | 432 | 562 | 1155 | 227 | 140 |
| 2007 | 624 | 631 | 321 | 405 | 775 | 842 | 236 | 101 |
| 2008 | 698 | 286 | 309 | 379 | 647 | 503 | 310 | 118 |
| 2009 | 847 | 336 | 266 | 542 | 520 | 505 | 208 | 140 |
| 2010 | 1256 | 351 | 260 | 507 | 807 | 550 | 307 | 260 |
| 2011 | 774 | 153 | 197 | 329 | 531 | 282 | 605 | 105 |
| 2012 | 883 | 224 | 113 | 409 | 507 | 545 | 449 | 148 |
| 2013 | 1060 | 344 | 138 | 269 | 1060 | 344 | 138 | 269 |
| 2014 | 911 | 392 | 133 | 345 | 654 | 652 | 727 | 291 |
| 2015 | 1058 | 621 | 141 | 391 | 662 | 904 | 841 | 318 |
| 2016 | 1297 | 861 | 159 | 435 | 874 | 1405 | 756 | 1375 |
| 2017 | 1775 | 838 | 215 | 344 | 1046 | 2209 | 739 | 163 |
| 2018 | 2131 | 974 | 230 | 312 | 1912 | 1990 | 751 | 215 |
| | | | | | | | | |

**Table 33.** Estimated Mexican landings of scalloped and great hammerheads by state (lb dw).

| | Scalloped hammerhead landings | | | | Great hammerhead landings | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Tamaulipas | Veracruz | Tabasco | Campeche | Tamaulipas | Veracruz | Tabasco | Campeche |
| 1976 | 45408 | 11841 | 55386 | 26946 | 4803 | 3562 | 974 | 10556 |
| 1977 | 98119 | 15818 | 64931 | 25701 | 10294 | 4806 | 1413 | 12719 |
| 1978 | 74988 | 10862 | 69177 | 20471 | 8041 | 3093 | 1427 | 12894 |
| 1979 | 125109 | 17340 | 75529 | 20244 | 13190 | 5063 | 1402 | 9993 |
| 1980 | 152388 | 21560 | 90182 | 21240 | 17545 | 6128 | 1622 | 8479 |
| 1981 | 424387 | 38264 | 132910 | 21375 | 44915 | 10382 | 2295 | 11140 |
| 1982 | 178174 | 43715 | 127703 | 36818 | 18748 | 12146 | 2177 | 14899 |
| 1983 | 174660 | 45053 | 104323 | 87859 | 20083 | 12846 | 2053 | 35956 |
| 1984 | 220916 | 68339 | 165327 | 88103 | 24577 | 19869 | 3041 | 36722 |
| 1985 | 252271 | 31217 | 146888 | 68374 | 26222 | 9150 | 2769 | 27224 |
| 1986 | 235824 | 30414 | 150268 | 55413 | 24736 | 8633 | 3253 | 27369 |
| 1987 | 270478 | 23486 | 157911 | 68965 | 29175 | 6693 | 3219 | 37554 |
| 1988 | 298441 | 28249 | 157643 | 67365 | 33219 | 7831 | 2893 | 36425 |
| 1989 | 327415 | 35232 | 134706 | 51630 | 35018 | 10242 | 2401 | 23825 |
| 1990 | 401517 | 36038 | 218793 | 58283 | 42505 | 10411 | 3867 | 30054 |
| 1991 | 289222 | 32742 | 262409 | 49056 | 31469 | 9454 | 4578 | 26012 |
| 1992 | 325979 | 33295 | 223523 | 105786 | 35480 | 9565 | 4053 | 43770 |
| 1993 | 367627 | 40518 | 187310 | 77720 | 38717 | 11829 | 3312 | 33558 |
| 1994 | 350962 | 35774 | 162273 | 59555 | 38646 | 10383 | 3038 | 28864 |
| 1995 | 286023 | 33369 | 148094 | 51934 | 38186 | 9642 | 2691 | 24929 |
| 1996 | 305849 | 39242 | 169338 | 50566 | 38792 | 11313 | 3030 | 25236 |
| 1997 | 143263 | 49400 | 108101 | 22428 | 20657 | 14317 | 1868 | 10399 |
| 1998 | 213119 | 28348 | 136881 | 35443 | 30061 | 8157 | 2309 | 14066 |
| 1999 | 153365 | 22498 | 136848 | 31333 | 22566 | 6393 | 2365 | 11837 |
| 2000 | 160862 | 18727 | 121874 | 35917 | 22553 | 5138 | 2141 | 13320 |
| 2001 | 168922 | 21852 | 116444 | 38019 | 24263 | 6069 | 1998 | 14090 |
| 2002 | 199284 | 18649 | 111727 | 31590 | 25488 | 5244 | 1874 | 11297 |
| 2003 | 179254 | 12778 | 118334 | 31720 | 24399 | 3565 | 2114 | 10467 |
| 2004 | 228292 | 11810 | 83556 | 33068 | 28916 | 3282 | 1498 | 10276 |
| 2005 | 115551 | 1845 | 406385 | 13271 | 12571 | 439 | 7061 | 5188 |
| 2006 | 107526 | 13739 | 104207 | 17535 | 15968 | 3792 | 1892 | 5692 |
| 2007 | 109656 | 17839 | 105919 | 16268 | 18698 | 5177 | 1929 | 5074 |
| 2008 | 121509 | 8560 | 102930 | 15357 | 18187 | 2446 | 1962 | 4952 |
| 2009 | 146060 | 9721 | 87916 | 21799 | 18782 | 2803 | 1614 | 6833 |
| 2010 | 216778 | 10243 | 87149 | 21120 | 28296 | 2947 | 1709 | 7509 |
| 2011 | 133764 | 4630 | 70397 | 13345 | 17855 | 1319 | 1767 | 4321 |
| 2012 | 152084 | 7296 | 41576 | 16689 | 19145 | 2040 | 1143 | 5523 |
| 2013 | 184933 | 9275 | 45964 | 11946 | 28580 | 2728 | 875 | 5120 |
| 2014 | 157592 | 11587 | 51261 | 15016 | 21376 | 3322 | 1597 | 6098 |
| 2015 | 182511 | 17851 | 55168 | 16952 | 23615 | 5157 | 1783 | 6809 |
| 2016 | 224067 | 25344 | 59956 | 24628 | 29724 | 7274 | 1766 | 16423 |
| 2017 | 305859 | 27960 | 77752 | 14254 | 38817 | 7770 | 2029 | 4979 |
| 2018 | 370638 | 30237 | 82713 | 13308 | 54741 | 8558 | 2120 | 5098 |
| | | | | | | | | |

**Table 34.** Estimated Mexican landings of scalloped and great hammerheads by major gear type (lb dw).

| | Scalloped hammerhead landings by gear | | | Great hammerhead landings by gear | | |
|---|---|---|---|---|---|---|
| Year | Longlines | Nets | Lines | Longlines | Nets | Lines |
| 1976 | 53650 | 79756 | 6176 | 3751 | 14663 | 1481 |
| 1977 | 63181 | 132424 | 8964 | 5207 | 21734 | 2291 |
| 1978 | 61723 | 106680 | 7095 | 4028 | 19844 | 1583 |
| 1979 | 70765 | 157048 | 10408 | 5349 | 21705 | 2594 |
| 1980 | 84416 | 188218 | 12736 | 6314 | 24198 | 3262 |
| 1981 | 127923 | 463111 | 25902 | 10684 | 51354 | 6694 |
| 1982 | 129164 | 236590 | 20656 | 11034 | 31704 | 5232 |
| 1983 | 124504 | 267029 | 20362 | 12301 | 53083 | 5553 |
| 1984 | 183601 | 329285 | 29800 | 17920 | 58199 | 8089 |
| 1985 | 142512 | 336371 | 19868 | 10322 | 50172 | 4872 |
| 1986 | 141427 | 311219 | 19273 | 10348 | 49047 | 4596 |
| 1987 | 145756 | 356519 | 18565 | 9613 | 62696 | 4333 |
| 1988 | 148473 | 382614 | 20612 | 10171 | 65197 | 4999 |
| 1989 | 133213 | 393180 | 22589 | 10878 | 54719 | 5889 |
| 1990 | 196146 | 491174 | 27310 | 12728 | 67592 | 6518 |
| 1991 | 222432 | 386344 | 24653 | 12168 | 53975 | 5370 |
| 1992 | 207713 | 456088 | 24782 | 12663 | 74491 | 5714 |
| 1993 | 180446 | 465987 | 26743 | 13210 | 67537 | 6669 |
| 1994 | 155289 | 429069 | 24207 | 11835 | 62883 | 6212 |
| 1995 | 141378 | 356681 | 21361 | 10879 | 58624 | 5946 |
| 1996 | 160236 | 380629 | 24131 | 12293 | 59564 | 6514 |
| 1997 | 115268 | 187265 | 20660 | 12075 | 29109 | 6056 |
| 1998 | 125899 | 270243 | 17650 | 8867 | 40869 | 4857 |
| 1999 | 120759 | 208859 | 14426 | 7418 | 32012 | 3730 |
| 2000 | 108671 | 215546 | 13162 | 6466 | 33348 | 3338 |
| 2001 | 107299 | 223858 | 14080 | 7045 | 35615 | 3760 |
| 2002 | 100679 | 246707 | 13863 | 6325 | 33982 | 3597 |
| 2003 | 101542 | 228634 | 11910 | 5355 | 32200 | 2989 |
| 2004 | 76638 | 268152 | 11938 | 4792 | 35933 | 3248 |
| 2005 | 296766 | 224606 | 15680 | 6863 | 17292 | 1104 |
| 2006 | 88314 | 144903 | 9790 | 4842 | 20091 | 2411 |
| 2007 | 91901 | 146763 | 11019 | 5846 | 21978 | 3054 |
| 2008 | 83715 | 155939 | 8703 | 4060 | 21325 | 2162 |
| 2009 | 75296 | 180948 | 9253 | 4099 | 23613 | 2319 |
| 2010 | 75480 | 248534 | 11275 | 4615 | 32751 | 3096 |
| 2011 | 57497 | 157653 | 6987 | 3121 | 20357 | 1785 |
| 2012 | 39393 | 170886 | 7366 | 3160 | 22582 | 2109 |
| 2013 | 43015 | 200191 | 8911 | 3680 | 30574 | 3050 |
| 2014 | 48762 | 177721 | 8973 | 4481 | 25232 | 2681 |
| 2015 | 56195 | 204805 | 11482 | 5944 | 27995 | 3425 |
| 2016 | 66445 | 252734 | 14816 | 7917 | 42715 | 4556 |
| 2017 | 79236 | 328353 | 18236 | 8291 | 39894 | 5410 |
| 2018 | 84550 | 391598 | 20748 | 9414 | 54222 | 6881 |
| | | | | | | |

**Table 35**. Post-release live discard mortality (PRLDM) rate (%) outcomes for electronically tagged scalloped and great hammerheads from multiple release locations in Florida west coast estuaries and bays adjacent to the Gulf of Mexico adapted from Gardiner et al. (2022, their Tables 1 and 2).

| | | | | |
|---|---|---|---|---|
| Scalloped hammerhead | | | | |
| | Gear type | Tags reporting | PRLDM | (%) |
| | GN | 2 | 2 | 100% |
| | DL | 1 | 0 | 0% |
| | | | | |
| Great hammerhead | | | | |
| | Source | Tags reporting | PRLDM | (%) |
| | RR | 1 | 1 | 100% |
| | BLL | 7 | 1 | 14% |

Gear type (GN = gillnet, DL = drumline, BLL = bottom longline, RR = rod and reel).

**Table 36**. Catches of scalloped hammerheads for areas combined in weight (lb dw). Total commercial catch is the maximum of the sum of commercial catches by gear and total commercial catches not disaggregated by gear; total recreational catch is the sum of total recreational AB1 catch and LPRM (live post-release mortality=B2 dead); total catch is the sum of total recreational and total commercial catch. See text for additional definitions of terms.

| Year | Total Bottom longline catch | Total Gillnet catch | Total hook and line + hand line catch | Pelagic longline dead discards | Total commercial catch | Total AB1 recreational catch | Total recreational LPRM | Total recreational catch | Total catch |
|---|---|---|---|---|---|---|---|---|---|
| 1981 | 0 | 0 | 0 | 0 | 0 | 344834 | 120621 | 465454 | 465454 |
| 1982 | 20095 | 4641 | 88 | 11446 | 49453 | 344834 | 120621 | 465454 | 514907 |
| 1983 | 40189 | 9342 | 175 | 23168 | 98906 | 262674 | 105935 | 368609 | 467515 |
| 1984 | 60284 | 13957 | 263 | 34615 | 148359 | 201196 | 78254 | 279450 | 427809 |
| 1985 | 80379 | 18649 | 351 | 46061 | 197812 | 192528 | 75544 | 268072 | 465884 |
| 1986 | 100474 | 23360 | 438 | 57507 | 247264 | 156621 | 57171 | 213792 | 461056 |
| 1987 | 120568 | 28219 | 526 | 84513 | 296717 | 157274 | 57747 | 215021 | 511738 |
| 1988 | 140663 | 32948 | 614 | 275099 | 449324 | 210126 | 61440 | 271566 | 720890 |
| 1989 | 160758 | 39096 | 701 | 127729 | 395623 | 322442 | 75539 | 397981 | 793604 |
| 1990 | 180853 | 44369 | 789 | 163350 | 445076 | 460766 | 85443 | 546209 | 991285 |
| 1991 | 79321 | 76921 | 121 | 111360 | 325196 | 471572 | 128370 | 599941 | 925137 |
| 1992 | 229490 | 50096 | 912 | 405737 | 737447 | 483904 | 222049 | 705953 | 1443400 |
| 1993 | 298117 | 29300 | 1597 | 44761 | 420944 | 296889 | 364756 | 661645 | 1082589 |
| 1994 | 508601 | 25247 | 43129 | 46221 | 676082 | 186186 | 231260 | 417446 | 1093528 |
| 1995 | 324146 | 22070 | 10393 | 89767 | 471014 | 135787 | 60918 | 196705 | 667719 |
| 1996 | 276803 | 30681 | 10758 | 15546 | 351177 | 141401 | 30676 | 172078 | 523255 |
| 1997 | 86146 | 28089 | 235 | 48258 | 171746 | 159323 | 29690 | 189013 | 360760 |
| 1998 | 95459 | 29054 | 1272 | 47384 | 186198 | 176826 | 84581 | 261407 | 447605 |
| 1999 | 108111 | 23392 | 9704 | 40433 | 187294 | 195243 | 193419 | 388662 | 575956 |
| 2000 | 69798 | 21011 | 388 | 46364 | 157837 | 212856 | 407217 | 620073 | 777911 |
| 2001 | 63314 | 19710 | 1182 | 55740 | 180295 | 185014 | 707696 | 892710 | 1073005 |
| 2002 | 97532 | 10098 | 2759 | 44239 | 205088 | 158624 | 702714 | 861338 | 1066426 |
| 2003 | 122966 | 47533 | 726 | 44239 | 234996 | 192135 | 646678 | 838812 | 1073808 |
| 2004 | 92665 | 26383 | 2690 | 44239 | 181461 | 231956 | 459143 | 691099 | 872560 |
| 2005 | 88680 | 9887 | 2346 | 44239 | 221448 | 291251 | 344016 | 635267 | 856715 |
| 2006 | 92643 | 15402 | 216 | 44239 | 205937 | 125684 | 234518 | 360202 | 566140 |
| 2007 | 22132 | 11526 | 83 | 96855 | 151883 | 68720 | 199444 | 268164 | 420047 |
| 2008 | 29237 | 77323 | 789 | 63284 | 177781 | 30799 | 194339 | 225138 | 402919 |
| 2009 | 77151 | 21045 | 13711 | 51367 | 168913 | 30665 | 226045 | 256710 | 425622 |
| 2010 | 44546 | 13458 | 1825 | 2401 | 68776 | 17743 | 308583 | 326326 | 395102 |
| 2011 | 65256 | 26130 | 1404 | 4092 | 103357 | 19021 | 414648 | 433670 | 537026 |
| 2012 | 57039 | 22371 | 9490 | 1900 | 90806 | 35643 | 483193 | 518836 | 609642 |
| 2013 | 31547 | 21145 | 1989 | 3240 | 58167 | 100491 | 336837 | 437328 | 495496 |
| 2014 | 36165 | 23388 | 409 | 34086 | 94048 | 177288 | 191907 | 369195 | 463243 |
| 2015 | 34149 | 57050 | 70 | 31145 | 122414 | 37735 | 139812 | 177547 | 299961 |
| 2016 | 18757 | 21741 | 17225 | 52595 | 114598 | 7026 | 125625 | 132651 | 247249 |
| 2017 | 27670 | 49017 | 3147 | 80614 | 160680 | 1288 | 133651 | 134939 | 295619 |
| 2018 | 20848 | 13266 | 17713 | 22552 | 74379 | 1288 | 133651 | 134939 | 209318 |
| 2019 | 12350 | 16214 | 205 | 10805 | 39574 | 1288 | 133651 | 134939 | 174513 |
| 2020 | 3682 | 8704 | 3172 | 66025 | 81799 | 1288 | 133651 | 134939 | 216738 |

**Table 37**. Catches of scalloped hammerheads for areas combined in numbers. Total commercial catch is the maximum of the sum of commercial catches by gear and total commercial catches not disaggregated by gear; total recreational catch is the sum of total recreational AB1 catch and LPRM; total catch is the sum of total recreational and total commercial catch. See text for additional definitions of terms.

| Year | Total Bottom longline catch | Total Gillnet catch | Total hook and line + hand line catch | Pelagic longline dead discards | Total commercial catch | Total AB1 recreational catch | Total recreational LPRM | Total recreational catch | Total catch |
|---|---|---|---|---|---|---|---|---|---|
| 1981 | 0 | 0 | 0 | 0 | 0 | 23641 | 22898 | 46539 | 46539 |
| 1982 | 227 | 138 | 1 | 163 | 829 | 23641 | 22898 | 46539 | 47368 |
| 1983 | 454 | 277 | 2 | 329 | 1659 | 19641 | 14312 | 33954 | 35612 |
| 1984 | 681 | 414 | 3 | 492 | 2488 | 16353 | 7444 | 23797 | 26285 |
| 1985 | 908 | 552 | 4 | 655 | 3318 | 13812 | 5644 | 19456 | 22774 |
| 1986 | 1135 | 692 | 5 | 817 | 4147 | 8373 | 2008 | 10380 | 14527 |
| 1987 | 1362 | 834 | 6 | 1201 | 4977 | 6134 | 1384 | 7518 | 12494 |
| 1988 | 1588 | 974 | 7 | 3909 | 6478 | 5822 | 1209 | 7031 | 13509 |
| 1989 | 1815 | 1144 | 8 | 1815 | 6635 | 8374 | 2501 | 10875 | 17510 |
| 1990 | 2042 | 1296 | 9 | 2321 | 7465 | 11299 | 4041 | 15341 | 22805 |
| 1991 | 896 | 2247 | 1 | 1583 | 5033 | 11283 | 7022 | 18305 | 23338 |
| 1992 | 2592 | 1448 | 10 | 7839 | 13220 | 11498 | 12474 | 23972 | 37192 |
| 1993 | 3367 | 812 | 18 | 536 | 6630 | 7262 | 16393 | 23655 | 30285 |
| 1994 | 4732 | 693 | 401 | 695 | 9320 | 4680 | 8397 | 13078 | 22398 |
| 1995 | 2761 | 605 | 89 | 803 | 5388 | 3404 | 4247 | 7651 | 13039 |
| 1996 | 2727 | 840 | 106 | 339 | 4612 | 3413 | 2335 | 5748 | 10360 |
| 1997 | 1291 | 743 | 4 | 680 | 3003 | 3670 | 2344 | 6014 | 9016 |
| 1998 | 1045 | 759 | 14 | 376 | 2409 | 3992 | 2296 | 6288 | 8697 |
| 1999 | 1003 | 599 | 90 | 505 | 2363 | 4449 | 2727 | 7176 | 9539 |
| 2000 | 788 | 543 | 4 | 434 | 2083 | 4937 | 3551 | 8488 | 10571 |
| 2001 | 860 | 515 | 16 | 1154 | 3314 | 4656 | 4925 | 9581 | 12895 |
| 2002 | 1056 | 625 | 30 | 423 | 3172 | 4272 | 5189 | 9461 | 12633 |
| 2003 | 1716 | 467 | 10 | 571 | 2764 | 5267 | 5736 | 11004 | 13767 |
| 2004 | 1417 | 420 | 41 | 783 | 2797 | 5868 | 5873 | 11741 | 14539 |
| 2005 | 1050 | 449 | 28 | 553 | 3949 | 6827 | 7049 | 13876 | 17825 |
| 2006 | 1391 | 509 | 3 | 877 | 4131 | 2909 | 6718 | 9627 | 13758 |
| 2007 | 482 | 750 | 2 | 1345 | 3568 | 1616 | 6933 | 8549 | 12117 |
| 2008 | 590 | 734 | 16 | 1269 | 2609 | 740 | 6085 | 6825 | 9434 |
| 2009 | 804 | 1142 | 143 | 1313 | 3830 | 746 | 5844 | 6590 | 10420 |
| 2010 | 511 | 807 | 21 | 55 | 1581 | 466 | 5359 | 5825 | 7406 |
| 2011 | 593 | 912 | 13 | 57 | 1855 | 511 | 4858 | 5369 | 7223 |
| 2012 | 507 | 1062 | 84 | 30 | 1781 | 939 | 4873 | 5812 | 7593 |
| 2013 | 301 | 2924 | 19 | 68 | 3311 | 2436 | 4543 | 6979 | 10290 |
| 2014 | 485 | 2011 | 5 | 506 | 3007 | 4132 | 4423 | 8555 | 11562 |
| 2015 | 294 | 1939 | 1 | 372 | 2605 | 890 | 3689 | 4579 | 7185 |
| 2016 | 232 | 1955 | 173 | 770 | 3130 | 193 | 2988 | 3181 | 6311 |
| 2017 | 267 | 532 | 30 | 1287 | 2115 | 39 | 2495 | 2534 | 4649 |
| 2018 | 236 | 1288 | 202 | 320 | 2047 | 39 | 2495 | 2534 | 4581 |
| 2019 | 133 | 1095 | 2 | 154 | 1384 | 39 | 2495 | 2534 | 3918 |
| 2020 | 55 | 361 | 43 | 938 | 1397 | 39 | 2495 | 2534 | 3931 |

**Table 38**. Catches of GOM scalloped hammerheads in weight (lb dw). Total commercial catch is the maximum of the sum of commercial catches by gear and total commercial catches not disaggregated by gear; total recreational catch is the sum of total recreational AB1 catch and LPRM; total catch is the sum of total recreational and total commercial catch. See text for additional definitions of terms.

| Year | Total Bottom longline catch | Total Gillnet catch | Total hook and line + hand line catch | Pelagic longline dead discards | Total commercial catch | Total AB1 recreational catch | Total recreational LPRM | Total recreational catch | Total catch |
|---|---|---|---|---|---|---|---|---|---|
| 1981 | 0 | 0 | 0 | 0 | 0 | 46365 | 1692 | 48057 | 48057 |
| 1982 | 3388 | 128 | 46 | 928 | 4489 | 46365 | 1692 | 48057 | 52546 |
| 1983 | 6775 | 256 | 91 | 1878 | 9001 | 36701 | 5334 | 42035 | 51036 |
| 1984 | 10163 | 385 | 137 | 2806 | 13490 | 27874 | 16796 | 44670 | 58160 |
| 1985 | 13550 | 513 | 182 | 3734 | 17979 | 24832 | 52889 | 77721 | 95700 |
| 1986 | 16938 | 641 | 228 | 4661 | 22468 | 26475 | 35971 | 62446 | 84914 |
| 1987 | 20326 | 769 | 273 | 6496 | 27865 | 33016 | 27198 | 60215 | 88079 |
| 1988 | 23713 | 898 | 319 | 20239 | 45169 | 47588 | 20565 | 68153 | 113322 |
| 1989 | 27101 | 1026 | 364 | 13441 | 41932 | 44311 | 14755 | 59065 | 100997 |
| 1990 | 30488 | 1154 | 410 | 19083 | 51135 | 24420 | 2934 | 27355 | 78490 |
| 1991 | 34507 | 1282 | 0 | 8821 | 45823 | 20770 | 2238 | 23008 | 68831 |
| 1992 | 33534 | 1284 | 875 | 4303 | 39995 | 22191 | 2652 | 24843 | 64838 |
| 1993 | 35449 | 1282 | 492 | 4303 | 41525 | 34473 | 10241 | 44714 | 86239 |
| 1994 | 91367 | 1286 | 30561 | 4303 | 127516 | 14113 | 3452 | 17564 | 145080 |
| 1995 | 157845 | 1283 | 1573 | 2292 | 169212 | 5516 | 1064 | 6581 | 175792 |
| 1996 | 187200 | 1296 | 7549 | 1519 | 204227 | 5368 | 694 | 6062 | 210289 |
| 1997 | 29529 | 1282 | 116 | 1598 | 35744 | 12613 | 1351 | 13965 | 49709 |
| 1998 | 43693 | 653 | 106 | 223 | 51577 | 31079 | 4167 | 35246 | 86823 |
| 1999 | 16130 | 1282 | 1 | 610 | 23758 | 20573 | 8261 | 28834 | 52592 |
| 2000 | 48215 | 855 | 127 | 14236 | 76088 | 14283 | 25179 | 39462 | 115550 |
| 2001 | 37548 | 945 | 0 | 3641 | 58358 | 14494 | 54993 | 69487 | 127845 |
| 2002 | 50598 | 58 | 0 | 4303 | 86592 | 22891 | 87083 | 109974 | 196566 |
| 2003 | 81602 | 1939 | 678 | 4303 | 101798 | 35027 | 66668 | 101695 | 203493 |
| 2004 | 57839 | 759 | 446 | 4303 | 76034 | 24324 | 40765 | 65089 | 141123 |
| 2005 | 106403 | 100 | 0 | 4303 | 167223 | 14485 | 18180 | 32666 | 199889 |
| 2006 | 53300 | 412 | 0 | 4303 | 90319 | 6421 | 7940 | 14360 | 104679 |
| 2007 | 11045 | 67 | 0 | 2013 | 24361 | 4290 | 4241 | 8531 | 32892 |
| 2008 | 16644 | 3232 | 372 | 13995 | 39822 | 3500 | 4476 | 7976 | 47798 |
| 2009 | 37790 | 663 | 2854 | 5784 | 55251 | 3394 | 9958 | 13352 | 68604 |
| 2010 | 16037 | 175 | 290 | 149 | 20739 | 3196 | 23312 | 26509 | 47248 |
| 2011 | 32795 | 1414 | 575 | 2301 | 43018 | 3662 | 38825 | 42487 | 85506 |
| 2012 | 39373 | 701 | 5827 | 386 | 46287 | 4786 | 30962 | 35748 | 82035 |
| 2013 | 6838 | 239 | 0 | 1315 | 8392 | 6301 | 20616 | 26917 | 35310 |
| 2014 | 9154 | 705 | 80 | 14028 | 23967 | 4397 | 10723 | 15120 | 39087 |
| 2015 | 13352 | 1808 | 70 | 4353 | 20443 | 2852 | 12887 | 15738 | 36181 |
| 2016 | 10010 | 594 | 17068 | 10937 | 42889 | 1627 | 16539 | 18165 | 61054 |
| 2017 | 19890 | 3725 | 3147 | 378 | 27371 | 1283 | 26573 | 27856 | 55228 |
| 2018 | 13953 | 177 | 17584 | 1346 | 33060 | 1283 | 26573 | 27856 | 60917 |
| 2019 | 9061 | 458 | 0 | 832 | 10452 | 1283 | 26573 | 27856 | 38308 |
| 2020 | 868 | 0 | 2882 | 0 | 3750 | 1283 | 26573 | 27856 | 31606 |

**Table 39**. Catches of GOM scalloped hammerheads in numbers. Total commercial catch is the maximum of the sum of commercial catches by gear and total commercial catches not disaggregated by gear; total recreational catch is the sum of total recreational AB1 catch and LPRM; total catch is the sum of total recreational and total commercial catch. See text for additional definitions of terms.

| Year | Total Bottom longline catch | Total Gillnet catch | Total hook and line + hand line catch | Pelagic longline dead discards | Total commercial catch | Total AB1 recreational catch | Total recreational LPRM | Total recreational catch | Total catch |
|---|---|---|---|---|---|---|---|---|---|
| 1981 | 0 | 0 | 0 | 0 | 0 | 2102 | 255 | 2357 | 2357 |
| 1982 | 40 | 35 | 1 | 13 | 89 | 2102 | 255 | 2357 | 2446 |
| 1983 | 81 | 8 | 1 | 27 | 116 | 1658 | 655 | 2313 | 2429 |
| 1984 | 121 | 11 | 2 | 40 | 174 | 1301 | 1678 | 2979 | 3153 |
| 1985 | 162 | 15 | 2 | 53 | 232 | 1217 | 4302 | 5519 | 5751 |
| 1986 | 202 | 19 | 3 | 66 | 290 | 1279 | 1302 | 2581 | 2872 |
| 1987 | 243 | 23 | 3 | 92 | 361 | 1501 | 649 | 2150 | 2512 |
| 1988 | 283 | 27 | 4 | 288 | 601 | 1997 | 324 | 2321 | 2922 |
| 1989 | 324 | 30 | 4 | 191 | 550 | 1864 | 489 | 2352 | 2902 |
| 1990 | 364 | 34 | 5 | 271 | 675 | 1043 | 190 | 1233 | 1907 |
| 1991 | 412 | 38 | 0 | 125 | 602 | 931 | 180 | 1111 | 1713 |
| 1992 | 401 | 38 | 10 | 83 | 532 | 1044 | 185 | 1230 | 1762 |
| 1993 | 424 | 38 | 6 | 52 | 519 | 1698 | 476 | 2174 | 2694 |
| 1994 | 766 | 38 | 256 | 65 | 1141 | 993 | 295 | 1288 | 2430 |
| 1995 | 1440 | 38 | 14 | 20 | 1717 | 465 | 184 | 650 | 2367 |
| 1996 | 1747 | 38 | 70 | 33 | 2150 | 341 | 95 | 435 | 2585 |
| 1997 | 729 | 38 | 3 | 23 | 889 | 418 | 82 | 500 | 1389 |
| 1998 | 668 | 19 | 2 | 2 | 836 | 622 | 87 | 709 | 1545 |
| 1999 | 696 | 38 | 0 | 8 | 934 | 467 | 116 | 583 | 1516 |
| 2000 | 576 | 25 | 2 | 133 | 953 | 383 | 240 | 623 | 1577 |
| 2001 | 560 | 28 | 0 | 75 | 994 | 509 | 415 | 925 | 1919 |
| 2002 | 689 | 14 | 0 | 41 | 1615 | 875 | 686 | 1561 | 3176 |
| 2003 | 825 | 13 | 7 | 55 | 960 | 1385 | 619 | 2004 | 2964 |
| 2004 | 748 | 10 | 6 | 76 | 1009 | 629 | 512 | 1141 | 2150 |
| 2005 | 620 | 12 | 0 | 54 | 1346 | 261 | 338 | 599 | 1945 |
| 2006 | 1043 | 16 | 0 | 85 | 2092 | 110 | 183 | 293 | 2384 |
| 2007 | 286 | 15 | 0 | 28 | 944 | 100 | 110 | 210 | 1154 |
| 2008 | 336 | 26 | 8 | 281 | 651 | 107 | 118 | 225 | 876 |
| 2009 | 402 | 54 | 30 | 148 | 1068 | 104 | 212 | 317 | 1385 |
| 2010 | 201 | 15 | 4 | 3 | 442 | 88 | 376 | 465 | 906 |
| 2011 | 274 | 62 | 5 | 32 | 616 | 98 | 407 | 505 | 1121 |
| 2012 | 373 | 45 | 55 | 6 | 732 | 125 | 337 | 461 | 1193 |
| 2013 | 68 | 51 | 0 | 27 | 157 | 179 | 277 | 456 | 613 |
| 2014 | 190 | 110 | 2 | 208 | 585 | 114 | 234 | 348 | 933 |
| 2015 | 147 | 128 | 1 | 52 | 376 | 66 | 307 | 373 | 749 |
| 2016 | 166 | 72 | 198 | 160 | 843 | 38 | 378 | 416 | 1259 |
| 2017 | 202 | 34 | 32 | 6 | 273 | 34 | 496 | 530 | 804 |
| 2018 | 186 | 28 | 238 | 19 | 771 | 34 | 496 | 530 | 1301 |
| 2019 | 97 | 46 | 0 | 12 | 176 | 34 | 496 | 530 | 707 |
| 2020 | 10 | 0 | 34 | 0 | 69 | 34 | 496 | 530 | 600 |

**Table 40**. Catches of ATL scalloped hammerheads in weight (lb dw). Total commercial catch is the maximum of the sum of commercial catches by gear and total commercial catches not disaggregated by gear; total recreational catch is the sum of total recreational AB1 catch and LPRM; total catch is the sum of total recreational and total commercial catch. See text for additional definitions of terms.

| Year | Total Bottom longline catch | Total Gillnet catch | Total hook and line + hand line catch | Pelagic longline dead discards | Total commercial catch | Total AB1 recreational catch | Total recreational LPRM | Total recreational catch | Total catch |
|---|---|---|---|---|---|---|---|---|---|
| 1981 | 0 | 0 | 0 | 0 | 0 | 276251 | 131889 | 408141 | 408141 |
| 1982 | 25469 | 4581 | 36 | 11430 | 45878 | 276251 | 131889 | 408141 | 454018 |
| 1983 | 50939 | 9224 | 72 | 23135 | 91755 | 101772 | 90553 | 192325 | 284080 |
| 1984 | 76408 | 13777 | 109 | 34565 | 137633 | 42156 | 39460 | 81616 | 219249 |
| 1985 | 101878 | 18412 | 145 | 45995 | 183510 | 35340 | 25687 | 61027 | 244537 |
| 1986 | 127347 | 23067 | 181 | 57425 | 229388 | 53448 | 25314 | 78763 | 308151 |
| 1987 | 152817 | 27876 | 217 | 84365 | 275265 | 93025 | 42987 | 136012 | 411277 |
| 1988 | 178286 | 32550 | 253 | 274617 | 485706 | 155373 | 68581 | 223954 | 709660 |
| 1989 | 203756 | 38713 | 290 | 127505 | 370264 | 264983 | 80331 | 345314 | 715578 |
| 1990 | 229225 | 43959 | 326 | 163064 | 436574 | 411972 | 88192 | 500164 | 936737 |
| 1991 | 61349 | 77022 | 98 | 111165 | 288394 | 456615 | 124943 | 581559 | 869953 |
| 1992 | 300448 | 49709 | 73 | 405737 | 755966 | 483664 | 215320 | 698984 | 1454950 |
| 1993 | 404694 | 28642 | 915 | 44761 | 479012 | 332019 | 357630 | 689649 | 1168661 |
| 1994 | 642570 | 24472 | 11626 | 46221 | 724889 | 228407 | 264168 | 492575 | 1217464 |
| 1995 | 238160 | 21234 | 7189 | 89767 | 356349 | 178347 | 81827 | 260174 | 616524 |
| 1996 | 123325 | 29966 | 2956 | 15519 | 171766 | 156319 | 40409 | 196727 | 368493 |
| 1997 | 64557 | 27553 | 101 | 48174 | 140385 | 147599 | 35457 | 183056 | 323442 |
| 1998 | 47850 | 21650 | 945 | 47302 | 117746 | 139307 | 80513 | 219820 | 337566 |
| 1999 | 48962 | 15872 | 7825 | 40363 | 113021 | 156589 | 181451 | 338040 | 451061 |
| 2000 | 23499 | 14865 | 216 | 46283 | 89408 | 174074 | 358662 | 532736 | 622144 |
| 2001 | 33454 | 14148 | 953 | 55642 | 122422 | 154092 | 680480 | 834573 | 956995 |
| 2002 | 33591 | 5921 | 2225 | 44162 | 96515 | 127903 | 724912 | 852815 | 949331 |
| 2003 | 74692 | 40553 | 72 | 44162 | 159479 | 157940 | 735427 | 893367 | 1052846 |
| 2004 | 43913 | 21356 | 2100 | 44162 | 111530 | 203163 | 528941 | 732104 | 843634 |
| 2005 | 38508 | 6038 | 2170 | 44162 | 94731 | 276442 | 398066 | 674508 | 769239 |
| 2006 | 41773 | 12534 | 174 | 44162 | 110770 | 120339 | 276395 | 396734 | 507504 |
| 2007 | 12772 | 6912 | 67 | 96686 | 123451 | 65195 | 232965 | 298160 | 421611 |
| 2008 | 15217 | 67869 | 354 | 63284 | 146725 | 27673 | 234543 | 262217 | 408941 |
| 2009 | 41909 | 12100 | 8895 | 51367 | 114272 | 27260 | 263510 | 290770 | 405042 |
| 2010 | 34463 | 8834 | 1252 | 2396 | 46946 | 14016 | 358975 | 372991 | 419936 |
| 2011 | 25181 | 15582 | 696 | 4085 | 46171 | 14806 | 446550 | 461356 | 507526 |
| 2012 | 8805 | 13392 | 3778 | 1897 | 36720 | 28437 | 507748 | 536185 | 572905 |
| 2013 | 7263 | 17607 | 1989 | 3234 | 46708 | 91072 | 372331 | 463404 | 510112 |
| 2014 | 8302 | 18293 | 329 | 34086 | 76999 | 172400 | 240253 | 412653 | 489653 |
| 2015 | 10719 | 38407 | 0 | 31145 | 87544 | 3060 | 186026 | 189086 | 276630 |
| 2016 | 6654 | 18481 | 157 | 52595 | 79161 | 54 | 161446 | 161500 | 240661 |
| 2017 | 8407 | 43066 | 0 | 80614 | 132116 | 2 | 152373 | 152376 | 284492 |
| 2018 | 4884 | 10818 | 129 | 22552 | 39656 | 2 | 152373 | 152376 | 192031 |
| 2019 | 961 | 13180 | 205 | 9825 | 25908 | 2 | 152373 | 152376 | 178284 |
| 2020 | 0 | 8704 | 290 | 66025 | 78049 | 2 | 152373 | 152376 | 230425 |

**Table 41**. Catches of ATL scalloped hammerheads in numbers. Total commercial catch is the maximum of the sum of commercial catches by gear and total commercial catches not disaggregated by gear; total recreational catch is the sum of total recreational AB1 catch and LPRM; total catch is the sum of total recreational and total commercial catch. See text for additional definitions of terms.

| Year | Total Bottom longline catch | Total Gillnet catch | Total hook and line + hand line catch | Pelagic longline dead discards | Total commercial catch | Total AB1 recreational catch | Total recreational LPRM | Total recreational catch | Total catch |
|---|---|---|---|---|---|---|---|---|---|
| 1981 | 0 | 0 | 0 | 0 | 0 | 25249 | 26004 | 51253 | 51253 |
| 1982 | 250 | 136 | 0 | 162 | 744 | 25249 | 26004 | 51253 | 51997 |
| 1983 | 500 | 272 | 1 | 329 | 1488 | 8248 | 12283 | 20530 | 22018 |
| 1984 | 750 | 408 | 1 | 491 | 2231 | 2872 | 3544 | 6416 | 8648 |
| 1985 | 1000 | 544 | 1 | 654 | 2975 | 1226 | 1503 | 2729 | 5704 |
| 1986 | 1251 | 681 | 2 | 816 | 3719 | 1474 | 771 | 2245 | 5964 |
| 1987 | 1501 | 821 | 2 | 1199 | 4463 | 2152 | 887 | 3039 | 7502 |
| 1988 | 1751 | 958 | 2 | 3903 | 6614 | 3593 | 1376 | 4969 | 11584 |
| 1989 | 2001 | 1122 | 3 | 1812 | 5950 | 6125 | 2475 | 8600 | 14551 |
| 1990 | 2251 | 1269 | 3 | 2317 | 6694 | 9522 | 3971 | 13493 | 20187 |
| 1991 | 602 | 2224 | 1 | 1580 | 4407 | 10554 | 6703 | 17258 | 21665 |
| 1992 | 2950 | 1409 | 1 | 7839 | 12340 | 11180 | 11538 | 22718 | 35058 |
| 1993 | 3974 | 753 | 9 | 536 | 5662 | 7674 | 15898 | 23573 | 29235 |
| 1994 | 6036 | 632 | 109 | 695 | 8188 | 5279 | 10730 | 16009 | 24197 |
| 1995 | 2006 | 546 | 61 | 803 | 3678 | 4122 | 6790 | 10912 | 14590 |
| 1996 | 1256 | 771 | 30 | 338 | 2425 | 3613 | 3663 | 7276 | 9701 |
| 1997 | 567 | 665 | 1 | 679 | 1919 | 3411 | 2837 | 6248 | 8167 |
| 1998 | 448 | 752 | 9 | 375 | 1584 | 3219 | 2138 | 5358 | 6942 |
| 1999 | 436 | 572 | 70 | 504 | 1596 | 3619 | 2429 | 6048 | 7644 |
| 2000 | 231 | 527 | 2 | 433 | 1259 | 4023 | 3065 | 7088 | 8347 |
| 2001 | 313 | 495 | 9 | 1152 | 2261 | 3632 | 4617 | 8249 | 10510 |
| 2002 | 463 | 620 | 31 | 422 | 1841 | 3082 | 5208 | 8290 | 10130 |
| 2003 | 903 | 462 | 1 | 570 | 1935 | 3834 | 6214 | 10048 | 11983 |
| 2004 | 692 | 412 | 33 | 781 | 1919 | 4836 | 6445 | 11281 | 13200 |
| 2005 | 563 | 443 | 32 | 552 | 1986 | 6436 | 7694 | 14131 | 16117 |
| 2006 | 350 | 497 | 1 | 876 | 1960 | 2781 | 7415 | 10197 | 12157 |
| 2007 | 190 | 740 | 1 | 1343 | 2530 | 1508 | 7527 | 9035 | 11564 |
| 2008 | 149 | 683 | 3 | 1269 | 2106 | 640 | 7084 | 7724 | 9830 |
| 2009 | 343 | 1063 | 73 | 1313 | 2791 | 640 | 7121 | 7761 | 10552 |
| 2010 | 301 | 779 | 11 | 55 | 1147 | 374 | 6947 | 7321 | 8468 |
| 2011 | 261 | 820 | 7 | 57 | 1198 | 408 | 5769 | 6176 | 7374 |
| 2012 | 68 | 947 | 29 | 30 | 1074 | 774 | 5397 | 6170 | 7245 |
| 2013 | 68 | 2970 | 18 | 68 | 3123 | 2183 | 4922 | 7104 | 10228 |
| 2014 | 274 | 2034 | 4 | 506 | 2818 | 4000 | 5121 | 9120 | 11938 |
| 2015 | 136 | 2290 | 0 | 372 | 2799 | 595 | 4548 | 5143 | 7942 |
| 2016 | 69 | 1964 | 1 | 770 | 2804 | 89 | 3630 | 3719 | 6523 |
| 2017 | 62 | 570 | 0 | 1287 | 1918 | 4 | 2845 | 2849 | 4767 |
| 2018 | 59 | 1323 | 1 | 320 | 1703 | 4 | 2845 | 2849 | 4552 |
| 2019 | 34 | 1124 | 2 | 140 | 1300 | 4 | 2845 | 2849 | 4149 |
| 2020 | 45 | 361 | 4 | 938 | 1348 | 4 | 2845 | 2849 | 4197 |

**Table 42**. Catches of great hammerheads in weight (lb dw). Total commercial catch is the maximum of the sum of commercial catches by gear and total commercial catches not disaggregated by gear; total recreational catch is the sum of total recreational AB1 catch and LPRM; total catch is the sum of total recreational and total commercial catch. See text for additional definitions of terms.

| Year | Total Bottom longline catch | Total Gillnet catch | Total hook and line + hand line catch | Pelagic longline dead discards | Total commercial catch | Total AB1 recreational catch | Total recreational LPRM | Total recreational catch | Total catch |
|---|---|---|---|---|---|---|---|---|---|
| 1981 | 0 | 0 | 0 | 0 | 0 | 1805080 | 1188771 | 2993851 | 2993851 |
| 1982 | 22580 | 14157 | 11 | 651 | 37399 | 1805080 | 1188771 | 2993851 | 3031250 |
| 1983 | 45160 | 28314 | 22 | 1317 | 74814 | 2353810 | 1304552 | 3658362 | 3733176 |
| 1984 | 67740 | 42471 | 34 | 1967 | 112213 | 3183814 | 1311445 | 4495258 | 4607471 |
| 1985 | 90321 | 56628 | 45 | 2618 | 149612 | 2908133 | 1037763 | 3945896 | 4095508 |
| 1986 | 112901 | 70786 | 56 | 3268 | 187011 | 2271091 | 819635 | 3090726 | 3277737 |
| 1987 | 135481 | 84943 | 67 | 4981 | 225471 | 1338955 | 509558 | 1848514 | 2073985 |
| 1988 | 158061 | 99100 | 78 | 16212 | 273452 | 844899 | 388267 | 1233167 | 1506618 |
| 1989 | 180641 | 113257 | 90 | 7527 | 301515 | 812657 | 303680 | 1116336 | 1417851 |
| 1990 | 203221 | 127414 | 101 | 9627 | 340363 | 1048784 | 276710 | 1325494 | 1665857 |
| 1991 | 61870 | 196477 | 18 | 6563 | 264927 | 1463934 | 248883 | 1712818 | 1977745 |
| 1992 | 264261 | 138762 | 117 | 21665 | 424804 | 987133 | 231498 | 1218631 | 1643435 |
| 1993 | 356276 | 89475 | 204 | 7157 | 453111 | 528352 | 256239 | 784591 | 1237702 |
| 1994 | 587130 | 81260 | 5509 | 5686 | 679585 | 356835 | 468713 | 825548 | 1505133 |
| 1995 | 258843 | 76231 | 1328 | 546 | 336947 | 337131 | 807241 | 1144372 | 1481319 |
| 1996 | 167915 | 88904 | 1374 | 916 | 259110 | 343424 | 1423679 | 1767103 | 2026212 |
| 1997 | 69717 | 77641 | 30 | 2844 | 150231 | 126380 | 604849 | 731229 | 881460 |
| 1998 | 51265 | 6534 | 162 | 2793 | 60753 | 70612 | 287768 | 358380 | 419133 |
| 1999 | 54675 | 131366 | 1240 | 2383 | 191344 | 54553 | 92722 | 147275 | 338619 |
| 2000 | 45394 | 166852 | 50 | 2732 | 231201 | 92000 | 74440 | 166440 | 397641 |
| 2001 | 46811 | 21478 | 151 | 3285 | 101137 | 95213 | 35302 | 130515 | 231653 |
| 2002 | 50113 | 47304 | 352 | 2607 | 137360 | 18356 | 27932 | 46287 | 183647 |
| 2003 | 111826 | 217562 | 93 | 2607 | 332088 | 4467 | 18973 | 23440 | 355527 |
| 2004 | 90940 | 555945 | 166 | 2607 | 649658 | 1475 | 22487 | 23962 | 673619 |
| 2005 | 33432 | 18622 | 116 | 2607 | 105650 | 4330 | 18655 | 22985 | 128635 |
| 2006 | 51387 | 82006 | 28 | 2607 | 163848 | 10089 | 17552 | 27642 | 191489 |
| 2007 | 13105 | 15248 | 12 | 5708 | 41031 | 20751 | 20335 | 41086 | 82117 |
| 2008 | 30756 | 29847 | 101 | 44 | 60749 | 9787 | 30417 | 40203 | 100952 |
| 2009 | 79516 | 30854 | 1752 | 118 | 112239 | 5741 | 44041 | 49782 | 162022 |
| 2010 | 53510 | 29465 | 252 | 141 | 83368 | 3001 | 37014 | 40015 | 123383 |
| 2011 | 56229 | 17707 | 179 | 241 | 74356 | 3342 | 27663 | 31005 | 105362 |
| 2012 | 8954 | 81235 | 1179 | 112 | 91480 | 2067 | 22230 | 24297 | 115777 |
| 2013 | 52403 | 58553 | 512 | 191 | 116661 | 1387 | 21111 | 22499 | 139159 |
| 2014 | 22930 | 14279 | 2094 | 5422 | 55782 | 898 | 31575 | 32473 | 88255 |
| 2015 | 37554 | 47992 | 13941 | 4554 | 105630 | 840 | 47013 | 47853 | 153483 |
| 2016 | 20987 | 39573 | 15198 | 2218 | 77976 | 272 | 69717 | 69989 | 147965 |
| 2017 | 29105 | 17743 | 966 | 1449 | 49938 | 72 | 53188 | 53260 | 103198 |
| 2018 | 60761 | 127112 | 1612 | 688 | 190174 | 72 | 53188 | 53260 | 243434 |
| 2019 | 42343 | 52325 | 1224 | 0 | 96042 | 72 | 53188 | 53260 | 149302 |
| 2020 | 9995 | 27773 | 409 | 0 | 38282 | 72 | 53188 | 53260 | 91542 |

**Table 43**. Catches of great hammerheads in numbers. Total commercial catch is the maximum of the sum of commercial catches by gear and total commercial catches not disaggregated by gear; total recreational catch is the sum of total recreational AB1 catch and LPRM; total catch is the sum of total recreational and total commercial catch. See text for additional definitions of terms.

| Year | Total Bottom longline catch | Total Gillnet catch | Total hook and line + hand line catch | Pelagic longline dead discards | Total commercial catch | Total AB1 recreational catch | Total recreational LPRM | Total recreational catch | Total catch |
|---|---|---|---|---|---|---|---|---|---|
| 1981 | 0 | 0 | 0 | 0 | 0 | 30549 | 39786 | 70335 | 70335 |
| 1982 | 133 | 136 | 0 | 5 | 274 | 30549 | 39786 | 70335 | 70609 |
| 1983 | 267 | 271 | 0 | 10 | 548 | 38694 | 41373 | 80067 | 80615 |
| 1984 | 400 | 407 | 0 | 15 | 822 | 51047 | 32318 | 83365 | 84187 |
| 1985 | 534 | 543 | 0 | 20 | 1096 | 47728 | 19483 | 67211 | 68307 |
| 1986 | 667 | 678 | 0 | 25 | 1370 | 38331 | 12598 | 50929 | 52300 |
| 1987 | 801 | 814 | 0 | 38 | 1652 | 22539 | 7978 | 30517 | 32169 |
| 1988 | 934 | 999 | 0 | 122 | 2055 | 14205 | 6536 | 20740 | 22796 |
| 1989 | 1067 | 1085 | 1 | 57 | 2210 | 14079 | 4412 | 18491 | 20701 |
| 1990 | 1201 | 1221 | 1 | 73 | 2495 | 19278 | 4844 | 24121 | 26616 |
| 1991 | 366 | 1882 | 0 | 49 | 2298 | 28009 | 5285 | 33294 | 35591 |
| 1992 | 1562 | 1330 | 1 | 254 | 3145 | 18896 | 7211 | 26107 | 29252 |
| 1993 | 2105 | 857 | 1 | 41 | 3005 | 9996 | 8054 | 18050 | 21055 |
| 1994 | 3110 | 779 | 29 | 24 | 3942 | 6592 | 9652 | 16243 | 20185 |
| 1995 | 2164 | 730 | 11 | 3 | 2908 | 6097 | 10140 | 16237 | 19145 |
| 1996 | 1422 | 852 | 12 | 11 | 2297 | 6086 | 10473 | 16559 | 18857 |
| 1997 | 515 | 744 | 0 | 24 | 1283 | 2299 | 5563 | 7862 | 9145 |
| 1998 | 378 | 63 | 1 | 16 | 457 | 1273 | 3204 | 4476 | 4934 |
| 1999 | 361 | 1259 | 8 | 17 | 1644 | 998 | 2186 | 3184 | 4829 |
| 2000 | 200 | 1599 | 0 | 21 | 1820 | 1650 | 2598 | 4247 | 6067 |
| 2001 | 242 | 206 | 1 | 31 | 479 | 1765 | 2950 | 4715 | 5194 |
| 2002 | 345 | 686 | 2 | 20 | 1053 | 377 | 1534 | 1910 | 2964 |
| 2003 | 769 | 1521 | 1 | 38 | 2328 | 97 | 705 | 803 | 3131 |
| 2004 | 642 | 5327 | 1 | 30 | 6000 | 33 | 408 | 442 | 6442 |
| 2005 | 132 | 178 | 0 | 24 | 335 | 87 | 389 | 477 | 812 |
| 2006 | 301 | 786 | 0 | 17 | 1104 | 188 | 419 | 606 | 1710 |
| 2007 | 94 | 146 | 0 | 18 | 258 | 358 | 449 | 808 | 1066 |
| 2008 | 191 | 286 | 1 | 0 | 478 | 182 | 585 | 767 | 1245 |
| 2009 | 476 | 296 | 10 | 1 | 783 | 111 | 741 | 852 | 1635 |
| 2010 | 302 | 282 | 1 | 1 | 587 | 58 | 622 | 679 | 1266 |
| 2011 | 326 | 170 | 1 | 3 | 500 | 60 | 464 | 524 | 1024 |
| 2012 | 53 | 778 | 7 | 1 | 839 | 36 | 373 | 410 | 1249 |
| 2013 | 271 | 561 | 3 | 2 | 837 | 26 | 354 | 381 | 1218 |
| 2014 | 176 | 132 | 10 | 65 | 383 | 19 | 530 | 549 | 932 |
| 2015 | 237 | 449 | 77 | 39 | 802 | 19 | 789 | 808 | 1610 |
| 2016 | 108 | 368 | 79 | 16 | 571 | 7 | 1171 | 1178 | 1749 |
| 2017 | 194 | 170 | 6 | 16 | 387 | 2 | 893 | 895 | 1282 |
| 2018 | 385 | 1214 | 10 | 5 | 1614 | 2 | 893 | 895 | 2509 |
| 2019 | 256 | 501 | 7 | 0 | 764 | 2 | 893 | 895 | 1659 |
| 2020 | 49 | 274 | 2 | 0 | 325 | 2 | 893 | 895 | 1220 |

**Table 44**. Catches of smooth hammerheads in weight (lb dw). Total commercial catch is the maximum of the sum of commercial catches by gear and total commercial catches not disaggregated by gear; total recreational catch is the sum of total recreational AB1 catch and LPRM; total catch is the sum of total recreational and total commercial catch. See text for additional definitions of terms.

| Year | Total Bottom longline catch | Total Gillnet catch | Total unknown gear | Pelagic longline dead discards | Total commercial catch | Total AB1 recreational catch | Total recreational LPRM | Total recreational catch | Total catch |
|---|---|---|---|---|---|---|---|---|---|
| 1981 | 0 | 3651 | 0 | 0 | 3651 | 18232 | 28852 | 47084 | 50735 |
| 1982 | 102 | 406 | 0 | 220 | 5360 | 18232 | 28852 | 47084 | 52443 |
| 1983 | 204 | 0 | 0 | 446 | 10719 | 11145 | 52243 | 63387 | 74107 |
| 1984 | 307 | 1217 | 0 | 666 | 16079 | 15779 | 138388 | 154167 | 170246 |
| 1985 | 409 | 1623 | 0 | 886 | 21439 | 24491 | 226635 | 251127 | 272565 |
| 1986 | 511 | 2028 | 0 | 1107 | 26799 | 70365 | 386063 | 456429 | 483227 |
| 1987 | 613 | 2434 | 0 | 1800 | 32158 | 83958 | 372880 | 456838 | 488997 |
| 1988 | 715 | 2840 | 0 | 5858 | 37518 | 87102 | 191568 | 278670 | 316188 |
| 1989 | 818 | 3245 | 0 | 2720 | 42878 | 83726 | 142396 | 226121 | 268999 |
| 1990 | 920 | 3651 | 0 | 3479 | 48238 | 89834 | 131028 | 220861 | 269099 |
| 1991 | 204 | 7326 | 0 | 2371 | 33827 | 150086 | 204139 | 354225 | 388052 |
| 1992 | 1214 | 3889 | 0 | 4329 | 61201 | 243597 | 119783 | 363379 | 424580 |
| 1993 | 1649 | 954 | 0 | 668 | 65763 | 360474 | 60555 | 421029 | 486792 |
| 1994 | 2658 | 465 | 2 | 220 | 107102 | 255864 | 27648 | 283512 | 390614 |
| 1995 | 1139 | 165 | 0 | 742 | 45160 | 170017 | 33746 | 203762 | 248922 |
| 1996 | 582 | 920 | 0 | 331 | 26667 | 120077 | 48187 | 168265 | 194932 |
| 1997 | 219 | 249 | 0 | 1028 | 10492 | 110034 | 75232 | 185266 | 195758 |
| 1998 | 113 | 389 | 0 | 1009 | 8388 | 85937 | 50033 | 135970 | 144358 |
| 1999 | 122 | 69 | 0 | 861 | 8215 | 52694 | 23790 | 76483 | 84699 |
| 2000 | 18 | 4 | 0 | 987 | 6036 | 34985 | 6157 | 41141 | 47178 |
| 2001 | 53 | 5 | 0 | 1187 | 11864 | 28578 | 3774 | 32352 | 44216 |
| 2002 | 77 | 148 | 0 | 942 | 15128 | 3439 | 3335 | 6774 | 21901 |
| 2003 | 386 | 116 | 0 | 942 | 17911 | 287 | 5531 | 5818 | 23729 |
| 2004 | 327 | 139 | 0 | 942 | 15251 | 30 | 5954 | 5984 | 21235 |
| 2005 | 166 | 7 | 0 | 942 | 23022 | 26 | 10693 | 10719 | 33741 |
| 2006 | 237 | 128 | 0 | 942 | 20587 | 33 | 18790 | 18823 | 39410 |
| 2007 | 65 | 2 | 0 | 2063 | 8775 | 10 | 32852 | 32863 | 41637 |
| 2008 | 507 | 317 | 0 | 63 | 7463 | 3 | 21964 | 21967 | 29430 |
| 2009 | 384 | 565 | 2540 | 43 | 20311 | 1 | 14322 | 14323 | 34634 |
| 2010 | 207 | 424 | 5607 | 51 | 14844 | 1 | 9551 | 9552 | 24396 |
| 2011 | 242 | 179 | 65 | 87 | 9949 | 28 | 6116 | 6144 | 16093 |
| 2012 | 41 | 4141 | 70 | 40 | 7244 | 801 | 4357 | 5158 | 12402 |
| 2013 | 0 | 179 | 0 | 69 | 329 | 22690 | 4430 | 27120 | 27449 |
| 2014 | 312 | 257 | 32 | 58 | 659 | 801 | 7304 | 8106 | 8765 |
| 2015 | 264 | 40 | 0 | 562 | 866 | 28 | 11334 | 11363 | 12229 |
| 2016 | 0 | 125 | 0 | 1385 | 1510 | 1 | 8707 | 8708 | 10219 |
| 2017 | 0 | 1127 | 0 | 6446 | 7639 | 1 | 6719 | 6720 | 14359 |
| 2018 | 0 | 530 | 0 | 286 | 816 | 1 | 6719 | 6720 | 7536 |
| 2019 | 0 | 13 | 0 | 1306 | 1346 | 1 | 6719 | 6720 | 8066 |
| 2020 | 0 | 0 | 0 | 361 | 361 | 1 | 6719 | 6720 | 7081 |

**Table 45**. Catches of smooth hammerheads in numbers. Total commercial catch is the maximum of the sum of commercial catches by gear and total commercial catches not disaggregated by gear; total recreational catch is the sum of total recreational AB1 catch and LPRM; total catch is the sum of total recreational and total commercial catch. See text for additional definitions of terms.

| Year | Total Bottom longline catch | Total Gillnet catch | Total unknown gear | Pelagic longline dead discards | Total commercial catch | Total AB1 recreational catch | Total recreational LPRM | Total recreational catch | Total catch |
|---|---|---|---|---|---|---|---|---|---|
| 1981 | 0 | 309 | 0 | 0 | 309 | 4095 | 872 | 4966 | 5276 |
| 1982 | 1 | 34 | 0 | 3 | 118 | 4095 | 872 | 4966 | 5085 |
| 1983 | 3 | 0 | 0 | 6 | 237 | 1198 | 1312 | 2511 | 2748 |
| 1984 | 4 | 103 | 0 | 9 | 355 | 810 | 2446 | 3256 | 3611 |
| 1985 | 5 | 138 | 0 | 12 | 473 | 624 | 3616 | 4240 | 4713 |
| 1986 | 7 | 172 | 0 | 14 | 592 | 2135 | 5820 | 7956 | 8547 |
| 1987 | 8 | 206 | 0 | 24 | 710 | 3071 | 6992 | 10064 | 10774 |
| 1988 | 9 | 241 | 0 | 77 | 828 | 3696 | 4020 | 7716 | 8544 |
| 1989 | 11 | 275 | 0 | 36 | 947 | 3943 | 2900 | 6844 | 7790 |
| 1990 | 12 | 309 | 0 | 46 | 1065 | 4414 | 2501 | 6916 | 7981 |
| 1991 | 3 | 621 | 0 | 31 | 739 | 6412 | 4698 | 11110 | 11849 |
| 1992 | 16 | 330 | 0 | 56 | 1336 | 7248 | 6468 | 13716 | 15053 |
| 1993 | 21 | 81 | 0 | 9 | 1474 | 7877 | 8661 | 16538 | 18013 |
| 1994 | 37 | 39 | 0 | 3 | 2584 | 4927 | 7000 | 11927 | 14511 |
| 1995 | 11 | 14 | 0 | 10 | 770 | 3273 | 5290 | 8563 | 9333 |
| 1996 | 8 | 78 | 0 | 1 | 594 | 2310 | 2032 | 4341 | 4935 |
| 1997 | 18 | 21 | 0 | 13 | 795 | 2114 | 1031 | 3144 | 3940 |
| 1998 | 1 | 33 | 0 | 26 | 192 | 1651 | 431 | 2082 | 2273 |
| 1999 | 2 | 6 | 0 | 11 | 177 | 1013 | 295 | 1308 | 1484 |
| 2000 | 1 | 0 | 0 | 13 | 327 | 675 | 112 | 788 | 1114 |
| 2001 | 1 | 0 | 0 | 16 | 256 | 554 | 84 | 638 | 894 |
| 2002 | 35 | 13 | 0 | 10 | 2031 | 135 | 73 | 208 | 2239 |
| 2003 | 5 | 10 | 0 | 14 | 396 | 26 | 113 | 139 | 535 |
| 2004 | 4 | 12 | 0 | 10 | 332 | 5 | 120 | 125 | 457 |
| 2005 | 2 | 1 | 0 | 22 | 498 | 5 | 215 | 220 | 718 |
| 2006 | 3 | 11 | 0 | 15 | 457 | 4 | 378 | 382 | 839 |
| 2007 | 1 | 0 | 0 | 44 | 195 | 3 | 660 | 663 | 858 |
| 2008 | 2 | 27 | 0 | 1 | 68 | 2 | 441 | 443 | 511 |
| 2009 | 5 | 34 | 33 | 0 | 433 | 1 | 288 | 289 | 722 |
| 2010 | 1 | 62 | 33 | 1 | 166 | 1 | 192 | 193 | 359 |
| 2011 | 3 | 15 | 1 | 3 | 225 | 8 | 175 | 184 | 408 |
| 2012 | 1 | 351 | 1 | 1 | 353 | 68 | 170 | 238 | 590 |
| 2013 | 0 | 15 | 0 | 3 | 19 | 559 | 198 | 757 | 776 |
| 2014 | 4 | 22 | 0 | 1 | 27 | 55 | 228 | 283 | 310 |
| 2015 | 3 | 3 | 0 | 7 | 14 | 5 | 261 | 266 | 281 |
| 2016 | 0 | 11 | 0 | 41 | 51 | 1 | 175 | 175 | 227 |
| 2017 | 0 | 96 | 0 | 148 | 243 | 1 | 135 | 136 | 379 |
| 2018 | 0 | 45 | 0 | 4 | 49 | 1 | 135 | 136 | 184 |
| 2019 | 0 | 1 | 0 | 17 | 18 | 1 | 135 | 136 | 154 |
| 2020 | 0 | 0 | 0 | 5 | 5 | 1 | 135 | 136 | 140 |

## 3.5 Figures

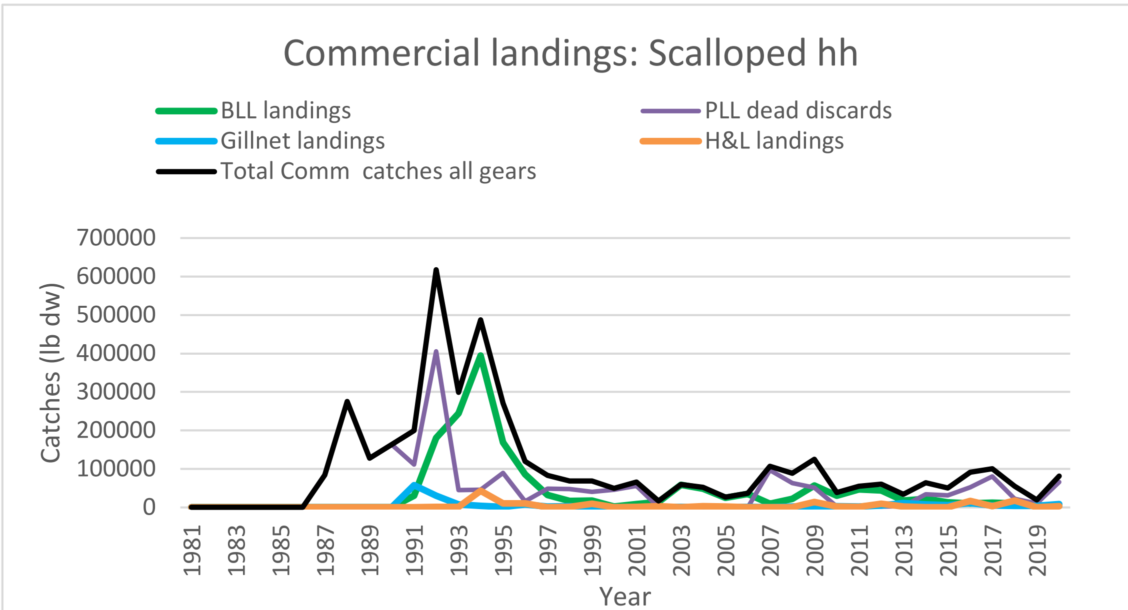



**Figure 1.** Commercial landings (lb dw) of scalloped hammerheads (all regions) by gear, including dead discards from the pelagic longline fishery. BLL=bottom longline; PLL=pelagic longline; H&L=hook and line.

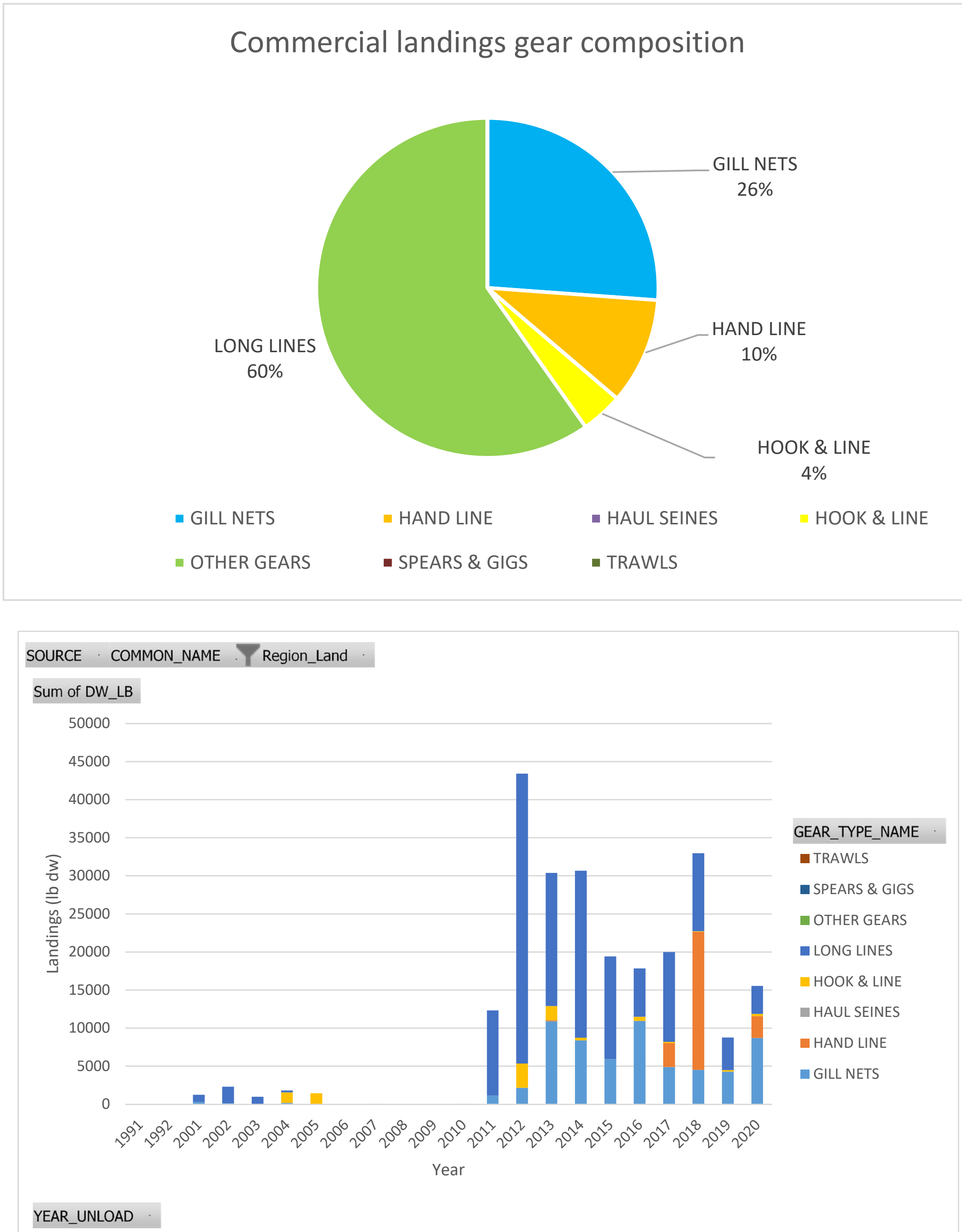



**Figure 2.** Commercial landings (lb dw) of scalloped hammerheads (all regions) by gear type from FINS for 1991-2020. Top panel: relative contribution for the entire time period; bottom panel: annual composition of the main gears by year.

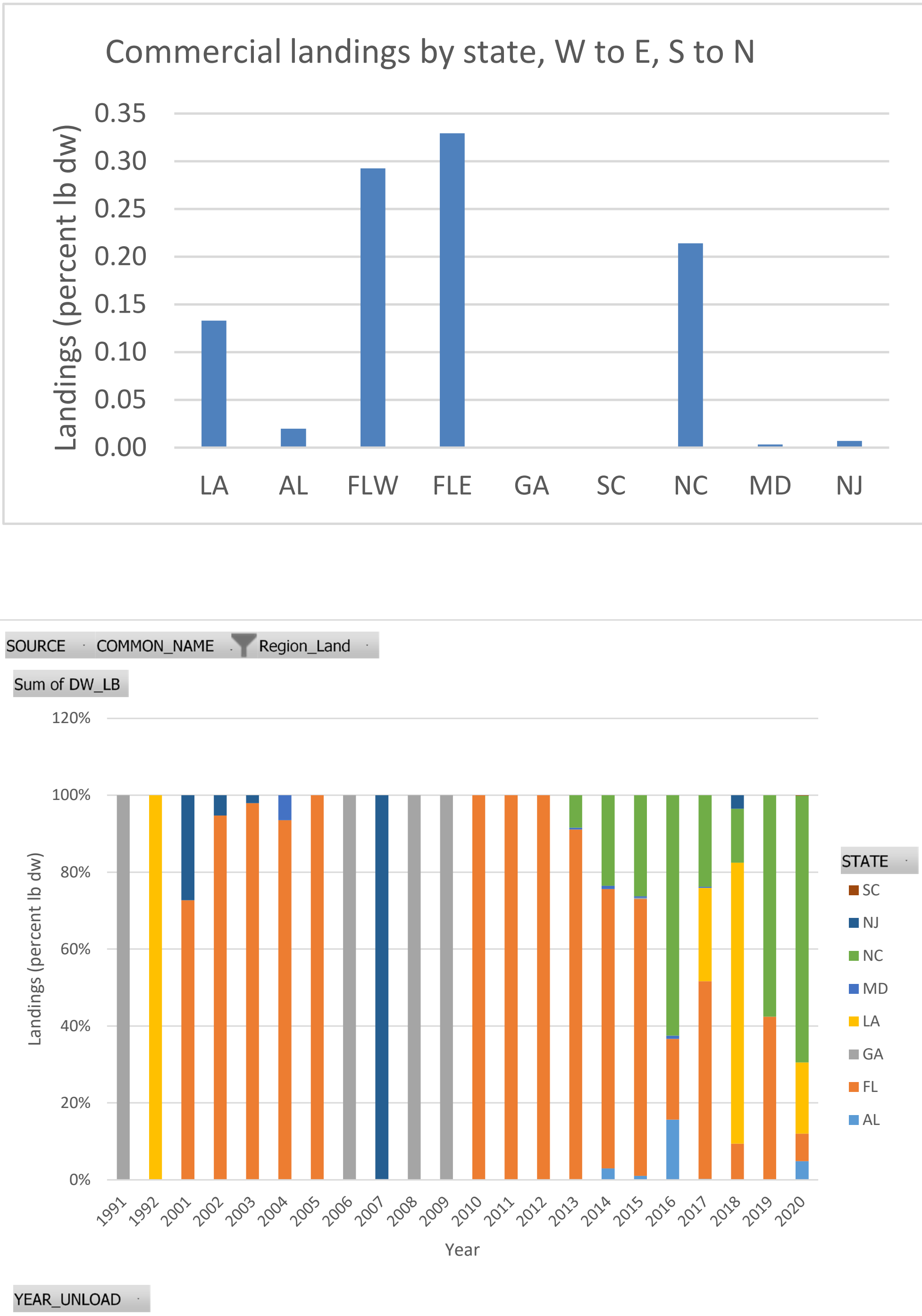



**Figure 3.** Commercial landings (lb dw) of scalloped hammerheads (all regions) by state of landing from FINS for 1991-2020. Top panel: relative contribution for the entire time period; bottom panel: composition of states by year

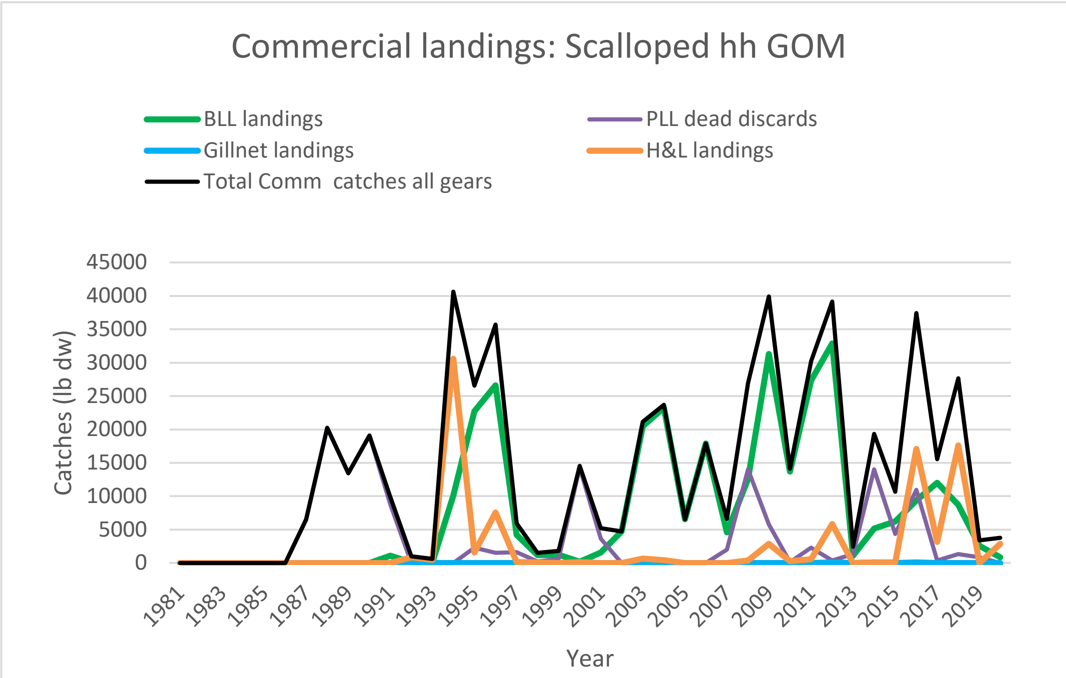



**Figure 4.** Commercial landings (lb dw) of scalloped hammerheads in the GOM by gear, including dead discards from the pelagic longline fishery. BLL=bottom longline; PLL=pelagic longline; H&L=hook and line.

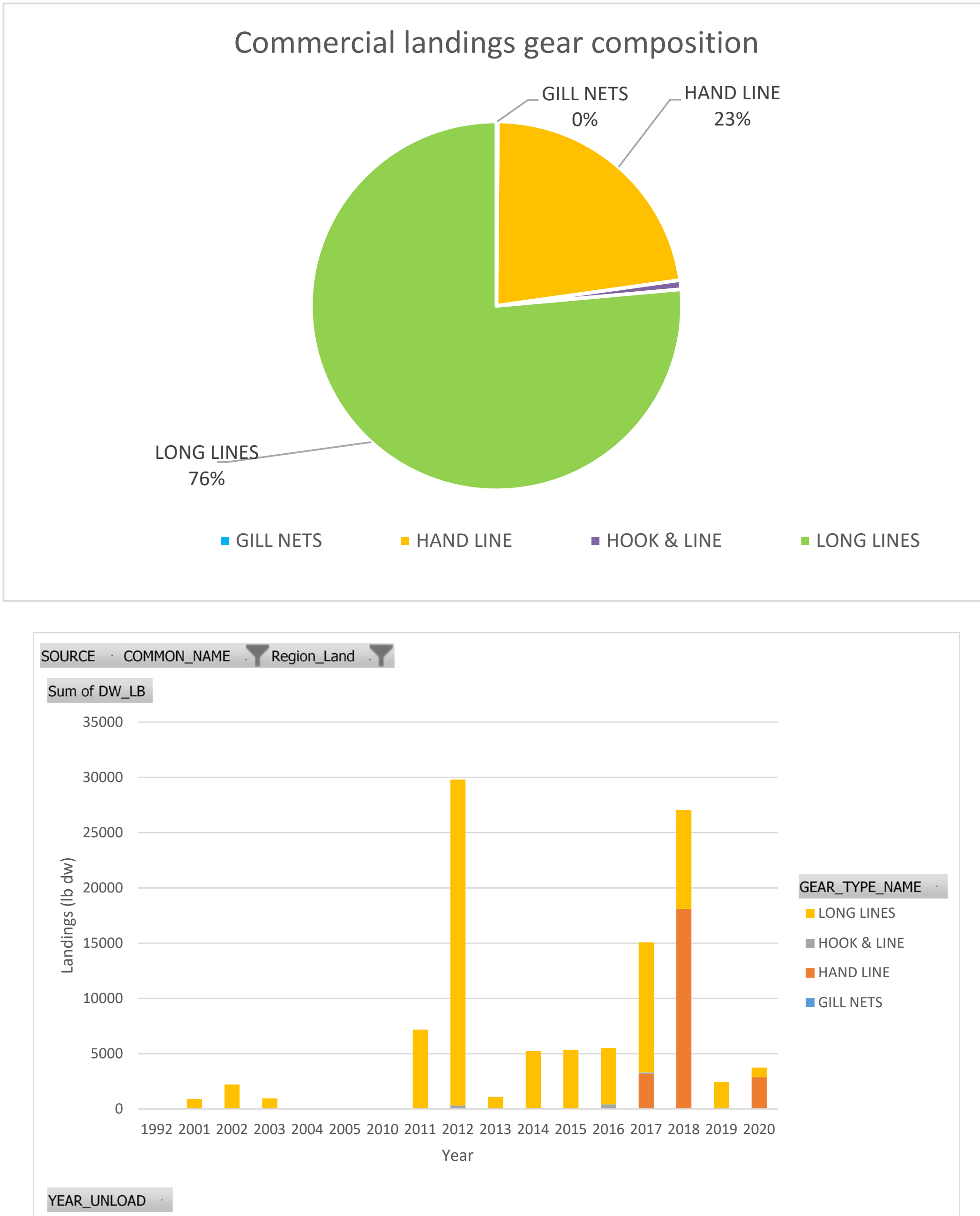



**Figure 4.** Commercial landings (lb dw) of scalloped hammerheads in the GOM by gear type from FINS for 1991-2020. Top panel: relative contribution for the entire time period; bottom panel: annual composition of the main gears by year.

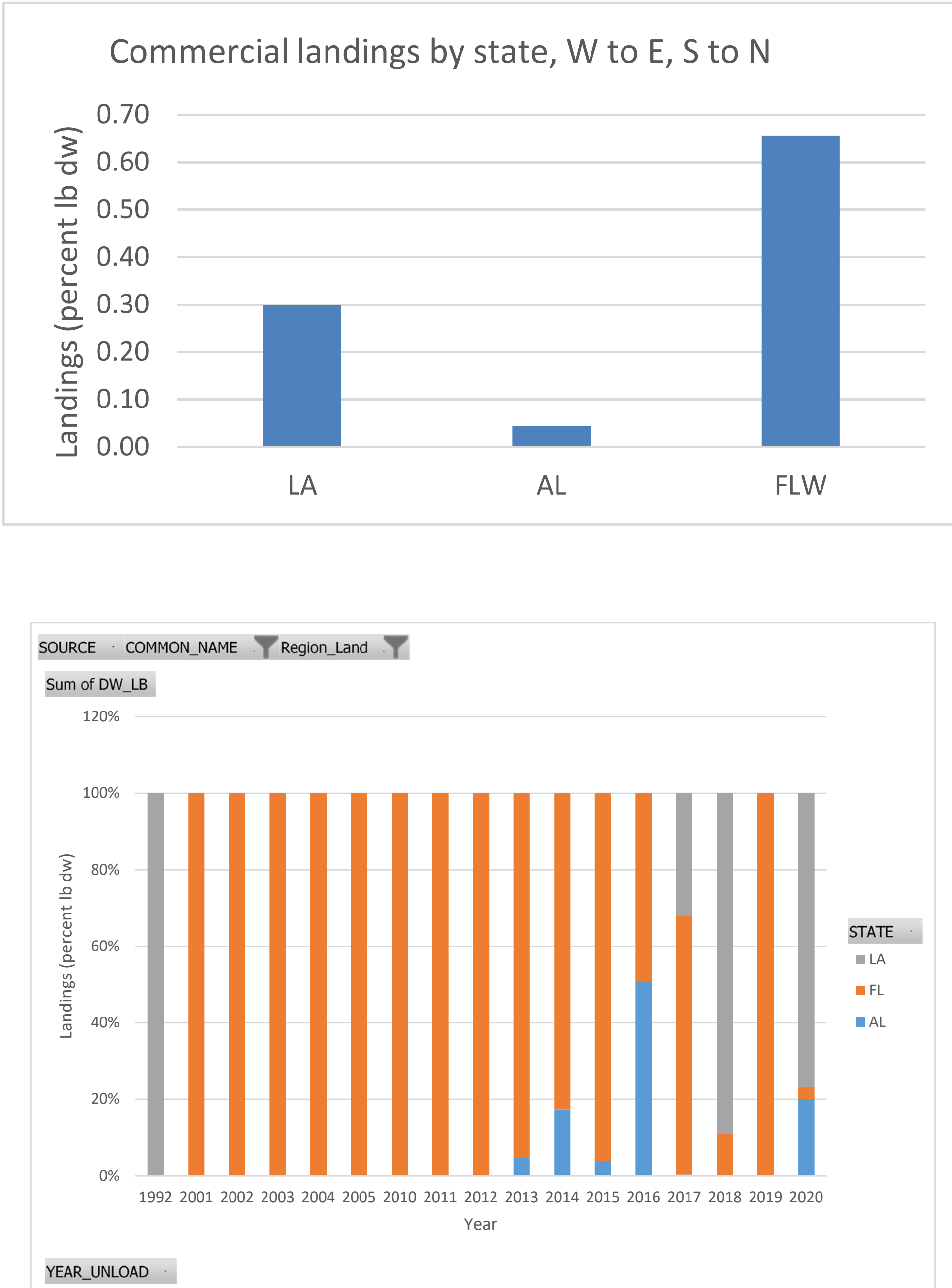



**Figure 6.** Commercial landings (lb dw) of scalloped hammerheads in the GOM by state of landing from FINS for 1991-2020. Top panel: relative contribution for the entire time period; bottom panel: composition of states by year.

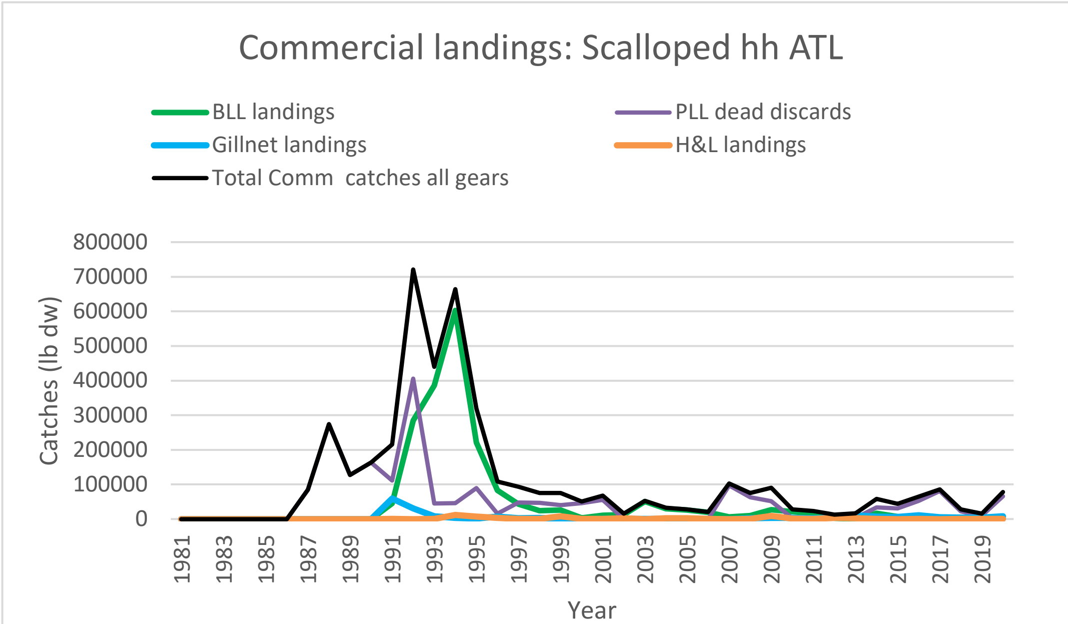
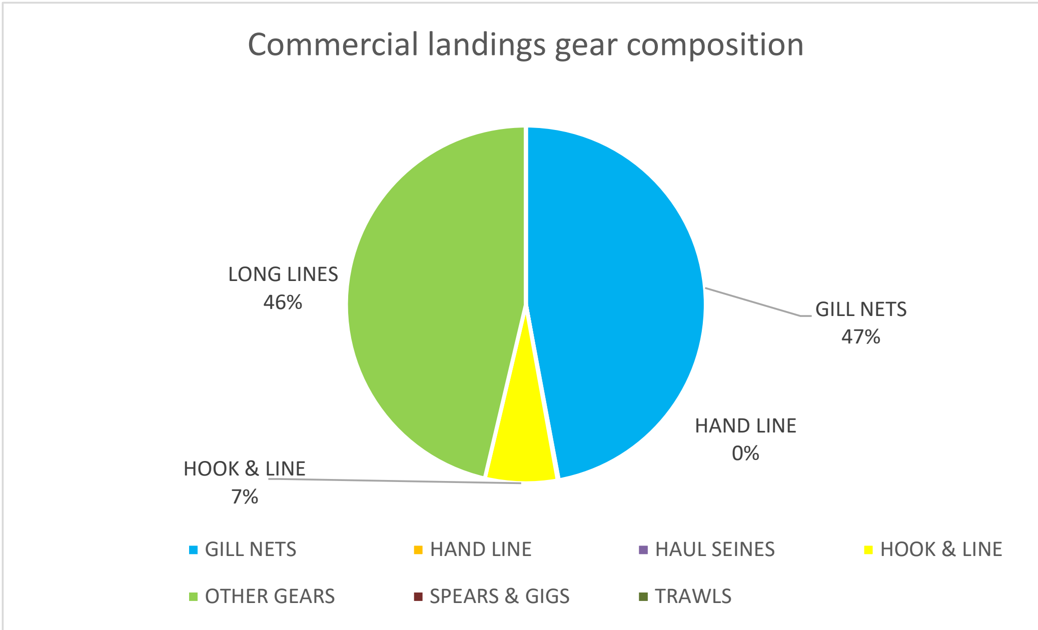



**Figure 7.** Commercial landings (lb dw) of scalloped hammerheads in the ATL by gear, including dead discards from the pelagic longline fishery. BLL=bottom longline; PLL=pelagic longline; H&L=hook and line.



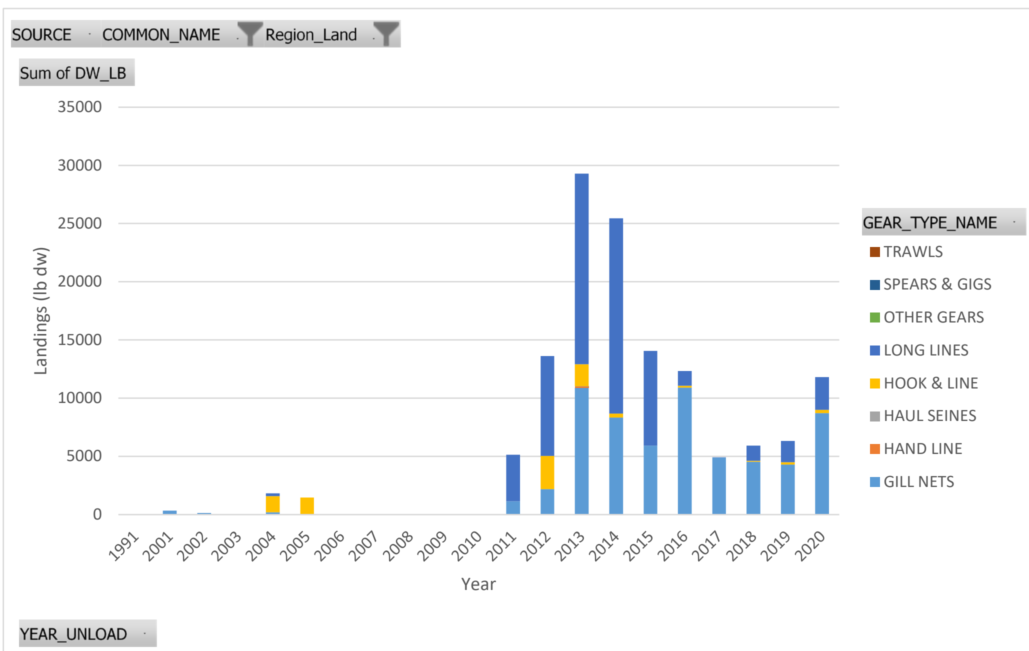
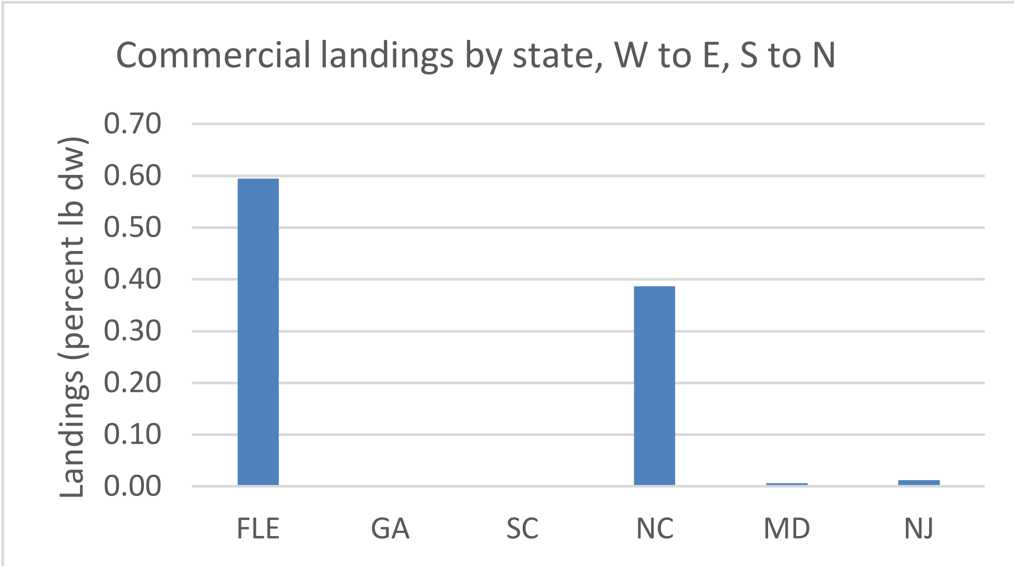




**Figure 8.** Commercial landings (lb dw) of scalloped hammerheads in the ATL by gear type from FINS for 1991-2020. Top panel: relative contribution for the entire time period; bottom panel: annual composition of the main gears by year.



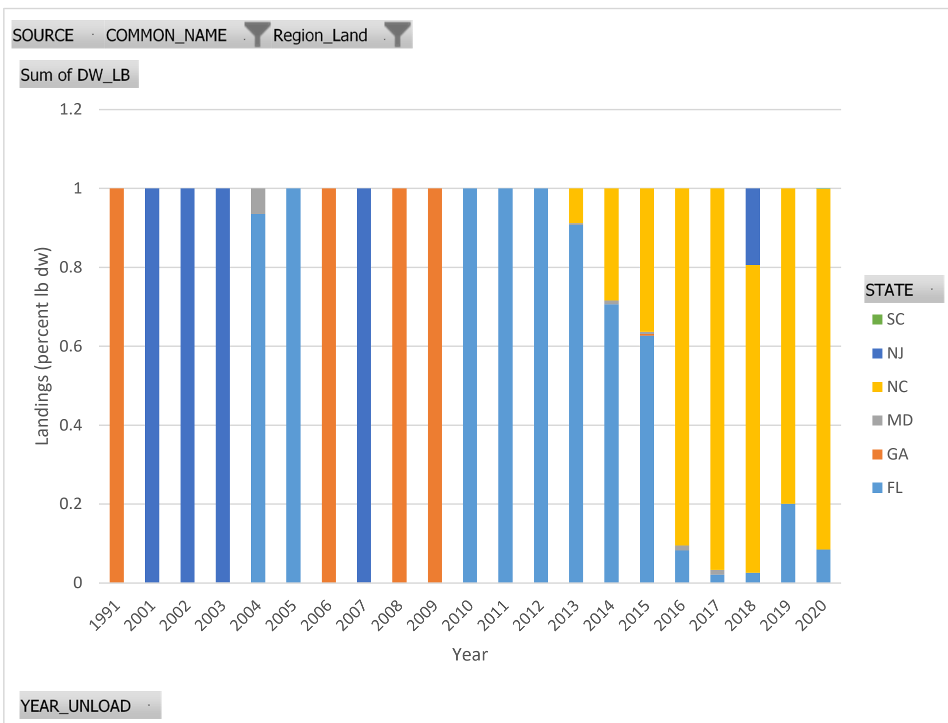




**Figure 9.** Commercial landings (lb dw) of scalloped hammerheads in the ATL by state of landing from FINS for 1991-2020. Top panel: relative contribution for the entire time period; bottom panel: composition of states by year.

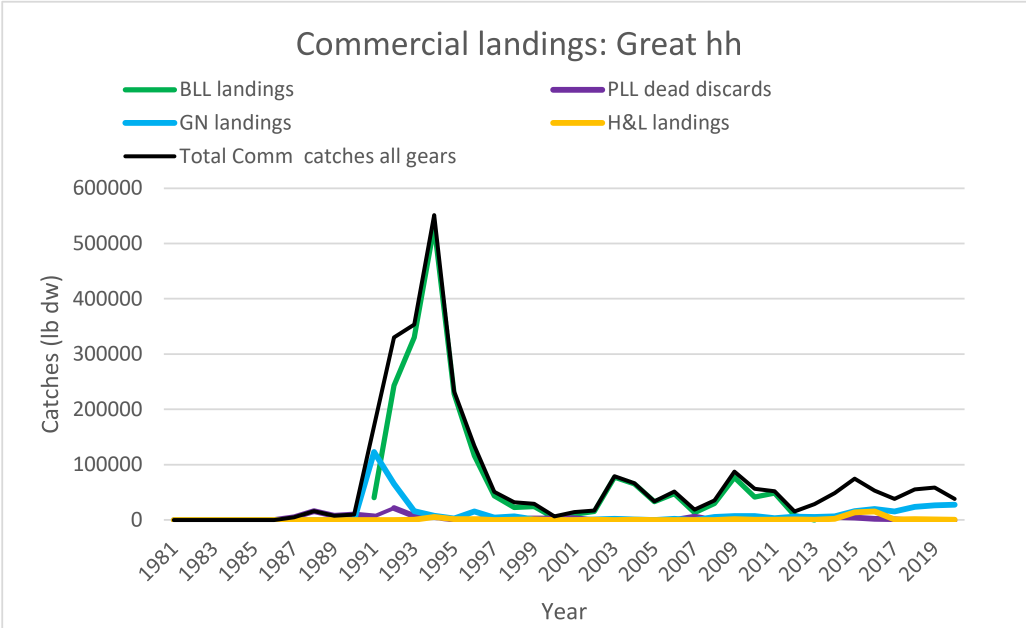



**Figure 10.** Commercial landings (lb dw) of great hammerheads by gear, including dead discards from the pelagic longline fishery. BLL=bottom longline; PLL=pelagic longline; H&L=hook and line.

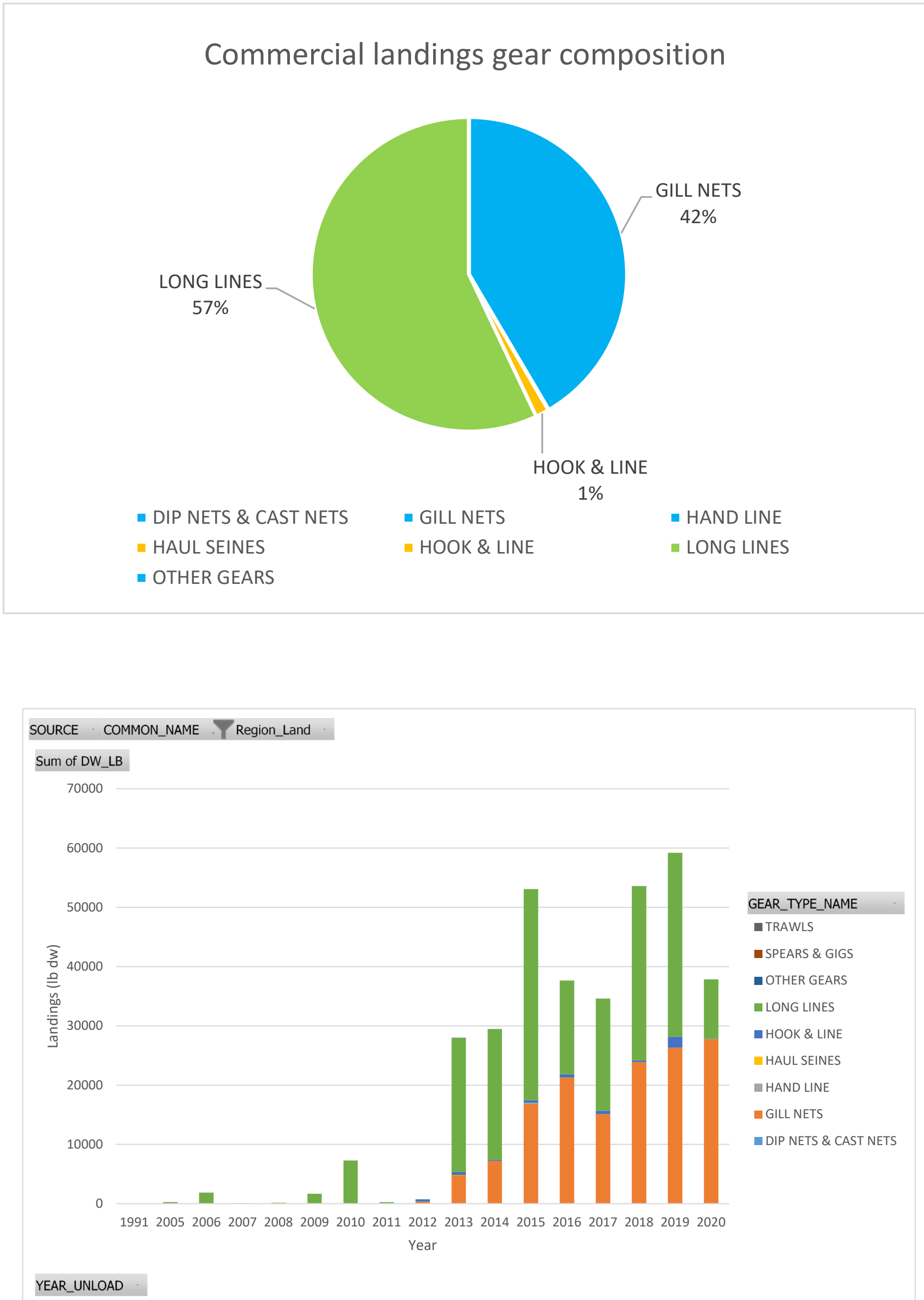
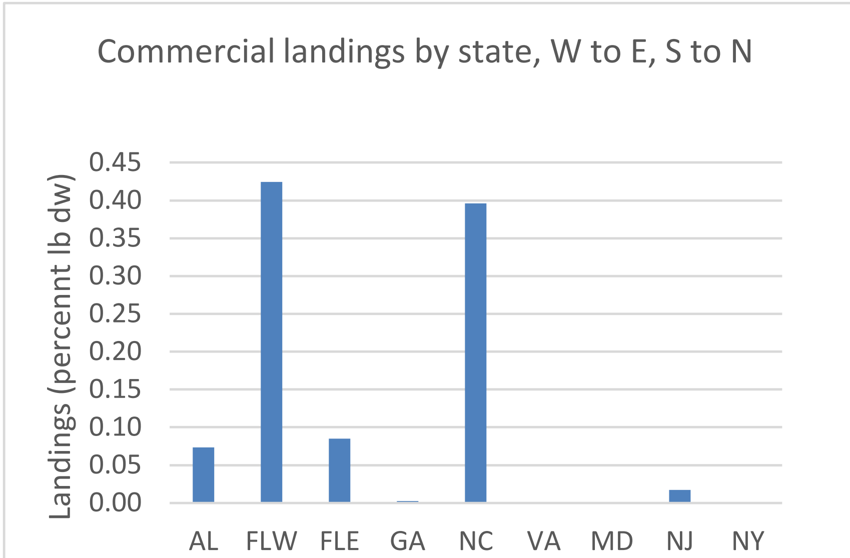



**Figure 11.** Commercial landings (lb dw) of great hammerheads by gear type from FINS for 1991-2020. Top panel: relative contribution for the entire time period; bottom panel: annual composition of the main gears by year.



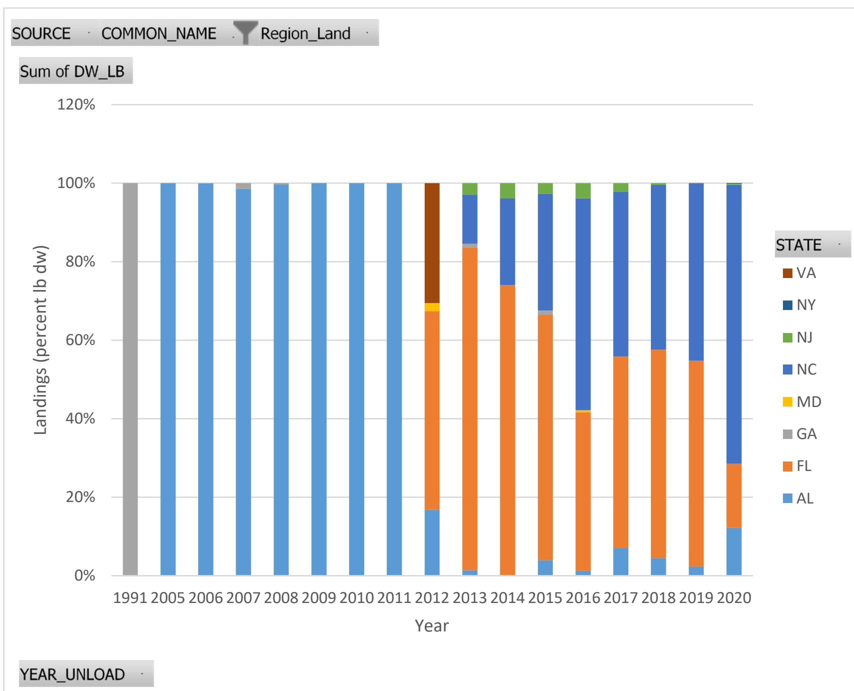




**Figure 12.** Commercial landings (lb dw) of great hammerheads by state of landing from FINS for 1991-2020.Top panel: relative contribution for the entire time period; bottom panel: composition of states by year.

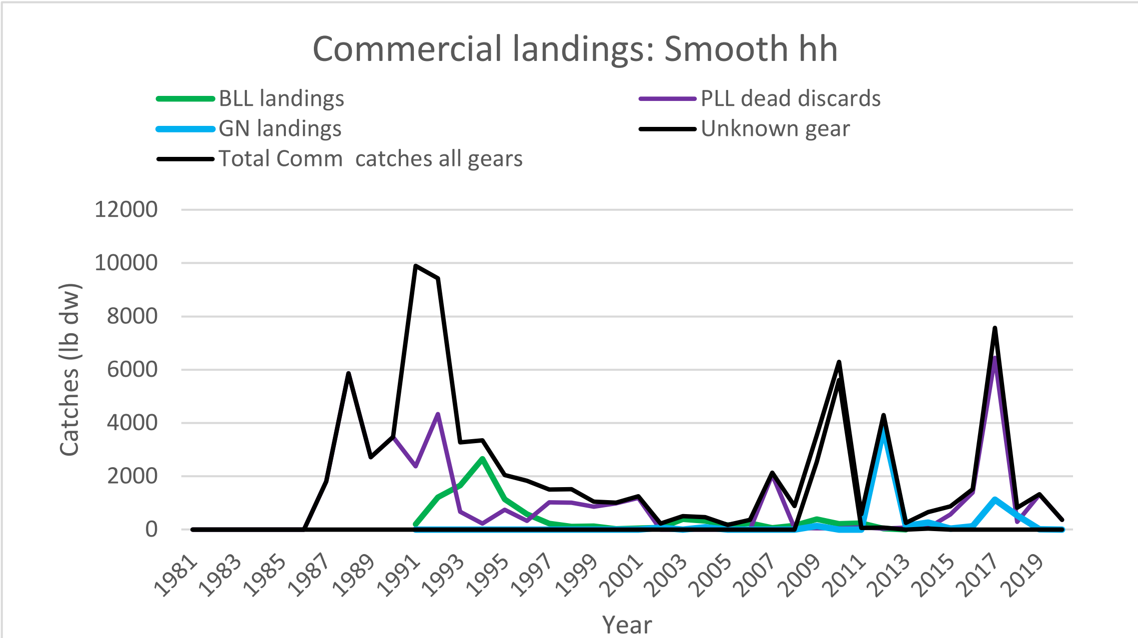
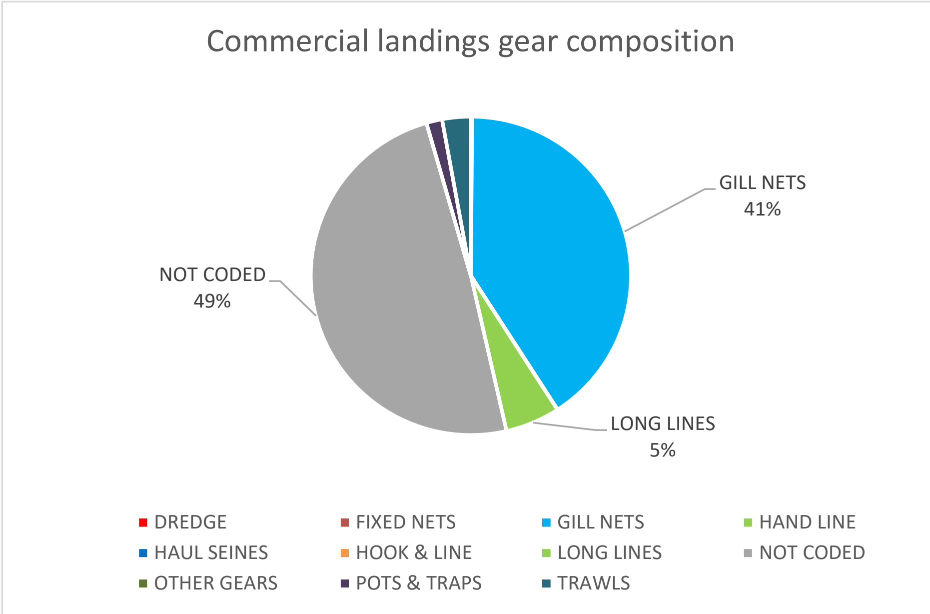



**Figure 13.** Commercial landings (lb dw) of smooth hammerheads by gear, including dead discards from the pelagic longline fishery. BLL=bottom longline; PLL=pelagic longline; H&L=hook and line.



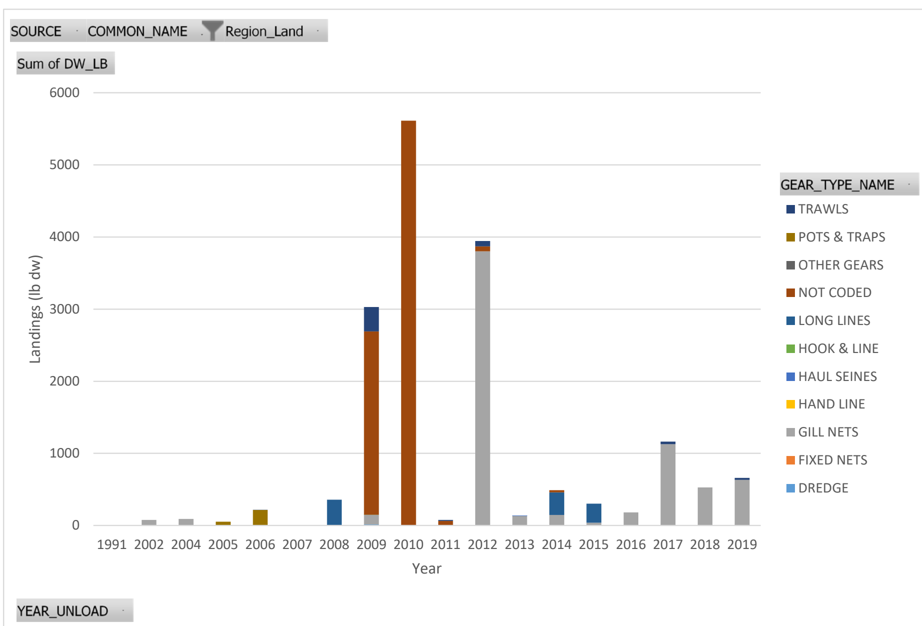




**Figure 14.** Commercial landings (lb dw) of smooth hammerheads by gear type from FINS for 1991-2020. Top panel: relative contribution for the entire time period; bottom panel: annual composition of the main gears by year.

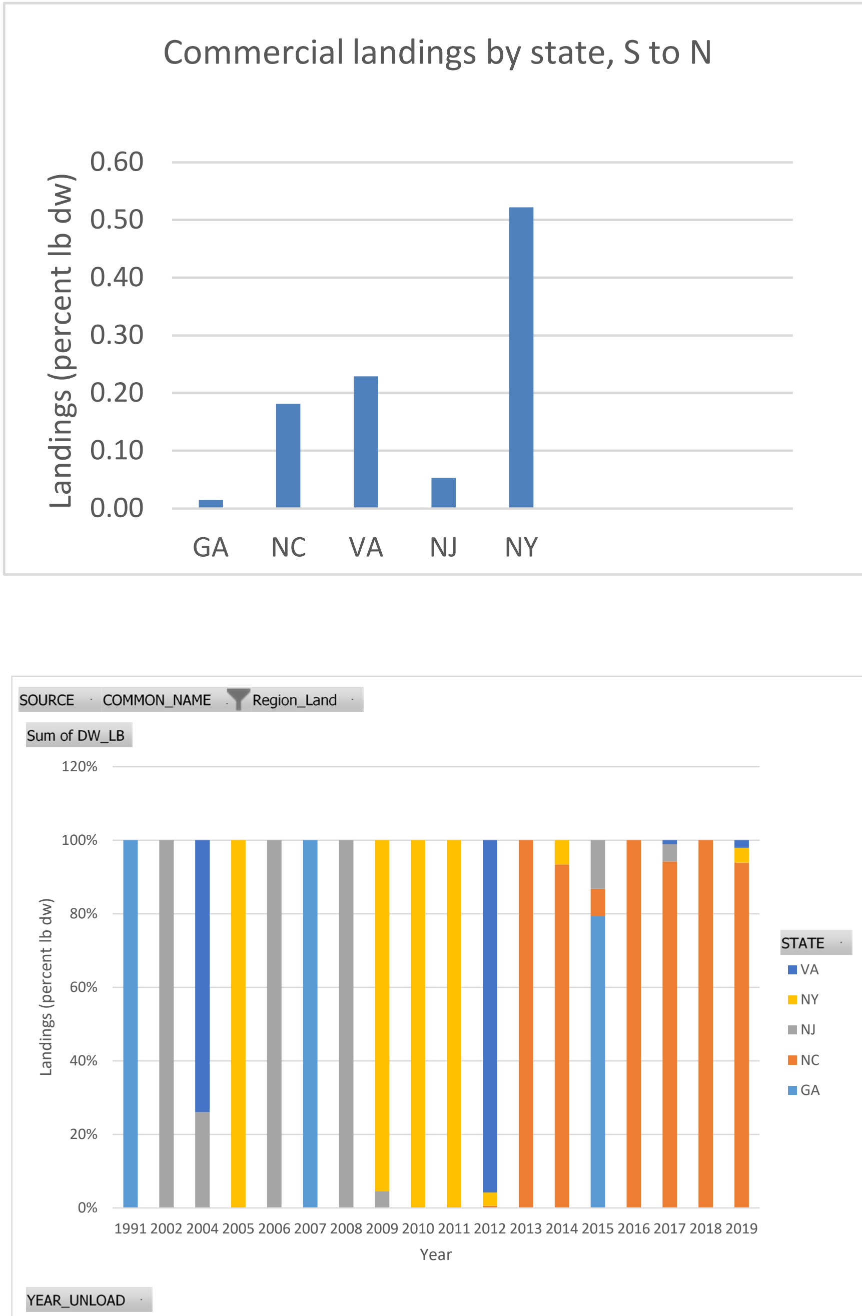
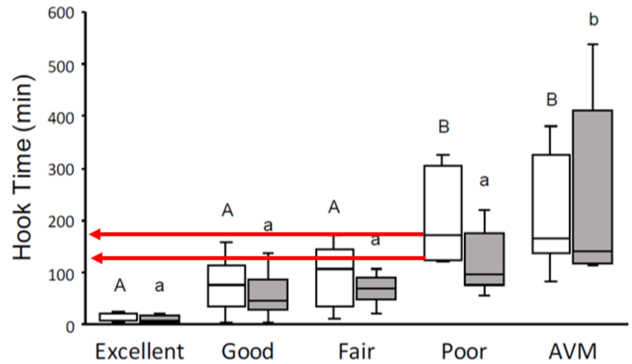



**Figure 15.** Commercial landings (lb dw) of smooth hammerheads by state of landing from FINS for 1991-2020.Top panel: relative contribution for the entire time period; bottom panel: composition of states by year.

A. Scalloped hammerheads in poor condition at release.




B. Great hammerheads in poor condition at release.

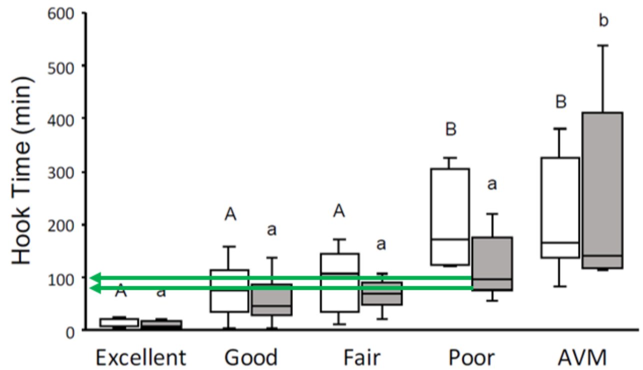
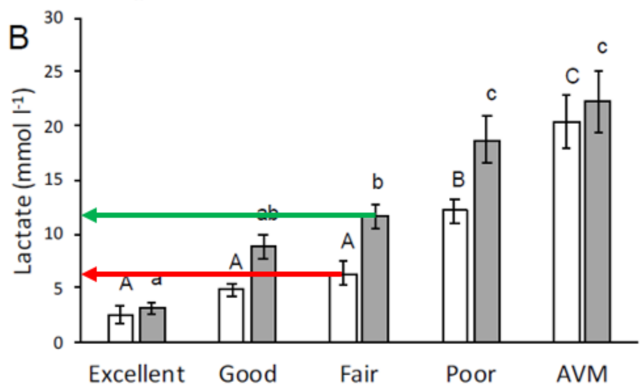



**Figure 16.** Box plots (quartiles) of scalloped (white, N = 86) and great (grey, N = 85) hammerheads release condition by hook time (min) (adapted from SEDAR77-DW09, their Figure 1); Scalloped hammerheads reached poor condition after about 120 – 180 minutes on hook (Panel A); Great hammerheads reached poor condition after about 80 – 100 minutes on hook (Panel B).

A. Lactate levels of scalloped and great hammerheads in fair condition.




B. Hook time of scalloped and great hammerheads with lactate levels associated with fair condition.

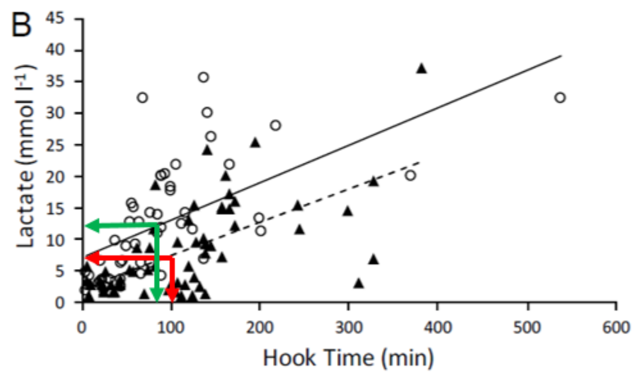
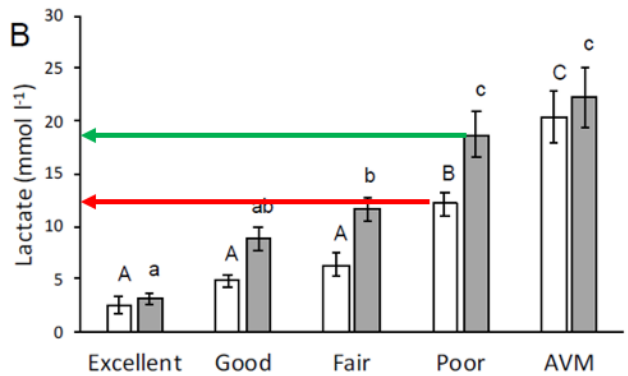



**Figure 17**. Lactate levels of scalloped (white bars) and great (grey bars) hammerheads released in fair condition were about 6 and 12 mmol $l^{-1}$, respectively (Panel A; Adapted from SEDAR77-DW09, their Figure 4), which corresponded to about 80 and 100 minutes of time on the hook for scalloped (closed triangles, dashed line) and great (open circles, solid line) hammerheads, respectively (Panel B; Adapted from SEDAR77-DW09, their Figure 2).

A. Lactate levels of scalloped and great hammerheads in poor condition.




B. Hook time of scalloped and great hammerheads with lactate levels associated with poor condition.

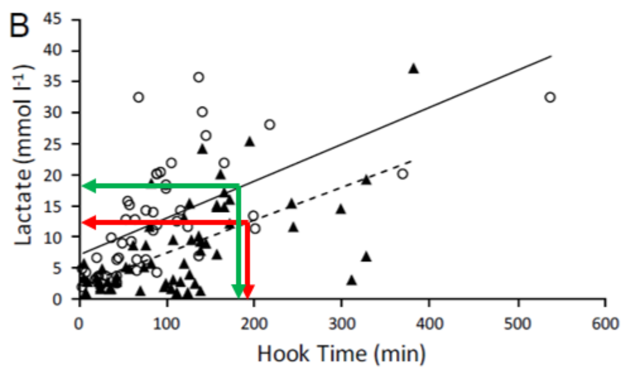
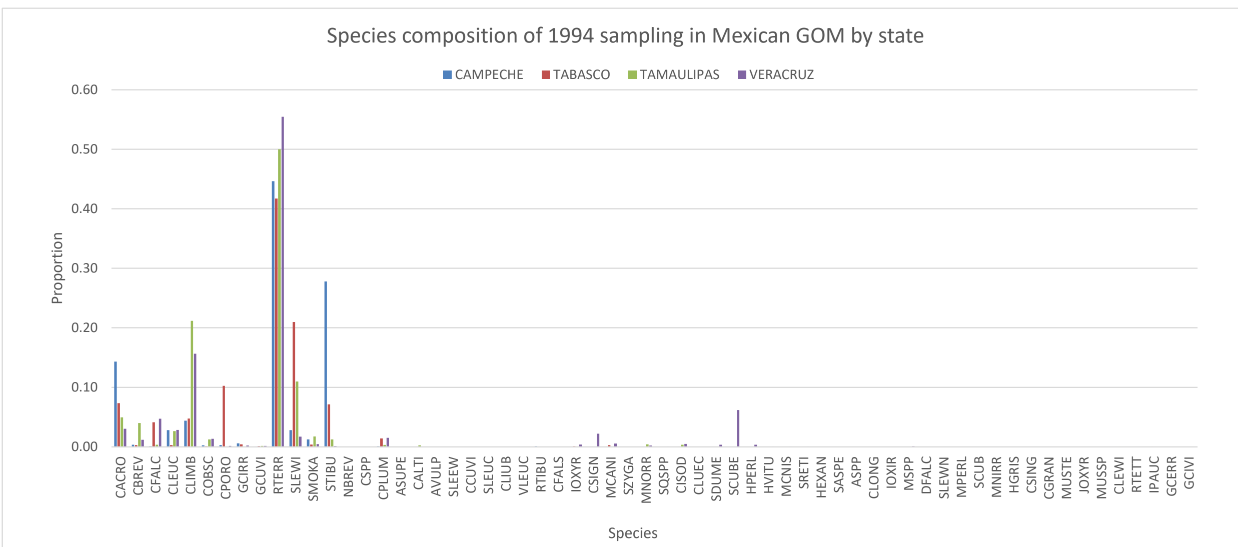


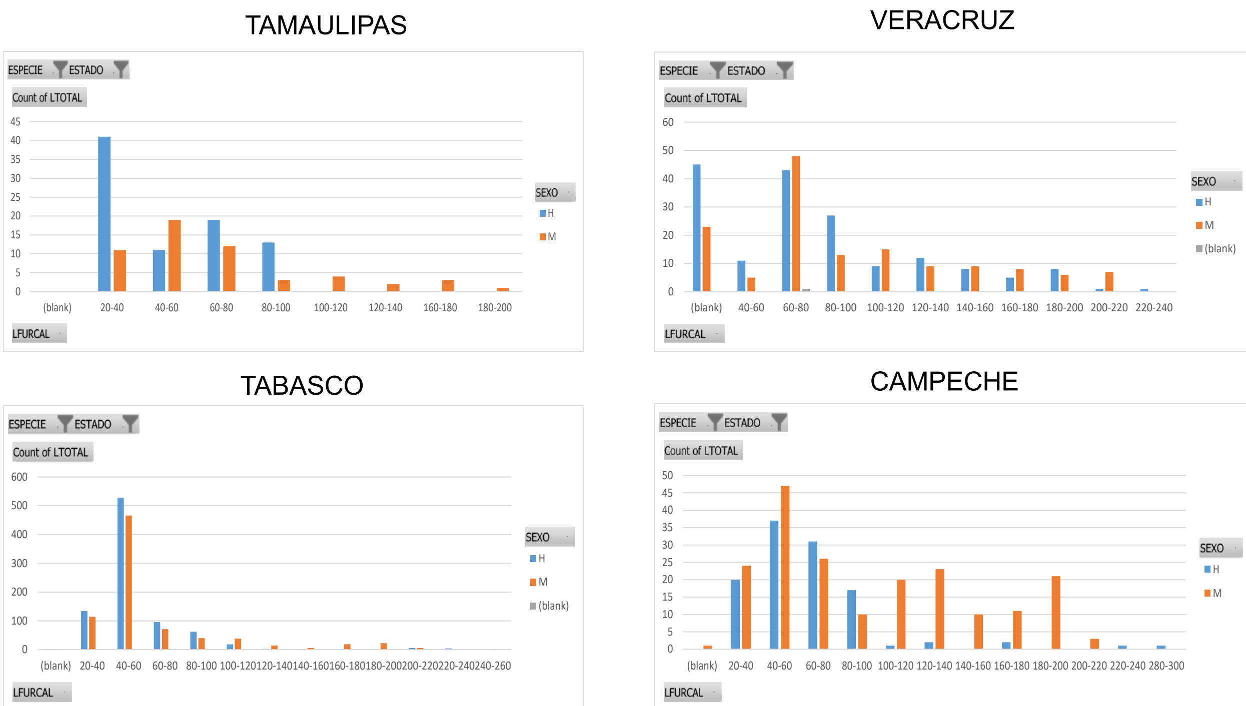

**Figure 18**. Lactate levels of scalloped (white bars) and great (grey bars) hammerheads released in poor condition were about 12 and 19 mmol $l^{-1}$, respectively (Panel A; Adapted from SEDAR77-DW09, their Figure 4), which corresponded to about 180 and 200 minutes of time on the hook for scalloped (closed triangles, dashed line) and great (open circles, solid line) hammerheads, respectively (Panel B; Adapted from SEDAR77-DW09, their Figure 2).


**Figure 19.** Map of Mexico showing the Gulf of Mexico states of Tamaulipas, Veracruz, Tabasco, and Campeche sampled during the 1993-1994 Castillo et al. (1998) monitoring study.



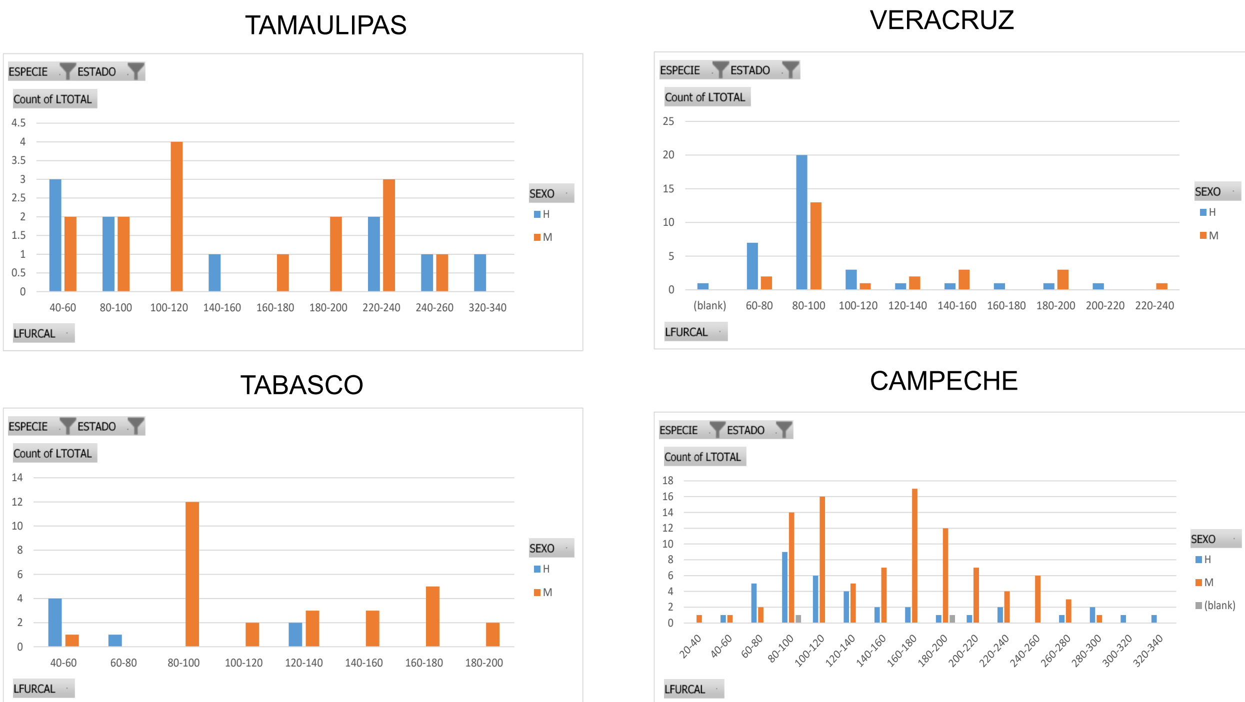

| | TAMAULIPAS | VERACRUZ | TABASCO | CAMPECHE | ALL |
|---|---|---|---|---|---|
| SLEWI | 0.110 | 0.017 | 0.210 | 0.028 | 0.054 |
| SMOKA | 0.017 | 0.005 | 0.004 | 0.012 | 0.009 |
| SZYGA | 0 | 3.64511E-05 | 0 | 0 | 1E-05 |
| | | | | | |

**Figure 20.** Species composition of sharks landed in the Mexico states of Tamaulipas, Veracruz, Tabasco, and Campeche observed in the 1993-1994 Castillo et al. (1998) monitoring study. The table shows scalloped hammerheads (SLEWI) were the main hammerhead species landed in each state, with smooth hammerhead (SZYGA) landings being negligible (SMOKA=great hammerhead).



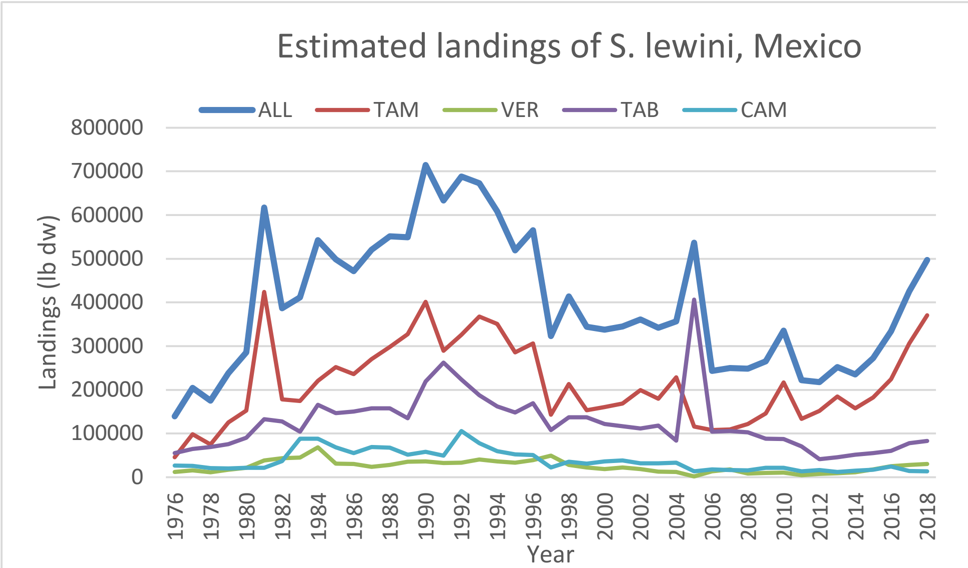

| | ALL both sexes | TAM both sexes | VER both sexes | TAB both sexes | CAM both sexes |
|---|---|---|---|---|---|
| % Cazon | 0.94 | 0.97 | 0.85 | 0.96 | 0.87 |
| % Tiburon | 0.06 | 0.03 | 0.15 | 0.04 | 0.13 |

**Figure 21.** Length-frequency distributions of scalloped hammerheads landed in Mexico states by sex (H=Hembra=Female; Macho=M=Male), and state observed in the 1993-1994 Castillo et al. (1998) monitoring study (upper panels). The table shows the proportion of scalloped hammerhead landings that were <150 cm TL ("cazones") and >=150 cm TL ("tiburones") for sexes combined computed as a weighted average (weighted by sample size for each sex). Most animals observed were immature and assigned to the "cazones" category.




| | ALL both sexes | TAM both sexes | VER both sexes | TAB both sexes | CAM both sexes |
|---|---|---|---|---|---|
| % Cazon | 0.66 | 0.56 | 0.88 | 0.80 | 0.54 |
| % Tiburon | 0.34 | 0.44 | 0.12 | 0.20 | 0.46 |

**Figure 22.** Length-frequency distributions of great hammerheads landed in Mexico states by sex (H=Hembra=Female; Macho=M=Male) and state observed in the 1993-1994 Castillo et al. (1998) monitoring study (upper panels). The table shows the proportion of great hammerhead landings that were <150 cm TL ("cazones") and >=150 cm TL ("tiburones") for sexes combined computed as a weighted average (weighted by sample size for each sex). Although a larger proportion of animals observed were assigned to the "tiburones" category, most animals were immature.



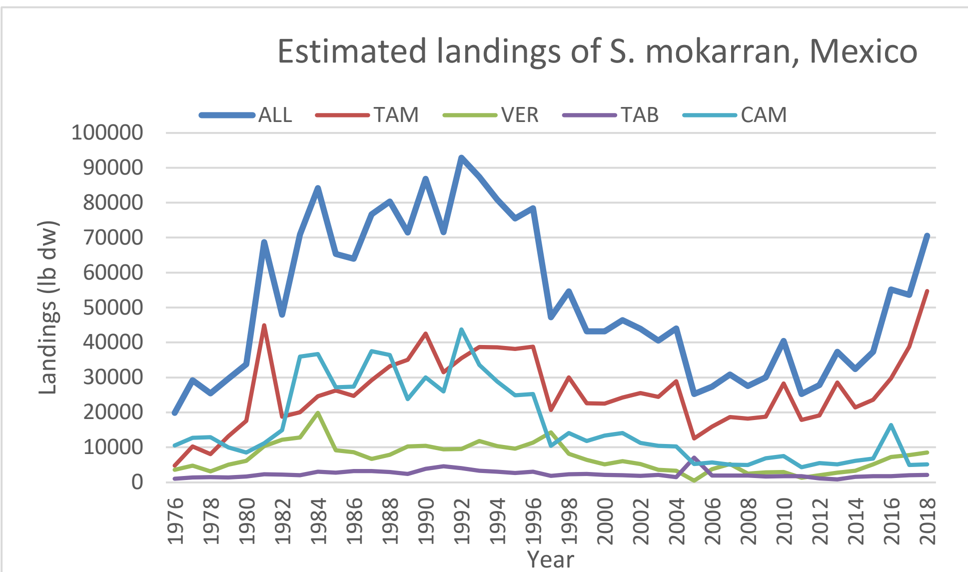
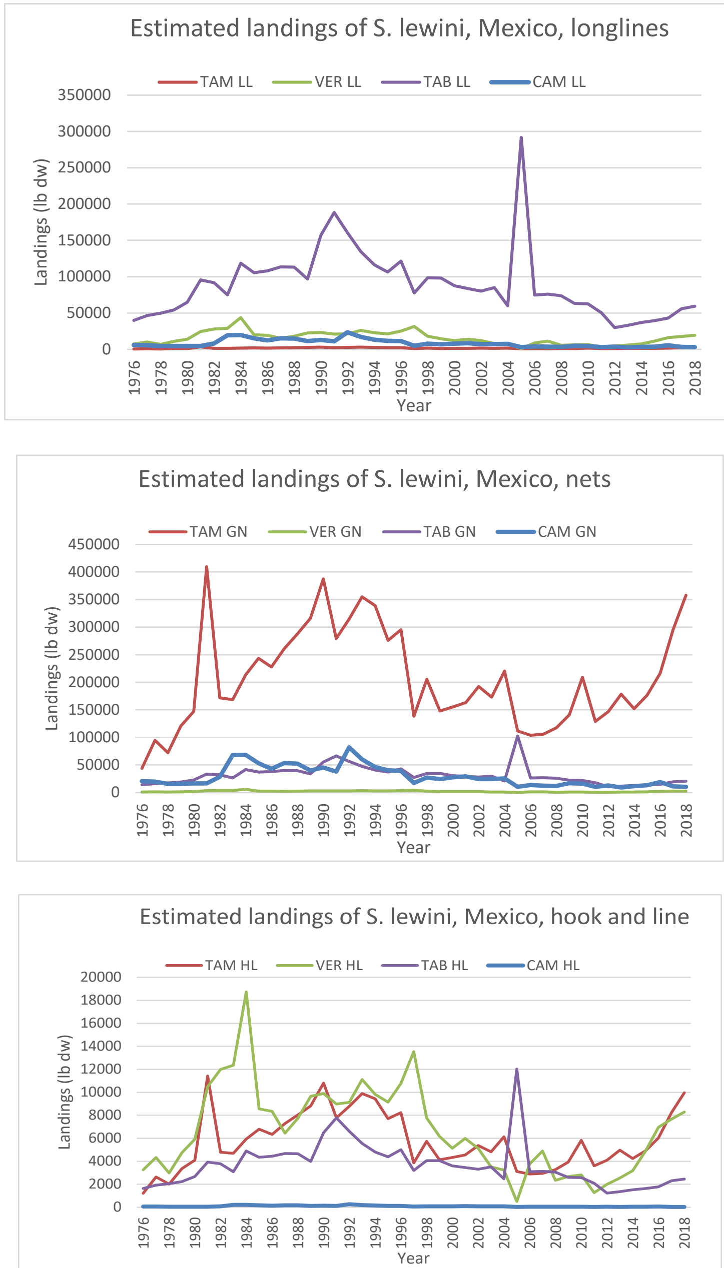
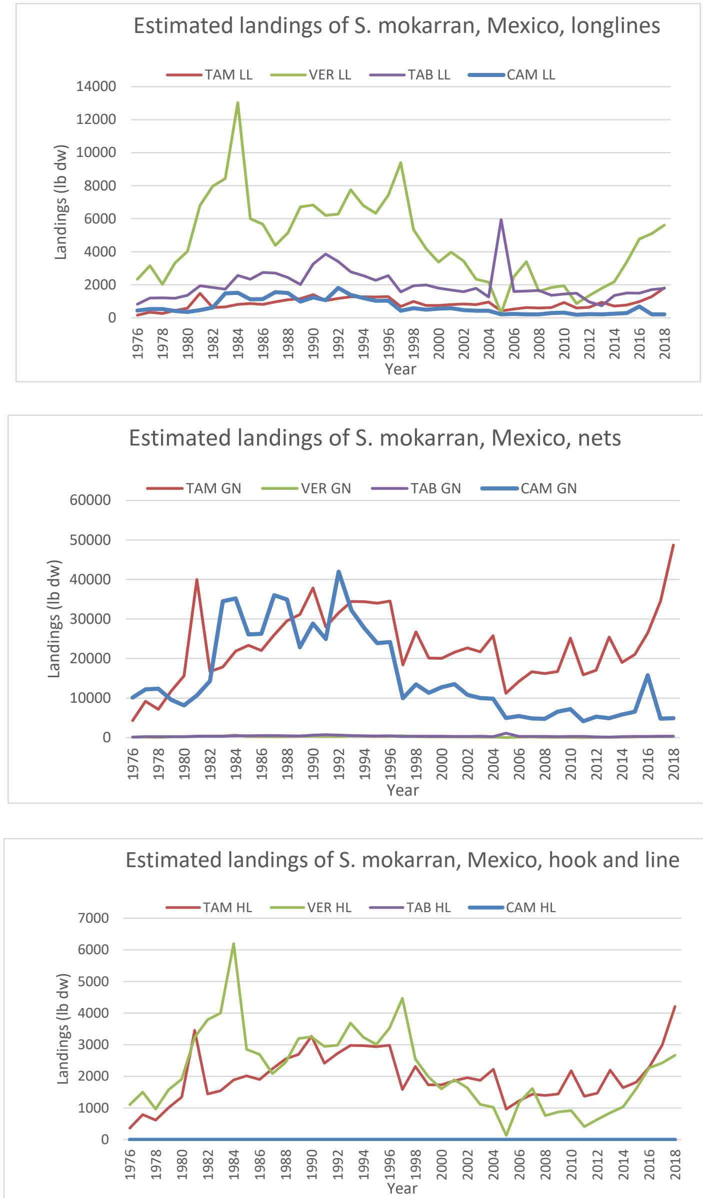




**Figure 23.** Estimated landings of scalloped (top) and great (bottom) hammerheads by Mexico state. Landings of "cazones" (<150 cm TL) and "tiburones" (>=150 cm TL) by state reported by the Comisión Nacional de Acuacultura y Pesca (Conapesca) were multiplied by the proportion that scalloped and great hammerheads make up of the entire catches and by the proportion of "cazones" and "tiburones" attributed to each species to obtain total estimates.



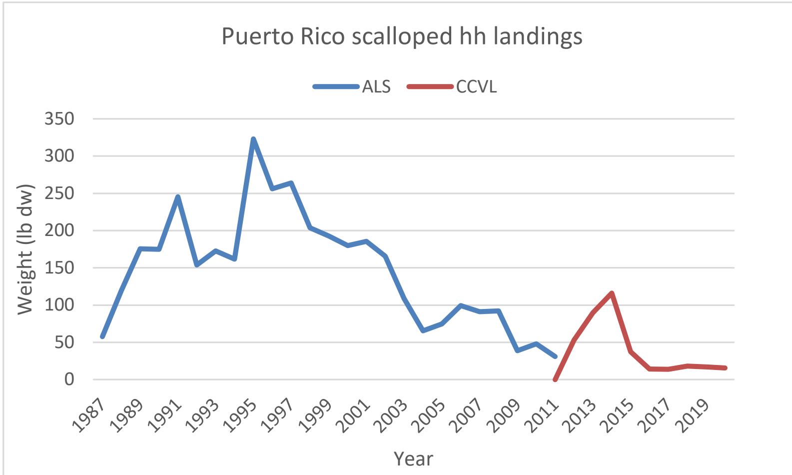

| | TAM | VER | TAB | CAM |
|---|---|---|---|---|
| LONGLINES | 0.01 | 0.64 | 0.72 | 0.22 |
| NETS | 0.97 | 0.09 | 0.25 | 0.78 |
| HOOK&LINE | 0.03 | 0.27 | 0.03 | 0.00 |

**Figure 24.** Estimated landings of scalloped hammerheads by gear and Mexico state. The table shows the percentage composition of gears that scalloped hammerheads were caught by state.




| | TAM | VER | TAB | CAM |
|---|---|---|---|---|
| LONGLINES | 0.03 | 0.66 | 0.84 | 0.04 |
| NETS | 0.89 | 0.03 | 0.16 | 0.96 |
| HOOK&LINE | 0.08 | 0.31 | 0.00 | 0.00 |

**Figure 25.** Estimated landings of great hammerheads by gear and Mexico state. The table shows the percentage composition of gears that great hammerheads were caught by state.



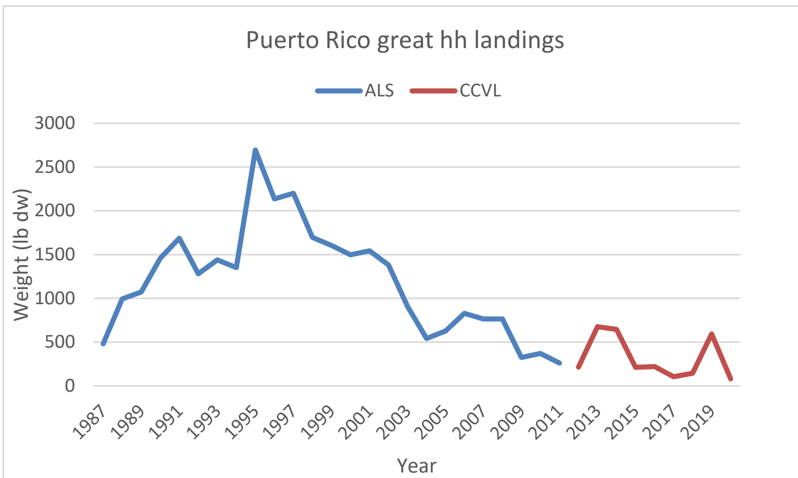




**Figure 26.** Landings of scalloped (top) and great (bottom) hammerheads from the Caribbean Commercial Vessel Logbook (CCVL) in 2011-2020 and from the Accumulated Landings System (ALS) for 1987-2011.

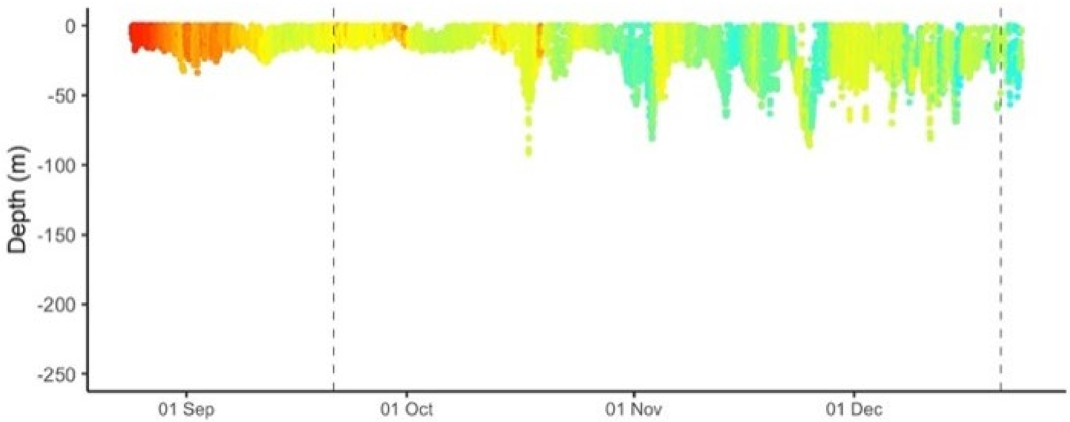



**Figure 27.** Vertical and thermal habitat use of a great hammerhead, *Sphyrna mokarran,* tagged with a PSAT using recreational fishing gear during South Carolina charter vessel based recreational angling, as described above. Red to blue color scale indicates warmer to cooler temperature. Adapted from SEDAR 77 Data Workshop presentation by Bryan Frazier – PRLDM in South Carolina charter vessel based recreational angling.

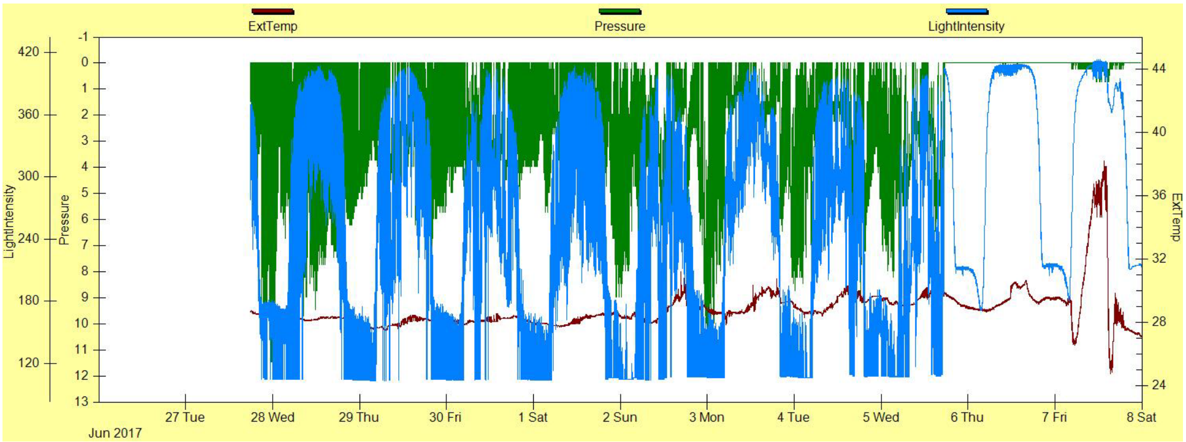



**Figure 28.** Depth, light intensity, and pressure (depth) of a great hammerhead, *Sphyrna mokarran* tagged with a PSATLife captured using recreational fishing gear during South Carolina charter vessel based recreational angling, as described above. Adapted from SEDAR 77 Data Workshop presentation by Bryan Frazier – PRLDM in South Carolina charter vessel based recreational angling.

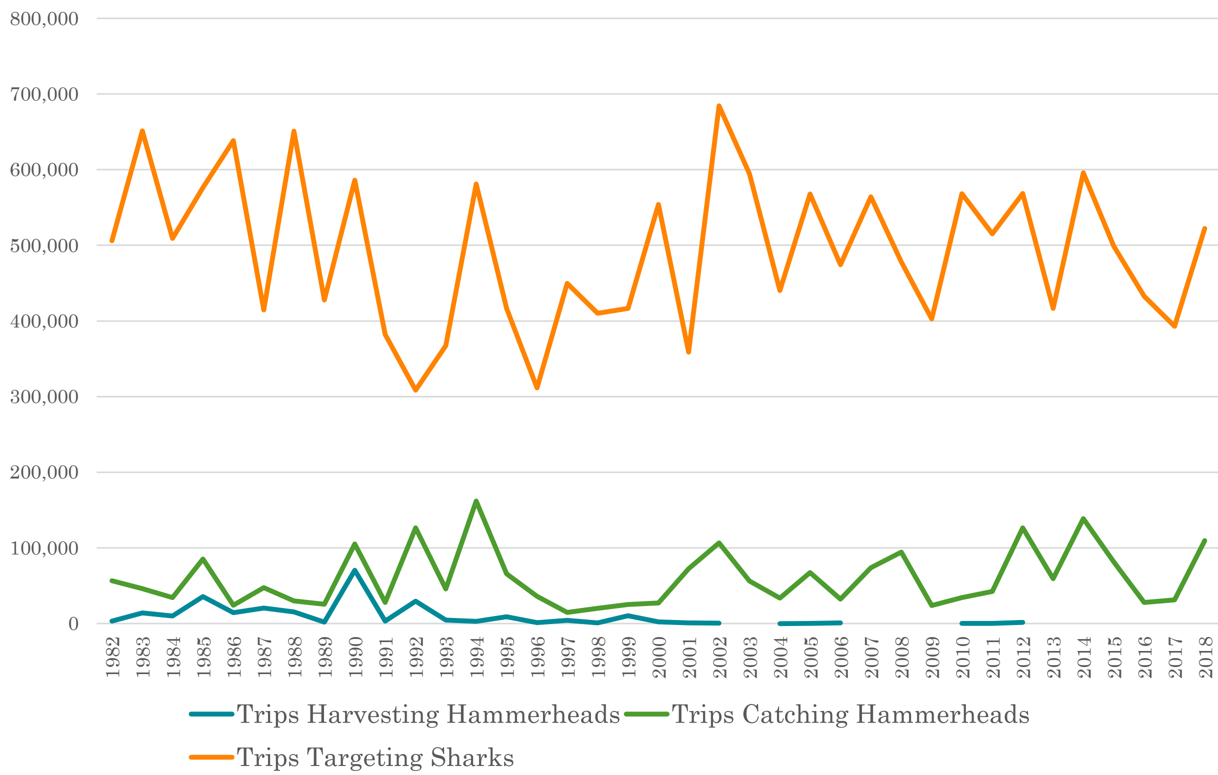



**Figure 29.** Summary of data used to calculate the proportion of shark targeted recreational fishing trips in the MRIP data base that captured or harvested hammerheads, as described above. The MRIP data base was queried for the number of MRIP trips: (1) targeting sharks (excluding pelagic, small coastals, and dogfish); (2) catching hammerheads, including generic hammerheads; (3) catching hammerheads identified to species; and (4) harvesting hammerheads identified to species. Adapted from SEDAR 77 Data Workshop presentation by Cliff Hutt – Proportion of shark targeted recreational fishing trips in the MRIP data base that captured or harvested hammerheads.

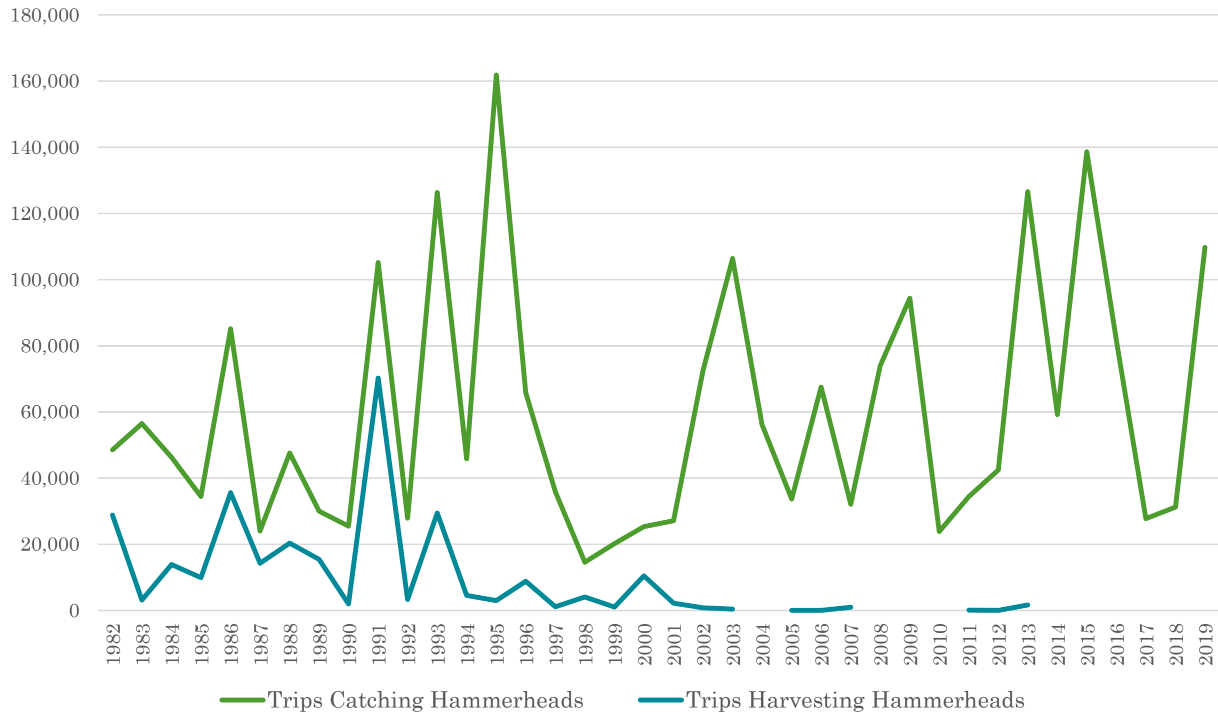



**Figure 30.** Summary of data used to calculate the proportion of shark targeted recreational fishing trips in the MRIP data base that captured or harvested hammerheads, as described above. The MRIP data base was queried as described in Figure 29. Adapted from SEDAR 77 Data Workshop presentation by Cliff Hutt – Proportion of shark targeted recreational fishing trips in the MRIP data base that captured or harvested hammerheads.

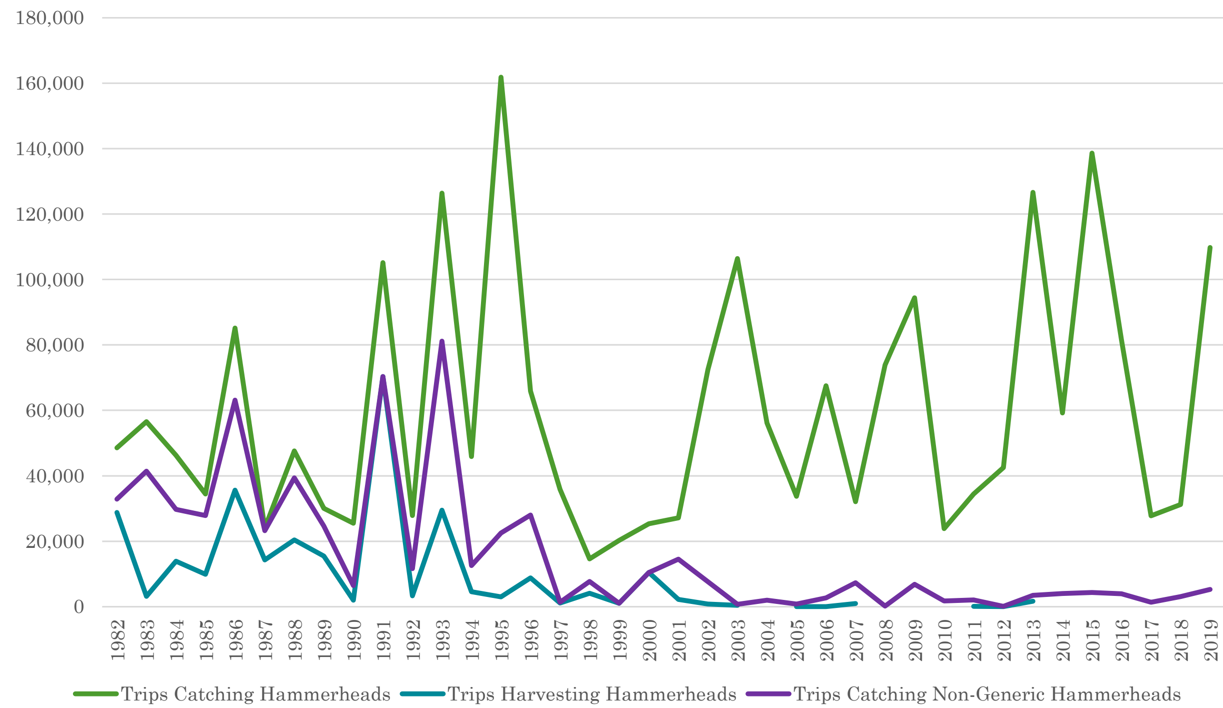



**Figure 31.** Summary of data used to calculate the proportion of shark targeted recreational fishing trips in the MRIP data base that captured or harvested hammerheads, as described above. The MRIP data base was queried as described in Figure 29. Adapted from SEDAR 77 Data Workshop presentation by Cliff Hutt – Proportion of shark targeted recreational fishing trips in the MRIP data base that captured or harvested hammerheads.

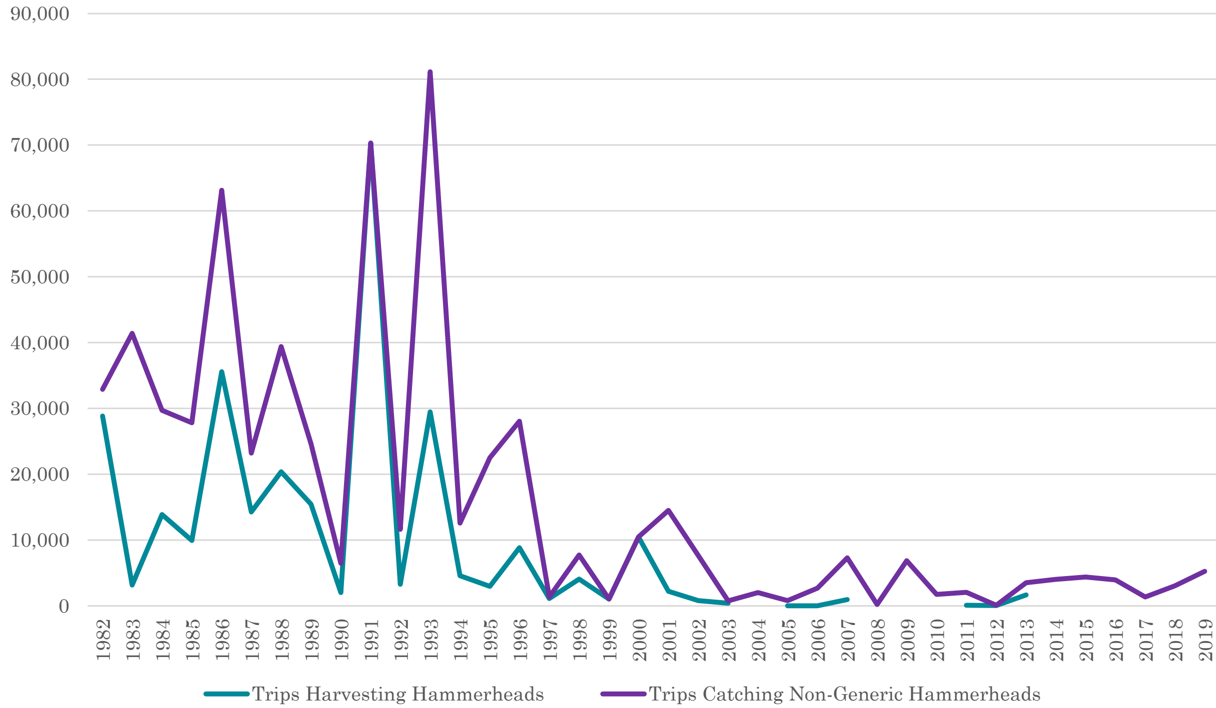
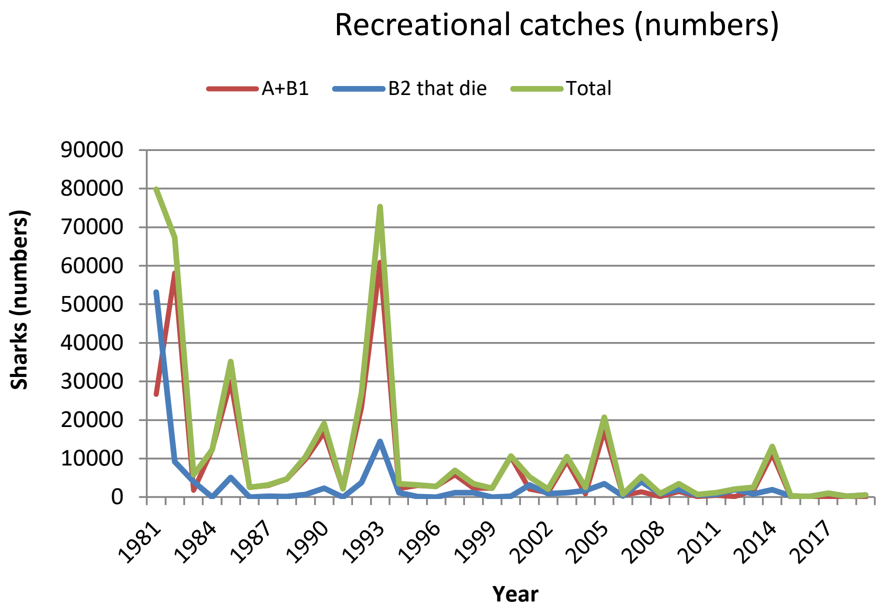



**Figure 32.** Summary of data used to calculate the proportion of shark targeted recreational fishing trips in the MRIP data base that captured or harvested hammerheads, as described above. The MRIP data base was queried as described in Figure 29. Adapted from SEDAR 77 Data Workshop presentation by Cliff Hutt – Proportion of shark targeted recreational fishing trips in the MRIP data base that captured or harvested hammerheads.



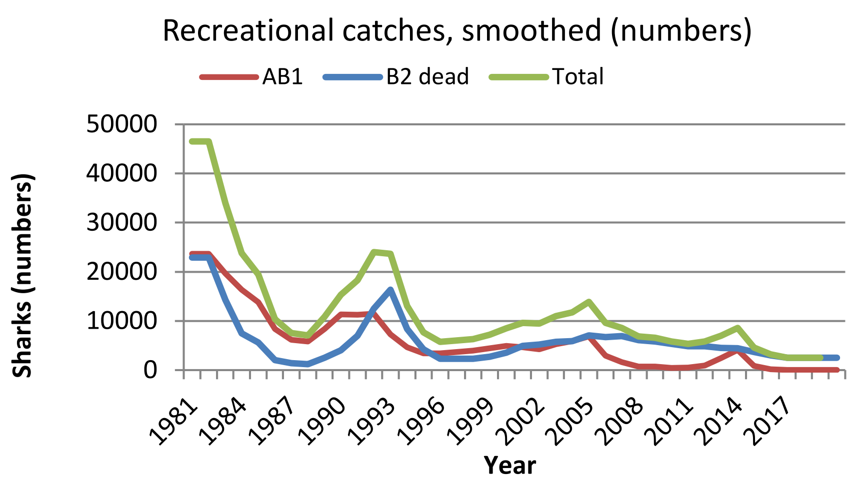
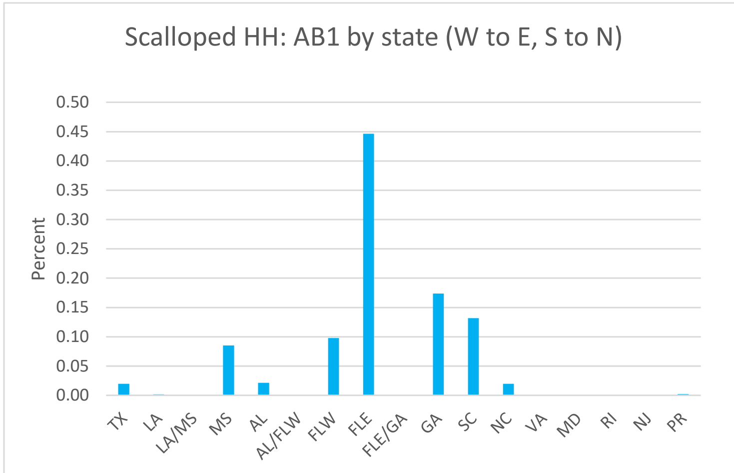
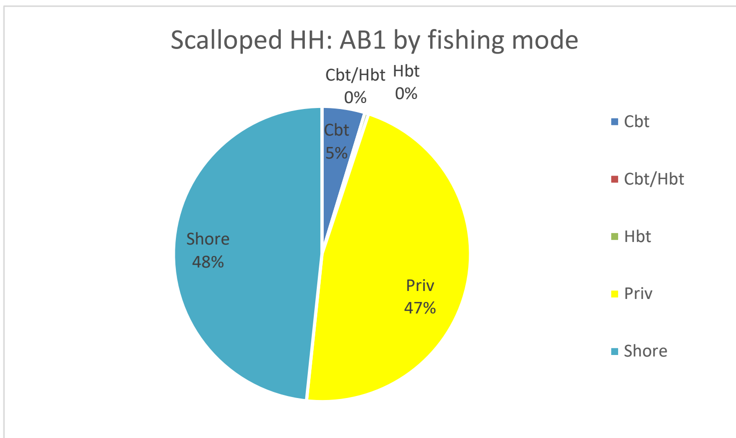




**Figure 33.** Recreational catches in numbers (AB1 and B2s that die assuming an initial arbitrary post-release mortality rate of 10%) of scalloped hammerheads (all regions) before smoothing (top) and after adjusting the 1982 AB1 estimate, smoothing the 1993 AB1 estimate, smoothing the entire series using a three-year moving geometric average, and using the recommended post-release mortality rate of 26.81% (bottom).



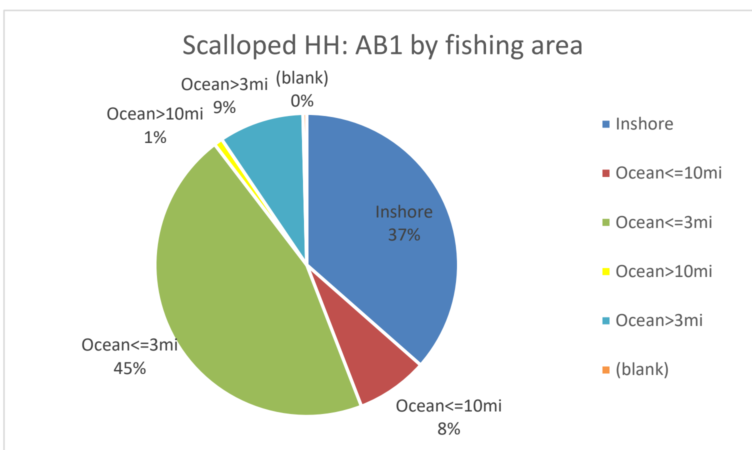
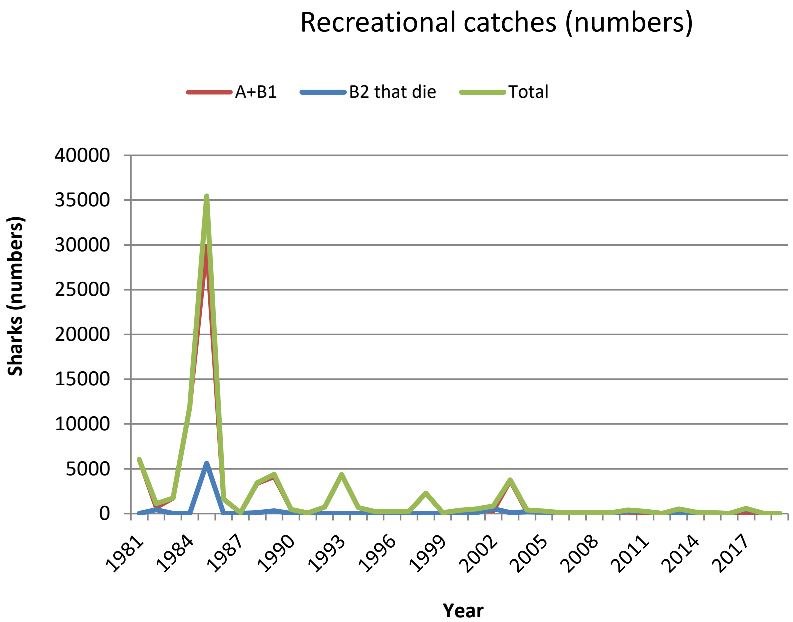




**Figure 34.** Recreational catches (AB1, numbers) of scalloped hammerhead by state (top), fishing mode (middle), and fishing area (bottom), 1981-2020. Note: "Blank" fishing area indicates catches reported in the Southeast Region Headboat Survey (SRHS).



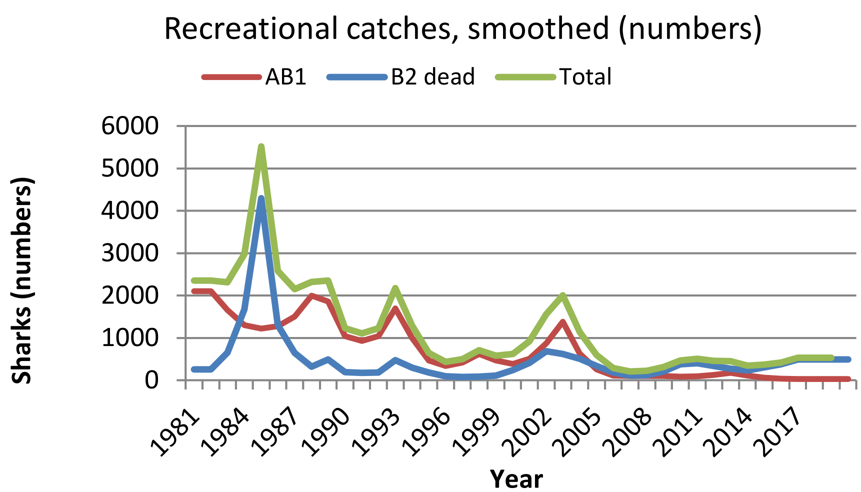




**Figure 35.** Recreational catches in numbers (AB1 and B2s that die assuming an initial arbitrary post-release mortality rate of 10%) of scalloped hammerheads in the GOM before smoothing (top) and after smoothing the 1984 and 1985 AB1 estimates, smoothing the entire series using a three-year moving geometric average, and using the recommended post-release mortality rate of 26.81% (bottom).

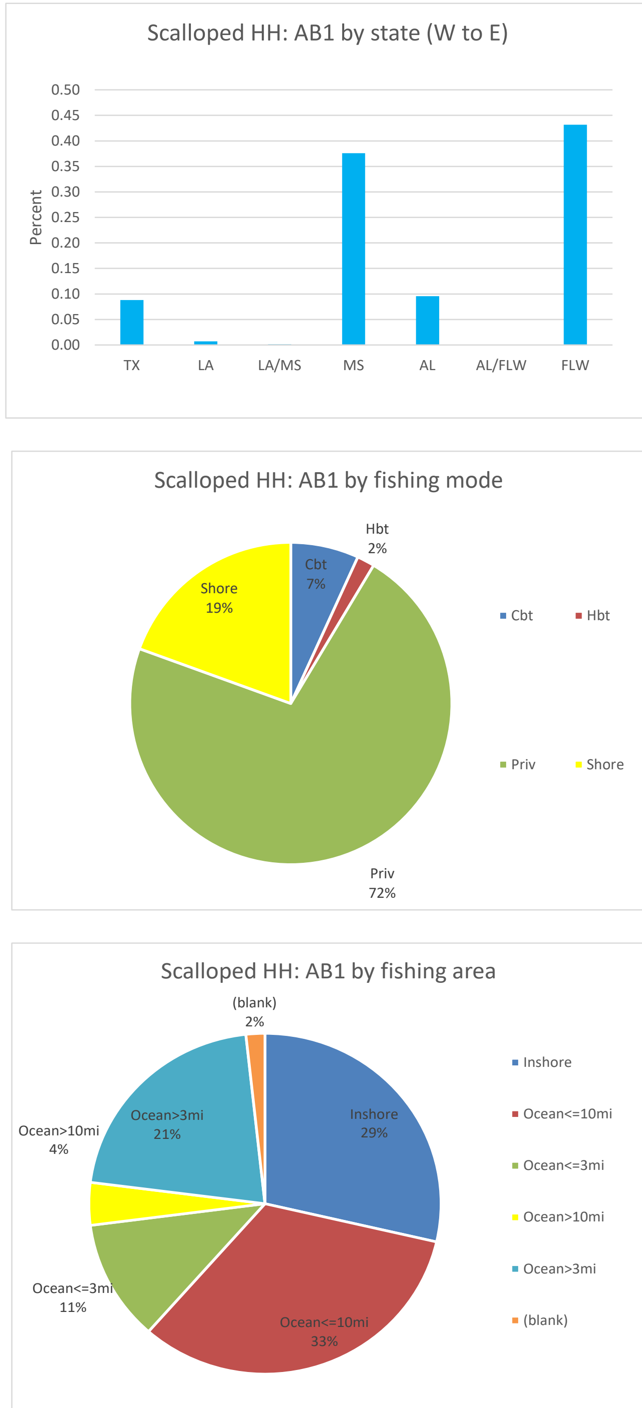
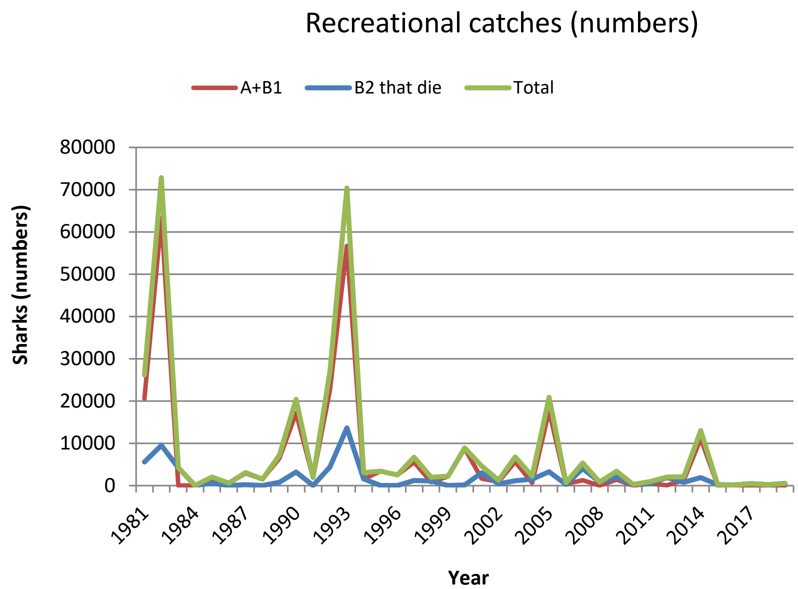



**Figure 36.** Recreational catches (AB1, numbers) of scalloped hammerheads in the GOM by state (top), fishing mode (middle), and fishing area (bottom), 1981-2020. Note: "Blank" fishing area indicates catches reported in the Southeast Region Headboat Survey (SRHS).



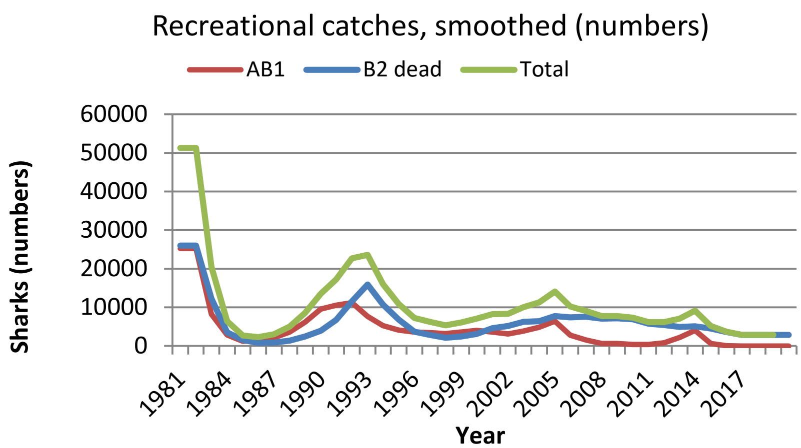




**Figure 37**. Recreational catches in numbers (AB1 and B2s that die assuming an initial arbitrary post-release mortality rate of 10%) of scalloped hammerheads in the ATL before smoothing (top) and after adjusting the 1982 AB1 estimate, smoothing the 1993 AB1 estimate, smoothing the entire series using a three-year moving geometric average, and using the recommended post-release mortality rate of 26.81% (bottom).

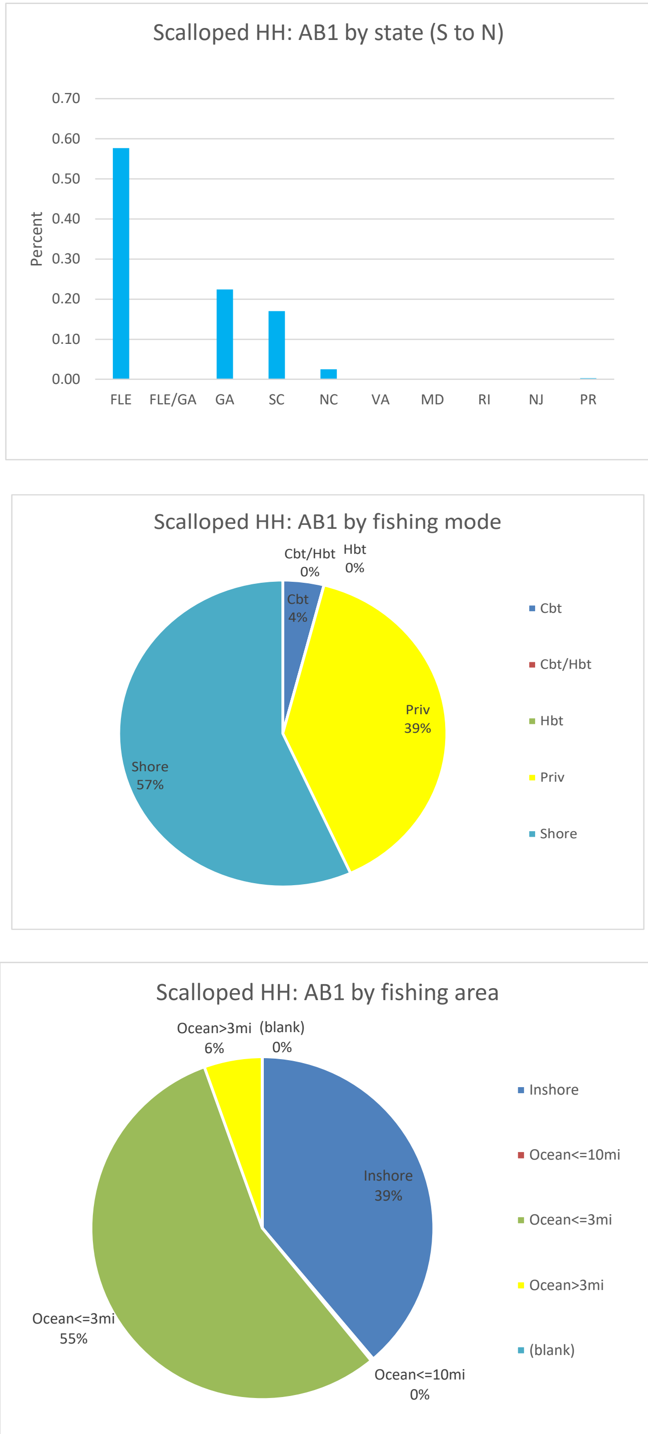



**Figure 38.** Recreational catches (AB1, numbers) of scalloped hammerheads in the ATL by state (top), fishing mode (middle), and fishing area (bottom), 1981-2020. Note: "Blank" fishing area indicates catches reported in the Southeast Region Headboat Survey (SRHS).

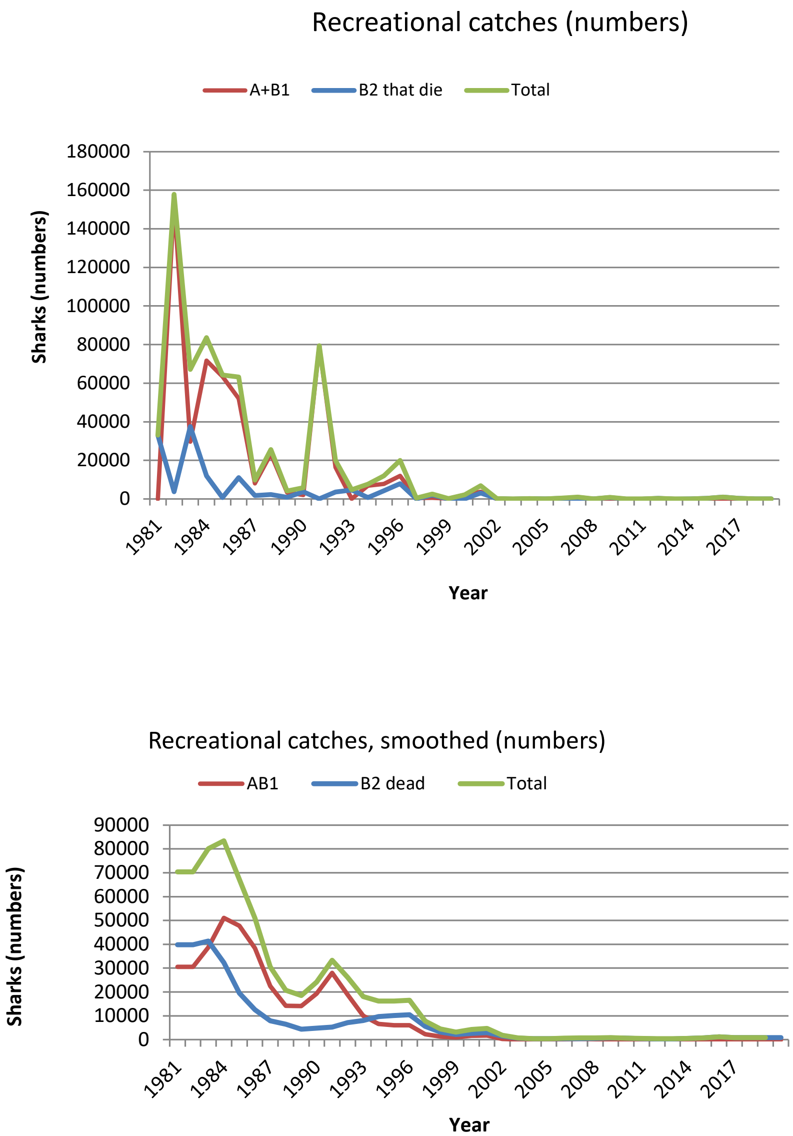
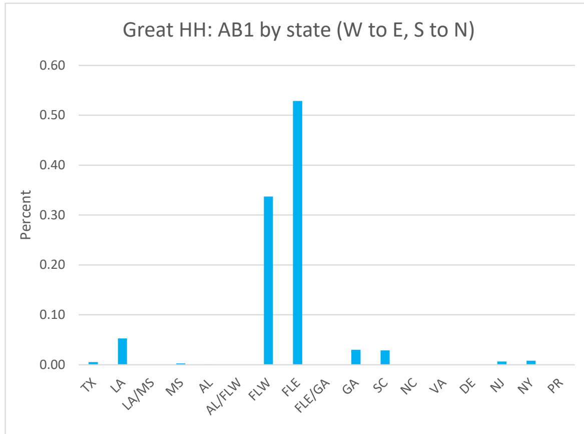
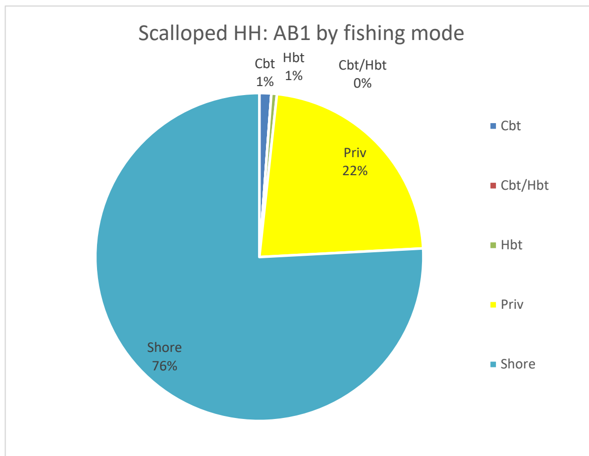



**Figure 39.** Recreational catches in numbers (AB1 and B2s that die assuming an initial arbitrary post-release mortality rate of 10%) of great hammerheads before smoothing (top) and after adjusting and smoothing the 1982 AB1 estimate, smoothing the entire series using a three-year moving geometric average, and using the recommended post-release mortality rate of 26.81% (bottom).



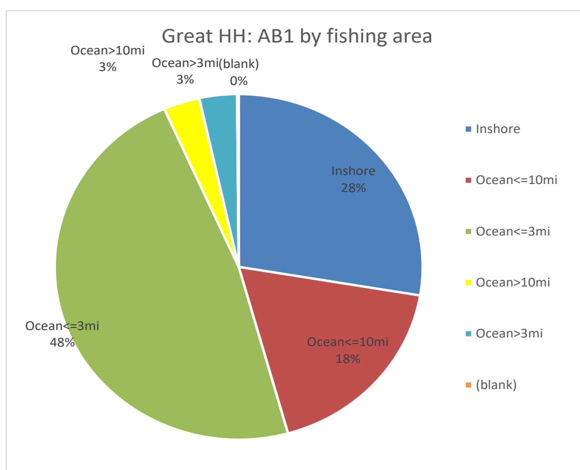
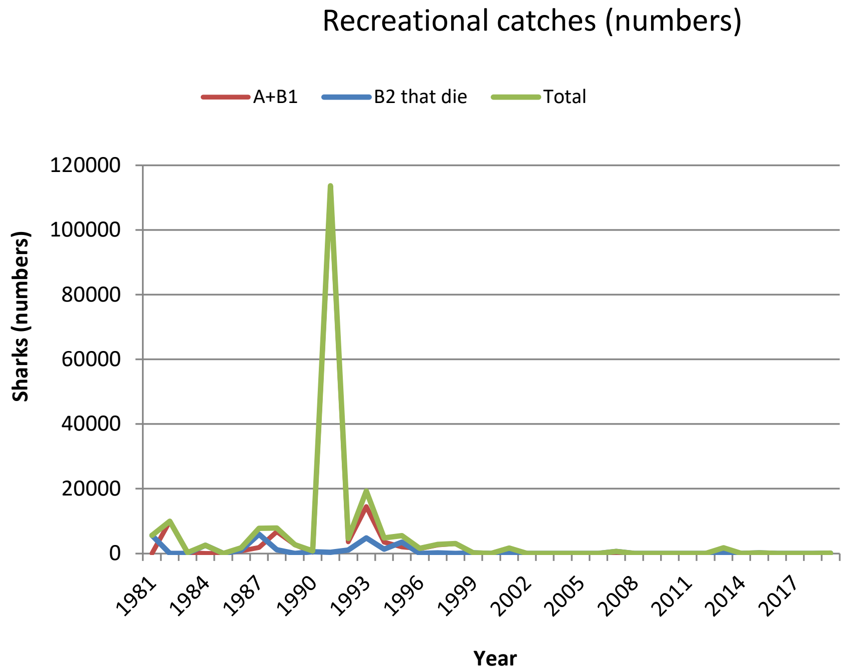




**Figure 40.** Recreational catches (AB1, numbers) of great hammerheads by state (top), fishing mode (middle), and fishing area (bottom), 1981-2020. Note: "Blank" fishing area indicates catches reported in the Southeast Region Headboat Survey (SRHS).



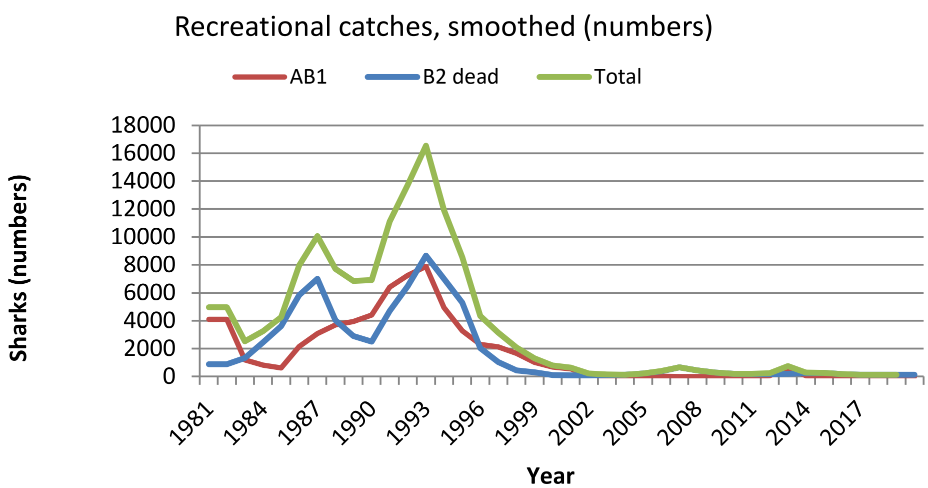




**Figure 41.** Recreational catches in numbers (AB1 and B2s that die assuming an initial arbitrary post-release mortality rate of 10%) of smooth hammerheads before smoothing (top) and after adjusting the 1991 AB1 estimate, smoothing the entire series using a three-year moving geometric average, and using the recommended post-release mortality rate of 26.81% (bottom).

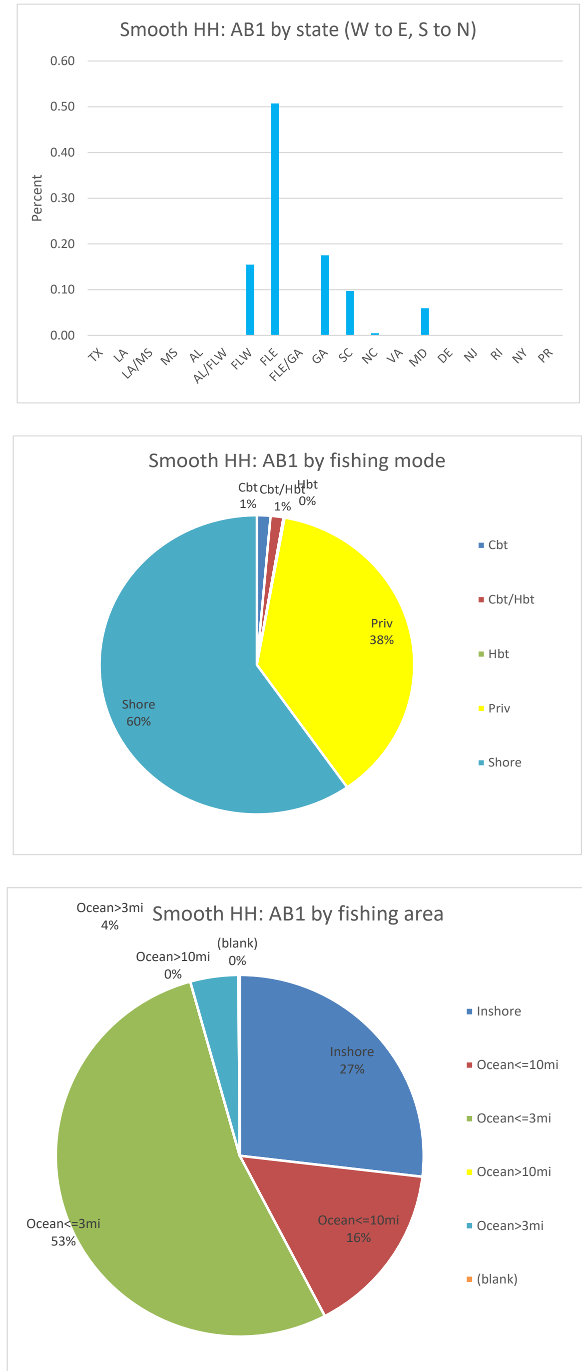



**Figure 42.** Recreational catches (AB1, numbers) of smooth hammerheads by state (top), fishing mode (middle), and fishing area (bottom), 1981-2020. Note: "Blank" fishing area indicates catches reported in the Southeast Region Headboat Survey (SRHS).

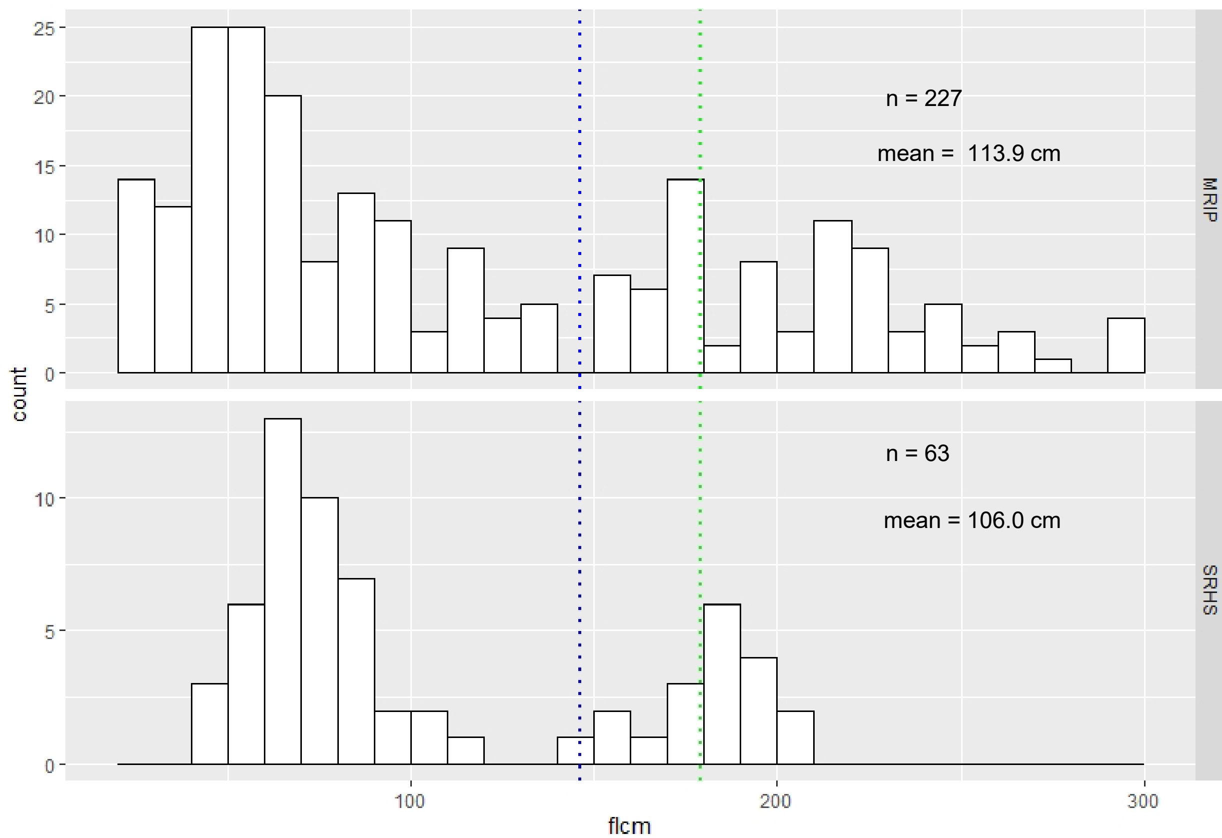



**Figure 43.** Length-frequency histograms of scalloped hammerheads in all regions caught in the MRIP and SRHS recreational surveys. The dotted blue and green lines denote the median length at maturity for males and females, respectively. MRIP= Marine Recreational Information Program (MRIP). SRHS=Southeast Region Headboat Survey.

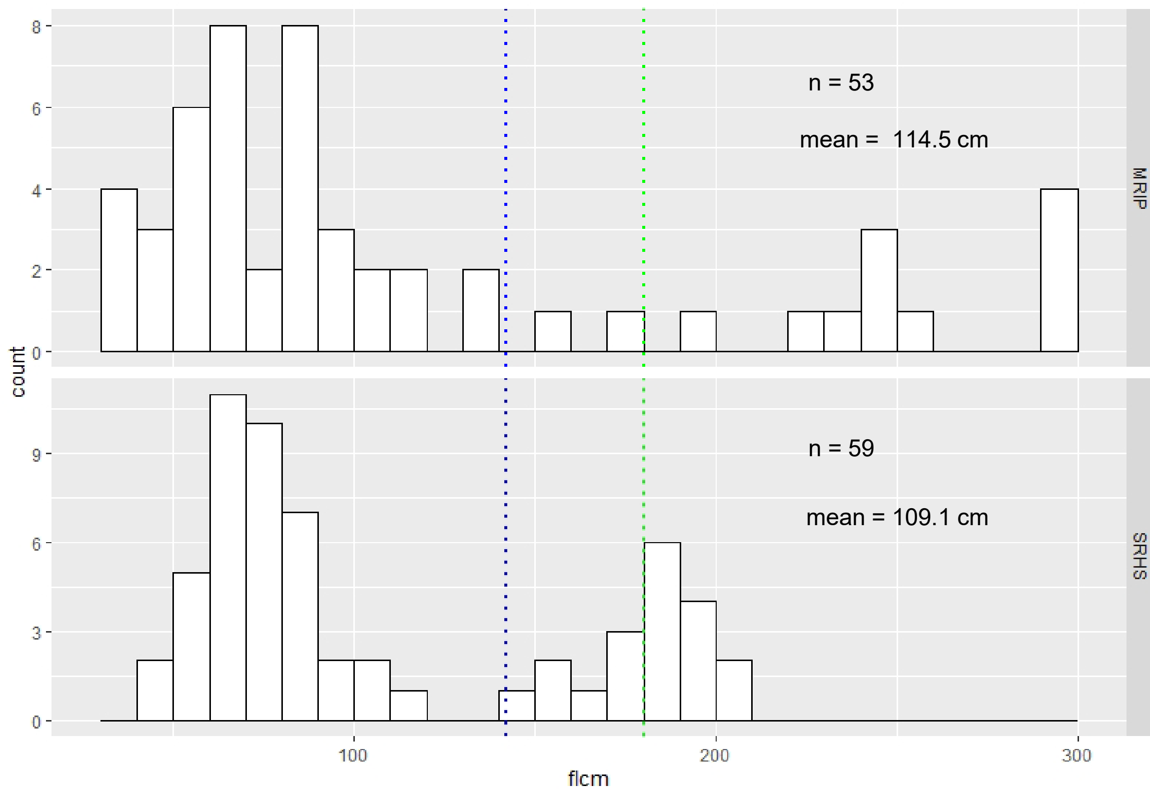



**Figure 44.** Length-frequency histograms of GOM scalloped hammerheads caught in the MRIP and SRHS recreational surveys. The dotted blue and green lines denote the median length at maturity for males and females, respectively. MRIP= Marine Recreational Information Program (MRIP). SRHS=Southeast Region Headboat Survey.

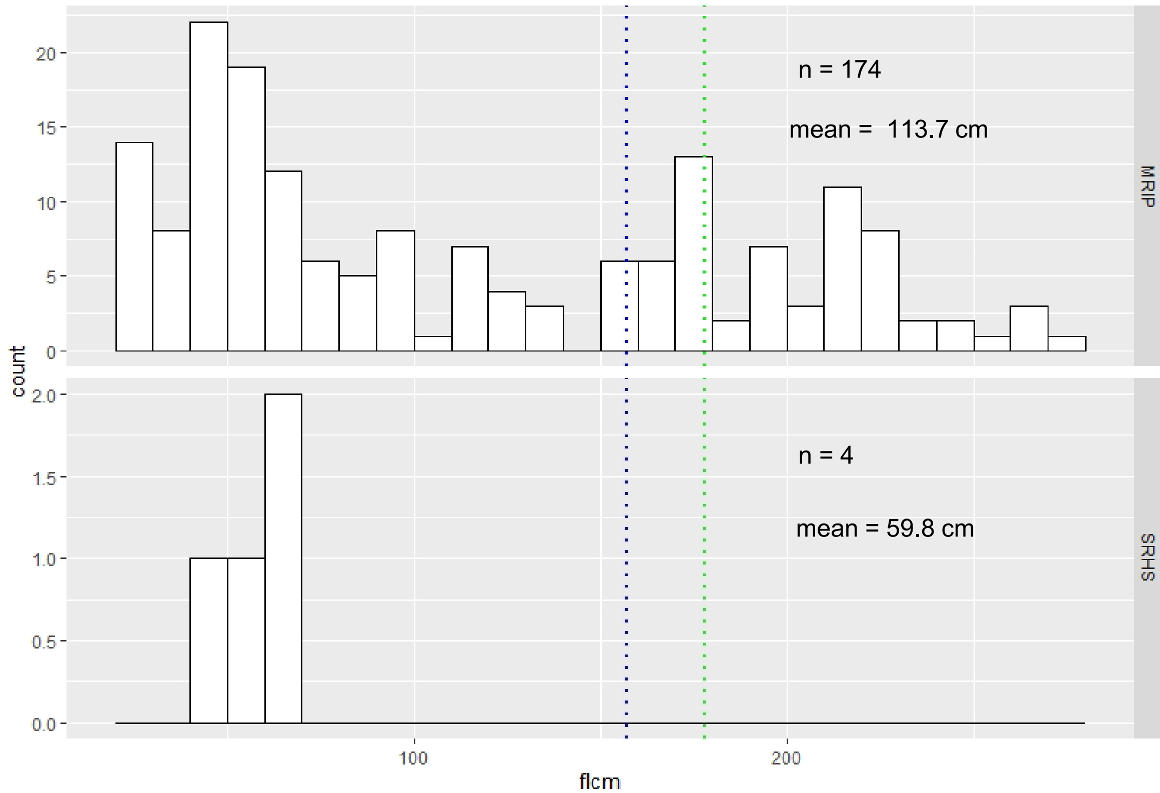



**Figure 45.** Length-frequency histograms of ATL scalloped hammerheads caught in the MRIP and SRHS recreational surveys. The dotted blue and green lines denote the median length at maturity for males and females, respectively. MRIP= Marine Recreational Information Program (MRIP). SRHS=Southeast Region Headboat Survey.

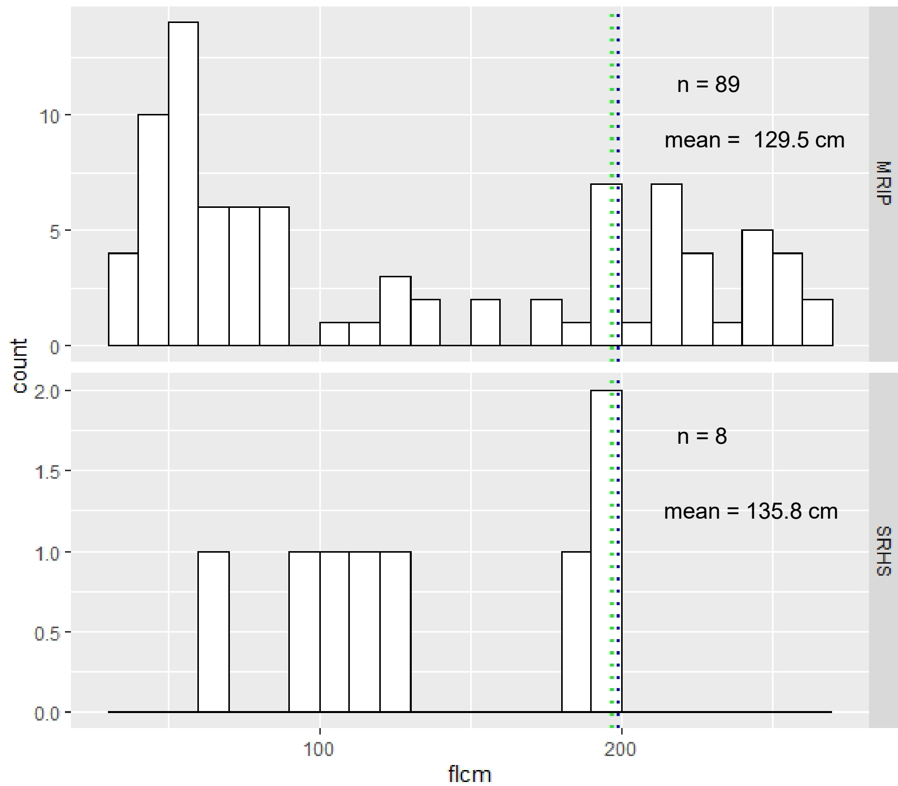



**Figure 46.** Length-frequency histograms of great hammerheads caught in the MRIP and SRHS recreational surveys. The dotted blue and green lines denote the median length at maturity for males and females, respectively. MRIP= Marine Recreational Information Program (MRIP). SRHS=Southeast Region Headboat Survey.

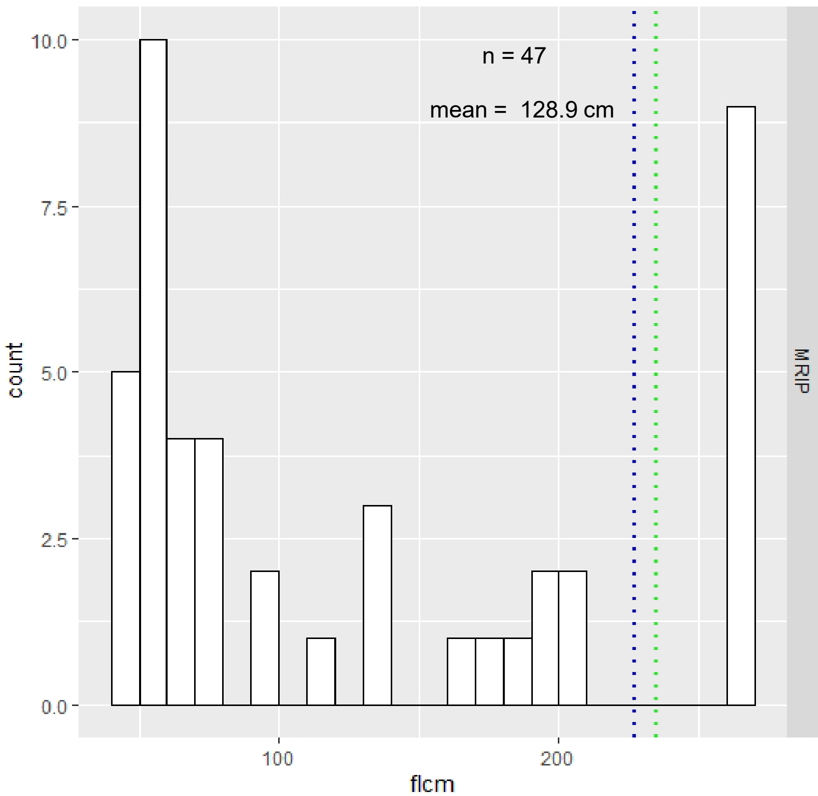



**Figure 47.** Length-frequency histograms of smooth hammerheads caught in the MRIP and SRHS recreational surveys. The dotted blue and green lines denote the median length at maturity for males and females, respectively. MRIP= Marine Recreational Information Program (MRIP). SRHS=Southeast Region Headboat Survey.

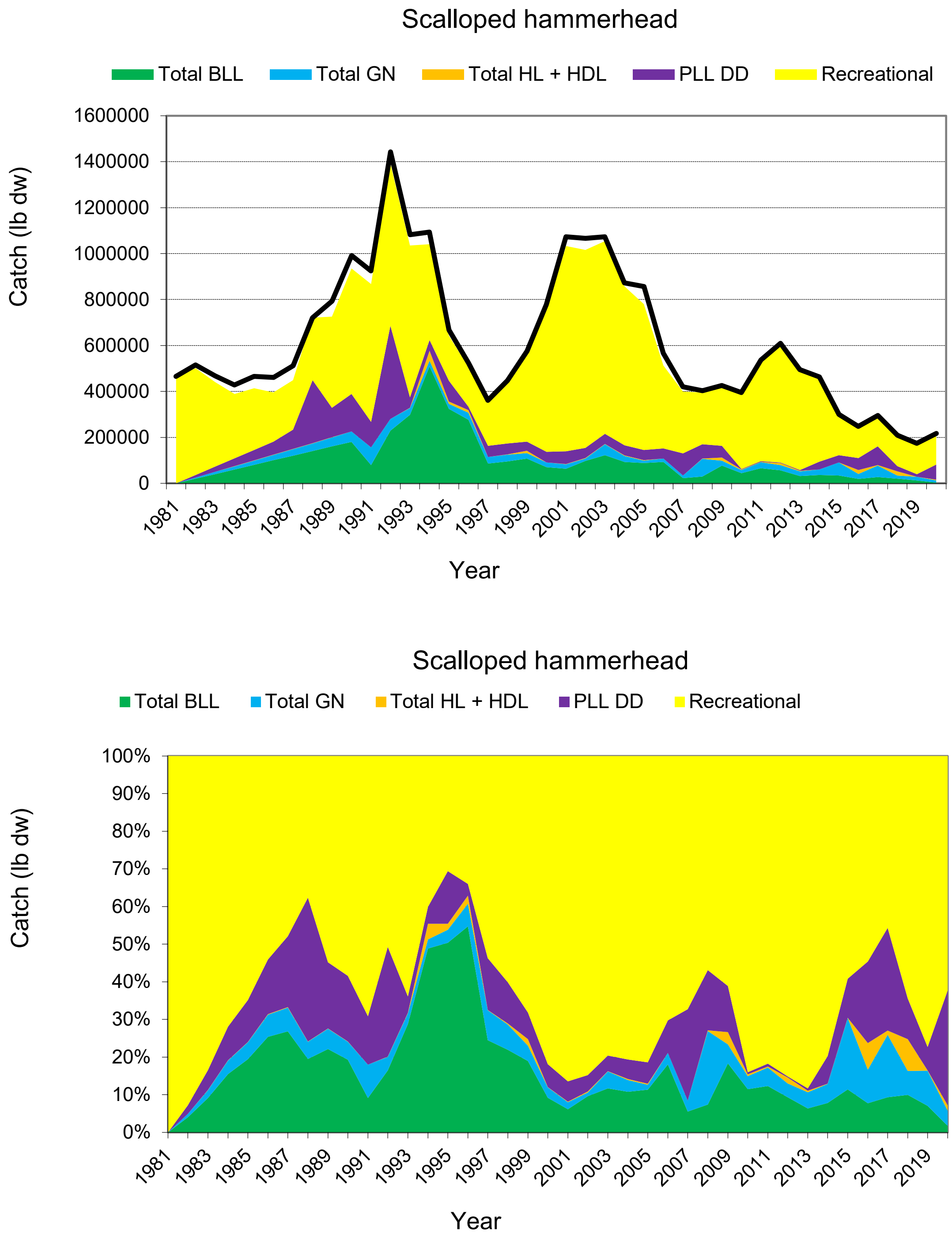



**Figure 48.** Commercial catches by gear and smoothed recreational catches of scalloped hammerheads in weight (lb dw), 1981-2020. Top panel: stacked catches by year; bottom panel: proportions by year.

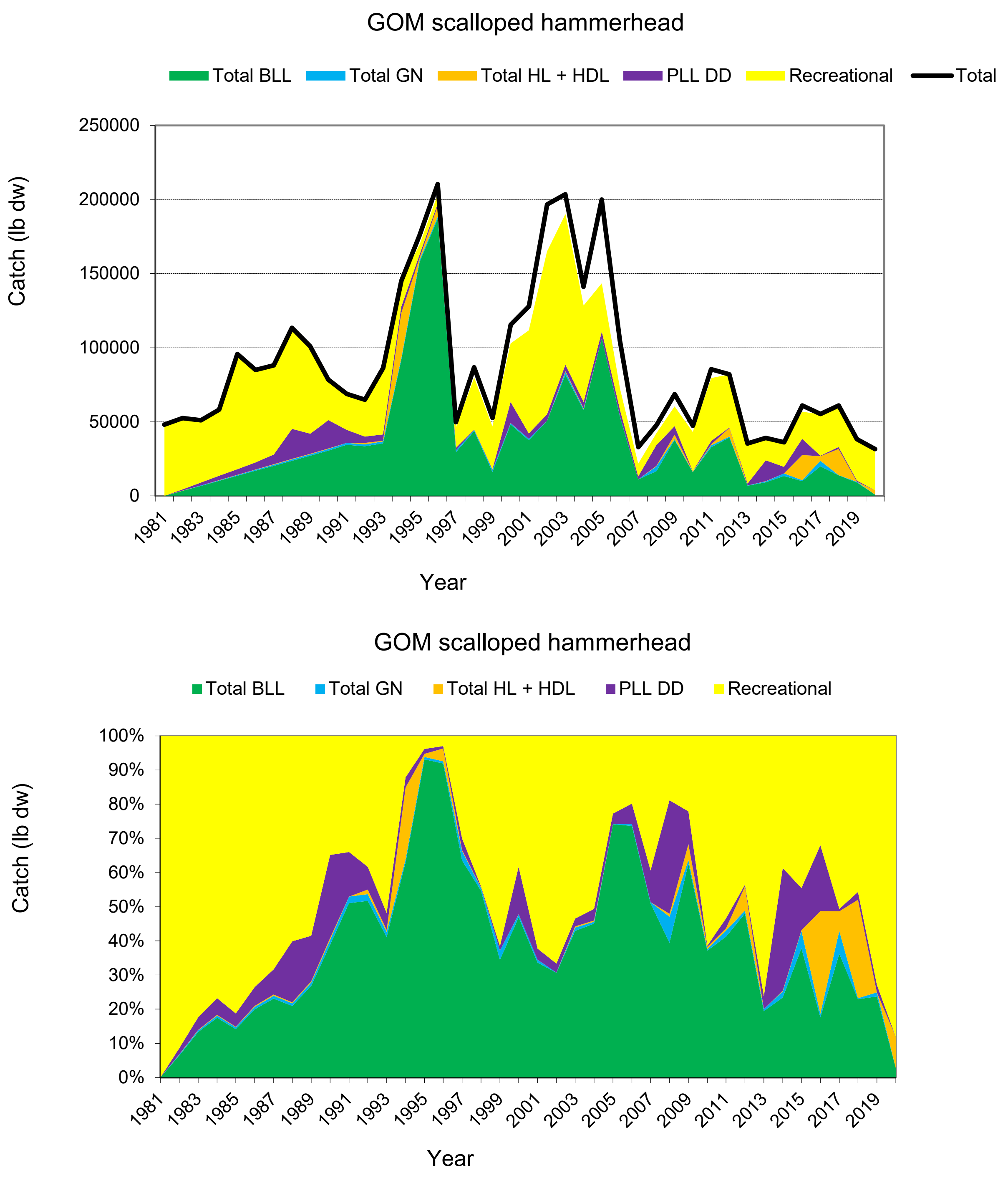
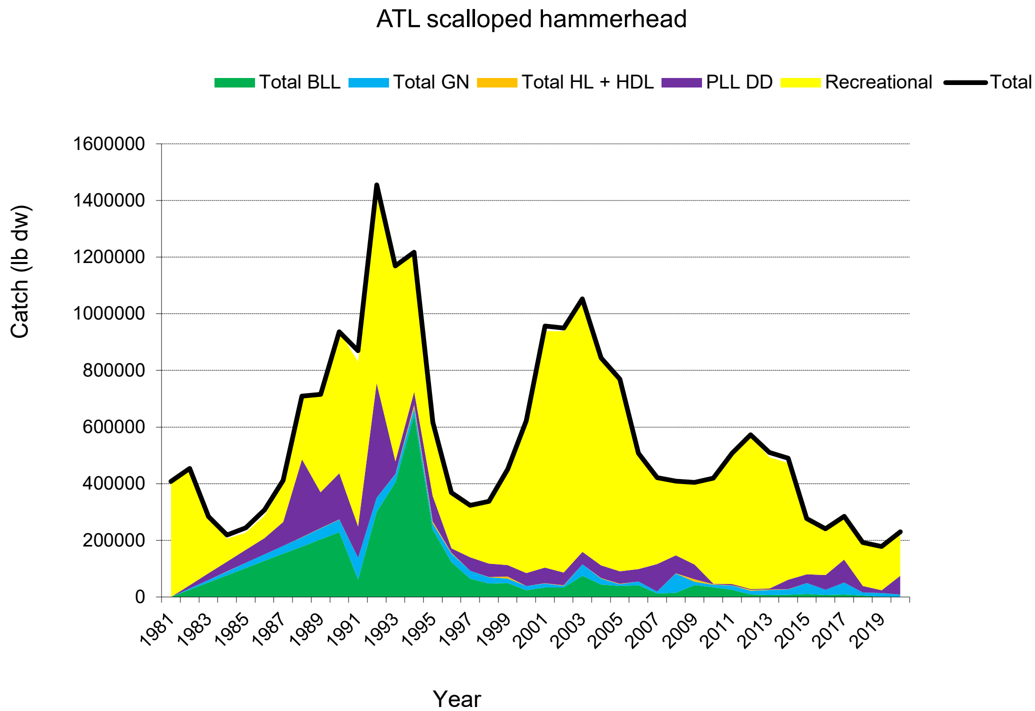



**Figure 49.** Commercial catches and smoothed recreational catches of GOM scalloped hammerheads in weight (lb dw), 1981-2020. Top panel: stacked catches by year; bottom panel: proportions by year.



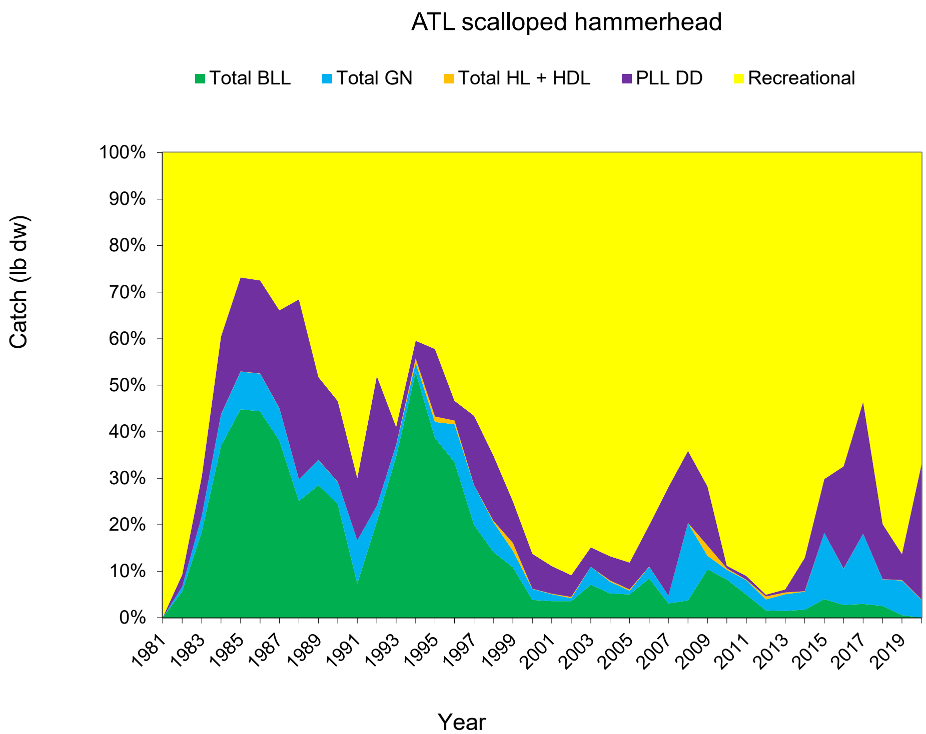




**Figure 50.** Commercial catches and smoothed recreational catches of ATL scalloped hammerheads in weight (lb dw), 1981-2020. Top panel: stacked catches by year; bottom panel: proportions by year.

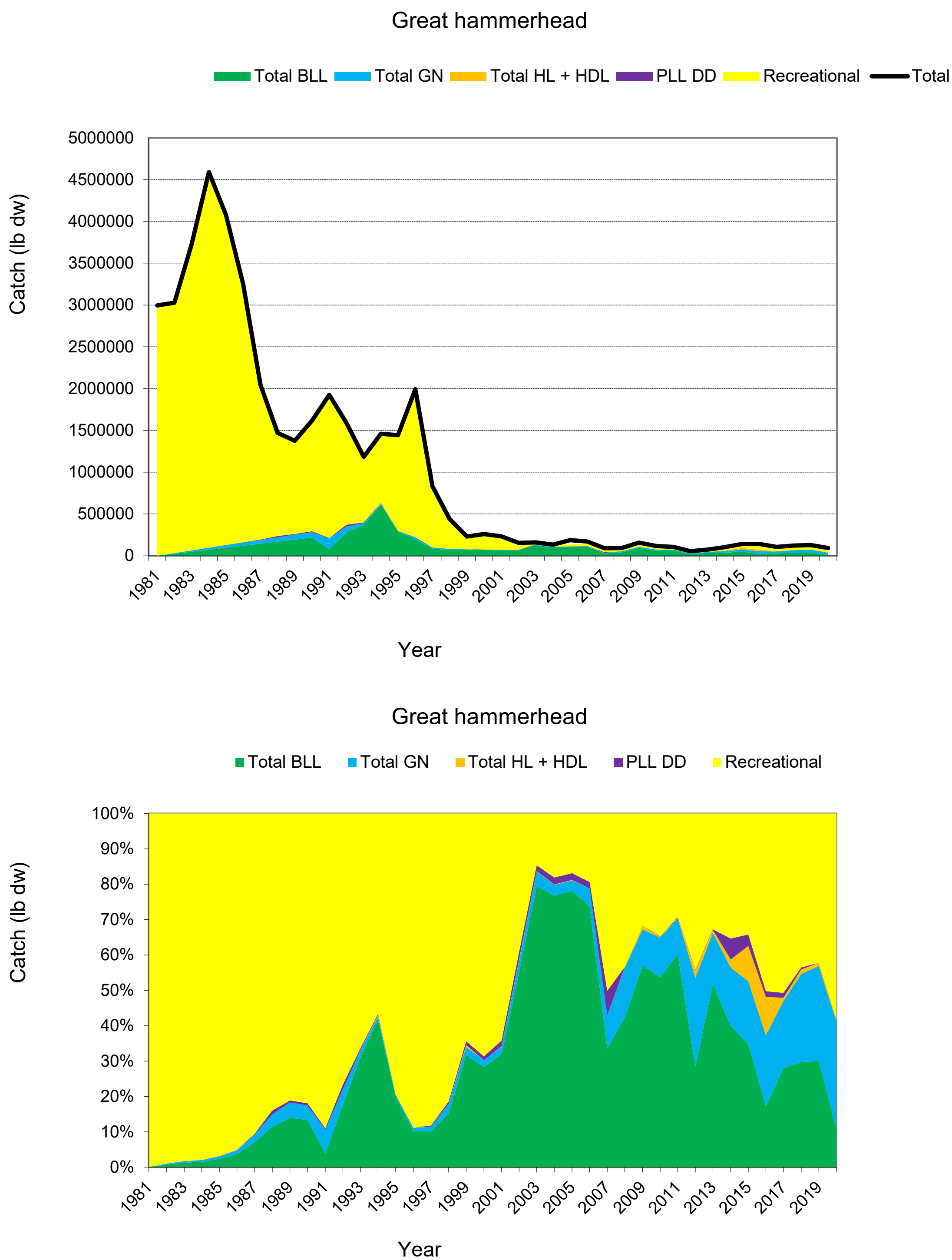
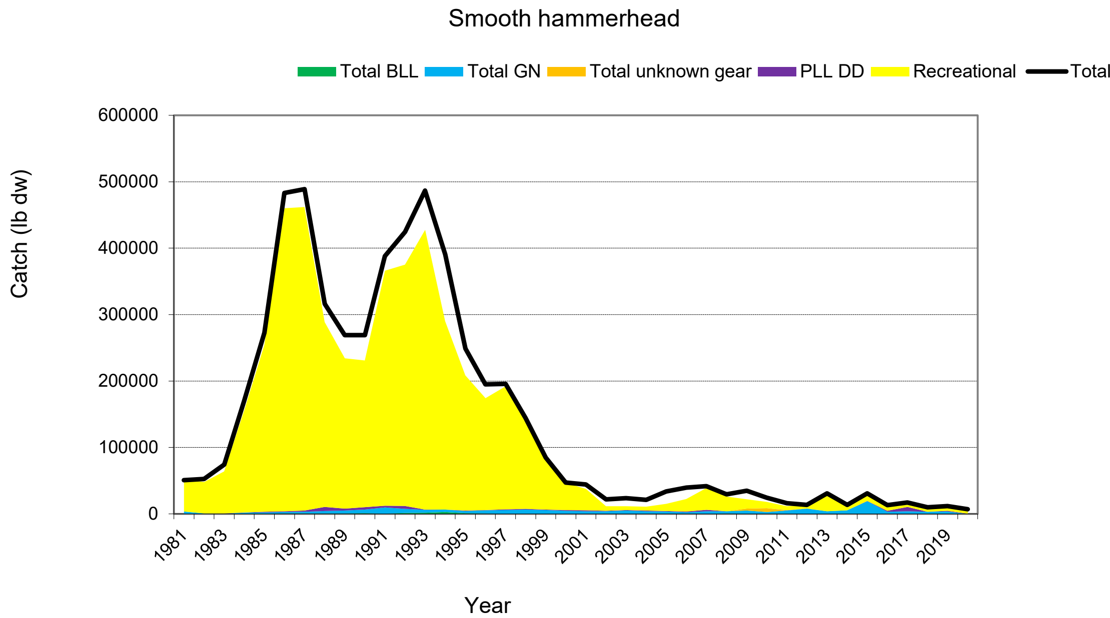



**Figure 51.** Commercial catches and smoothed recreational catches of great hammerheads in weight (lb dw), 1981-2020. Top panel: stacked catches by year; bottom panel: proportions by year.



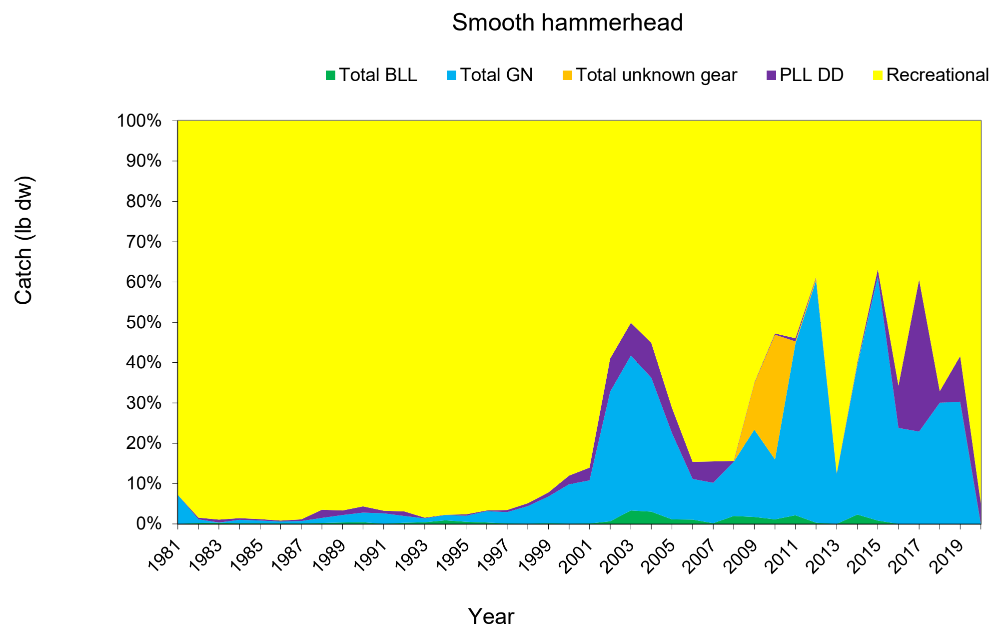




**Figure 52.** Commercial catches and smoothed recreational catches of smooth hammerheads in weight (lb dw), 1981-2020. Top panel: stacked catches by year; bottom panel: proportions by year

# 4. Indices of Population Abundance

## 4.1 Overview

During the initial webinars for SEDAR77, data sources were preliminary examined in terms of their usefulness in developing an index of abundance. Thirty-one (31) data sources were initially considered for use in developing indices of abundance (Table 1). No data sources were considered for Carolina hammerhead due to the difficulty in differentiating the species in the field without genetic analysis. Indices were constructed using both scientific survey and fishery-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 were fishery-dependent or from a scientific survey, the data were standardized using a form of the generalized linear model (Aitchison, 1955). In some cases, scalloped hammerhead datasets were subset to create an Age 0 complex (61 cm FL, young-of-the-year, SEDAR77-DW) and an Age 1+ complex (62 cm FL and greater, juvenile to adult, SEDAR77-DW) to facilitate the creation of recruitment indices (Age 0). The delta-lognormal modeling methods were the most often used to estimate relative abundance indices for great and scalloped hammerheads (Pennington, 1983; Bradu and Mundlak, 1970). The main advantage of using this method is allowance for the probability of zero catch (Ortiz et al., 2000). Elements considered for each data series ranged from the statistical diagnostics of the analysis to the temporal and spatial coverage of the index (Table 2). The Group also used a flowchart developed by ICCAT in its decision-making process (Figure 1). In previous SEDARs for sharks, the indices working group ranked indices on a scale of 1-5 as a means of attributing relative weights for the stock assessment. As was done at SEDAR65, the Group discussed that there is likely little difference among several of the categorical designations and decided to drop that method and to 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.

Group Membership

John Carlson, (Leader)…..……………………………NOAA Fisheries Service- Panama City, FL
Cami McCandless (Co-Leader)…..…………..………NOAA Fisheries Service, Narragansett, RI
Elizabeth Babcock………………………..Rosenstiel School of Marine and Atmospheric Science
Dean Courtney……………………………………..NOAA Fisheries Service- Panama City, FL
J. Marcus Drymon………………………………………………… Mississippi State University
R. Dean Grubbs………………………………………………...………Florida State University Neil
Hammerschlag………………………Rosenstiel School of Marine and Atmospheric Science
Eric Hoffmayer…………………………………….….NOAA Fisheries Service- Pascagoula, MS Andrea
Kroetz……………………………………..NOAA Fisheries Service- Panama City, FL
Robert J Latour……………………………………..............Virginia Institute of Marine Science Adam
Pollack……………………………………....NOAA Fisheries Service- Pascagoula, MS

## 4.2 Review Of Indices –Scalloped Hammerhead-

### 4.2.1 Fishery-Dependent Indices

*Pelagic Longline Observer Program (SEDAR77-DW08)*

In 1992, the National Marine Fisheries Service (NMFS) initiated scientific sampling of the U.S. large pelagic fisheries longline fleet, as mandated by the U.S. Swordfish Fisheries Management Plan and subsequently the Atlantic Highly Migratory Species Fishery Management Plan (1998). Scientific observers were placed aboard vessels participating in the Atlantic pelagic longline fishery. Relative abundance indices from data collected by observers have been previously developed and used in a variety of assessments of pelagic species primarily under the auspices of the International Commission for the Conservation of Atlantic Tunas (ICCAT). A data set was developed based on the observer programs as described in Beerkircher et al. (2002) and Cortés et al. (2007). Following recommendations of the stock identification workshop, separate indices were evaluated for the three putative scalloped hammerhead stocks defined in the stock identification workshop by the geographic region: (1) the Atlantic Ocean and Gulf of Mexico regions combined (base); (2) the Atlantic Ocean region alone (sensitivity); and (3) the Gulf of Mexico region alone (sensitivity). However, it was not possible to develop and index for the Gulf of Mexico region alone because the model would not converge with only Year as a covariate. For the Atlantic Ocean and Gulf of Mexico regions combined (base) and the Atlantic Ocean region alone (sensitivity) the CPUE was standardized using generalized linear mixed 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 (Lo et al. 1992).

**Decision: The Group determined that because this series is stock wide and used in previous stock assessments for other pelagic species, the series should be retained for use in the scalloped hammerhead stock assessment base model. The recommendation is for Age 1+ scalloped hammerhead stocks in the Atlantic Ocean and Gulf of Mexico regions combined (Base; Tables 3 and 5) and the Atlantic Ocean region (Sensitivity; Tables 3 and 6). There was discussion relative to the initial abundance in 1992 being much higher than the remainder of the series. It was noted that this high value was also found for other species (e.g. shortfin mako) and as there was no obvious explanation, the data point was retained in the time series.**

*Shark Bottom Longline Observer Program and Shark Research Fishery (SEDAR77-DW12)*

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 combined data set was developed based on observer programs from Morgan et al. (2009) and Mathers et al. (2018). 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 2008-2019 for vessels in the research fishery. The time series covers a broad area (North Carolina to eastern Gulf of Mexico) over a long temporal period (1993-2019). Following recommendations of the stock identification workshop, separate indices were evaluated for the three putative scalloped hammerhead stocks defined in the stock identification workshop by the geographic region: (1) the Atlantic Ocean and Gulf of Mexico regions combined (base); (2) the Atlantic Ocean region alone (sensitivity); and (3) the Gulf of Mexico region alone (sensitivity). For each region, the CPUE was standardized using generalized linear mixed 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 (Lo et al. 1992).

**Decision: The Group determined that because this series is stock wide and used in previous stock assessments for sharks, the series should be retained for use in the scalloped hammerhead stock assessment base model. The recommendation is for Age 1+ scalloped hammerhead stocks in the Atlantic Ocean and Gulf of Mexico regions combined (Base; Tables 3 and 5), the Atlantic Ocean region (Sensitivity; Tables 3 and 6), and the Gulf of Mexico region (Sensitivity; Tables 3 and 7) including both the non-research (≤ year 2007) and the research (≥ year 2008) time series in each region.**

*Southeast Coastal Gillnet Observer Program (SEDAR77-DW13)*

Observer coverage of the Florida-Georgia shark gillnet fishery began in 1992, and has since documented the many changes to effort, gear characteristics, and target species the fishery has undergone following the implementation of multiple fisheries regulations. In 2005, the gillnet observer program was expanded to include all vessels that have an active directed shark permit and fish with sink gillnet gear. These vessels were not previously subject to observer coverage because they either were targeting non-highly migratory species or were not fishing gillnets in a drift or strike fashion. In 2006, the National Marine Fisheries Service Southeast Regional Office requested further expansion of the scope of the gillnet observer program to include all vessels fishing gillnets regardless of target, and for coverage to be extended to cover the full geographic range of gillnet fishing effort in the southeast United States. Based on these regulations and on current funding levels, the gillnet observer program now covers all anchored (sink, stab, set), strike, or drift gillnet fishing by vessels that fish from Florida to North Carolina and the Gulf of Mexico year-round. Following recommendations of the stock identification workshop, separate indices were evaluated for the three putative scalloped hammerhead stocks defined in the stock identification workshop by the geographic region: (1) the Atlantic Ocean and Gulf of Mexico regions combined (base); (2) the Atlantic Ocean region alone (sensitivity); and (3) the Gulf of Mexico region alone (sensitivity). However, abundance trends were not developed specific to the Gulf of Mexico due to low proportion positives. For the Atlantic Ocean and Gulf of Mexico regions combined (base) and the Atlantic Ocean region alone (sensitivity) the CPUE was standardized using generalized linear mixed 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 (Lo et al. 1992).

**Decision: The Group determined that because this series is stock wide and used in previous stock assessments for sharks, the series should be retained for use in the scalloped hammerhead stock**

**assessment. However, given the higher CVs and the presence of other indices it was recommended this time series be used as a sensitivity. The recommendation is for use as an additional sensitivity analysis of Age 1+ scalloped hammerhead stocks in the Atlantic Ocean and Gulf of Mexico regions combined (Sensitivity; Tables 3 and 8), and the Atlantic Ocean region alone (Sensitivity; Tables 3 and 8).**

### 4.2.2 Scientific Survey Indices

*Dauphin Island Sea Laboratory Bottom Longline Survey (SEDAR77-DW06)*

Scalloped hammerheads (*Sphyrna lewini*) are a common shelf-associated shark off the coast of Alabama. From May 2006 to October 2019, 230 scalloped hammerheads were captured during 1311 fisheries-independent bottom longline sets. Trends in catch by sex were examined and catch data were standardized using a negative binomial generalized linear model to create a standardized index of relative abundance. Males were significantly larger and more abundant than females and few females larger than 175 cm stretch total length were caught. The standardized index of relative abundance indicated that the relative abundance of scalloped hammerheads in the sampling region has remained relatively stable over the past 14 years.

**Decision: The Group determined that because this series covers a relatively long time period, the series should be retained for use in the scalloped hammerhead stock assessment. However, given that the time series is limited spatially (only off the coast of Alabama) and it overlaps with the SEFSC bottom longline survey (SEDAR77-DW24), it was recommended that this time series be used as a sensitivity. The recommendation is for Age 1+ scalloped hammerhead stocks in the Gulf of Mexico region alone (Tables 3 and 8).**

*Florida State University Bottom Longline Survey (SEDAR77-DW14)*

The Florida State University longline survey was expanded in 2011 to include regular sampling in southwest Florida in an effort to capture smalltooth sawfish for research directed at promoting recovery of this endangered species. This work is concentrated in two areas, in Everglades National Park, mostly in northern Florida Bay, along the middle to lower Florida Keys, primarily along the shelf break. Along the Florida Keys, scalloped and great hammerhead sharks are among the most frequently encountered species in this survey. The FSU survey targets coastal sharks and smalltooth sawfish using fishery-independent longlines consisting of a 4.0 mm monofilament main line that is anchored on each end and marked with a surface buoy bearing the permit numbers. Each mainline set was approximately 750 m long. A standard set included 50 or 100 gangions consisting of a stainless-steel tuna clip with an 8/0 stainless steel swivel attached to 2.5 m of 300 kg monofilament that was doubled in the terminal 25 cm and attached to 16/0 non-offset circle hook. Hooks were baited with ladyfish *Elops saurus* or Spanish mackerel *Scomberomorus maculatus*. Depth (m), turbidity (cm), water temperature (°C), salinity, and dissolved oxygen (mg $l^{-1}$) were recorded from the surface to the bottom for all sets made in depths of less than 10 m, and bottom water temperature (°C) was recorded for those greater than 10 m deep. Targeted soak times were 1 h to minimize mortality, and all lines were set during daylight hours. The line was hauled in the order and direction it was set and teleosts and elasmobranchs were sampled as they were caught during retrieval. Areas sampled included the Atlantic side of the Florida Keys from Key West to Islamorada and inside ENP from Florida Bay north to Ponce de Leon Bay. The CPUE was standardized using generalized linear mixed 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 (Lo et al. 1992).

**Decision: The series covers a proportion of the stock not sampled by other surveys. The initial analysis of these data resulted in high CVs and a low proportion positive. The Group decided that a post-analysis be conducted on a subset of data based on habitat. Data were refined and post-analysis conducted on a subset of data to reduce true zeros from areas where hammerheads would never or rarely be available. The revised indices were recommended for use in the scalloped hammerhead stock assessment base model. The recommendation is for Age 1+ scalloped hammerhead stocks in the Atlantic Ocean and Gulf of Mexico regions combined (Base; Tables 3 and 5) and the Gulf of Mexico region alone (Sensitivity; Tables 3 and 7).**

*NOAA Fisheries-Southeast Fisheries Science Center- Bottom Longline Survey (SEDAR77-DW24)*

The Southeast Fisheries Science Center Mississippi Laboratories (MSLABS) has conducted standardized bottom longline surveys in the Gulf of Mexico (GOM), Caribbean, and Western North Atlantic Ocean (Atlantic) since 1995. Additionally, in 2011 the Congressional Supplemental Sampling Program (CSSP) was conducted, where high levels of standardized bottom longline survey effort were maintained from April through October. Data from the MSLABS Bottom Longline Survey and the CSSP Survey were used to produce a relative abundance index for scalloped hammerhead (*Sphyrna lewini*) and great hammerhead (*Sphyrna mokarran*). One abundance index was calculated for great hammerhead that included data from both the GOM and Atlantic. Following recommendations of the stock identification workshop, separate indices were evaluated for the three putative scalloped hammerhead stocks defined in the stock identification workshop by the geographic region: (1) the Atlantic Ocean and Gulf of Mexico regions combined (base); (2) the Atlantic Ocean region alone (sensitivity); and (3) the Gulf of Mexico region alone (sensitivity). Delta-lognormal modeling methods were used to estimate relative abundance indices for great and scalloped hammerheads. All age 0 scalloped hammerhead (FL < 61 cm) were removed when building the dataset for the abundance indices.

**Decision: The Group determined that because this series is stock wide and used in previous stock assessments for sharks, the series should be retained for use in the scalloped hammerhead stock assessment base model. The recommendation is for Age 1+ scalloped hammerhead stocks in the Atlantic Ocean and Gulf of Mexico regions combined (Base; Tables 3 and 5), the Atlantic Ocean region alone (Sensitivity; Tables 3 and 6), and the Gulf of Mexico region alone (Sensitivity; Tables 3 and 7).**

*NOAA Northeast Fisheries Science Center coastal shark bottom longline survey (SEDAR77-DW28)*

This document details scalloped hammerhead shark catches from the Northeast Fisheries Science Center (NEFSC) coastal shark bottom longline survey conducted by the Apex Predators Program from 1996-2018. Data from this survey were used to examine the trends in relative abundance in the waters off the east coast of the United States. Catch per unit effort (CPUE) in number of sharks per 100 hook hours were 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 mixed 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 increasing trend in scalloped hammerhead shark relative abundance across the survey years from 1996 to 2018.

**Decision: The initial standardized CPUE results showed an increasing trend in scalloped hammerhead shark relative abundance across the survey years from 1996 to 2018. This result is not supported by the life history of the species, particularly the large increase in the final years of the survey. Following SEDAR 77 panel feedback, additional analyses were undertaken that modified the spatial coverage of the survey (excluding non-repeated stations and excluding areas), modified model development (excluding year until all covariates were incorporated), and incorporating habitat suitability. Although some improvements were seen in model fit, diagnostics, and estimated trends, these models still seemed to be driven by the year effect and/or overinflated some estimates (habitat suitability weighting). Therefore, resulting indices from these analyses for the NEFSC coastal shark bottom longline survey are not recommended for use in the SEDAR 77 assessment for scalloped hammerhead sharks at this time. However, during the final post- Data Workshop webinar it was decided that spatiotemporal modelling should be investigated and results reviewed during the first Assessment Workshop webinar for potential incorporation into the assessment as a recommended index or in a sensitivity run if recommended for inclusion by the Assessment Workshop panel.**

*Texas Parks and Wildlife Gillnet Survey (SEDAR77-DW16)*

This paper determines a relative abundance index for young-of-the-year scalloped hammerhead sharks utilizing a scientific survey gillnet survey by the Texas Parks and Wildlife Department, Coastal Fisheries Division. The protocol for the survey, as it is constituted today, has been standardized since 1982 with the purpose of monitoring relative abundance and size of organisms, their spatial and temporal distribution, and species composition of the community and selected environmental parameters known to influence their distribution and abundance. Surveys were conducted in 10 major bay systems along the Texas coast in the northwestern Gulf of Mexico from 1982 to 2019. The CPUE was standardized using generalized linear mixed 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 (Lo et al. 1992).

**Decision: Although the proportion positive was low for scalloped hammerhead, the Group noted the temporal and spatial coverage of the series (1982-2019; entire Texas coast). As the survey**

**largely catches only juveniles, the series was recommended for use in the scalloped hammerhead stock assessment base model as a potential recruitment series (Age 0). The recommendation is for Age 0 scalloped hammerhead stocks in the Atlantic Ocean and Gulf of Mexico regions combined (Base; Tables 3 and 9) and Gulf of Mexico region alone (Sensitivity; Tables 3 and 9).**

*Northeast Gulf of Mexico (GULFSPAN) Gillnet Survey (SEDAR77-DW17)*

Fishery-independent surveys of coastal shark populations have taken place since 1994 in the eastern and northern Gulf of Mexico. The cooperative Gulf of Mexico Shark Pupping and Nursery (GULFSPAN) survey began in 1996 to examine the distribution and abundance of juvenile sharks in coastal areas. The ultimate intent of this survey is to continue to describe and further refine shark essential fish habitat as mandated by the Magnuson-Steven Fishery Conservation and Management Act. NOAA Fisheries Panama City Laboratory oversees the survey. In 2003, Gulf Coast Research Laboratory at the University of Southern Mississippi was added to the survey. In 2007, additional participants included the Florida Natural History Museum at the University of Florida and Dauphin Island Sea Laboratory at the University of South Alabama. In 2008, the Florida State University Coastal and Marine Laboratory became a collaborator. In 2016 and 2017, New College of Florida and Havenworth Coastal Conservation became collaborators in the GULFSPAN project, respectively. Preliminary examination of the data indicated the occurrence of scalloped hammerhead was highest in the northern Gulf of Mexico for the NOAA and University of Southern Mississippi surveys. While the other surveys did capture scalloped hammerhead, the frequency of capture (<1%) was too low to develop a reliable index and these surveys were excluded. The CPUE was standardized using generalized linear mixed 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 (Lo et al. 1992).

**Decision: The survey has been used in previous shark assessments. As the survey largely catches only juveniles, the series was recommended for use in the scalloped hammerhead stock assessment base model as a potential recruitment series (Age 0). The recommendation is for Age 0 scalloped hammerhead stocks in the Atlantic Ocean and Gulf of Mexico regions combined (Base; Tables 3 and 9) and Gulf of Mexico region alone (Sensitivity; Tables 3 and 9).**

*Cooperative Atlantic States Shark Pupping and Nursery longline survey (SEDAR77-DW30)*

This document details the shark catches from the Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) longline surveys conducted in estuarine and nearshore waters from South Carolina to northern Florida. Catch per unit effort (CPUE) in number of sharks per 100 hook hours were used to examine young-of-the-year scalloped hammerhead shark relative abundance from 2005-2019. The CPUE was standardized using 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 index of abundance from the COASTSPAN longline survey shows an overall decreasing trend in in relative abundance for YOY scalloped hammerhead across survey years.

**Decision: The survey has been used in previous shark assessments. As the survey largely catches only juveniles, the series was recommended for use in the scalloped hammerhead stock assessment base model as a potential recruitment series (Age 0). The recommendation is for Age 0 scalloped hammerhead stocks in the in the Atlantic Ocean and Gulf of Mexico regions combined (Base; Tables 3 and 9) and Atlantic region alone (Sensitivity; Tables 3 and 9).**

*South Carolina Department of Natural Resources, Cooperative Atlantic States Shark Pupping and Nursery long-gillnet survey (SEDAR77-DW31)*

This document details scalloped hammerhead shark catches from the South Carolina Department of Natural Resources (SCDNR), Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) long-gillnet survey (2001-2019). Catch per unit effort (CPUE) in number of sharks per net hour were used to examine young-of-the-year (YOY) scalloped hammerhead shark relative abundance in South Carolina's estuarine 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. Nominal and standardized CPUE results from the COASTSPAN long-gillnet survey indicate a slight increasing trend in YOY scalloped hammerhead relative abundance across survey years.

**Decision: Although the survey is limited spatially, it has been used in previous shark assessments. As the survey largely catches only juveniles, the series was recommended for use in the scalloped hammerhead stock assessment base model as a potential recruitment series (Age 0). The recommendation is for Age 0 scalloped hammerhead stocks in the Atlantic Ocean and Gulf of Mexico regions combined (Base; Tables 3 and 9) and Atlantic region alone (Sensitivity; Tables 3 and 9).**

*South Carolina Department of Natural Resources, Cooperative Atlantic States Shark Pupping and Nursery short-gillnet survey (SEDAR77-DW32)*

This document details scalloped hammerhead shark catches from the South Carolina Department of Natural Resources (SCDNR), Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) short-gillnet survey (2007-2019). Catch per unit effort (CPUE) in number of sharks per net hour were used to examine the young-of-year (YOY) scalloped hammerhead sharks trend in South Carolina estuaries for use as a recruitment index in the SEDAR 77 stock assessment. The CPUE was standardized using generalized linear mixed 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. Nominal and standardized CPUE results from the COASTSPAN short-gillnet survey indicate an overall decreasing trend in YOY scalloped hammerhead shark relative abundance during the survey years.

**Decision: Although the survey is limited spatially and contained missing years, it has been used in previous shark assessments. As the survey largely catches only juveniles, the series was recommended for use in the scalloped hammerhead stock assessment base model as a potential recruitment series (Age 0). The recommendation is for Age 0 scalloped hammerhead stocks in the Atlantic Ocean and Gulf of Mexico regions combined (Base; Tables 3 and 9) and Atlantic region alone (Sensitivity; Tables 3 and 9).**

*Standardized index of abundance for scalloped hammerhead sharks from the University of North Carolina shark longline survey south of Shakleford Banks (SEDAR77-DW33)*

This document details the scalloped hammerhead catch from April-November, 1981-2019, at two fixed stations in Onslow Bay south of Shackleford Banks, North Carolina. Catch per unit effort (CPUE) by set in number of sharks per number of set hooks were examined by year. The CPUE was standardized using 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 majority of catches occurred during April and early May (82%), which were not consistently sampled across years due to weather and logistical constraints. The standardized relative abundance for scalloped hammerhead sharks shows a variable but overall decreasing trend through the early 1990s followed by an increasing trend throughout the remainder of the time series.

**Decision: The survey is limited spatially but is long term and began in 1981. However, in many years the catches are very low (0-3) which suggests it may not be a good survey for tracking abundance. However, the time series has been used in previous shark assessments (blacknose shark) and the Group agreed that the series should be retained for use in the scalloped hammerhead stock assessment, but it was recommended that this time series be used as a sensitivity. The recommendation is for Age 1+ scalloped hammerhead Atlantic Ocean and Gulf of Mexico regions combined and in the Atlantic region (Table 6).**

### 4.2.3 Summary-Scalloped Hammmerhead

The geographic coverage of the abundance indices for scalloped hammerhead shark are in Figures 2-6 and plots of the relative indices (index/mean index of the time series) by year are in Figures 7-11. The Indices Working Group recommends compiling indices for use in stock assessment consistent with scalloped hammerhead Stock ID Workshop recommendations to separate indices for the three putative scalloped hammerhead stocks defined in the stock identification workshop by the geographic region: (1) the Atlantic Ocean and Gulf of Mexico regions combined (base); (2) the Atlantic Ocean region alone (sensitivity); and (3) the Gulf of Mexico region alone (sensitivity):

1. Compile indices for a base model in the Atlantic Ocean and Gulf of Mexico regions combined from the recommended scalloped hammerhead stock assessment indices as follows:

   a. Include each recommended stock wide Age 1+ index (Tables 3 and 5); and

   b. Include each recommended regional Age 0 index (Tables 3 and 9) as a potential recruitment index within the base model.

2. Compile indices for an Atlantic region sensitivity model from the recommended scalloped hammerhead stock assessment indices as follows:

a. Include each recommended regional Age 1+ index (Tables 3 and 6), from the Atlantic region within the Atlantic region model; and

b. Include each recommended regional Age 0 index from the Atlantic region (Tables 3 and 9) as a potential recruitment index within the Atlantic region model.

3. Compile indices for a Gulf of Mexico region sensitivity model from the recommended scalloped hammerhead stock assessment indices as follows:

a. Include each recommended regional Age 1+ index (Tables 3 and 7), from the Gulf of Mexico region within the Gulf of Mexico region model; and

b. Include each recommended regional Age 0 index from the Gulf of Mexico region (Tables 3 and 9) as a potential recruitment index within the Gulf of Mexico region model.

4. Compile additional recommended indices of abundance for Age 1+ scalloped hammerhead sensitivity analysis as described in Tables 3 and 8.

## 4.3 Review Of Indices –Great Hammerhead

### 4.3.1 Fishery-Dependent Indices

*Shark Bottom Longline Observer Program (SEDAR77-DW12)*

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 combined data set was developed based on observer programs from Morgan et al. (2009) and Mathers et al. (2018). 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 2008-2019 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 eastern Gulf of Mexico) over a long temporal period (1993-2019). The CPUE was standardized using generalized linear mixed 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 (Lo et al. 1992).

**Decision: The Group determined that because this series is stock wide and used in previous stock assessments for sharks, the series should be retained for use in the stock assessment. The recommendation is for the stock wide great hammerhead stock assessment base run (Table 10), including both the non-research (≤ year 2007) and the research (≥ year 2008) time series.**

### 4.3.2 Scientific Survey Indices

*Florida State University Bottom Longline Survey (SEDAR77-DW14)*

The Florida State University longline survey was expanded in 2011 to include regular sampling in southwest Florida in an effort to capture smalltooth sawfish for research directed at promoting recovery of this endangered species. This work is concentrated in two areas, in Everglades National Park, mostly in northern Florida Bay, along the middle to lower Florida Keys, primarily along the shelf break. Along the Florida Keys, scalloped and great hammerhead sharks are among the most frequently encountered species in this survey. The FSU survey targets coastal sharks and smalltooth sawfish using fishery-independent longlines consisting of a 4.0 mm monofilament main line that is anchored on each end and marked with a surface buoy bearing the permit numbers. Each mainline set was approximately 750 m long. A standard set included 50 or 100 gangions consisting of a stainless steel tuna clip with an 8/0 stainless steel swivel attached to 2.5 m of 300 kg monofilament that was doubled in the terminal 25 cm and attached to 16/0 non-offset circle hook. Hooks were baited with ladyfish *Elops saurus* or Spanish mackerel *Scomberomorus maculatus*. Depth (m), turbidity (cm), water temperature (°C), salinity, and dissolved oxygen (mg $l^{-1}$) were recorded from the surface to the bottom for all sets made in depths of less than 10 m, and bottom water temperature (°C) was recorded for those greater than 10 m deep. Targeted soak times were 1 h to minimize mortality, and all lines were set during daylight hours. The line was hauled in the order and direction it was set and teleosts and elasmobranchs were sampled as they were caught during retrieval. Areas sampled included the Atlantic side of the Florida Keys from Key West to Islamorada and inside ENP from Florida Bay north to Ponce de Leon Bay. The CPUE was standardized using generalized linear mixed 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 (Lo et al. 1992).

**Decision: The initial analysis of these data resulted in high CVs and a low proportion positive. The Group decided that a post-analysis be conducted on a subset of data based on habitat (i.e. samples were only included if they represented habitat where great hammerheads would be expected to be found) to reduce true zeros from areas where hammerheads are not available. The revised indices were recommended for use in the stock wide great hammerhead stock assessment base run (Table 10).**

*Rosenstiel School of Marine and Atmospheric Science Drumline Survey (SEDAR65-DW15)*

Shark surveys were conducted year-round, encompassing Florida's wet season (May-October) and dry season (November – April). Shark surveys in the Keys region predominately occurred between January 2009 and December 2013, whereas surveys in the Miami region primarily occurred between April 2014 and February 2021. Daily sampling locations were selected randomly within inshore or offshore habitats. Sharks were surveyed using a standardized and minimally invasive drumline fishing method as described in Gallagher et al. (2014). The fishing gear consisted of a submerged 20-kg weight tied to a line running to the surface by means of an attached inflatable buoy. A 23-m monofilament ganglion line (~400 kg test) was attached to the submerged weight by a swivel, which terminated at a baited 16/0 5°-offset circle hook. Two sets of five baited drumlines were deployed and hooks were baited with a standardized type of cut fish, primarily great barracuda (*Sphyrna barracuda*) and false albacore (*Euthynnus alletteratus*), and to a lesser degree ladyfish (*Elops saurus*), greater amberjack (*Seriola dumerili*) and jack crevalle (*Caranx hippos*). Each drumline within a set was separated by ~100 m. Catch per unit effort were calculated by dividing the number of hammerheads captured by the total soak time of the 10 drumlines deployed at a specific site on a given day. Data were analyzed using the gamlss R package with a negative binomial distribution. Model covariates including month, region (Keys vs Miami), Habitat (Bay vs Ocean), Season (Wet vs Dry) and Latitude and Longitude. Soak Time was included as an offset in the model

**Decision: Similar to the Florida State University longline series, the initial analysis of these data resulted in high CVs and a low proportion positive. The Group decided that a post-analysis be**

**conducted on subset of data based on habitat (i.e. samples were only included if they represented habitat where great hammerheads would be expected to be found) to reduce true zeros from areas where hammerheads are not available. The revised indices were recommended use in the for stock wide great hammerhead stock assessment base run (Table 10).**

*NOAA Fisheries-Southeast Fisheries Science Center- Bottom Longline Survey (SEDAR77-DW24)*

The Southeast Fisheries Science Center Mississippi Laboratories (MSLABS) has conducted standardized bottom longline surveys in the Gulf of Mexico (GOM), Caribbean, and Western North Atlantic Ocean (Atlantic) since 1995. Additionally, in 2011, the Congressional Supplemental Sampling Program (CSSP) was conducted, where high levels of standardized bottom longline survey effort were maintained from April through October. Data from the MSLABS Bottom Longline Survey and the CSSP Survey were used to produce a relative abundance index for scalloped hammerhead (*Sphyrna lewini*) and great hammerhead (*Sphyrna mokarran*). One abundance index was calculated for great hammerhead that included data from both the GOM and Atlantic. Three abundance indices were calculated for scalloped hammerhead, with one covering both the GOM and Atlantic, and with the other two covering the GOM and Atlantic separately. The CPUE was standardized using generalized linear mixed 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 (Lo et al. 1992).

**Decision: The Group determined that because this series is stock wide and used in previous stock assessments for sharks, the series should be retained for use in the stock assessment. The recommendation is for use in the stock wide great hammerhead stock assessment base run (Table 10).**

*SEAMAP Bottom Longline Survey (SEDAR77-DW25)*

A combined index of great hammerhead abundance from scientific survey bottom longline (BLL) surveys conducted in coastal waters of the northern Gulf of Mexico was generated using Southeast Area Monitoring and Assessment Program (SEAMAP) BLL (AL-TX, 2008-2019) and Dauphin Island Sea Lab BLL (2006-2019) data. Both BLL surveys used the same gear, bait, and identical deployment protocols. Due to a change in survey design of the SEAMAP BLL survey, which started sampling exclusively in waters between 3-10m in 2015 to complement the NMFS bottom longline survey and the fact that the majority of the great hammerhead sharks were caught in shallow waters (<15m), the datasets were truncated to include only stations that occurred in less than 15 m of water. The index extends from 2006 to 2019, and resulted in 85 great hammerheads captured during 1,279 BLL sets. Standardized catch rates were estimated using a delta-lognormal modeling method. Nominal and standardized great hammerhead catch rates remained relatively stable throughout the survey period.

**Decision: The Group recommended that this series be retained for use in the assessment. It was noted that the time series represents sampling with the spatial distribution of great hammerhead where there are few indices. The recommendation is for use in the stock wide great hammerhead stock assessment base run (Table 9).**

### 4.3.3 Summary-Great Hammerhead

The geographic coverage of the abundance indices for great hammerhead shark are in Figure 12 and plots of the relative indices (index/mean index of the time series) by year are in Figures 13. The Indices Working Group recommends compiling indices for use in stock assessment consistent with great hammerhead Stock ID Workshop recommendations:

1. Compile indices for a base model from the recommended great hammerhead stock assessment indices as follows:

    a. Include each recommended stock wide Age 1+ index (Table 10) within the base model.

## 4.4 Review Of Indices –Smooth Hammerhead

During the initial webinars for SEDAR77, data sources were preliminary examined in terms of their usefulness in developing an index of abundance for smooth hammerhead. Two data sources were identified; the pelagic longline observer program and the personal logbooks of a recreational charter Captain, Mark Sampson, which are being archived in a database at Maryland Department of Natural Resources. While data from the pelagic longline observer program was previously analyzed in Jiao et al. (2011), the initial analysis noted a very low proportion positive (<1%) and many years with no (0) catches of smooth hammerhead. Therefore, the data were deemed not to be useful for describing the abundance of smooth hammerhead. The initial examination of the data provided by Maryland Department of Natural Resources was incomplete due to issues related to COVID. The data that were provided had covariates with multiply levels (e.g trip type had over 70 levels) that would be difficult to refine without considerable work. While the data series has great promise, it will require much more time and resources to understand the data. It was suggested this data source be examined in the future as a potential thesis project for a student.

## 4.5 Review Of Indices –Carolina Hammerhead

During the initial webinars for SEDAR77, it was determined that without genetic verification it would not be possible to separate catches of Carolina hammerhead from scalloped hammerhead when trying to derive indices of abundance. Therefore, no indices are currently available for Carolina hammerhead.

## 4.6 Research Recommendations

1. During the assessment process, explore the utility of combining multiple indices into one scalloped hammerhead index using the Bayesian hierarchical model (Conn, 2009) or Dynamic Factor Analysis (Peterson et al., 2017). The data series that could potentially be combined as a recruitment index are Texas Parks and Wildlife gillnet series, Gulfspan gillnet series, South Carolina Coastspan Gillnet Long and Short Series and the Coastspan Longline Series.

2. Examine the utility of spatiotemporal modelling as a way to improve the indices of abundance for the NEFSC longline survey.

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## 4.8 Tables

**Table 1.** Data sources initially examined as potential indices of abundance for hammerhead sharks. Area(s)=the area the data source covered following recommendations from the stock identification process for all hammerheads.

| Data source | Area(s) | Hammerhead Species Considered | Further develop as an index | Factors for not developing as an index |
|---|---|---|---|---|
| Shark bottom longline observer program and shark research fishery | All | Scalloped/Great | Yes | |
| | | | | |
| Southeast gillnet observer program | All | Scalloped | Yes | |
| | Gulf of Mexico | Scalloped | No | Low catches |
| | Atlantic | Scalloped | Yes | |
| | All | Great | No | Low catches |
| | | | | |
| Pelagic longline observer program | All | Scalloped | Yes | |
| | All | Smooth | No | Low proportion positive, No catches in many years |
| | | | | |
| SEFSC Bottom Longline Survey | All | Great/Scalloped | Yes | |
| | | | | |
| Texas Parks and Wildlife Gillnet | All/Gulf of Mexico | Scalloped | Yes | |
| Everglades National Park Creel Census | Gulf of Mexico | Scalloped | No | Low catches, species identification |
| | | | | |
| Mote Marine Laboratory Longline | Gulf of Mexico | Great/Scalloped | No | Low catches |
| | | | | |
| Mote Drumline Survey | Gulf of Mexico | Great | No | Low catches |
| | | | | |

**Table 1 Continued:** Data sources initially examined as potential indices of abundance for hammerhead sharks. Area(s)=the area the data source covered following recommendations from the stock identification process for all hammerheads.

| | | | | |
|---|---|---|---|---|
| Dauphin Island Sea Laboratory Longline Survey | All/Gulf of Mexico | Scalloped | Yes | |
| | | | | |
| GULFSPAN Gillnet Series | All/Gulf of Mexico | | | |
| NMFS-Panama City | | Scalloped | Yes | |
| Mote Marine Laboratory | | Great/Scalloped | No | Low catches; Limited temporally |
| Havenworth Consulting | | Scalloped | No | Low catches; Limited temporally |
| Florida State University | | Scalloped | No | Low catches |
| New College | | Scalloped | No | Low catches; Limited temporally |
| Gulf Coast Research Laboratory | | Scalloped | Yes | |
| | | | | |
| Virginia Institute of Marine Science Longline | Atlantic | Scalloped | No | Low catches |
| | | | | |
| SEAMAP Coastal Bottom Longline | Gulf of Mexico | Scalloped | No | Low catches/Survey(s) already present in the area |
| | All | Great | Yes | |
| | | | | |
| SEAMAP Trawl | Atlantic | Scalloped | No | Low catches |
| | | | | |
| Florida State University Longline Sawfish | All/Gulf of Mexico | Great/Scalloped | Yes | |
| | | | | |
| Mark Sampson Logbook Recreational Series | Atlantic | Scalloped/Smooth | No | Database not complete |
| | | | | |
| Rosenstiel School of Marine and Atmospheric Science Drumline | All | Great | Yes | |
| | | | | |

| **Table 1 Continued:** Data sources initially examined as potential indices of abundance for hammerhead sharks. Area(s)=the area the data source covered following recommendations from the stock identification process for all hammerheads. | | | | |
|---|---|---|---|---|
| Electronic Monitoring of Gulf of Mexico reeffish fishery | Gulf of Mexico | Scalloped | No | Data was preliminary |
| | | | | |
| NEFSC-Bottom Longline Survey | All/Atlantic | Scalloped | Yes | |
| | | Great | No | Low catches |
| | | | | |
| South Carolina SEAMAP longline | Atlantic | Scalloped | No | Low proportion positive, No catches in many years |
| | | | | |
| COASTSPAN Series | | | | |
| Bottom Longline | All/Atlantic | Scalloped | Yes | |
| South Carolina Large Gillnet | All/Atlantic | Scalloped | Yes | |
| South Carolina Small Gillnet | All/Atlantic | Scalloped | Yes | |
| | | | | |
| South Carolina Red Drum Survey | Atlantic | Scalloped | No | Low proportion positive, No catches in many years |
| University North Carolina Longline | All/Atlantic | Scalloped | Yes | |
| GA Seamap Longline | Atlantic | Scalloped | No | Low proportion positive, No catches in many years |
| NEFSC Observer Gillnet | Atlantic | Smooth | No | Low catches |

**Table 2.** 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) |

**Table 3.** Scalloped hammerhead indices recommended by the Indices Working Group, including the corresponding SEDAR document number, the area covered, age class sampled and index type (fishery dependent or scientific survey).

| Index Name | SEDAR Document Number | Area(s) | Age Class | Index Type | Base/Sensitivity |
|---|---|---|---|---|---|
| Pelagic Longline Observer Program | SEDAR77-DW08 | All/Atlantic | Age 1+ | Fishery Dependent | Base/Sensitivity |
| SEFSC Shark Bottom Longline Observer Program | SEDAR77-DW12 | All/Atlantic/Gulf of Mexico | Age 1+ | Fishery Dependent | Base/Sensitivity/Sensitivity |
| Florida State University Longline Survey | SEDAR77-DW14 | All/Gulf of Mexico | Age 1+ | Scientific Survey | Base/Sensitivity |
| Gulfspan Gillnet Survey | SEDAR77-DW17 | All/Gulf of Mexico | Age 0 | Scientific Survey | Base/Sensitivity |
| Texas Parks and Wildlife Gillnet Survey | SEDAR77-DW16 | All/Gulf of Mexico | Age 0 | Scientific Survey | Base/Sensitivity |
| SEFSC Bottom Longline Survey | SEDAR77-DW24 | All/Atlantic/Gulf of Mexico | Age 1+ | Scientific Survey | Base/Sensitivity/Sensitivity |
| COASTSPAN Longline | SEDAR77-DW30 | All/Atlantic | Age 0 | Scientific Survey | Base/Sensitivity |
| SC COASTSPAN Long and Short Gillnet Survey | SEDAR77-DW31 and 32 | All/Atlantic | Age 0 | Scientific Survey | Base/Sensitivity |
| SEFSC Southeast Gillnet Observer Program | SEDAR77-DW13 | All/Atlantic | Age 1+ | Fishery Dependent | Sensitivity/Sensitivity |
| Dauphin Island Sea Laboratory Longline Survey | SEDAR77-DW06 | Gulf of Mexico | Age 1+ | Scientific Survey | Sensitivity |
| University of North Carolina Longline Survey | SEDAR77-DW33 | All/Atlantic | Age 1+ | Scientific Survey | Sensitivity/Sensitivity |

**Table 4.** Great hammerhead indices recommended by the Indices Working Group, including the corresponding SEDAR document number, the area covered, age class sampled and index type (fishery dependent or scientific survey).

| Index Name | SEDAR Document Number | Area(s) | Age Class | Index Type | Base/Sensitivity |
|---|---|---|---|---|---|
| SEFSC Shark Bottom Longline Observer Program | SEDAR77-DW12 | All/ | Age 1+ | Fishery Dependent | Base |
| Florida State University Longline Survey | SEDAR77-DW14 | All | Age 1+ | Scientific Survey | Base |
| SEAMAP Bottom Longline Survey | SEDAR77-DW25 | All | Age 1+ | Scientific Survey | Base |
| Rosenstiel School of Marine and Atmospheric Science Drumline | SEDAR77-DW15 | All/ | Age 1+ | Scientific Survey | Base |
| SEFSC Bottom Longline Survey | SEDAR77-DW24 | All | Age 1+ | Scientific Survey | Base |

**Table 5.** Recommended base stock wide indices of abundance for Age 1+ scalloped hammerhead including index name, the value of catch per unit effort, and SEDAR document number. CV is the coefficient of variation for the annual index value. Missing values in a given year correspond to zero catches (index value of 0 and no CV), where no sampling occurred (ns), or when the model did not converge (nc).

| | Pelagic Longline SEDAR77-DW08 sharks per 1000 hooks | | Shark Bottom Longline SEDAR77-DW12 sharks per 10000 hooks | | Shark Research Fishery SEDAR77-DW12 sharks per 10000 hooks | | FSU Longline SEDAR77-DW14 sharks per 100 hook hour | | SEFSC MS Bottom Longline SEDAR77-DW24 number sharks per hook-hour | |
|---|---|---|---|---|---|---|---|---|---|---|
| year | index | CV | index | CV | index | CV | index | CV | index | CV |
| 1992 | 0.174 | 0.741 | | | | | | | | |
| 1993 | 0.062 | 0.565 | | | | | | | | |
| 1994 | 0.045 | 0.645 | 5.867 | 0.430 | | | | | | |
| 1995 | 0.039 | 0.629 | 8.990 | 0.419 | | | | | 0.081 | 0.337 |
| 1996 | 0.014 | 1.231 | 9.030 | 0.398 | | | | | 0.052 | 0.438 |
| 1997 | 0.070 | 0.729 | 9.015 | 0.503 | | | | | 0.063 | 0.310 |
| 1998 | 0.077 | 0.880 | 12.811 | 0.452 | | | | | ns | |
| 1999 | 0.018 | 1.066 | 3.266 | 0.714 | | | | | 0.050 | 0.339 |
| 2000 | 0.017 | 0.772 | 0.281 | 1.596 | | | | | 0.071 | 0.247 |
| 2001 | 0.052 | 0.807 | 12.125 | 0.447 | | | | | 0.115 | 0.219 |
| 2002 | 0.017 | 1.319 | 16.468 | 0.390 | | | | | 0.093 | 0.177 |
| 2003 | 0.038 | 0.785 | 20.271 | 0.343 | | | | | 0.154 | 0.209 |
| 2004 | 0.035 | 0.772 | 16.563 | 0.378 | | | | | 0.056 | 0.312 |
| 2005 | 0.040 | 0.642 | 6.975 | 0.509 | | | | | 0.112 | 0.475 |
| 2006 | 0.050 | 0.777 | 25.205 | 0.405 | | | | | 0.060 | 0.358 |
| 2007 | 0.049 | 0.591 | 15.530 | 0.562 | | | | | 0.088 | 0.327 |
| 2008 | 0.073 | 0.497 | | | 4.129 | 0.773 | | | 0.095 | 0.372 |
| 2009 | 0.101 | 0.449 | | | 65.590 | 0.331 | | | 0.129 | 0.268 |
| 2010 | 0.084 | 0.488 | | | 46.926 | 0.328 | | | 0.142 | 0.242 |
| 2011 | 0.054 | 0.481 | | | 58.507 | 0.325 | 0.003 | 0.333 | 0.066 | 0.269 |
| 2012 | 0.101 | 0.471 | | | 90.500 | 0.374 | ns | | 0.060 | 0.358 |
| 2013 | 0.046 | 0.458 | | | 53.035 | 0.396 | ns | | 0.061 | 0.312 |
| 2014 | 0.038 | 0.551 | | | 68.047 | 0.358 | 0.001 | 1.147 | 0.079 | 0.337 |
| 2015 | 0.039 | 0.516 | | | 99.944 | 0.371 | 0.006 | 0.468 | 0.157 | 0.219 |
| 2016 | 0.041 | 0.521 | | | 68.444 | 0.360 | 0.004 | 0.777 | 0.094 | 0.295 |
| 2017 | 0.073 | 0.523 | | | 89.840 | 0.361 | 0.009 | 0.271 | 0.126 | 0.243 |
| 2018 | 0.033 | 0.688 | | | 42.589 | 0.395 | 0.003 | 0.656 | 0.094 | 0.275 |
| 2019 | 0.015 | 0.918 | | | 44.341 | 0.387 | 0.002 | 0.796 | 0.118 | 0.294 |

**Table 6.** Recommended indices of abundance for the Atlantic Ocean region of Age 1+ scalloped hammerhead sensitivity analysis including index name, the value of catch per unit effort and SEDAR document number. CV is the coefficient of variation for the annual index value. Missing values in a given year correspond to zero catches (index value of 0 and no CV), where no sampling occurred (ns), or when the model did not converge (nc).

| | Pelagic Longline SEDAR77-DW08 sharks per 1000 hooks | | Shark Bottom Longline SEDAR77-DW12 sharks per 10000 hooks | | Shark Research Fishery SEDAR77-DW12 sharks per 10000 hooks | | SEFSC MS Bottom Longline SEDAR77-DW24 number sharks per hook-hour | |
|---|---|---|---|---|---|---|---|---|
| **year** | **index** | **CV** | **index** | **CV** | **index** | **CV** | **index** | **CV** |
| 1992 | 0.232 | 0.571 | | | | | | |
| 1993 | 0.100 | 0.459 | | | | | | |
| 1994 | 0.087 | 0.517 | 9.514 | 0.350 | | | | |
| 1995 | 0.085 | 0.486 | 11.957 | 0.351 | | | 0.068 | 0.624 |
| 1996 | 0.022 | 0.842 | 12.727 | 0.330 | | | 0.034 | 1.108 |
| 1997 | 0.145 | 0.538 | 6.067 | 0.553 | | | ns | |
| 1998 | 0.130 | 0.608 | 17.577 | 0.308 | | | ns | |
| 1999 | 0.038 | 0.761 | 5.929 | 0.744 | | | ns | |
| 2000 | 0.059 | 0.553 | 0.229 | 1.482 | | | 0.016 | 0.781 |
| 2001 | 0.122 | 0.596 | 16.904 | 0.377 | | | ns | |
| 2002 | 0.041 | 0.884 | 17.461 | 0.366 | | | 0.074 | 0.310 |
| 2003 | 0.069 | 0.632 | 12.811 | 0.333 | | | ns | |
| 2004 | 0.068 | 0.617 | 7.867 | 0.421 | | | ns | |
| 2005 | 0.116 | 0.530 | 11.620 | 0.674 | | | 0.031 | 1.104 |
| 2006 | 0.122 | 0.594 | 63.093 | 0.375 | | | 0.105 | 0.646 |
| 2007 | 0.189 | 0.492 | 21.511 | 0.593 | | | ns | |
| 2008 | 0.095 | 0.543 | | | 0.000 | | 0.149 | 0.527 |
| 2009 | 0.174 | 0.456 | | | 63.443 | 0.427 | 0.194 | 0.623 |
| 2010 | 0.144 | 0.406 | | | 46.747 | 0.255 | 0.229 | 0.408 |
| 2011 | 0.097 | 0.462 | | | 37.435 | 0.271 | 0.135 | 0.492 |
| 2012 | 0.201 | 0.437 | | | 91.472 | 0.304 | 0.064 | 0.783 |
| 2013 | 0.025 | 0.578 | | | 64.498 | 0.438 | 0.100 | 0.636 |
| 2014 | 0.047 | 0.513 | | | 53.727 | 0.287 | 0.060 | 0.665 |
| 2015 | 0.097 | 0.432 | | | 63.541 | 0.348 | 0.236 | 0.370 |
| 2016 | 0.092 | 0.432 | | | 56.871 | 0.315 | 0.036 | 0.777 |
| 2017 | 0.152 | 0.402 | | | 40.475 | 0.368 | 0.091 | 0.549 |
| 2018 | 0.070 | 0.536 | | | 41.877 | 0.368 | 0.055 | 0.642 |
| 2019 | 0.035 | 0.658 | | | 22.889 | 0.504 | 0.120 | 0.552 |

**Table 7.** Recommended indices of abundance for the Gulf of Mexico region of Age 1+ scalloped hammerhead sensitivity analysis including index name, the value of catch per unit effort and SEDAR document number. Missing values in a given year correspond to zero catches (index value of 0 and no CV), where no sampling occurred (ns), or when the model did not converge (nc).

| | Shark Bottom Longline Observer | | Shark Research Fishery | | FSU Longline | | SEFSC MS Bottom Longline | |
|---|---|---|---|---|---|---|---|---|
| | SEDAR77-DW12 | | SEDAR77-DW12 | | SEDAR77-DW14 | | SEDAR77-DW24 | |
| | sharks per 10000 hooks | | sharks per 10000 hooks | | sharks per 100 hook hour | | number sharks per hook-hour | |
| year | index | CV | index | CV | index | CV | index | CV |
| 1994 | 0.727 | 1.100 | | | | | | |
| 1995 | 4.445 | 0.801 | | | | | 0.090 | 0.402 |
| 1996 | 6.603 | 0.621 | | | | | 0.057 | 0.476 |
| 1997 | 23.542 | 0.632 | | | | | 0.086 | 0.306 |
| 1998 | 6.604 | 0.665 | | | | | ns | |
| 1999 | 0.399 | 1.511 | | | | | 0.048 | 0.332 |
| 2000 | ns | | | | | | 0.111 | 0.259 |
| 2001 | 11.066 | 0.628 | | | | | 0.109 | 0.211 |
| 2002 | 14.561 | 0.459 | | | | | 0.080 | 0.241 |
| 2003 | 24.324 | 0.353 | | | | | 0.147 | 0.200 |
| 2004 | 24.302 | 0.344 | | | | | 0.062 | 0.307 |
| 2005 | 3.808 | 0.642 | | | | | 0.145 | 0.525 |
| 2006 | 6.982 | 0.774 | | | | | 0.042 | 0.435 |
| 2007 | 19.646 | 0.796 | | | | | 0.084 | 0.319 |
| 2008 | | | 11.196 | 0.878 | | | 0.082 | 0.522 |
| 2009 | | | 84.325 | 0.260 | | | 0.095 | 0.305 |
| 2010 | | | 41.180 | 0.339 | | | 0.110 | 0.302 |
| 2011 | | | 50.887 | 0.311 | 0.003 | 0.333 | 0.047 | 0.320 |
| 2012 | | | 64.255 | 0.544 | ns | | 0.055 | 0.402 |
| 2013 | | | 67.233 | 0.397 | ns | | 0.050 | 0.356 |
| 2014 | | | 61.826 | 0.556 | 0.001 | 1.147 | 0.070 | 0.400 |
| 2015 | | | 216.816 | 0.366 | 0.006 | 0.468 | 0.131 | 0.271 |
| 2016 | | | 78.541 | 0.452 | 0.004 | 0.777 | 0.111 | 0.317 |
| 2017 | | | 260.287 | 0.321 | 0.009 | 0.271 | 0.120 | 0.281 |
| 2018 | | | 31.181 | 0.472 | 0.003 | 0.656 | 0.099 | 0.305 |
| 2019 | | | 71.195 | 0.352 | 0.002 | 0.796 | 0.109 | 0.350 |

**Table 8.** Additional recommended indices of abundance for Age 1+ scalloped hammerhead sensitivity analysis including index name, the value of catch per unit effort, the area sampled and SEDAR document number (See Table 3 for the regions recommended for sensitivity analysis with each index). Missing values in a given year correspond to zero catches (index value of 0 and no CV), where no sampling occurred (ns), or when the model did not converge (nc).

| | Dauphin Island Sea Lab | | Southeast Gillnet Observer | | Univ North Carolina | | Southeast Gillnet | |
|---|---|---|---|---|---|---|---|---|
| | SEDAR77-DW-06 | | SEDAR77-DW13 | | SEDAR77-DW-33 | | SEDAR77-DW13 | |
| | Gulf of Mexico | | Stock wide | | Stockwide/Atlantic | | Atlantic | |
| | shark 100 hook/hour | | sharks/(net length*net depth*soak time/10000000)) | | shark per hook | | sharks/(net length*net depth*soak time/10000000)) | |
| **year** | **index** | **CV** | **index** | **CV** | **index** | **CV** | **index** | **CV** |
| 1981 | | | | | 0.008 | 0.350 | | |
| 1982 | | | | | 0.005 | 0.286 | | |
| 1983 | | | | | 0.007 | 0.246 | | |
| 1984 | | | | | 0.007 | 0.299 | | |
| 1985 | | | | | 0.001 | 0.447 | | |
| 1986 | | | | | 0.006 | 0.307 | | |
| 1987 | | | | | 0.005 | 0.339 | | |
| 1988 | | | | | 0.007 | 0.301 | | |
| 1989 | | | | | 0.001 | 0.735 | | |
| 1990 | | | | | 0.000 | 1.045 | | |
| 1991 | | | | | 0.000 | 1.042 | | |
| 1992 | | | | | 0.000 | 1.042 | | |
| 1993 | | | | | 0.002 | 0.576 | | |
| 1994 | | | | | 0.001 | 1.038 | | |
| 1995 | | | | | 0.000 | | | |
| 1996 | | | | | 0.001 | 1.051 | | |
| 1997 | | | | | 0.000 | 1.087 | | |
| 1998 | | | 28.901 | 1.149 | 0.001 | 0.736 | 17.261 | 1.235 |
| 1999 | | | 3.901 | 0.806 | 0.005 | 0.725 | 3.358 | 0.779 |
| 2000 | | | 24.642 | 0.718 | 0.002 | 0.581 | 13.957 | 0.758 |
| 2001 | | | 6.986 | 0.714 | 0.001 | 1.054 | 10.132 | 0.680 |
| 2002 | | | 6.308 | 0.765 | 0.001 | 0.739 | 7.090 | 0.771 |
| 2003 | | | 3.667 | 0.917 | 0.001 | 1.042 | 4.840 | 0.877 |
| 2004 | | | 23.651 | 0.723 | 0.001 | 1.043 | 27.603 | 0.670 |
| 2005 | | | 22.095 | 0.575 | 0.002 | 0.760 | 31.277 | 0.552 |
| 2006 | 0.127 | 0.531 | 37.384 | 0.596 | 0.006 | 0.399 | 36.875 | 0.608 |
| 2007 | 0.068 | 0.515 | 11.077 | 0.922 | 0.006 | 0.385 | 7.145 | 0.901 |
| 2008 | 0.103 | 0.387 | 11.252 | 0.695 | 0.003 | 0.730 | 19.188 | 0.696 |
| 2009 | nc | | 18.625 | 0.662 | 0.000 | | 26.397 | 0.604 |
| 2010 | 0.047 | 1.038 | 18.804 | 0.829 | 0.001 | 1.043 | 21.259 | 0.834 |
| 2011 | 0.073 | 0.474 | 23.339 | 0.808 | 0.005 | 0.367 | 29.713 | 0.739 |
| 2012 | 0.175 | 0.458 | 27.013 | 0.682 | 0.002 | 1.049 | 22.212 | 0.618 |
| 2013 | 0.480 | 0.495 | 41.607 | 0.798 | 0.009 | 0.358 | 50.386 | 0.770 |
| 2014 | 0.097 | 0.322 | 25.509 | 1.037 | 0.001 | 1.039 | 42.718 | 0.976 |
| 2015 | 0.090 | 0.310 | 18.620 | 0.968 | 0.004 | 0.576 | 13.233 | 0.900 |
| 2016 | 0.118 | 0.284 | 21.464 | 0.877 | 0.002 | 0.755 | 25.716 | 0.805 |
| 2017 | 0.104 | 0.308 | 0.702 | 1.450 | 0.004 | 0.710 | 0.462 | 1.928 |
| 2018 | 0.204 | 0.271 | 124.260 | 0.775 | 0.003 | 0.575 | 83.657 | 0.781 |
| 2019 | 0.040 | 0.430 | 54.626 | 0.822 | 0.006 | 0.479 | 33.383 | 0.885 |

**Table 9.** Recommended base indices of abundance for the Age 0 scalloped hammerhead including index name, the value of catch per unit effort, the area sampled and SEDAR document number (See Table 3 for the regions recommended for base model and sensitivity analysis with each index). CV is the coefficient of variation for the annual index value. Missing values in a given year correspond to zero catches (index value of 0 and no CV), where no sampling occurred (ns), or when the model did not converge (nc).

| | TXPWD-Gillnet | | GULFSPAN | | COASTSPAN - LL | | SCCOASTGN - LONG | | SCCOASTGN - SHORT | |
|---|---|---|---|---|---|---|---|---|---|---|
| | SEDAR77 DW-16 | | SEDAR77 DW-17 | | SEDAR77-DW-30 | | SEDAR77-DW-31 | | SEDAR77 DW-32 | |
| | Stockwide/Gulf of Mexico | | Stockwide/Gulf of Mexico | | Stockwide/Atlantic | | Stockwide/Atlantic | | Stockwide/Atlantic | |
| | sharks per net per hour | | sharks per net per hour | | sharks per 100 hook hours | | sharks per net hour | | sharks per net hour | |
| year | index | CV | index | CV | index | CV | index | CV | index | CV |
| 1982 | 0.00033 | | | | | | | | | |
| 1983 | 0.00042 | 0.912 | | | | | | | | |
| 1984 | 0.00000 | | | | | | | | | |
| 1985 | 0.00015 | | | | | | | | | |
| 1986 | 0.00035 | 0.732 | | | | | | | | |
| 1987 | 0.00000 | | | | | | | | | |
| 1988 | 0.00050 | 0.618 | | | | | | | | |
| 1989 | 0.00012 | | | | | | | | | |
| 1990 | 0.00090 | 0.603 | | | | | | | | |
| 1991 | 0.00053 | 0.749 | | | | | | | | |
| 1992 | 0.00000 | | | | | | | | | |
| 1993 | 0.00032 | 0.819 | | | | | | | | |
| 1994 | 0.00027 | 0.848 | | | | | | | | |
| 1995 | 0.00010 | 1.165 | | | | | | | | |
| 1996 | 0.00093 | 0.536 | 0.009 | 0.294 | | | | | | |
| 1997 | 0.00172 | 0.666 | 0.016 | 0.461 | | | | | | |
| 1998 | 0.00031 | 0.842 | 0.002 | 0.548 | | | | | | |
| 1999 | 0.00021 | 0.781 | 0.091 | 0.312 | | | | | | |
| 2000 | 0.00048 | 0.589 | 0.156 | 0.253 | | | | | | |
| 2001 | 0.00150 | 0.603 | 0.148 | 0.302 | | | 1.250 | 0.479 | | |
| 2002 | 0.00033 | 0.822 | 0.15 | 0.166 | | | 0.788 | 0.518 | | |
| 2003 | 0.00183 | 0.577 | 0.102 | 0.181 | | | 2.742 | 0.450 | | |
| 2004 | 0.00075 | 0.689 | 0.07 | 0.227 | | | 0.541 | 1.432 | | |
| 2005 | 0.00254 | 0.517 | 0.048 | 0.373 | 5.464 | 0.529 | 0.625 | 0.538 | | |
| 2006 | 0.00069 | 0.630 | 0.079 | 0.22 | 8.119 | 0.416 | 0.981 | 1.018 | | |
| 2007 | 0.00079 | 0.778 | 0.168 | 0.171 | 1.976 | 1.128 | 1.952 | 0.533 | 0.171 | 0.423 |
| 2008 | 0.00075 | 0.703 | 0.172 | 0.189 | 1.730 | 1.165 | 1.384 | 0.707 | 0.286 | 0.581 |
| 2009 | 0.00095 | 0.560 | 0.163 | 0.2 | 3.482 | 0.654 | 7.298 | 1.383 | 0.000 | |
| 2010 | 0.00213 | 0.598 | 0.208 | 0.211 | 9.376 | 0.327 | 2.297 | 0.854 | 0.114 | 0.581 |
| 2011 | 0.00091 | 0.563 | 0.159 | 0.201 | 3.876 | 0.372 | 1.487 | 0.540 | 0.113 | 0.307 |
| 2012 | 0.00124 | 0.540 | 0.093 | 0.217 | 1.907 | 0.469 | 8.180 | 0.527 | 0.116 | 0.307 |
| 2013 | 0.00484 | 0.428 | 0.129 | 0.215 | 2.052 | 0.427 | 4.058 | 0.451 | 0.090 | 0.423 |
| 2014 | 0.00198 | 0.477 | 0.141 | 0.207 | 2.443 | 0.548 | 2.204 | 0.695 | 0.000 | |
| 2015 | 0.00283 | 0.565 | 0.068 | 0.252 | 1.158 | 0.554 | 0.969 | 0.616 | 0.020 | 0.581 |
| 2016 | 0.00191 | 0.590 | 0.124 | 0.235 | 1.899 | 0.419 | 1.675 | 0.538 | 0.098 | 0.351 |
| 2017 | 0.00041 | 0.775 | 0.184 | 0.2 | 1.123 | 0.519 | 6.808 | 0.341 | 0.000 | |
| 2018 | 0.00482 | 0.499 | 0.21 | 0.225 | 0.738 | 0.565 | 3.725 | 0.547 | 0.000 | |
| 2019 | 0.00248 | 0.514 | 0.176 | 0.265 | 1.029 | 1.175 | 3.305 | 0.423 | 0.021 | 0.581 |

**Table 10.** Recommended base stock wide indices of abundance for great hammerhead shark including index name and SEDAR document number CV is the coefficient of variation for the annual index value. Missing values in a given year correspond to zero catches (index value of 0 and no CV), where no sampling occurred (ns), or when the model did not converge (nc).

| | Shark Bottom Longline | | Shark Research | | FSU Longline | | RSMAS Drumline | | SEFSC MS Bottom Longline | | SEAMAP BLL survey | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SEDAR77-DW12 | | SEDAR77-DW12 | | SEDAR77-DW14 | | SEDAR77-DW15 | | SEDAR77-DW24 | | SEDAR77-DW25 | |
| | sharks per 10000 hooks | | sharks per 10000 hooks | | sharks per 100 hook hour | | number of sharks per 10 drumlines per hour | | number sharks per hook-hour | | number sharks per hook-hour | |
| year | index | CV | index | CV | index | CV | index | CV | index | CV | index | CV |
| 1994 | 1.071 | 0.478 | | | | | | | | | | |
| 1995 | 5.908 | 0.206 | | | | | | | 0.016 | 0.518 | | |
| 1996 | 6.749 | 0.229 | | | | | | | 0.018 | 0.556 | | |
| 1997 | 9.424 | 0.303 | | | | | | | 0.007 | 0.497 | | |
| 1998 | 10.140 | 0.246 | | | | | | | ns | | | |
| 1999 | 7.511 | 0.270 | | | | | | | 0.002 | 1.081 | | |
| 2000 | 3.207 | 0.473 | | | | | | | 0.002 | 0.784 | | |
| 2001 | 3.674 | 0.371 | | | | | | | 0.009 | 0.482 | | |
| 2002 | 11.726 | 0.212 | | | | | | | 0.003 | 0.648 | | |
| 2003 | 9.966 | 0.207 | | | | | | | 0.012 | 0.454 | | |
| 2004 | 7.873 | 0.226 | | | | | | | 0.009 | 0.486 | | |
| 2005 | 6.425 | 0.293 | | | | | | | 0.004 | 1.074 | | |
| 2006 | 5.261 | 0.300 | | | | | | | 0.006 | 0.650 | 0.013 | 1.062 |
| 2007 | 9.718 | 0.272 | | | | | | | 0.006 | 0.782 | 0.045 | 0.525 |
| 2008 | | | 40.370 | 0.226 | | | | | 0.008 | 0.655 | 0.109 | 0.344 |
| 2009 | | | 29.215 | 0.244 | | | 0.027 | 0.707 | 0.011 | 0.519 | 0.039 | 0.728 |
| 2010 | | | 18.072 | 0.221 | | | 0.055 | 0.297 | 0.021 | 0.477 | 0.050 | 0.716 |
| 2011 | | | 26.748 | 0.190 | 0.001 | 0.291 | 0.053 | 0.265 | 0.004 | 0.648 | 0.000 | . |
| 2012 | | | 43.110 | 0.308 | ns | | 0.036 | 0.317 | 0.017 | 0.479 | 0.064 | 0.532 |
| 2013 | | | 52.307 | 0.199 | 0.001 | 0.734 | 0.039 | 0.268 | 0.006 | 0.651 | 0.142 | 0.456 |
| 2014 | | | 40.176 | 0.218 | 0.002 | 0.729 | 0.053 | 0.241 | 0.012 | 0.650 | 0.173 | 0.323 |
| 2015 | | | 57.252 | 0.174 | 0.002 | 0.598 | 0.048 | 0.255 | 0.011 | 0.489 | 0.051 | 0.421 |
| 2016 | | | 26.352 | 0.294 | 0.003 | 0.296 | 0.074 | 0.194 | 0.014 | 0.485 | 0.089 | 0.335 |
| 2017 | | | 47.025 | 0.193 | 0.004 | 0.293 | 0.055 | 0.180 | 0.023 | 0.414 | 0.081 | 0.451 |
| 2018 | | | 26.739 | 0.250 | 0.003 | 0.302 | 0.053 | 0.197 | 0.020 | 0.416 | 0.043 | 0.521 |
| 2019 | | | 43.489 | 0.220 | 0.002 | 0.519 | 0.053 | 0.184 | 0.036 | 0.372 | 0.088 | 0.449 |

## 4.9 Figures

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

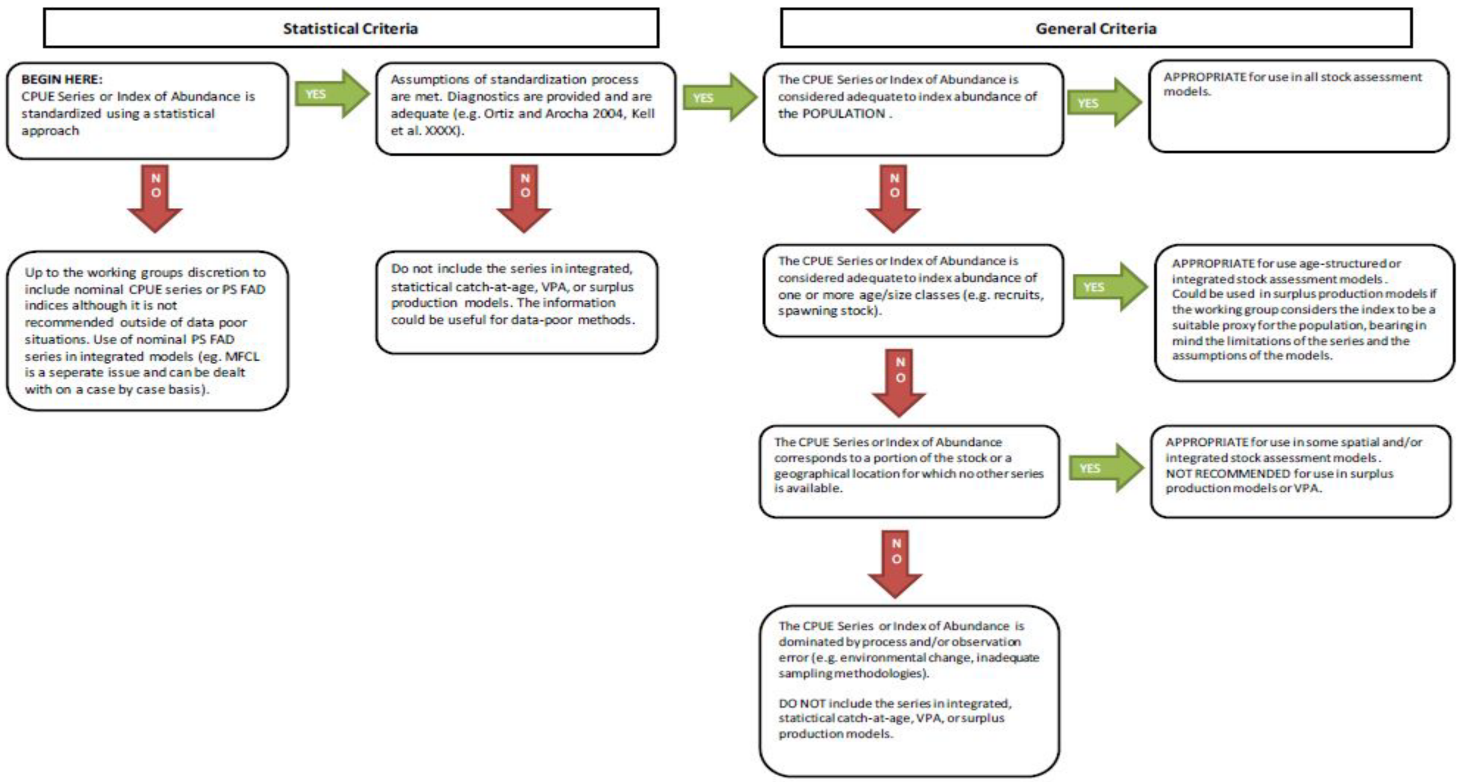


**Figure 2.** Approximate linear coverage of the stock wide base abundance indices for the Age 1+ scalloped hammerhead shark. Colors of the labeled abundance series correspond to the linear coverage.

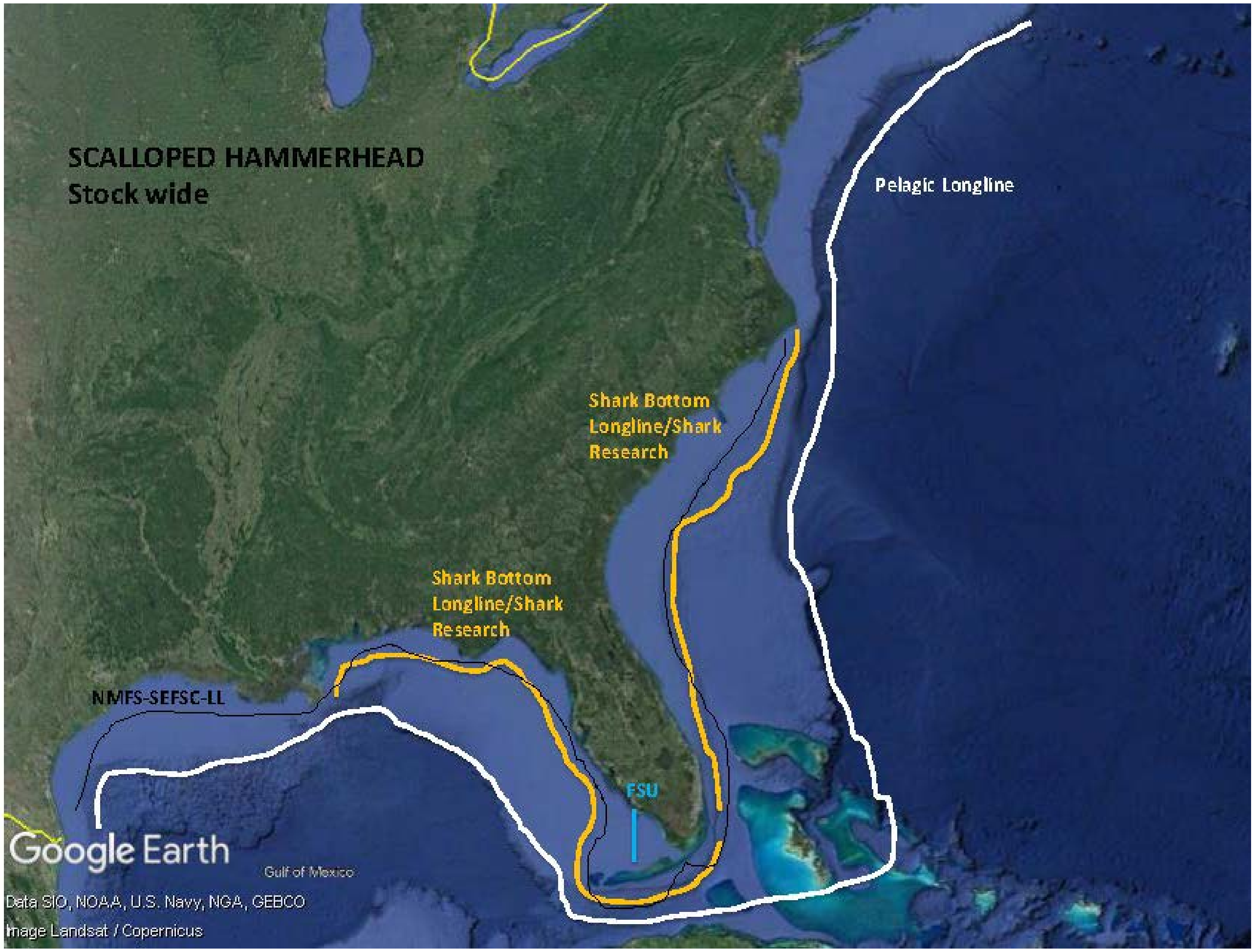


**Figure 3.** Approximate linear coverage of the Atlantic Ocean base abundance indices for the Age 1+ scalloped hammerhead shark**.** Colors of the labeled abundance series correspond to the linear coverage.

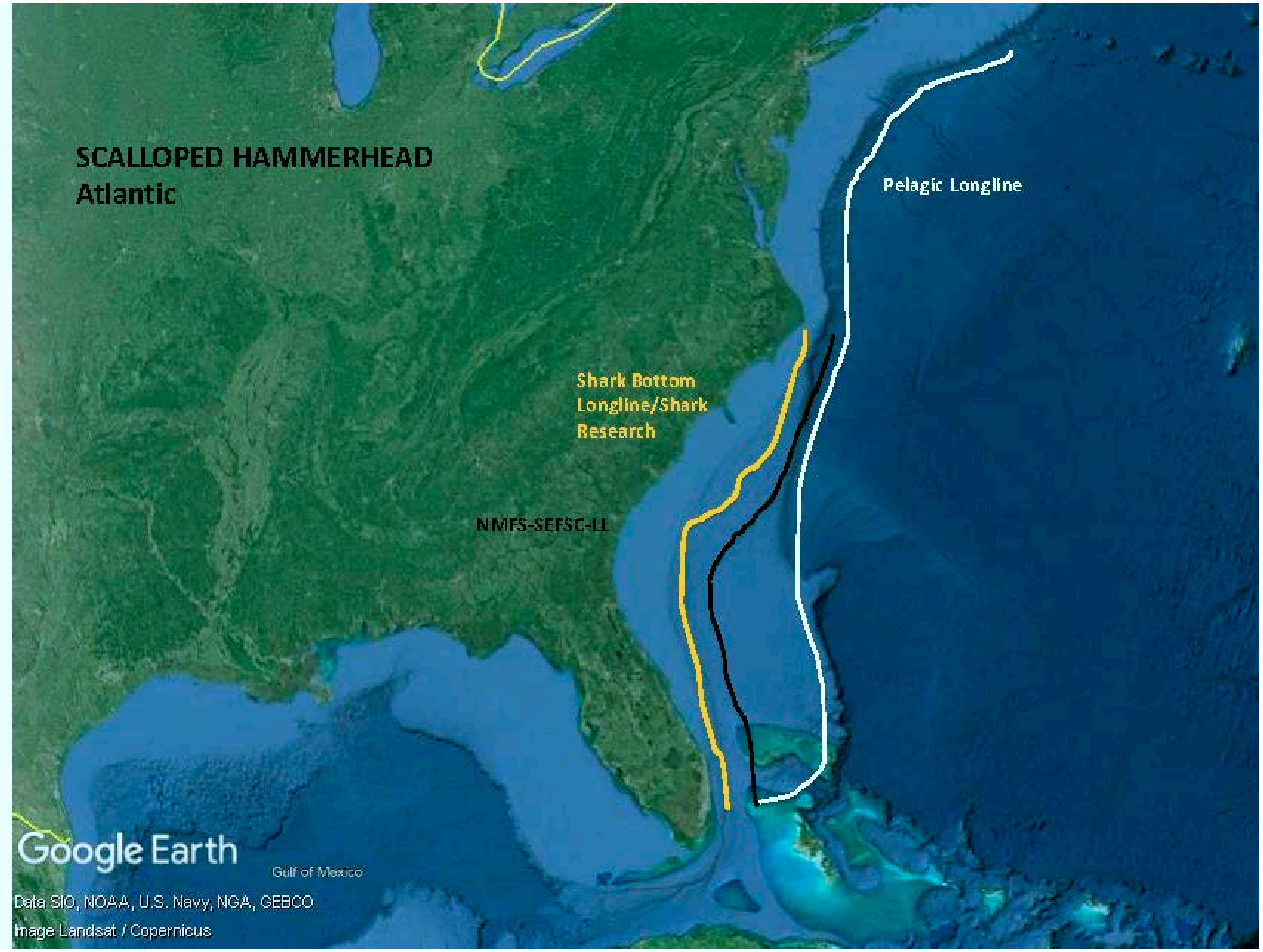


**Figure 4.** Approximate linear coverage of the Gulf of Mexico base abundance indices for the Age 1+ scalloped hammerhead shark. Colors of the labeled abundance series correspond to the linear coverage.

**Figure 5.** Approximate linear coverage of the sensitivity abundance indices for the Age 1+ scalloped hammerhead shark. Colors of the labeled abundance series correspond to the linear coverage.

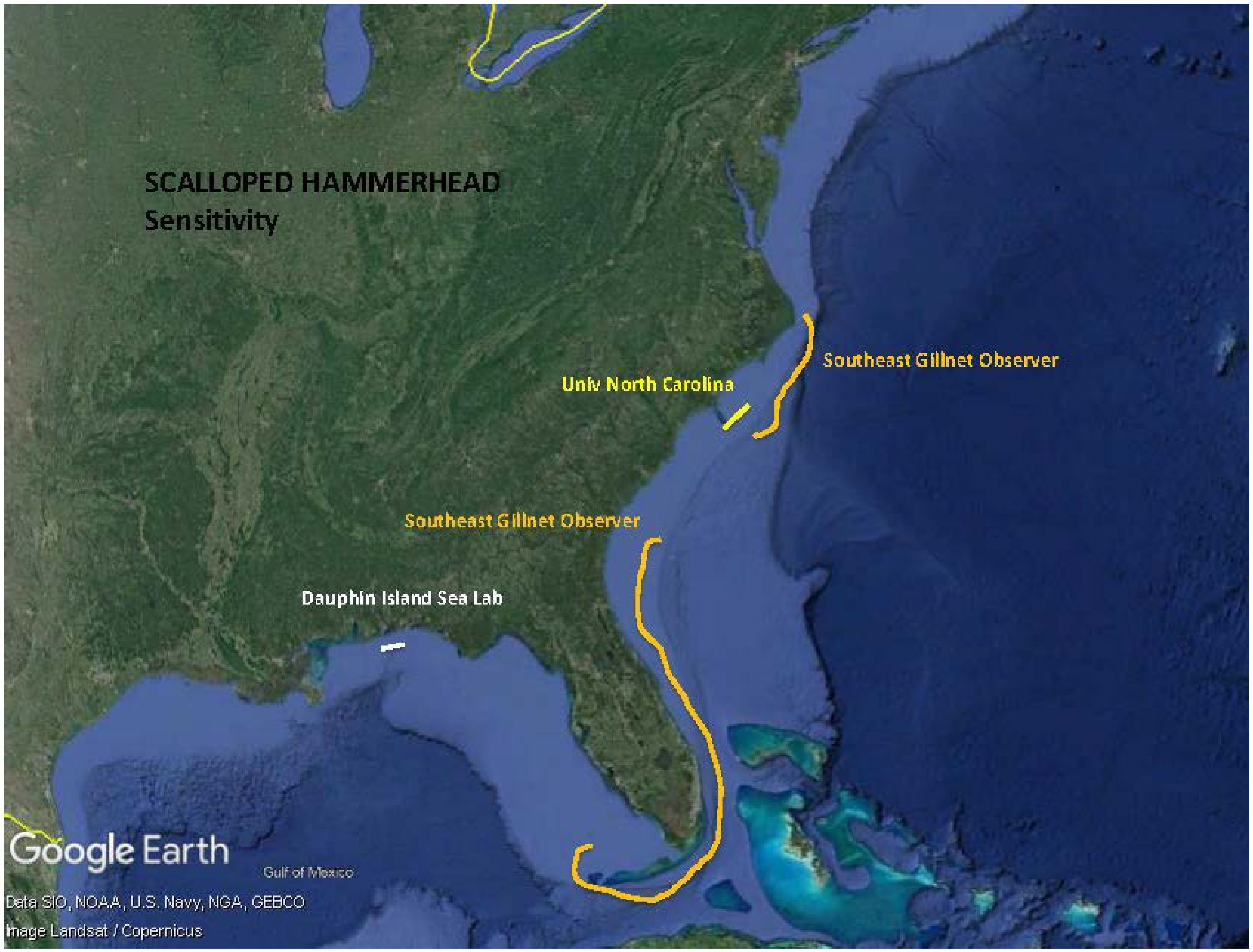


**Figure 6.** Approximate linear coverage of the recruitment (Age 0) abundance indices for the scalloped hammerhead shark. Colors of the labeled abundance series correspond to the linear coverage.

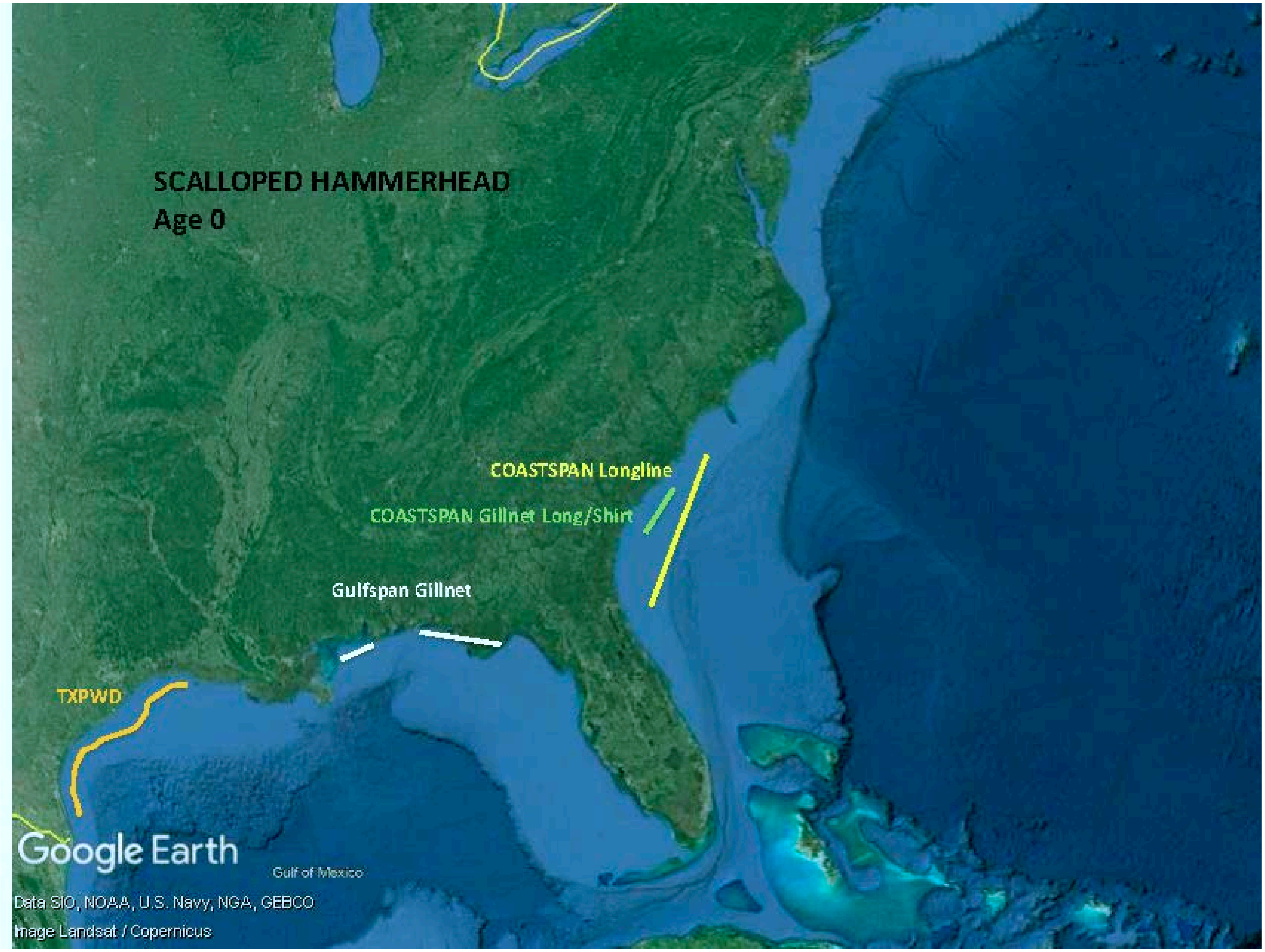


**Figure 7.** Plot of mean annual values of relative abundance for each stock wide base time series recommended for the Age 1+ scalloped hammerhead shark base run by the Indices Working Group. For each index, values were converted to a common scale for plotting purposes by dividing mean annual values for a time series by the average of all mean annual values for that specific time series.

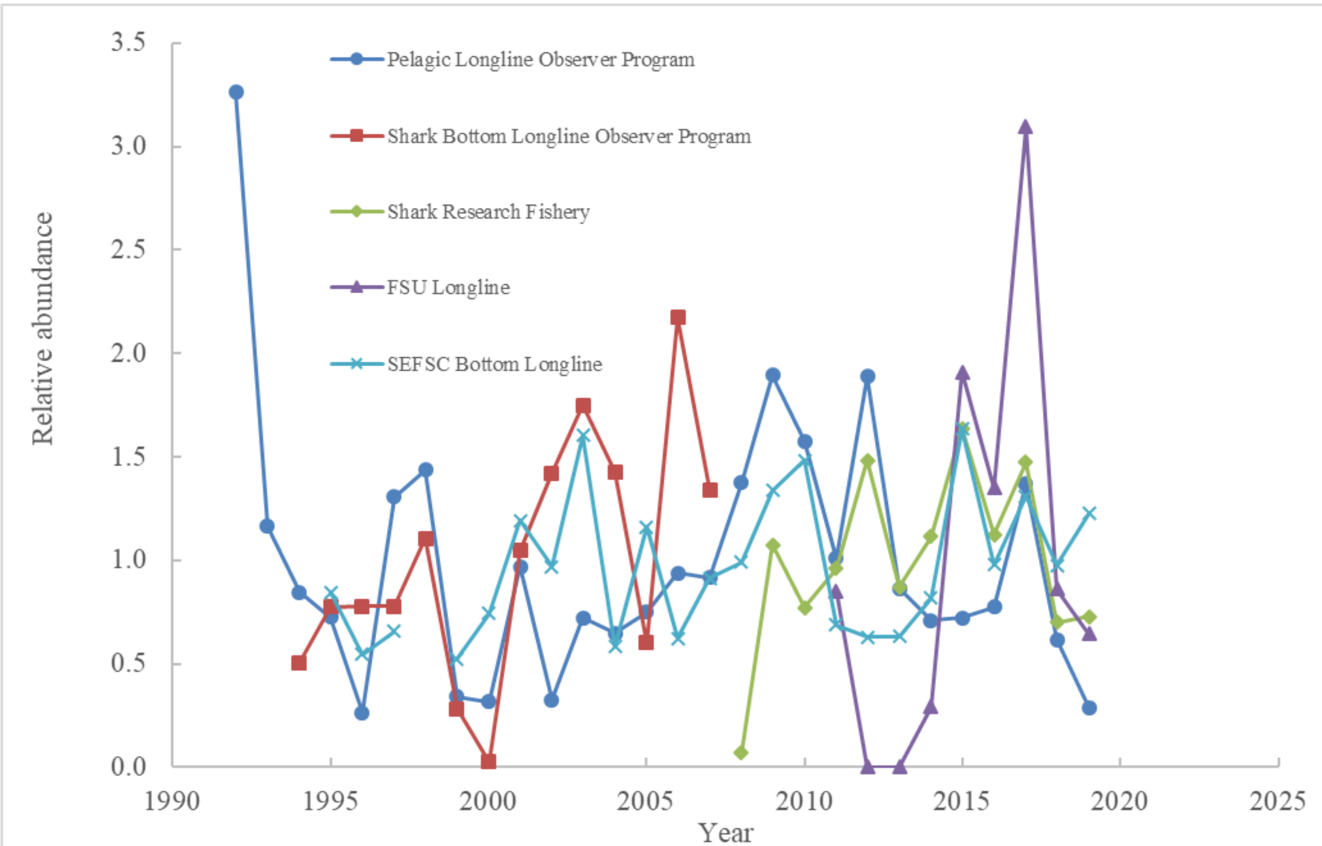


**Figure 8.** Plot of mean annual values of relative abundance for each Atlantic Ocean base time series recommended for the Age 1+ scalloped hammerhead shark base run by the Indices Working Group. For each index, values were converted to a common scale for plotting purposes by dividing mean annual values for a time series by the average of all mean annual values for that specific time series.

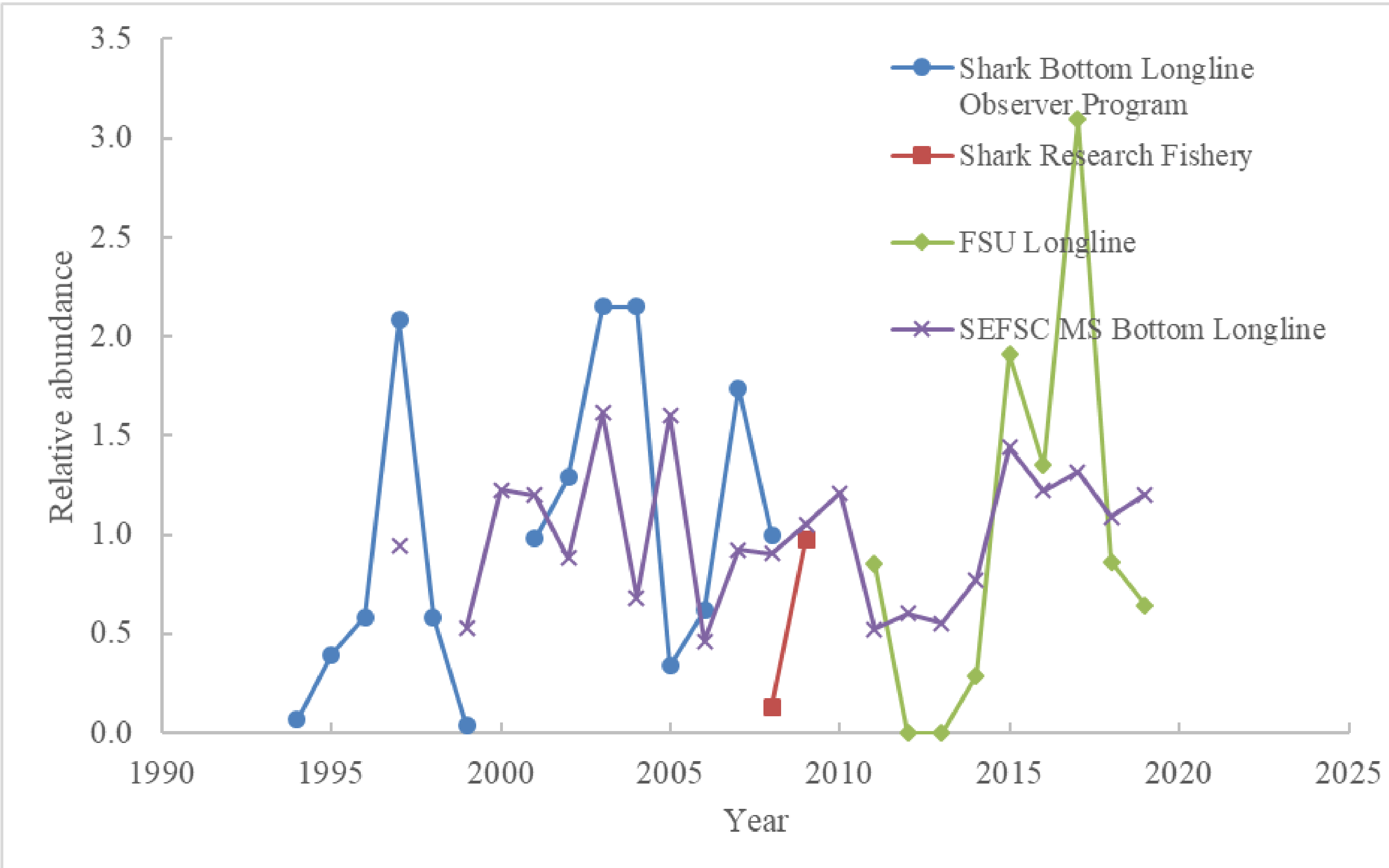


**Figure 9.** Plot of mean annual values of relative abundance for each Gulf of Mexico base time series recommended for the Age 1+ scalloped hammerhead shark base run by the Indices Working Group. For each index, values were converted to a common scale for plotting purposes by dividing mean annual values for a time series by the average of all mean annual values for that specific time series.

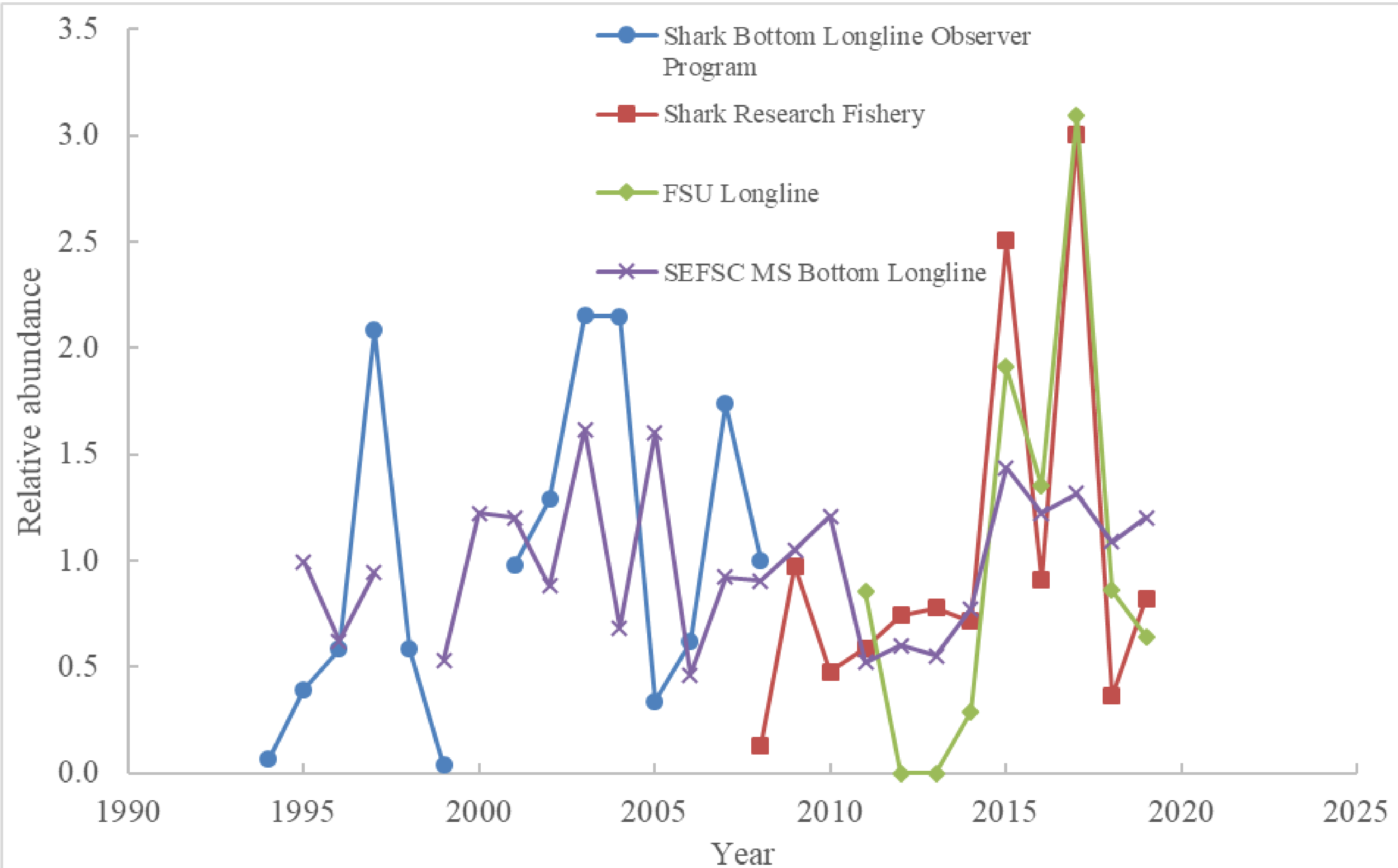


**Figure 10.** Plot of mean annual values of relative abundance for each sensitivity time series recommended for the Age 1+ scalloped hammerhead shark base run by the Indices Working Group. For each index, values were converted to a common scale for plotting purposes by dividing mean annual values for a time series by the average of all mean annual values for that specific time series.

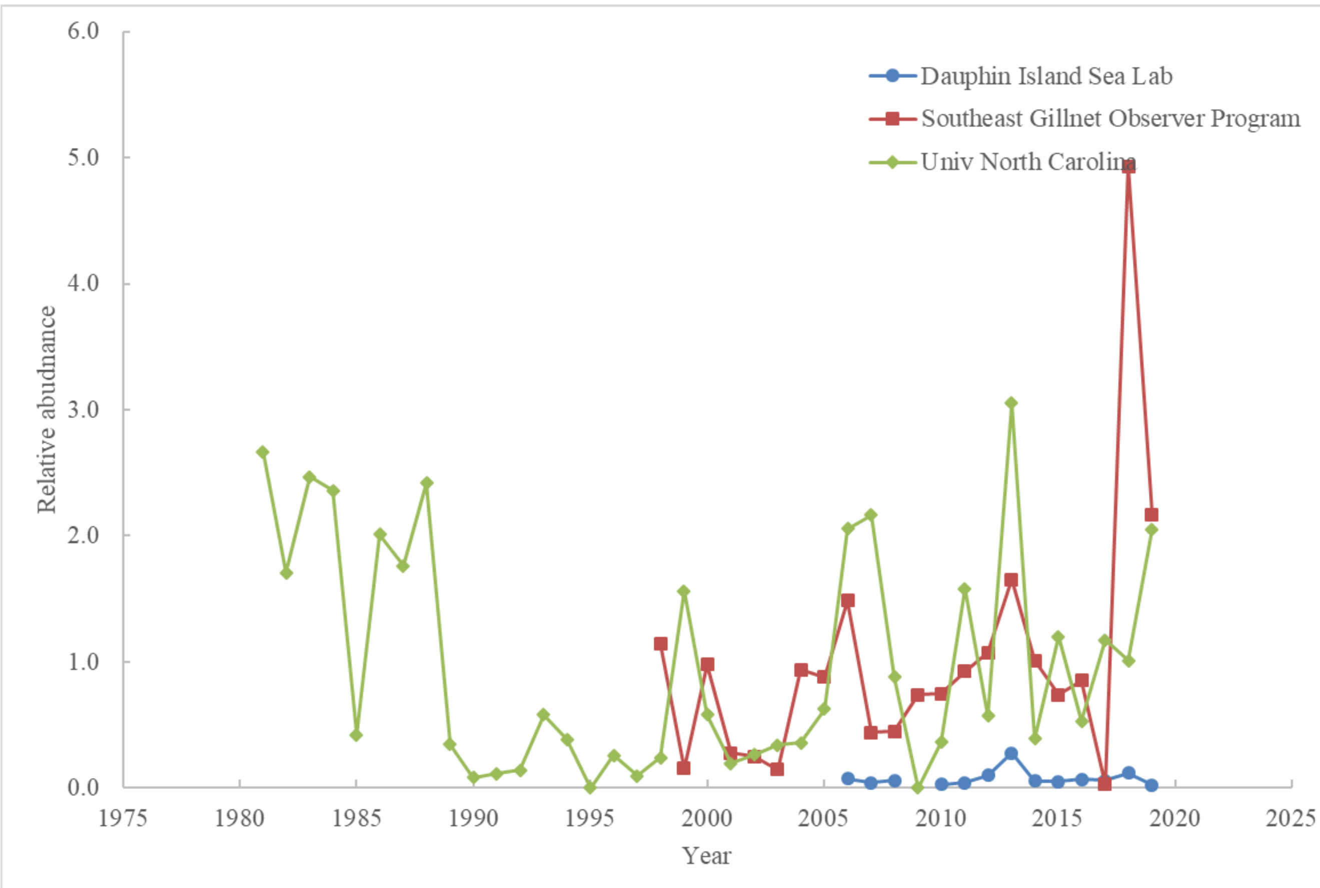


**Figure 11.** Plot of mean annual values of relative abundance for the recruitment (Age 0) time series recommended for the scalloped hammerhead shark base run by the Indices Working Group. For each index, values were converted to a common scale for plotting purposes by dividing mean annual values for a time series by the average of all mean annual values for that specific time series.

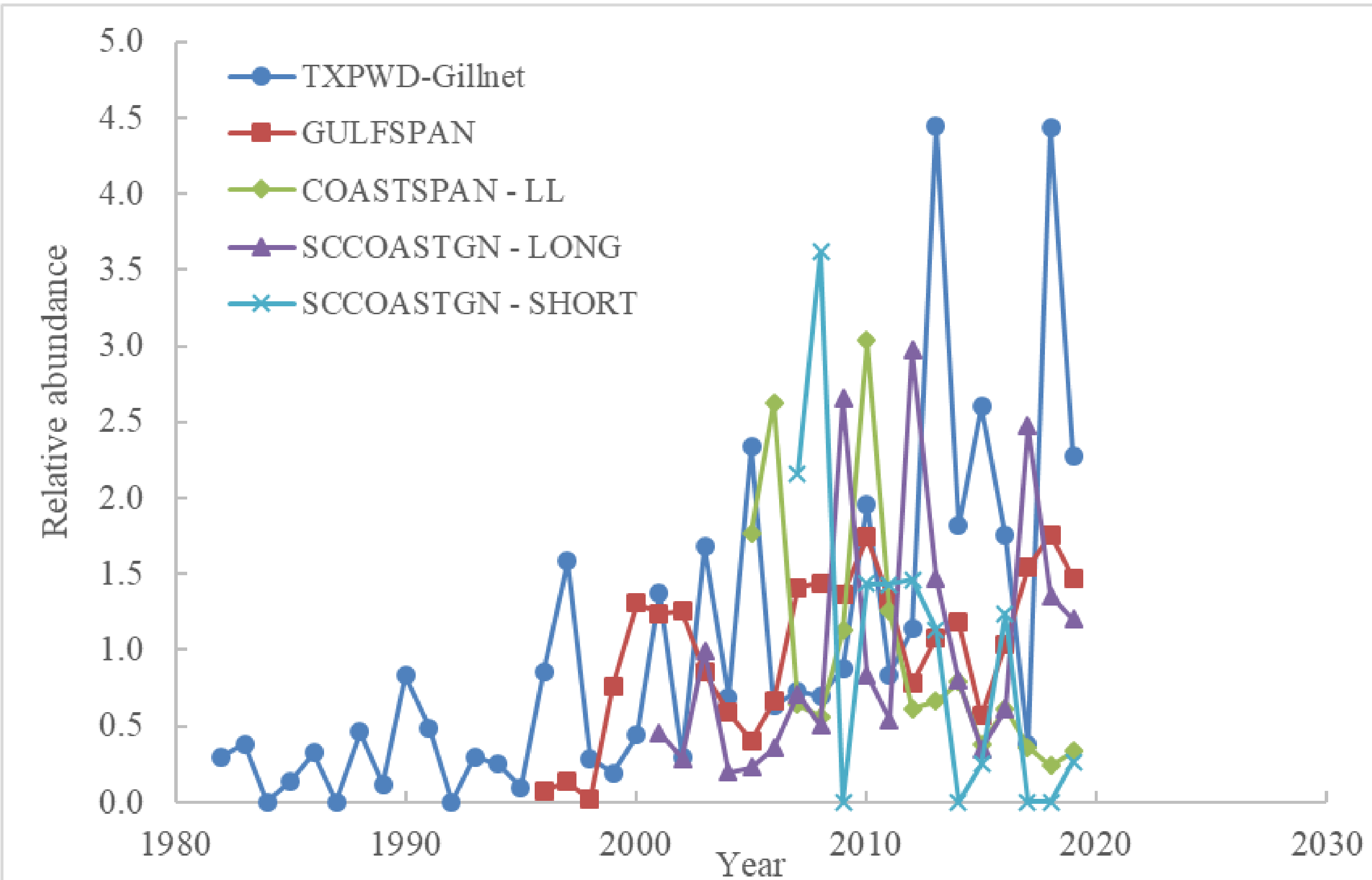


**Figure 12.** Approximate linear coverage of the stock wide abundance indices for the great hammerhead shark. Colors of the labeled abundance series correspond to the linear coverage.

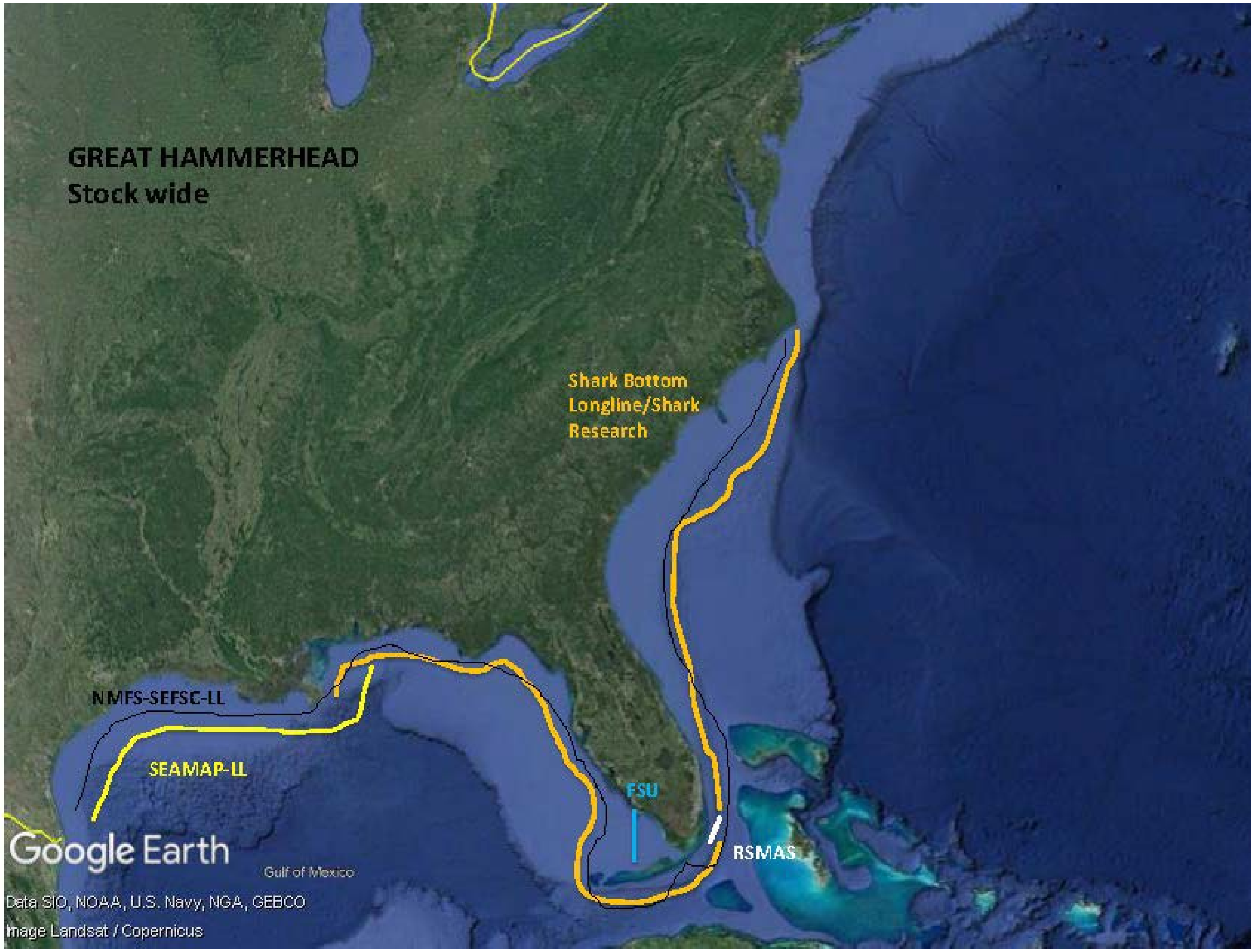
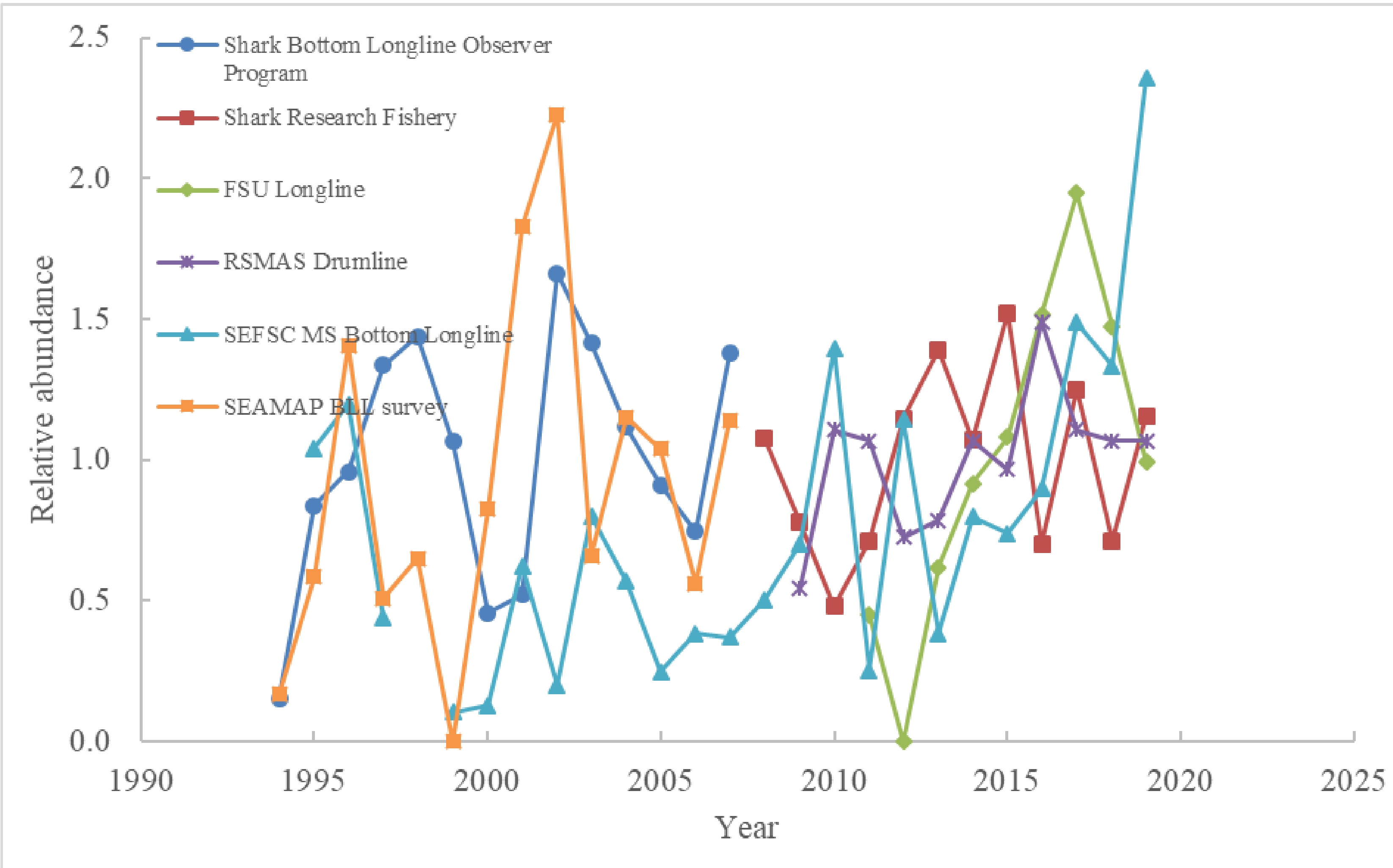


**Figure 13.** Plot of mean annual values of relative abundance for time series recommended for the great hammerhead shark base run by the Indices Working Group. For each index, values were converted to a common scale for plotting purposes by dividing mean annual values for a time series by the average of all mean annual values for that specific time series.



## 4.10 Length Frequency

**Summary**

A complete overview of the length-frequency data is summarized in Kroetz and Courtney (2022).

Twenty-seven data sources were submitted for possible use in the assessment, many with multiple surveys for multiple gear types. Fishery-dependent (commercial and recreational surveys) contributed 13,084 records whereas fishery-independent surveys contributed 9,024 records of all four species. Scalloped hammerheads had the highest frequency of catches compared to the other species in commercial and recreational gears and Carolina hammerheads were captured the least. Bottom longline gear was the primary gear that captured hammerheads, and other gears included gillnets, pelagic longlines, hook and line/rod and reel, and trawls. Age 0 (young-of-the-year) scalloped hammerheads were primarily captured in fishery-independent gillnets, followed by bottom longlines whereas Age 1+ (juveniles to adults) scalloped hammerheads were primarily captured in bottom longline gear followed by gillnets. Great hammerheads were primarily captured in bottom longlines and drumlines, while smooth hammerheads were captured primarily in bottom longlines. The few Carolina hammerheads captured were in gillnets and trawls.

# 5. Ecological Factors

Ecosystem Workgroup participants

| | |
|---|---|
| Michelle Passerotti-Leader | National Marine Fisheries Service, Narragansett, RI |
| William Driggers | National Marine Fisheries Service, Pascagoula, MS |
| Bryan Frazier | South Carolina Department of Natural Resources |
| Jayne Gardiner | New College of Florida, Sarasota, FL |
| Kristin Hannan | National Marine Fisheries Service, Pascagoula, MS |
| Derek Kraft | National Marine Fisheries Service, HMS Division |
| Max Lee | Mote Marine Laboratory, Sarasota, FL |
| Heather Moncrief-Cox | National Marine Fisheries Service, Panama City, FL |
| David Portnoy | Texas A&M University, Corpus Christi, TX |

Scalloped *Sphyrna lewini*, Carolina *Sphyrna gilberti*, great *Sphyrna mokarran* and smooth hammerheads *Sphyrna zygaena* are long-lived, highly migratory species that inhabit both coastal and oceanic environments. As such, throughout their ranges in the western North Atlantic Ocean and the Gulf of Mexico, they are subject to a wide range of environmental and ecological variables with the potential to affect their populations. Herein, we summarize available information to address the directives of Terms of Reference (TOR) #7, specifically, providing a general overview of known habitat, diet, species associations, and environmental envelopes for developing habitat suitability projections for each species, where available. We also provide broad considerations of ecological factors with the potential to affect these species and, hence, to affect ecosystem-based management of these species. Lists of co-occurring species from survey data are not provided, but an effort should be made in future assessments to develop a standardized way to capture this information. We also provide a list of research recommendations, in no particular order of importance, to address knowledge gaps with regard to the ecology of these species toward the development of an ecosystem based management approach.

## 5.1 Habitat

*Established Essential Fish Habitat (EFH)*

As documented most recently in Amendment 10 to the Consolidated Atlantic Highly Migratory Species Fishery Management Plan (NMFS 2017), essential fish habitat (EFH) was established for scalloped and great hammerheads in the Gulf of Mexico and western North Atlantic Ocean (Figures 1 and 2) based upon data available through 2015 in published scientific literature and from unpublished sources, such as scientific surveys and fisheries monitoring programs. Available environmental parameters associated with the occurrence of hammerheads, including, depth, dissolved oxygen, salinity and temperature ranges, were incorporated into the published EFH identification models (NMFS 2017) and are summarized here in Table 1 based on documentation in Amendment 10. There is currently no designated EFH for smooth or Carolina hammerheads due to limited data for these two species. Updated environmental parameters available since 2015 are also provided herein, described below. Broad categorization of known habitat preferences for each species are provided in Table 6 from existing literature and unpublished sources.

## 5.2 Environmental envelopes

As an update and supplement to the data utilized for the Amendment 10 EFH designation (NMFS 2017), environmental parameters associated with catches of all four hammerhead species from fishery-independent and –dependent surveys that were submitted for use in the current assessment are provided in Tables 2-5. It is important to note that not all surveys were used to produce indices of abundance for inclusion in assessment models. For those that were used, associated environmental parameters may or may not have been found to influence abundance. Indices for which any environmental parameter was determined to be a significant factor are indicated in each table.

## 5.3 Diet

Broad categorization of known diet characteristics for each species are summarized in Table 6 from existing literature and unpublished sources.

## 5.4 Factors with potential to affect ecology and population dynamics of hammerheads

**Climate:**

- changes in oceanographic conditions and trends (e.g. current/circulation patterns, salinity, dissolved oxygen, pH, etc.)
- species distribution effects due to changing climate and resulting range shifts, expansions or contractions
- phenology
- prey distribution and abundance
- understanding potential for changes in life history characteristics (e.g. growth rate, age at maturity) as a result of climate change

**Persistent environmental disturbances:**

- anthropogenic sources, such as contaminants (e.g. industrial/agricultural runoff), with higher potential to impact nursery areas

**Episodic events:**

- harmful algal blooms (HABs)
- hypoxia events
- oil spills
- extreme weather events (e.g. hurricanes)

**Habitat disruption:**

- coastal development
- dredging
- energy production structures
- loss of seagrass or salt marsh (prey habitat)

## 5.5 Research recommendations

- Improve understanding of all aspects of biology of hammerheads, particularly with regard to smooth and Carolina hammerhead occurrence, life history, and diet
- Investigate Bulls Bay, SC as a Habitat Area of Particular Concern for Carolina hammerhead
- Increase genetic surveillance to not only identify Carolina hammerhead individuals in the Atlantic, but also as a means to study use of nursery habitats and potential philopatry among all four species, potentially using close-kin mark-recapture techniques.
- Improve understanding of sex- and life stage-critical habitat for all species, particularly with regard to identification of essential habitat for data-poor species and life stages (Carolina and smooth hammerhead as well as young-of-year great hammerhead).
- Investigate impacts of environmental changes on life history characteristics, such as growth and reproduction
- Increase efforts in tagging and tracking to evaluate potential climate-induced range shifts
- Develop habitat suitability models for projecting climate-induced shifts in species distributions over time
- Increase effort for collecting environmental/oceanographic data with occurrence and movement data to identify linkages
- Assess the levels of environmental contaminants in hammerhead species and how those impact physiology and reproductive success
- Study the response of hammerhead species to harmful algal blooms and how those phenomena affect behavior and physiology

## 5.6 Figures

Figure 1. Essential Fish Habitat for scalloped hammerhead *Sphyrna lewini* by life stage as designated by Amendment 10 to the HMS FMP (NMFS 2017). Map courtesy of J. Cudney, NOAA Fisheries.

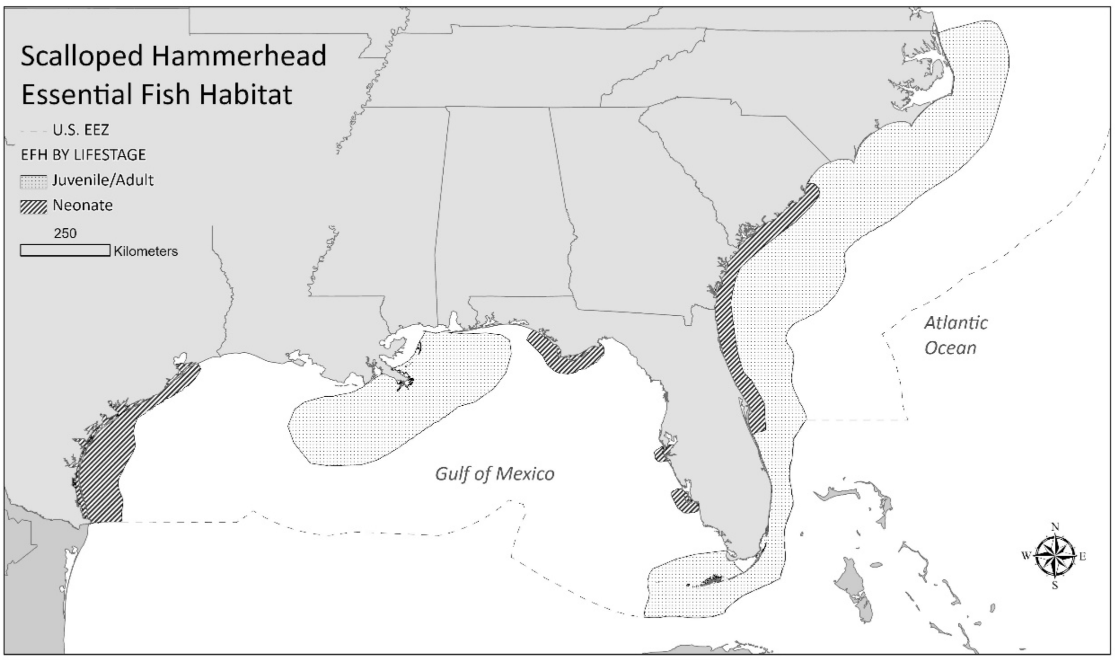
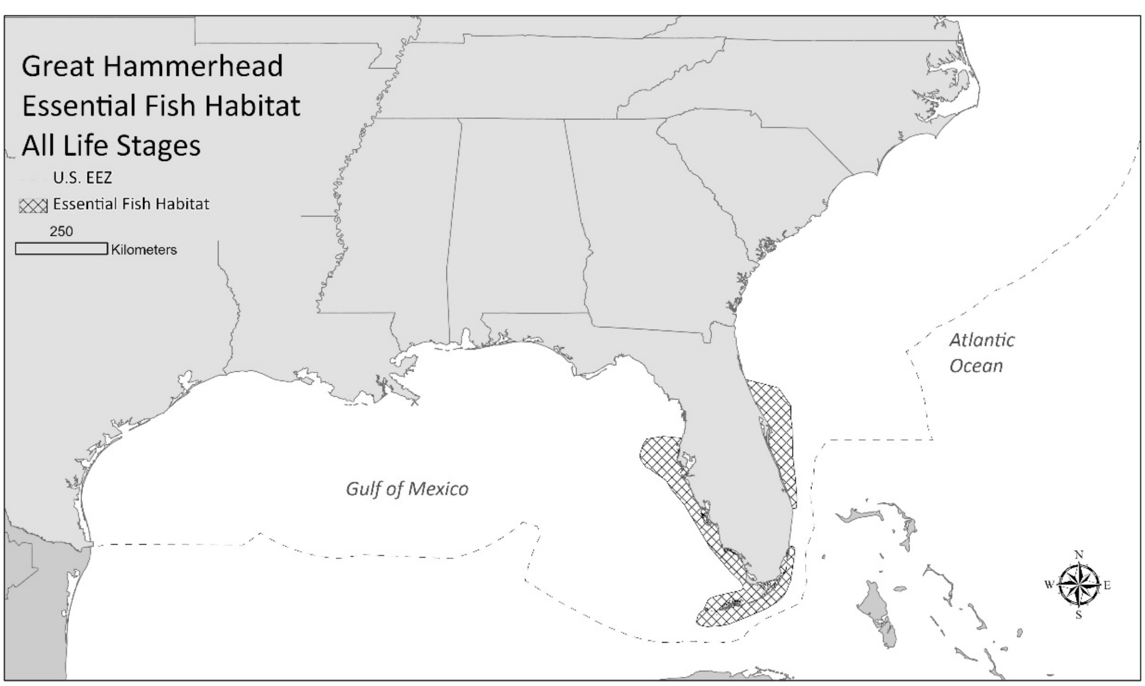



Figure 2. Essential Fish Habitat for great hammerhead *Sphyrna mokarran* as designated by Amendment 10 to the HMS FMP (NMFS 2017). Map courtesy of J. Cudney, NOAA Fisheries.



## 5.7 Tables

Table 1. Environmental parameters associated with NMFS Essential Fish Habitat (EFH) delineation for scalloped hammerhead *Sphyrna lewini* and great hammerhead *Sphyrna mokarran* by species and life stage, as specified in the most recent EFH report (NMFS 2017). YOY=young of the year (age 1).

| Species | Lifestage | Temp | Salinity | DO | Depth |
|---|---|---|---|---|---|
| *Sphyrna lewini* | Neonate/YOY (≤ 45 cm TL) | 23.2-30.2°C | 27.6-36.3 ppt | 5.1-5.5 mL/L | 5.0-6.0 m |
| *Sphyrna mokarran* | Neonate/YOY<br>Juveniles (< 224 cm FL)<br>Adults (≥ 224 cm FL) | 23.9-31.5°C | 20.8-34.2 ppt | 5.3-7.6 mg/L | 1.8-5.5 m |

Table 2. Environmental variable ranges associated with positive catches of scalloped hammerhead *Sphyrna lewini* from fishery-dependent and –independent sources in the Gulf of Mexico (GOM) and western North Atlantic (ATL). Variable values in parentheses represent the observed range of each variable measured across all sets. For sources that were used to generate abundance indices for this assessment (in bold), an asterisk (*) denotes variables that were found to be significant factors for at least one final index model. LL = longline, GN = gillnet, 1+ = catches modeled for ages ≥1, 0+ = catches modeled for ages ≥0, YOY = catches modeled for young of the year (age 1) only.

| Source (Ages modeled) | Region | Year range | Temperature (°C) | Salinity (psu) | DO (mg/L) | Depth (m) | Contact/Reference |
|---|---|---|---|---|---|---|---|
| **SEFSC Bottom LL (1+)** | **GOM** | **1995-2019*** | **11.1-31.8 (6.8-31.9)** | **26.4-36.8 (17.9-26.4)** | **0.1-7.71 (0-10.6)** | **14.0-295.0 (7.0-375.0)*** | **W. Driggers/SEDAR 77-DW24** |
| **FSUCML Keys LL (0+)** | **GOM** | **2011-2021** | **18.5-30.9 (17.1-33.9)** | **35.3-36.8 (5.56-45.3)** | **5.2-7.36 (0.2-10.19)** | **11.3-75.0 (0.9-75.1)** | **R.D. Grubbs/SEDAR 77-DW14** |
| **GULFSPAN GN (YOY)** | **GOM** | **1996-2019** | **20.9-33.4 (9.8-34.2)** | **16.6-38.0 (0.19-40.0)** | **1.0-8.2 (0.0-14.0)** | **0.0-10.0 (0.0-21.0)** | **J. Carlson/SEDAR 77-DW17** |
| **Pelagic LL Observer Program (1+)** | **GOM/ATL** | **1992-2019** | **10.7-30.7 (-1.1-35.4)** | | | **10.1-960.1 (5.6-2520.1)** | **J. Carlson/SEDAR 77-DW8** |
| **Texas Parks & Wildlife GN (YOY)** | **GOM** | **1982-2019*** | **18.5-37.0 (6.0-38.0)** | **11.1-43.2 (0.0-70.8)** | **2.6-11.6 (0.0-26.0)** | | **J. Carlson/SEDAR 77-DW16** |
| **Shark Bottom LL Observer Program (0+)** | **GOM/ATL** | **1994-2019*** | **7.8-33.8 (7.8-33.8)** | | | **2.9-110.0 (1.6-490.8)*** | **J. Carlson/SEDAR 77-DW12** |
| **SCDNR Red Drum LL (0+)** | **ATL** | **1997-2006*** | **20.0-31.0 (19.0-37.0)** | **25.0-34.0 (23.0-35.0)** | | **3.4-16.2 (3.4-17.1)** | **C. McCandless/SEDAR 77-DW29** |
| **SCDNR SEAMAP LL (0+)** | **ATL** | **2008-2019*** | **18.7-30.2 (13.1-31.8)** | **24.4-36.7 (0.10-39.0)*** | | **4.6-17.7 (3.0-22.4)** | **C. McCandless/SEDAR 77-DW29** |
| **SCDNR COASTSPAN Long GN (YOY)** | **ATL** | **2001-2018*** | **22.5-31.2 (20.4-31.3)** | **1.05-37.4 (15-38)** | | **0.6-4.6 (0.6-5.4)** | **C. McCandless/SEDAR 77-DW31** |
| **SCDNR COASTSPAN Short GN (YOY)** | **ATL** | **2007-2019*** | **20.9-30.4 (18.9-31.2)** | **16.0-35.0 (16-37.2)** | | **1.2-3.7 (1.2-3.7)** | **C. McCandless/SEDAR 77-DW32** |
| **COASTSPAN LL (YOY)** | **ATL** | **2005-2019*** | **20.2-38.2 (6.7-39.1)** | **14.6-37.3 (1.2-38.1)*** | | **1.2-15.5 (1.1-17.2)*** | **C. McCandless/SEDAR 77-DW30** |
| **NEFSC LL (1+)** | **ATL** | **1996-2018*** | **17.7-26.2 (13.1-26.2)*** | **31.1-36.7 (29.2-37)** | | **10.5-67.8 (10.4-67.8)*** | **C. McCandless/SEDAR 77-DW28** |
| **UNC LL (1+)** | **ATL** | **1981-2019*** | **16.1-31.0 (8.6-31.5)*** | | | | **C. McCandless/SEDAR 77-DW33** |
| New College of Florida LL | GOM | 2015-2021 | 23.5-32.4 (14.5-33.2) | 24.0-36.7 (14.5-37.4) | 4.68-8.06 (3.12-10.3) | 1.68-3.30 (0.48-8.40) | J. Gardiner/SEDAR 77-SID-05 |
| GOM SEAMAP Bottom LL | GOM | 2008-2021 | 13.2-30.7 (12.2-32.1) | 24.0-37.4 (4.9-38) | 1.2-7.8 (0.1-12.3) | 5.5-332.2 (1.4-332.2) | E. Hoffmayer |
| FSUCML Deep Sea LL | GOM | 2011-2018 | 7.93-15.04 (4.12-19.6) | | | 195-504 (90-2646) | R.D. Grubbs |

| **Table 2 Continued** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Source (Ages modeled)** | **Region** | **Year range** | **Temperature (°C)** | **Salinity (psu)** | **DO (mg/L)** | **Depth (m)** | **Contact/Reference** |
| FSUCML Big Bend GN/LL | GOM | 2009-2021 | 16.4-31.4 | 27.4-34.4 | 2.5-7.92 | 2.3-5.9 | R.D. Grubbs |
| Texas A&M Marine Genomics GN | GOM | 2015-2021 | 26.5-32.8 (21.9-32.8) | 21.8-38.5 (10-39.9 ) | 4.55-10.5 (1.55-10.5) | 4.29-4.65 (2.33-4.74) | D. Portnoy |
| Dauphin Island Sea Lab LL | GOM | 2006-2019 | 17.2-30.1 (12.7-32.0) | 23.9-37.6 (0.03-38.0) | 1.2-7.4 (0.2-10.6) | 2.7-104.0 (1.5-111.0) | M. Drymon/SEDAR 77-DW06 |

Table 3. Environmental variable ranges associated with positive catches of Carolina hammerhead *Sphyrna gilberti* from South Carolina Department of Natural Resources fishery-independent surveys in the western North Atlantic (ATL). Values in parentheses represent the observed range of each variable measured across all sets for each source. Indices of abundance were not compiled due to lack of data.

| **Source** | **Region** | **Year range** | **Temperature (°C)** | **Salinity (psu)** | **DO (mg/L)** | **Depth (m)** | **Contact/Reference** |
|---|---|---|---|---|---|---|---|
| SCDNR (all surveys) | ATL | 1994-2021 | 19.0-30.4 (9.7-35.0) | 22.7-36.3 (0.0-38.9) | 4.3-7.1 (2.4-10.8) | 1.5-15.8 (0.5-700) | B. Frazier |

Table 4. Environmental variable ranges associated with positive catches of great hammerhead *Sphyrna mokarran* from fishery-dependent and –independent sources in the Gulf of Mexico (GOM) and western North Atlantic (ATL). Values in parentheses represent the observed range of each variable measured across all sets for each source. For sources that were used to generate abundance indices for this assessment (in bold), an asterisk (*) denotes variables that were found to be significant factors for indices modeling. LL = longline, GN = gillnet, 1+ = catches modeled for ages ≥1, 0+ = catches modeled for ages ≥0, YOY = catches modeled for young of the year (age 1) only.

| Source (Ages modeled) | Region | Year range | Temperature (°C) | Salinity (ppt) | DO (mg/L) | Depth (m) | Contact/Reference |
|---|---|---|---|---|---|---|---|
| **SEFSC Bottom LL (Age 1+)** | **GOM** | **1995-2019*** | **14.0-30.8 (6.8-31.9)** | **31.8-36.7 (17.9-26.4)** | **0.1-7.71 (0-10.6)** | **11.4-138.3 (7-375)*** | **W. Driggers/SEDAR 77-DW24** |
| **GOM SEAMAP Bottom LL (Age 1+)** | **GOM** | **2008-2021*** | **21.3-31 (12.2-32.1)** | **22.3-38.2 (4.9-38)*** | **1.4-8.2 (0.1-12.3)*** | **3.7-14.9 (1.4-332.2)** | **E. Hoffmayer/SEDAR77-DW25** |
| **Shark Bottom LL Observer Program (0+)** | **GOM/ATL** | **1994-2019*** | **14.8-32.7 (7.8-33.8)** | | | **2.0-66.7 (1.6-490.8)*** | **J. Carlson/SEDAR 77-DW12** |
| **FSUCML Keys LL (0+)** | **GOM** | **2011-2021*** | **18.5-31.2 (17.1-33.9)** | **32.5-39.7 (5.56-45.3)*** | **3.82-7.36 (0.2-10.19)** | **2.1-72.0 (0.9-75.1)*** | **R.D. Grubbs/SEDAR 77-DW14** |
| New College of Florida LL | GOM | 2015-2021 | 24.9-31.3 (14.5-33.2) | 21.8-36.6 (0.30-37.4) | 5.25-7.42 (3.12-10.3) | 1.91-6.53 (0.48-8.4) | J. Gardiner/SEDAR 77-SID-05 |
| SCDNR (all surveys) | ATL | 1994-2021 | 20.7-30.7 (9.7-35.0) | 27.8-35 (0.0-38.9) | 4.2-7.7 (2.4-10.8) | 2.1-21.0 (0.5-700) | B. Frazier |
| NEFSC LL | ATL | 1996-2018 | 21.3-24.1 (6.1-26.0) | 36.0-36.6 (29.2-37.0) | | 15.0-43.9 (6.6-67.8) | C. McCandless |
| FSUCML Deep Sea LL | GOM | 2011-2018 | 11.49 (4.12-19.61) | | | 297 (90-2646) | R.D. Grubbs |
| FSUCML Big Bend GN/LL | GOM | 2009-2021 | 21.7-31.1 | 27.3-34.7 | 4.67-8.88 | 2.0-6.7 | R.D. Grubbs |

Table 5. Environmental ranges associated with positive catches of smooth hammerhead *Sphyrna zygaena* from South Carolina Department of Natural Resources fishery-independent surveys in the western North Atlantic (ATL). Values in parentheses represent the full range of each variable measured across all sets for each source. Indices of abundance were not compiled due to lack of data.

| Source | Region | Year range | Temperature (°C) | Salinity (ppt) | DO (mg/L) | Depth (m) | Contact/Reference |
|---|---|---|---|---|---|---|---|
| SCDNR (all surveys) | ATL | 1994-2021 | 23.2 (9.7-35.0) | 35 (0.0-38.9) | 6.8 (2.4-10.8) | 91.2 (0.5-700) | B. Frazier |

Table 6. General habitat and diet information for scalloped *Sphyrna lewini*, Carolina *Sphyrna gilberti*, great *Sphyrna mokarran*, and smooth *Sphyrna zygaena* hammerheads. References for studies outside the western North Atlantic/Gulf of Mexico were included when region-specific data were lacking.

| Species | Habitat | Trophic level/Diet |
|---|---|---|
| *Sphyrna lewini* | • Depth: shallow to ~275m, although documented to 1045m (Moore and Gates 2015)<br>• Exploit shallow estuaries for use as nursery grounds, with juveniles migrating offshore near adulthood (Stevens and Lyle 1989).<br>• Sub-adults/adults known to occupy deep waters potentially for foraging purposes, while also exploiting the mixed layer and shallower shelf habitats depending on location. Some evidence for preference for high relief/bottom structure (Wells et al. 2018)<br>• Vertical diel migrations are apparent, likely for foraging (Hoffmayer et al. 2013). | 4.1 (Cortés 1999);<br>• YOY: Broad diet in comparison to other non-hammerhead species (SCDNR, unpublished)<br>• Juvenile prey items: mix of fish and crustaceans<br>• Adult prey items: larger/higher level prey (squid, teleosts); sexual segregation may lead to dietary differences (Klimley 1987) |
| *Sphyrna gilberti* | • Depth: unknown<br>• Center of young juvenile abundance in US waters: Bulls Bay, SC (nursery area; Quattro 2006; Barker et al. 2021); documented occurrences in Trinidad (D. Portnoy, TAMU, unpublished) | 4.1 (from *S. lewini*, Cortés 1999; likely the same due to species similarities)<br>• YOY: Broad diet in comparison to other non-hammerhead species – similar to scalloped hammerhead (SCDNR, unpublished)<br>• Juvenile prey items: mix of fish and crustaceans (A. Galloway, SCDNR, unpublished) |
| *Sphyrna mokarran* | • Depth: near-surface to 300m (Ebert et al. 2013; Weigmann 2016)<br>• Shallow coastal waters, but migrate offshore to pelagic habitats; habitat use can be seasonal (Calich et al. 2018; Gardiner et al. 2021) and/or related to prey availability (Calich et al. 2021)<br>• Some evidence of philopatry to coastal habitats (Hammerschlag et al. 2011a, b; Graham et al. 2016; Guttridge et al. 2017; Gardiner et al. 2021)<br>• Evidence of pupping grounds off South Carolina and western Florida (Barker et al. 2017; Heuter & Tyminski 2007); young juvenile habitat off Miami, Florida (MacDonald et al. 2021) | 4.3 (Cortés 1999);<br>• Prey items: teleost fishes, sharks and rays<br>• cephalopods are notably less prevalent in diet than in other hammerhead species (Smale & Cliff 1993; Raoult et al. 2019) |
| *Sphyrna zygaena* | • Depth: near-surface to 260m; in southern Atlantic, prefer < 50m (Kotas 2004; Vooren et al. 2005; Santos & Coelho 2018)<br>• Coastal, pelagic, and semi-oceanic waters off and on continental shelves (Compagno 2005)<br>• Salinity may play a role in habitat selection, especially in estuarine waters (Burgess, unpublished; Doño 2008; González Pestana 2018) | 4.2 (Cortés 1999);<br>• Prey items: primarily cephalopods, but bony fishes, crustaceans, small elasmobranchs also documented (Bornatowski et al. 2014).<br>• Some evidence of ontogenetic diet shift (Gonzalez-Pestana et al. 2017)<br>• Low overlap with co-occurring scalloped hammerhead (Loor-Andrade et al. 2015) |

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## 6. Length Composition Section

**Length Composition Contributors**

Andrea Kroetz, Lead ……………………………………………NMFS SEFSC, Panama City, FL
Dean Courtney, co-Lead …..…………………………………NMFS SEFSC, Panama City, FL
Kesley Banks……………………………………...Texas A&M University, Corpus Christi, TX
Juan Carlos Pérez Jiménez……………………El Colegio de la Frontera Sur, Campeche, México
John Carlson…..……………………………………………NMFS SEFSC, Panama City, FL
Enric Cortés…………………………………………………..NMFS SEFSC, Panama City, FL
Sascha Cushner……………………………………………………...NMFS SEFSC, Miami, FL
Marcus Drymon………………………………………Mississippi State University, Biloxi, MS
Mark Fisher…………………………..Texas Parks and Wildlife Department, Port O'Connor, TX
Bryan Frazier…………………..South Carolina Department of Natural Resources, Columbia, SC
Jayne Gardiner…………………………………………...New College of Florida, Sarasota, FL
R. Dean Grubbs…………………………………...……Florida State University, St. Teresa, FL
Neil Hammerschlag….………Rosenstiel School of Marine and Atmospheric Science, Miami, FL
Jill Hendon………………………………University of Southern Mississippi, Ocean Springs, MS
Eric Hoffmayer…………………………………………...NMFS SEFSC, Pascagoula, MS
Alyssa Mathers………………………………………………..NMFS SEFSC, Panama City, FL
Cami McCandless….…………………………..………..………NMFS NEFSC, Narragansett, RI
Jack Morris………………………………………………...Mote Marine Laboratory, Sarasota, FL
Adam Pollack………………..………………………………...NMFS SEFSC, Pascagoula, MS
Dave Portnoy………………………………………...Texas A&M University, Corpus Christi, TX
Mark Sampson……………………………………………Recreational fisherman, Ocean City, MD

## 6.1 Length Composition Submitted For Use In The Assessment Workshop

***Overview***

This document details length composition data sources submitted for four species of hammerhead sharks during the SEDAR 77 Data Workshop for possible use in the SEDAR 77 HMS Hammerhead Sharks stock assessment. Great (*Sphyrna mokarran*), scalloped (*S. lewini*), smooth (*S. zygaena*), and Carolina (*S. gilberti*) hammerheads length composition data were submitted from commercial, recreational, and scientific surveys and summarized here. The goal for all of the data is to provide numbers of available length data (and their distribution) by species so that the assessment team can decide which stock assessment software to use for each species. Data were binned into 5 cm fork length increments by year (terminal year 2019) and matrices extracted for stock assessment model input. Length compositions were plotted for each species to show length-frequency histograms. Twenty-seven data sources (several with multiple surveys) were submitted for a total of 22,108 records collected for the four hammerhead species between 1973 and 2019. Variability in years of data available, species, and the size distributions of recorded specimens was present among the different data sources. Fishery-dependent (commercial and recreational surveys) contributed 13,084 records of the four species whereas fishery-independent surveys contributed 9,024 records.

***Introduction***

The proposed analytical approach to be implemented in this assessment with these data is a length-based, age-structured statistical model (Stock Synthesis; Methot and Wetzel 2013; e.g., Wetzel and Punt 2011a, 2011b). Stock Synthesis utilizes an integrated modeling approach (Maunder and Punt 2013) to take advantage of the many data sources available, including length composition data. Once data are organized into 'fleets' based on similar length compositions, selectivity for each fleet can be estimated in the Stock Synthesis model from the time series of binned length data. Similarly, available length composition time series obtained for accepted CPUE indices will be reviewed during subsequent assessment webinars in order to determine if there are sufficient length data to represent the length composition distributions of each accepted CPUE index. Length-based selectivity for CPUE indices with representative length composition distributions will be estimated in the Stock Synthesis model from the time series of binned length data. Length-based selectivity for CPUE indices without representative length composition distributions will be set equal to (mirror) CPUE indices with representative length composition distributions.

***Methods***

Length composition data for great, scalloped, smooth, and Carolina hammerheads were submitted during the SEDAR 77 Data Workshop, which occurred from December 13-17, 2021. The goal for all of the data is to provide numbers of available length data (and their distribution) by species so that the assessment team can decide which stock assessment software to use for each species. The available length composition time series data were obtained from fisheries-independent scientific surveys as well as from fishery-dependent sources from commercial and recreational catch data and were available from 1973-2019 (Table 1), depending on the data source. Data were recorded by fisheries research biologists, scientific observers, commercial, and recreational fishers from various surveys and fishing events. Length data from each dataset were omitted from analyses if it exceeded biologically plausible measurements for the species reported in SEDAR77-DW18. Fork length measurements (cm FL) were used if available and data were converted to cm FL from other measured length units with the equation for combined sexes given in SEDAR 77-DW03. Data were subset into three regions: Gulf of Mexico, Atlantic Ocean, and combined Gulf of Mexico and Atlantic Ocean. Recommendations from the Stock ID Final Report (SEDAR 2022) were followed as to how to treat each stock. Thus, scalloped hammerhead data were separated out into each of the three regions if data were available whereas great, smooth, and Carolina hammerheads were grouped into the combined regions only. Data were further subset into males, females, unknown sex, and combined sex for each species and region. Scalloped hammerheads were further subset to create an Age 0 complex (≤ 61 cm FL, young-of-the-year) and an Age 1+ complex (≥ 62 cm FL, juvenile to adult) to match that of the Indices Working Group, as described in SEDAR77-DW24, which is consistent with the interpretation of the size at Age 0 of scalloped hammerheads among the various data sources. Length data were then binned by year into 5 cm FL increments and the matrices extracted for stock assessment model input (i.e., Stock Synthesis). Length-frequency histograms were created for each species and sex matrix with length at 50% maturity ($L_{50}$) denoted in each plot obtained from SEDAR77-DW18.

## 6.2 Fishery-Dependent Data Sources

*Recreational Catches: Marine Recreational Information Program (MRIP) and the Southeast Region Head Boat Survey (SRHS)*

Length composition data for hammerheads were available via the Marine Recreational Information Program (MRIP) and the Southeast Region Headboat Survey (SRHS) operated by the Southeast Fisheries Science Center (SEFSC) Beaufort Laboratory as described in the Catches Section of this report and in SEDAR77-DW04. MRIP and SRHS were combined to create one Recreational Survey category (n=430). Data were split into three regions: Gulf of Mexico, Atlantic Ocean, and combined Gulf of Mexico and Atlantic Ocean. Provided data ranged from 1981-2015 for Age 0 (n=85) and Age 1+ (n=203) scalloped hammerheads, combined ages of great (n=97) hammerheads, and for smooth hammerheads (n=45) (Table 2). No sex was recorded for these surveys so single matrices were created for each species in the Gulf of Mexico, Atlantic Ocean, and combined regions.

*South Carolina Department of Natural Resources (SCDNR)*

Commercial trawl and gillnet data were available through the South Carolina Department of Natural Resources (n=85) ranging from 2006-2019 for the Atlantic Ocean. Length data were provided for Age 0 (n=37) and Age 1+ (n=10) scalloped hammerheads and for Carolina hammerheads (n=13) collected using trawl gear. Age 1+ (n=12) scalloped hammerheads were collected in gillnet gear along with Carolina hammerheads (n=13) (Table 2).

*Mexican Gulf of Mexico Artisanal Shark Fisheries*

Intensive monitoring of the artisanal shark fisheries in the coastal waters of the Mexican Gulf of Mexico provided length data from 1982-2019 (n=1,637) to be considered for use in the assessment (Table 2; see SEDAR77-DW04 for further details). Artisanal gillnet and bottom longline gears provided length composition data in the Gulf of Mexico for Age 0 (n=778) and Age 1+ (n=797) scalloped hammerheads, and combined ages of great hammerheads (n=62).

*NOAA Fisheries Northeast Fishery Science Center (NEFSC) Cooperative Shark Tagging Program (CSTP)*

The Cooperative Shark Tagging Program, launched in 1962, is a collaborative effort among recreational anglers, the commercial fishing industry, and NOAA Fisheries to learn more about the life history of Atlantic Sharks. Most CSTP participants tag the sharks they catch with a rod and reel while fishing recreationally. Other participants include commercial anglers using longline and net gear, biologists, and NOAA fisheries observers. Length composition data were available from 1962-2019 (n=2,576) (Table 2). A large amount of data included estimated fork lengths, thus matrices were made for both measured and estimated lengths for the Gulf of Mexico, Atlantic Ocean, and combined regions. Gears included were commercial and recreational trawl, gillnet, bottom longline, rod and reel, and handline. Age 0 scalloped hammerheads were caught by trawl (n=6), gillnet (n=2), longline (n=1), and rod and reel (n=322) gears. Age 1+ scalloped hammerheads were caught by trawl (n=393), gillnet (n=18), longline (n=248), and rod and reel (n=1035) gears. Combined ages of great hammerheads were captured by longline (n=17) and rod and reel gears (n=276), smooth hammerheads by longline (n=34) and rod and reel gears (n=218).

*Texas Shark Rodeo*

Data collected from anglers targeting sharks participating in the Texas Shark Rodeo were available from 2014-2019 for the Gulf of Mexico (n=146). Age 0 (n=31) and Age 1+ (n=50) scalloped hammerheads and all ages combined of great (n=65) had length information (Table 2).

*Recreational Logbook*

Personal logbooks of recreational charter Captain, Mark Sampson, are being archived in a database at Maryland Department of Natural Resources. These data were available from 2007-2019 (n=88) and provided length compositions for Age 1+ (n=30) scalloped hammerheads and for smooth hammerheads (n=58) in the Atlantic Ocean (Table 2).

*Southeast Coastal Gillnet Observer Program (GNOP)*

Observer coverage of the Florida-Georgia shark gillnet fishery began in 1992, and has since documented the many changes to effort, gear characteristics, and target species the fishery has undergone following the implementation of multiple fisheries regulations as described in SEDAR77-DW13. A large amount of data included estimated fork lengths, thus matrices were made for both measured and estimated lengths for the Gulf of Mexico, Atlantic Ocean, and combined regions (n=303). Length composition data were available from 1999-2019 and provided information for Age 0 (n=32) and Age 1+ (n=213) scalloped hammerheads, combined ages of great hammerheads (n=44), and for smooth hammerheads (n=14) (Table 2).

*Shark Bottom Longline Observer Program (BLLOP)*

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 as described in SEDAR77-DW12. Length composition data were available from 1994-2019 (n=4,219) and include data prior to the Shark Research Fishery that was run by the University of Florida. Length data were provided for Age 0 (n=13) and Age 1+ (n=2,782) scalloped hammerheads, all ages combined of great hammerheads (n=1,409), and for smooth hammerheads (n=15) (Table 2). Matrices were created for the Gulf of Mexico, Atlantic Ocean, and combined regions.

*Pelagic Longline Observer Program (PLLOP)*

In 1992, the National Marine Fisheries Service (NMFS) initiated scientific sampling of the U.S. large pelagic fisheries longline fleet, as mandated by the U.S. Swordfish Fisheries Management Plan and subsequently the Atlantic Highly Migratory Species Fishery Management Plan (1998). Scientific observers were placed aboard vessels participating in the Atlantic pelagic longline fishery as described in SEDAR77-DW08. Length composition data were available from 1992-2019 (n=3,600). A large amount of data included estimated fork lengths, thus matrices were made for both measured and estimated lengths for the Gulf of Mexico, Atlantic Ocean, and combined regions. Length data for Age 1+ (n=3,195) scalloped hammerheads, combined ages of great hammerheads (n=297), and for smooth hammerheads (n=108) (Table 2).

## 6.3 Fishery-Independent Data Sources

*Northeast Gulf of Mexico (GULFSPAN) Gillnet Survey*

Fishery-independent surveys of coastal shark populations have taken place since 1994 in the eastern and northern Gulf of Mexico. The cooperative GULFSPAN gillnet survey began in 1996 to examine the distribution and abundance of juvenile sharks in coastal areas as described in SEDAR77-DW17 and data were available from 1994-2019 (n=1,742). Length data were provided for Age 0 (n=1,530) and Age 1+ (n=187) scalloped hammerheads and combined ages of great hammerheads (n=25) in the Gulf of Mexico (Table 3).

*Texas Parks and Wildlife Gillnet Survey*

The Texas Parks and Wildlife Department, Coastal Fisheries Division runs a fishery-independent gillnet survey to monitor the relative abundance and size of organisms, their spatial and temporal distribution, species composition of the community, and selected environmental parameters known to influence their distribution and abundance. Surveys were conducted in 10 major bay systems along the Texas coast in the northwestern Gulf of Mexico from 1982 to 2019 as described in SEDAR77-DW16. Length composition data were provided for 662 animals consisting of Age 0 (n=569) and Age 1+ (n=81) scalloped hammerheads and combined ages of great hammerheads (n=25) (Table 3).

*Florida State University Bottom Longline Survey*

The Florida State University bottom longline survey was expanded in 2011 to include regular sampling in southwest Florida in an effort to capture smalltooth sawfish, *Pristis pectinata*, for research directed at promoting recovery of this endangered species. This work is concentrated in two areas, in Everglades National Park, mostly in northern Florida Bay, along the middle to lower Florida Keys, primarily along the shelf break as described in SEDAR77-DW14. Length composition data (n=219) were available from 2011-2019 for Age 1+ scalloped hammerheads (n=76) and combined ages of great hammerheads (n=143) in the Gulf of Mexico (Table 3).

*NOAA Fisheries Southeast Fisheries Science Center Bottom Longline Survey*

NOAA Fisheries SEFSC Mississippi Laboratories has conducted standardized bottom longline surveys in the western North Atlantic Ocean since 1995 as described in SEDAR77-DW24. Length compositions were provided for 703 animals from 1995-2019 consisting of Age 0 (n=9) and Age 1+ (n=598) scalloped hammerheads and combined ages of great hammerheads (n=96) (Table 3). Matrices were created for the Gulf of Mexico, Atlantic Ocean, and combined regions.

*NOAA Northeast Fisheries Science Center Coastal Shark Bottom Longline Survey*

The NOAA Fisheries NEFSC Apex Predators Program has conducted coastal shark bottom longline surveys from 1996-2018 along the Atlantic coast of the United States as described in SEDAR77-DW28. Length compositions were available for 259 animals consisting of Age 1+ (n=251) scalloped hammerheads and combined ages of great hammerheads (n=8) (Table 3).

*Southeast Area Monitoring and Assessment Program Bottom Longline Survey*

Fishery-independent bottom longline surveys have been conducted in coastal waters of the northern Gulf of Mexico by the Southeast Area Monitoring and Assessment Program (SEAMAP) via NOAA Fisheries SEFSC Mississippi Labs, the Dauphin Island Sea Lab, Gulf Coast Research Laboratory, Louisiana Department of Wildlife and Fisheries, and Texas Parks and Wildlife Department as described in SEDAR77-DW25. Surveys spanned from Texas to Alabama providing length compositions for 153 animals from 2008-2019: Age 0 (n=3) and Age 1+ (n=86) scalloped hammerheads and combined ages of great hammerheads (n=64) (Table 3).

*NOAA Fisheries Cooperative Atlantic States Shark Pupping and Nursery Longline Survey*

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 SCDNR, Georgia Department of Natural Resources (GADNR), and the University of North Florida (UNF) in collaboration with NMFS Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) program began sampling for sharks using longline and gillnet methods in several of their state's estuaries and nearshore waters as described in SEDAR77-DW30. Length composition from longline surveys were available from 2000-2019, providing data for 477 animals. Age 0 (n=439) and Age 1+ (n=37) scalloped hammerheads and one Carolina hammerhead were captured by longline gear on the Atlantic coast (Table 3).

*South Carolina Department of Natural Resources, Cooperative Atlantic States Shark Pupping and Nursery Long-Gillnet Survey*

In an effort to examine the use of South Carolina's estuarine waters as nursery areas for coastal shark species the SCDNR Marine Resources Division, in collaboration with NMFS COASTSPAN Survey began sampling for sharks using longline and gillnet methods in several estuaries within South Carolina as described in SEDAR77-DW31. Length composition data from long gillnet were available from 2001-2019 for 1,060 animals in the Atlantic Ocean. Age 0 (n=1,017) and Age 1+ (n=8) scalloped hammerheads and combined ages of Carolina (n=35) hammerheads were captured by gillnet gear (Table 3).

*South Carolina Department of Natural Resources, Cooperative Atlantic States Shark Pupping and Nursery Short-Gillnet Survey*

In an effort to increase sampling effort in South Carolina's estuarine waters SCDNR Marine Resources Division, in collaboration with NMFS COASTSPAN Survey added an additional survey gear (short gillnet) in 2006 to the established longline and gillnet methods that had been ongoing in several estuaries within South Carolina since 1998 as described in SEDAR77-DW32. Length composition data were available for short gillnet gear from 2007-2019 for Age 0 scalloped hammerheads (n=34) in the Atlantic Ocean (Table 3).

*South Carolina Department of Natural Resources Red Drum Bottom longline*

The SCDNR runs a long-term monitoring program for adult red drum, *Sciaenops ocellatus*, in the coastal waters of South Carolina as described in SEDAR77-DW29. Length composition data were available from 1995-2006 for Age 0 (n=52) and Age 1+ (n=34) scalloped hammerheads in the Atlantic Ocean (Table 3).

*South Carolina Department of Natural Resources SEAMAP Bottom Longline*

Under SEAMAP, the SCDNR red drum longline survey was modified from a fixed-station survey to a random stratified multispecies survey in 2007 in response to the needs of stock assessment biologists and to increase coverage along the coast as described in SEDAR77-DW29. Length composition data were available from 2007-2019 for 53 animals. Age 0 (n=34) and Age 1+ (n=12) scalloped hammerheads and combined ages of great (n=7) hammerheads were captured by longlines in the Atlantic Ocean (Table 3).

*South Carolina Department of Natural Resources Scientific Trawl*

The SCDNR runs a scientific trawl survey that provided length composition data for 122 animals from 2006-2019. Age 0 (n=68) and Age 1+ (n=21) scalloped hammerheads, combined ages of great (n=5), and for Carolina (n=28) hammerheads were captured by trawl gear in the Atlantic Ocean (Table 3).

*Texas A&M University Corpus Christi Gillnet and Longline Surveys*

Texas A&M University Corpus Christi runs a longline and gillnet program in Corpus Christi Bay to sample shark assemblages within the bay. Length composition data were available for 12 Age 0 scalloped hammerhead collected between 2017-2018. Nine (n=9) were captured by gillnet gear and three were captured by longline gear for the Gulf of Mexico region (Table 3).

*University of North Carolina Shark Longline Survey*

A bi-weekly longline survey has been conducted at two fixed stations south of Shackleford Banks in Onslow Bay, North Carolina by the University of North Carolina (UNC), Institute of Marine Sciences starting in 1972 as described in SEDAR77-DW33. Length composition data were available for 506 scalloped hammerheads from 1972-2019. Eight Age 0 and 498 Age 1+ scalloped hammerheads were captured by longline gear in the Atlantic Ocean during this survey (Table 3).

*Rosenstiel School of Marine and Atmospheric Science Drumline Survey*

Shark drumline surveys have been conducted by the Rosenstiel School of Marine and Atmospheric Science from Miami through the middle Florida Keys to examine spatial, seasonal, and environmental patterns in shark occurrence, catch per unit effort, composition, and demographic structure as described in SEDAR65-DW15. Length composition data were available for 220 animals from 2008-2019. Age 1+ (n=17) scalloped hammerheads and combined ages of great (n=203) hammerheads were captured by drumline gear (Table 3). Matrices were created for the Gulf of Mexico, Atlantic Ocean, and combined regions.

*Mote Marine Laboratory Surveys*

Mote Marine Laboratory has conducted long-term sampling of shark assemblages in the eastern Gulf of Mexico utilizing longline, drumline, and gillnet gears. Length composition data were available for 337 animals from 1992-2019. Longline gear captured 79 animals comprised of Age 1+ (n=20) scalloped hammerheads and combined ages of great (n=59) hammerheads. Drumline gear captured 78 animals consisting of Age 1+ (n=8) scalloped hammerheads and combined ages of great (n=70) hammerheads. Gillnet gear captured 180 animals consisting of Age 0 (n=76) and Age 1+ (n=5) scalloped hammerheads and combined ages of great (n=99) hammerheads (Table 3). Matrices for each gear type were created for the Gulf of Mexico.

*Dauphin Island Sea Lab (DISL) Bottom Longline Survey*

Fishery-independent bottom longline surveys have been conducted out of the Dauphin Island Sea Lab by the University of South Alabama since 2006 as described in SEDAR77-DW06 and under

SEAMAP as described in SEDAR77-DW25. Length composition data were available for 250 animals from 2006-2019. Age 1+ (n=182) scalloped and combined ages of great (n=68) hammerheads were captured in the Gulf of Mexico (Table 3). ***Note: there are 31 animals (n=21 great hammerhead, n= 10 scalloped hammerhead) that were captured under the SEAMAP survey. These lengths were also included in the SEAMAP length composition summary described here to match the index development for SEAMAP, which included some of the DISL stations.***

*Georgia Department of Natural Resources, SEAMAP Bottom Longline Survey*

Under SEAMAP, the GADNR conducts a bottom longline survey off the Georgia coast in the Atlantic Ocean. Length composition data were available for 38 scalloped hammerheads from 2007-2019. Age 0 (n=31) and Age 1+ (n=7) animals were captured (Table 3).

*NOAA Fisheries Cooperative Shark Tagging Program*

The CSTP provided length composition data for 2,122 animals from 1962-2019 from six scientific gear types: trawl, gillnet, longline, rod and reel, drumline, and handline. A large amount of data included estimated fork lengths, thus matrices were made for both measured and estimated lengths for the Gulf of Mexico, Atlantic Ocean, and combined regions. Trawl gear captured Age 0 (n=5) and Age 1+ (n=7) scalloped hammerheads; gillnet gear captured Age 0 (n=173) and Age 1+ (n=19) scalloped hammerheads; longline gear captured Age 0 (n=168) and Age 1+ (n=1499) scalloped hammerheads, combined ages of great (n=72) and smooth (n=27) hammerheads; rod and reel gear captured Age 0 (n=6) and Age 1+ (n=13) scalloped hammerheads, combined ages of great (n=7) and smooth (n=5) hammerheads; drumline gear captured 97 great hammerheads (combined ages); and handline gear captured 24 great hammerheads (combined ages) (Table 3).

## 6.4 Summary

Twenty-seven data sources were submitted for possible use in the assessment, many with multiple surveys for multiple gear types. Fishery-dependent (commercial and recreational surveys) contributed 13,084 records (Figure 1) whereas fishery-independent surveys contributed 9,024 records of all four species (Figure 2). Scalloped hammerheads had the highest frequency of catches compared to the other species in commercial and recreational gears and Carolina hammerheads were captured the least. Bottom longline gear was the primary gear that captured hammerheads, and other gears included gillnets, pelagic longlines, hook and line/rod and reel, and trawls (Figure 1). Age 0 (young-of-the-year) scalloped hammerheads were primarily captured in fishery-independent gillnets, followed by bottom longlines (Figure 2) whereas Age 1+ (juveniles to adults) scalloped hammerheads were primarily captured in bottom longline gear followed by gillnets (Figure 2). Great hammerheads were primarily captured in bottom longlines and drumlines, while smooth hammerheads were captured primarily in bottom longlines. The few Carolina hammerheads captured were in gillnets and trawls (Figure 2).

Length composition for Age 0 scalloped hammerheads ranged from 21-61 cm FL (Figure 3) and from 62-400 cm FL for Age 1+ (Figure 4). Great hammerheads length composition ranged from 26-365 cm FL (Figure 5) and smooth hammerheads from 29-350 cm FL (Figure 6). Carolina hammerhead length composition ranged from 27-104 cm FL (Figure 7). Length compositions of each data source of males and females of each species were plotted to provide visualization of available data. Example plots of one fishery-dependent and one fishery-independent survey can are provided below.

**Example length-frequency compositions for HMS hammerhead sharks submitted during the SEDAR 77 Data Workshop for possible inclusion in the SEDAR 77 stock assessment**

1. Length composition data for hammerheads were available via the Marine Recreational Information Program (MRIP) and the Southeast Region Headboat Survey (SRHS) operated by the Southeast Fisheries Science Center (SEFSC) Beaufort Laboratory (as described in the methods section of the main text and summarized in Table 2 above; Figures 8-10). MRIP and SRHS were combined to create one Recreational Survey (n=430) that includes all fishery-dependent recreational catches. Data were split into three regions: Gulf of Mexico, Atlantic Ocean, and combined Gulf of Mexico and Atlantic Ocean. Female length at 50% maturity are denoted by a red dashed line and males length at 50% maturity are denoted by solid blue lines for each region as described in SEDAR77-DW18.

2. Length compositions for hammerheads were available from NOAA Fisheries Southeast Fisheries Science Center (SEFSC) Mississippi Laboratories standardized fishery-independent bottom longline survey (n=703, NMFS Longline; as described in the methods section of the main text and summarized in Table 3 above; Figures 11-16). Data were split into three regions: Gulf of Mexico, Atlantic Ocean, and combined Gulf of Mexico and Atlantic Ocean. Female length at 50% maturity are denoted by a red dashed line and males length at 50% maturity are denoted by solid blue lines for each region as described in SEDAR77-DW18.

### *References*

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Methot R. D. and C. R. Wetzel. 2013. Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management. Fisheries Research 142:86–99.

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## 6.5 Tables

**Table 1**. Summary of available length composition data for scalloped (*S. lewini*), great (*S. mokarran*), smooth (*S. zygaena*), and Carolina (*S. gilberti*) hammerheads from 1973-2019. Data were broken into fishery-independent and fishery-dependent data sources and 'estimated' refers to fork lengths (FL cm) that were estimated and thus not exact measurements. Age 0 refers to scalloped hammerheads (<61 cm FL) and Age 1+ scalloped hammerheads refers to (>61 cm FL). If not noted, ages are combined for species. Abbreviations are as follows: SHH = scalloped hammerheads, GHH = great hammerheads, SMH = smooth hammerheads, and CHH = Carolina hammerheads.

| **Data Sources** | **Age 0 SHH** | **Age 1+ SHH** | **All GHH** | **All SMH** | **All CHH** | **Total** |
|---|---|---|---|---|---|---|
| Fishery-Independent | 4234 | 2216 | 981 | 30 | 64 | 7525 |
| Estimated Fishery-Independent | 0 | 1440 | 57 | 2 | - | 1499 |
| Total | 4234 | 3656 | 1038 | 32 | 64 | 9024 |
| Fishery-Dependent | 1191 | 5172 | 1820 | 269 | 26 | 8478 |
| Estimated Fishery-Dependent | 116 | 3814 | 453 | 223 | - | 4606 |
| Total | 1307 | 8986 | 2273 | 492 | 26 | 13084 |
| **Grand Total** | 5541 | 12642 | 3311 | 524 | 90 | **22108** |

**Table 2**. Fishery-dependent data sources from commercial and recreational catches for possible use in the assessment. Age 0 refers to scalloped hammerheads (≤61 cm FL) and Age 1+ scalloped hammerheads refers to (≥62 cm FL). If not noted, ages are combined for species. Abbreviations are as follows: SHH = scalloped hammerheads, GHH = great hammerheads, SMH = smooth hammerheads, and CHH = Carolina hammerheads.

| Data Source | Years of Coverage | Age 0 SHH | Age 1+ SHH | GHH | SMH | CHH |
|---|---|---|---|---|---|---|
| Recreational Catches | | | | | | |
| *MRIP, SRHS* | 1981-2015 | 85 | 203 | 97 | 45 | 0 |
| South Carolina Department of Natural Resources | | | | | | |
| *Commercial trawl* | 2006-2019 | 37 | 10 | 0 | 0 | 13 |
| *Commercial gillnet* | 2006-2019 | 0 | 12 | 0 | 0 | 13 |
| Mexican Gulf of Mexico Artisanal fisheries | | | | | | |
| *Gillnet* | 1982-2019 | 122 | 408 | 44 | 0 | 0 |
| *Longline* | 1982-2019 | 656 | 389 | 18 | 0 | 0 |
| Cooperative Shark Tagging Program | | | | | | |
| *Commercial/recreational trawl* | 1962-2019 | 6 | 393 | 0 | 0 | 0 |
| *Commercial/recreational gillnet* | 1962-2019 | 2 | 18 | 0 | 0 | 0 |
| *Commercial/recreational longline* | 1962-2019 | 1 | 248 | 17 | 34 | 0 |
| *Commercial/recreational rod and reel* | 1962-2019 | 322 | 1035 | 276 | 218 | 0 |
| *Commercial/recreational handline* | 1962-2019 | 0 | 0 | 6 | 0 | 0 |
| Texas Shark Rodeo | 2014-2019 | 31 | 50 | 65 | 0 | 0 |
| Recreational Logbook (Mark Sampson) | 2007-2019 | 0 | 30 | 0 | 58 | 0 |
| Southeast Coastal Gillnet Observer Program | 1999-2019 | 32 | 213 | 44 | 14 | 0 |
| Shark Bottom Longline Observer Program | | | | | | |
| *All vessels (includes UF BLL)* | 1994-2005 | 13 | 1056 | 418 | 8 | 0 |
| *Shark Research Fishery* | 2005-2019 | 0 | 1726 | 991 | 7 | 0 |
| Pelagic Longline Observer Program | 1992-2019 | 0 | 3195 | 297 | 108 | 0 |
| | **TOTAL** | **1307** | **8986** | **2273** | **492** | **26** |

**Table 3**. Fishery-independent data for possible use in the assessment. Age 0 refers to scalloped hammerheads (≤61 cm FL) and Age 1+ scalloped hammerheads refers to (≥62 cm FL). If not noted, ages are combined for species. Abbreviations are as follows: SHH = scalloped hammerheads, GHH = great hammerheads, SMH = smooth hammerheads, and CHH = Carolina hammerheads.

| Data Source | Years of Coverage | Age 0 SHH | Age 1+ SHH | GHH | SMH | CHH |
|---|---|---|---|---|---|---|
| Northeast Gulf of Mexico (GULFSPAN) Gillnet Survey | 1994-2019 | 1530 | 187 | 25 | 0 | 0 |
| Texas Park and Wildlife Gillnet Survey | 1982-2019 | 569 | 81 | 12 | 0 | 0 |
| NOAA Fisheries | | | | | | |
| *Southeast Area Monitoring and Assessment Program (SEAMAP) Bottom Longline Survey* | 2008-2019 | 3 | 86 | 64 | 0 | 0 |
| *Northeast Fisheries Science Center (NEFSC) coastal shark bottom longline survey* | 1996-2018 | 0 | 251 | 8 | 0 | 0 |
| *Southeast Fisheries Science Center (SEFSC) Bottom Longline Survey* | 1995-2019 | 9 | 598 | 96 | 0 | 0 |
| *Cooperative Shark Tagging Program scientific trawl* | 1962-2019 | 5 | 7 | 0 | 0 | 0 |
| *Cooperative Shark Tagging Program scientific gillnet* | 1962-2019 | 173 | 19 | 0 | 0 | 0 |
| *Cooperative Shark Tagging Program scientific longline* | 1962-2019 | 168 | 1499 | 72 | 27 | 0 |
| *Cooperative Shark Tagging Program scientific rod and reel* | 1962-2019 | 6 | 13 | 7 | 5 | 0 |
| *Cooperative Shark Tagging Program scientific drumline* | 1962-2019 | 0 | 0 | 97 | 0 | 0 |
| *Cooperative Shark Tagging Program scientific handline* | 1962-2019 | 0 | 0 | 24 | 0 | 0 |
| Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) | | | | | | |
| *Long gillnet* | 2001-2019 | 1017 | 8 | 0 | 0 | 35 |
| *Short gillnet* | 2007-2019 | 34 | 0 | 0 | 0 | 0 |
| *Bottom longline* | 2000-2019 | 439 | 37 | 0 | 0 | 1 |
| Georgia Department of Natural Resources (GADNR) SEAMAP | 2007-2019 | 31 | 7 | 0 | 0 | 0 |
| South Carolina Department of Natural Resources (SCDNR) | | | | | | |
| *Red drum longline* | 1995-2006 | 52 | 34 | 0 | 0 | 0 |
| *SEAMAP longline* | 2007-2019 | 34 | 12 | 7 | 0 | 0 |
| *Scientific Trawl* | 2006-2019 | 68 | 21 | 5 | 0 | 28 |
| University of North Carolina Longline survey | 1973-2019 | 8 | 498 | 0 | 0 | 0 |

**Table 3**. Continued.

| Data Source | Years of Coverage | Age 0 SHH | Age 1+ SHH | GHH | SMH | CHH |
|---|---|---|---|---|---|---|
| Texas A&M University Corpus Christi | | | | | | |
| *Gillnet* | 2017-2018 | 9 | 0 | 0 | 0 | 0 |
| *Longline* | 2017-2018 | 3 | 0 | 0 | 0 | 0 |
| Dauphin Island Sea Lab (DISL) Bottom Longline Survey | 2006-2019 | 0 | 182* | 68* | 0 | 0 |
| Florida State University Bottom Longline Survey | 2011-2019 | 0 | 76 | 143 | 0 | 0 |
| Rosenstiel School of Marine and Atmospheric Science Drumline Survey | 2008-2019 | 0 | 17 | 203 | 0 | 0 |
| Mote Marine Lab | | | | | | |
| *Longline* | 1992-2019 | 0 | 20 | 59 | 0 | 0 |
| *Drumline* | 1992-2019 | 0 | 8 | 70 | 0 | 0 |
| *Gillnet* | 1992-2019 | 76 | 5 | 99 | 0 | 0 |
| | **TOTAL** | **4234** | **3656** | **1038** | **32** | **64** |

Asterisk (*) indicates that 10 SHH and 21 GHH lengths from DISL were included in SEAMAP length composition summary to match the index development for SEAMAP, which included some DISL stations. Totals do not include these 31 animals.

## 6.6 Figures

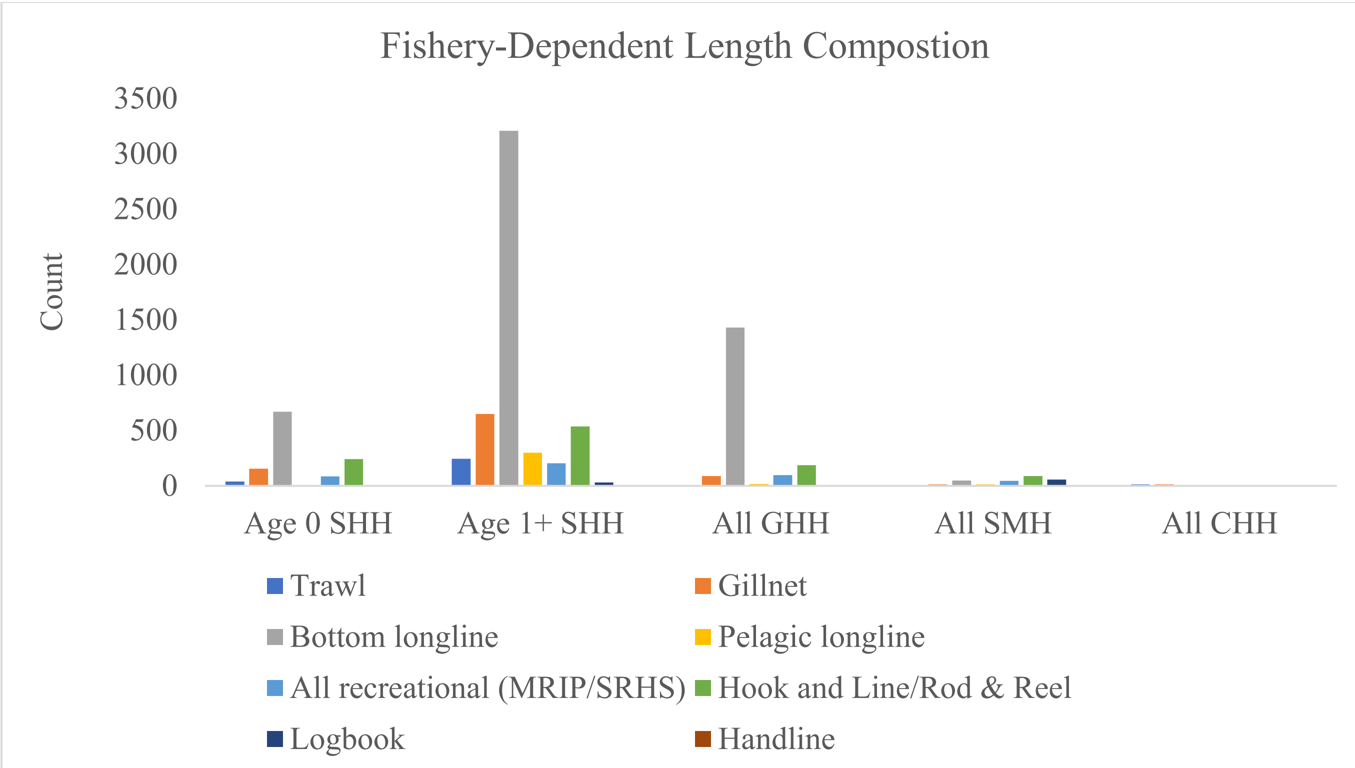


**Figure 5. Length compositions for scalloped (SHH), great (GHH), smooth (SMH), and Carolina (CHH) hammerheads from fishery-dependent data sources. Gear types are summarized for combined Gulf of Mexico and Atlantic Ocean regions for each species. Ages are combined for GHH, SMH, and CHH.**

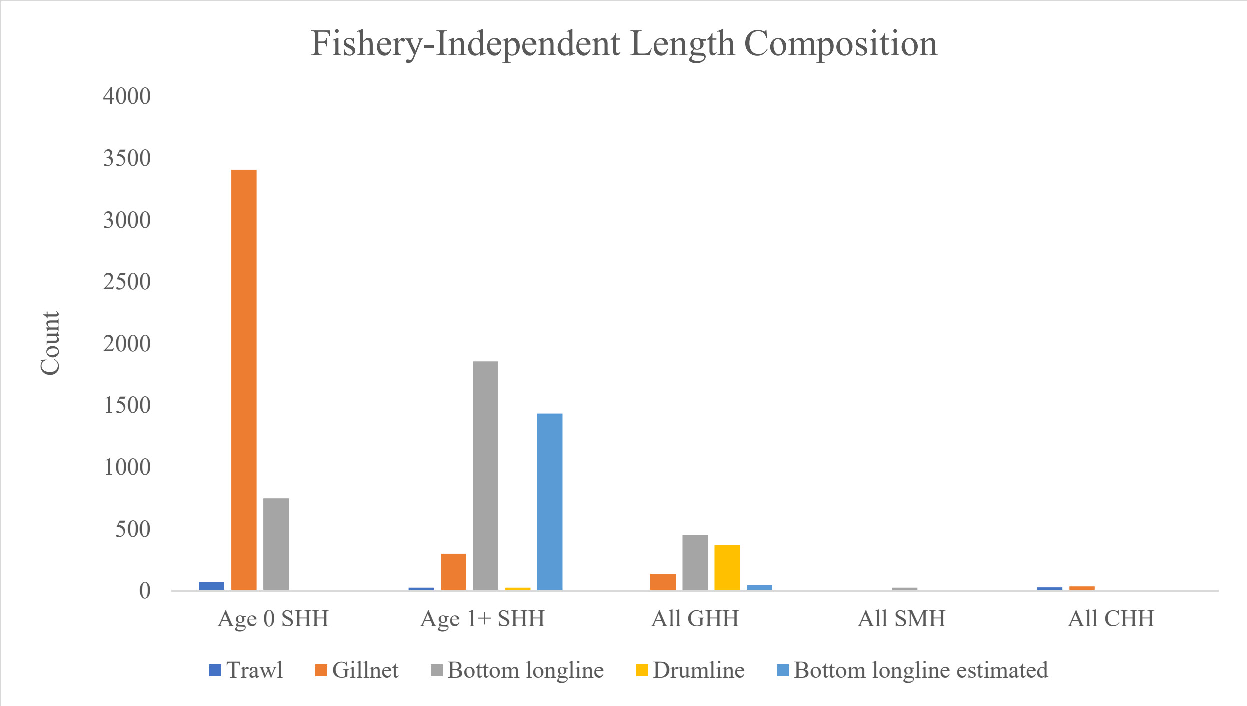


**Figure 6. Length compositions for scalloped (SHH), great (GHH), smooth (SMH), and Carolina (CHH) hammerheads from fishery-independent data sources. Gear types are summarized for combined Gulf of Mexico and Atlantic Ocean regions for each species. Ages are combined for GHH, SMH, and CHH.**

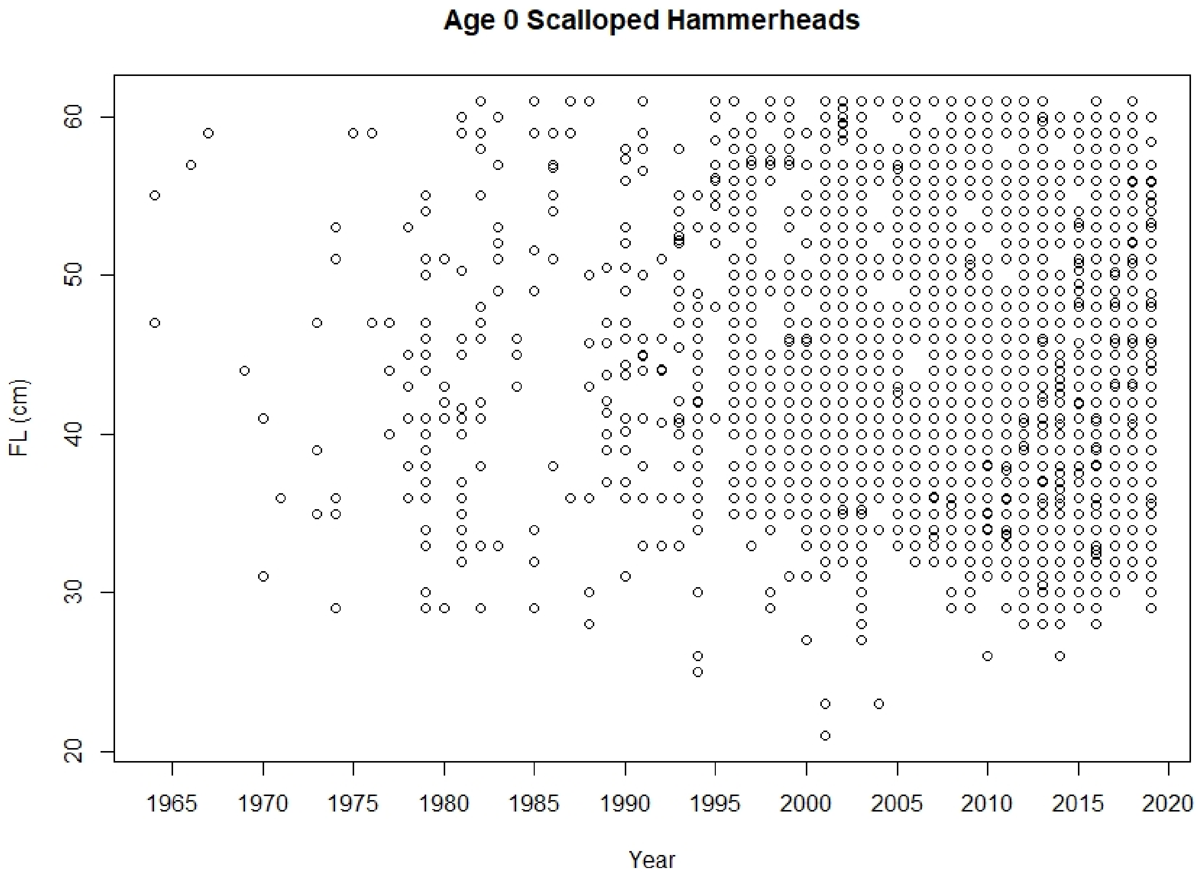


**Figure 7. Length composition of Age 0 scalloped hammerheads across available years for potential use in the assessment. Fishery-dependent and independent data are combined.**

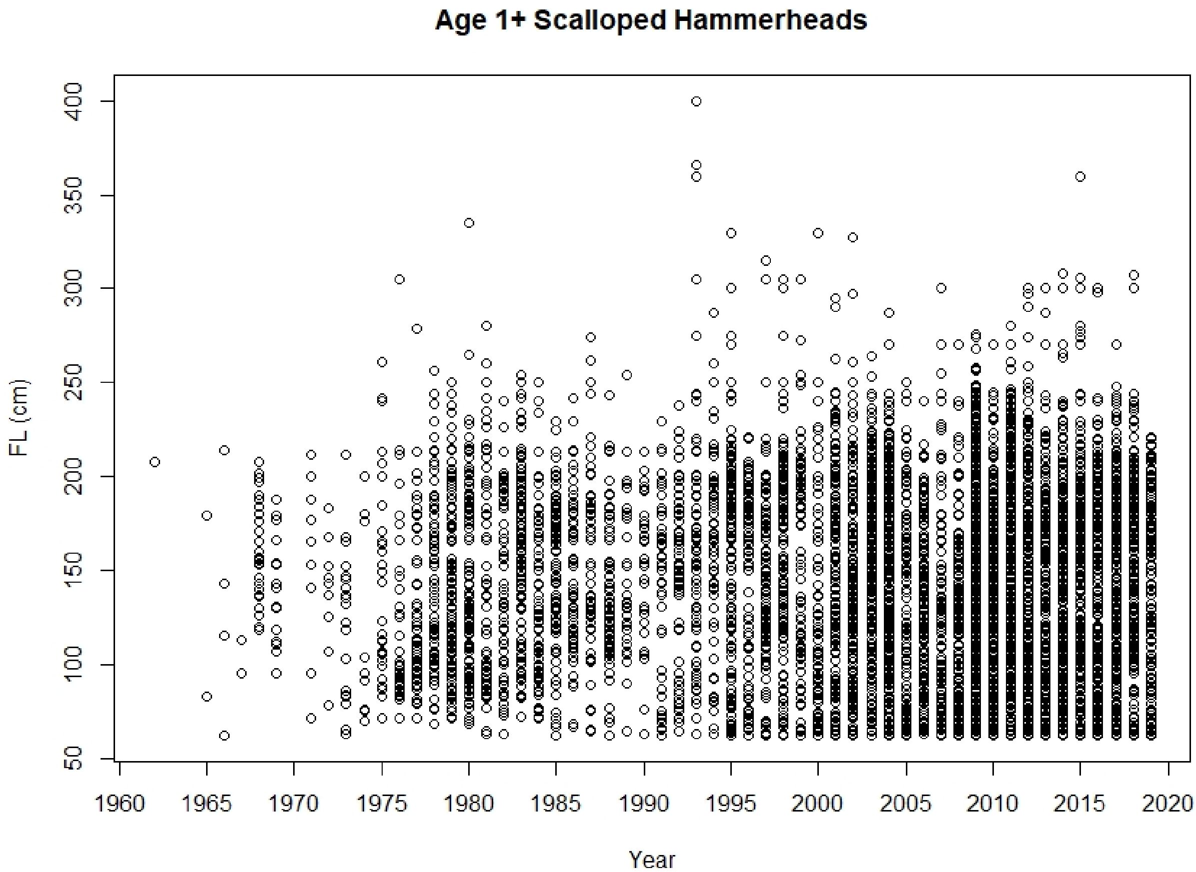


**Figure 8. Length composition of Age 1+ scalloped hammerheads across available years for potential use in the assessment. Fishery-dependent and independent data are combined.**

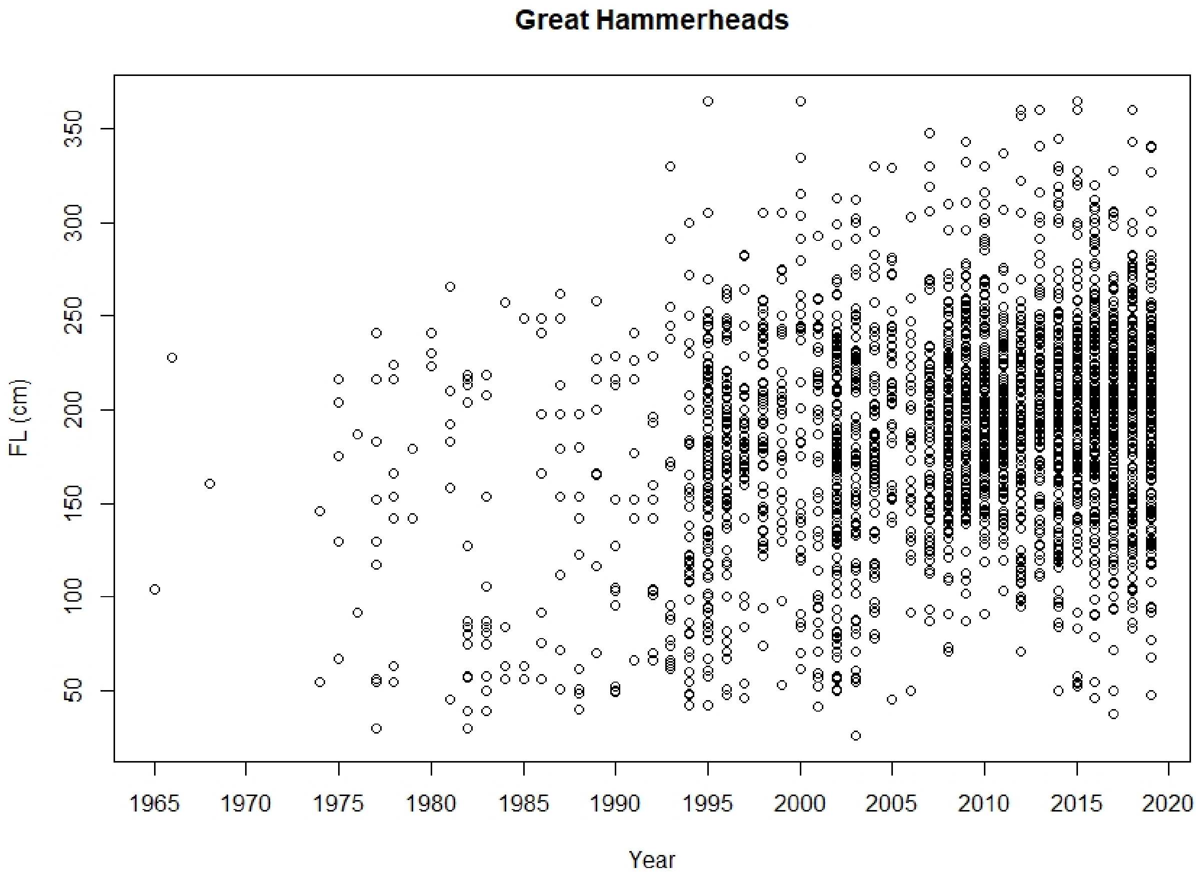


**Figure 9. Length composition of combined ages of great hammerheads across available years for potential use in the assessment. Fishery-dependent and independent data are combined.**

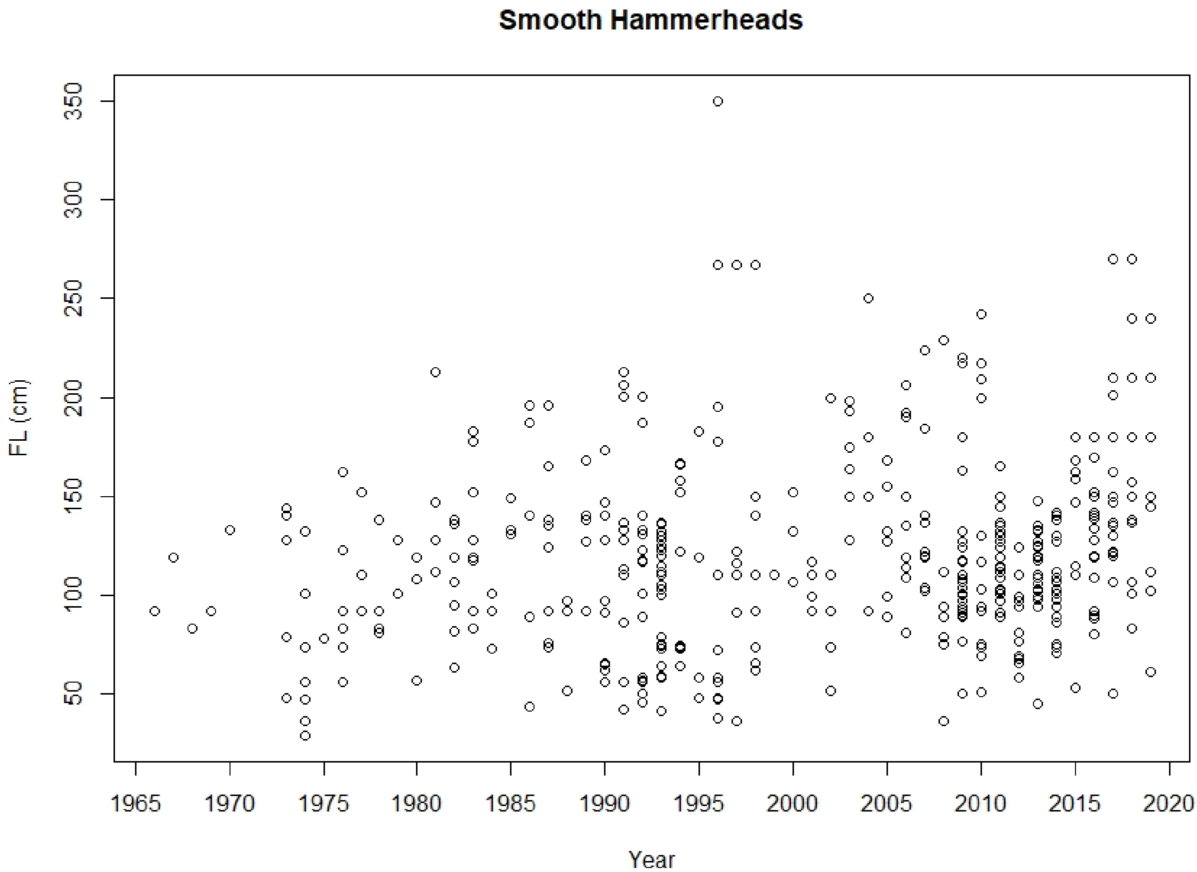


**Figure 10. Length composition of combined ages of smooth hammerheads across available years for potential use in the assessment. Fishery-dependent and independent data are combined.**

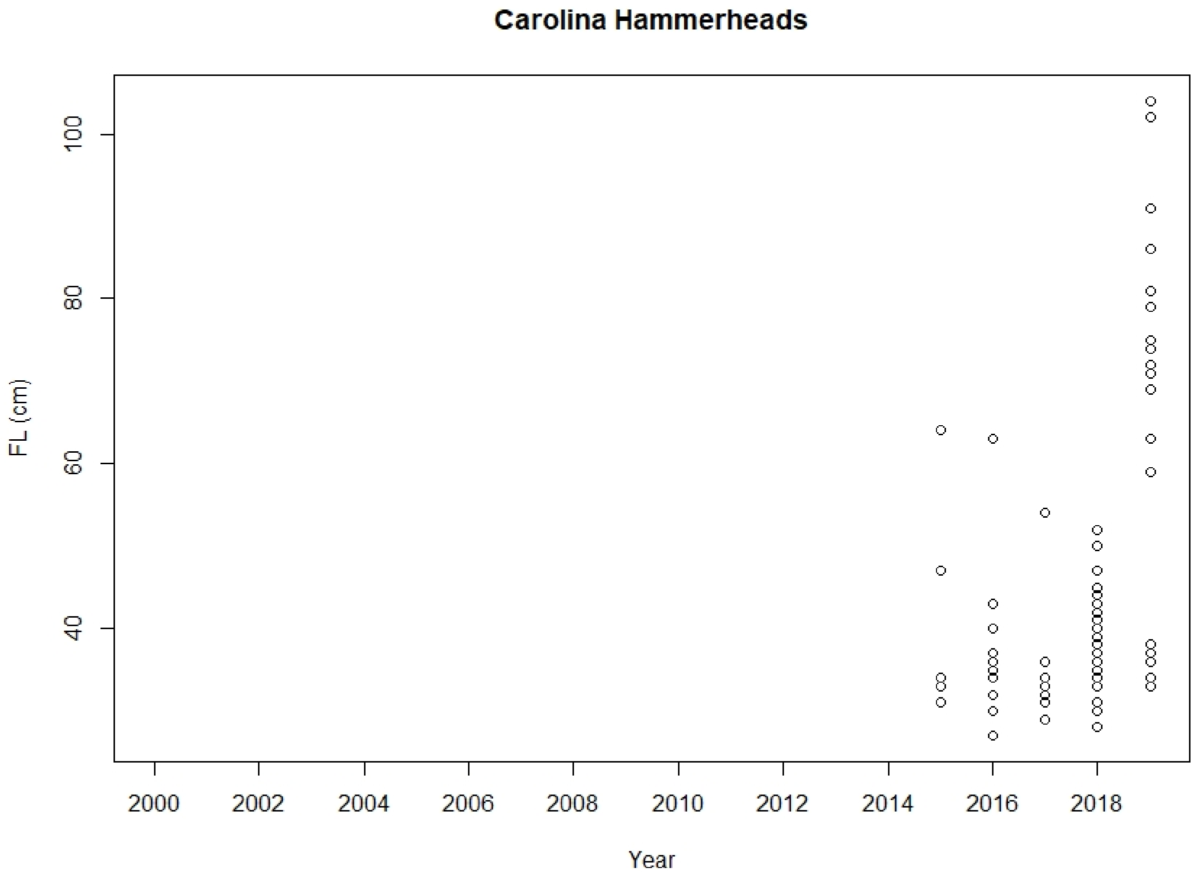


**Figure 11. Length composition of combined ages of Carolina hammerheads across available years for potential use in the assessment. Fishery-dependent and independent data are combined.**

## Combined Gulf of Mexico and Atlantic Ocean Regions

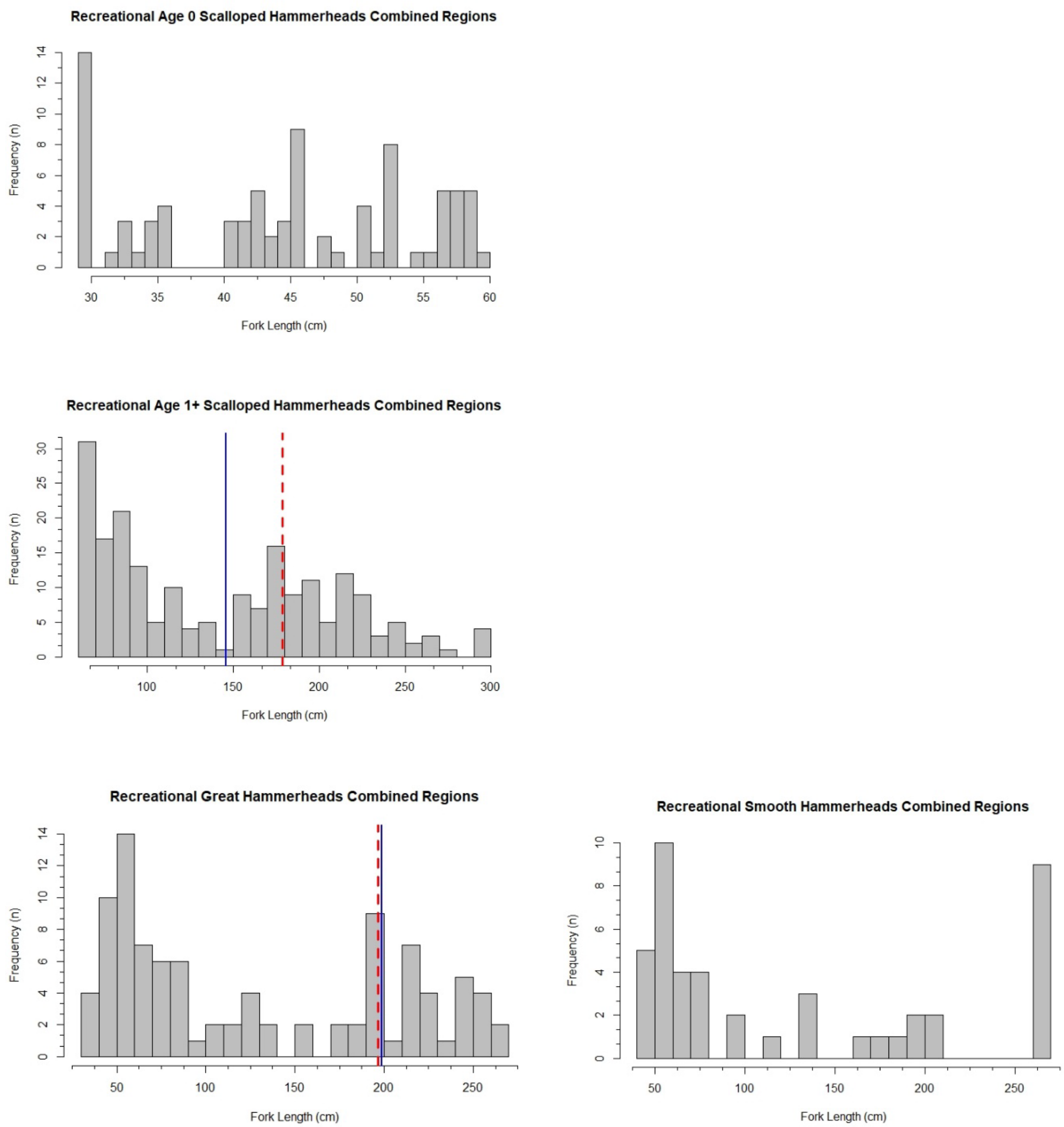


**Figure 8.** Recreational length composition data for hammerheads for the combined Gulf of Mexico and Atlantic Ocean regions.

**Atlantic Ocean Region**

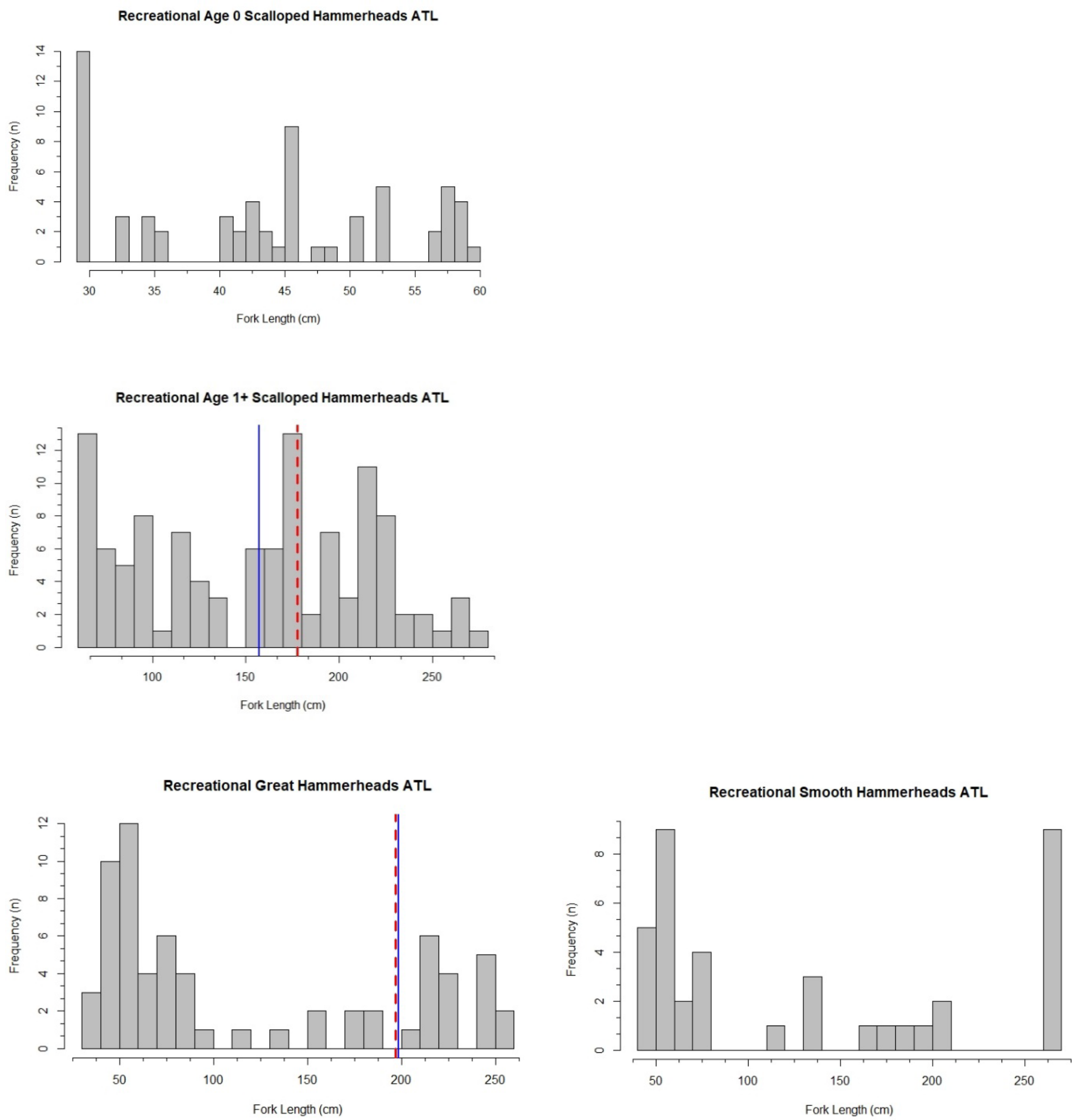


**Figure 9.** Recreational length composition data for hammerheads for the Atlantic Ocean region.

## Gulf of Mexico Region

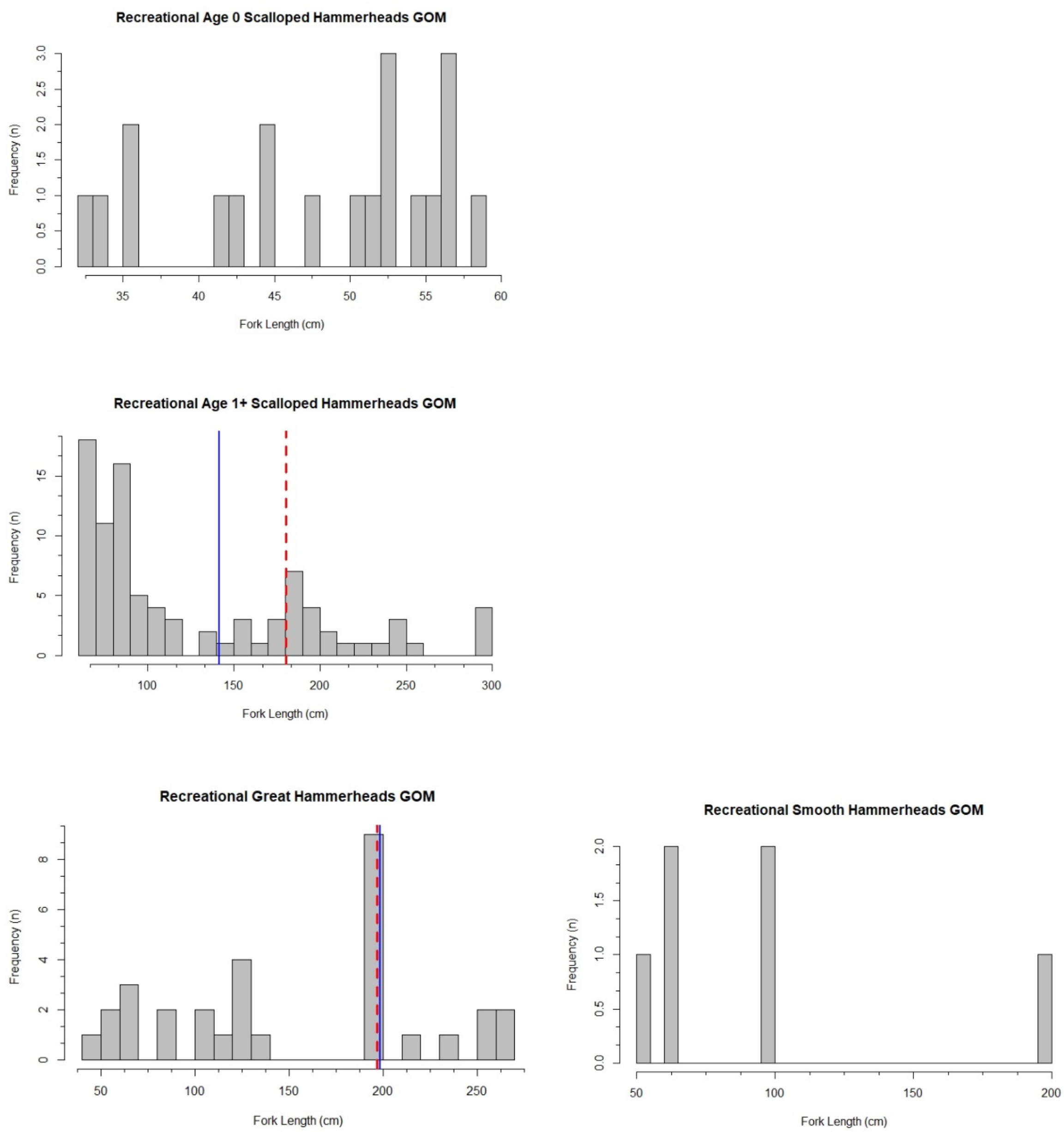


**Figure 10.** Recreational length composition data for hammerheads for the Gulf of Mexico region.

## Combined Gulf of Mexico and Atlantic Ocean Regions

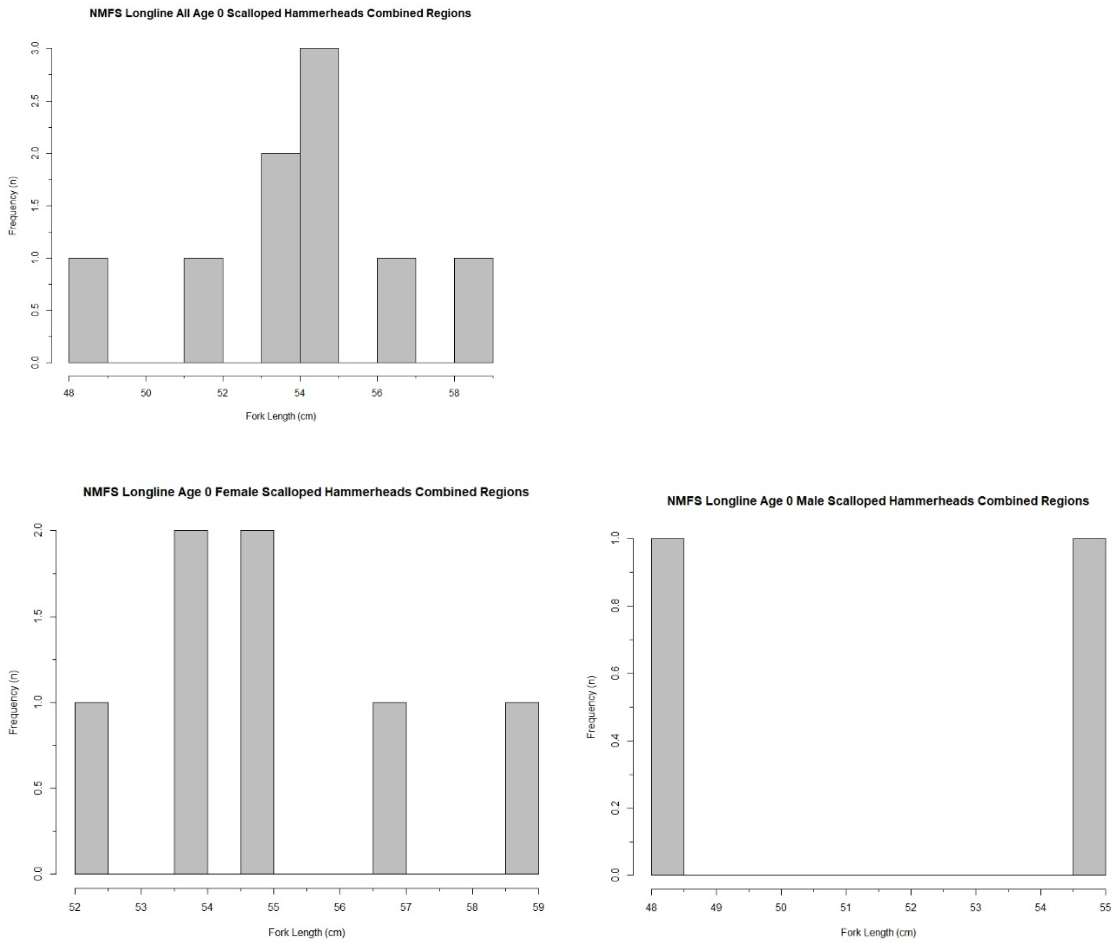


**Figure 11.** Fishery-independent bottom longline survey length composition data for Age 0 scalloped hammerheads for the combined Gulf of Mexico and Atlantic Ocean regions.

## Combined Gulf of Mexico and Atlantic Ocean Regions

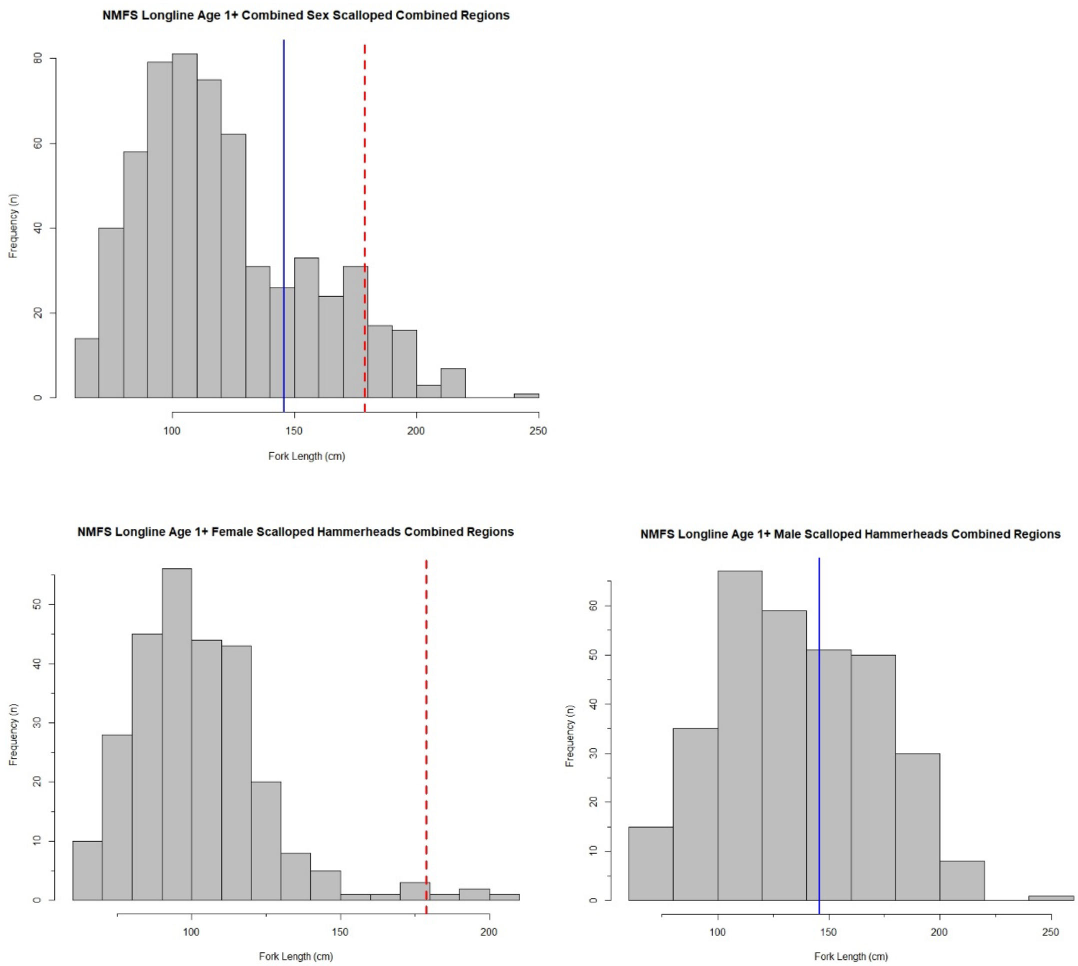


**Figure 12.** Fishery-independent bottom longline survey length composition data for Age 1+ scalloped hammerheads for the combined Gulf of Mexico and Atlantic Ocean regions.

## Combined Gulf of Mexico and Atlantic Ocean Regions

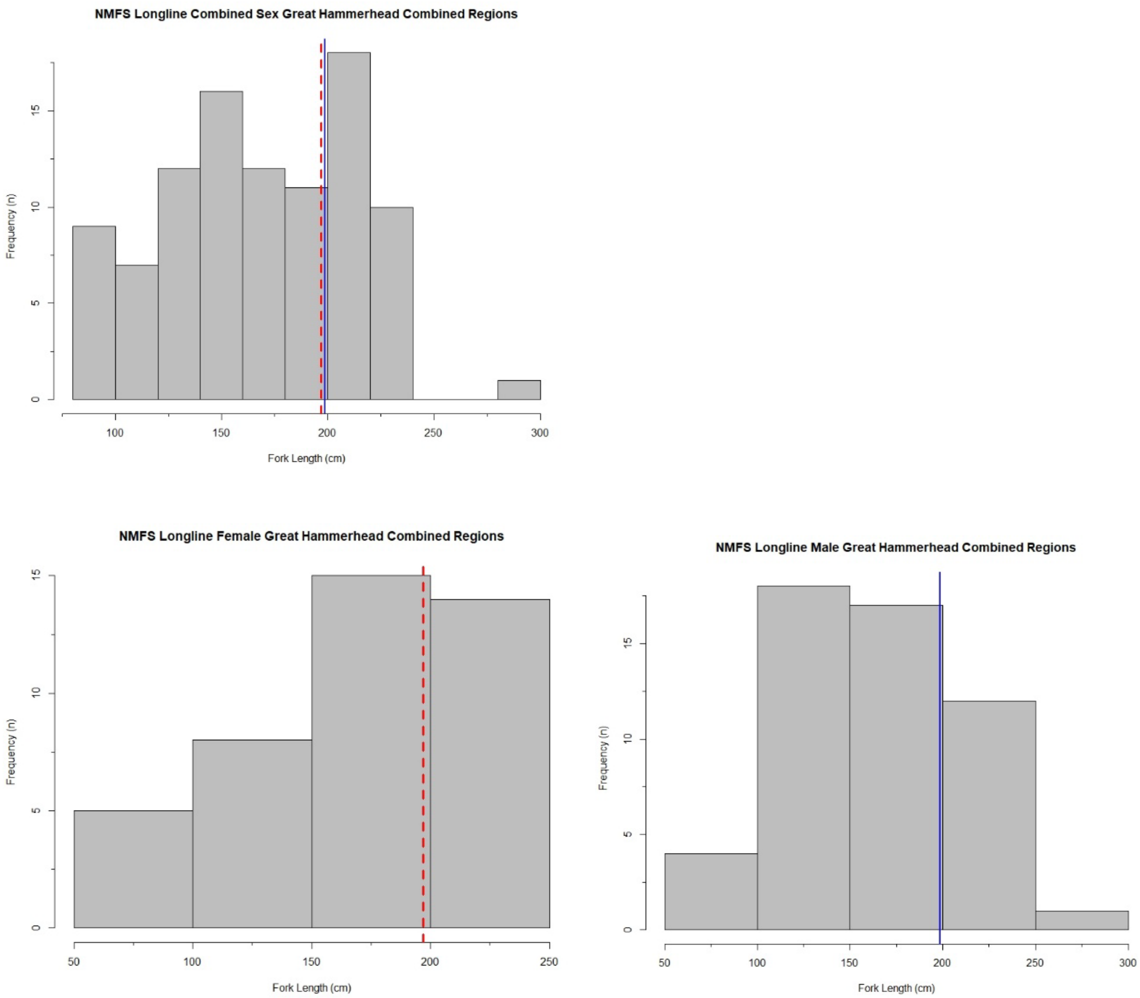


**Figure 13.** Fishery-independent bottom longline survey length composition data for great hammerheads for the combined Gulf of Mexico and Atlantic Ocean regions.

## Atlantic Ocean Region

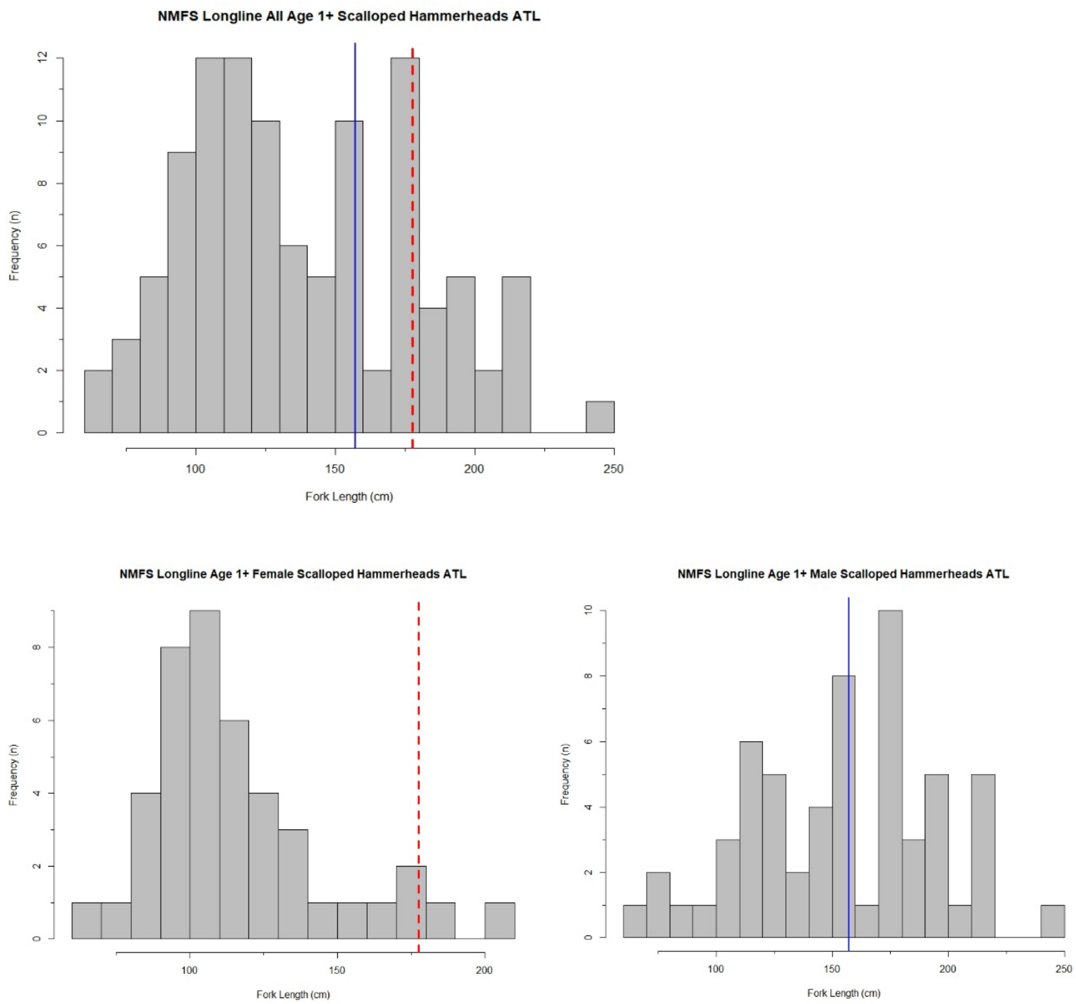


**Figure 14.** Fishery-independent bottom longline survey length composition data for Age 1+ scalloped hammerheads for the Atlantic Ocean region.

## Gulf of Mexico Region

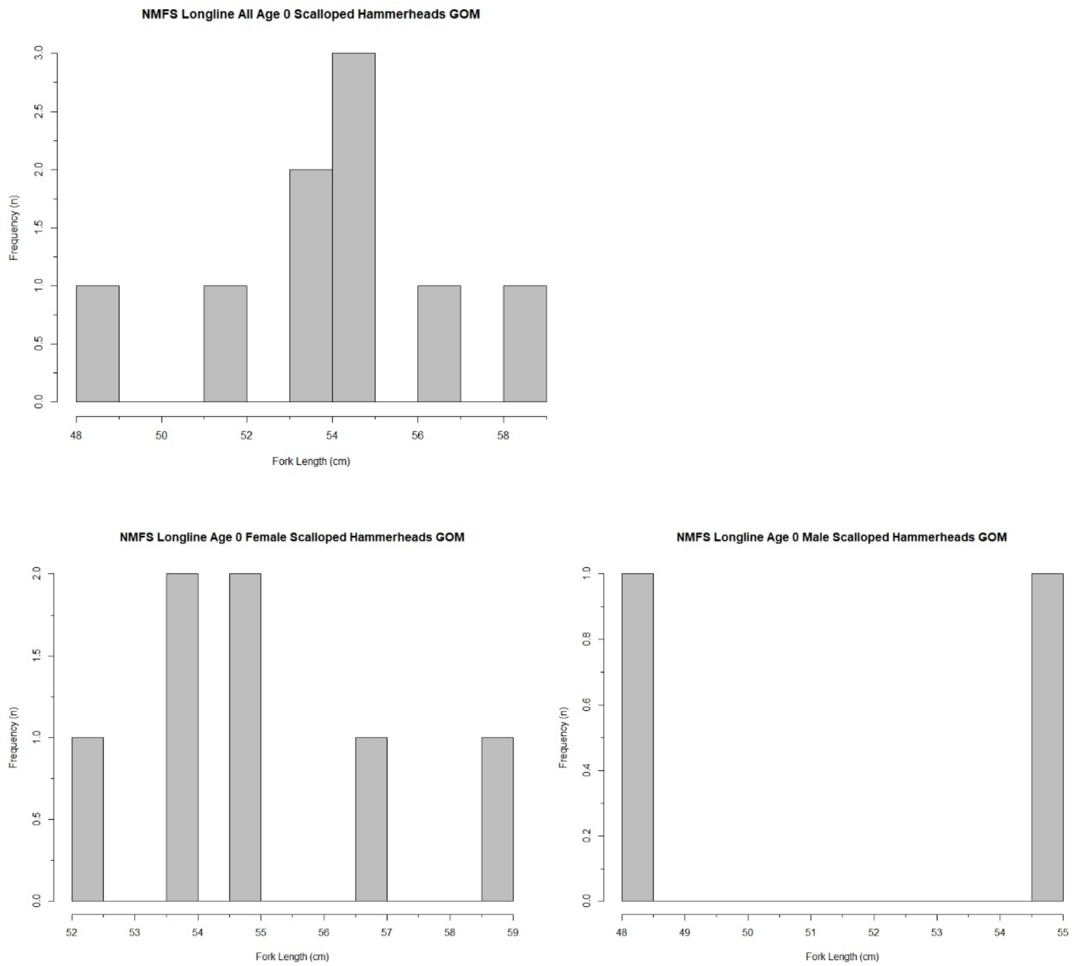


**Figure 15.** Fishery-independent bottom longline survey length composition data for Age 0 scalloped hammerheads for the Gulf of Mexico region.

## Gulf of Mexico Region

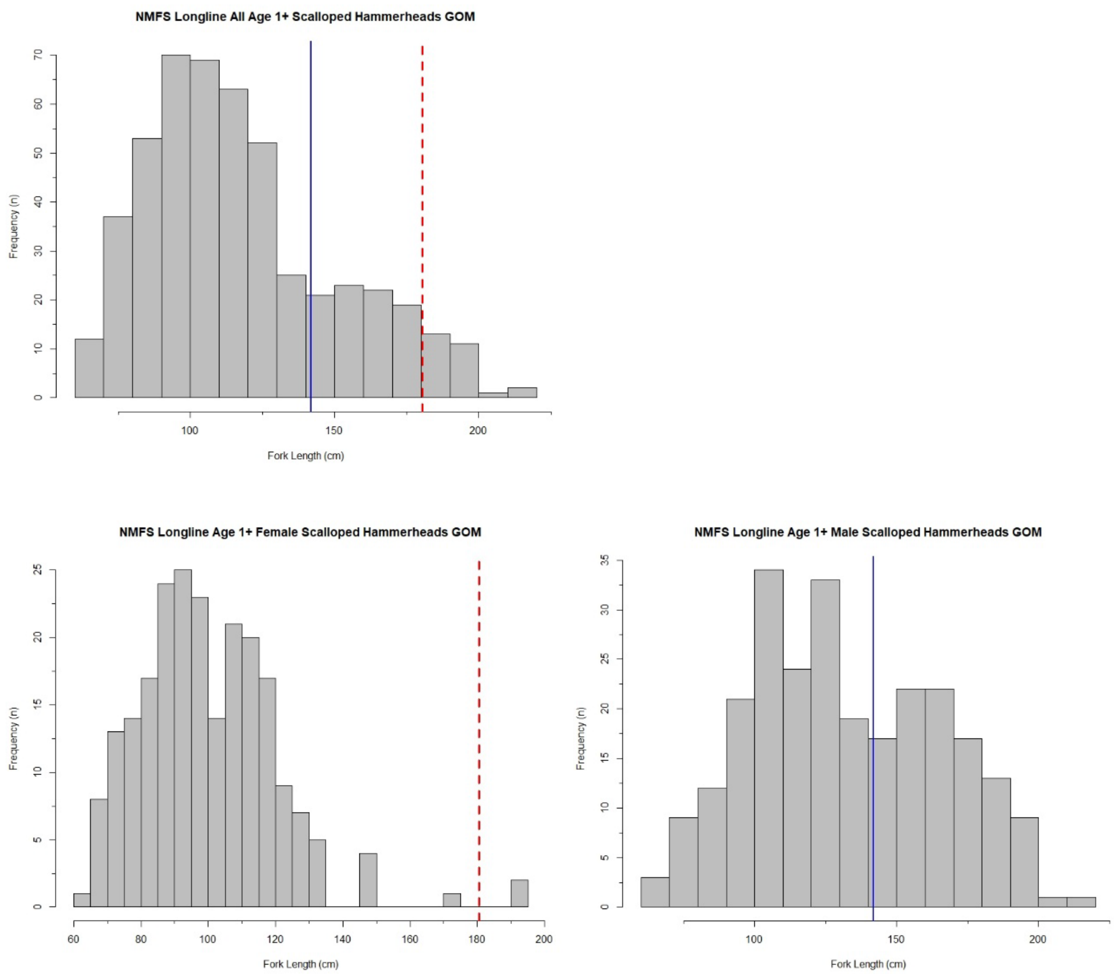


**Figure 16.** Fishery-independent bottom longline survey length composition data for Age 1+ scalloped hammerheads for the Gulf of Mexico region.