SEDAR

Southeast Data, Assessment, and Review

SEDAR 58

Cobia Stock ID Workshop Report

May 2018

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

Contents

1. Introduction

1.1 Workshop Time and Place

The Cobia Stock ID Workshop was held April 10-12, 2018 in Charleston, SC. A Data Scoping webinar was held prior to the workshop on February 5, 2018. This webinar was originally scheduled for January 22, 2018 but was rescheduled due to the federal government closure.

1.2 Terms of Reference

Workshop Goal: Review Cobia stock structure and unit stock definitions and consider whether changes are required.

1. Review information including genetic studies, growth patterns, movement and migration, existing stock definitions, otolith chemistry, oceanographic and habitat characteristics, prior SEDAR stock ID recommendations and any other relevant information on stock structure.

2. Make recommendations on biological stock structure and the assessment unit stock or stocks to be addressed through SEDAR 58 and document the rationale behind the recommendations.

3. Discuss the strength of evidence in support of stock ID recommendations with particular attention on those that result in a mismatch of biological stock structure, assessment unit stock recommendations, and existing management unit boundaries.

4. If biological stock structure recommendations, assessment stock unit recommendations, and existing management units (state and federal) do not align, provide guidance to address the relative risks (biological and management) and consequences of managing based on existing Council or prior assessment boundaries.

5. Provide recommendations for future research on stock structure.

6. Prepare a report providing complete documentation of workshop recommendations and decisions.

1.3 List of Participants

PANELISTS	**FUNCTION**	**AFFILIATION**
Nikolai Klibansky	Workshop Chair	SEFSC Beaufort
Genetics Work Group		
George Sedberry	*Work Group Leader*	SAFMC SSC
Meredith Bartron/Nathan Whelan*	Work Group Member	USFWS
Tanya Darden	Work Group Member	SCDNR
John Gold*	Work Group Member	Texas A&M
Jeff Isley	Work Group Member	SEFSC Miami
Jan McDowell	Work Group Member	VIMS
Life History/Biology Work Group		
Jennifer Potts	*Work Group Leader*	SEFSC Beaufort
Kevin Craig	Work Group Member	SEFSC Beaufort
Jim Franks	Work Group Member	GCRL
Angela Giuliano^	Work Group Member	MD DNR
Wade Hardy	Work Group Member	MDMR
Andy Ostrowski	Work Group Member	SEFSC Beaufort
Jim Tolan	Work Group Member	GMFMC SSC
Spatial Distribution/Movement Work Group		
Kevin Weng	*Work Group Leader*	VIMS
Ken Brennan	Work Group Member	SEFSC Beaufort
Jeff Buckel	Work Group Member	SAFMC SSC
Dan Goethel*	Work Group Member	SEFSC Miami
John Graves*/Douglas Jensen	Work Group Member	VIMS
David Hanisko	Work Group Member	SEFSC Pascagoula
Chris Kalinowsky	Work Group Member	GADNR
Susanna Musick	Work Group Member	VIMS
Steve Poland[+]	Work Group Member	NCDMF
Matt Perkinson[+]	Work Group Member	SCDNR
Jim Whittington	Work Group Member	FL FWCC
Chris Wilson	Work Group Member	NCDMF
Joy Young	Work Group Member	FL FWCC

APPOINTED OBSERVERS	**AFFILIATION**
Aaron Kelly	NC
Bill Gorham	NC; SAFMC C/M AP

Ira Laks	FL; SAFMC C/M AP

COUNCIL MEMBERS	**AFFILIATION**
Anna Beckwith*	SAFMC
Tim Griner	SAFMC

STAFF	**AFFILIATION**
Julia Byrd	SEDAR Coordinator
John Carmichael	SAFMC/SEDAR
Mike Errigo	SAFMC
Mike Larkin	SERO
Julie Neer	SEDAR
Cameron Rhodes	SAFMC
Ryan Rindone	GMFMC
Mike Schmidtke	ASMFC
Christina Wiegand	SAFMC

In-Person Workshop Attendees

Karl Brenkert, Brenkert Drones
Dan Crear, VIMS
Mike Denson, SCDNR
Vivian Matter, SEFSC Miami
Wiley Sinkus, SCDNR
Matt Walker, SCDNR
Beth Wrege, SEFSC Miami
Justin Yost, SCDNR

Webinar Attendees

Beverly Barnett, SEFSC Panama City
Wes Blow, SAFMC Cobia Mackerel AP, Cobia Sub-Panel
Mark Brown, SAFMC
Michelle Duval, SAFMC
Travis Kemp, NC
Patrick Link, VA

^ Denotes individuals in the Life History work group that are either contributing data/analysis and/or indicated that they would be able to contribute to Spatial Distribution/Movement work group.

+ Denotes individuals in the Spatial Distribution/Movement work group that are either contributing data/analysis and/or indicated that they would be able to contribute to Life History work group.

Appointees marked with a * are appointed to the workshop but may not be able to attend the meeting. They will provide data, review materials, and/or will be available via internet or phone for questions as needed.

1.4 Document List

Documents available for the SEDAR 58 Stock ID Workshop.

Document #	Title	Authors
Documents Prepared for the Stock ID Workshop (SID)		
SEDAR58-SID-01	Predicting the distribution of Cobia, *Rachycentron canadum*, seasonally, for mid-century, and for the end-of-century	Crear et al. 2018
SEDAR58-SID-02	Use of Pop-Up Satellite Archival Tags (PSATs) to Investigate the Movements, Habitat Utilization, and Post-Release Survival of Cobia (*Rachycentron canadum*) that Summer in Virginia Waters	Jensen & Graves 2018
SEDAR58-SID-03	Summary results of a genetic-based investigation of Cobia (*Rachycentron canadum*)	McDowell et al. 2018
SEDAR58-SID-04	Population Genetic Analysis of Cobia within U.S. Coastal Waters	Darden et al. 2018
SEDAR58-SID-05	Evaluation of Cobia movements using tag-recapture data from the Gulf of Mexico and South Atlantic coast of the United States	Perkinson et al. 2018b
SEDAR58-SID-06	Summary Report of the North Carolina Division of Marine Fisheries Cobia (*Rachycentron canadum*) Acoustic Tagging	Poland 2018
SEDAR58-SID-07	A brief summary of scientifically collected distribution data for Cobia (*Rachycentron canadum*) in U.S. waters of the Atlantic and Gulf of Mexico	Klibansky 2018
SEDAR58-SID-08	Cobia Telemetry Working Paper (revised 4/10/2018)	Young et al. 2018
SEDAR58-SID-09	Distribution and abundance of Cobia (*Rachycentron canadum*) larvae captured in ichthyoplankton samples during National Marine Fisheries Service and Southeast Area Monitoring and Assessment Program fishery-independent resource surveys	Hanisko et al. 2018
SEDAR58-SID-10	Spatial and Temporal Distribution of Cobia, Southeast U.S. and Gulf of Mexico	Wrege 2018
SEDAR58-SID-11	VIMS Cobia Tagging Program	Weng et al. 2018
Reference Documents		
SEDAR58-RD01	SEDAR 28 South Atlantic Cobia Stock Assessment Report	SEDAR 28

SEDAR58-RD02	SEDAR 28 Gulf of Mexico Cobia Stock Assessment Report	SEDAR 28
SEDAR58-RD03	List of documents and working papers for SEDAR 28 (South Atlantic Cobia and Spanish Mackerel) – all documents available on the SEDAR website.	SEDAR 28
SEDAR58-RD04	Managing A Marine Stock Portfolio: Stock Identification, Structure, and Management of 25 Fishery Species along the Atlantic Coast of the United States	McBride 2014
SEDAR58-RD05	Chapter 22: Interdisciplinary Evaluation of Spatial Population Structure for Definition of Fishery Management Units (excerpt from Stock Identification Methods – Second Edition)	Cadrin et al. 2014
SEDAR58-RD06	Mitochondrial DNA Analysis of Cobia *Rachycentron canadum* Population Structure Using Restriction Fragment Length Polymorphisms and Cytochrome B Sequence Variation	Hrincevich 1993
SEDAR58-RD07	Population Genetic Comparisons among Cobia from the Northern Gulf of Mexico, U.S. Western Atlantic, and Southeast Asia	Gold et al. 2013
SEDAR58-RD08	Population genetics of Cobia (*Rachycentron canadum*): implications for fishery management along the coast of the southeastern United States	Darden et al. 2014
SEDAR58-RD09	Growth, mortality, and movement of Cobia (*Rachycentron canadum*)	Dippold et al. 2017
SEDAR58-RD10	Assessment of Cobia, *Rachycentron canadum*, in the waters of the U.S. Gulf of Mexico	Williams, 2001
SEDAR58-RD11	Life history of Cobia, *Rachycentron canadum* (Osteichthyes: Rachycentridae), in North Carolina waters	Smith 1995
SEDAR58-RD12	A review of age, growth, and reproduction of Cobia *Rachycentron canadum*, from U.S. water of the Gulf of Mexico and Atlantic ocean	Franks and Brown-Peterson, 2002
SEDAR58-RD13	An assessment of Cobia in Southeast U.S. waters	Thompson 1995
SEDAR58-RD14	Reproductive biology of Cobia, *Rachycentron canadum*, from coastal waters of the southern United States	Brown-Peterson et al. 2001
SEDAR58-RD15	Age and growth of Cobia, *Rachycentron canadum*, from the northeastern Gulf of Mexico	Franks et al. 1999
SEDAR58-RD16	Synopsis of biological data on the Cobia *Rachycentron canadum* (Pisces: Rachycentridae)	Shaffer and Nakamura 1989

SEDAR58-RD17	Age, growth, and reproductive biology of greater amberjack and Cobia from Louisiana waters	Thompson et al. 1991
SEDAR58-RD18	Cobia (*Rachycentron canadum*) stock assessment study in the Gulf of Mexico and in the South Atlantic	Burns et al. 1998
SEDAR58-RD19	Gonadal maturation in the Cobia, *Rachycentron canadum*, from the northcentral Gulf of Mexico	Lotz et al. 1996
SEDAR58-RD20	Length-weight relationships, location and depth distributions for select Gulf of Mexico reef fish species	Pulver & Whatley 2016
SEDAR58-RD21	Inshore spawning of Cobia (*Rachycentron canadum)* in South Carolina	Lefebvre & Denson 2012
SEDAR58-RD22	Determining the stock boundary between South Atlantic and Gulf of Mexico managed stocks of Cobia, *Rachycentron canadum*, through the use of telemetry and population genetics	Perkinson et al. 2018a
SEDAR58-RD23	SAFMC Mackerel Cobia Advisory Panel and Cobia Sub-Panel Cobia Fishery Performance Report April 2017	SAFMC Mackerel Cobia AP & Cobia Sub-Panel 2017
SEDAR58-RD24	Spawning of the Cobia, *Rachycentron canadum*, in the Chesapeake Bay Area, with Observations of Juvenile Specimens	Joseph et al. 1964

2. Workshop Findings

Background

SEDAR 28 was the last assessment for the Atlantic and Gulf of Mexico Cobia stocks. The assessment unit stocks for SEDAR 28 were as follows:

- Atlantic stock: Florida/Georgia border north to New York
- Gulf stock: Florida/Georgia border south through the U.S. Gulf of Mexico.

During SEDAR 28, genetic and conventional tagging data were the primary data sources available to inform stock identification discussions. The SEDAR 28 Data Workshop Panel also discussed the spatial resolution of assessment input data and considered potential management boundaries. More detailed documentation of these discussions and the final stock structure recommendations are in the SEDAR 28 South Atlantic Cobia Stock Assessment Report (SEDAR 2013b; see Data Workshop section in SEDAR58-RD01).

Stock identification for the upcoming SEDAR 58 Atlantic Cobia assessment will be resolved prior to the Data Workshop stage, using the multi-step Stock ID Process developed by the SEDAR Steering Committee in September 2016. This process includes the following:

- **Stock ID Workshop**: Participants will review all available information on Cobia stock structure and develop recommendations on biological and assessment unit stocks.
- **Stock ID Review Workshop**: An independent panel will evaluate the recommendations from the Stock ID Workshop and determine whether the stock structure recommended is reasonable and appropriate for use in the assessment.
- **Joint Cooperator Technical Review Webinar**: Participants will review and evaluate the findings from the Stock ID Workshop and Review Workshop, recommend the Cobia assessment unit stock for SEDAR 58, and draft an appropriate stock structure Term of Reference (ToR).
- **Science and Management Leadership Call:** If a change in stock ID is recommended that causes a stock to cross Cooperator jurisdictions, the Leadership Group will determine how to resolve the discrepancy and provide guidance on appropriate ToRs to provide the necessary and appropriate management parameters.

This report summarizes the findings and recommendations of the first stage of this process, the Stock ID Workshop. The overall goal of this workshop was to review Cobia stock structure and unit stock definitions and consider whether changes were required. There were several new data sources available for consideration, including, additional genetic studies, updated conventional tagging analyses, and new acoustic telemetry and satellite tagging data.

The SEDAR 58 Cobia Stock ID Panel used the SEDAR 28 definition of assessment unit stock as an initial working hypothesis and reviewed all available information to address the Terms of Reference and develop assessment and biological unit stock recommendations.

2.1 ToR #1: *Review information including genetic studies, growth patterns, movement and migration, existing stock definitions, otolith chemistry, oceanographic and habitat characteristics, prior SEDAR stock ID recommendations and any other relevant information on stock structure.*

To address ToR# 1, the SEDAR 58 Stock ID Workshop participants were divided into three work groups: genetics, life history/biology, and spatial distribution/movement. Each work group reviewed the information available within its topical area, presented the group's findings to the entire Panel in plenary sessions, and prepared a written report. The reports from each working group are provided below in Section 2.1 and Section 2.5.

2.1.1 Genetics

Genetics Breakout Workgroup Appointed Participants

George Sedberry (Group Leader)	SAFMC SSC
Meredith Bartron	USFWS
Tanya Darden	SCDNR
John Gold	Texas A&M (retired)
Jeff Isely	SEFSC Miami
Jan McDowell	VIMS

Genetics Breakout Workgroup Observers

Mike Denson	SCDNR
Bill Gorham	Stakeholder (Appointed Observer)
Matt Walker	SCDNR
Wiley Sinkus	SCDNR
Mike Larkin	SERO

Literature and Data Review and Evaluation

The genetics workgroup used a genetics-based definition of stock as determined by genetic sampling within spawning periods to identify biological reproductive groups. The workgroup also recognized that it is important to understand potential movement-based stock mixing during other periods when fishing may occur. Sampling and analyses included collections in known reproductive areas and movement corridors.

The genetics breakout group reviewed the literature and available data sets relevant to the genetic population structure of Cobia. Working documents that were reviewed by the breakout workgroup during the workshop included the following:

Working Papers:
- SEDAR58-SID-03: McDowell, VIMS Cobia genetics study
- SEDAR58-SID-04: Darden et al. 2018, Cobia genetics analysis within U.S. Coastal Waters

Relevant Reference Documents:
- Hrincevich 1993 (SEDAR58-RD06)
- Gold et al. 2013 (SEDAR58-RD07)
- Darden et al. 2014 (SEDAR58-RD08)
- Lefebvre & Denson 2012 (inshore spawning in SC; SEDAR58-RD21)
- Perkinson et al. 2018a (telemetry & genetics; SEDAR58-RD22)

These papers include early exploratory genetic work with Cobia and later papers with larger sample sizes, incorporating more refined methods. Papers were reviewed in approximate chronological order; some later papers incorporated data from earlier work, which resulted in more complete (spatially and temporally) data sets and relevant recent analysis methods.

Hrincevich 1993 (SEDAR58-RD06)

The MS Thesis by Hrincevich (1993) included data from restriction-fragment-length polymorphism (RFLP) analysis of mitochondrial DNA (mtDNA), and an analysis of mitochondrial genome size. The study represents a preliminary analysis of methods to detect genetic population structure in Cobia. No evidence from the RFLP analysis supported the presence of subgroups of Cobia either within or between the Gulf of Mexico and Atlantic. Sample sizes and geographic distribution of samples were limited and not applicable to addressing stock structure in Cobia.

Lefebvre and Denson 2012 (SEDAR58-RD21)

Lefebvre and Denson (2012) documented estuarine spawning of Cobia in South Carolina waters (Port Royal and St. Helena Sounds) by examining gonad histology and sampling for eggs and early larvae. They also conducted laboratory analyses of early development in relation to temperature. Laboratory studies corroborated conditions seen in the field during spawning from April to June in the estuary. The inshore migration of Cobia from April to June, the presence of actively spawning females, significantly higher gonadosomatic index (GSI) values, and the collection of eggs inside the sounds all confirmed that these estuaries provide spawning habitat for Cobia.

The presence of pelagic Cobia eggs indicates that spawning also occurs in Chesapeake Bay (see Joseph et al. 1964; SEDAR58-RD24). Discussion by the genetics workgroup indicated that there are no other spawning locations along the U.S. Atlantic or Gulf of Mexico coasts documented in the literature.

Gold et al. 2013 (SEDAR58-RD07)
John Gold participated in the genetics workgroup by telephone to help review this paper. Dr. Gold stated his study was designed to address a specific aquaculture question regarding sources of broodstock rather than to address Gulf of Mexico and Atlantic stock structure. The genetics workgroup acknowledged that 28 microsatellite loci were used; however, many of the markers had a low level of polymorphism within U.S. waters and the sample sizes in the study and their location distribution were limited to Virginia (n=35), Mississippi (n=46) and Louisiana (n=14). Likewise, the sample size for mtDNA sequence analysis was very small; 352 bases from the cytochrome-b mitochondrial gene were sequenced from five individuals from each of the above locations. Dr. Gold noted that the number of informative loci is more important than sample sizes, but acknowledged a better-designed study would be warranted to address stock identification in the U.S. The genetics workgroup agreed with his assessment and acknowledged that the two more recent microsatellite studies (Darden et al. 2014, Darden et al. 2018) had higher samples sizes for comparison of Gulf and Atlantic samples and loci with a higher average level of polymorphism within fish from U.S. waters. The F_{ST} values reported in Gold et al. (2013) are on the same order of magnitude as more recent studies (both at the Atlantic and global scales).

McDowell et al. 2018 (SEDAR58-SID-03)
This document reports on a genetic study that included an expanded suite of 27 variable microsatellite markers and high sample sizes from Virginia (n = 95) and the Gulf of Mexico (n = 310), with more limited sampling from North Carolina (n = 8) and Florida (n = 14) (Figure 1). McDowell et al. (2018) included 427 samples (318 from Virginia and North Carolina, 95 from the Gulf of Mexico, and 14 from Stuart, Florida). In addition to microsatellite analysis of those samples, about 160 individuals were sequenced for mtDNA variability that could indicate population structure (see McDowell et al. 2018 for sampling details). Analyses of microsatellite and mtDNA markers supported genetic distinction between the Atlantic and Gulf of Mexico samples. The limited number of samples from the east coast of Florida indicated alignment with the Gulf of Mexico population (Figure 2). It was agreed that the Florida samples reported on by Darden et al. (2018) provide a better understanding of the genetic characteristics of locations along the east coast of Florida.

Darden et al. 2014 (SEDAR58-RD08), Perkinson et al. 2018a (SEDAR58-RD22), and Darden et al. 2018 (SEDAR58-SID-04)
Data collected and analyzed in Darden et al. (2014) and Perkinson et al. (2018a) were included and further analyzed along with additional samples in Darden et al. (2018). Perkinson et al. (2018a) focused primarily on telemetry and found two major groups of Cobia in the study area: a South Carolina/Georgia group and a central Florida/south Florida group. The results of this telemetry project agreed with the external tagging and genetic analysis used in SEDAR 28 and did not refute the current management boundary, and assessment unit boundary used in SEDAR 28, at the Florida/Georgia border. The Spatial Distribution/Movement Workgroup further considered this paper in regards to the tagging results.

Darden et al. (2018) used a suite of 10 microsatellite markers with 2,796 samples from 18 collection locations ranging from Virginia to Corpus Christi, Texas (Figure 3). Three different sample selection criteria were used to generate multiple final analysis data sets. These data sets included 1) all selected samples available; 2) selected samples collected during Cobia spawning season defined for each state; and 3) selected samples collected during Cobia spawning season defined as April through June for all locations. All showed the same gene flow patterns following analyses, therefore results from the data set that included only fish collected during the spawning seasons, with spawning season defined separately for each state, were reported in the working paper. STRUCTURE, F_{ST}, and AMOVA analyses supported genetically distinct Atlantic (South Carolina and northward) and Gulf of Mexico (Texas to Ft. Pierce, Florida) genetic groupings representing separate populations (Figure 4). Locations within the sample range from Cape Canaveral, Florida through Savannah, Georgia were not genetically distinct from either the Gulf of Mexico or Atlantic populations and represent a "zone of uncertainty" in terms of gene flow patterns. This result is likely attributable to the relatively low sample sizes from northern Florida and Georgia combined with the lack of specific locality data for the samples taken around Cape Canaveral, FL. Private alleles (alleles that are found only in a single population among a broader collection of populations (Szpiecha and Rosenberg 2011) were found at very low frequencies at all locations except those within the zone of uncertainty, which may be a result of the low sample size from this area. The zone of uncertainty could alternately represent an area of intermittent use by individuals from both the Atlantic and Gulf of Mexico groups, resulting in the inconclusive assignment to either group for the limited samples obtained. Increased sample sizes and finer scale sampling across this area could resolve this uncertainty.

Effective number of migrant estimates were provided for context of average number of individuals exchanging genetic material per year (ranged from 0.2 - 5.9 fish per year) based on a seven-year generation time (Figure 5).

Additional Discussion

The genetics workgroup further discussed movement and behavior of the South Carolina inshore population, which is thought to be resident year-round. Cobia do occur offshore of South Carolina in deeper areas in the winter, and Cobia are caught offshore of adjacent states during the winter.

The workgroup also discussed the SCDNR stock enhancement program. SCDNR staff described the history of the program, including periods and number of fish stocked (including the recent genetic-based modeling assessment to determine responsible restoration planning) and clarified that genetic identification was used with all fish stocked with the program and all stocked fish have been removed from all SCDNR genetic data sets and genetic analyses. However, it was acknowledged that F1 hybrids of hatchery X wild fish could not be identified. Hatchery-produced Cobia released into South Carolina estuaries where spawning has been documented have been recaptured in spawning aggregations during subsequent spawning years (only within the stocked estuary).

The genetics workgroup acknowledged a dearth of samples available from Jacksonville, Florida to Brunswick, Georgia and felt that this was in spite of extensive efforts to obtain samples from this area. It was noted that the lower number of samples from this area may reflect either reduced abundance or reduced availability of the fish to the fishery. Information from fishermen indicates that there are not as many anglers in this area targeting Cobia (perhaps due to lower numbers of anglers along the southern Georgia coast).

Conclusions from the Genetics Workgroup

- Genetic data from Darden et al. (2018) and McDowell et al. (2018) are consistent with the presence of distinct Gulf of Mexico and U.S. Atlantic east coast stocks.
    - Genetic data from Darden et al. (2018) potentially suggest four different genetic groups
        - Gulf of Mexico (including the southeast coast of Florida up to the Canaveral area)
        - inshore South Carolina
        - offshore South Carolina/offshore North Carolina
        - inshore North Carolina/Virginia.
- Divergence (F_{ST}) values between populations are acknowledged low; however, the differences are statistically significant.
- Data presented in Darden et al. (2018) and McDowell et al. (2018) suggest that further refinement of genetic groups may be possible
    - Questions remain as to the classification of the group ranging from north of Canaveral and into Georgia, and conclusions are limited by currently-available sample sizes.

- Nothing in the genetic analyses refutes the current placement of the assessment unit stock boundary at the Georgia/Florida border; however, the actual boundary could not be refined based on the genetic data due to sampling limitations. The genetics group acknowledges that the boundary may be south of the Georgia/Florida border (but north of the Brevard/Indian River FL county border).

Genetics Consensus Statement

Genetically distinct spawning stocks occur in the Atlantic (VA to Port Royal Sound, SC) and Gulf of Mexico (extending westward and north up to Fort Pierce, FL on the east coast of FL). The recent genetic data suggest a spawning stock transition zone within the range from Savannah, GA through Brevard County, FL (Brevard/Indian River county line) and do not refute placement of the stock boundary at the FL/GA line. Additional genetic data analyzed since SEDAR 28 reinforces the conclusion from the prior SEDAR that there is a stock separation somewhere within this geographic range. Increased fine-scale (spatial and temporal) sampling within the "zone of uncertainty" could refine the boundary between the Atlantic and Gulf of Mexico stocks, and evaluate any mixing zone that might occur. Based on the results of Darden et al. (2018):

- There is evidence of sub-structure within the Atlantic
- SC and NC/VA inshore areas (within estuaries and barrier islands) are each distinct sub-groups, the NC/SC offshore areas also form a distinct sub-group.
- Collections within the transition zone are not consistent with a genetic stock distinct from the Atlantic and Gulf of Mexico stocks.

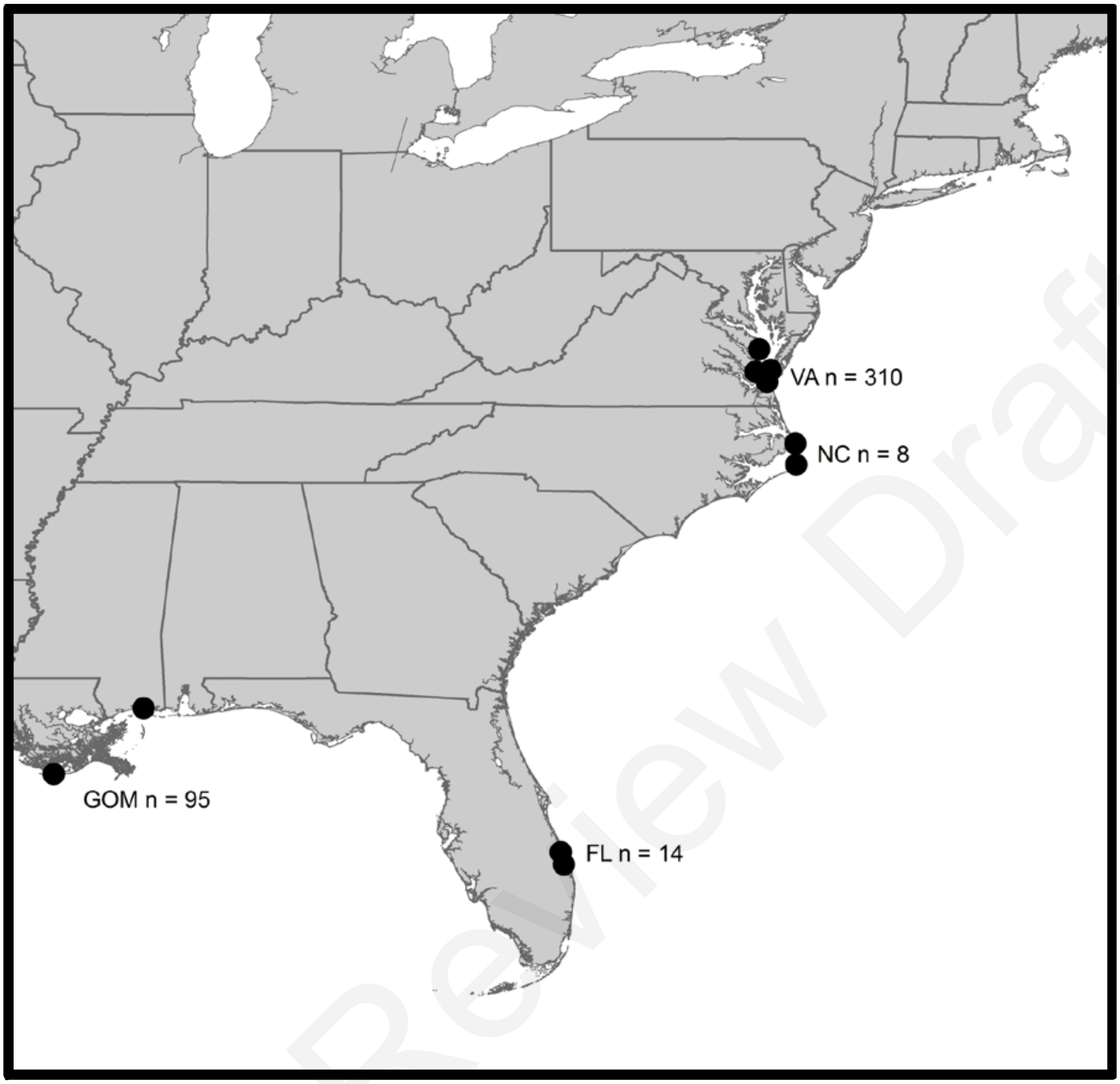


Figure 1. Location and sample size of genetic samples analyzed by McDowell et al. (2018)

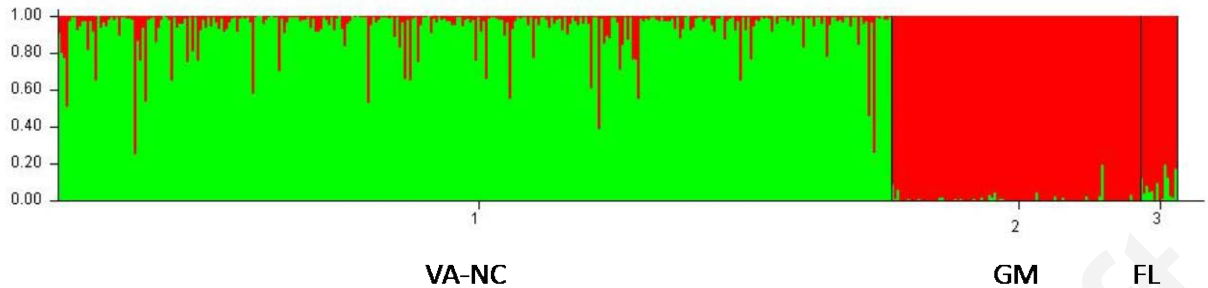


Figure 2. STRUCTURE plot of McDowell et al. (2018) genetic data from Mid-Atlantic (VA-NC, N=318), Gulf of Mexico (GM, N=95), and Stuart, Florida (FL, N=14) samples. The STRUCTURE simulations shown in this figure were performed using an admixture model of ancestry, correlated allele frequencies, K=2 and a burn-in of 100,000 followed by 500,000 Markov chain Monte Carlo iterations. Each vertical bar represents a single individual in the plot, with colors indicating percent ancestry to each genetic group. Collections are geographically oriented from Virginia/North Carolina on the left, to the Gulf of Mexico, with Stuart Florida on the right. The Stuart, FL samples have a high level of shared ancestry with Gulf of Mexico samples.

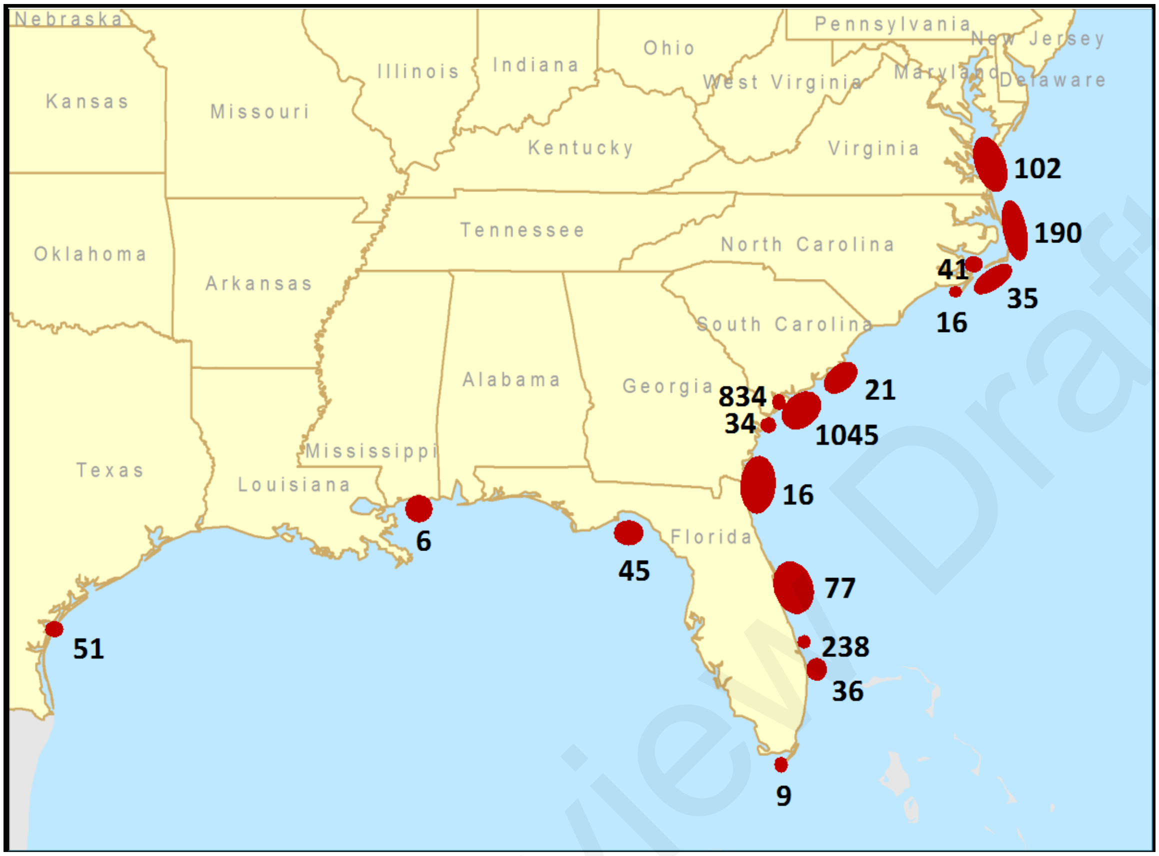


Figure 3. Sample size and distribution reported in Darden et al. (2018). The extent of each symbol along the coast indicates the geographic range of the sample collection; however, symbol size is unrelated to sample size (numbers adjacent to collection location).

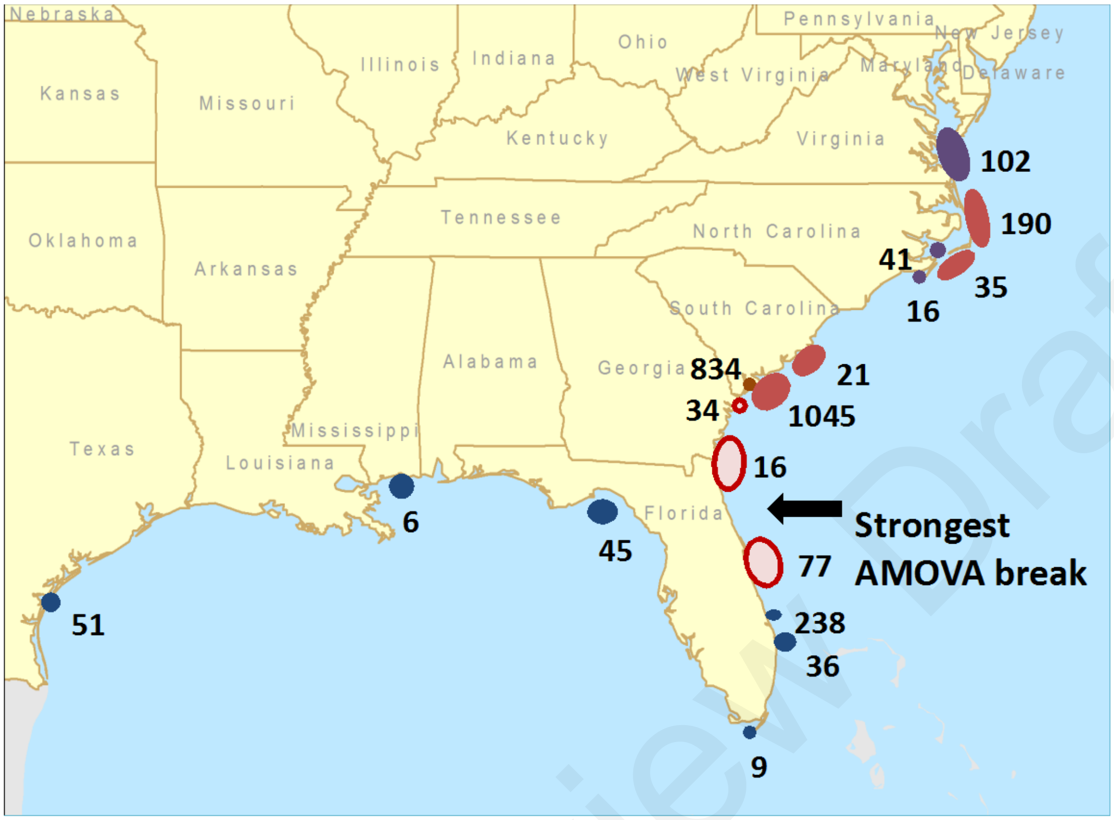


Figure 4. Summary of genetic population structure patterns based on STRUCTURE, F_{ST}, AND AMOVA. Each solid color represents a genetically distinct population while the light red hatched locations ("zone of uncertainty") are genetically similar to both Gulf of Mexico and Atlantic populations. Private alleles were found at very low frequencies at all locations except those within the zone of uncertainty off Florida, where the strongest AMOVA break was detected.

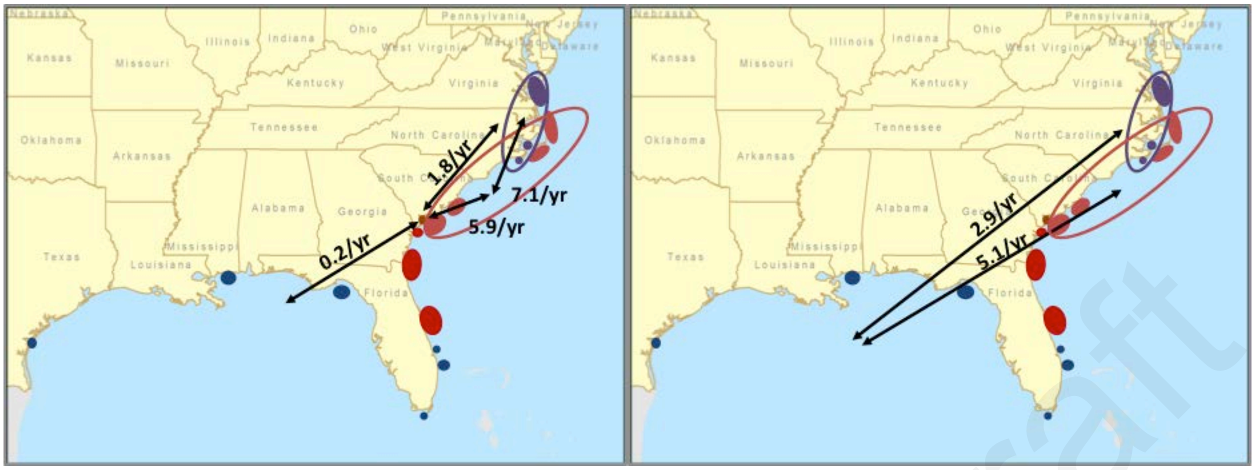


Figure 5. Effective number of migrants between genetically distinct populations of Cobia. Average per year calculations are based on a seven-year generation time.

2.1.2 Life History / Biology

Life History Work Group Participants
Jennifer Potts[1] – NMFS, Beaufort, NC (Group Leader and data provider)
Andy Ostrowski[1] – NMFS, Beaufort, NC (Rapporteur)
Kevin Craig[1] – NMFS, Beaufort, NC
Justin Yost[2] – SCDNR, Charleston, SC (data provider)
Angela Giuliano[1] – Maryland Department of Natural Resources
James Tolan[1] – Texas Parks and Wildlife (GMFMC SSC representative)
Wade Hardy[1] – Mississippi Department of Marine Resources
Jim Franks[1] - Gulf Coast Research Laboratory (data provider)
Ira Laks[3] – Florida; SAFMC C/M AP

(1. Workshop Panelist; 2. Participant; 3. Appointed Observer)

The Life History Work Group (LHG) was tasked with analyzing or reviewing available biological data on Cobia throughout its range from the Gulf of Mexico (GOM) and U.S. Atlantic coast (ATL). Three main topics of biological data were considered: weight-length relationship, age and growth, and reproductive biology. Data containing whole weight and lengths from fishery-dependent dockside sampling programs and fishery-independent surveys were compiled to determine possible differences in the weight-length relationship by state, latitude or other spatial designation. Age data from the Gulf of Mexico did not include any new information since SEDAR 28. Age data from the ATL included SEDAR 28 data and updated information by SCDNR, NMFS Beaufort, Virginia Marine Resources Commission (VMRC) and Florida Fish and Wildlife Conservation Commission (FWC). Table 1 contains a list of sources for the weight-length data and age data. No new information on the reproductive biology of Cobia was available for this workshop. The LHG did review the reproductive biology as presented in the reference documents and information in SEDAR 28 reports. Research recommendations are compiled and listed in Section 2.5 TOR #5 of the workshop report.

Whole-Weight Fork Length relationship
Whole weight - fork length (W-FL) data were available from a total of 14 sources, which included fishery-dependent and fishery-independent surveys, from the Gulf of Mexico to the Mid-Atlantic (n = 11,146). The weight-length relationships by state or other spatial area were examined to determine if some growth differences could be detected. Data were graphed by individual states for W-FL (Figure 6) resulting in no obvious visual differences in those relationships between states or geographic area, a trend that was further displayed when all graphed together (Figure 7). The data were further combined by region (NJ through SC, Ga-East

Florida, West Florida, AL-LA, and TX) to observe if there was a regional relationship (Figure 8). Very few samples were collected in Georgia and they were combined with the east coast of Florida. Samples from the Florida Keys were combined with West Florida. NJ-SC had the heaviest fish at length. Florida both east (GA – EFL) and west coast (WFL), had the lightest fish at length, and GOM Cobia (AL – LA and TX) were in middle. However, there were no clear differences in the relationship until fish reach 1300 mm FL, which are primarily female Cobia (Franks et al., 1999). These differences could be explained by latitudinal shifts (e.g. larger fish occurring at more northern latitudes) or sampling season differences (e.g. sampling fish during the spawning season vs. the rest of the year). The distribution of samples by month did reveal differences in sampling intensities. Ninety-two percent (92%) of samples from New Jersey through South Carolina were obtained during the Cobia spawning season, when females can weigh considerably more than during other months. Only 65% of samples from East and West Florida and 77% from Alabama through Texas were obtained during the spawning season. The available weight – length data of Cobia did not support any differences throughout its range.

Consensus Statement: The relationship between whole weight and fork length of Cobia was not biologically different throughout the range of Cobia in the U.S. Atlantic and Gulf of Mexico. These data did not provide evidence of stock separation.

Maximum Age

Another life history parameter examined was the maximum (max) age recorded between potential stocks of Cobia. An assumption was made that rates of exploitation over time throughout the fish's range were similar. The oldest fish were found in the Atlantic, and specifically in the most northern extent of the Cobia's range (Table 2). The max age observed in the Atlantic was 16 years compared to 11 years in the GOM. The year in which the max age was recorded in each state/area is also listed in Table 2. The oldest ages were found to be in recent years suggesting that fishing pressure over time was not an explanation for the trend. The LHG noted that the sample sizes and different sampling regimes may be an explanation for the difference in max age of Cobia by area. Running a simple regression analysis on max age and sample size indicated sample size differences accounted for 73% of the variation (Figure 9). Virginia and SC had the largest sample sizes, while NC and the rest had less than 500 samples per state/area. This analysis showed that the smaller sample sizes may not be capturing the true max age in the GOM and that an increase in number of samples would increase the likelihood in catching the oldest fish.

Consensus Statement: The difference in observed max age by state/area of the Cobia's range was not conclusive in identifying possible stock structure.

Size at Age

Cobia length (FL) at age data were analyzed to gather information on stock structure of Cobia. Based on the literature and currently available data, females grow larger at age than males. Female Cobia length at biological age was plotted (Figure 10). In general, there was a large range of length at each age within and among states with overlap between them. Length at age differences were noticed when comparing max ages and lengths across regions for the combined sex data (Table 2). Cobia fork length distributions were similar across regions, but max age observed differed (i.e. larger fish at younger ages in the GOM compared to the ATL).

Differences in growth of Cobia by sex and state were then analyzed by comparing the mean lengths at age. Cobia within the GOM (MS-TX and AL- WFL) appear to be larger at younger ages for both female and male compared to the ATL states (Figure 11). To increase sample sizes, we combined a few states within a range: MS-TX, AL- WFL/Keys, EFL, SC, NC, VA. The GOM states showed similar average length at ages at younger ages, as do the ATL states including the east coast of Florida samples (GA/FL line through Miami-Dade County). Von Bertalanffy growth models were run on data from the GOM (Texas through west coast of Florida and the Florida Keys) and ATL (east coast of Florida through Virginia). The models took into account the left truncated distribution of length at age imposed by the minimum size limit regulations on the fishery-dependent samples. For each sex, the parameter estimates of L_∞ and t_0 were similar between the two regions, but the K values were very different (Table 3). Figure 12 illustrates the differences in growth between the GOM and Atlantic. The LHG discussed potential reasons, specifically abiotic factors, to explain the differences in growth, such as water temperature and food availability. Anecdotal evidence suggests potential differences in prey availability between the GOM and Atlantic, with more prey available in the GOM as a reason for larger mean size at age. However, lack of studies to quantify prey and energetics of Cobia cannot support these claims and warrant further study.

Consensus Statement: Differences in growth of Cobia exists between the GOM (Texas – Florida Keys) and Atlantic (Miami-Dade County Florida north to Virginia). The data, specifically from the GOM and east coast of Florida, are limited. At this time, not enough data are available to define definitively Cobia stock structure.

Reproductive Biology

Overall, no new reproductive data for Cobia were available for review at the SEDAR 58 stock ID workshop. While some macroscopic gonadal data were provided by VMRC, it was unclear which stages would be considered mature in their classification scheme. Additionally, all of the samples were from the spawning season (May - September) and from fishery-dependent sources. Similarly, SCDNR provided additional gonad weight and macroscopic gonad staging data, but all fish were collected during the spawning season and from the recreational fishery. Given the high minimum size limit regulations, any fish from the recreational fishery are likely to be mature. These new data did not provide any different information from what was available to SEDAR 28.

The information summarized here is based on the reproduction data compiled for the SEDAR 28 Atlantic and Gulf of Mexico Cobia stock assessments. Reproductive data used for SEDAR 28 primarily came from Brown-Peterson et al. (2001) and Franks and Brown-Peterson (2002). In the South Atlantic, the spawning season is reported to occur from April through July and peak in May and June (Brown-Peterson et al. 2001). Based on mean female gonadosomatic index (GSI) values, peak GSI was in May in South Carolina and June in North Carolina (SEDAR 2013b). Literature reported peak spawning in Virginia was in July (Joseph et al. 1964). These values of peak spawning are closely tied to when these areas reach 20-25°C (SEDAR 2013b). Males appear to reach sexual maturity well before they reach age 1. Few small females were evaluated in SEDAR 28 but the recommendation from the data workshop was that all fish age-3+ were mature. No matter what age, all female fish >800 mm FL were mature, less than the minimum size in the commercial and recreational fisheries (838 mm FL). Spawning frequency in the South Atlantic was estimated to be every 4 to 6 days.

In the Gulf of Mexico, female GSI values began to increase in March, peaking in July in the eastern Gulf of Mexico and peaking in May in the north-central Gulf of Mexico (Brown-Peterson et al. 2001). As most of the Gulf of Mexico sampling has focused on fishery dependent sampling with a 33 inch FL minimum size (838 mm), very few small or immature Cobia have been captured (Franks and Brown-Peterson 2002). As in the Atlantic, fish appeared to mature early with the smallest males maturing at age 0 or 1 and smallest females maturing at age 1 or 2. The recommendation from the data workshop was that all fish age-3+ were mature (SEDAR 2013a). Brown-Peterson et al. (2001) estimated that fish in the north-central Gulf of Mexico spawn every 4-5 days and this was the value recommended in the SEDAR 28 Data Workshop (S28). While Brown-Peterson et al. (2001) estimated a longer spawning frequency of 9 to12 days for the western Gulf of Mexico, they cautioned that these samples were taken in the latter part of the spawning season and were possibly not typical of the Gulf overall.

In estimating batch fecundity, samples had to be combined for the southeastern U.S., the eastern Gulf of Mexico, and the north-central Gulf of Mexico due to low sample sizes (SEDAR 2013a and SEDAR 2013b). In addition, there were no size- or age-based estimates for the number of spawns per year so annual fecundity could only be poorly estimated. While the data suggested a power relationship between batch fecundity and body weight, the model fit was poor and spawning stock biomass was suggested to estimate reproductive potential rather than fecundity for both stocks.

Consensus statement: The reproductive biology of Cobia could not definitively define stock structure due to lack of data from east coast of Florida or data that would include more comprehensive information on spawning locations.

Overall recommendation

There is some suggestion of differences in growth between the GOM and Atlantic (including the entire East Coast of Florida), but this difference could be a function of sample size differences, food availability, and temperature. There is also a suggestion of differences in max age between the two regions; however, it is largely explained by sample size differences. There is a lack of reproductive biology data, especially a large gap in data for the east coast of Florida and the Florida Keys (Figure 13), to be informative at this time. Based on these factors, there is insufficient recent life history information to suggest changes to the existing stock structure identified in SEDAR 28.

Table 1. Data sources of whole weight-fork length (W-L) and age data for SEDAR 58 Cobia Stock ID. (GOM = Gulf of Mexico; SA = South Atlantic)

Source	W-L	Location	Age	Location
Trip Interview Program	Yes	GOM and SA	No	
Southeast Region Headboat Survey	Yes	GOM and SA	No	
MRIP	Yes	Louisiana – U.S. Atlantic	No	
NMFS Bottom Longline Survey	Yes	Texas – East Coast Florida	No	
NMFS Pelagic Acoustic Trawl Survey	Yes	Texas – West Coast Florida	No	
GOM SEAMAP Summer/Fall Trawl Survey	Yes	Texas – West Coast Florida		
SA SEAMAP Trawl Survey (SCDNR)	Yes	North Carolina – East Coast Florida	No	
SCDNR	Yes	South Carolina – East Coast Florida	Yes	South Carolina – East Coast Florida
GCRL	Yes	Texas – West Coast Florida	Yes	Texas – West Coast Florida
Mote Marine Laboratory	Yes	Texas – southeast coast Florida	Yes	Texas – southeast coast Florida
NMFS Panama City	No		Yes	Louisiana and West Coast Florida
GADNR	Yes	South Carolina	Yes	South Carolina
NMFS Beaufort	Yes	Virginia - Georgia	Yes	Virginia – East Coast Florida
VMRC	Yes	Virginia	Yes	Virginia
NCDMF	Yes	North Carolina	Yes	North Carolina
FWC	No		Yes	East and West Coast Florida

Table 2: Cobia age data by state or area including sample size, fork length ranges, calendar age and the year that the fish with the max ages were caught, all sexes combined. (Note that maximum age of 11 years was reported for the Gulf of Mexico in Franks et al. (1999), but the specific data were not available during SEDAR 58 Stock ID workshop.)

		Fork Length		Calendar Age		
State	**Sample Size**	**Min**	**Max**	**Min**	**Max**	**Year Max age caught**
VA	2069	320	1610	0	16	2006
NC	431	214	1588	0	14	1994
SC	2512	93	1425	0	13	2009, 2014
GA	6	266	1008	0	5	2014
EFL	416	397	1314	1	11	2003
WFL	295	355	1585	0	9	1996
FLKEYS	43	700	1220	1	7	1996
AL	41	760	1520	2	9	1990
MS	289	397	1639	1	8	1988, 2007
LA	208	840	1440	1	9	1989, 1990, 1996
TX	87	370	1350	0	9	1989
GOM	88	493	1530	1	9	1989

Table 3: Von Bertalanffy growth parameters for Cobia by sex and region. The Atlantic region includes data from Virginia south through Volusia County, Florida. The GOM region includes data from Brevard County, Florida through the U.S. waters of the GOM.

Group	Linf	K	t0	sigma
Atlantic Female	1410	0.25	-0.79	112.33
GOM Female	1408	0.36	-0.55	117.74
Atlantic Male	1138	0.31	-0.98	70.67
GOM male	1178	0.43	-0.54	103.11

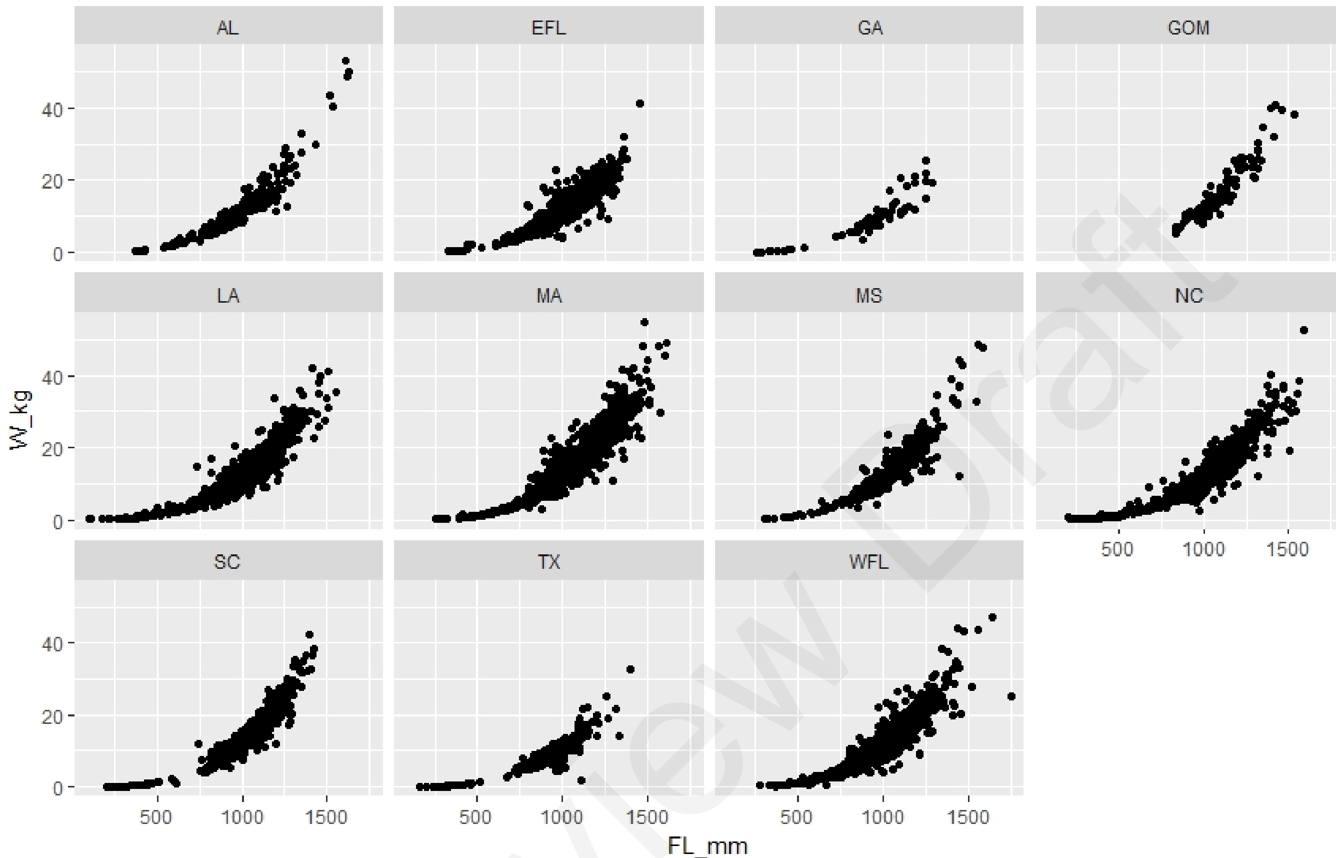


Figure 6: Whole weight (kg) to Fork Length (FL, mm) relationship for the range of Cobia from the Gulf of Mexico through the Mid-Atlantic by state. (Note: MA = Mid-Atlantic which includes data primarily from Virginia with <10 samples from New Jersey and Maryland combined)

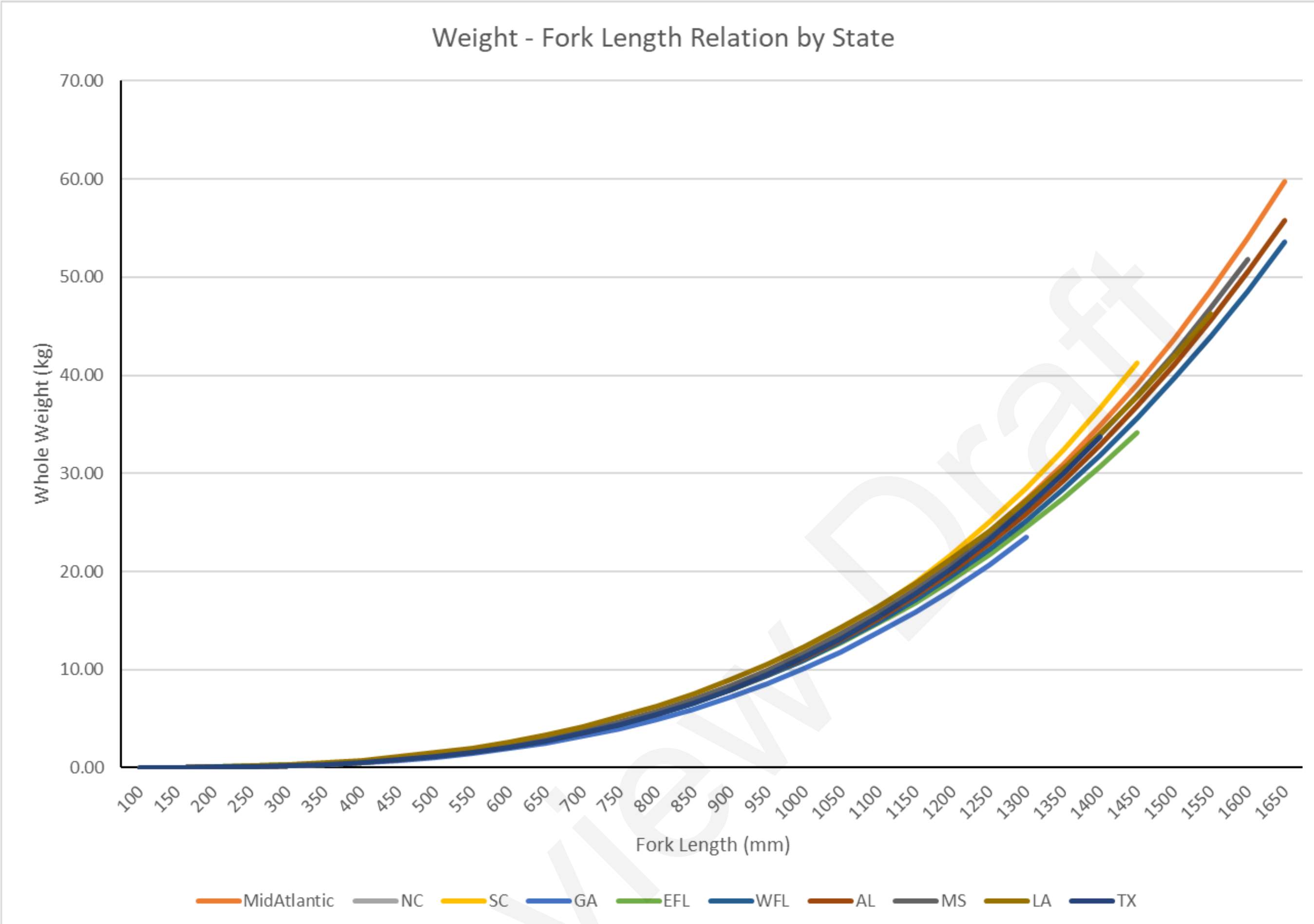


Figure 7: Cobia weight-fork length relationship by state.

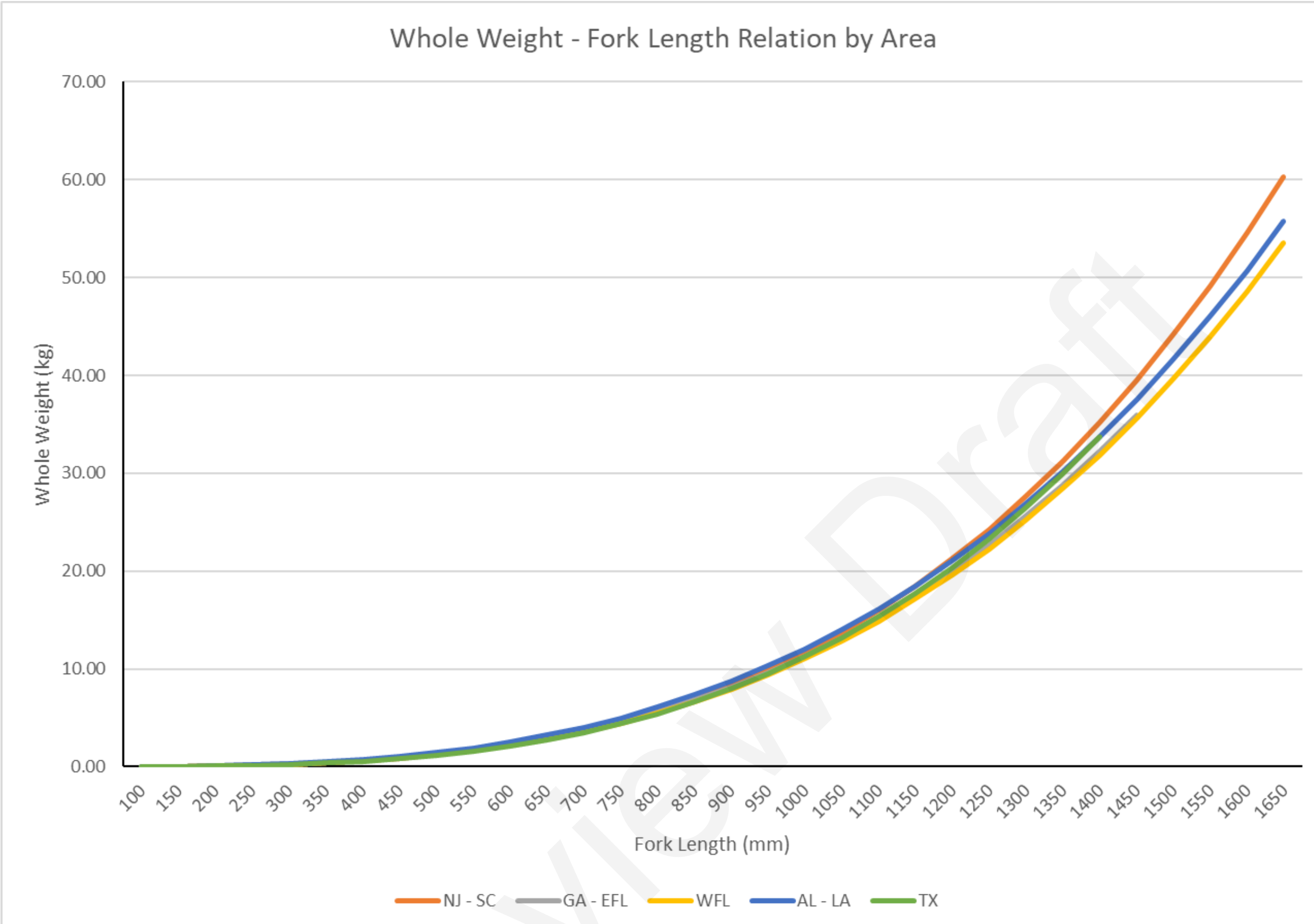


Figure 8: Cobia weight-fork length relationship by region: NJ- SC, GA-East Florida, West Florida, AL-LA, and TX

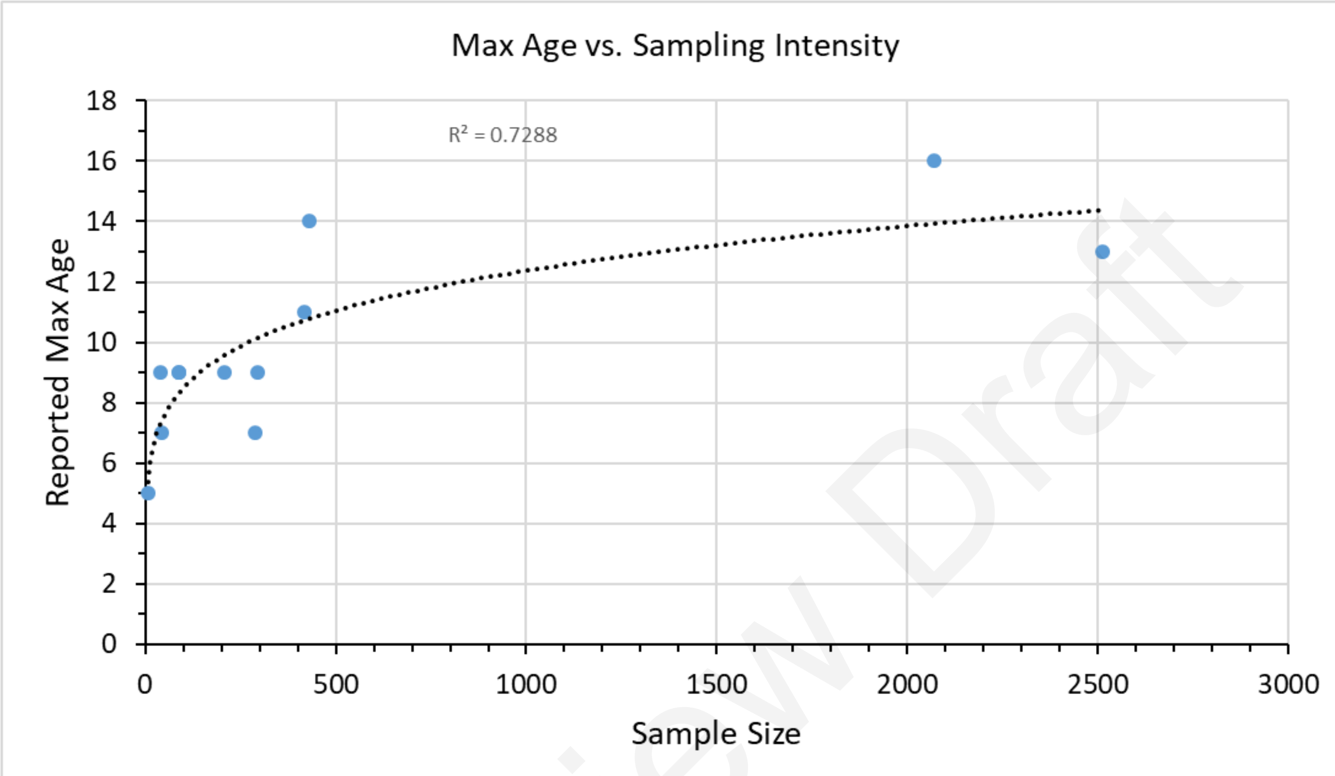


Figure 9. Regression analysis of maximum age recorded to sample size from age data sets submitted for the SEDAR 58 Cobia Stock ID Workshop.

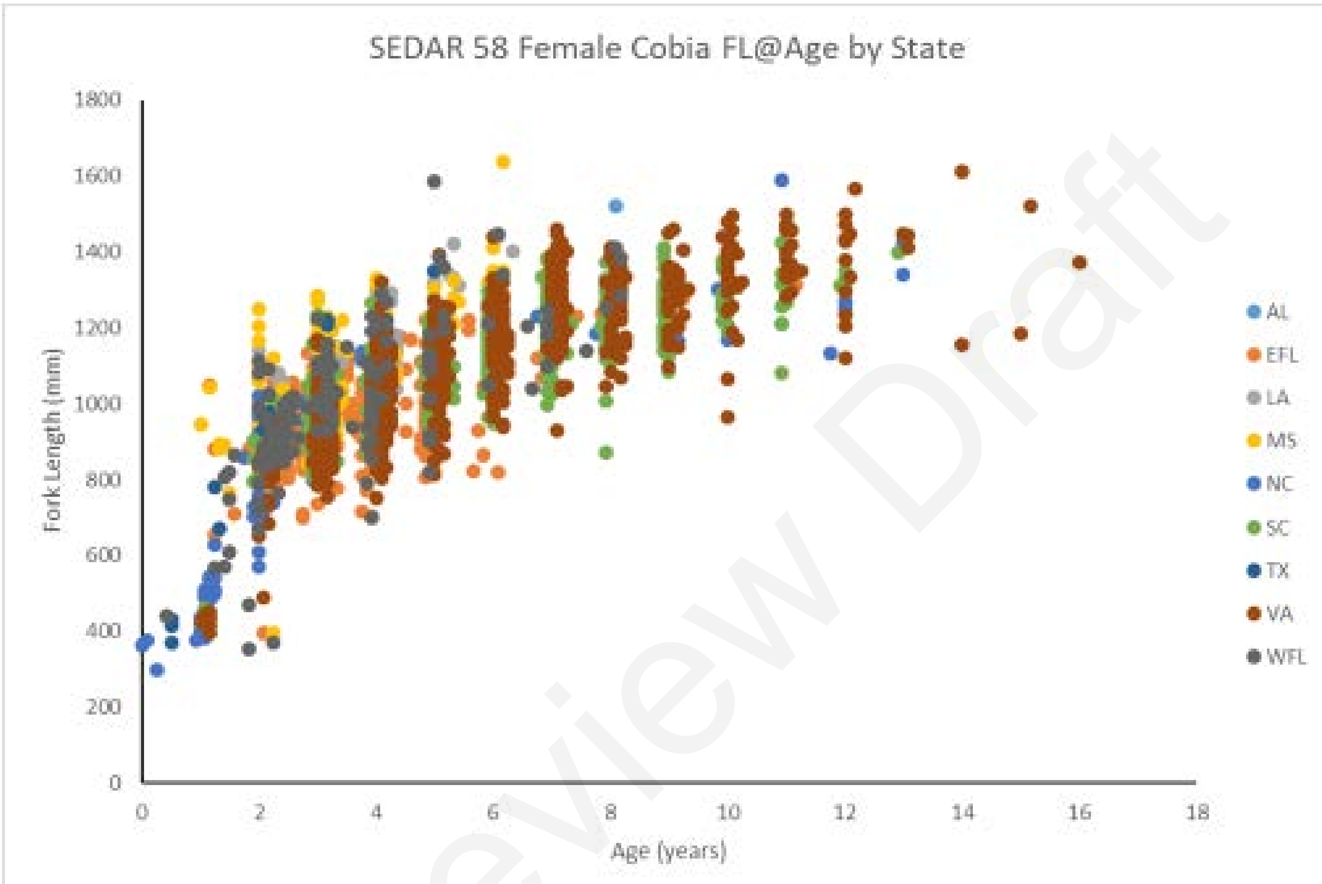
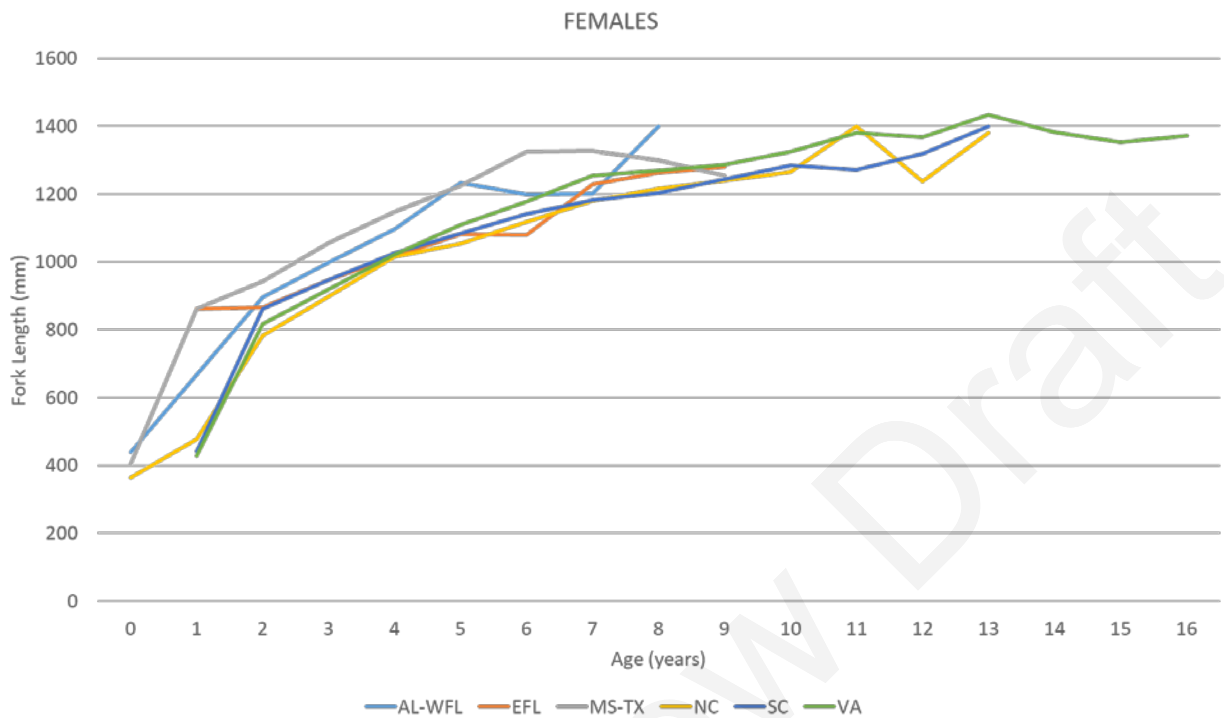


Figure 10: Observed fork length at biological (fractional) age of female Cobia by state/area.

A.



B.

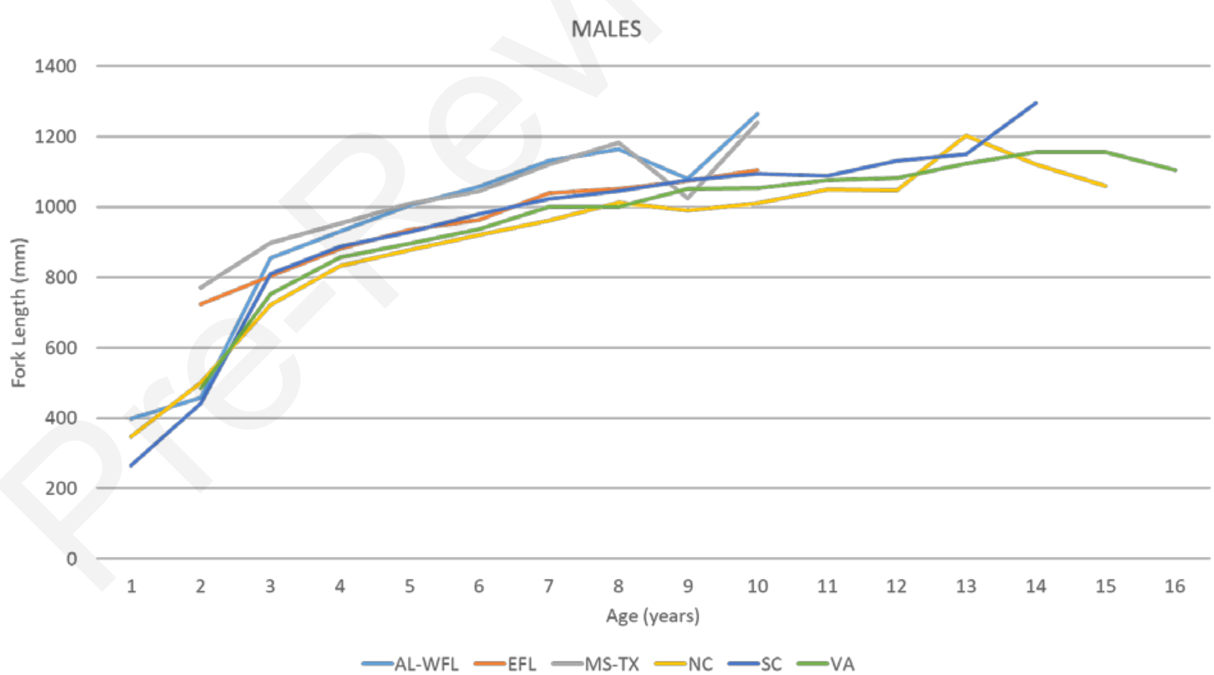
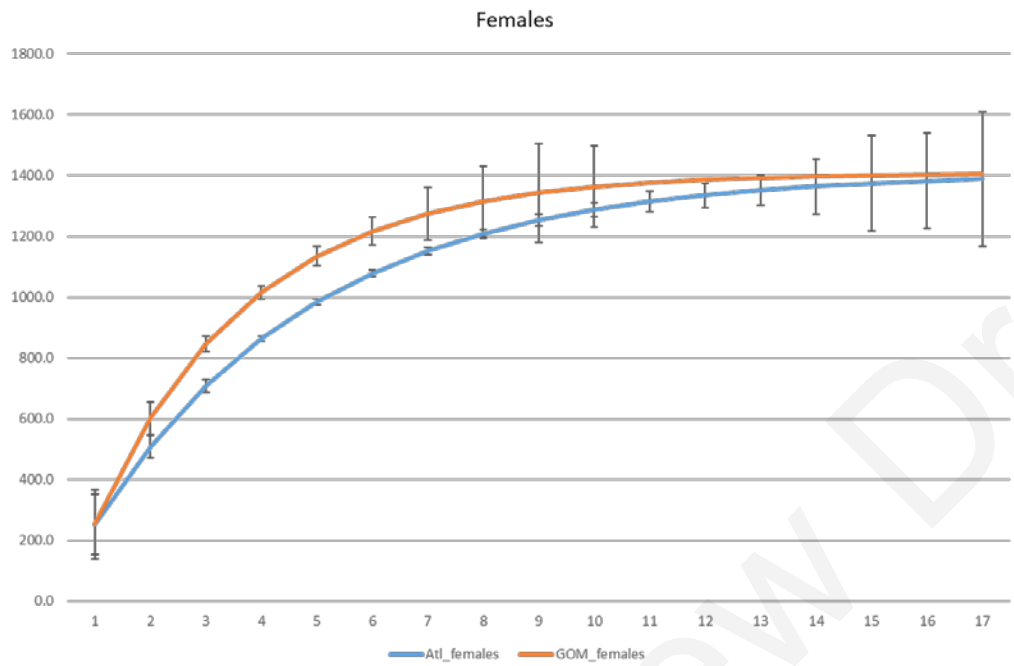


Figure 11: Average Cobia female (A) and male (B) size at age, by region.

A.



B.

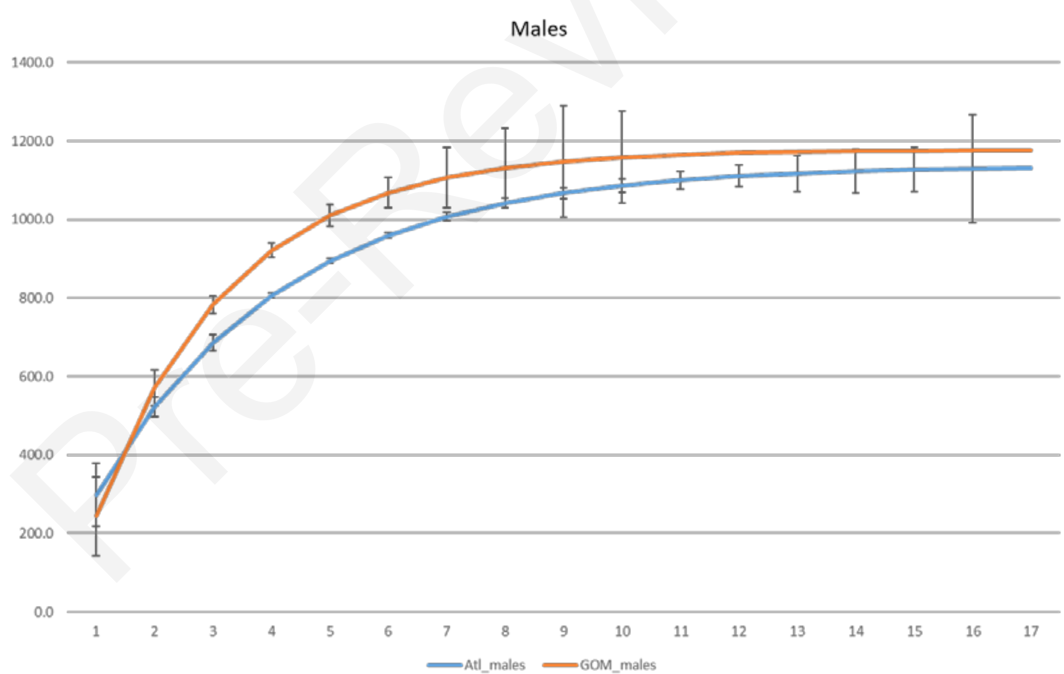


Figure 12: Von Bertalanffy growth models of Cobia for (A) females and (B) males by region: GOM (Texas – Southeast Florida) and Atlantic (Northeast Florida – Virginia). Error bars represent 95% confidence intervals around mean observed length at age.

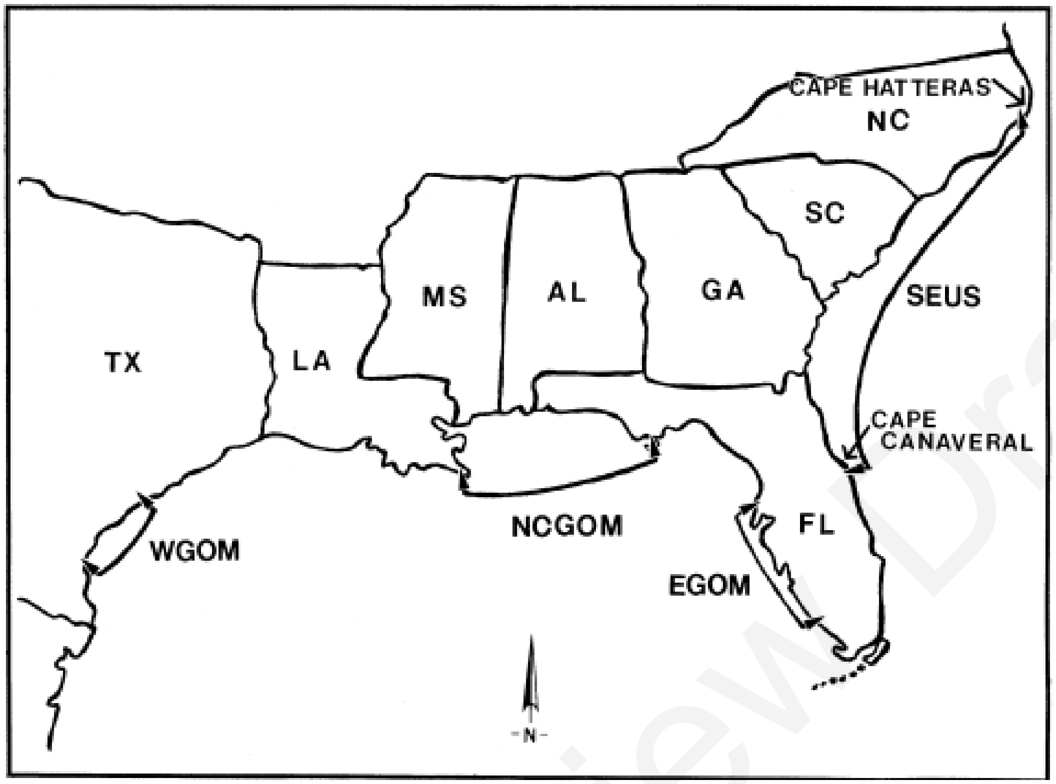


Figure 13. Areas sampled for Cobia within the southern United States. SEUS = southeastern United States; EGOM = eastern Gulf of Mexico; NCGOM = northcentral Gulf of Mexico; WGOM = western Gulf of Mexico (From Brown-Peterson et al. 2001).

2.1.3 Spatial Distribution / Movement

Spatial Distribution and Movement Working Group Panelists

Kevin Weng (Group Leader)	VIMS
Ken Brennan	SEFSC Beaufort
Jeff Buckel	SAFMC SSC
Jim Franks	GCRL
David Hanisko	SEFSC Pascagoula
Douglas Jensen	VIMS
Chris Kalinowsky	GADNR
Susanna Musick	VIMS
Matt Perkinson	SCDNR
Steve Poland	NCDMF
Jim Whittington	FL FWCC
Chris Wilson	NCDMF
Joy Young	FL FWCC

Spatial Distribution and Movement Working Group Contributors

Karl Brenkert	Brenkert Drone Services
Dan Crear	VIMS
Tim Griner	SAFMC (appointed Council representative)
Aaron Kelly	NC Fisherman (appointed observer)
Ira Laks	SAFMC Cobia/Mackerel AP (appointed observer)
Vivian Matter	SEFSC Miami
Beth Wrege	SEFSC Miami

This report summarizes the findings of the Spatial Distribution and Movement Working Group (Spatial Working Group) at the SEDAR 58 Stock ID workshop, held 10-12 April 2018 in Charleston, SC. Herein, the Spatial Working Group provides a response to Stock ID Workshop ToR #1, by reviewing relevant information on spatial distribution and movement that might inform existing stock definitions and stock structure of Cobia in the Gulf of Mexico and the U.S. Atlantic. The Spatial Working Group also provides a response to ToR #5 in Section 2.5 by making recommendations for future research on stock structure. The Spatial Working Group considered data and analyses of Cobia distribution and movement using a combination of datasets including conventional tagging, acoustic tagging, satellite tagging, commercial catch data, and fishery-independent collections.

The Spatial Working Group reviewed a variety of data sources and working papers providing information on distribution and movement of Cobia in the Gulf of Mexico and U.S. Atlantic.

Spatial distribution information included data from scientific surveys (Hanisko et al. 2018, Klibansky 2018) and catch data from fishery-dependent sources (Wrege 2018). Movement data were comprised of traditional (dart) tagging data (Perkinson et al. 2018b), acoustic tagging data (Poland 2018, Weng et al. 2018, Young et al. 2018), and satellite tagging data (Jensen and Graves 2018). A summary of datasets reviewed and their contributions is provided in Table 4.

Considering that one of the main goals of the SEDAR 58 Stock ID process is to review existing stock definitions, the Spatial Working Group focused initial efforts on evaluating whether the spatial distribution and movement data supported a change in the existing management boundary, at the Florida-Georgia (FL-GA) border. Further efforts went toward investigating the biological stock structure within the Atlantic region and the potential for sub-regional biological stock structure. The Spatial Working Group did not consider the stock substructure in the Gulf of Mexico, but data exist for such an analysis at a future time.

Spatial distribution

Data on presence or absence of primarily juvenile and adult Cobia from fishery-dependent and independent surveys were compiled to provide a sense of the general distribution of Cobia in the Gulf of Mexico and the Atlantic (Klibansky 2018; Figure 14). Data from 15 scientific surveys were compiled where spatial location of Cobia catch was available at fine resolution. In most cases, latitude and longitude was available to a resolution of about 1 minute (~1 nautical mile). Most of Cobia represented in this compiled data were recorded by the Southeast Regional Headboat Survey (n=78,723 Cobia from 42,049 fishing trips). These data showed a fairly continuous distribution of Cobia presence from the U.S.-Mexico border along the coast of the Gulf of Mexico and the U.S. east coast across the NC-VA border, then present inshore up to southern NJ (and noting that Cobia also occur in Mexican waters but our datasets do not extend there). The Spatial Working Group acknowledged this information provided a sense of the extent of the Cobia distribution in U.S. waters and generally found a lack of clear breaks in the regional distribution that might indicate stock structure. There was a narrow band of Cobia absence extending out from the central GA coast, but it is possible that this is an artefact of low fishing effort in the area. Most fishing activity occurs at the north and south regions of the GA coast, Savannah (north) and Brunswick/St. Simons Island (south), with much less effort in central GA. Anglers report Cobia from this area, and acoustically tagged Cobia are detected on the array at Brunswick, GA. Other data sources did indicate a possible stock structure break between Brunswick, GA and Cape Canaveral, FL.

Abundant ichthyoplankton survey data for the Gulf of Mexico, were available, providing some insight into Cobia larval distribution (Hanisko et al. 2018; Figure 15). However, these surveys tend to progress from west to east over the course of a sampling season, thus the Spatial Working Group found the distribution information to be somewhat confounded with expected seasonal abundance of Cobia larvae, due to spawning seasonality. So although larvae were apparently more abundant in the western Gulf of Mexico, this may be partly due to sampling in the eastern Gulf occurring at a time of year when few Cobia are still in a larval stage. Ichthyoplankton surveys were rarely conducted in the Atlantic (Figure 15). During the data scoping phase of the SEDAR 58 Cobia Stock ID process, no other sources of larval survey data containing substantial numbers of Cobia were identified.

Movement

The Spatial Working Group reviewed and discussed tagging data extensively during the Stock ID Workshop. Due to the oceanography of the north Atlantic, migratory species can find warmer waters during winter in two ways: migrating along the coast to the south, or moving offshore into the Gulf Stream. It is not yet clear how different groups of Cobia are using these strategies, but indications of both strategies are evident in available data, noting that bias exists in observation effort. Most of the available movement data for Cobia in the Atlantic show along-coast movement due to telemetry receiver coverage near the coast and increased fishing pressure closer to shore, but it is likely that onshore-offshore seasonal movement is also important in the Atlantic. Evidence for these types of movement is discussed in separate sections below.

Along-coast movement

The two major sources used to examine along-coast movement were the combined conventional tagging analysis (Perkinson et al. 2018b) and the acoustic telemetry analysis (Young et al. 2018).

Conventional Tagging

Data for Cobia, tagged with conventional stainless steel and nylon barbed dart tags, from eight individual tagging programs, were compiled and analyzed by Perkinson et al. 2018b (Table A1). A total of n = 25,867 Cobia were grouped by the spatial zone they were tagged in, over 32 years (1986-2017). These nine spatial zones, varying widely in size, were (from south to north): 1. Gulf of Mexico, 2. Florida Keys, 3. Florida, south of Brevard County, 4. Florida, within Brevard County, 5. Florida, north of Brevard County, 6. Georgia, 7. South Carolina, 8. North Carolina, 9. Virginia. Cobia were recaptured but not tagged in a tenth zone, north of Virginia (Figure 16). A total of n = 1,750 Cobia that were tagged were later recaptured (6.7% of tagged fish), excluding n = 264 Cobia at large for fewer than 30 days, and n = 114 with missing information. Of these Cobia, n = 969 were tagged in the Gulf of Mexico, leaving n = 781 tagged in all other zones combined. On average, these fish were 786 mm FL and at large for 464 days. Most recaptured Cobia were recaptured in the zone they were tagged in (78% overall, 70% excluding fish tagged in the Gulf of Mexico zone). The vast majority of Cobia were tagged and recaptured on the same side of the FL-GA border (98% overall, 95% excluding Gulf of Mexico). Considering the Cobia that crossed the FL-GA border between tag and recapture (n = 43 overall, n = 39 excluding Gulf of Mexico), movement occurred in both directions at similar rates (overall: south to north = 1%, north to south = 1%; excluding Gulf of Mexico: south to north = 2%, north to south = 3%).

Conventional tagging analysis indicates that Cobia tagged in the Gulf of Mexico (n=969 recaptures; tagged primarily Mar-Nov; mean days at large = 449) are largely recaptured in the Gulf of Mexico (84.8%). Another 14.8% were recaptured in the Florida Keys or along the east coast of Florida, while only four fish (0.4%) have been recaptured north of the FL-GA border.

Cobia tagged in the Florida Keys (n=181 recaptures; tagged Jan-Dec; mean days at large = 362) have not been recaptured north of Cape Canaveral, FL (Perkinson et al. 2018b). Cobia tagged in the Florida Keys are most frequently recaptured in the Keys or in the Gulf of Mexico (Figure 17). Therefore, it is unlikely that the Florida Keys serve as an overwintering area for Cobia found in coastal areas along Georgia, South Carolina, North Carolina, and Virginia during spring, summer, and fall.

By comparison, Cobia tagged within Brevard County, FL (encompassing Cape Canaveral; n=90 recaptures; tagged Jan-Nov; mean days at large = 400) dispersed widely throughout the Gulf of Mexico and South Atlantic (Figure 18), suggesting that Gulf and Atlantic stock individuals may both occur in this area. Most fish tagged in the Brevard zone were recaptured along the east coast of Florida, the Florida Keys, or Gulf of Mexico (85.6%), while 14.4% were recaptured north of the current management boundary. Most recaptures occurred from fish tagged in the Brevard zone during March and April. One fish tagged in Florida north of Brevard County moved north, and was recaptured in South Carolina, three years after tagging. Of the seven Cobia tagged in Florida south of Brevard County (mean days at large = 430), most moved south (n=2 recaptured in the FL Keys, n=2 recaptured in Gulf of Mexico) while three remained in the area.

Whereas Cobia tagged in Brevard County, FL dispersed widely, Cobia tagged in Virginia (n=351 recaptures; tagged primarily May-Sep; mean days at large = 539) and South Carolina (n=128 recaptures; tagged primarily May-Aug; mean days at large = 496) were largely recaptured back in the same zones where tagging occurred (VA = 83.5%, SC = 87.5%) with smaller percentages of recaptures occurring along the east coast of Florida (VA = 2.3%; SC = 10.2%; Figure 19). Additionally, small percentages of Cobia that were tagged in VA and SC made much longer movements than average (i.e. strayers) and were recaptured in the Gulf of Mexico (VA = 0.9%; SC = 0.8%). Relatively few fish tagged in North Carolina were recaptured (n=21 recaptures; tagged May-Sep; mean days at large = 766), most of which had moved north into Virginia (85.7%). Two Cobia, tagged in Georgia, moved north into North Carolina after four and seven years at large.

Acoustic tagging
Results from fish tagged with acoustic transmitters in South Carolina, Georgia, and Florida during 2016-2017 (Young et al. 2018) largely overlap with the results from the conventional tagging analysis. To date, no Cobia tagged in South Carolina or Georgia have been detected on receivers in Florida (Figure 20). Tagged fish moving to central and south FL are very likely to be detected, given the large number of receivers in those areas. However, there is a large gap in coverage in northern Florida and southern Georgia between arrays located at Ponce Inlet, FL and Brunswick, GA, a distance of roughly 230 km. Additionally, the majority of receivers along the east coast are located within 30 km of shore and coverage in deeper offshore waters is very sparse. Cobia tagged in South Carolina and Georgia were present along those coasts during April-November and were completely absent from detection during December-March (2016-2017; Figure 21).

Cobia acoustically-tagged in central Florida (Cape Canaveral) and South Florida (Jupiter/St. Lucie) had minimal exchange across the Florida-Georgia border with 6/71 (8.5%) being detected in either Georgia or South Carolina for short periods of time. Four of these six Cobia were only detected in Georgia and South Carolina during fall, outside of the known spawning window. Cobia acoustically-tagged in Florida were largely resident to the east coast of Florida, with 28% detected moving into the Florida Keys during March-May (Figure 22) and three that were detected in the Gulf of Mexico to date. However, acoustic telemetry receiver arrays are not as robust along the Gulf of Mexico as the South Atlantic and more Cobia may have migrated into the Gulf without detection. This is underscored by a Cobia tagged on the east coast of Florida and harvested by an angler offshore of Tampa, Florida without detection during its movement north.

Onshore-offshore seasonal movement
Because Cobia typically inhabit waters that are warmer than 20℃ (Franks and Brown-Peterson 2002, Perkinson et al. 2018a), the traditional assumption has been that Cobia north of Florida migrate south to find suitably warm water during the winter months. Given the oceanography of the Atlantic, it is also possible that warmer waters could be accessed during the winter by moving offshore towards the Gulf Stream (i.e., moving east instead of south). Such movements would take fish into waters that presently lack acoustic receiver coverage, and where directed fishing effort for Cobia is very low. There is evidence that some proportion of Cobia in the VA-GA area overwinter on the shelf and shelf-break, rather than move directly south, based on pop-up satellite archival tags (PSAT) data (Jensen and Graves 2018), commercial landings (Wrege 2018), and the acoustic (Young et al. 2018) and conventional tagging datasets (Perkinson et al. 2018b). Figure 23 shows pop-off locations of Cobia (>940 mm TL; n = 24) fitted with PSAT tags in Virginia state waters during August and September of 2016 and 2017 (Jensen and Graves 2018). While one tag surfaced as far south as Daytona Beach, Florida, other pop-off locations

indicate that the tagged Cobia were on the continental shelf offshore of North Carolina and South Carolina during winter. All PSAT reports prior to 15 November were within 10 kilometers of shore, while all reports 15 November - 15 March occurred at distances greater than 15 kilometers from shore, providing strong evidence for offshore movement in winter months.

Commercial logbook data (Figure 24) show cumulative landings during 2012-2017 of 1,697-2,751 pounds offshore of North Carolina's outer banks during January, when gillnet, handline, and troll fisheries are occurring (Wrege 2018). While the commercial catch data are reported in geographically large areas that include both inshore and offshore waters of the Outer Banks, these inshore waters are much colder than Cobia thermal range during the winter. The reported catches could be from fishing effort in offshore waters nearer to the Gulf Stream, which would be within Cobia thermal range, and as such, these data are consistent with the hypothesis of offshore wintering. As previously mentioned, Cobia acoustically-tagged in South Carolina and Georgia (Young et al. 2018) were completely absent from detection on coastal arrays during winter (Figure 21 and Figure 25), suggesting that they move into areas where receivers are not present (deeper water, northern Florida, or both). Finally, the high rates of recapture of conventionally-tagged fish (Perkinson et al. 2018b) within the tagging estuary of Cobia from both Chesapeake Bay, VA and Port Royal Sound, SC indicate movement during winter into areas where there is decreased fishing pressure (i.e., deeper waters). When taken collectively, the available data suggests that east-west or inshore-offshore movement behavior occurs for Cobia within the current Atlantic migratory group.

The greatest evidence for offshore overwintering habitats comes from PSAT tagging and commercial catch data; however, the PSAT dataset is limited to a few observations, and the commercial catch data have coarse spatial resolution and are for fisheries that do not target Cobia. For the acoustic telemetry and conventional tagging datasets, the evidence is negative; in other words, there is a lack of data for fish locations during winter for individuals tagged in GA, SC, NC and VA, suggesting that the fish are going to areas that do not have receivers and are not heavily targeted by anglers.

Evaluating the existing management boundary

The information reviewed by the Spatial Working Group suggest that limited movement of Cobia occurs between the Gulf of Mexico and Atlantic with a suggestion of a regional boundary between Brunswick, GA and Cape Canaveral, FL. The southern extent of the Atlantic Cobia stock is uncertain, but the working group agreed that it was useful to consider the more common movements of fish (i.e., placing less weight on rare long distance movements). Fish tagged north of the FL-GA border are frequently detected north of that border, and only rarely detected south of that border. Fish tagged off Brevard County FL primarily stay in central FL or move to the south. Therefore, the southern extent of the Atlantic Cobia stock is thought to lie somewhere north of the Volusia/Brevard FL county line, and south of the Glynn/Camden GA county line. Further uncertainty is introduced because acoustic tagging in central FL has occurred during summer, when a putative group of more migratory individuals moving between FL and the GA to VA region would have migrated to the north, and thus would have been missed by the summer tagging effort in FL. The lack of both acoustic receivers and acoustically and conventionally tagged fish released between these two points means that we lack data to suggest a more precise boundary.

The Spatial Working Group concluded that the data do not provide reason to move the management boundary from the FL-GA border. A zone of uncertainty expected to contain the true boundary between these regions was defined where the interchange between groups is not well characterized, and very few data are available (Figure 26). Future research may provide better spatial resolution on the precise location of a regional biological stock boundary between the Gulf of Mexico and Atlantic.

Stock-structure at the sub-regional scale

In addition to the consideration of the above data sources, network analyses were performed on the entire acoustic tagging dataset (Young et al. 2018). Figure 27 is a visualization of a one-mode network demonstrating connectivity between individual Cobia that were detected in the same general area (0.1 degrees latitude/longitude) in the same month and is color coded by tagging region. Cobia tagged in central/south Florida and South Carolina/Georgia largely group together spatio-temporally and the two groups have little exchange with each other. The tags labeled on the lower panel indicate fish that overlapped in space and time between the two groups and consists of fish that moved from Florida into Georgia/South Carolina, thus their central location. Figure 28 shows the directed movements of Cobia between regions, with thicker lines indicating a greater number of fish, and arrows indicating directionality. Exchange occurs most frequently between Georgia/South Carolina and central Florida/south Florida/Florida Keys. The individual-based network documents the presence of two behaviorally distinct groups of Cobia that align with the current management boundary at the FL/GA border, and with limited crossover of individuals. The region-based network demonstrates the spatial segregation of Cobia into subgroups, with limited connectivity across the FL/GA border.

Similar to the region-based network analysis, during the workshop, a one-mode network analysis based on release and capture zones using conventional tagging data from Perkinson et al. (2018b) was conducted. The resulting plot shows movement between zones with darker lines indicating greater amounts of movement and arrows indicating directionality. It is important to note that this analysis can be biased by the number of recaptures that occur in each zone and fishing pressure, which are not constant over the entire area. However, they provide the ability to visualize which zones are most connected by Cobia movements. Figure 29 depicts all movements between zones, while Figure 30 shows the most common movements between zones by excluding rare movements from the analysis. Reflexive ties (i.e. capture in the same zone as tagging) are ignored, thus tagging zones without a large degree of movement into other areas (e.g., South Carolina) are not captured in the top 89% of movements. The plot indicates that core movements occur between VA and NC, central FL and south FL/GOM, and the FL Keys and GOM. No core movements occur between zones on opposite sides of the FL/GA border.

Taken together, the acoustic telemetry and conventional tagging data suggest that some degree of substructure may occur in Atlantic Cobia. Based on telemetry data (Young et al. 2018), Cobia tagged in waters offshore (defined as outside of barrier islands and not within the estuaries) of South Carolina and Georgia largely intermix in their movement patterns. However, conventional tagging data (Perkinson et al. 2018b) suggests that Cobia tagged inshore within the Port Royal Sound estuary in South Carolina show minimal exchange with other regions. Conventional tagging data suggest that Cobia tagged in North Carolina and within the Chesapeake Bay have a high degree of exchange with each other and little exchange with South Carolina/Georgia. Along the east coast of Florida, acoustic telemetry data to date indicate that some fish may be largely resident to central/south Florida while others migrate into the Florida Keys and as far as the northern Gulf of Mexico. The east coast of Florida appears to be a highly complex mixing area for Cobia and additional detections of tagged Cobia will provide greater clarity on the level of substructure in the region.

Spatial Distribution and Movement Working Group Consensus Statements

Spatial tagging data suggests the existence of at least two distinct biological stocks of Cobia at the regional scale, the Gulf of Mexico biological stock and the Atlantic biological stock. The separation of these stocks is most likely to occur in a zone between the Brevard/Indian River FL county line and the Glynn/Camden GA county line). Evidence suggests that the southern extent of the Atlantic biological stock is most likely to occur between the Glynn/Camden GA county line, south of Jekyll Island, GA, and the Brevard/Volusia FL county line, north of Cape Canaveral. The current resolution of the conventional and acoustic tagging datasets did not allow for further refinement of a regional scale biological stock boundary. Additional tagging resources between the Brevard/Volusia FL county line and the Glynn/Camden GA county line may further refine the regional scale biological stock boundary. There is evidence of multiple sub-regional biological stocks within the Atlantic, based on site fidelity and limited exchange between areas.

Table 4. Summary of datasets reviewed by the Spatial Distribution/Movement Working Group.

Data set	Working paper	Can it refine mtg boundary?	Can it inform movements?	Substructure
Presence/absence (multiple fishery independent and dependent data)	S58-SID07 Klibansky	Maybe with other data.	Partly/along with other data	maybe
Presence probabilities; presence/absence (SEAMAP surveys in GOM)	S58-SID09 Hanisko et al.	No	Partly/along with other data	maybe
Commercial fishery (pounds); all commercial gear (longline, bottom hl; trolling)	S58-SID10 Wrege	Maybe	Yes on north south, with seasonal; maybe for inshore/offshore (cells big)	Yes
Conventional tagging	S58-SID05 Perkinson et al.	Yes	Yes (north south and then look at overwintering by time);	Yes
Pop up satellite tagging	S58-SID02 Jensen and Graves	Maybe but need bigger data set	North south migrations absolutely (southerly) And inshore vs offshore (overwintering – yes)	With more tags?
Telemetry tags	S58-SID08 Young et al.	Helpful for stock line	Helpful for migrations inshore/offshore and north/south.	yes

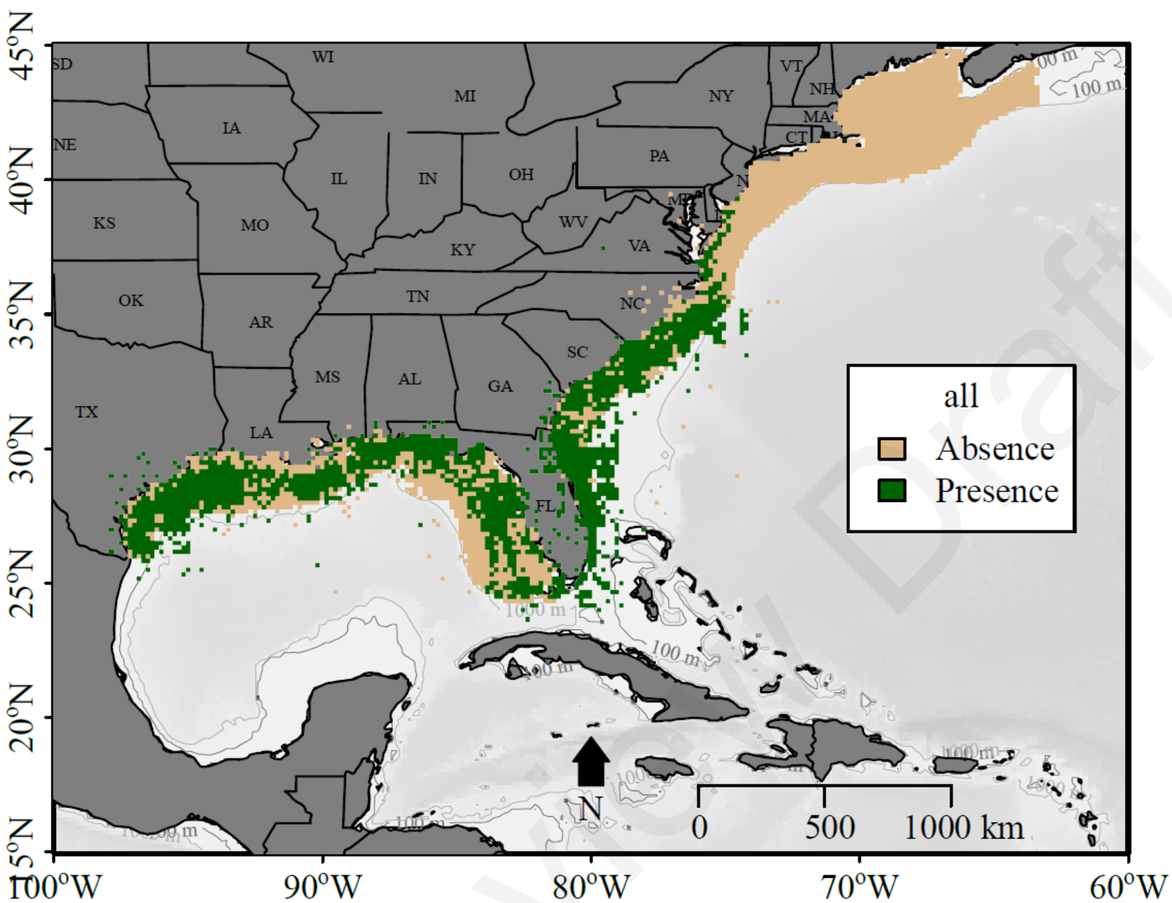


Figure 14. Presence/absence of Cobia in the Gulf of Mexico and U.S. Atlantic by 10 minute grid square combining all sources of information collected by scientific staff, for gear types that sometimes catch Cobia, where latitude and longitude information were provided. ***Reprint of Figure 3 from Klibansky (2018).***

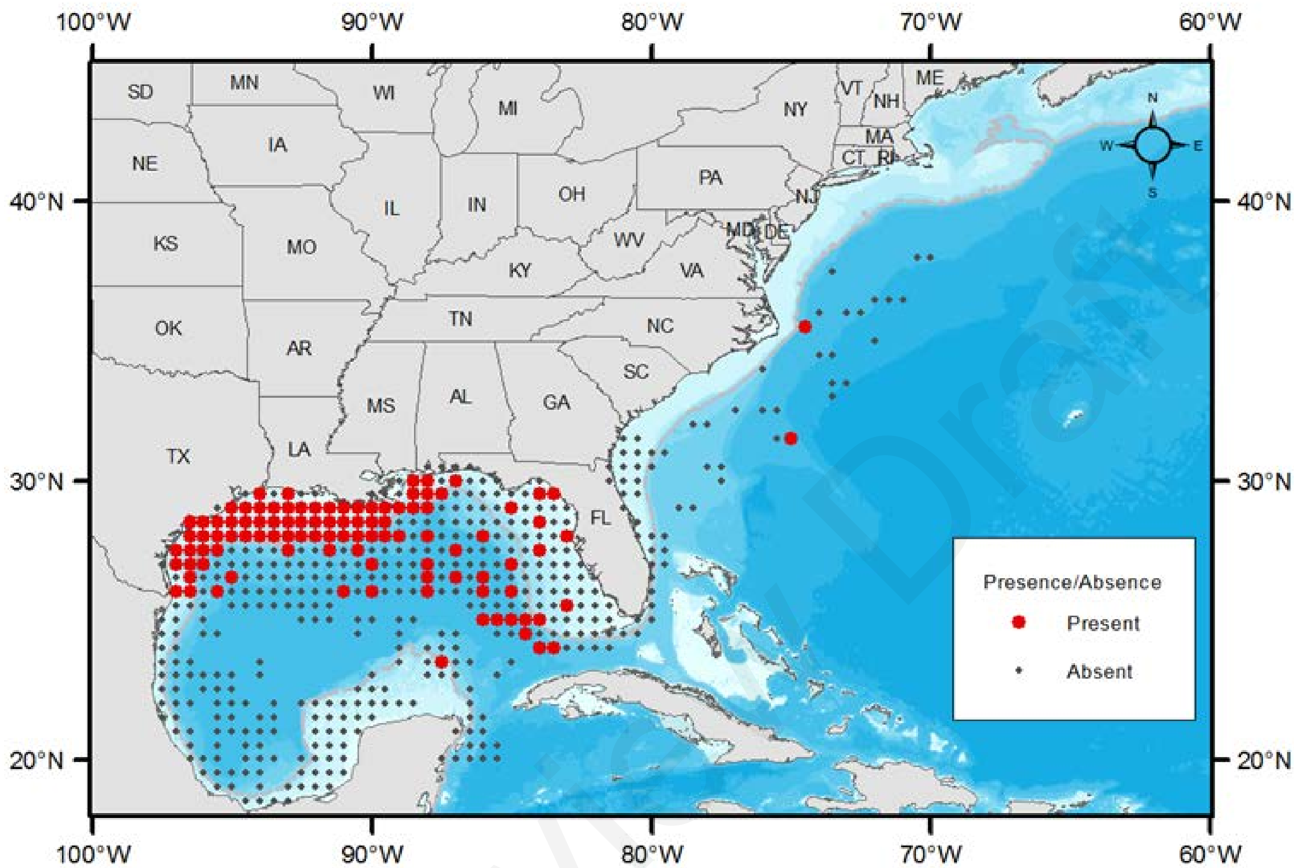


Figure 15. Larval presence absence from NMFS and SEAMAP (Southeast Area Monitoring and Assessment Program) fishery-Independent surveys. ***Reprint of Figure 2 from Hanisko et al. (2018)***

Figure 16. Tagging and recapture zones of Cobia in the southeastern United States designated for the purpose of partitioning and analyzing tag-recapture data. *Reprinted from Figure 1 of Perkinson et al. (2018b).*

Figure 17. Conventional tag recaptures of Cobia tagged in the Florida Keys. Rectangle indicates the general tagging area. *Reprinted from Figure 12 of Perkinson et al. (2018b).*

Figure 18. Conventional tag recaptures of Cobia tagged in the Brevard zone. Rectangle indicates the general tagging area. *Reprinted from Figure 9 of Perkinson et al. (2018b).*

Figure 19. Conventional tag recaptures of Cobia tagged in Virginia (top) and South Carolina (bottom). Rectangle indicates the general tagging area. *Reprinted from Figures 3 and 7 of Perkinson et al. (2018b).*

Figure 20. Detection extent of Cobia acoustically-tagged in South Carolina and Georgia during 2016-2017. This figure was generated during the workshop using information from NOAA Cooperative Research Program Final Report for Grant Number NA15NMF4540105, which is provided to SEDAR as supplementary document SEDAR58-RD22.

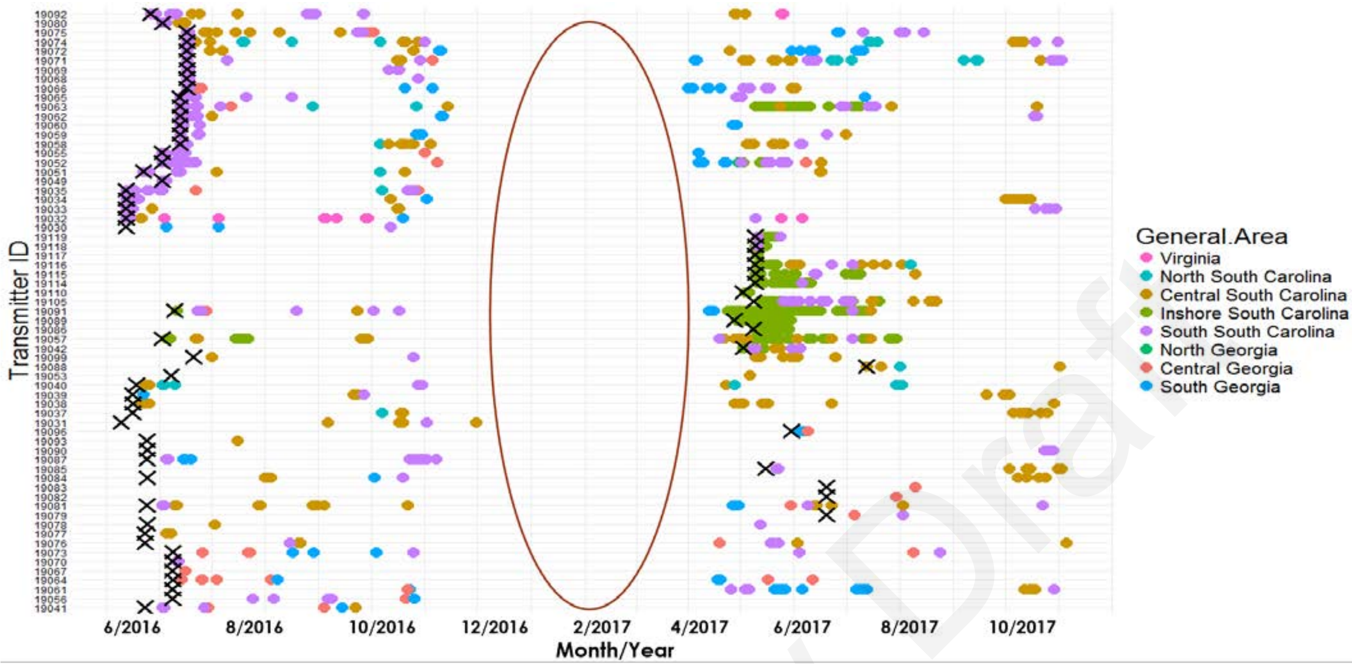


Figure 21. Abacus plot of Cobia acoustically-tagged in SC and GA during 2016-2017 showing the detections of individual fish by receiver location. The X indicates tagging date and the oval indicates the period during December-March when no detections occurred. ***Reprinted from Figure 12 in SEDAR-SID-08 (Young et al. 2018).***

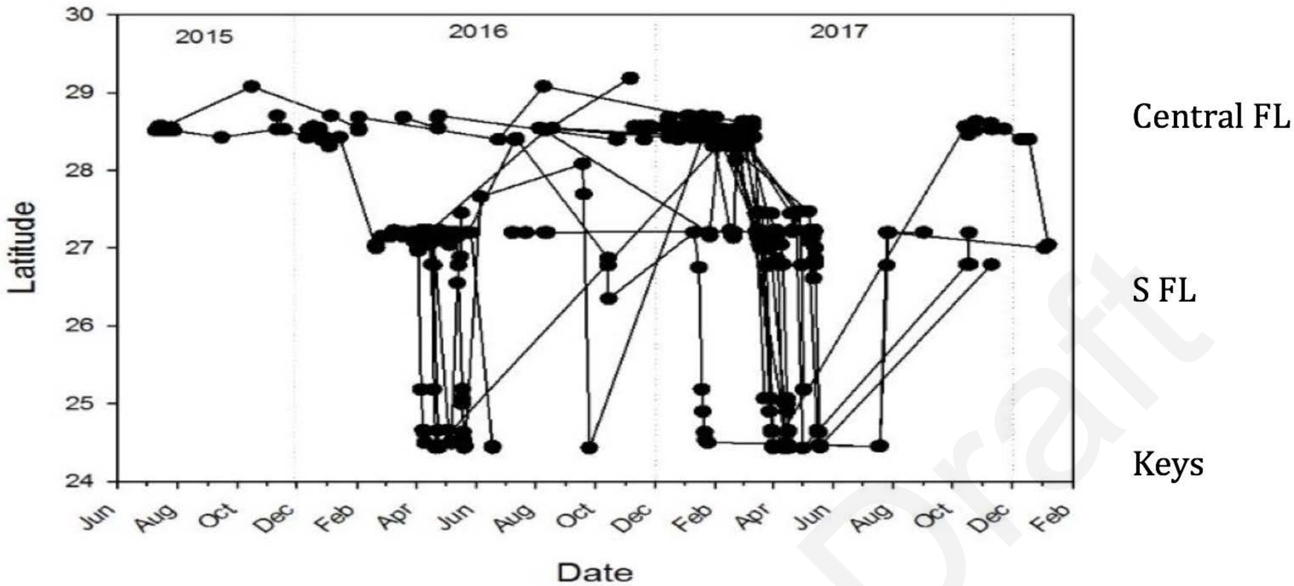


Figure 22. Cobia moving south to the FL Keys (n=20). ***Reprinted from Figure 7 of Young et al. (2018).***

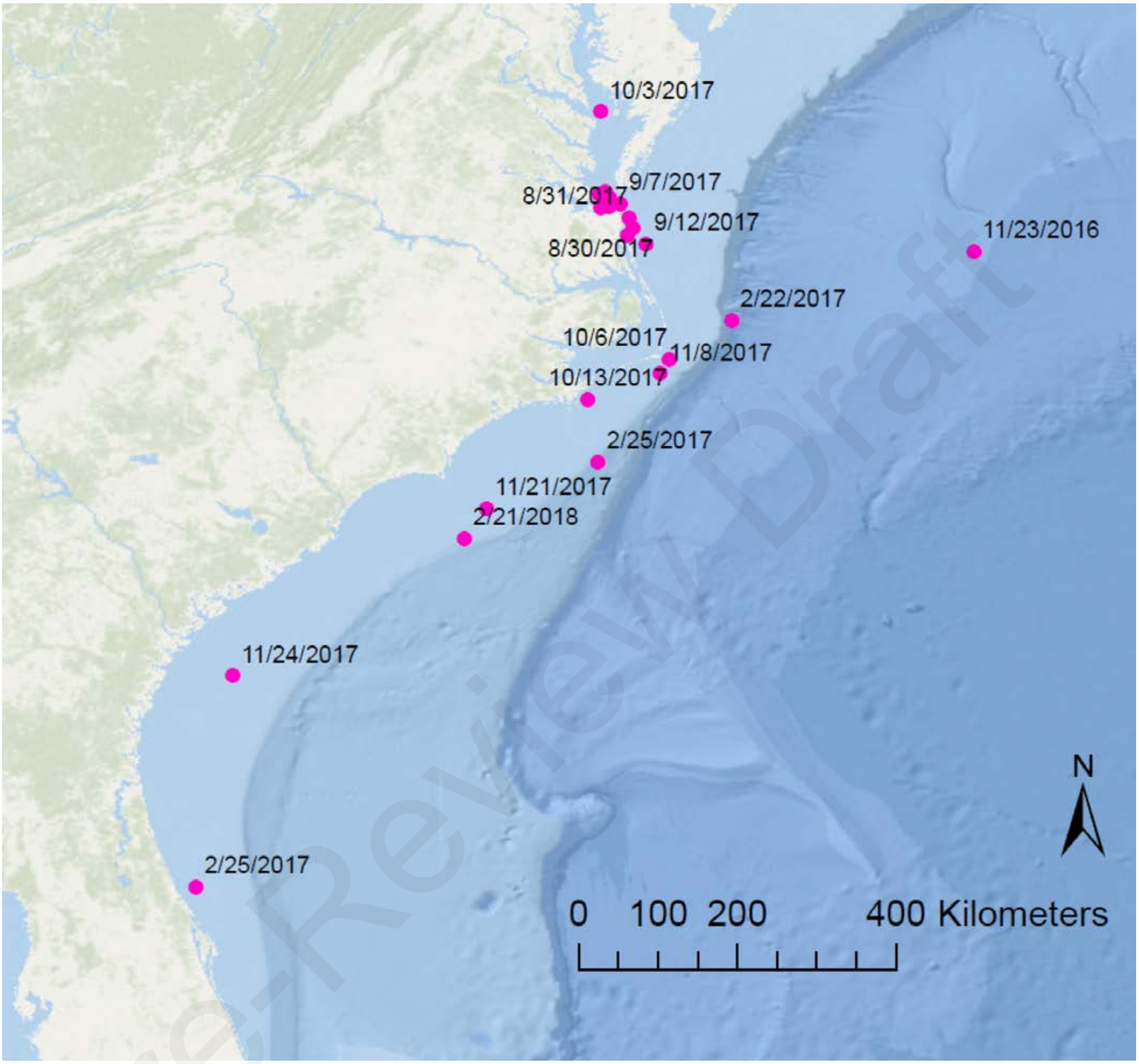


Figure 23. Map showing satellite tag reporting dates and locations of fish tagged in Virginia state waters (in the Chesapeake Bay or within 3 miles of the Virginia shoreline) in the months of August and September in 2016 and 2017. Each point represents a unique fish. The point farthest from shore labeled 11/23/2016 was the tag's first location reported after floating on the surface for 4 days; it was likely south of Hatteras, NC when it released from the fish based on comparisons with other tag drift trajectories. All other locations are assumed to be actual with 1.5 kilometer accuracy within hours of releasing from the fish. ***Reprinted from Figure 2 of Jensen and Graves (2018)***

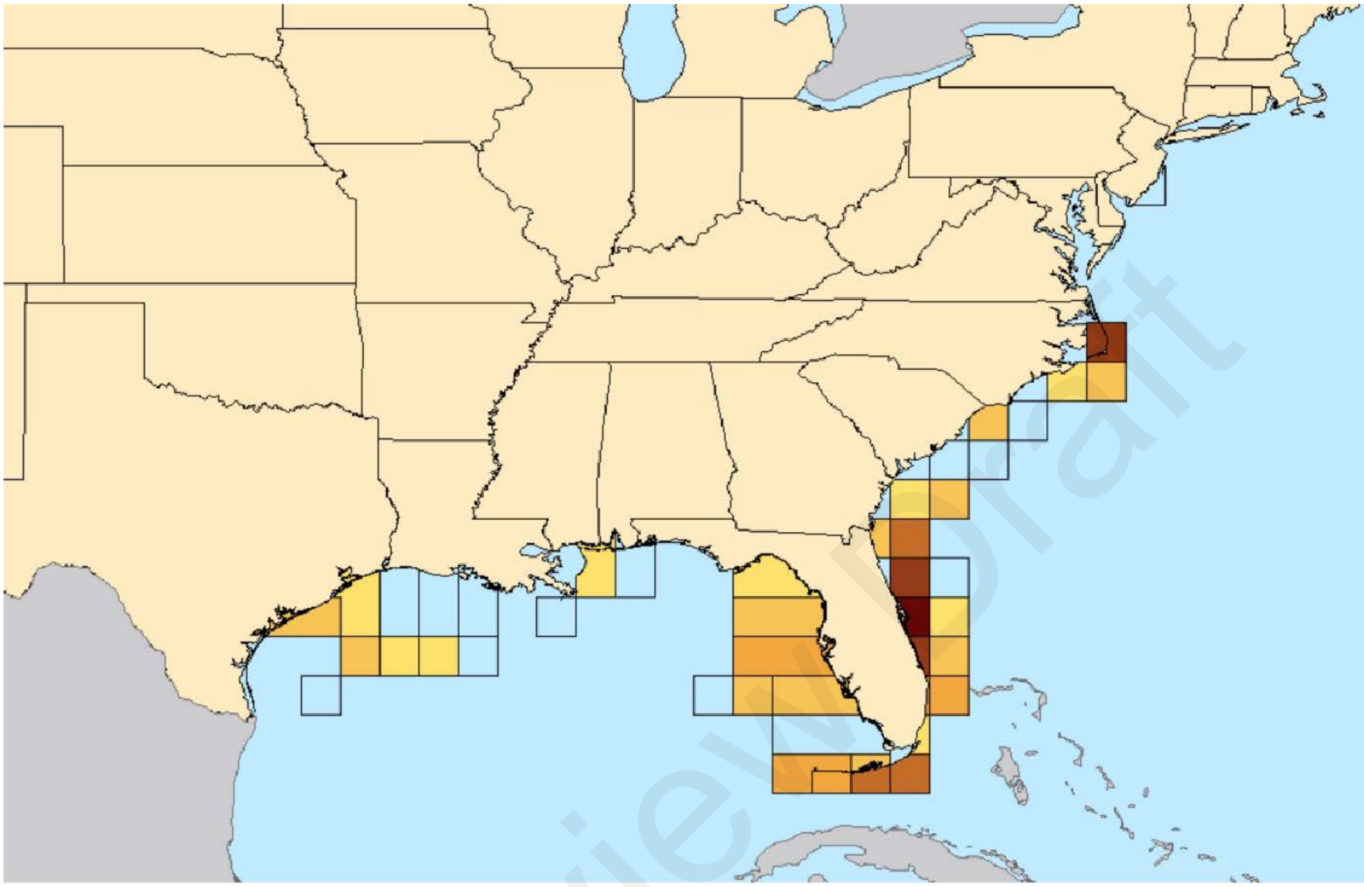


Figure 24. January commercial logbook landings, by 1 x 1 degree grids, summed from 2013-2017. Darker colors indicate more landings. ***Reprinted from figures in SEDAR58-SID-10 (Wrege, 2018). All months are shown in Figures A1 and A2 of this report.***

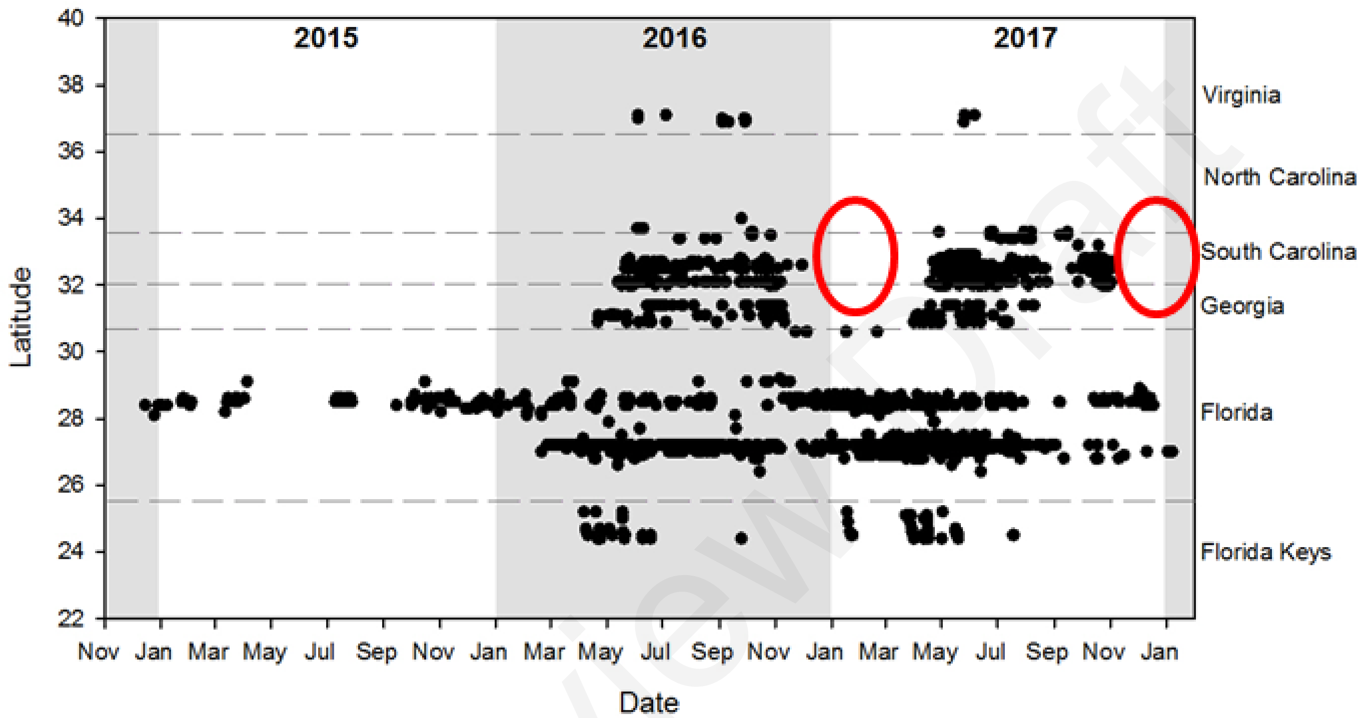


Figure 25. Detection by time and latitude of Cobia tagged with acoustic transmitters in South Carolina, Georgia, and Florida. The red circles indicate periods when no Cobia are detected off South Carolina and Georgia. Based on data from Young et al. (2018).

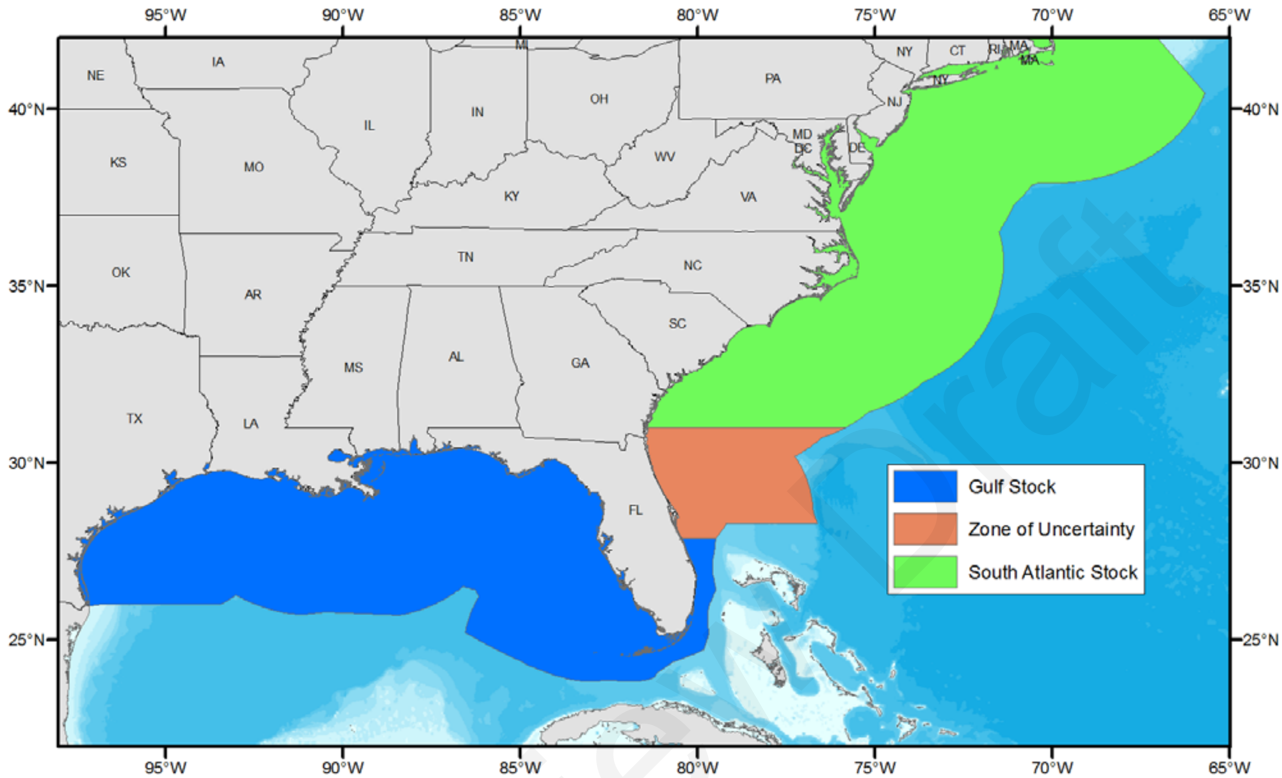


Figure 26. Proposal for new zone of uncertainty, between the Glynn/Camden GA county line and the Brevard/Indian River FL county line. While spatial data are consistent with a southern extent of the Atlantic Cobia stock occurring north of the Brevard/Volusia FL county line, inclusion of all of Brevard County in the zone of uncertainty reflects evidence for the presence of multiple Atlantic subgroups of fish in central FL, as well as fish from the Gulf of Mexico biological stock.

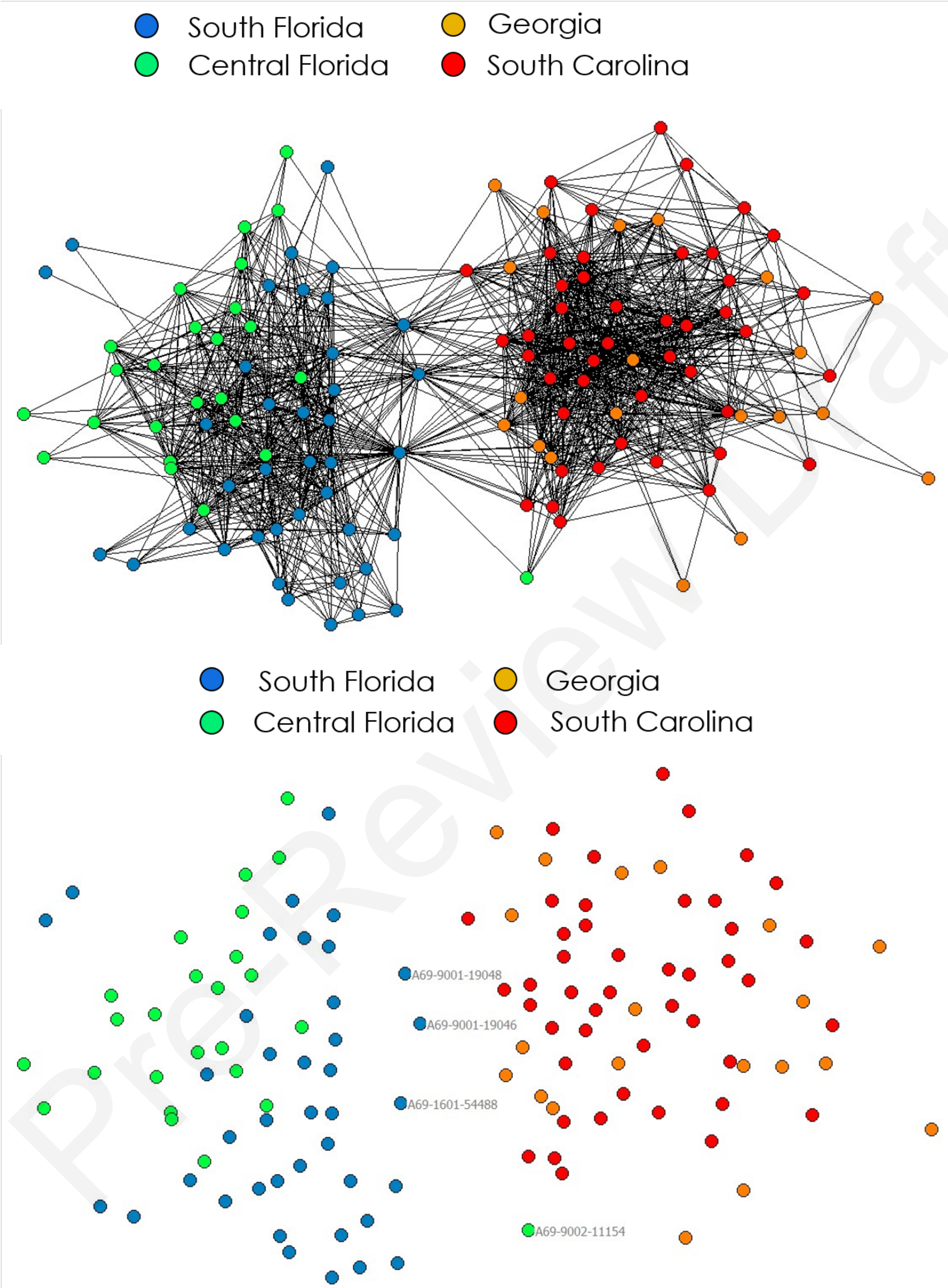


Figure 27. One-mode network analysis plots of detections of Cobia tagged in South Carolina, Georgia, and Florida, with (upper panel) and without (lower panel) connective lines. Based on data from Young et al. (2018).

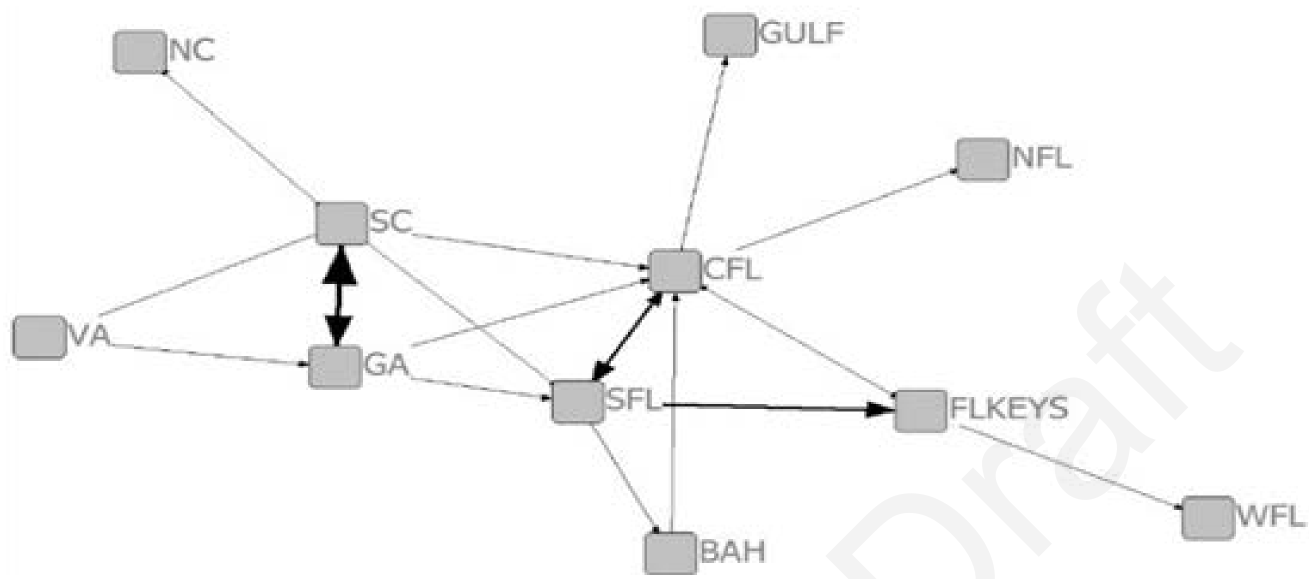


Figure 28. One-mode network analysis of acoustic tagging data evaluating movement exchange of Cobia between regions. NC = North Carolina, GULF = Gulf of Mexico, NFL = north Florida, SC = South Carolina, CFL = central Florida, VA = Virginia, GA = Georgia, SFL = south Florida, FLKEYS = Florida Keys, BAH = Bahamas, WFL = west Florida. Based on data from Young et al. (2018).

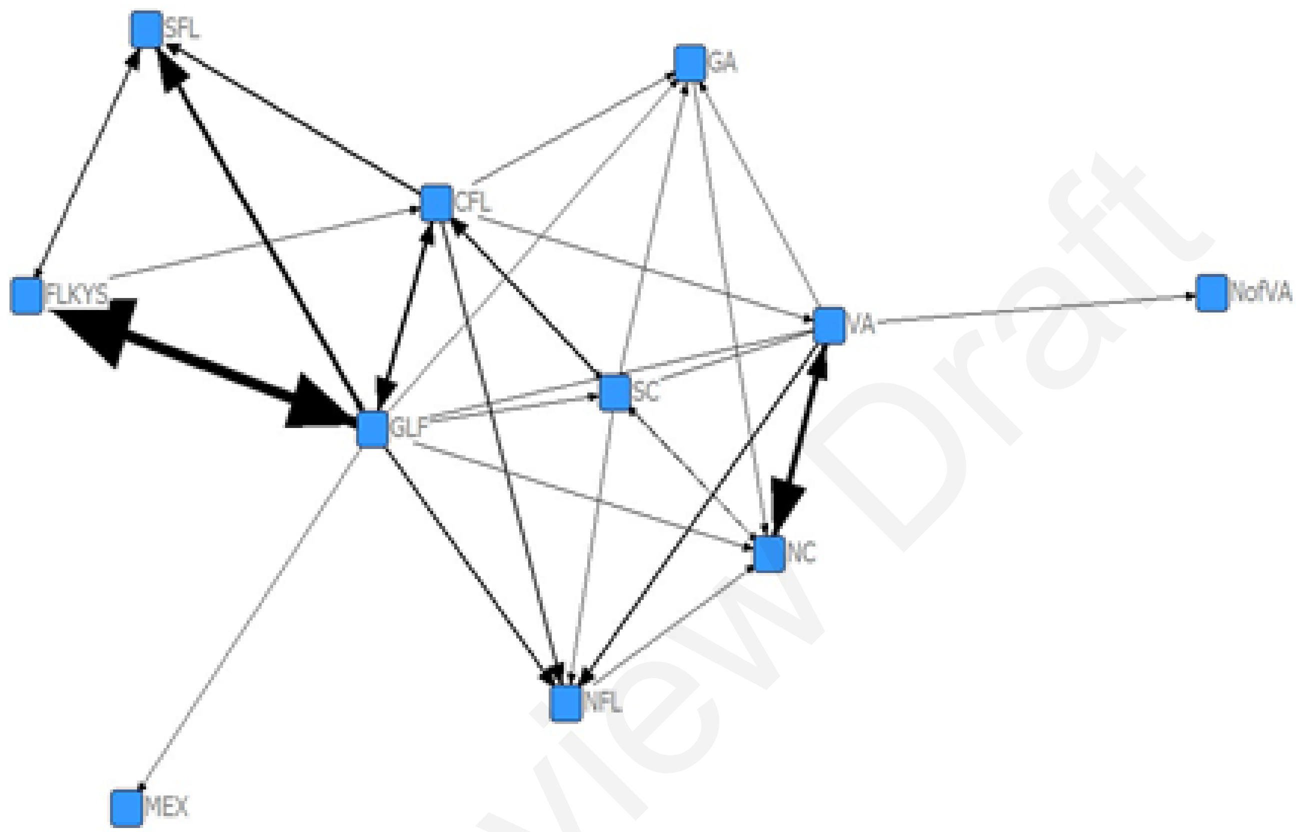


Figure 29. Visualizations of one mode matrix using conventional dart tag data, showing connectivity between regions. NofVA = north of Virginia, VA = Virginia, NC = North Carolina, SC = South Carolina, GA = Georgia, NFL = north Florida, CFL = central Florida, SFL = south Florida, FLKYS = Florida Keys, GLF = Gulf of Mexico, MEX = Mexico. Based on data from from Perkinson et al. (2018b).

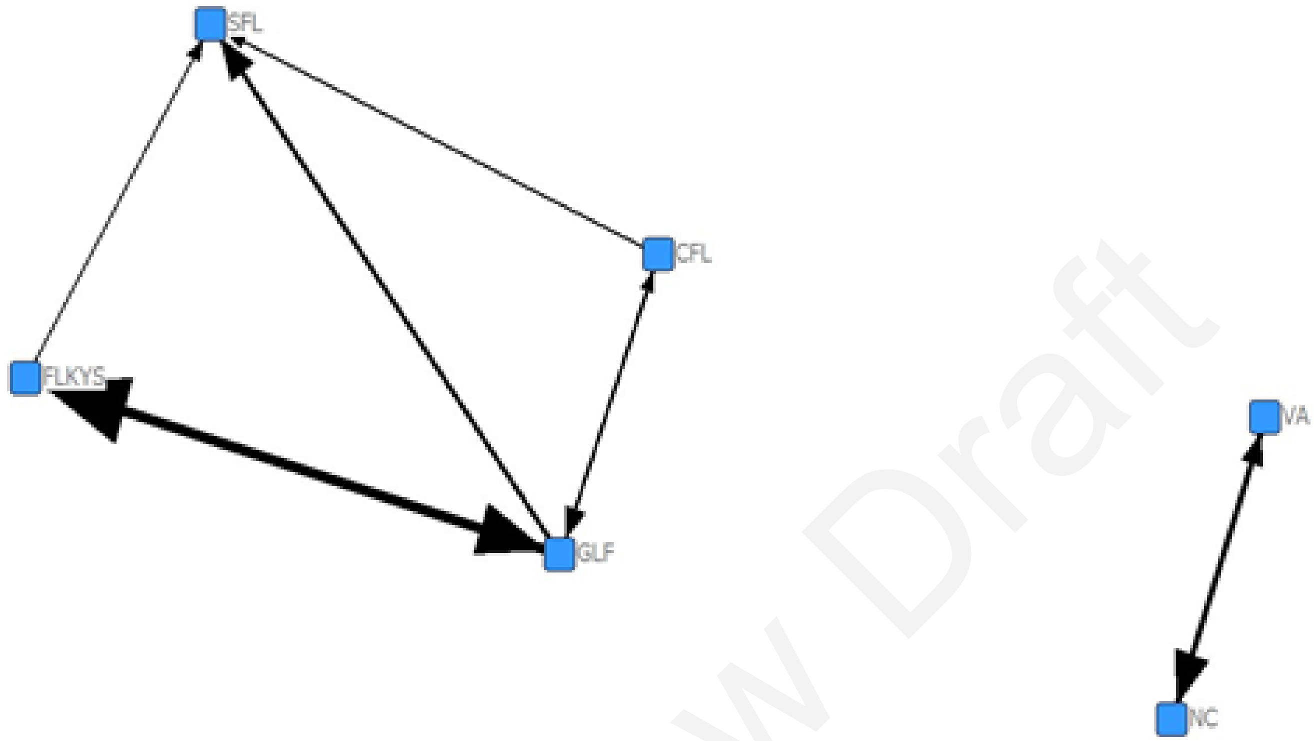


Figure 30. Visualization of one mode matrix showing the most common movements between regions, based on conventional dart tag data. The analysis looks for natural breaks in the data to exclude rare movements, thus presenting the most common movements, which in this case is the top 89% of tagged Cobia. Therefore, this figure shows connectivity between regions for the "stayer individuals", excluding the "strayers" that make longer distance movements. VA = Virginia, NC = North Carolina, CFL = central Florida, SFL = south Florida, FLKYS = Florida Keys, GLF = Gulf of Mexico. Based on data from from Perkinson et al. (2018b).

Appendix

Table A1. Cobia movements between regions based on conventional tagging. Left column shows region where fish was tagged, top row shows region where fish were recaptured.

	CFL	FLKYS	GA	GLF	NC	NFL	SC	SFL	VA	NofVA	MEX
CFL	33	5	2	20	4	10	1	9	6	0	0
FLKYS	2	104	0	66	0	0	0	8	0	0	0
GA	0	0	0	0	2	0	0	0	0	0	0
GLF	15	90	1	820	1	9	2	29	0	0	2
NC	0	0	0	0	1	0	1	0	19	0	0
NFL	0	0	0	0	1	0	0	0	0	0	0
SC	7	0	1	1	1	4	112	0	0	0	0
SFL	0	2	0	2	0	0	0	3	0	0	0
VA	1	0	1	3	42	7	2	0	293	2	0
NofVA	0	0	0	0	0	0	0	0	0	0	0
MEX	0	0	0	0	0	0	0	0	0	0	0

Reported Pounds of Cobia in January 2012-2017

Reported Pounds of Cobia in February 2012-2017

Reported Pounds of Cobia in March 2012-2017

Reported Pounds of Cobia in April 2012-2017

Reported Pounds of Cobia in May 2012-2017

Reported Pounds of Cobia in June 2012-2017

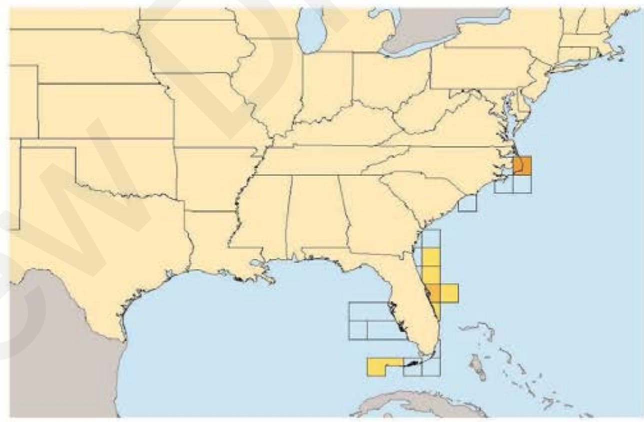
Figure A1. Spatial distribution of commercial catch 2012-2017 by Month: January through June.

Reported Pounds of Cobia in July 2012-2017

Reported Pounds of Cobia in August 2012-2017

Reported Pounds of Cobia in September 2012-2017

Reported Pounds of Cobia in October 2012-2017



Reported Pounds of Cobia in November 2012-2017

Reported Pounds of Cobia in December 2012-2017

Figure A2. Spatial distribution of commercial catch 2012-2017 by Month: July through December.

2.2 ToR #2: *Make recommendations on biological stock structure and the assessment unit stock or stocks to be addressed through SEDAR 58 and document the rationale behind the recommendations.*

Biological Stocks

The SEDAR 58 Cobia Stock ID Workshop Panel (hereafter, Panel) recommended that Cobia be considered two distinct biological stocks at the regional scale: the Gulf of Mexico stock (south of Brevard/Indian River FL county line) and the Atlantic stock (from north of Glynn/Camden county GA line).

Genetics data, suggested two distinct spawning stocks at the regional scale: the Gulf of Mexico (extending up to Fort Pierce, FL) and the Atlantic (VA to Port Royal Sound, SC). Genetics data suggested a spawning stock transition zone within the range from Savannah, GA through Brevard County, FL (Brevard/Indian River county line; see Section 2.1.1 Genetics for further details). Spatial tagging data also suggested the existence of two distinct biological stocks at the regional scale: the Gulf of Mexico stock (south of Brevard County, FL) and the Atlantic stock (from north of Brunswick, GA). Consistent with the conclusions of the Genetics Working Group, spatial tagging data suggested a transition zone between Brevard County, FL and Brunswick, GA (see Section 2.1.3 Spatial Distribution / Movement for further details). Life history data were generally insufficient to provide information on stock structure of Cobia. Weight-length relationships did not show any differences throughout the entire range. There was limited evidence of a growth difference between the Gulf of Mexico (TX to west FL, including the Florida Keys) and the Atlantic (Miami-Dade counties, FL north through VA). The distribution of samples was very limited along the east coast of FL and GA, hampering analyses of potential growth differences between the Gulf of Mexico and Atlantic which might aid in identifying a specific boundary within the transition zone (see Section 2.1.2 Life History / Biology for further details).

Overall, the available data suggested the existence of two biological stocks at the regional scale, with stock separation occurring within a transition zone, ranging from the southern boundary of Brevard County, FL to Brunswick, GA (a range of ≈370km). More precise location of this separation was partly limited by the available data. Additional spatial resolution, abundance, and distribution of data may allow for further refinement of the transition zone, especially from the northern boundary of Brevard County, FL (i.e. the Brevard/Volusia County line) to the Glynn/Camden County, GA line.

At the sub-regional scale, both genetics and spatial data suggested evidence of biological stock structure within the Atlantic. Sub-regional structure was not investigated in the Gulf of Mexico. The Panel concluded that both SC and NC/VA inshore areas (within estuaries and barrier islands) were each distinct biological stocks. However, genetics and spatial tagging data were inconsistent with the conclusion that the NC/SC offshore area is a distinct biological stock (see Section 2.1.1 Genetics and Section 2.1.3 Spatial Distribution / Movement for further details).

Assessment Unit Stocks

The Panel recommended that Cobia be considered two assessment unit stocks: the Gulf of Mexico stock and the Atlantic stock. Data support a separation within a transition zone between Brevard County, FL to Glynn/Camden County, GA. However, the data did not identify a specific boundary within this transition zone separating the two biological stocks. The current management boundary at the FL/GA line lies within the transition zone, thus Panel recommends the use of the FL/GA line as a boundary between the Gulf of Mexico and the Atlantic assessment unit stocks. Though evidence exists for biological stock structure at the sub-regional scale in the Atlantic, the Panel found that the specific definitions of biological stock structure at this scale were still developing and not defined well enough to adequately define assessment stock units (see Section 2.3 ToR #3).

2.3 ToR #3: *Discuss the strength of evidence in support of stock ID recommendations with particular attention on those that result in a mismatch of biological stock structure, assessment unit stock recommendations, and existing management unit boundaries.*

There is strong evidence, from both tagging and genetics data, for separate Gulf of Mexico and Atlantic biological stocks, and for the existence of a transition zone separating these two biological stocks. However, existing data could not identify a specific boundary between these two biological stocks within the transition zone. The current management boundary at the FL/GA line falls within the defined transition zone (≈30km south of the northern edge of the transition zone at Brunswick, GA). This recommendation generally supports the existing management boundary and the assessment unit stock defined by SEDAR 28 (FL/GA). As noted below under ToR #4 "the recommended biological stock structure, assessment stock unit, and existing management units are in agreement regarding the Gulf of Mexico and Atlantic stocks".

At the sub-regional scale, data suggest the existence of multiple biological stocks within the Atlantic. While the Panel found data suggesting sub-regional structuring to be strong, it found that the specific definitions of biological stock structure at this scale were still developing and not defined well enough to adequately define assessment stock units. For example, the spatial boundaries of an assessment stock unit need to be defined precisely enough that assessment data inputs can be filtered accordingly. While spatial boundaries were well defined at the regional scale, they were not well defined at the sub-regional scale.

On a practical note, thorough consideration of stock separation at the current Cobia management boundary at the FL/GA line consumed much of the first two days of the two and a half day Cobia

Stock ID Workshop. Thus, even if definitions of biological stock structure at the sub-regional scale in the Atlantic were more completely developed, and the Panel considered recommending multiple sub-regional assessment stock units, the process of defining these stock units (i.e. determining the precise boundaries that separate them) would probably require additional time and resources.

The Panel did not evaluate sub-regional stock structure within the Gulf of Mexico. Additional work to examine sub-regional structure within the Gulf of Mexico is needed.

2.4 ToR #4: *If biological stock structure recommendations, assessment stock unit recommendations, and existing management units (state and federal) do not align, provide guidance to address the relative risks (biological and management) and consequences of managing based on existing Council or prior assessment boundaries.*

The recommended biological stock structure, assessment stock units, and existing management units are in agreement regarding the Gulf of Mexico and Atlantic stocks. While data considered at the Stock ID Workshop suggested the existence of multiple biological stocks at the sub-region scale within the Atlantic, the specific definitions of biological stock structure at this scale are still developing and not defined well enough to adequately define assessment stock units. Though the Panel did not review much of the data that will likely be considered for input into Cobia stock assessment models, it speculated that assessing sub-regional Atlantic stock units may be problematic, based on knowledge of data limitations from the previous assessment (SEDAR 28).

The existence of sub-regional biological stock structure, within the Atlantic, has potential implications if a single Atlantic stock unit is assessed. Sub-regional biological stocks may exhibit distinct population dynamics, which would not be captured by a regional scale assessment model. Additionally, if localized depletion of a sub-regional stock was to occur, it may not be reflected in a regional scale assessment model.

The Panel felt that potential management risks were difficult to assess at this time given the changing management structure of Cobia in the region.

2.5 ToR #5: *Provide recommendations for future research on stock structure.*

2.5.1 Genetics

Research recommendations included the following:

- Collect and analyze more samples from Jacksonville, Florida through Brunswick, Georgia along the Atlantic coast.

- Evaluate potential substructure within the Gulf of Mexico stock, including potential population substructure in Tampa Bay, along the Florida panhandle, and in the existing sample distribution gap off of Louisiana.
- Additional life history studies to document spawning locations outside of coastal South Carolina.
- Examine inshore versus offshore genetic structure in other states that harbor year-round inshore populations.
- Samples should be distributed temporally throughout the spawning season, which can vary by location. Samples obtained outside of the spawning season may not reflect the genetic stock being sampled, given observed movement of some individuals from spawning grounds.

2.5.2 Life History / Biology

1. More, randomly-collected age samples throughout the range of Cobia are needed.

   Cobia are exploited primarily by the charter boat fleet and private recreational fishery. Randomly collected biological samples of Cobia from the recreational fishery will provide essential data inputs to stock assessments. Only 130 new age data points spanning 18 years from the GOM have been made available since SEDAR 28. The majority of all age samples were collected from South Carolina and Virginia. Most of those samples were from carcass collection programs from the recreational fishery, which may not be able to be used to characterize the fishery landings due to the non-random sample collection method.

2. Reproductive biological information throughout the range of Cobia are needed. No reproductive data exists for the east coast of Florida and the Florida Keys. More specific information on the locations of spawning is needed, and in particular from both estuarine and offshore waters. Estimates of fecundity need to be made throughout the range of Cobia.

   Since SEDAR 28, no significant additional reproductive sampling has been conducted. The majority of the data used in that assessment was published in 2001 and 2002 with some newer data from South Carolina. In SEDAR 28, it was noted that few fish were sampled at small sizes (ages 0-2) before they enter the fishery at age 3 and that even the 3 year olds may have been the largest 3 year olds due to the size regulations. Relying on fishery dependent sampling, where the recreational minimum size limit is 33 inches FL in the Gulf of Mexico and increasing to 36 inches FL in the south Atlantic, results in only sampling fish likely to be mature. Additional sampling, particularly at smaller sizes and younger ages, would help to better define the steepness of the maturity curve and the proportion mature at age. Fish in this size range have traditionally been difficult to locate and sample so having information on fish at these sizes would also help to delineate habitat requirements for juvenile fish.

It was also noted in the stock ID workshop that none of the samples collected for Brown-Peterson et al. (2001) were from the southeastern portion of Florida or the Florida Keys (Figure 13) and sampling was likely minimal from the east coast of Florida in general. This data gap is important to fill, particularly given the acoustic tagging data that suggests the possibility of a resident Florida group and not having clear information on from where these east coast Florida fish recruit (e.g. are they migrants from other areas or is there reproduction occurring in this area?).

3. Information on larval dispersion is needed to elucidate stock structure of Cobia.

   While larval data was submitted late to the workshop (see SEDAR 58 Working Paper S58-SID09), most of the larval data collected at this point comes from the Gulf of Mexico with less effort conducted in the Atlantic. While Cobia larvae were present in many of the Gulf of Mexico samples, very few positive Cobia larvae tows were observed in the South Atlantic. Previous work in South Carolina (Lefebvre and Denson 2012) and Chesapeake Bay (Joseph et al. 1964) suggest that Cobia on the east coast use some estuaries for spawning, although there is likely an offshore spawning contingent also. More information on larval presence/absence, particularly from the east coast of the United States, could help to better define where fish are spawning and suggest other unique spawning sub-groups. A better understanding of spawning locations may also allow for predictions on how and where larvae are dispersed, providing support for the observed genetic differences, and possibly helping to define the stock boundary area.

4. A fishery-independent survey is needed to monitor Cobia and obtain biological information on Cobia below the minimum size limits imposed on the fishery.

5. Ecosystem studies are needed for Cobia with regards to prey availability and energetics to better understand growth differences of the species throughout its range.

2.5.3 Spatial Distribution / Movement

Priorities

- Refine understanding of ATL-GOM boundary and zone of uncertainty by installing acoustic arrays between Canaveral FL and Brunswick GA, plus more tagging in this region.
- Try to detect overwintering fish by extending acoustic arrays to shelf break

- Determine spawning grounds by sampling for ripe adults / ichthyoplankton
- The Spatial Working Group felt that it was important to undertake another stock ID process in approximately three years, and before the next assessment, to incorporate data that is anticipated in the next few years (there are many acoustically-tagged cobia presently at large).

Telemetry

Stock boundary and zone of uncertainty

- Improve spatial resolution near the existing stock boundary (GA-FL line) by adding additional acoustic arrays between Canaveral FL and Brunswick GA.
- Tag additional fish in the same area and extend tagging to Savannah GA using acoustic, conventional, and PSAT tags, with distribution of tagging effort across seasons.

Onshore-offshore movement and overwintering

- Extend existing acoustic receiver arrays to the shelf break and add additional receiver arrays between Canaveral FL and Brunswick GA. In some cases this will mean that acoustic receivers cannot be deployed and recovered by divers, but there may be buoys that can be attached to. In addition, acoustic releases can be used to deploy and recover receivers in deep water, depending on presence of bottom-trawl fisheries or other hazards.
- PSAT tagging of fish from FL to VA, and northern GOM, to understand over-wintering habitat, which can provide locations where there are no receivers and no fishing effort.
- Since there is presently decreased fishing effort in the putative over-wintering areas (e.g., offshore), increased sampling in these areas could be useful.

Existing detection network

- It is very important that the existing acoustic network remains in place and functional, which will require ongoing funding and effort (e.g., Chesapeake Bay, Pensacola Bay, offshore areas of NC). Some of the existing receiver arrays may be in projects that are closing down, so there is some risk that portions of the tracking network will be removed in the near future (e.g., Navy array at Chesapeake Bay mouth).

Conventional tagging

- More conventional tagging data is needed in data poor areas of Georgia and North Florida, along with the Cape Canaveral area, where little recent tagging data is available. In areas where cobia are available for much of the year, programs should focus on tagging over multiple seasons to ensure that any differing movement behaviors are represented.
- Cooperative tagging programs exist in VA and NC and in GOM; increase cooperative tagging in SC, and begin tagging in GA and the FL east coast.

- Ideally, auxiliary experiments to estimate tag shedding (e.g. double tagging) and tag reporting (e.g. high and low reward tags) are done as part of new or ongoing conventional tagging studies. This auxiliary information allows for estimation of fishing and natural mortality rates from the conventional tag returns.

Other topics

- Analyze existing PSAT data to get environmental preferences, particularly for overwintering individuals.
- Use oceanographic databases to determine temperature for time-location detections of cobia in acoustic dataset, and fishery presence-absence survey data.
- Look for existing plankton survey data. Determine if new ichthyoplankton research is planned or possible.
- Establish/continue collection programs to help identify spawning locations in all regions. This would include collecting gonads, otoliths, and genetics. NC and SC are collecting from dock sampling programs (genetics) and carcass collection programs (gonads). Similar programs in other regions would yield useful data.

2.5.4 Overall

In addition to the research recommendations above, the Panel recommends that Cobia stock ID should be re-evaluated in three to five years.

2.6 ToR #6: *Prepare a report providing complete documentation of workshop recommendations and decisions.*

The SEDAR 58 Cobia Stock ID Workshop's discussions and recommendations are documented through this report.

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