Recommendations from the SEDAR 50 (Blueline Tilefish) Stock ID Work Group Meeting

SEDAR 50 Stock ID Work Group

SEDAR50-DW12

Submitted: 15 August 2016

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1. Introduction

1.1 Workshop Time and Place

The SEDAR 50 (Atlantic Blueline Tilefish) Stock ID Work Group meeting was held June 28-30, 2016 in Raleigh, NC.

1.2 Terms of Reference

1. Review stock structure and unit stock definitions and consider whether changes are required.

NOTE: Information and recommendations to address this TOR will be developed prior to the Data Workshop by a Stock ID work group. The recommendations of the workgroup will be reviewed by the data workshop panel. The work group, including representatives from the SAFMC and MAFMC, and the Southeast and Greater Atlantic Regions, is charged with addressing the following:

a. *Review genetics studies, growth patterns, existing stock definitions, prior SEDAR stock ID recommendations and any other relevant information on Blueline Tilefish stock structure.*
b. *Make recommendations on biological stock structure and define the unit stock or stocks to be addressed through this assessment.*
c. *Provide recommendations to address Council management jurisdictions, to support management of the stock or stocks, and specification of management benchmarks and fishing levels, by Council jurisdiction (SAFMC/MAFMC) in a manner consistent with the productivity measures of the assessment.*
d. *Document work group discussion and recommendations through a working paper for SEDAR 50.*
e. *Work Group recommendations will be used to address Data Workshop Term of Reference 1: Review stock structure and unit stock definitions and consider whether changes are required.*

1.3 List of Participants

Work Group Members

Joey Ballenger, SCDNR
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John Carmichael, SAFMC/SEDAR
Julie O'Dell, SAFMC

In-Person Workshop Attendees
Kate Wilke, TNC

Webinar Attendees
Anna Beckwith, SAFMC
Michelle Duval, SAFMC
Rusty Hudson, SFA
Michael Schmidtke, ODU
Michael Freeman, FL fisherman

*Work group members who participated in the meeting via webinar.
**Work group members who did not attend the in-person workshop, but were available for questions/input via email or phone.

1.4 Document List

Documents available for the SEDAR 50 Stock ID Work Group meeting.

Document #	Title	Authors
Documents Prepared for the Data Workshop (DW)		
SEDAR50-DW01	Brief Summary – Habitat and Developing Spatial Species Information for Blueline Tilefish in the South Atlantic Region	Pugliese 2016
SEDAR50-DW02	Summary of the 2015 Blueline Tilefish cooperative-with-industry data collection project	Kellison 2016
SEDAR50-DW03	A Preliminary Assessment of Reproductive Parameters for Blueline Tilefish in Atlantic Waters from Virginia to Florida	Kolmos et al. 2016

SEDAR50-DW04	Distribution of scientifically collected Blueline Tilefish (*Caulolatilus microps*) in the Atlantic, and associated habitat	Klibansky 2016
SEDAR50-DW05	Summary of the results of a genetic-based investigation of Blueline Tilefish (*Caulolatilus microps*)	McDowell 2016
SEDAR50-DW06	Preliminary Genetic Population Structure of Blueline Tilefish *Caulolatilus microps* along the East Coast of the United States	O'Donnell and Darden 2016
SEDAR50-DW07	Description of age and growth for Blueline Tilefish, *Caulolatilus microps*, caught north and south of Cape Hatteras, NC	Schmidtke and Jones 2016
SEDAR50-DW08	Standard Operative Procedure for Embedding and Sectioning Blueline Tilefish (*Caulolatilus microps*)	Ostrowski 2016
SEDAR50-DW09	Summary of Northeast Fisheries Science Center Blueline Tilefish Survey Data	Nitschke and Miller 2016
SEDAR50-DW10	Summary of Mid-Atlantic Commercial Blueline Tilefish Data	Nitschke and Miller 2016
SEDAR50-DW11	Distribution of Blueline Tilefish (*Caulolatilus microps*) in the U.S. EEZ from fishery-dependent and fishery-independent data collections	Farmer and Klibansky 2016
Reference Documents		
SEDAR50-RD01	SEDAR 32 South Atlantic Blueline Tilefish Stock Assessment Report	SEDAR 32
SEDAR50-RD02	List of documents and working papers for SEDAR 32 (South Atlantic Blueline Tilefish and Gray Triggerfish) – all documents available on the SEDAR website.	SEDAR 32
SEDAR50-RD03	Managing A Marine Stock Portfolio: Stock Identification, Structure, and Management of 25 Fishery Species along the Atlantic Coast of the United States	McBride 2014
SEDAR50-RD04	Workshop to Determine Optimal Approaches for Surveying the Deep-Water Species Complex Off the Southeastern U.S. Atlantic Coast	Carmichael et al. 2015
SEDAR50-RD05	Report to Virginia Marine Resources Commission: Grant F-132-R-2 The Population Dynamics of Blueline and Golden Tilefish, Snowy and Warsaw Grouper and Wreckfish	Schmidtke et al. 2015

SEDAR50-RD06	Estimated Catch of Blueline Tilefish in the Mid-Atlantic Region: Application of the Delphi Survey Process	Allen et al. 2016
SEDAR50-RD07	MAFMC Memo: Blueline Tilefish Catch Series	Didden 2015
SEDAR50-RD08	Reproductive Biology of the Blueline Tilefish, *Caulolatilus microps*, off North Carolina and South Carolina	Ross and Merriner 1983
SEDAR50-RD09	Fish species associated with shipwreck and natural hard-bottom habitats from the middle to outer continental shelf of the Middle Atlantic Bight near Norfolk Canyon	Ross et al. 2016
SEDAR50-RD10	Systematics and Biology of the Tilefishes (Perciformes: Branchiostegidae and Malacanthidae), with Descriptions of Two New Species	Dooley 1978
SEDAR50-RD11	Integrating DNA barcoding of fish eggs into ichthyoplankton monitoring programs	Lewis et al. 2015
SEDAR50-RD12	Age, growth, and reproductive biology of Blueline Tilefish along the southeastern coast of the United States, 1982-1999	Harris et al. 2004
SEDAR50-RD13	Description of the Circulation on the Continental Shelf	Bumpus 1973
SEDAR50-RD14	Spawning Locations for Atlantic Reef Fishes off the Southeastern U.S.	Sedberry et al. 2006
SEDAR50-RD15	Observations and a Model of the Mean Circulation over the Middle Atlantic Bight Continental Shelf	Lentz 2008
SEDAR50-RD16	Modeling larval connectivity of the Atlantic surfclams within the Middle Atlantic Bight: Model development, larval dispersal and metapopulation connectivity	Zhang et al. 2015
SEDAR50-RD17	Tilefishes of the Genus *Caulolatilus* Construct Burrows in the Sea Floor	Able et al. 1987
SEDAR50-RD18	Delineation of Tilefish, *Lopholatilus chamaeleonticeps*, Stocks Along the United States East Coast and in the Gulf of Mexico	Katz et al. 1983
SEDAR50-RD19	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

SEDAR50-RD20	Overview of sampling gears and standard protocols used by the Southeast Reef Fish Survey and its partners	Smart et al. 2015
SEDAR50-RD21	Age, Growth, and Mortality of Blueline Tilefish from North Carolina and South Carolina	Ross and Huntsman 1982
SEDAR50-RD22	Radiocarbon from nuclear testing applied to age validation of black drum, *Pogonias cromis*	Campana and Jones 1998
SEDAR50-RD23	A long- lived life history for a tropical, deepwater snapper (*Pristipomoides filamentosus*): bomb radiocarbon and lead-radium dating as extensions of daily increment analyses in otoliths	Andrews et al. 2012
SEDAR50-RD24	Age and growth of bluespine unicornfish (*Naso unicornis*): a half-century life-span for a keystone browser, with a novel approach to bomb radiocarbon dating in the Hawaiian Islands	Andrews et al. 2016
SEDAR50-RD25	Age, growth and reproduction of the barrelfish *Hyperoglyphe perciformis* (Mitchill) in the western North Atlantic	Filer and Sedberry 2008
SEDAR50-RD26	Age, growth, and spawning season of red bream (*Beryx decadactylus*) off the southeastern United States	Friess and Sedberry 2011
SEDAR50-RD27	Great longevity of speckled hind (*Epinephelus drummondhayi*), a deep-water grouper, with novel use of postbomb radiocarbon dating in the Gulf of Mexico	Andrews et al. 2013
SEDAR50-RD28	Refined bomb radiocarbon dating of two iconic fishes of the Great Barrier Reef	Andrews et al. 2015
SEDAR50-RD29	Age validation of the North Atlantic stock of wreckfish (*Polyprion americanus*), based on bomb radiocarbon (^{14}C), and new estimates of life history parameters	Lytton et al. 2016
SEDAR50-RD30	Stock Complexes for Fisheries Management in the Gulf of Mexico	Farmer et al. 2016

2. Workshop Findings

2.1 ToR #1a: *Review genetics studies, growth patterns, existing stock definitions, prior SEDAR stock ID recommendations and any other relevant information on Blueline Tilefish stock structure.*

To address ToR# 1a, the SEDAR 50 Stock ID Work Group divided into three breakout groups: genetics, life history, and spatial distribution. Each breakout group reviewed the information available within its topical area and presented the group's findings to the entire work group in plenary sessions.

2.1.1 Genetics

Workgroup Participants

Kevin Craig (Group Leader)
Jason Didden (Rapporteur)
Tanya Darden
Lisa Kerr
Jan McDowell
Tim O'Donnell
Fred Serchuk
Erik Williams

Data Review and Evaluation

The genetics breakout group reviewed the literature and available data sets relevant to the genetic population structure of Blueline Tilefish. Two studies have been conducted on the genetic structure of Blueline Tilefish, specifically the SCDNR (O'Donnell & Darden, SEDAR50-DW06) and VIMS (McDowell, SEDAR50-DW05) studies. The VIMS study was considered the more scientifically robust of the two studies because of the larger number of molecular markers specific to Blueline Tilefish, the broader geographic coverage of the samples, and the larger sample sizes. The only other genetic study available was from a closely related species, Golden Tilefish (Katz et al. 1983, SEDAR50-RD18); this study evaluated population structure using allozyme data and meristic and morphometric characters. The breakout group concluded that the Katz et al. study had limited relevance for the evaluation of Blueline Tilefish population structure because the study had limited sampling, used a dated methodology (two allozyme markers with two alleles each), the results were sometimes inconsistent between molecular and morphological markers, and it was based on a different species. In addition, sufficient genetic data were available for direct evaluation of Blueline Tilefish genetic population structure from the SCDNR and VIMS studies. Therefore, the breakout group only considered the latter two studies for review and evaluation (SEDAR50-DW05; SEDAR50-DW06).

The SCDNR study used four microsatellite markers originally developed for Red Snapper (*Lutjanus campechanus*) and Spotted Seatrout (*Cynoscion nebulosus*), which had 4 to 13 alleles per locus in Blueline Tilefish. A total of 259 samples were obtained and genotyped from locations ranging from Norfolk Canyon, off the coast of Virginia, south to the Atlantic coast of northern Florida (Figure 1). The microsatellite data were evaluated using a variety of analyses including comparisons of allele frequency distributions, pairwise comparisons of F_{ST} (a measure of genetic distance), and population assignment testing implemented in the computer program STRUCTURE. No genetic population structure was detected, indicating Blueline Tilefish comprise a single panmictic, or randomly mating, population along the U.S. Atlantic Coast.

The more comprehensive VIMS study used 23 microsatellite markers developed specifically for Blueline Tilefish, as well as a 407 base pair (bp) sequence segment of the mitochondrial DNA (mtDNA) control region. A total of 505 samples obtained from locations from Hudson Canyon, off the coast of New York, south to the Florida Keys—as well as 15 samples collected from the Gulf of Mexico (West Florida shelf)—were genotyped at all microsatellite loci (Figure 2). All 23 microsatellite loci were polymorphic, with a range of 6 to 21 alleles per locus. Population pairwise F_{ST} values were small; the largest value was 0.003 between the Western Florida sample and the North Carolina sample taken north of Cape Hatteras, and most pairwise values were 0. No pairwise F_{ST} comparisons were significant based on 10,000 permutations of the data (Table 2 in SEDAR50-DW05), indicating a lack of genetic structure among geographic collections. Likewise, an analysis of molecular variance (AMOVA) using multiple alternate groupings of geographic sample locations showed no significant genetic variance due to variation among any of the tested scenarios, consistent with a lack of genetic population structure. There was no indication of isolation by distance based on a Mantel test. In summary, thorough analysis of the microsatellite data showed no evidence of multiple genetic populations of Blueline Tilefish. The data were consistent with a single panmictic population with high levels of gene flow throughout the sampled range (i.e., consistent with the SCDNR study).

The results of the mtDNA analysis were concordant with the results based on the microsatellite data. Analysis of 188 mtDNA control region sequences sampled from across the range of Blueline Tilefish resulted in 72 haplotypes with 59 variable sites. The most common haplotype, haplotype 9, was recovered 39 times (20.7% of sequences) and was recovered in all locations with the exception of the Western Florida sample, which had a very small sample size (Table 3 in SEDAR50-DW05). Haplotype diversity was high both across all samples (0.94) and within samples from all geographic regions, ranging from 0.89 in North Carolina north of Cape Hatteras to 1.0 (every haplotype was unique) in Delaware. Nucleotide diversity was low across all samples (0.008) and within samples from each geographic location, ranging from 0.006 in samples from North Carolina north of Cape Hatteras to 0.010 in samples from South Carolina, indicating a very low level of divergence among haplotypes (Table 4 in SEDAR50-DW05). There were no significant differences among sample locations based on population pairwise Φ_{ST}

values (significance assessed based on 10,000 permutations of the data; Table 2 in SEDAR50-DW05). As with the analysis of the microsatellite data, an analysis of molecular variance (AMOVA) using multiple alternate groupings of the data showed no significant genetic variance due to variation among groups. The analyses based on the mtDNA data did not support sex-biased dispersal of Blueline Tilefish and were consistent with the results of the analysis of the microsatellite data, which indicated a single panmictic population.

The genetics breakout group had extensive discussions about the quality of the molecular markers and the experimental designs and analyses used in both studies relative to their ability to detect genetic population structure. The group agreed that the VIMS study represented the more robust data set in terms of markers, spatial coverage, and sample sizes, but the SCDNR study was important for the purpose of comparison because the samples were independent (different fish than those in the VIMS study) and different molecular markers were used. There was also consensus that the number of microsatellite loci and the high allelic richness of the VIMS suite of markers provided sufficient power to detect genetic population structure. The sampling design had particularly high power to discriminate potential broad-scale genetic differences north and south of Cape Hatteras, and was generally sufficient to detect finer-scale genetic structure, with sufficient sample sizes collected in waters off of most states where Blueline Tilefish occur (Figure 2). The Working Group acknowledged that the sample sizes from the Gulf of Mexico were limited (n=15 fish; but note n=60 nearby in the Florida Keys), but the lack of significant genetic differences in any of the pairwise comparisons among sample locations is consistent with a single genetic population from Hudson Canyon extending into the northeastern Gulf of Mexico. Both studies included samples from a small number of years (mostly 2015-2016) and included fish of multiple age groups (SCDNR 2011-2015; VIMS 2015-2016). The Work Group agreed that the temporal sampling and mixed age composition of samples from both studies were appropriate to evaluate contemporary patterns of gene flow and genetic population structure because the samples span a time period (2-5 years) less than the generation time for Blueline Tilefish; however, the sampling was not appropriate to evaluate potential temporal changes in gene flow patterns. Finally, the group agreed that the VIMS microsatellite marker suite has the power to discriminate population structure comparable to a typical SNP (single nucleotide polymorphisms) suite based on the number of markers and fish sample sizes. Appendices have been included with documents from both studies to provide all sample collection and supplemental data to permit additional analyses in the future (SEDAR50-DW05, SEDAR50-DW06).

Conclusions

The Work Group concluded that there is no scientific evidence of genetic heterogeneity within Blueline Tilefish across sampled locations, despite thorough genetic analysis. The data and analyses support a single, panmictic genetic population extending from the Hudson Canyon south to the Florida Keys with further indication of connectivity into the northeastern Gulf of

Mexico (based on smaller sample size of fish collected on the West Florida shelf). This conclusion is based on the consistency of results from two independent genetic studies (both markers and samples were independent) and two marker types (microsatellite and mitochondrial), with all results indicating a high level of gene flow across the sampled regions. The high level of allelic richness and genetic diversity throughout the sampling range in the VIMS study suggests a genetically healthy population with no indications of bottlenecks or founder effects (i.e. no evidence of an extreme reduction in population size or an isolated, small colonization event into a new geographic area). While the genetic data cannot determine whether a range expansion has occurred, if a recent northward range expansion is assumed, the data suggest that the leading population edge has remained genetically well connected with the parent geographic distribution.

The genetics breakout group identified several plausible mechanisms that could result in the observed genetic homogeneity in Blueline Tilefish along the U.S. Atlantic and Gulf coast, including oceanographic mechanisms that could transport larval products produced within both regions and through the Florida Straits over a protracted spawning period. Adult movement may also play a role in genetic exchange, although less is known about adult movement and the current assumption is that such movement is limited. A more complete understanding of interactions between the life history of Blueline Tilefish and oceanographic influences is needed to better develop a mechanistic model of gene flow processes for Blueline Tilefish.

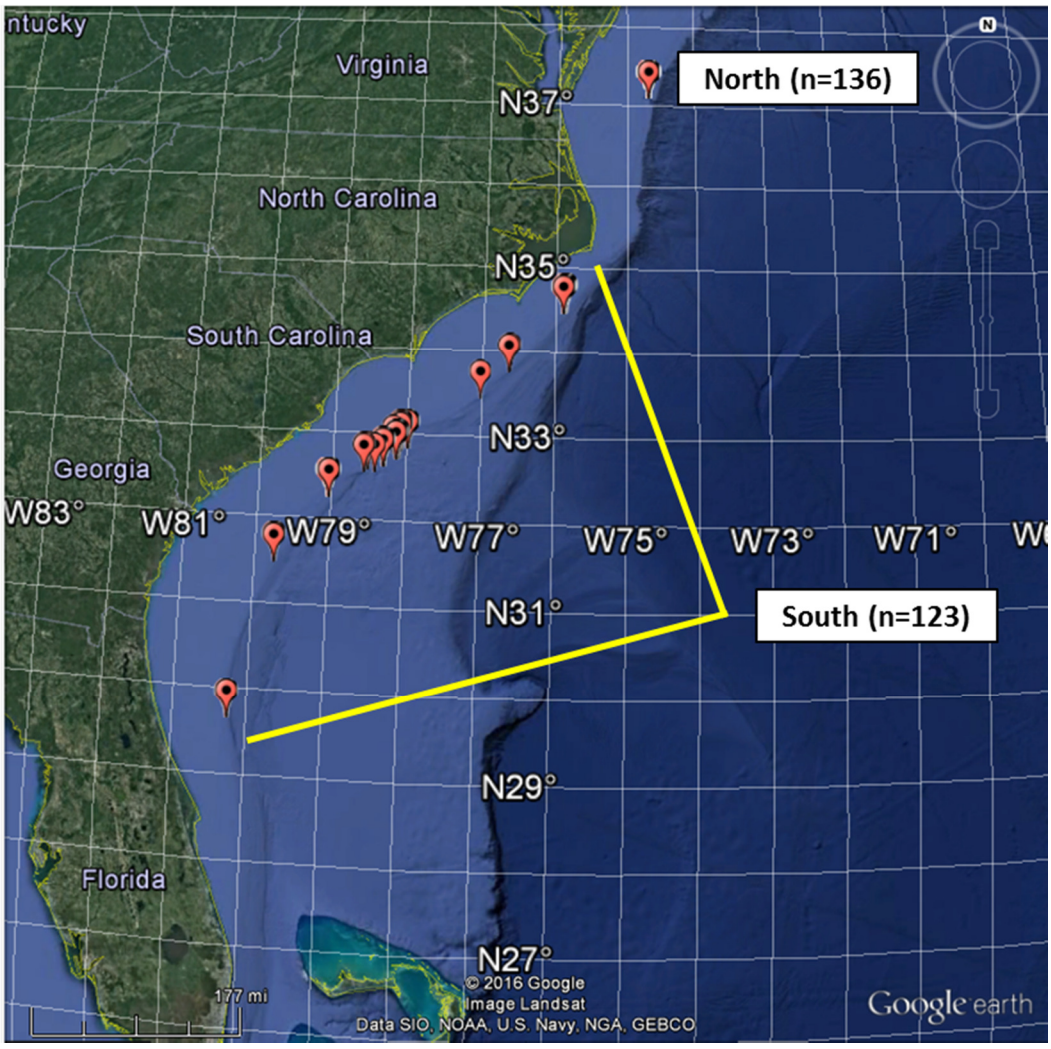

Figure 1. Sample collection locations for Blueline Tilefish used in SCDNR genetics study.

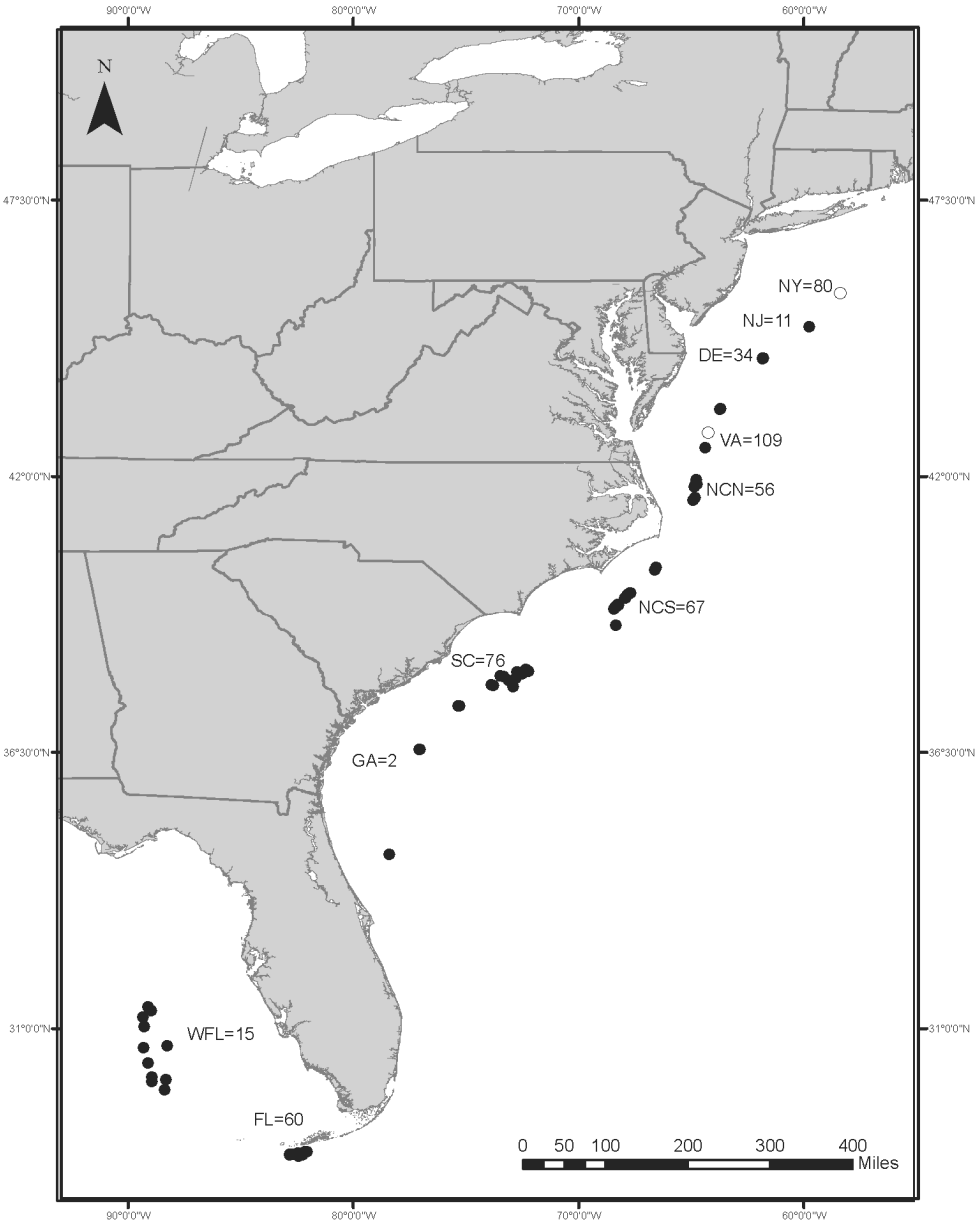

Figure 2. Sample collection locations for Blueline Tilefish used in the VIMS genetics study. Closed circles indicate a known lat/long fish capture location. Open circles indicate an approximate location or statistical area was reported by the sample collector. NY-New York, NJ-New Jersey, DE-Delaware, VA-Virginia, NCN-North Carolina North of Cape Hatteras, NCS-North Carolina South of Cape Hatteras, SC-South Carolina, GA-Georgia, FL-Florida Keys, WFL-Western Florida. Metadata can be found in SEDAR50-DW05 Appendix 1.

2.1.2 Life History

In-person participants:
Jennifer Potts (Group Leader)
Andy Ostrowski
David Wyanski
Myra Brouwer (Rapporteur)
Beverly Barnett – observer, SEFSC Panama City

Webinar participants:
Cynthia Jones
Michael Schmidtke
Tom Miller

The life history breakout group reviewed data on the biology of Blueline Tilefish. Little to no data exist to inform managers about larval duration, larval dispersal, juvenile habitat, or movement and migration of adult fish. Age data from samples collected from New Jersey south through the Florida Keys were available, but were reviewed with caution due to concerns about consistency in age readings between laboratories. Data were provided by Old Dominion University (ODU), the National Marine Fisheries Service – Beaufort Laboratory (NMFS), and the South Carolina Department of Natural Resources (SCDNR). Analyses of reproductive data were conducted by SCDNR using the same set of samples from SCDNR and ODU that were included in the age data set, with the addition of reproductive data from samples collected by NMFS in 2015. In the group's discussion of stock delineations, specific emphasis was devoted to information on size-at-age and reproductive biology.

Age and growth

Age data for Blueline Tilefish in the U.S. Atlantic came from three sources: South Atlantic fishery-dependent sources, South Atlantic fishery-independent sources, and Mid-Atlantic fishery-dependent sources primarily operating off Virginia. Because age data are important inputs to stock assessment models, age readings must be consistent among laboratories. After the exchanges of calibration sets of otolith sections processed and read by each of the three laboratories providing data, a pattern of monotonically increasing bias in age readings (i.e., bias increasing with age) was revealed (Figure 3). These inconsistencies in age readings were not discovered until a few weeks before the stock ID workshop and could not be easily resolved. The biologists involved in age readings felt the best option to address the issue was to hold an in-person age workshop. Because of the inconsistent age readings, no inferences regarding the growth of Blueline Tilefish across latitudinal gradients could be made. Thus, the age data at the current meeting could not be used to delineate possible stock structure.

Due to the difficulty of aging Blueline Tilefish otolith structures and the current aging inconsistencies, SCDNR conducted a validation study testing for levels of bomb radiocarbon in the cores of the otoliths. Forty paired samples were used so that one otolith could be retained for sectioning and reading, while the other otolith of the pair was destroyed to obtain the ΔC^{14} (i.e. radiocarbon) levels. Twenty of the samples were from a previous study conducted by SCDNR (Harris 2013, SEDAR36-RD07), and 20 were new samples. These data were considered useful to inform age readers on interpretation of the otolith structure, and this information will be used during the age workshop.

Reproduction

In preparation for the benchmark stock assessment, a reproductive biology dataset comprising samples from three sources was analyzed to discern evidence of spatial variation along the Atlantic Coast of the U.S. The specimens (n=2,386) were collected from New Jersey to the Florida Keys (largely from South Carolina, Virginia, and North Carolina) during fishery-independent and fishery-dependent sampling between 1979 and 2015. Sampling gear consisted of hook and line efforts, chevron traps, short bottom longlines, and long bottom longlines.

Most specimens were collected off South Carolina (n=1,456; 53%) during the Southeast Reef Fish Survey (SERFS), a joint fisheries-independent monitoring survey of Marine Resources Monitoring, Assessment, and Prediction Program (MARMAP), the South East Area Monitoring and Assessment Program-South Atlantic (SEAMAP-SA) (both housed at SCDNR's Marine Resources Research Institute), and the South East Fishery Independent Survey (SEFIS; a NMFS project operated by SEFSC, Beaufort, NC).

In 2015, a large fishery-dependent sampling effort was made by NMFS contributing 827 specimens with reproductive data (Kellison, SEDAR50-DW02). Sampling was conducted using standardized protocols by cooperating fishermen on industry vessels along the Atlantic Coast, from South Carolina through Virginia. Sampling information and biological samples (morphometrics, otoliths, fin clips, and gonad tissues) were collected by a trained NMFS-Southeast Fisheries Science Center fishery observer. To date, 80% of the histological sections from these specimens have been examined.

The third source of reproductive data was a study completed by ODU that included 272 samples captured in the Norfolk Canyon during 2009-2014 (Schmidtke et al. 2015, SEDAR50-RD05). These specimens came from both commercial and recreational fisheries, as well as from special charters aboard recreational vessels that were arranged by scientists from the Center for Quantitative Fisheries Ecology at ODU and the Virginia Marine Resources Commission.

Data from these three sources were combined and analyzed to evaluate sex ratios by area, spawning seasonality, female maturity at size, and female spawning fraction at size (Kolmos,

SEDAR50-DW03). Female maturity and spawning fraction at age by area could not be analyzed because of the aging discrepancies previously described above.

The reproductive data available at the workshop have some spatial and substantial temporal limitations, but analyses of the data were generally indicative of one population along the Atlantic Coast of the U.S. from the Florida Keys to Virginia. There was no evidence of noteworthy spatial differences in reproductive parameters (i.e., sex ratio, spawning fraction at age). A comparison of maturity ogives by area was not performed due to the limited number (n=4) of immature females in the dataset. The overall female:male sex ratio slightly favored females in all sampling areas except Georgia (see Table 1 in SEDAR50-DW03), which had the smallest sample size (n=15). Only in the South Carolina samples was the sex ratio statistically skewed towards more females (1.24:1; n=1,337; X^2 =14.87; P<0.001) but this was not considered to be biologically significant.

Studies conducted off the Carolinas (Ross and Merriner 2003, SEDAR50-RD08; Harris et al. 2004, SEDAR50-RD12) found that Blueline Tilefish are prolific spawners with an extended spawning season from February through October (Harris et al. 2004, SEDAR50-RD12). In the current dataset, spawning females with available location data (n=882) were mostly collected from South Carolina, Virginia, and North Carolina; however, spawning individuals were also collected from the Florida Keys through Virginia (see Table 4 in SEDAR50-DW03). The dataset shows that substantial spawning occurs north of Cape Hatteras, with no strong evidence for regional differences in the timing of spawning peaks and no evidence along the Atlantic Coast of site-specific spawning activity indicative of aggregations (Figure 4). Given that 83% of the 170 female specimens from Virginia have evidence of spawning, it is likely that spawning also happens north of VA. The two specimens reported as captured off New Jersey were also in spawning condition.

Spawning fraction measures the proportion of mature females spawning daily. For this preliminary analysis of reproductive data, the duration of the spawning indicators was not estimated and hence this proportionally reduced the fractions to a 24-hr period. These unadjusted results could still be used to examine trends with size (mm FL). The results of size-based analyses revealed a high spawning fraction overall, but no latitudinal variation in spawning fraction. The size-based results did not reveal an increasing trend, but rather a sustained high spawning fraction, usually in the range of 0.81-0.89 starting at 300 mm FL (see Table 10 and Figure 2 in SEDAR50-DW03).

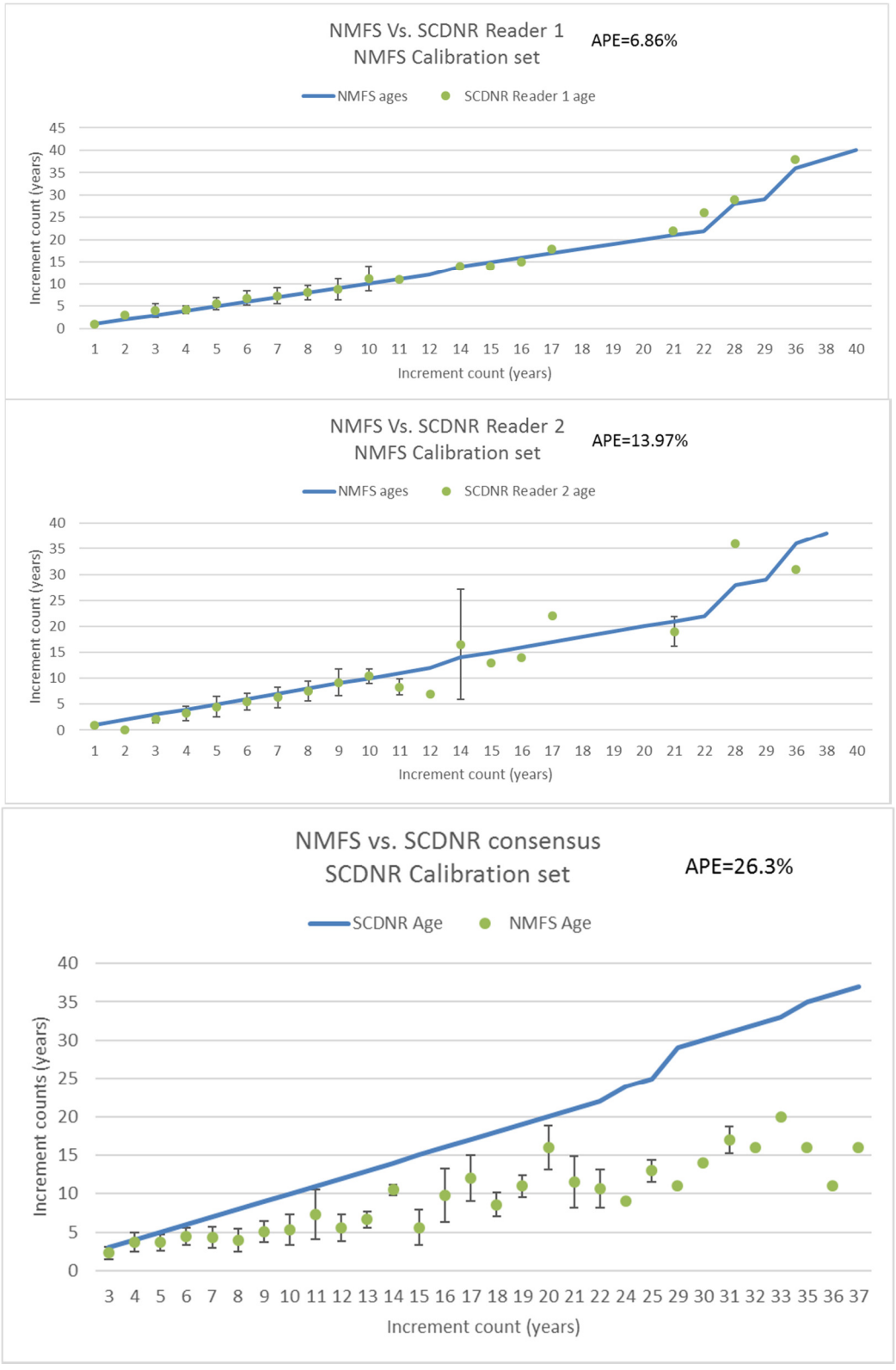

Figure 3. Comparison of age readings between laboratories, for sets of otoliths developed for calibrating age readings. APE = average percent error.

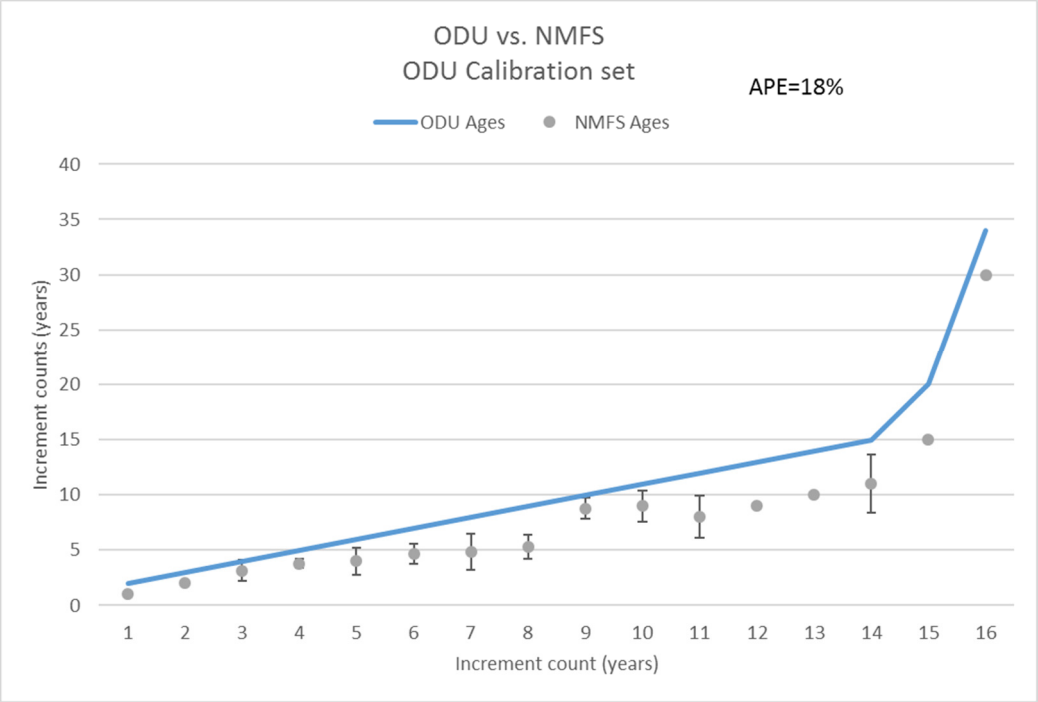

Figure 3 (cont). Comparison of age readings between laboratories, for sets of otoliths developed for calibrating age readings. APE = average percent error.

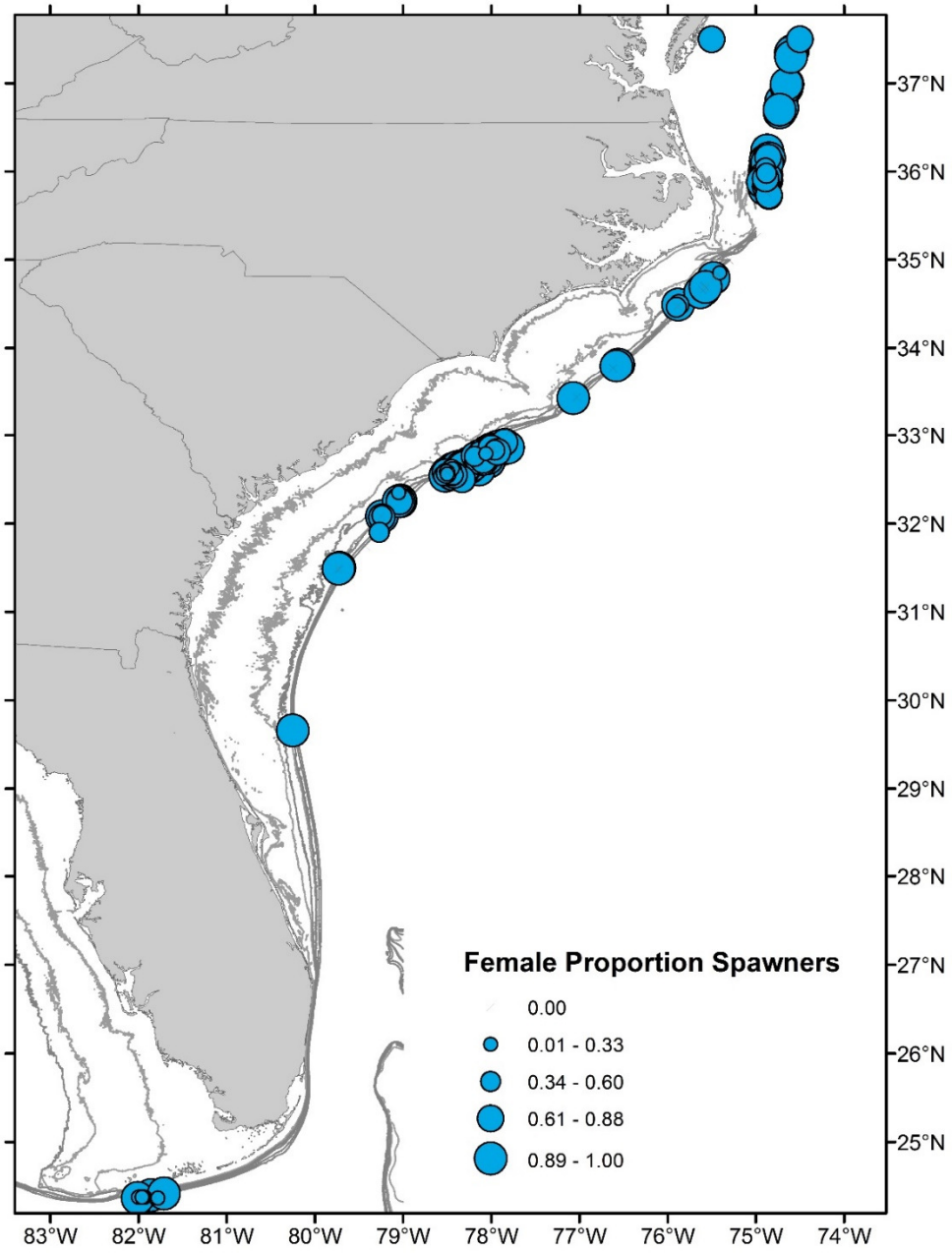

Figure 4. Proportion of female Blueline Tilefish spawners (n spawners / n adults) by sampling location (± 0.01 degrees Latitude). Data from all sources (SERFS, NMFS, and ODU) and months (Jan-Dec) were included in the analysis.

2.1.3 Spatial Distribution

Group Membership
Paul Nitschke, NEFSC (Group Leader)
Mike Errigo, SAFMC Staff
Joey Ballenger, SCDNR
John Boreman, MAFMC SSC
Nick Farmer, SERO
Nikolai Klibansky, SEFSC Beaufort
Doug Potts, GARFO
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Todd Kellison**, SEFSC Beaufort

The spatial distribution breakout group examined data on Blueline Tilefish spatial distributions from a variety of fishery-dependent and fishery-independent sources. The group also examined evidence of a possible increase in abundance of Blueline Tilefish in the Mid-Atlantic region. No single comprehensive survey or fishery-dependent data source exists that spans the entire Blueline Tilefish distribution range from the Gulf of Mexico to the South Atlantic and Mid-Atlantic Bight.

Spatial distribution information from fishery-dependent sources is likely influenced by changes in fishing effort, both temporally and spatially. In addition, fishery-dependent, self-reported logbook data are often imprecise as spatial location information is often generalized for an entire fishing trip. Effort changes also need to be considered to determine the true population distribution. Effort in fishery-independent sources are usually standardized over space and time, but the low catchability of Blueline Tilefish in the surveys limits their utility in determining population distribution and abundance. This is especially true with the low catchability of Blueline Tilefish in Northeast Fisheries Science Center (NEFSC) bottom trawl surveys (BTS), where only 46 total individuals have been caught in the spring, winter, and fall bottom trawl surveys during the entire time series (SEDAR50-DW09; Table 1).

Fishery-dependent observer data in the Mid-Atlantic, collected by the Northeast Fishery Observer Program (NEFOP), has mostly recorded Blueline Tilefish as bycatch in commercial trawl fisheries (SEDAR50-DW10). In general, trawl fishery effort is higher in the northern portion of the Mid-Atlantic and off southern New England near the northern limits of the population distribution of Blueline Tilefish (Figure 5). The NMFS SEFSC funded Cooperative-with-industry Data Collection Project (CDCP) in 2015 had a broad geographic footprint, sampling Blueline Tilefish off the Florida Keys, off mid-SC, and off NC-VA (Figure 6). However, this study was primarily designed to collect biological samples and relied on the captains' abilities to target Blueline Tilefish by using different gear types (SEDAR50-DW02);

Blueline Tilefish were caught at or near most locations fished (Figure 6). Limited fishery-independent sampling off the FL to mid-SC region had few encounters of Blueline Tilefish, but commercial landings information assigned to depth and area indicated a continuous distribution of Blueline Tilefish within narrow bands of available habitat in this area (Figure 5 in SEDAR50-DW11).

Combined distribution patterns from the different data sources suggest a continuous distribution from the Gulf of Mexico into the Mid-Atlantic Bight (Figure 1 in SEDAR50-DW11). Records of Blueline Tilefish from both fishery-independent and –dependent sources were particularly common and continuous from Cape Lookout, NC up to the coast of MD (Figures 7 and 8). Therefore, the spatial breakout group concluded that there is no evidence of a stock break at either the North Carolina – Virginia border or at Cape Hatteras. The evidence for a continuous stock from mid-SC south through the Florida Keys was less definitive (Figure 7 and 8), though the group could not discern whether this reflected lower localized abundance or reduced sampling effort in the region. Given that population genetic data (SEDAR50-DW05) suggest a single population all along the Atlantic Coast, and that some Blueline Tilefish were observed in the combined distribution data off the east coast of FL north to mid-SC, the spatial distribution breakout group concluded that a near continuous distribution of genetically related Blueline Tilefish probably exists along the Atlantic Coast from the Florida Keys through the mid-Atlantic Bight.

Analysis of the habitats at locations where Blueline Tilefish have been caught in the Gulf of Mexico and off the Atlantic Coast suggests that bottom type is not restricting the population range (SEDAR50-DW04, SEDAR50-DW11). Although some general differences exist in habitats between the Mid-Atlantic and South Atlantic Bight and also between the West Florida shelf and the northern Gulf of Mexico, these differences do not appear to limit the distribution of Blueline Tilefish across the regions. However, the group noted that the course resolution of the sediment data collected at point locations and interpolated to surrounding areas could be masking important small-scale habitat preferences that may affect Blueline Tilefish distribution. Past ROV and submersible studies have shown that Blueline Tilefish are found in high-relief hard bottom, low-relief hard bottom, and mixed hard and soft bottom habitats (from lowest to highest densities) off South Carolina. The same study found them absent on coral rubble, manganese-phosphorite and soft (sand/mud) bottom (S. Yeckley, M.S. thesis in preparation, Savannah State University). They have also been found associated with hard bottom in the Mid-Atlantic Bight (Ross et al. 2016, SEDAR50-RD09).

Water temperatures where Blueline Tilefish have been caught suggest that the northern limit of the species is influenced by bottom temperature, especially relative to their confamilial Golden Tilefish. No Blueline Tilefish were captured in waters less than 8^{o}C bottom temperature (Figure 9), whereas Golden Tilefish have been collected in NEFSC surveys at locations where bottom

temperatures were as cold as 3ºC. The northern limits of the distributions of both species may also be limited by winter bottom temperatures, which are not reflected in the spring and fall NEFSC trawl survey data. The spatial distribution breakout group recommends further research to better understand the thermal tolerance of Blueline Tilefish.

The group noted that anecdotal information from the Golden Tilefish longline fishery (and from Golden Tilefish studies conducted during the 1970s and 1980s) suggests that the catch of Blueline Tilefish in the Mid-Atlantic region near the Hudson and Norfolk Canyons was a relatively rare event. The NEFSC trawl surveys do not catch Blueline Tilefish well; only a single Blueline Tilefish was caught north of Cape Hatteras from 1967 to 2000, while just 45 specimens were captured from 2001 to 2015 (SEDAR50-DW09; Table 1). Temporal evidence for any increase in the abundance of Blueline Tilefish in the Mid-Atlantic is not evident based on commercial data sources; however note that there was not a commercial Blueline Tilefish reporting code before the Golden Tilefish Fishery Management Plan was enacted in 2001.

Blueline Tilefish are similar to Golden Tilefish in that they inhabit burrows, and males grow larger than females. Burrowing may suggest the species does not migrate over long distances during its adult life. Dispersal of the species is thought to occur primarily through egg and larval transport during a protracted spawning season; however, very little is known about the egg and larval stages (Dooley 1978, SEDAR50-RD10). Water current flow maps suggest that larval transport is likely from the Gulf of Mexico to the South Atlantic and from the South Atlantic to the Mid-Atlantic (Figure 10). This connectivity through egg and larval drift is also supported by drifter buoy data (Figures 11 & 12; SEDAR50-DW11). The spatial distribution group also noted that satellite drifter data show evidence of potential larval retention in the South Atlantic and Mid-Atlantic regions, as well as the potential for a general larval drift from south to north (Figure 12; SEDAR50-DW11).

The available spatial distribution data suggest there is a potential break in Blueline Tilefish distribution on the east coast of Florida or off the Georgia coast (Figure 13). However, bottom characteristics and water currents make this area difficult to fish and survey, which may explain the low survey catches. Commercial logbook data (Figure 8), recreational catches, past ROV studies (Able et al. 1987, SEDAR50-RD17), and commercial CPUE information (Figure 14) show that Blueline Tilefish occur in this region but perhaps at lower densities (Figures 5 and 7 in SEDAR50-DW11). Commercial and recreational catches and spatial distribution data suggest higher abundance off the Florida Keys. An investigation into the distribution of Blueline Tilefish in the Gulf of Mexico suggested that over 99% of the Blueline Tilefish within the Gulf of Mexico are located off the west coast of Florida in close proximity to Key West (Figures 11 and 12; SEDAR50-DW11). Distributions of Blueline Tilefish off the Florida Keys appear to be contiguous with those off the west coast of Florida. Loop current information suggests that egg and larval supply from spawning off the west coast of Florida would likely contribute to

recruitment in the Florida Keys, and perhaps further north into the South Atlantic Bight via the Florida Current and Gulf Stream (SEDAR50-DW11).

The spatial distribution breakout group developed four hypotheses regarding the southern distributional boundary of Blueline Tilefish:

1) Accept the stock boundary determined during SEDAR 32 (i.e., include the Florida Keys with the Atlantic stock).
2. Include the Florida Keys and eastern Florida in the Gulf of Mexico stock and break the stocks at the Florida-Georgia border.
3. Treat Western Florida and Atlantic Blueline Tilefish as a single population.
4. Treat the Gulf of Mexico and Atlantic Blueline Tilefish as a single population.

The group extensively discussed and considered each of these options, and concluded that hypothesis 4 (i.e., a single population extending from the Gulf of Mexico and throughout the Atlantic Coast) was the most likely and most parsimonious with the available data.

Table 1. Numbers of Blueline Tilefish caught in NEFSC bottom trawl surveys. The fall survey was conducted from 1967-2015 (which included strata south to Cape Hatteras), winter survey from 1992-2007, and spring survey from 1968-2015. Note: no Blueline Tilefish were caught between 1982 and 1991.

Year	Fall	Winter	Spring	Total
1982			2[1]	2
1991	1			1
1992				
1993				
1994	1[1]			1
1995				
1996				
1997				
1998				
1999				
2000				
2001		1		1
2002		1		1
2003	7	4		11
2004	3			3
2005				
2006	5			5
2007	2	3		5
2008				
2009	1			1
2010			1	1
2011				
2012				
2013			6	6
2014	2			2
2015	4		2	6
Total	26	9	11	46

[1] Strata south of Cape Hatteras

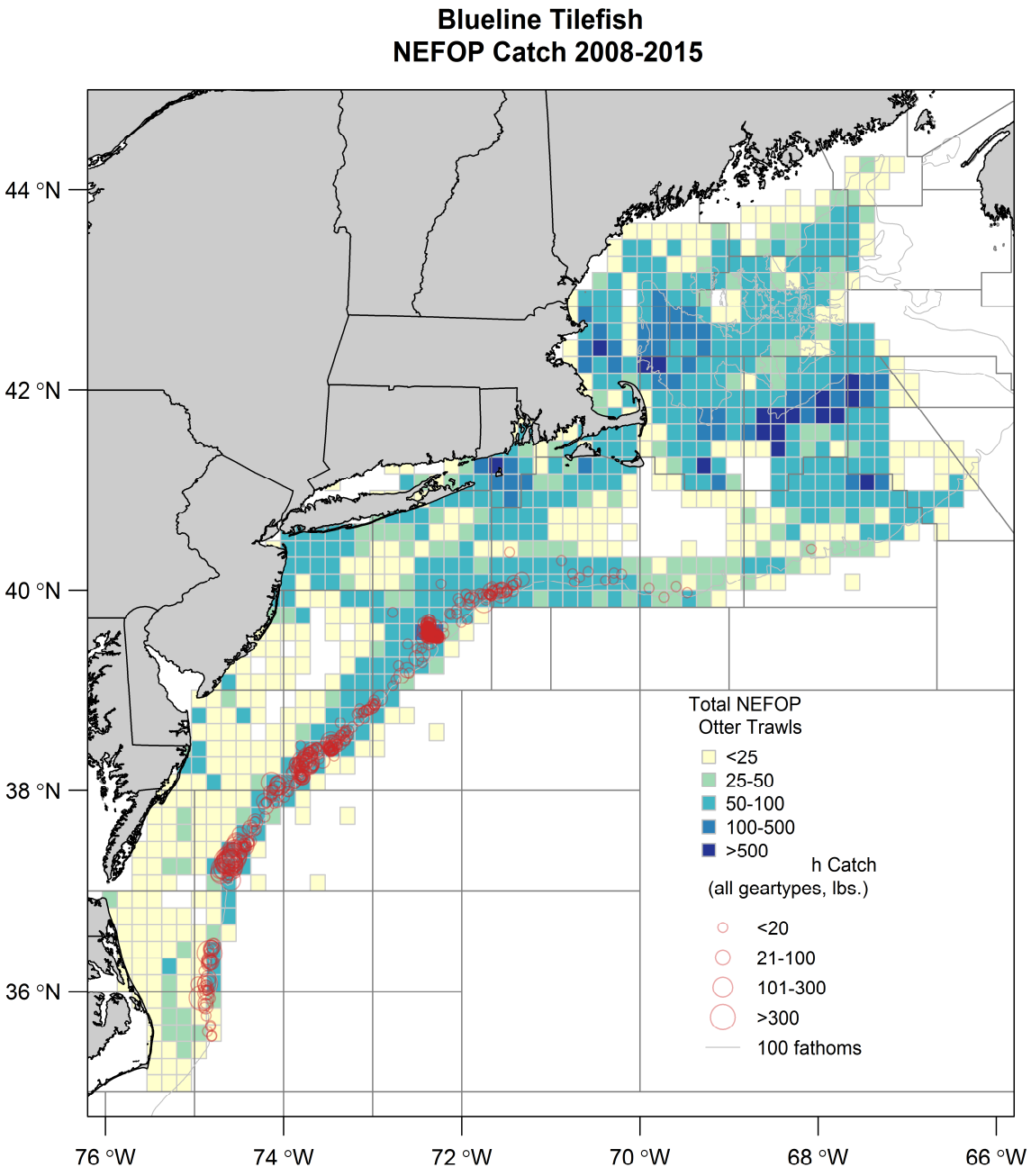

Figure 5. Blueline Tilefish caught (in pounds) in NEFOP hauls for all gear types from 2008 to 2015. Total NEFOP trawl effort (2008-2015) in total tows is also shown by 10-minute square.

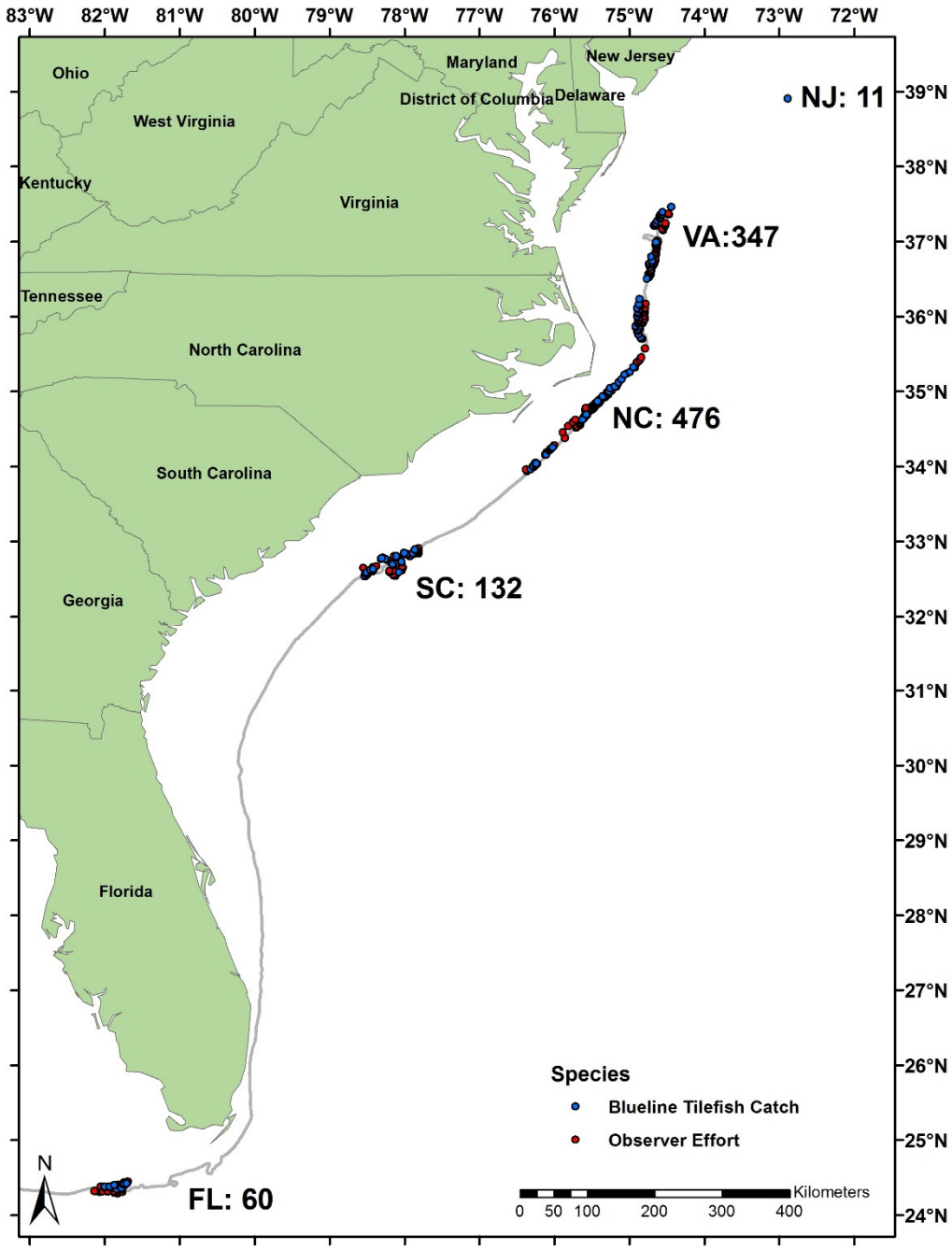

Figure 6. Blueline Tilefish catch (n = 1026) and effort during the Cooperative-with-industry Data Collection Project in 2015. Effort data were not available for New Jersey.

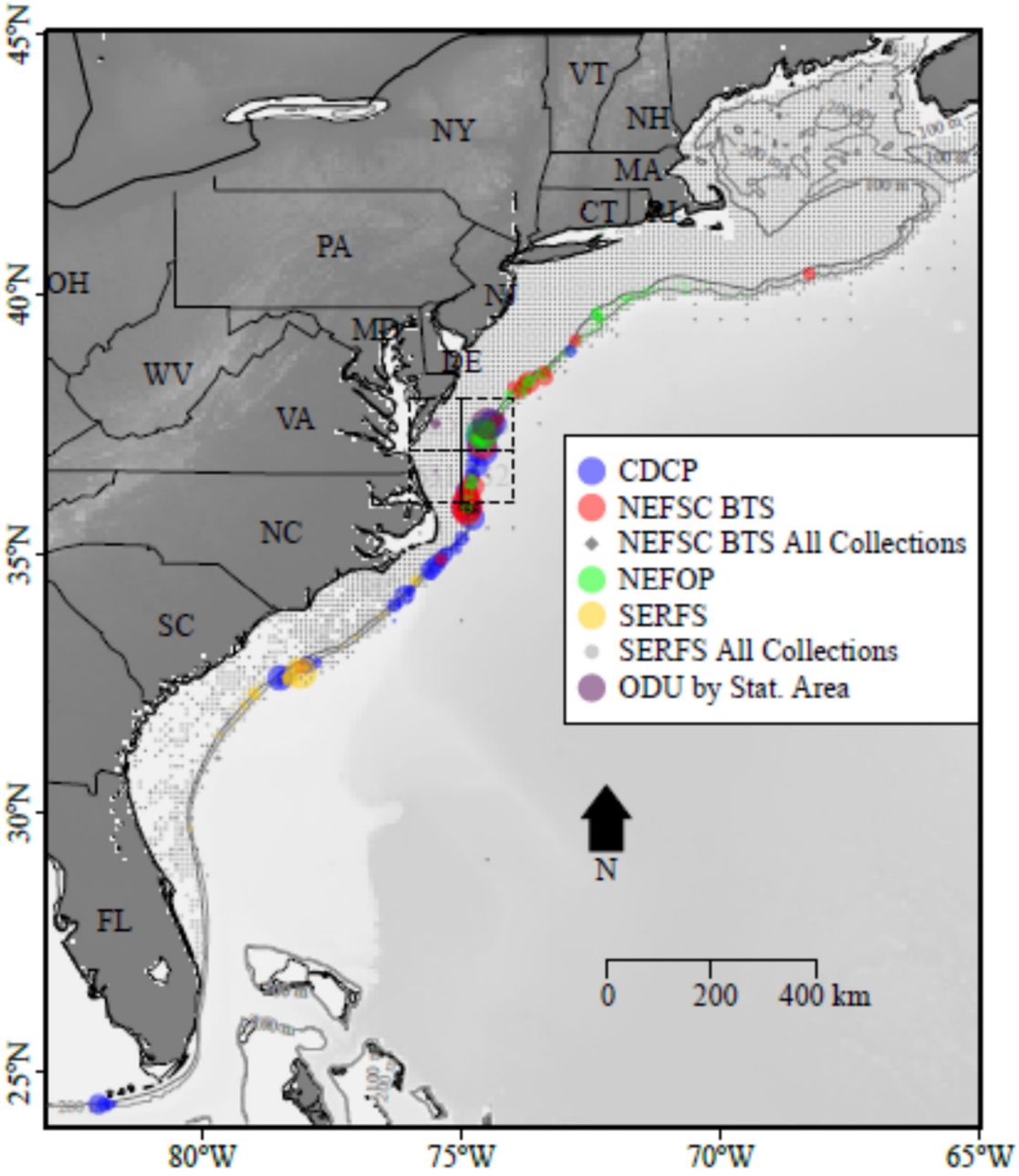

Figure 7. Map of all positive Blueline Tilefish collection locations and all sampling locations for NEFSC winter, spring, and fall bottom trawl surveys from 1967-2015, and all Southeast Reef Fish Survey (SERFS) sampling locations for gear types known to catch Blueline Tilefish, from 1977-2015. For NEFSC, SERFS, NEFOP, and CDCP samples, observations were aggregated by 0.1 X 0.1° lat-lon bins. Samples from the Old Dominion University (ODU) study were presented at the highest spatial resolution available, 1.0 X 1.0° lat-lon statistical grid cells. Point colors and shapes are presented in the legend. For points representing positive Blueline Tilefish collections, point size (area) is scaled to the maximum number of fish caught (or pounds caught for NEFOP data) in any lat-lon bin for each data set (i.e., points are scaled separately for each data set).

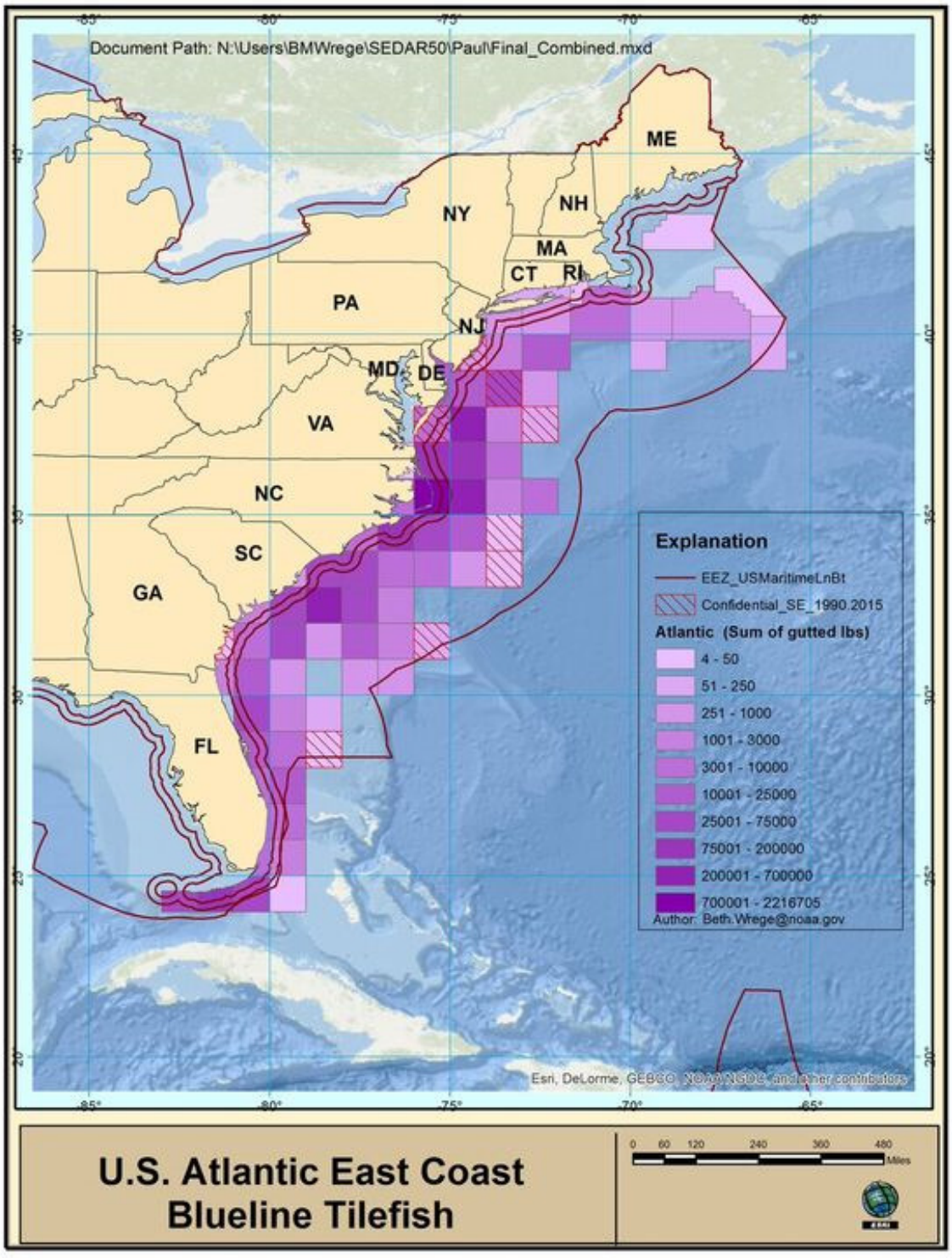

Figure 8. Combined NEFSC Vessel Trip Reports (VTR) and Southeast Fisheries Science Center (SEFSC) commercial logbook Blueline Tilefish landings data.

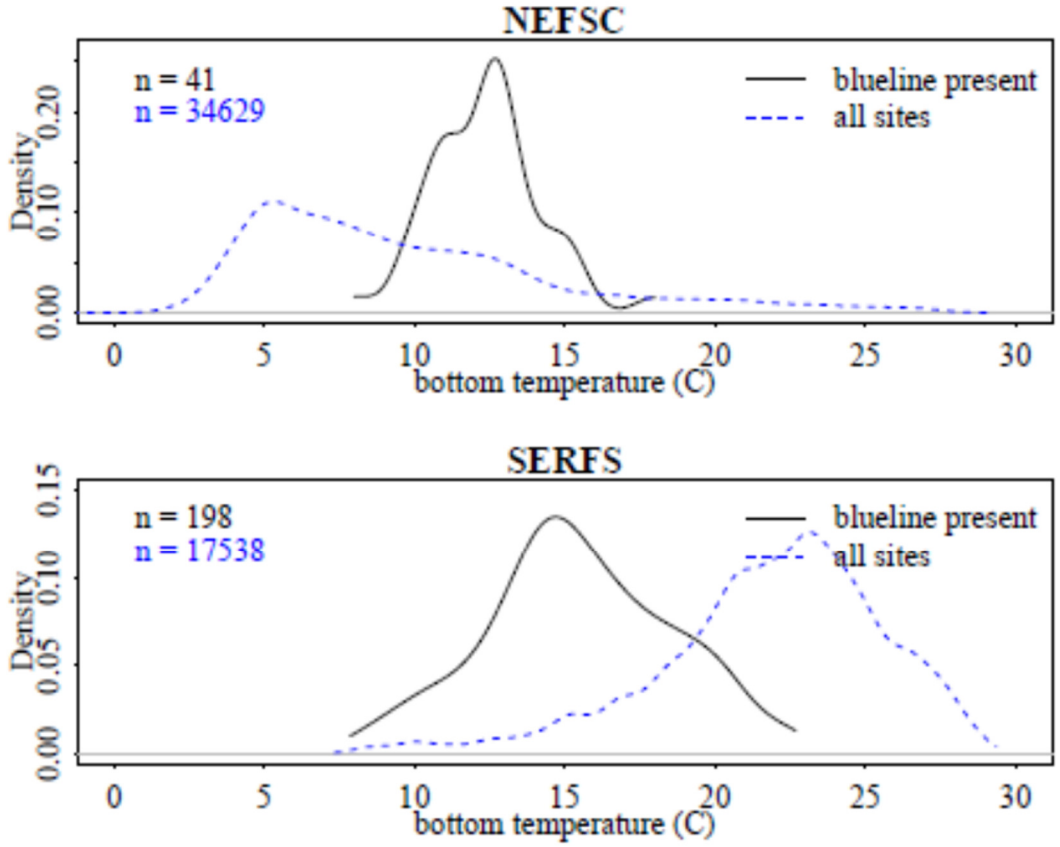

Figure 9. Density plots of Blueline Tilefish presence at a sampling site, by bottom temperature in degrees Celsius, plotted separately for each collection that recorded bottom temperature. For NEFSC BTS and SERFS, density plots of all sampling sites were also drawn. Sample sizes (n) indicate number of sampling sites.

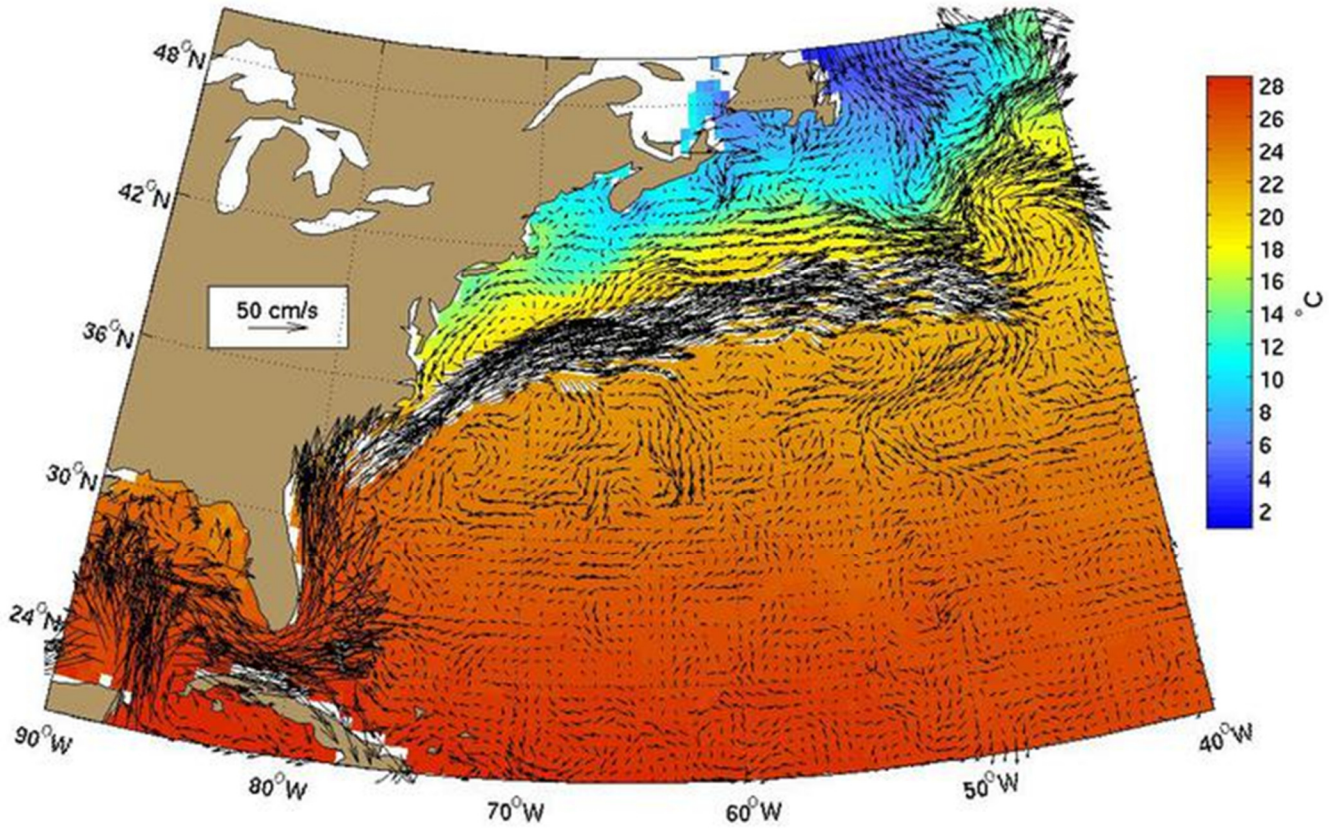

Figure 10. Global ocean surface velocities from drifters with sea surface temperature. Source: http://oceancurrents.rsmas.miami.edu/atlantic/gulf-stream_2.html (accessed August 2016).

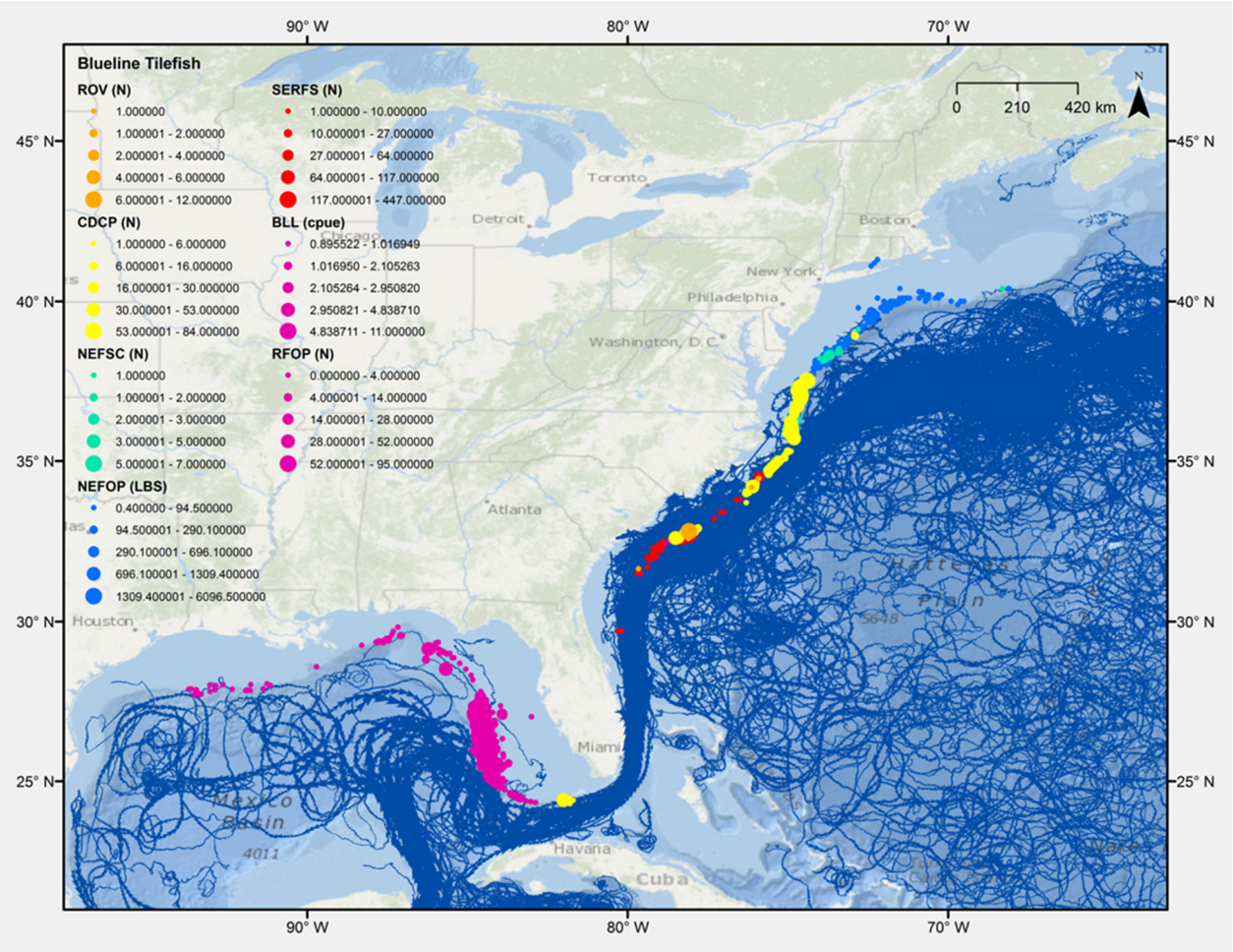

Figure 11. Positive encounters (circles) of Blueline Tilefish by various sampling programs from the Gulf of Mexico to the Gulf of Maine relative to 15,000 surface drifter buoy tracks from the Global Drifter Program. National Marine Fisheries Bottom Longline (NMFS-BLL) and Southeast Reef Fish Observer Program (RFOP) encounters with Blueline Tilefish are presented under the same color scheme to protect confidentiality. Drifter arrow sizes correspond to speed of movement.

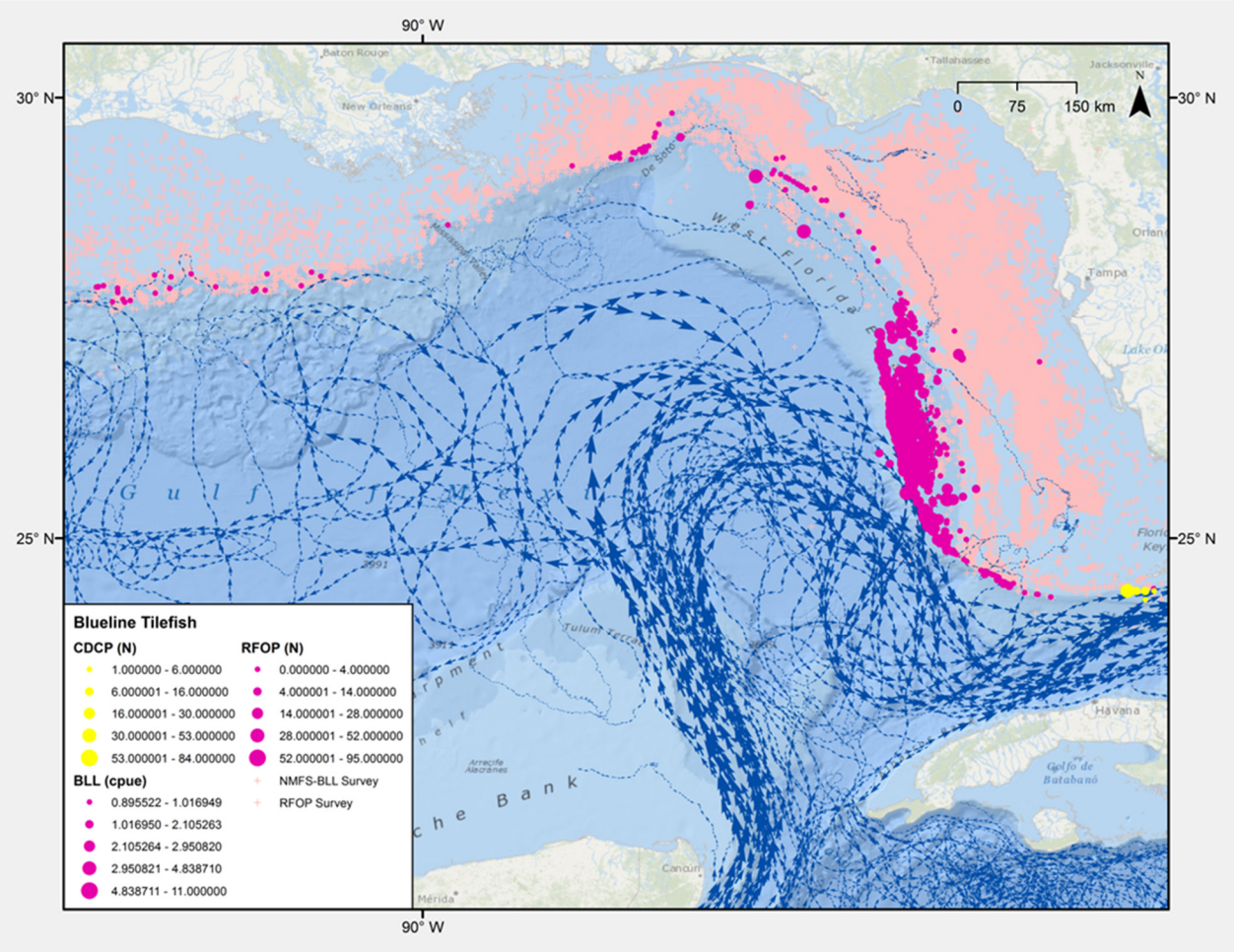

Figure 12. Positive encounters (circles) of Blueline Tilefish by various sampling programs in the Gulf of Mexico relative to 15,000 surface drifter buoy tracks from the Global Drifter Program. NMFS-BLL and RFOP encounters with Blueline Tilefish are presented under the same color scheme to protect confidentiality. Drifter arrow sizes correspond to speed of movement.

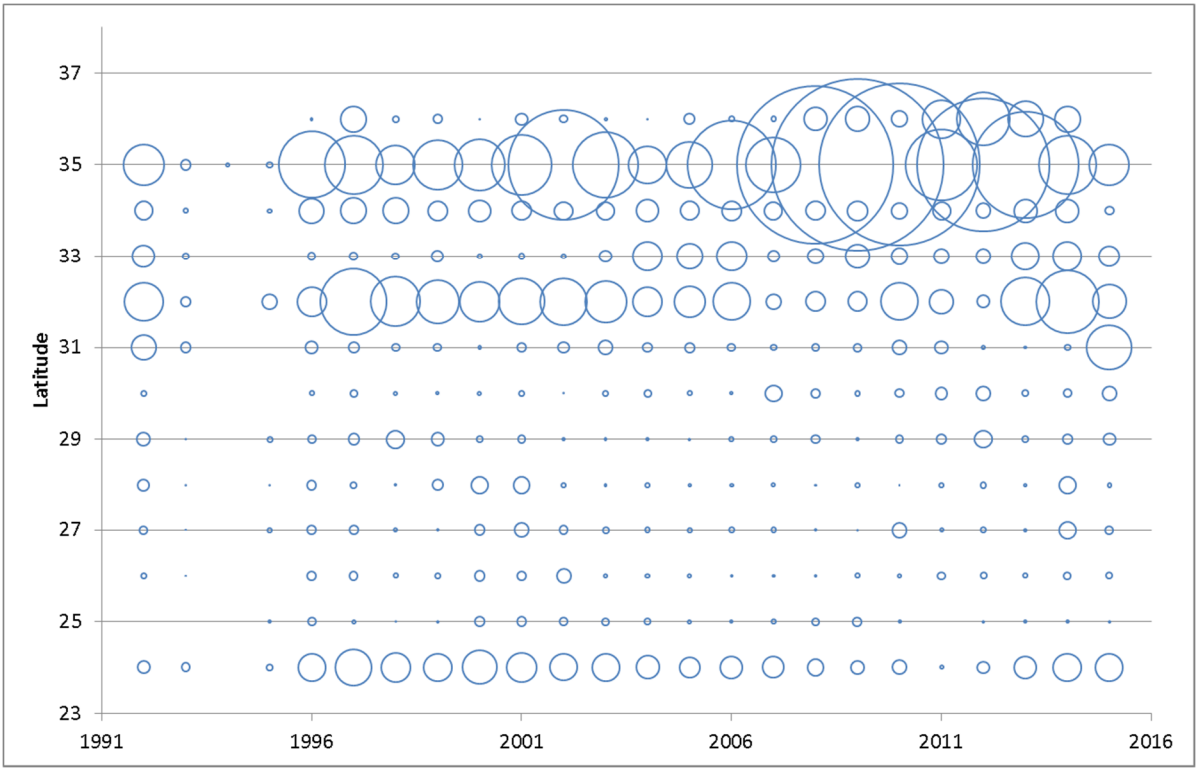

Figure 13. Blueline Tilefish commercial landings (pounds, whole weight) reported caught in the SAFMC's jurisdiction by latitude and year. Bubble sizes are scaled to annual mean for time series to protect confidentiality. Source: SEFSC Commercial Logbook Program (accessed April 2016).

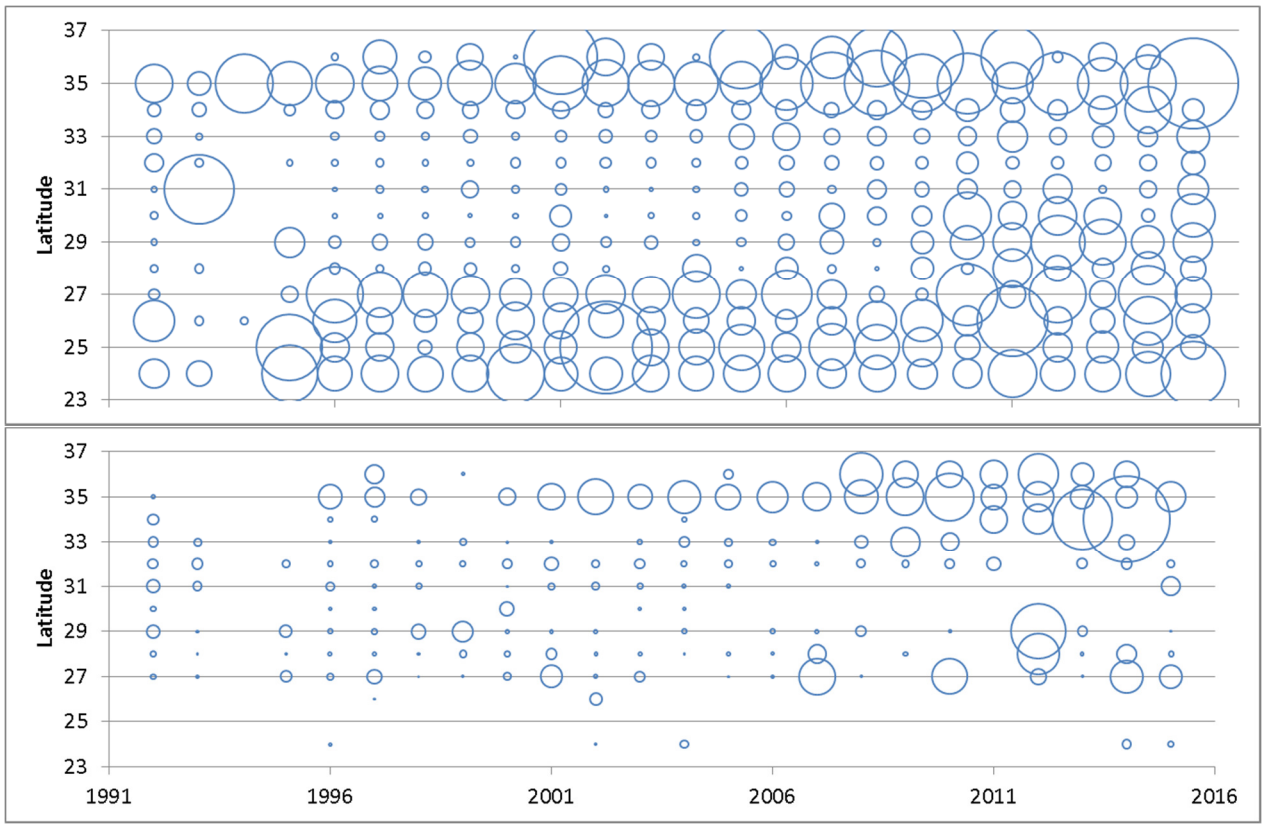

Figure 14. Blueline Tilefish commercial catch-per-unit-effort on directed hook-and-line (top) and longline (bottom) trips in the SAFMC's jurisdiction by latitude and year. Bubble sizes scaled to annual mean for time series to protect confidentiality. Source: SEFSC Commercial Logbook Program (accessed April 2016).

2.1.4 Research Recommendations

Genetics

- Given the results of the genetic work on Blueline Tilefish evaluated here and the limitations identified in the Katz et al. 1983 (SEDAR50-RD18) Golden Tilefish study, patterns in genetic population structure should be revisited for other deep-water species (including Golden Tilefish) using contemporary genetic approaches and analyses.
- To develop a mechanistic understanding of processes facilitating gene flow for Blueline Tilefish, further research should be undertaken to evaluate spawning season duration, pelagic larval stage duration, and adult movements.
- Additional genetic sampling should be conducted in the Gulf of Mexico (Florida Keys to the Texas-Mexico border) to further evaluate the potential for genetic structure across the Gulf of Mexico.

Life History

- Age reading interpretation of Blueline Tilefish otoliths need to be resolved. Other age validation techniques should be investigated (e.g., Pb\Ra ratio).
- Reproductive biology studies of Blueline Tilefish should be expanded to include the full distributional range of the species, specifically targeting samples from the west and east coasts of Florida and the Mid-Atlantic region. These data are needed to assess possible shifts in spawning season. Sampling of young fish is needed to improve the maturity ogive.
- Better information is needed on the movement or migration of juvenile and adult Blueline Tilefish.
- Studies should be conducted on the identification of Blueline Tilefish larvae and also on the location, duration, and dispersal mechanisms of the egg and larval stages.

Spatial Distribution

- Further research should be conducted to understand the thermal tolerance of Blueline Tilefish.
- Surveys should be conducted to try to document the distribution of early life stages.
- Further studies are needed on habitat preferences over the whole range of the species.
- Particle modeling to investigate hypotheses about movement of eggs and larvae.
- Research into movement of adults.

Overall

- A continuous, random, stratified survey should be developed and implemented for Blueline Tilefish throughout its range.

2.2 ToR #1b: *Make recommendations on biological stock structure and define the unit stock or stocks to be addressed through this assessment.*

The Work Group recommended that Blueline Tilefish from the Gulf of Mexico and along the entire U.S. Atlantic seaboard be considered a single biological population unit. Genetic studies indicate large amounts of gene flow throughout the geographic range, indicative of a single genetic population extending from at least U.S. Atlantic Ocean waters off New York to the West Florida Shelf in the northeastern Gulf of Mexico. While information is lacking on genetic population structure throughout the Gulf of Mexico, the potential for larval dispersal via the Loop Current and the small amount of Gulf landings (< 0.5%) outside of the West Florida Shelf region led to the decision to include the entire Gulf of Mexico as part of the unit stock. While there remains insufficient data on larval distribution/duration and adult migration to definitively identify the mechanisms facilitating gene flow, the genetic connectivity cannot be ignored in future assessment and management activities. Relatively high densities of Blueline Tilefish on the West Florida Shelf near currents flowing rapidly around Florida into the South Atlantic suggest that transport of eggs and larvae between these regions could be substantial.

2.3 ToR # 1c: *Provide recommendations to address Council management jurisdictions, to support management of the stock or stocks, and specification of management benchmarks and fishing levels, by Council jurisdiction (SAFMC/MAFMC) in a manner consistent with the productivity measures of the assessment.*

The available biological data does not support the existence of separate biological populations at either the MAFMC/SAFMC or SAFMC/GMFMC jurisdictional boundaries. Despite limited understanding of the physical mechanism facilitating gene flow, the level of genetic connectivity, suggests that management measures should be consistently applied throughout the range of the species. Unfortunately, there is insufficient data to fully understand the nature and structure of the production function linking spawning potential to subsequent recruitment in Blueline Tilefish. Without a well-defined production function, fishery biological reference points cannot be directly estimated from commonly used population dynamics models (e.g. BAM or SS3). The large geographic range of the species (New York to West Florida) suggests that reproductive linkages are likely based on smaller unit(s) but at exactly what scale and how they function is unknown.

Should a method be developed for estimating a coastwide ACL, the Work Group discussed the possibility of using historic landings time series, CPUE, and habitat distribution as potential methods to allocate Blueline Tilefish within Council jurisdictions. In the past, Councils have used historical landings to allocate between regions. However, due to the short duration of Blueline Tilefish fishing effort in some Council jurisdictions and restrictive regulations for part of the recent time series, the Work Group did not think this would be an ideal method for

allocation of Blueline Tilefish. There are also concerns about potential issues arising due to discrepancies between where fish are landed versus where fish are caught, and how the fishery is prosecuted (often crossing jurisdictional boundaries). Using CPUE has similar challenges due to issues that confound Blueline Tilefish fishery effort including changes in targeting, multi-species trips, and gear types. Overall, the Work Group thought that using habitat distributions might be the most appropriate approach for guiding allocation decisions, but the Group recognized that only limited information exists on Blueline Tilefish habitat suitability and distribution. The Work Group thought that using areas defined by depth and temperature ranges suitable for Blueline Tilefish would be the most feasible approach for allocating a coastwide ACL, and that modeling techniques could be investigated to predict suitable Blueline Tilefish habitat within each Council's jurisdiction. Each of the allocation approaches discussed by the Work Group has potential strengths and weaknesses, and there are likely other methods that could be used to address this issue. The information offered here is for consideration by managers recognizing that allocation is typically a management decision.

2.4 ToR #1d: *Document work group discussion and recommendations through a working paper for SEDAR 50.*

The SEDAR 50 Stock ID work group's discussions and recommendations are documented through this working paper, SEDAR50-DW12.

2.5 ToR#1e: *Work Group recommendations will be used to address Data Workshop Term of Reference 1: Review stock structure and unit stock definitions and consider whether changes are required.*

SEDAR50-DW12 will be reviewed by SEDAR 50 Data Workshop panelists to address SEDAR 50 Data Workshop ToR#1.

Literature Cited

Able, K. W., D. C. Twichell, C. B. Grimes, and R. S. Jones. 1987. Tilefishes of the Genus *Caulolatilus* Construct Burrows in the Sea Floor. Bulletin of Marine Science 40(1): 1-10. SEDAR50-RD17.

Dooley, J. K. 1978. Systematics and Biology of the Tilefishes (Perciformes: Branchiostegidae and Malacanthidae), with Descriptions of Two New Species. NOAA Technical Report NMFS Circular 411. 86pp. SEDAR50-RD10.

Farmer, N. and N. Klibansky. 2016. Distribution of Blueline Tilefish (*Caulolatilus microps*) in the U.S. EEZ from fishery-dependent and fishery-independent data collections. SEDAR50-DW11. SEDAR, North Charleston, SC. 23 pp.

Harris, P. J. 2013. Validation of ages for species of the deepwater snapper/grouper complex off the southeastern coast of the United States. SEDAR36-RD07. SEDAR, North Charleston, SC.

Harris, P., D. M. Wyanski, and P. T. P. Mikell. 2004. Age, Growth, and Reproductive Biology of Blueline Tilefish along the Southeastern Coast of the United States, 1982-1999. Transactions of the American Fisheries Society 133:1190-1204. SEDAR50-RD12.

Katz, S. J., C. B. Grimes, and K. W. Able. 1983. Delineation of Tilefish, *Lopholatilus chamaeleonticeps*, Stocks Along the United States East Coast and in the Gulf of Mexico. Fishery Bulletin 81: 41-50. SEDAR50-RD18.

Kellison, T. 2016. Summary of the 2015 Blueline Tilefish cooperative-with-industry data collection project. SEDAR50-DW02. SEDAR, North Charleston, SC. 11 pp.

Klibansky, N. 2016. Distribution of scientifically collected Blueline Tilefish (*Caulolatilus microps*) in the Atlantic, and associated habitat. SEDAR50-DW04. SEDAR, North Charleston, SC. 29 pp.

Kolmos, K. J., S. Falk, D. M. Wyanski, and M.A. Schmidtke. 2016. A Preliminary Assessment of Reproductive Parameters for Blueline Tilefish in Atlantic Waters from Virginia to Florida. SEDAR50-DW03. SEDAR, North Charleston, SC. 15 pp.

McDowell, J. 2016. Summary of the results of a genetic-based investigation of Blueline Tilefish (*Caulolatilus microps*). SEDAR50-DW05. SEDAR, North Charleston, SC. 34 pp.

Nitschke, P. and A. Miller. 2016. Summary of Northeast Fisheries Science Center Blueline Tilefish Survey Data. SEDAR50-DW09. SEDAR, North Charleston, SC. 8 pp.

Nitschke, P. and A. Miller. 2016. Summary of Mid-Atlantic Commercial Blueline Tilefish Data. SEDAR50-DW10. SEDAR, North Charleston, SC. 13 pp.

O'Donnell, T. and T. Darden. 2016. Preliminary Genetic Population Structure of Blueline Tilefish *Caulolatilus microps* along the East Coast of the United States. SEDAR50-DW06. SEDAR, North Charleston, SC. 12 pp.

Ross, J .L., and J. V. Merriner. 1983. Reproductive biology of the Blueline Tilefish, *Caulolatilus microps*, off North Carolina and South Carolina. Fishery Bulletin 81: 553-568. SEDAR50-RD08.

Ross, S. W., M. Rhode, S. T. Viada, and R. Mather. 2016. Fish species associated with shipwreck and natural hard-bottom habitats from the middle to outer continental shelf of the Middle Atlantic Night near Norfolk Canyon. Fishery Bulletin 114: 45-57. SEDAR50-RD09.

Schmidtke, M., K. Kirch, and C. M. Jones. 2015. Report to the Virginia Marine Resources Commission Grant F-132-R-2: The Population Dynamics of Blueline and Golden Tilefish, Snowy and Warsaw Grouper, and Wreckfish. 21pp. SEDAR50-RD05.