Blueline Tilefish Assessment Approach: Stock structure, data structure, and modeling approach

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Table of contents

Stock Structure

- Blueline Tilefish are found from the Campeche Bank off of the Yucatàn Peninsula, Mexico, throughout the Gulf of Mexico, and up to Georges Bank off of Massachusetts, US
- Managed as Gulf of Mexico and the Atlantic stocks
- Three Fishery Management Councils (FMCs):
  1. Mid-Atlantic FMC (north of North Carolina/Virginia state border)
  2. South-Atlantic FMC (south side of Florida keys to NC/VA border)
  3. Gulf of Mexico FMC (Gulf of Mexico including areas north of the Florida Keys)
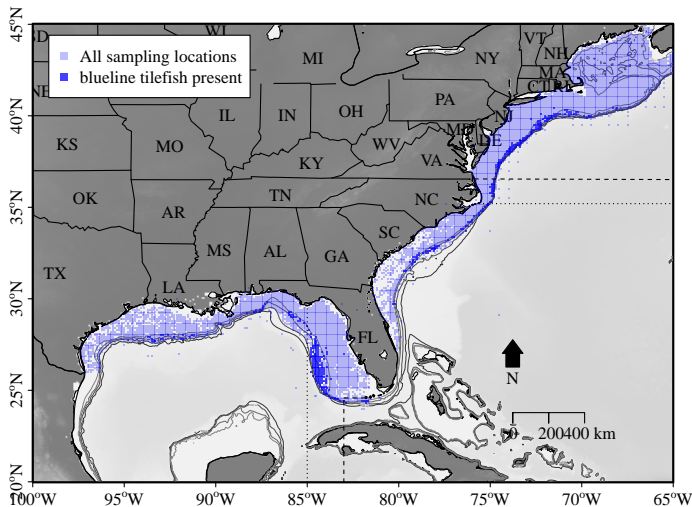
Stock Structure

- Out of concern for potential stock split at the SAFMC/MAFMC boundary, a SEDAR 50 Stock ID Work Group Meeting was held June 28-30, 2016

- The Stock ID Work Group considered genetics, life history data, adult distributions, oceanographic features, and data on drifter movement

- Focused on the Atlantic coast, not expecting connectivity with Gulf of Mexico to be a major issue

Stock Structure

Presence/absence of Blueline Tilefish based on composite scientific survey data
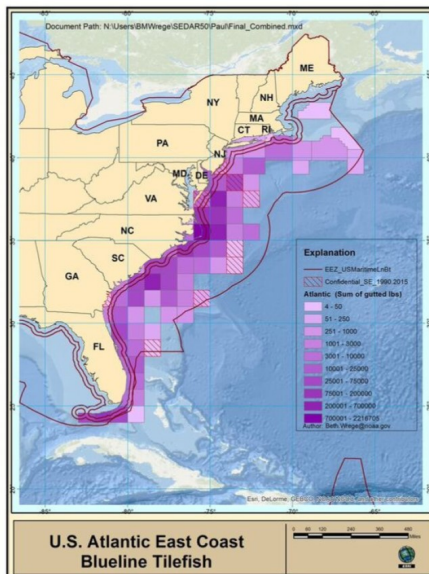
Stock Structure

Atlantic commercial landings

- Reported landings of Blueline Tilefish based on composite Northeast Fisheries Science Center (NEFSC) Vessel Trip Reports (VTR) and Southeast Fisheries Science Center (SEFSC) commercial logbook landings
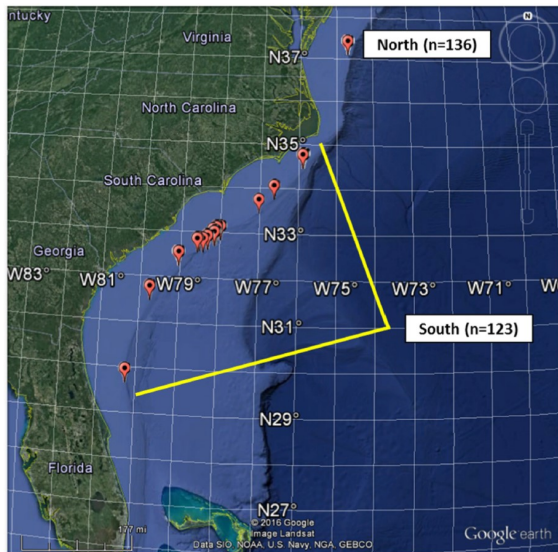
- Stock ID Workgroup Report Figure 8

U.S. Atlantic East Coast
Blueline Tilefish

Stock Structure

Blueline Tilefish genetics sample collection locations and sample sizes

- Stock ID Workgroup Report Figure 1
- Data from O'Donnell and Darden (2016) genetics study
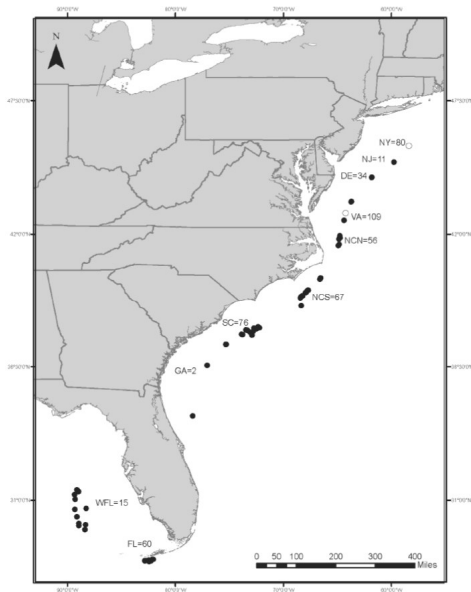- $n = 259$

Stock Structure

Blueline Tilefish genetics sample collection locations and sample sizes

- Stock ID Workgroup Report Figure 2
- Data from McDowell (2016) genetics study
- $n = 510$

Stock Structure

McDowell (2016) Table 2

- F_{ST} is a measure of genetic difference
- "MS" samples were from the West Florida Shelf
- No pairwise comparisons were significant

Table 2. Population pairwise F_{ST} values based on 23 microsatellite loci (lower matrix). Population pairwise Φ_{ST} values based on the mitochondrial control region (lower matrix). New York (NY), Delaware (DE), Virginia (VA), North Carolina North of Cape Hatteras (NCN), North Carolina South of Cape Hatteras (NCS), South Carolina (SC), Florida (FL), Mississippi (MS). There were no significant pairwise comparisons based on either class of molecular marker.

	NY	DE	VA	NCN	NCS	SC	FL	MS
NY	*	-0.00144	-0.00047	0.01391	0.00106	-0.00700	-0.00789	-0.01119
DE	-0.00151	*	0.00205	-0.00279	-0.00209	-0.02601	-0.00906	0.03915
VA	-0.00045	-0.00218	*	0.01045	-0.01496	-0.00513	-0.01110	-0.01307
NCN	-0.00056	-0.00112	-0.00025	*	-0.00291	-0.00734	-0.00519	0.01626
NCS	-0.00012	-0.00204	0.00082	0.00074	*	-0.00399	-0.00436	-0.00451
SC	-0.00066	-0.00166	-0.00084	0.00036	-0.00088	*	-0.01320	0.00110
FL	-0.00067	-0.00216	-0.00057	-0.00085	-0.00054	-0.00004	*	-0.01607
MS	-0.00073	-0.00277	0.00042	0.00014	0.00329	-0.00057	0.00023	*

Stock Structure

Conclusions of genetics studies

- No scientific evidence of genetic heterogeneity across sampled locations
- Support for single panmictic genetic population from Hudson Canyon to Florida Keys
- Indications of connectivity with northeastern Gulf of Mexico based on smaller sample size
- Indications of high level of gene flow across areas sampled
- Results consistent across two genetics studies
- Results consistent across two marker types (microsatellite and mitochondrial)

Stock Structure

Possible mechanisms for gene flow

- Movement of adults
  - ▶ No tagging data to inform adult Blueline tilefish movement
  - ▶ Limited tagging data for Golden Tilefish (*Lopholatilus chamaeleonticeps*) suggests adult movement is minimal
  - ▶ Blueline Tilefish adults occupy burrows for shelter
  - ▶ Stock ID Work Group noted adult movement is assumed to be limited
  - ▶ However, since distribution of adults appears continuous across the SAFMC/MAFMC boundary, even limited adult movement could cross that boundary
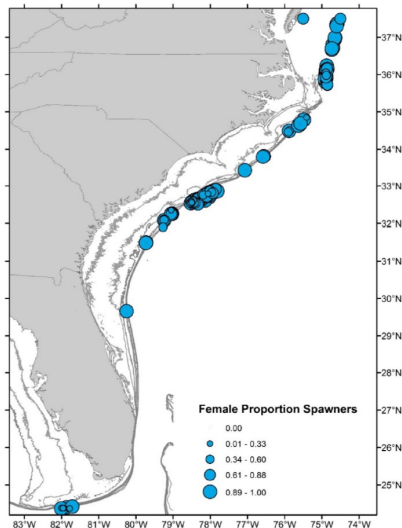
Stock Structure

Possible mechanisms for gene flow

- Movement of eggs and larvae
  - ▸ Blueline Tilefish eggs are planktonic (Lewis et al. 2016)
  - ▸ Golden Tilefish larvae are planktonic
  - ▸ Blueline Tilefish larvae are probably also planktonic
  - ▸ Is there likely to be substantial flow of planktonic life stages among Council regions?

Stock Structure

Possible mechanisms for gene flow

Proportion of female Blueline
Tilefish spawning (n
spawners/n mature females)
by sampling location

- Stock ID Workgroup
  Report Figure 4

- Data contributed by
  Southeast Reef Fish
  Survey (SERFS),
  National Marine
  Fisheries Service
  (SERFS), and Old
  Dominion University
  (ODU)

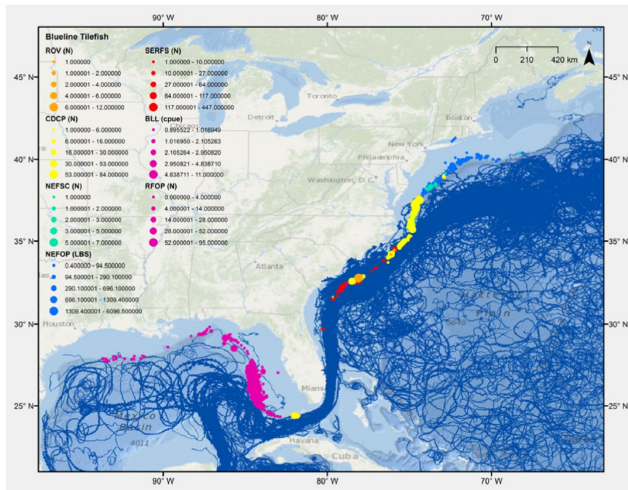- Blueline spawn often
  wherever they are found

Female Proportion Spawners
- 0.00
- 0.01 - 0.33
- 0.34 - 0.60
- 0.61 - 0.88
- 0.89 - 1.00

Stock Structure

Stock ID Workgroup Report Figure 10: Current vectors and water temperature

Stock Structure
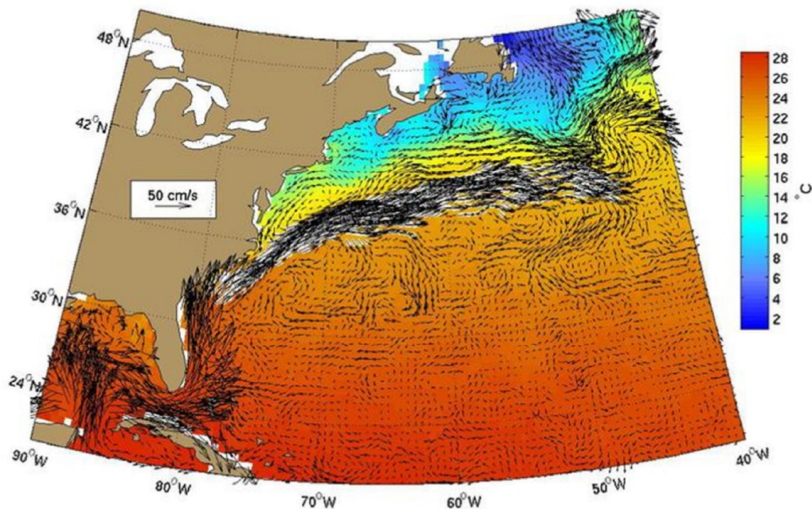
Stock ID Workgroup Report Figure 11: Surface drifter movement relative to Blueline Tilefish distribution

Stock Structure

Possible mechanisms for gene flow

- Is there likely to be flow of planktonic life stages among Council regions?
    - ▶ Strong currents flow through Blueline Tilefish habitat from the Gulf of Mexico Loop Current, into the Gulf Stream current, along the Atlantic Coast through the SAFMC region into the MAFMC region
    - ▶ Blueline spawn often wherever they are found
    - ▶ Stock ID Work Group concluded 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"
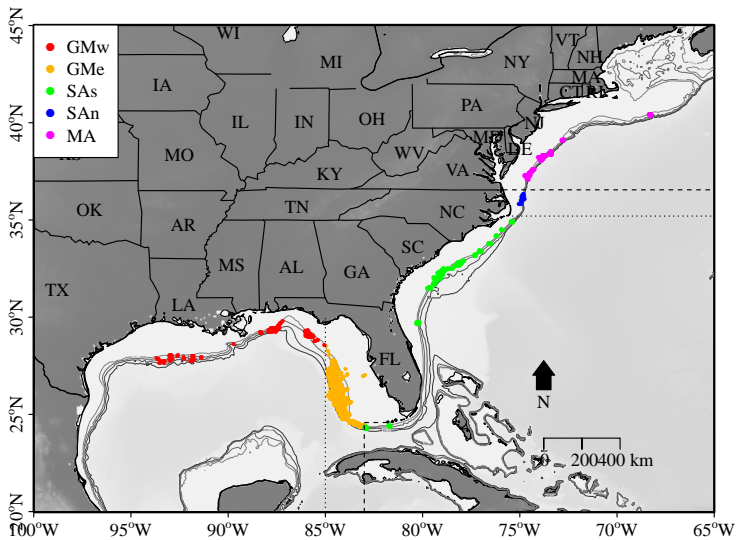
Stock Structure

Further analysis of drifter data and Blueline Tilefish distribution

- Klibansky, N. 2017. Estimating dispersal of blueline tilefish (*Cauloatilus microps*) eggs and larvae from drifter data. SEDAR50-DW23. SEDAR, North Charleston, SC. 22 pp.
  - ▶ Overlaid drogue surface drifter paths with known locations of Blueline Tilefish presence
  - ▶ Tracked surface drifters for 1 to 6 weeks, from the time they passed over Blueline Tilefish locations
  - ▶ Start and end regions identified for each drifter
  - ▶ Proportions of drifters moving between regions at each time step calculated
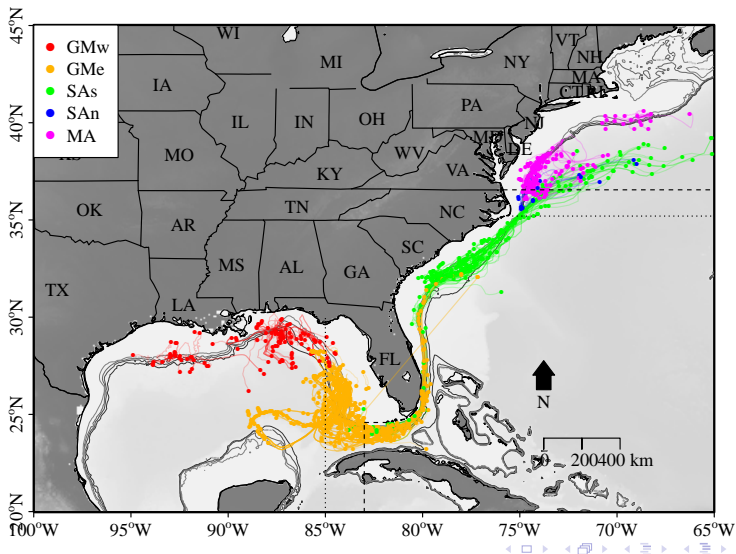
Stock Structure

SEDAR50-DW23: Drifters at time zero (t_0)

Stock Structure
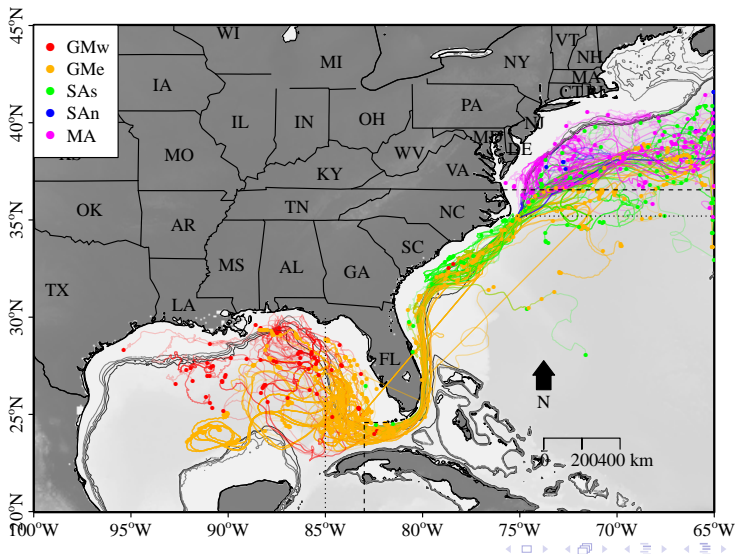
Stock Structure

SEDAR50-DW23: Drifters after six weeks (t_6)

Stock Structure

Table: Summary of movement of resampled drifters between council regions, 1, 2, 4, and 6 weeks after release. Rows represent the council region where the drifter originated while columns represent the region where the drifter was found in a subsequent week. Values in each row sum to one, indicating proportions of drifters released in each region, that were present in each region at weeks 1-6.

Origin	GMw	GMe	SAs	SAn	MA
Week 1					
GMw	0.93	0.07	0.00	0.00	0.00
GMe	0.21	0.52	0.27	0.00	0.00
SAs	0.00	0.01	0.72	0.07	0.19
SAn	0.00	0.00	0.00	0.50	0.50
MA	0.00	0.00	0.00	0.16	0.84
Week 2					
GMw	0.90	0.10	0.00	0.00	0.00
GMe	0.22	0.43	0.33	0.01	0.01
SAs	0.00	0.01	0.61	0.11	0.28
SAn	0.00	0.00	0.00	0.50	0.50
MA	0.00	0.00	0.00	0.20	0.80
Week 4					
GMw	0.81	0.16	0.03	0.00	0.00
GMe	0.24	0.31	0.35	0.04	0.06
SAs	0.00	0.01	0.35	0.14	0.50
SAn	0.00	0.00	0.00	0.00	1.00
MA	0.00	0.00	0.00	0.16	0.84
Week 6					
GMw	0.76	0.17	0.07	0.00	0.00
GMe	0.25	0.26	0.31	0.07	0.12
SAs	0.00	0.01	0.34	0.10	0.56
SAn	0.00	0.00	0.00	0.00	1.00
MA	0.00	0.00	0.01	0.08	0.91

Stock Structure

Possible mechanisms for gene flow

- Results SEDAR50-DW23
    - ▶ Supports conclusions of Stock ID Workgroup
    - ▶ Shows substantial proportions of drifters from the eastern Gulf of Mexico (GMe) are found in the Atlantic south of Cape Hatteras region (SAs) after 1, 2, 4, or 6 weeks
    - ▶ Shows substantial proportions of drifters from the SAs region are found in the Mid-Atlantic (MA) region after 1, 2, 4, or 6 weeks
    - ▶ Drifter movement into the Gulf of Mexico from the Atlantic is minimal
    - ▶ Drifter movement from the MA to the SAFMC region north of Cape Hatteras (SAn) is moderate, but movement from the MA to areas south of Cape Hatteras is minimal
    - ▶ If planktonic stages of Blueline Tilefish behave as drifters, similar movements may also occur
    - ▶ *Note: Figures shown in the slides above are from an updated version of SEDAR50-DW23 which separated drifters between Cape Hatteras and the SAFMC/MAFMC boundary into SAn*

Stock Structure

- Review of results of the Stock ID Work Group Meeting by a Review Panel of scientists from the regional Science and Statistics Committees (SSCs) effectively accepted the results of the Stock ID Work Group (October 28, 2016 webinar)

- Leadership Group accepted the findings of the SSC Panel but found the lack of genetics samples from the western Gulf of Mexico were insufficient to support the existence of a single stock of Blueline Tilefish spanning both the Gulf of Mexico and Atlantic

- The Leadership Group then recommended "using the boundary between the Gulf of Mexico and South Atlantic Council as the Southwestern boundary for the SEDAR 50 stock assessment of Blueline Tilefish"

Stock Structure

- Conclusions of The Leadership Group determined unit stock definition stated in Assessment Workshop Term of Reference (ToR) 1: "the entire US Atlantic seaboard, using the boundary between the Gulf of Mexico and South Atlantic Councils as the southwestern boundary for the stock unit to assess"

- Exploration of models based recommendations of the Stock ID Work Group and the SSC Stock ID Review Panel (i.e. models including the Gulf of Mexico) was requested as part of ToR 6, in characterizing uncertainty

Stock Structure

- Structure of data used to develop indices of abundance further affected the spatial structure of the assessment
- Indices of abundance were developed at the SEDAR 50 Data Workshop for five spatial regions:
    1. South Atlantic (SAFMC region)
    2. South Atlantic north of Cape Canaveral
    3. South Atlantic south of Cape Canaveral
    4. Gulf of Mexico (GAFMC region)
    5. South Atlantic and Gulf of Mexico combined
- Landings data were provided at that same spatial resolution in order to match the indices
- Length data were also broken down spatially
- Most other data sources were not rich enough to be spatially explicit

Stock Structure

- The SEDAR 50 assessment of Atlantic Blueline Tilefish initially focused on data from the Atlantic GMFMC/SAFMC boundary in the Florida Keys

- Problems with early models led the Assessment Panel to reconsider the spatial ranges of the landings data and indices of abundance

- Because the data used to develop the indices of abundance did not adequately characterize fisheries north of Cape Hatteras, the Assessment Panel decided to also restrict landings data used in the Atlantic assessment to the area south of Cape Hatteras

- This decision resulted in more appropriate model of population dynamic south of Cape Hatteras, but required the area north of Cape Hatteras to be assessed in separate analyses

- Still a third set of models was developed to characterize dynamics in the Gulf of Mexico to consider potential affects on Blueline Tilefish in the Atlantic

Stock Structure

Separate analyses were developed for:

1. Atlantic south of Cape Hatteras
2. Atlantic north of Cape Hatteras
3. Gulf of Mexico

Data Structure
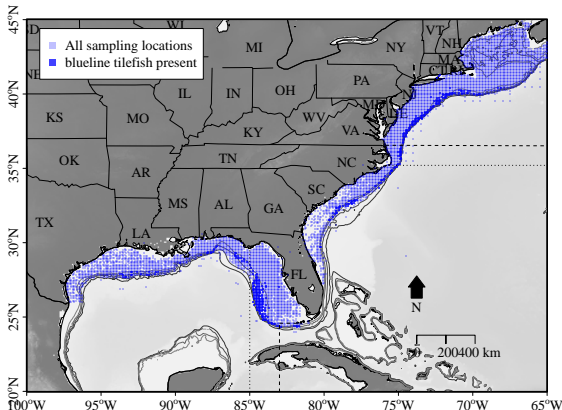
1. Age data
2. Length data
3. Indices of abundance
4. Removals (landings and dead discards)
5. Life history parameters
6. Beverton-Holt steepness parameter

Data Structure

Age Data

- In the previous assessment of Atlantic Blueline Tilefish (SEDAR 32; 2013) aging data were used and the stock was modeled using a statistical catch-at-age model

- At the SEDAR 50 was scheduled, it was expected that aging data would also be available

- During Blueline Tilefish Age Workshop II (August 29-31, 2016) ages were determined not to be reliable

- Therefore no valid age data were available for SEDAR 50

- No age compositions

- Growth model and natural mortality estimates estimated from other data sources

Data Structure

Atlantic south of Cape Hatteras: length data

- Three fleets:
  1. Commercial handline (1983-2015; $n = 9347$ fish)
  2. Commercial longline (1984-2015; $n = 15646$ fish)
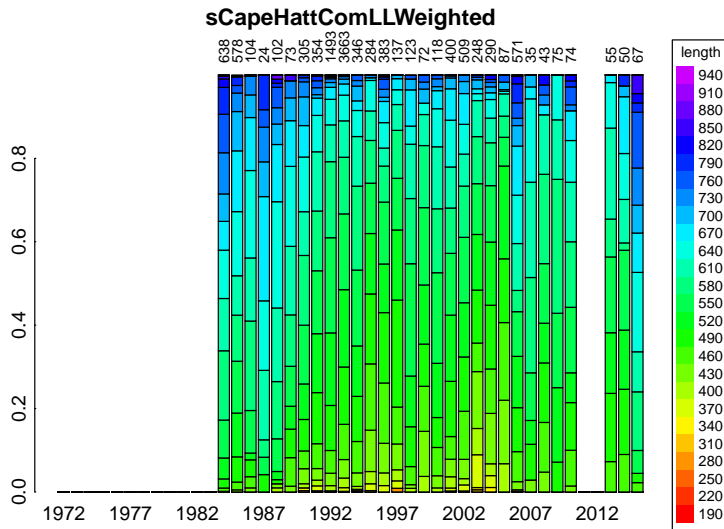 3. General recreational (1972-2015; $n = 6044$ fish)
     Combining lengths from:
     - ★ Headboat survey
     - ★ Marine Recreational Information Program (MRIP) survey

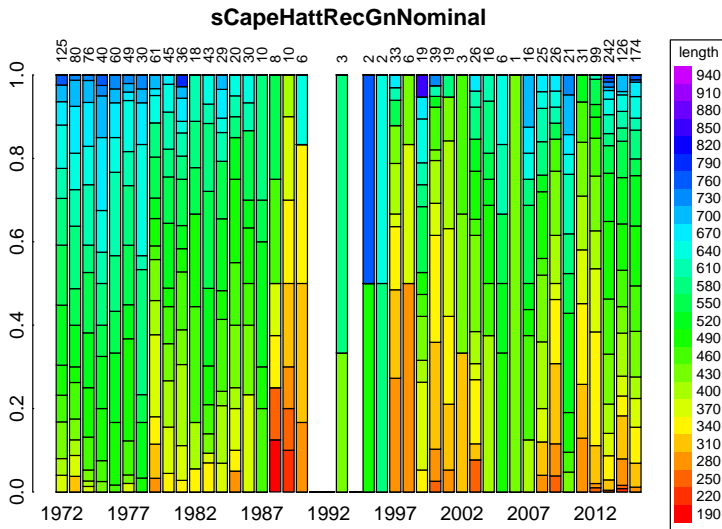**Atlantic south of Cape Hatteras: commercial handline lengths**

sCapeHattComHLWeighted

Data Structure
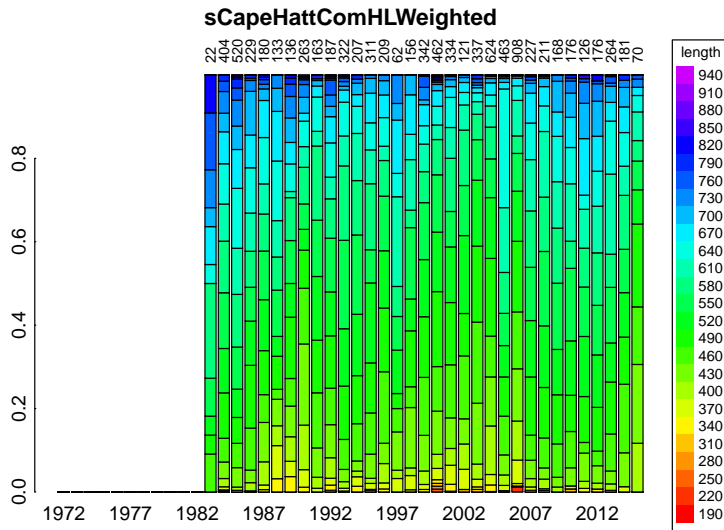
Atlantic south of Cape Hatteras: commercial longline lengths

Data Structure

Atlantic south of Cape Hatteras: general recreational lengths
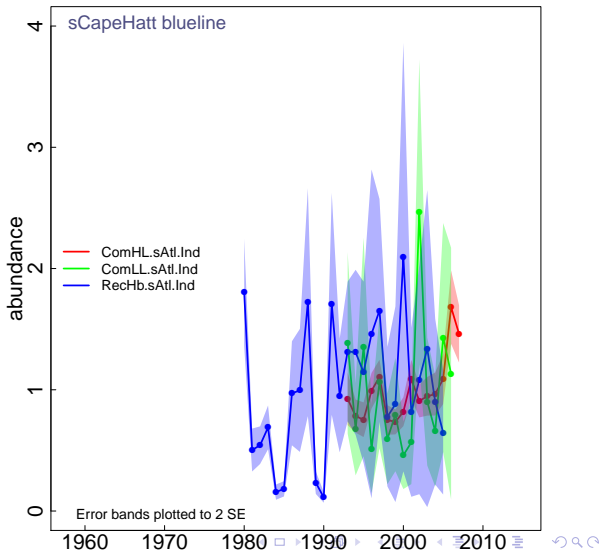

sCapeHattRecGnNominal

Data Structure

Atlantic south of Cape Hatteras: indices

- Three fleets:
  1. Commercial handline (1993-2007)
  2. Commercial longline (1993-2008)
  3. Recreational headboat (1993-2006)

Data Structure

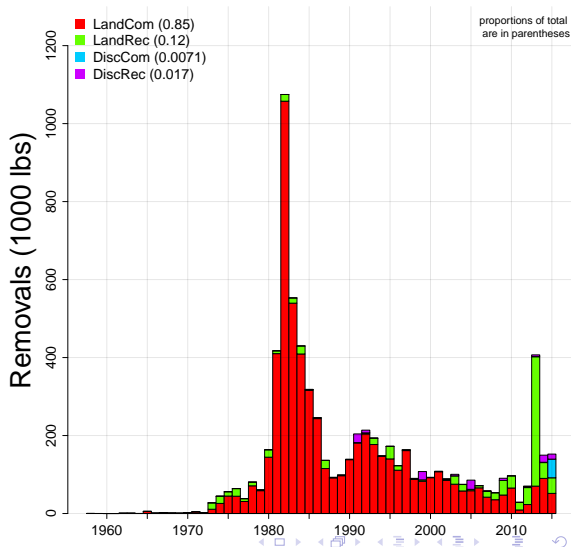**Atlantic south of Cape Hatteras: indices**

Indices of abundance

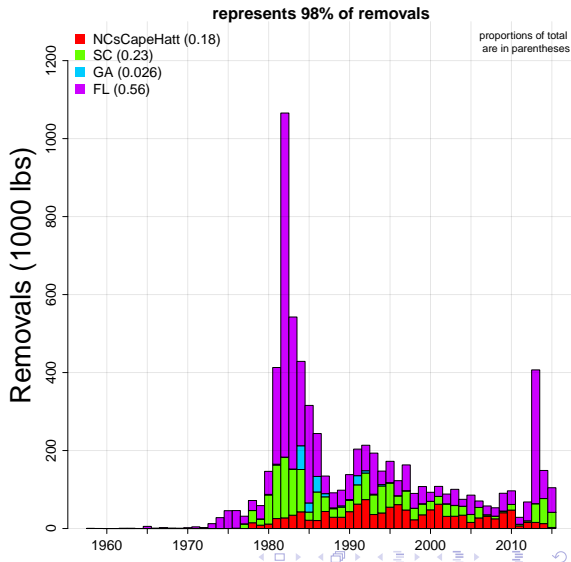# Data Structure

Atlantic south of Cape Hatteras: removals

Removals by fleet

- Includes landings and dead discards
- Discard mortalities were determined by the data workshop
  - Com. 95%
  - Rec. 82%

Data Structure

Atlantic south of Cape Hatteras: removals

Removals by aggregated
area

Data Structure

Atlantic south of Cape Hatteras: life history

- Growth
  - Parameters of a Von Bertelanffy growth model were estimated from meta-analysis at the SEDAR 50 Data Workshop
    - $\star$ $L_\infty = 690$ mm FL was estimated from a distribution of Blueline Tilefish lengths
    - $\star$ $K = 0.16$ yr^{-1} estimated from relationship between L_∞ and K from meta-analysis of related species
    - $\star$ $t_0 = -1.33$ yr estimated as the mean t_0 from meta-analysis of related species
- Natural mortality
  - Assumed a maximum age (t_{max}) of 40 yr based on Golden Tilefish
  - Then et al. (2014) equation: $4.899 t_{max}^{-0.916} = M = 0.17$

Data Structure

Atlantic south of Cape Hatteras: life history

- Female reproductive output at age
  - ▶ Female maturity
    - ★ Length at 50% maturity estimated from empirical data for Blueline Tilefish in the Atlantic ($n = 1353$ fish) though only 4 fish were immature ($L_{50} = 305$ mm FL)
  - ▶ batch fecundity
    - ★ Batch fecundity as a function of length was empirical from data for Blueline Tilefish in the Atlantic ($n = 39$ fish)
  - ▶ batch number
    - ★ Estimated from empirical data for Blueline Tilefish in the Atlantic (94 spawns per year)
  - ▶ sex ratio
    - ★ Estimated from empirical data for Blueline Tilefish in the Atlantic (1:1; $n = 2524$)

Data Structure

Atlantic south of Cape Hatteras: Beverton-Holt steepness

- Assumed value of 0.836 based meta-analysis from SEDAR 32

- SEDAR 32 value based on species with a similar life history from Myers et al. (2002), meta-analysis of demersal fish stocks by Shertzer and Conn (2012), and the value assumed in prior assessments of a similar species (e.g., SEDAR 25, golden tilefish).

Data Structure

Atlantic north of Cape Hatteras: length data

- Two fleets:
  1. Commercial handline (1985-2014; $n = 652$ fish)
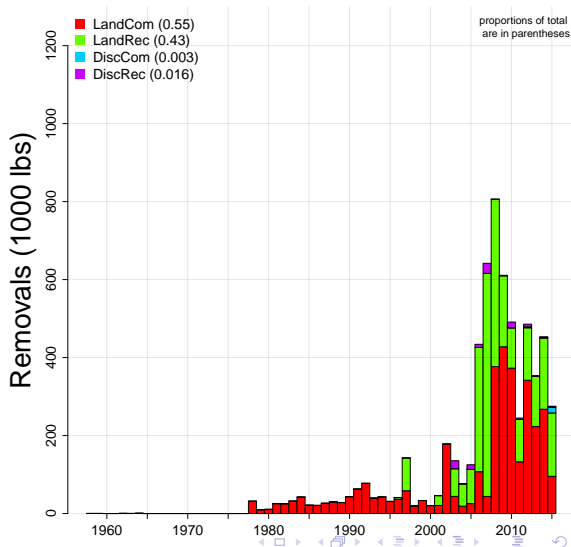 2. Commercial longline (2008-2015; $n = 4345$ fish)

Data Structure

Atlantic north of Cape Hatteras: indices

- There are no available indices to represent this area

Data Structure
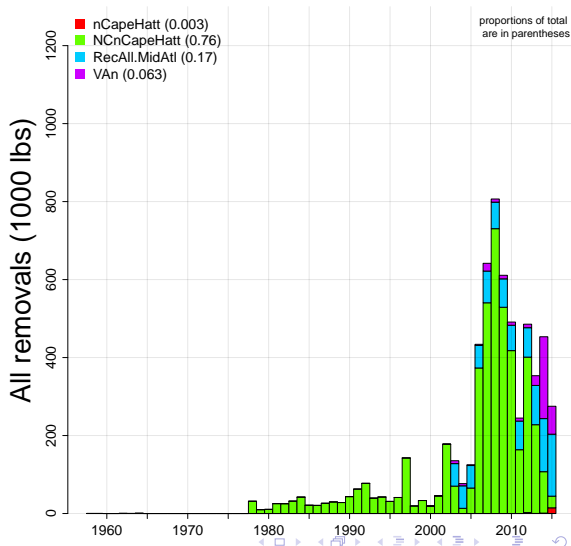
Atlantic north of Cape Hatteras: removals

Removals by fleet

- Includes landings and dead discards

Data Structure

Atlantic north of Cape Hatteras: removals

Removals by area

Data Structure

Atlantic north of Cape Hatteras: life history and Beverton-Holt steepness

- Used same values as for Atlantic south of Cape Hatteras

Data Structure

Gulf of Mexico: length data

- Two fleets:
    1. Commercial handline (1985-2015; $n = 1342$ fish)
    2. Commercial longline (1984-2015; $n = 12237$ fish)
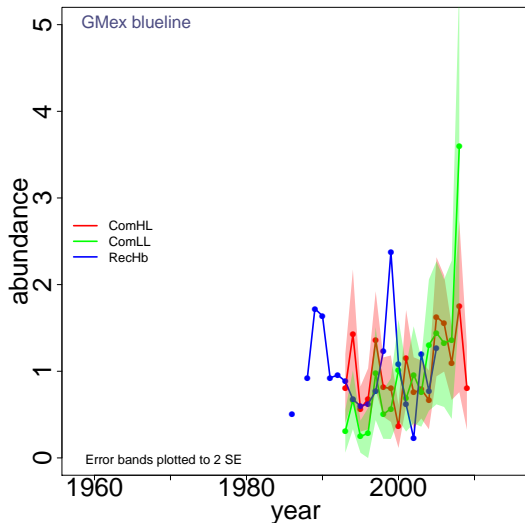
Data Structure

Gulf of Mexico: indices

- Three fleets:
    1. Commercial handline (1993-2009)
    2. Commercial longline (1993-2008)
    3. Recreational headboat (1986-2005)

Data Structure

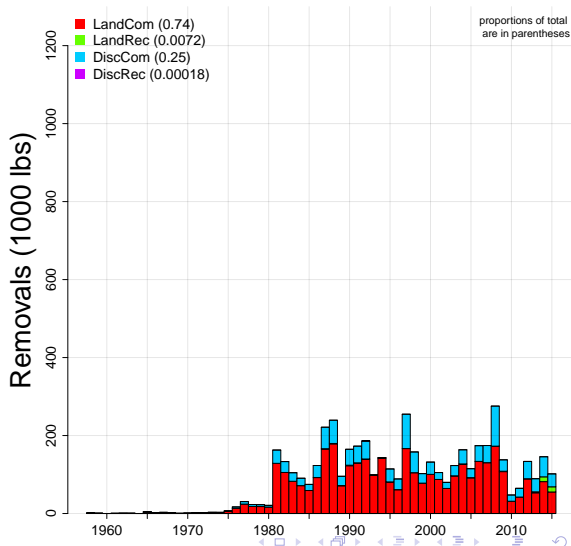**Gulf of Mexico: indices**

Indices of abundance

Data Structure

Gulf of Mexico: removals

Removals by fleet

- Includes landings and dead discards

Data Structure

Gulf of Mexico: removals

Removals by area

Data Structure
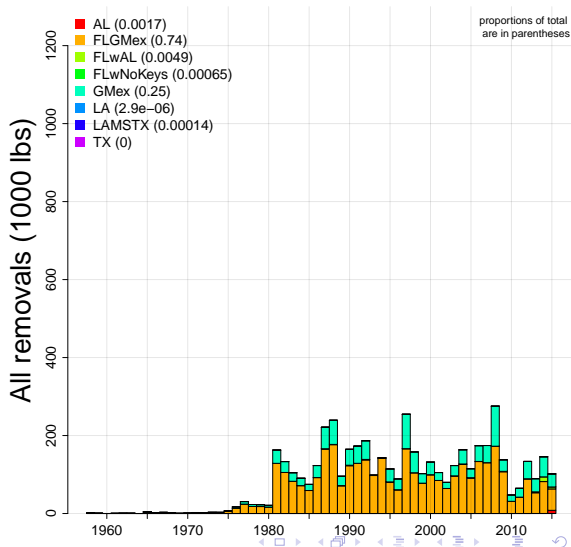
Gulf of Mexico: life history and Beverton-Holt steepness

- Used same values as for Atlantic south of Cape Hatteras

Modeling Approach

Atlantic south of Cape Hatteras

- Age-aggregated surplus production models were chosen as the primary models for management advice since the necessary data were most reliable

- An age-structured production models were also run, but was used only as supplementary analysis since life history data and Beverton-Holt steepness was based on meta-analysis

- Stochastic stock-reduction analysis was attempted but the Assessment Panel did not find it informative

- Data limited methods (R package DLMtool) were also conducted for comparison with similar analysis in the Atlantic north of Cape Hatteras

Modeling Approach

Atlantic north of Cape Hatteras

- Data limited methods (R package DLMtool) were the best avaiable to provide management advice for this region

Modeling Approach

Gulf of Mexico

- Age-aggregated surplus production models were the best available for this region
- Data limited methods (R package `DLMtool`) were also conducted as supplementary analysis
- These analyses are not meant to provide management advice for the Gulf of Mexico but rather to provide information about potential influence of Gulf of Mexico Blueline Tilefish on the Atlantic