Fisheries-independent pilot survey for Golden (Lopholatilus chamaelonticeps) and Blueline (Caulolatilus microps) Tilefish throughout the range from Georges Bank to Cape Hatteras

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The Survey Team

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Project Objectives

Objective 1: Establish a comprehensive fishery-independent bottom long-line survey for the Golden and Blueline Tilefish along the Atlantic coast.

Objective 2: Quantify the relative abundance, distribution and size-structure of the two species.

Objective 3: Evaluate the role of environmental variables in driving the observed spatial distribution patterns.

Objective 4: Evaluate proposed survey design (cost, proposed sampling intensity and statistical power).
Objective 1: Establish A Comprehensive Survey

- Survey design: Consisted of stations representing the “core” fishing areas based on commercial catch and deeper/shallower “expanded” region to evaluate areas outside of the traditional fishery.
- Stratified random sampling design (Target – 206 stations)
  - 9 north-south regions & 4 depth ranges, resulting from Montauk Meeting (April 2017)
  - Stations were initially allocated to strata approximately in proportion to area
  - No stations allocated to most northern strata (01,02) with exception of 02-3
  - Minimum of 3 stations per depth strata (01,04)
  - Core region = 164 stations; Expanded region = 42 stations
- Two cruises: July 19-28/August 5-16
Strata consisted of 9 north-south regions and 4 depth ranges:

1. 41-44.9 fa (75-82 m)
2. 45-53.9 fa (82-97 m)
3. 54-137.9 fa (97-252 m)
4. 138-166 fa (252-304 m)
We used bottom long-lines that consisted of a one-nautical mile (1,852 m) mainline equipped with 150 evenly spaced gangions.

**Hook sizes:**
- small = 8/0
- regular = 12/0
- large = 14/0

Distributed by a ratio of 20-60-20.

15 (10%) hook timers per set.
Objective 2: Quantify Abundance, Distribution & Size-Structure

- Survey statistics:
  - 194 stations
  - 188 CTD casts
  - 25 days

Tissues from 554 tilefish, including fin, reproductive, muscle, liver, stomach and otoliths were sampled.
Size Distribution of Catch by Depth

Small individuals were generally caught in shallower depth strata

Survey dominated by Goldens ~45 cm and Bluelines ~60 cm
Small hooks caught most individuals.

For large individuals, there was no difference among hook size.
Blueline Catch by Hook Size

Small hooks caught all size classes

Large hooks did not catch small fish
Objective 2: Key Findings

- Golden Tilefish showed a core area of abundance approximately from south of the Hudson Canyon near Toms Complex to southern Georges Bank near Veatch Canyon.
  - Catches were patchy throughout the range.
  - Depth strata 3 dominated catches, none were captured in depth strata 1.
- Catches of Blueline Tilefish were low and patchy.
- Larger hooks did not capture more large Tilefish of both species; however, small hooks captured a greater number of small Tilefish.
  - Golden catch was dominated by 45 cm individuals
  - Blueline catch was dominated by 60 cm individuals
Objective 3: Environmental Drivers of Spatial Distribution

Perry & Smith 1994:
Method for identifying associations between environmental conditions and distributions of fish using survey data

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<th>Parameter</th>
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<th>50th</th>
<th>95th</th>
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<tr>
<td>Temperature (°C)</td>
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<td>12.1</td>
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<tr>
<td>Dissolved Oxygen (mg/L)</td>
<td>5.9</td>
<td>6.1</td>
<td>6.6</td>
</tr>
<tr>
<td>Depth (m)</td>
<td>113</td>
<td>128</td>
<td>165</td>
</tr>
</tbody>
</table>
Objective 3: Key Findings

Results:
- Golden Tilefish occupied a very narrow temperature range and relatively narrow depth, oxygen and salinity range.
  - Possible limitation for range expansion.
  - Sensitive to environment change.
- Blueline Tilefish results were not significant; however, the species also displayed a limited temperature and depth range.

Emerging trends:
- Relationships would be further defined with additional sampling; especially, for Blueline Tilefish.
- The multivariable Generalized Additive Models (GAMs) did identify habitat drivers but samples size limited model performance for both species.
Objective 4: Optimizing Survey Design

- Sampling designs (following Cochran 1979):
  - **Random Allocation**—ignores strata and collects samples at random locations
  - **Proportional Allocation**—allocation of samples to strata is proportional to the size of each strata
  - **Optimum Allocation**—tries to balance precision and cost

- Evaluation function:
  - Cost = fixed cost + sampling cost – revenue

- Step I: Minimize the variance of the mean and the cost to estimate the optimal proportion of samples in each strata.

- Step II: To determine the total sample size a fixed variance or a fixed cost is chosen. We did the former by choosing a $cv$.

- Used to evaluate each species in core areas and species combined.
Study Area (Golden + Blueline)

Basic survey results:
- $\bar{y}_{st} = 3.06$ fish per line
- $s(\bar{y}_{st}) = 0.38$
- $cv = 0.13$
- $n = 194$
- 95% CI $= [2.30, 3.82]$

Precision
- $cv_{ran} = 0.17$
- $cv_{prop} = 0.14$
- $cv_{opt} = 0.09$

Cost opt allocation:
- Field survey cost $= $149,273
- Revenue $= $7,177
- Net $= $142,096

Optimum stratification:
- Shift sampling allocation toward six strata (03-3, 04-3, 05-3, 07-3, 08-2, 09-2) with the highest $\bar{y}_{st}, S_h$
- Optimum allocation reduce $cv$ to 0.09 with no increased sampling effort
Objective 4: Key Findings

- Proportional and optimum allocation of samples produce gains in precision over random sampling for the overall survey.

- For the overall survey, it seems possible to obtain a $cv$ of 10% or better by shifting sampling effort to strata with larger mean stratified abundance.

- For the individual models – a 30% increase in sampling effort would also be required for Golden Tilefish to meet a $cv = 0.1$ for optimal allocation. Sampling would need to be increased almost 10-fold for Blueline Tilefish (very patchy distribution).

- Revenue generated by selling fish can reduce the survey cost by 2-10%.
Final Thoughts

- We designed and implemented an ambitious survey.
- The survey has provided data in many key areas:
  - Distribution and regional relative abundance
  - Data on hook selectivity with potential implications to the use of a domed shaped selectivity function in the stock assessment
  - Environmental habitat associations
- Future surveys could target “core” areas or the entire area.
- Estimated optimal survey costs were consistent with actual project cost ($1,200 under current project!).
- Future survey would have higher personnel cost (current:~80k).
- Successful collaboration between industry, research and the council.