FINAL REPORT (December 31, 2020)

PROJECT: Fishery-independent 2020 bottom longline survey for the Mid-Atlantic Golden Tilefish (*Lopholatilus chamaeleonticeps*) stock (Award #: 1910035)

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Key findings:

Abundance and distribution:

- GTF showed a core area of abundance approximately from south of the Hudson Canyon near Toms Complex to southern Georges Bank near Veatch Canyon consistent with 2017 pilot survey findings.
- Depth strata 3 (54-137.9 fathoms) dominated catches consistent with pilot survey findings.
- Small hooks (8/0) captured a greater number of small GTF consistent with pilot survey findings.

Survey design analysis:

- By shifting survey effort to strata with larger mean abundance, variance and area based on recommendations from the pilot survey, the 2020 survey obtained a cv of 12%, a reduction of 14% compared to the 2017 pilot survey.
- Revenue generated by selling fish reduced the survey cost by 5%. The survey cost was limited due to market value of GTF during the COVID19 pandemic. We expect that revenue generated during this survey would have been greater if not for the pandemic.

***Recommendations*:**

1.0 Data from the two surveys provide the information needed to track cohorts and to inform assessment model selectivity (i.e., domed shaped selectivity) for GTF in the core region of abundance. The combined data can serve to address the tradeoff between using a single hook verses multiple hook sizes.

2.0 Data from the two surveys provide important information to suggest that there is a slight reduction in catchability of the larger fish on the small hooks. This can be used to inform the dome shaped selectivity pattern in the assessment. Aging of the 2013-year class from the 2017 survey to the 2020 survey would help confirm selectivity differences with hook size.

3.0 A smaller survey focused on the core region of abundance (depth strata 2 and 3) conducted each year using only small hooks could be more valuable in providing information on pre-recruits (year class strengths before they are fully recruited to the fishery) than a full survey conducted in alternate years. However, additional data analyses need to be conducted to assess this point.

4.0 The 2020 GTF survey produce lower CVs than reported for the pilot survey. However, caution in interpretation is warranted given the use of three versus two hook sizes among the surveys.

5.0 The 2020 survey did not produce a large amount of revenue from sold fish, like the pilot survey. This is in part due to the low market value of GTF during the COVID-19 pandemic. However, we recommend that future surveys continue to sell GTF to offset survey costs for two primary reasons: first, some years may produce large revenues and second discarded fish have very low survival and would be wasted.

6.0 Due to COVID-related guidance, the 2020 survey was delayed until July. The survey being conducted in July does provide a comparative timeline with the pilot survey

7.0 Due to COVID-related guidance, the 2020 survey was conducted with a single scientific personal. The current project benefited from the additional F/V crew participation in data and sample collection and future surveys will require 1 additional person to assist in cruise and data analyses. Considering the current implementation of the survey this could be achieved by a graduate student or additional crew member.

Background

The 2020 Golden Tilefish fishery-independent bottom longline survey was developed based on recommendations from the pilot Golden (GTF) and Blueline (BTL) Tilefish fishery-independent bottom longline survey conducted in the summer of 2017 (Frisk et al. 2018; http://www.mafmc.org/tilefish). The goal of the pilot survey was five-fold; (1) Establish a comprehensive fishery-independent bottom long-line survey for GTF and BTL along the Atlantic coast; (2) Quantify the number of individuals and size-structure of the two species; (3) Determine the spatial distribution of both species and identify preferred depth strata across size range; (4) Evaluate the role of environmental variables in driving the observed spatial distribution patterns and; (5) Evaluate proposed sampling intensity and statistical power.

The 2017 pilot survey was conducted from Georges Bank to Cape Hatteras. The low incidence of encounters with BTL during the pilot survey prompted recommendations from the Tilefish Survey Review Committee to focus the 2020 survey on GTF only (https://www.mafmc.org/tilefish). The goal of this 2020 fishery-independent bottom longline survey was to derive an index of abundance for GTF stock while also reducing the cost of the survey. Further recommendations based on the results of the pilot survey, suggested that an index of relative abundance for the GTF stock could be accomplished with a reduced number of stations focused on the core region of GTF occupation. Specifically, the 2020 survey design included 115 stations sampled in a single trip of 14 days; a reduction in effort of approximately 50% from the pilot survey. The 2020 survey was designed to begin a fishery-independent time series for GTF while also addressing considerations for optimizing a long-term GTF bottom long-line survey; (1) optimal survey periodicity (annual or biennial) and (2) hook selectivity.

2020 Survey Design

The 2020 Golden Tilefish (GTF) survey used a stratified random design consistent with the 2017 pilot survey with a target of 115 stations. This was a reduction in stations from 206 to 115. The 2020 survey consisted of sampling stations representing the core fishing areas for the mid-Atlantic GTF population based on commercial catch data and the 2017 pilot survey. The core area included 4 north-south regions (N-S codes 3-6) based on NEFSC bottom trawl survey latitudinal strata boundaries and 3 depth ranges (depth codes 2-4), developed for the 2017 pilot survey (Figure 1, inset), that considered GTF depth distributions. Stratification was based on the following depth ranges (in fathoms/meters): 2 = 45-53.9/82.3-98.6, 3 = 54-137.9/98.8-252.2 and 4 = 138-166/252.4-303.6. The N-S strata are labeled 03 to 06 and the depths 2-4; coded as for example 03-2 (Figure 1).

Stations were allocated to strata approximately in proportion to area, consistent with station allocation from the 2017 pilot survey (Table 1). Under the reduced survey area in 2020, no stations were allocated to N-S strata 01, 02, 07, 08 and 09 or inner depth strata 01 (41-44.9 fa/75-82.1 m). After assigning stations based on area, additional stations were added to depth strata 04 to meet a minimum of three stations in each of those depth strata. Overall, the 2020 survey had a total of 115 completed stations (Table 1).

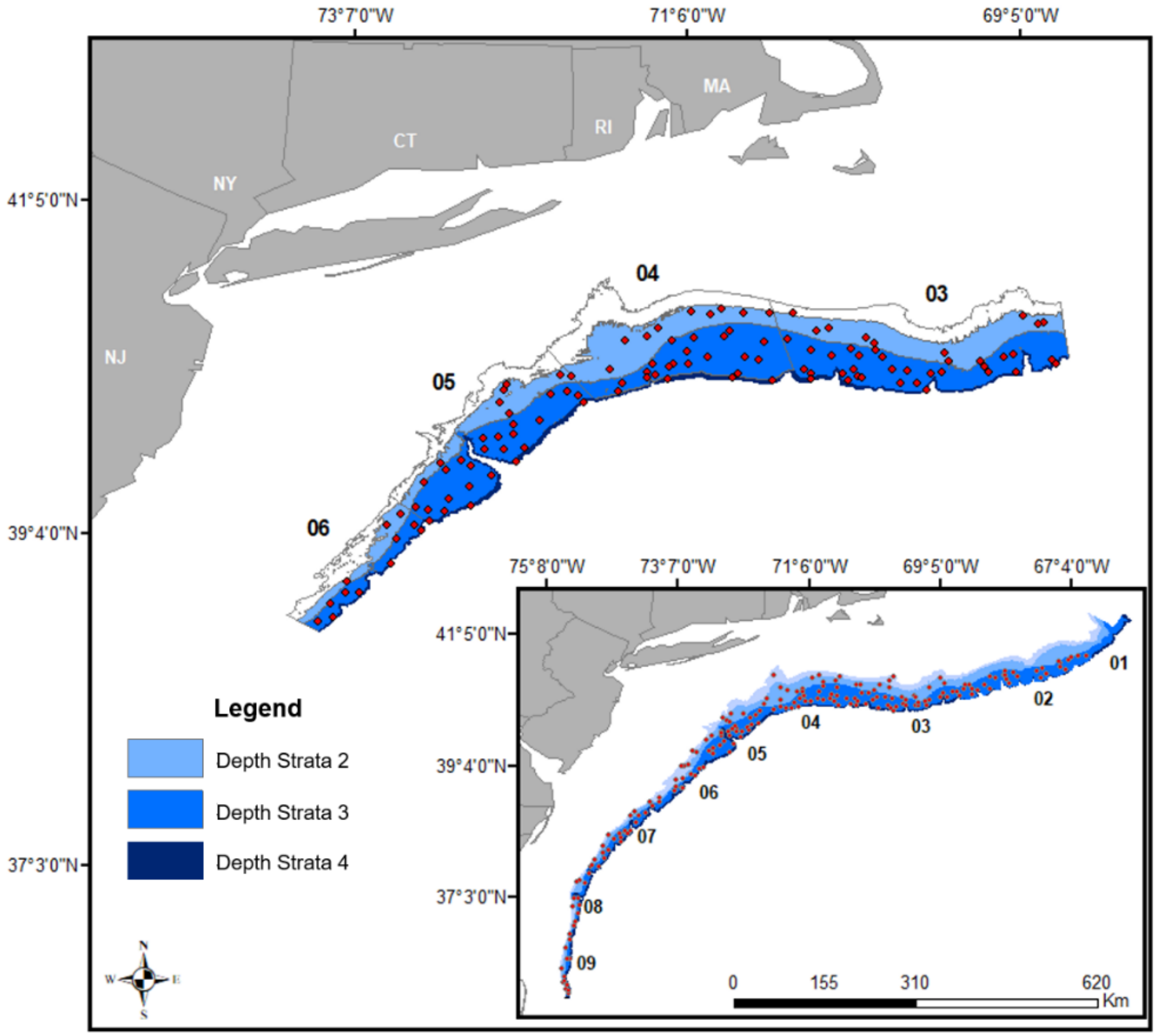

Figure 1. Stratified random sampling design for the 2020 survey compared to the 2017 pilot survey sampling design (inset). Strata included four north-south regions (03-06) and three depth ranges (2-4). See Table 1 for the distribution and allocation of stations within each stratum.

The survey was initially scheduled for month of June for purposes of measuring GTF maturation prior to peak spawning while also allowing for reduced dogfish interactions and possible gear saturation issues within the survey. However, due to logistical constraints associated with COVID-19, the survey was conducted July 7th-July 19th. F/V Sea Capture personal included Captain John Nolan and crew members, Robert Aaronson, Andrew Foglia and Tom Eshenfelder. Scientific crew included Jill Olin (MTU).

Table 1. Distribution and allocation of stations by latitude-depth strata in the 2020 survey.

Strata	Area (km^2)	% Total Area	# Proposed	# Actual
03--2	2320.7	14.3	9	10
03--3	3184.3	19.6	27	27
03--4	177.3	1.1	3	4
04--2	2167.4	13.4	10	9
04--3	2538.4	15.7	20	19
04--4	240.7	1.5	3	2
05--2	1236.1	7.6	6	7
05--3	2720.4	16.8	22	22
05--4	208.6	1.3	3	3
06--2	630.7	3.9	3	3
06--3	727.7	4.5	6	6
06--4	57.3	0.4	3	3

Gear and deployment

We used bottom long-lines that consisted of one-nautical mile (1,852 m) mainline equipped with 150 evenly spaced gangions. Hook saturation was not observed during the 2017 pilot survey when deploying 150 gangions per line, therefore, to maintain consistency and allow for comparisons among surveys, 150 hooks were deployed per set.

We deployed two different offset circle hook sizes, distributed at a ratio of 50-50 per each set; these included small hooks (small = 8/0) and those that used by the industry (regular = 12/0). The use of two offset circle hook sizes is a departure from the 2017 pilot survey where we deployed three different offset circle hook sizes (small = 8/0, regular = 12/0, large = 14/0), distributed at a ratio of 20-60-20. The goal of deploying the different hook sizes in 2017 was to inform hook selectivity, track cohorts and to provide information that can be used in a pre-recruit index. The pilot survey indicated that small circle hooks (8/0) caught few large GTF and more small GTF relative to regular circle hooks (12/0), and large circle hooks (14/0) caught few individuals overall. Given these findings, the 2020 survey was designed to determine if the small circle hooks (8/0) could provide additional information to a pre-recruit index relative to the regular circle hooks (12/0) as well as inform assessment model selectivity (i.e., domed shaped selectivity).

The pilot survey used a consistent bait size across hooks to standardize attraction and reduce potential bias across hook sizes. The use of a consistent bait size for all hook sizes was determined to be problematic, as GTF < 30 cm may have difficulty taking the bait or are able to consume bait without biting the hook. Thus, the potential existed that the number of small GTF captured on small circle hooks during the pilot survey were biased. Following the recommendation from the Tilefish Survey Review Committee, bait (*Illex* spp.) size was scaled with hook size in the 2020 survey, with smaller baits used on small circle hooks relative to regular circle hooks. Bait presence was recorded by hook number and hook size for each set. Catch by hook number and hook size was also recorded for each set.

The pilot survey design included the deployment of hook timers on 10% of the regular circle hooks for each set (30 per set). Activation of the hook timer failed on nearly every deployment, with a total of three timers being activated overall during the 2017 survey. The three hook timers that did activate indicated a duration of 22-30 minutes of fishing before catching. Hook timers were not used in the 2020 survey due to low incidences of activation and slowed deployment and haul speed. However, the data from the three activated timers informed deployment duration for the 2020 survey. All attempts to maintain a consistent soak duration were made, with a minimum of 50 minutes. However, to accommodate the number of stations in the survey and the steam time between locations, soak time ranged from 50–484 minutes with an average soak time of 121 minutes. There was no relationship between soak time and GTF catch

(Supplemental Figure 1). All fishing occurred in daylight hours, with the first line set no earlier than sunrise (~5:00) and the last no later than 30 minutes before sunset (~21:30). There was no relationship between GTF catch and the time of initial deployment (Supplemental Figure 2).

A single temperature logger was attached to the mid-line and two current meters (when possible) were attached at the end of each line (see summary by strata in Table 2 and by station in Supplemental Table 1). Missing temperature and current meter data results from the loss of a temperature logger and issues with current meter deployment at those sites. Current meter output data include: speed (cm/sec), bearing (°) and velocity (cm/sec) provided in north and east components. Negative values represent current to the south and west, respectively. Data were averaged over 5 min burst intervals for the duration of each deployment following Lowell Instrument guidelines (Supplemental Table 1).

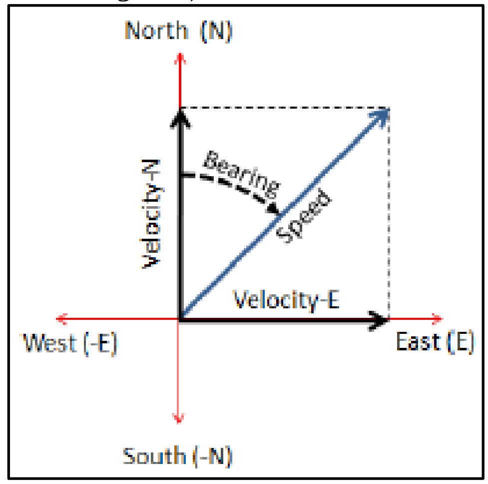

Figure 2. Current meter output illustrating the relationship between speed, bearing and velocity (Lowell Instruments).

Species-level identifications were recorded in the field and all individuals were enumerated, measured for total length (TL; mm) in the case of fishes and disk width (DW; mm) in the case of skates and rays, and weighed (kg) with hand-held spring scale. GTF were sexed (via examination of gonads upon dissection in the field) and gonads were classified as immature or mature following the criteria outlined in Idelberger (1985). Immature classes included developing gonads. Mature classes included ripe and resting gonads. Tilefish catch-per-unit-effort (CPUE), from a total of 115 sets was expressed as numbers of individuals per number of hooks deployed.

Table 2. Summary of depth (range) and water temperature (mean ± SD; °C) for the three depth strata.

Strata	n	Depth (fa)	Depth (m)	Surface Temperature (°C)	Bottom Temperature (°C)
2	22	45–66	82–98	21.6 ± 1.6	10.9 ± 1.2
3	66	54–139	99–250	21.8 ± 2.0	12.6 ± 0.6
4	11	138-166	250–303	21.3 ± 3.6	11.0 ± 1.1

Abundance and distribution

Catch was recorded from all strata sampled during the survey. A total of 2,390 individuals were collected during the survey and included 16 species with GTF (*n* = 971), Spotted Hake (*n* = 743) and Smooth Dogfish (*n* = 518) dominating the catch (Supplemental Table 2). The 2020 survey resulted in higher catch of GTF compared with the 2017 survey (*n* = 619), even with 91 fewer stations sampled. A single mature BTL (FL: 64.0 cm; WT: 3.5 kg) was caught from strata 03-3 on a small circle hook during the 2020 survey. There was a notable increase in the number of Dogfish (Smooth + Spiny) caught in 2020 (*n* = 521) relative to 2017 (*n* = 9). These individuals ranged in size from 30-74 cm (mean ± SD; 51.6 ± 4.6). This may be a consequence of the timing of the survey, being conducted in early July (2020) compared with late-July and August (2017).

Consistent with the pilot survey, GTF were in highest abundance in depth strata 03 (99-252m; Figure 3), with the core region of abundance ranging from the southern edge of the Hudson Canyon to Veatch Canyon on Georges Bank (Figure 4). Stations in the shallowest and deepest strata (Figure 3) did not catch large abundances of GTF.

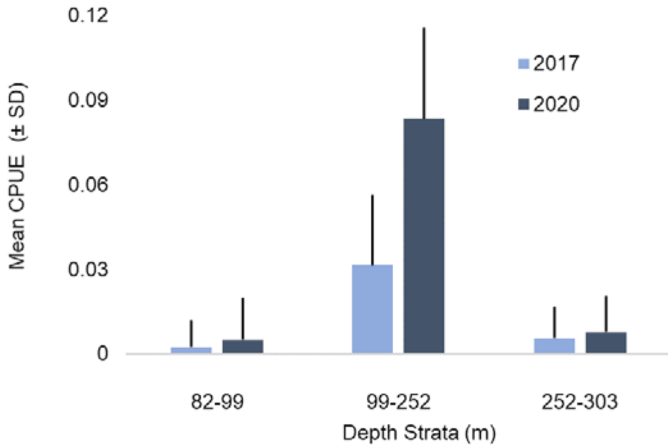

Figure 3. GTF CPUE (numbers per hook) by depth strata for the 2017 and 2020 surveys. Data are mean (± SD).

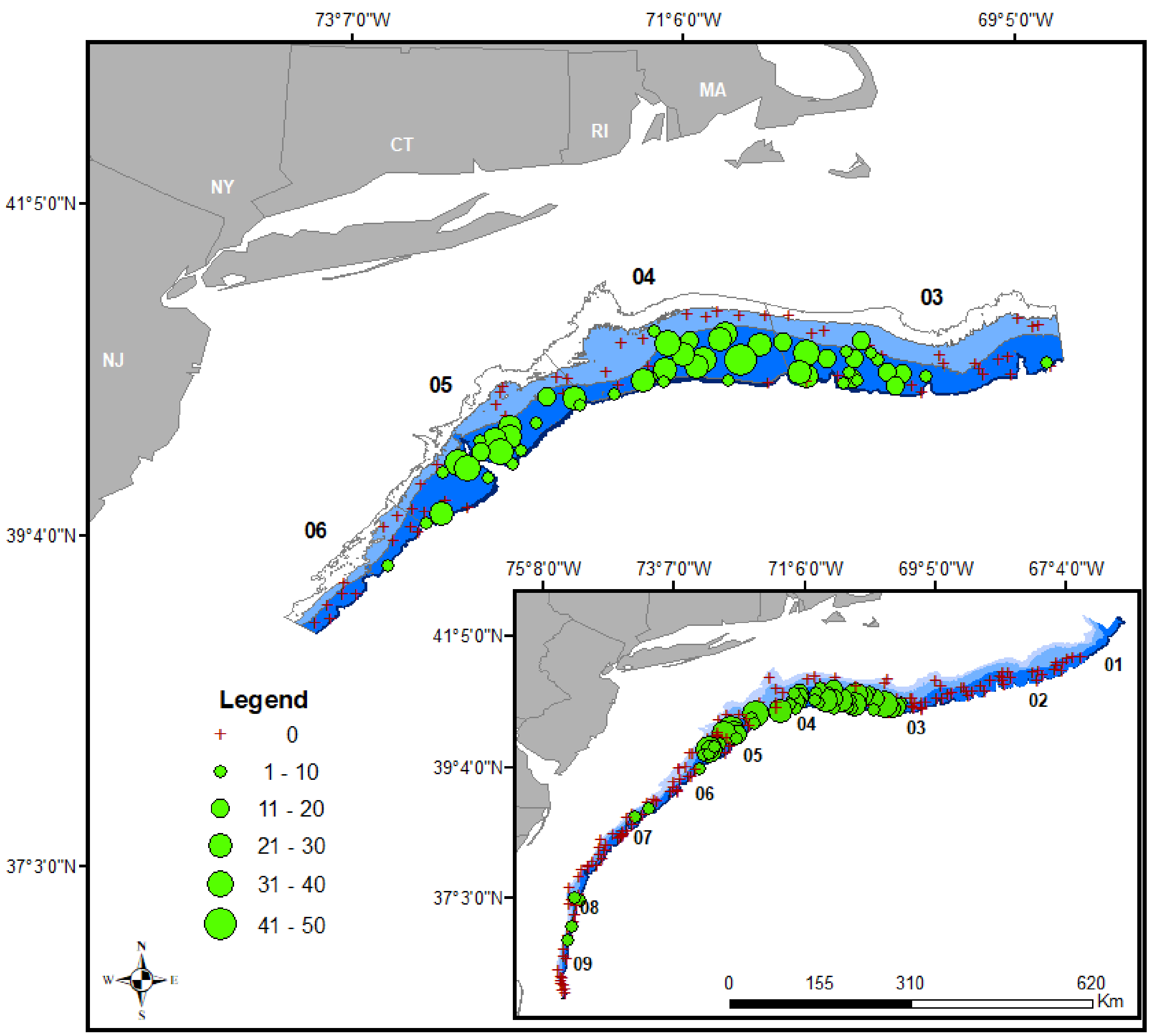

Figure 4. Station locations and distribution of GTF caught (number of individuals) in the 2020 survey (left panel) and the 2017 survey (inset). Zero catches are represented by (+).

Size-structure and maturity

A narrower size range of GTF were caught during the 2020 survey compared with the pilot survey; GTF ranged in size from 21 to 87 cm and weighed 0.2 to 6.0 kg. The survey was dominated by catches of GTF that averaged (± SD) 46 ± 9.4 cm in length (Figure 5). Smaller GTF were generally caught in shallower depth strata (Figure 4). There is a trend of increasing GTF length with depth; however, confidence intervals overlapped, and no further tests were conducted. Female GTF were collected from the deepest two strata, whereas male and unknown sex GTF were collected from all strata (Figure 5).

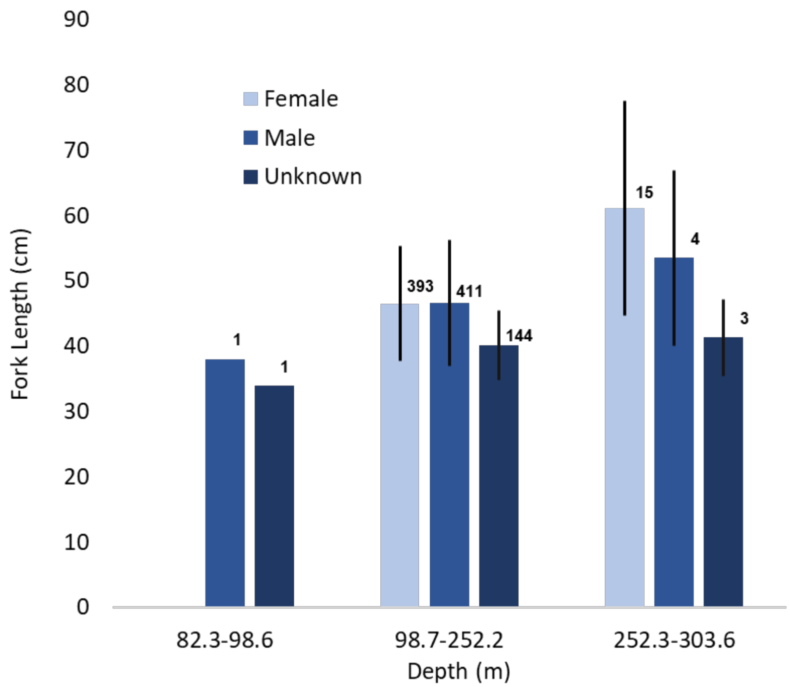

Figure 5. Catch (*n* indicated on bar) of GTF by fork length (cm). Data are mean (± SD) by sex.

Gonads were classified as immature or mature for all GTF caught in the survey. The proportion of immature and mature GTF was similar across all depth strata (Figure 6). The overall catch of GTF was dominated by immature individuals (Figure 6) from depth strata 02. Immature GTF were collected from all three depth strata; mature GTF were collected from the two deepest strata (Figure 6).

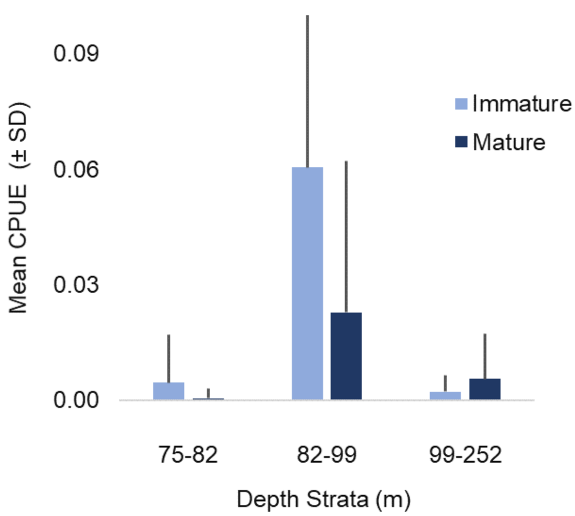

Figure 6. CPUE of maturity classes of GTF by depth strata.

Biological sampling
The 2020 survey provided an opportunity to collect and archive additional samples for future studies. A total of 184 GTF were sub-sampled for a range of tissues. These included fin, reproductive, muscle, liver, stomach, and otoliths. All tissues are currently being stored by J. Olin for future analyses.
To date, tissue samples collected from GTF and BTL as part of the 2017 pilot survey have laid the basis for the following research contributions:

- Olin JA, Shipley ON, Cerrato RM, Nitschke P, Magen C, Frisk MG. 2020. Separation of realized ecological niche axes among sympatric tilefishes provides insight into potential drivers of co-occurrence in the NW Atlantic. *Ecology and Evolution* 10: 10886–10898.
- Snyder SM, Olin JA, Pulster EL, Murawski SA. 2020. Spatial contrasts in hepatic and biliary PAHs in Tilefish (*Lopholatilus chamaeleonticeps*) throughout the Gulf of Mexico, with comparison to the Northwest Atlantic. *Environmental Pollution* 258: 113775.
- Roose H, Paterson G, Frisk MJ, Cerrato RM, Nitschke P, Olin JA. Regional patterns of mercury bioaccumulation among northwest Atlantic Golden (*Lopholatilus chamaeleonticeps*) and Blueline (*Caulolatilus microps*) Tilefish. *Expected submission: Science of the Total Environment: February 2021*.
- Dawson KM. Use of otolith microchemistry to infer early life history characteristics of Golden Tilefish (*Lopholatilus chamaeleonticeps*) in the NW Atlantic. *MS Thesis submission: May 2021*.

Gear Selectivity
A total number of 17,250 hooks in equal proportion were deployed in the 2020 survey (Table 3). Across all strata the average proportion of empty hooks was 76% (Table 3). Ten percent of the hooks retained bait upon retrieval, with regular hooks retaining bait at a higher frequency than small hooks across all strata (Table 3). Proportionally, the number of baited hooks returned to the boat was lowest in depth strata 04 (~5%) and highest in depth strata 03 (~71%). There was no relationship between soak time and the number of returned baits for either hook size (Supplemental Figure 3). Similarly, the fewest GTF were caught in depth strata 04 (Table 3). Small hooks caught 673 GTF (~70% of GTF catch) and regular hooks caught 298 GTF (~30% of GTF catch), with the majority of catch from depth strata 03 (Table 3).

Table 3. Summary of hook deployment and retrieval. Data represent the number of hooks deployed, fate of returned hook, total catch and catch of GTF by hook size (SM = small; REG = regular).

Strata	# Hooks Deployed	# Returned Bait	# Returned Bait SM/REG	Total Catch	Total GTF Catch	GTF Catch SM/REG	% Empty
03--2	1500	99	44/55	175	20	16/4	82
03--3	4050	376	176/200	466	227	159/68	79
03--4	600	45	20/25	48	0	0/0	85
04--2	1350	271	127/144	117	2	1/1	71
04--3	2850	343	139/204	715	371	254/117	63
04--4	300	47	17/30	12	3	3/0	80
05--2	1050	12	4/8	86	0	0/0	91
05--3	3300	468	189/279	585	337	234/103	68
05--4	450	1	1/0	37	10	6/4	92
06--2	450	39	23/16	17	0	0/0	88
06--3	900	51	17/34	109	0	0/0	82
06--4	450	0	0/0	23	1	0/1	95
Total	*17250*	*1752*	*757/955*	*2390*	*971*	*673/298*	*76%*

The distribution of catch across hook sizes was similar between the two surveys with small hooks overall catching the most GTF (Table 3). The spatial distribution of GTF catch was similar between hook sizes. The majority of GTF were caught in N-S strata 04 and 05 in depth strata 03 (Figure 7).

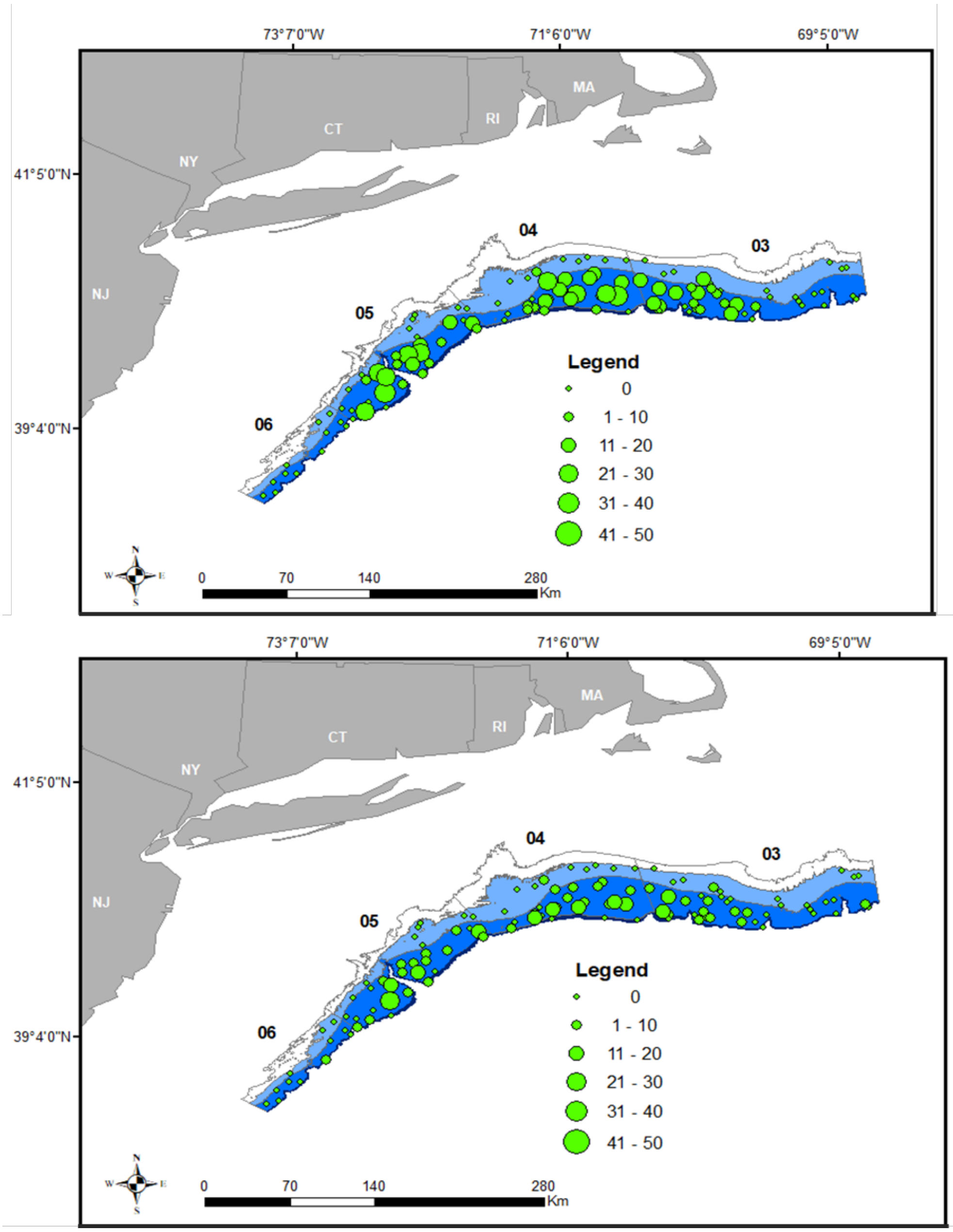

Figure 7. Spatial distribution of GTF by small (top panel) and regular (bottom panel) circle hooks sizes.

Small hooks caught GTF that ranged in length from 20-90 cm FL while regular hooks caught GTF that ranged in length from 30-90 cm FL (Figure 8 left panel). The highest catch for both hook sizes was of 40-50 cm GTF (Figure 8 left panel). The pilot survey showed that smaller hooks had higher catch rates than both regular and large hooks (Figure 8 right panel). Catch results of the pilot survey suggested that selectively of the small and regular hooks could be different. Specifically, there was a slight indication that smaller hooks caught fewer large and smaller GTF relative to regular hooks. This trend does appear

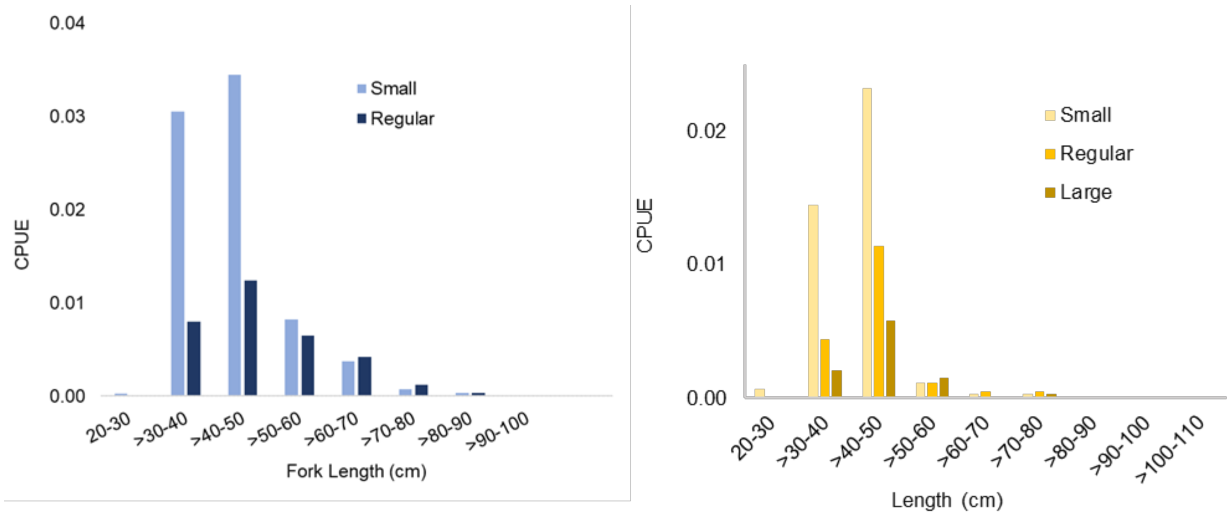

Figure 8. Length distributed CPUE by hook size from the 2020 (left panel) and 2017 (right panel) surveys.

in the 2020 survey, as catches were slightly larger for regular hooks in the (60-90 and 70-80 cm blocks Figures 8). The 2020 survey results are important for determining the differences in selectivity between hook sizes and to inform the optimal hook size to be used in a future GTF survey. This survey illustrates the tradeoff in catch rates between the hook sizes and the differences with selectivity (Figures 8 and 9). Careful consideration should be given to the small differences in potential catchability of the larger fish relative to regular hooks in future surveys versus the increase in overall catch rates of the smaller hook. For example, since catch rates are much higher for the small hooks with potentially only a small reduction in catch rates for the larger fish, then perhaps a reduction in survey effort that is done every year using the more efficient small hook size could yield better information given a fixed amount of funds available to conduct the survey. The 2020 survey does provide important information that suggests there is a slight reduction in catchability of the larger fish on the smaller hooks which can be used to inform the dome shaped selectivity pattern in the assessment. However, a smaller survey that is conducted each year using only smaller hooks could be more valuable in providing information on pre-recruits (year class strengths before they are fully recruited to the fishery).

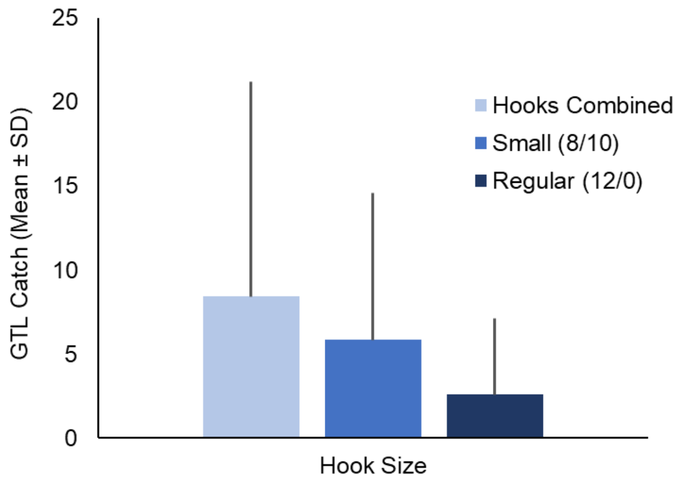

Figure 9. Mean GTF catch by hook size in 2020.

It was expected that the strong 2013-year class of GTF observed in the pilot survey would be larger in 2020 and result in higher catch rates of larger fish relative to the pilot. Catch of larger GTF was higher in the 2020 survey relative to the pilot, especially in GTF > 50 cm which is in line with the expected growth of the 2013-year class (Figure 9). Aging of the large 2013-year class from the 2017 survey with samples from the 2020 survey would help confirm selectivity differences with hook size. Considering the entire size range of GTF caught in the 2020 survey, small hooks caught more small fish (20-30 cm GTF) and caught a similar number of large fish as regular hooks (>70 cm; Figure 8 left panel). These findings are consistent with 2017 catch (Figure 8 right panel).

The observed GTF length data of GTF from the 2020 survey did not follow a common statistical distribution and appears in two modes between 35–50 cm fork length (Figure 10). This is a similar trend to that was observed in the pilot survey data. The two modes were most apparent in the small hook relative to the regular hook data. These two modes appear to lineup with age groups in the GTF population which can also be seen in the stock assessment. Because the data did not follow a common distribution, and appeared bi-model, typical analyses comparing means were not utilized. Instead, the observed length distributions were analyzed to determine if they originated from the same population using the non-parametric Kruskal-Wallis test. Significant differences in the distributions were not estimated by hook size (X^2 = 0.699, df = 1, p = 0.403). However, cumulative distribution functions of catch at length for small and regular hooks did show differences in cumulative catch by length class (Supplemental Figure 4), consistent with small hooks catching smaller GTF compared with regular hooks (Supplemental Figure 4).

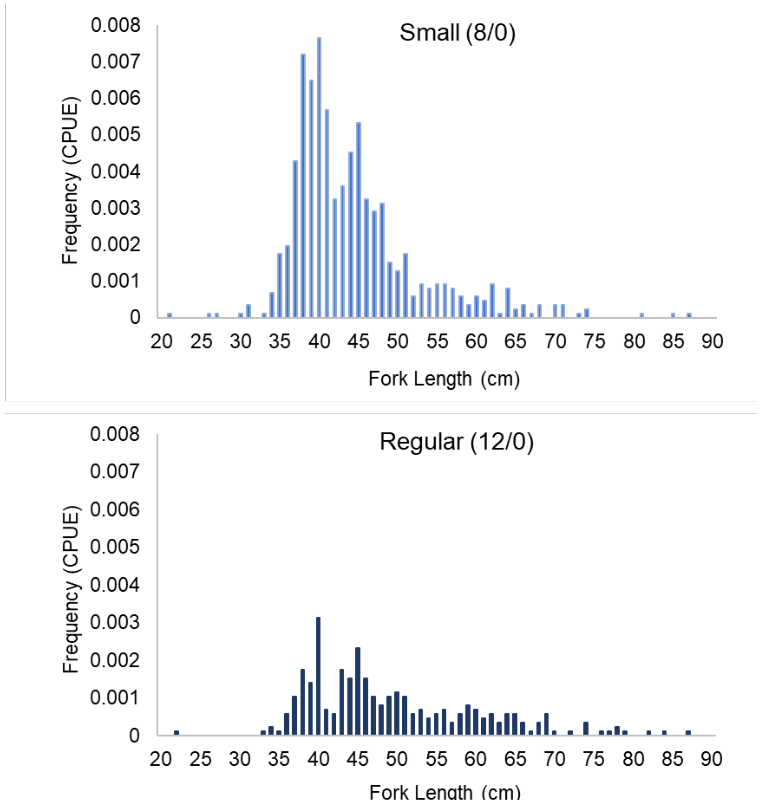

Figure 10. Length frequency of GTF by hook size from the 2020 survey.

Evaluation of survey design

The efficacy of the 2020 survey was evaluated by comparing the uncertainty of the estimated catch-weighted mean catch from stratified sampling ($\bar{y}_{st}$) with the pilot survey using an optimal allocation model where the financial cost of sampling is incorporated into the selection of the number of samples in each strata (see Frisk et al. 2018 for details of method). The intent of this evaluation is to compare the efficacy of a reduced sampling effort statistical power, catch levels, and financial cost. The optimum allocation approach was modified from Cochran (1977) by including a term reducing the cost of the survey by an amount equal to the value of the GTF sold to the market.

The optimum allocation results from the pilot survey when considering only the core area for GTF in the pilot survey (03-2, 03-3, 03-4, 04-2, 04-3, 04-4, 05-2, 05-3, 05-4), resulted in an estimated catch-weighted mean catch from stratified sampling ($\bar{y}_{st}$) of 5.34 individuals per line with a standard error ($s(\bar{y}_{st})$) of 0.92 individuals per line. A total of 94 stations were sampled within the core area during the pilot survey. The coefficient of variation ($s(\bar{y}_{st})/\ \bar{y}_{st}$) was 0.14. From these results, it was recommended to increase the fraction of samples in strata 03-3, 04-3, and 05-3 to improve the coefficient of variation and increase revenue from the sale of GTF. These strata had the largest mean catches per line, standard deviations, and potential revenue. The total cost of the 2017 pilot survey was $224K, with a field survey costs of $150K and sampling costs of ~74K with $6K in revenue.

In general terms, when comparing core catches from the pilot survey to the 2020 survey, there was an overall increase in GTF catch in the 2020 survey for a similar number of stations deployed (116 stations in pilot vs. 115 stations in 2020). The core area for GTF in 2020 (03-2, 03-3, 03-4, 04-2, 04-3, 04-4, 05-2, 05-3, 05-4; *n* = 103 stations), was expanded by the inclusion of strata 06-2, 06-3, 06-4 (*n* = 12 stations). The total cost of the 2020 survey was $175K with field survey costs of $84K and sampling costs of ~$89K with $9K in revenue. The estimated catch-weighted mean catch from stratified sampling ($\bar{y}_{st}$) was 7.68 individuals per line with a standard error ($s(\bar{y}_{st})$) of 0.92 individuals per line. A total of 115 stations were sampled within the core area. The coefficient of variation ($s(\bar{y}_{st})/\ \bar{y}_{st}$) was 0.12. Revenue generated by the sale of GTF caught during the 2020 survey offset the sampling cost by ~5%.

It is important to note that these evaluations of survey design did not standardize by hook size. Therefore, comparisons among years need to be made with caution as there were three hooks sizes used in the pilot survey and two hook sizes used in the 2020 survey. Given the differences in catch among hook sizes, particularly the large (14/0) hooks used in the pilot, the difference between surveys (3 hook sizes vs. 2 hook sizes) with respect to hooks deployed have the potential to alter the coefficient of variation.

Survey Summary

- Soak duration was set for 50 minutes. This was a reduction from the pilot survey that set minimum soak duration of 60 minutes. Soak duration was longer than 50 minutes at most stations due to the deployment of multiple lines at a single time. Deployment of multiple lines was necessary to accommodate the number of stations during the timeframe of the survey. There was no relationship between GTF catch and soak duration for either hook size. Fishermen experience suggests that catches occur quickly after deployment (Nolan L.; Nolan J., personal communication, 2020) and that soak time has little effect on catch rates. We recommend standardizing soak duration to the extent possible in future surveys to allow for completion of the survey and consistency among years, but recognize the number and distance between stations and survey length will influence soak time.

- Bait size was scaled relative to hook size. This differed from the pilot survey that used a consistent bait size among all hooks. The reduction in bait size for small hooks in the 2020 survey may have contributed to the higher catch rates in the 2020 survey relative to the pilot and the lower frequency of returned bait observed on small hooks. We recommend continued scaling of bait to hook size in future surveys to further assess this finding.

- Bait retention across the survey was 10%, with regular hooks retaining bait at a higher frequency than small hooks. There was no relationship between soak time and bait retention for either hook size. The greater retention of bait on regular hooks may result from higher catch on small hooks in general and of smaller GTF and scaled bait size. These data combined with the measure of bait retention from the pilot survey could be used to estimate gear saturation.

- Current meter data are summarized in Supplemental Table 1. Raw data may be useful for determining the current flow and extent of bait plume.

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Nolan, L. 2020. Personal communication. Ex-member of the MAFMC and tilefish commercial fisher. Montauk, NY.

Nolan, J. 2020. Personal communication. Tilefish Advisory Panel Member of the MAFMC and tilefish commercial fisher. Montauk, NY.

Supplemental Table 1. Summary of current meter (CM) data (5 minute intervals) by station, including soak time (minutes), temperature (°C), speed (cm/sec), heading (°), veolocity (N; cm/sec) and velocity (E; cm/sec). Data are mean ± SD for the duration of deployment.

Station	Strata	Soak Time	Temperature	Speed	Heading	Velocity-N	Velocity-E
1	03--4	71	12.7 ± 0.1	11.9 ± 3.7	161.9 ± 13.5	-10.6 ± 2.8	3.9 ± 4.6
2	03--3	86	13.0 ± 0.01	24.0 ± 3.3	27.3 ± 5.2	21.3 ± 3.3	10.9 ± 2.3
3	03--2	60	NA	NA	NA	NA	NA
4	03--2	67	11.5 ± 0.1	5.6 ± 4.6	160.1 ± 95.9	-1.1 ± 5.1	-1.4 ± 4.8
5	03--2	64	8.6 ± 0.1	13.3 ± 1.1	216.9 ± 12.3	-10.4 ± 1.7	-7.9 ± 2.5
6	03--2	50	NA	NA	NA	NA	NA
7	03--3	360	11.5 ± 0.01	10.5 ± 1.0	49.9 ± 9.0	6.8 ± 1.7	7.8 ± 0.6
8	03--3	80	NA	NA	NA	NA	NA
9	03--3	77	12.8 ± 0.1	7.6 ± 6.7	140.9 ± 56.2	-3.3 ± 6.0	1.1 ± 7.4
10	03--3	84	13.2 ± 0.2	15.7 ± 12.1	100.1 ± 149.7	11.5 ± 14.8	-1.1 ± 6.3
11	03--3	207	12.8 ± 0.01	13.6 ± 0.6	108.1 ± 11.9	-4.1 ± 2.6	12.6 ± 1.1
12	03--3	284	NA	NA	NA	NA	NA
13	03--2	64	12.7 ± 0.1	2.2 ± 1.7	106.7 ± 106.0	1.4 ± 1.5	1.5 ± 1.3
14	03--2	59	12.9 ± 0.2	7.1 ± 3.2	320.1 ± 21.2	5.1 ± 2.9	-4.4 ± 2.8
15	03--3	61	12.3 ± 0.2	16.9 ± 10.6	103.4 ± 45.0	-0.9 ± 6.6	14.7 ± 11.7
16	03--3	78	12.6 ± 0.01	19.1 ± 5.9	181.2 ± 22.0	-17.0 ± 2.7	-1.4 ± 10.4
17	03--3	86	12.9 ± 0.01	11.6 ± 6.4	224.2 ± 13.0	-7.6 ± 1.9	-8.1 ± 6.9
18	03--3	50	13.4 ± 0.01	6.4 ± 3.2	123.3 ± 149.6	5.5 ± 3.9	0.8 ± 2.6
19	03--3	172	13.5 ± 0.01	22.1 ± 13.3	130.3 ± 36.2	-10.2 ± 11.6	13.9 ± 15.4
20	03--3	210	12.3 ± 0.01	10.6 ± 2.0	191.3 ± 18.7	-9.8 ± 1.5	-2.5 ± 3.5
21	03--3	134	12.0 ± 0.01	11.1 ± 6.2	77.2 ± 52.0	2.9 ± 4.8	9.3 ± 6.6
22	03--3	68	13.2 ± 0.01	8.4 ± 0.2	174.7 ± 5.6	-8.3 ± 0.2	0.8 ± 0.8
23	03--3	79	NA	NA	NA	NA	NA
24	03--3	71	13.1 ± 0.01	12.2 ± 0.3	146.6 ± 0.9	-10.2 ± 0.3	6.7 ± 0.2
25	03--3	275	13.1 ± 0.01	12.7 ± 3.9	100.4 ± 24.8	-1.7 ± 4.9	11.5 ± 4.3
26	03--3	78	11.8 ± 0.01	6.3 ± 0.6	199.1 ± 16.2	-5.7 ± 1.0	-2.0 ± 1.6
27	03--3	484	12.8 ± 0.01	8.7 ± 1.3	39.3 ± 15.0	6.4 ± 1.4	5.5 ± 2.2
28	03--3	52	NA	NA	NA	NA	NA
29	03--3	51	12.7 ± 0.1	12.9 ± 8.8	112.0 ± 45.3	-1.7 ± 8.3	8.6 ± 10.0
30	03--3	57	12.4 ± 0.1	12.9 ± 1.5	145.0 ± 5.8	-10.5 ± 1.2	7.4 ± 1.6
31	03--3	55	12.2 ± 0.3	14.2 ± 4.8	181.6 ± 13.5	-13.7 ± 4.4	-0.1 ± 4.1
32	03--3	138	NA	NA	NA	NA	NA
33	03--4	81	12.5 ± 1.4	9.5 ± 4.5	117.6 ± 74.5	1.9 ± 6.6	5.4 ± 6.1
34	03--4	60	10.3 ± 1.1	12.2 ± 3.0	120.8 ± 65.9	-0.8 ± 3.3	10.3 ± 6.5
35	03--3	220	NA	NA	NA	NA	NA
36	03--2	80	9.9 ± 0.01	9.0 ± 1.4	313.6 ± 98.5	8.3 ± 0.8	-2.7 ± 2.4
37	03--2	97	9.9 ± 0.01	17.0 ± 0.4	58.9 ± 2.0	8.8 ± 0.6	14.6 ± 0.5
38	03--2	138	9.7 ± 0.1	8.8 ± 5.6	274.4 ± 35.4	1.0 ± 5.0	-7.6 ± 4.9
39	03--3	50	12.2 ± 0.1	10.8 ± 9.0	269.6 ± 48.9	0.2 ± 10.1	-6.3 ± 7.5
40	04--3	147	12.6 ± 0.01	9.5 ± 1.5	216.8 ± 17.8	-7.2 ± 2.0	-5.5 ± 2.6
41	04--2	140	NA	NA	NA	NA	NA
42	04--2	236	NA	NA	NA	NA	NA
43	04--3	69	12.8 ± 0.01	14.4 ± 1.1	62.2 ± 7.2	6.6 ± 1.3	12.7 ± 1.6

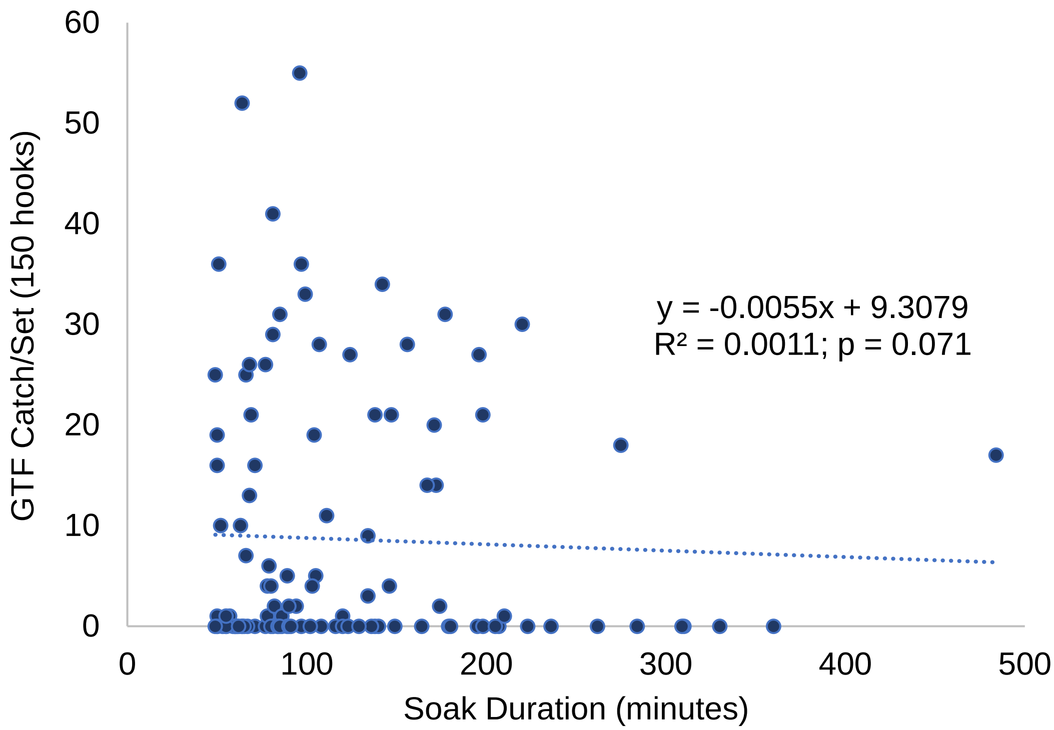
44	04--3	96	12.8 ± 0.01	3.6 ± 1.4	215.2 ± 80.1	-1.3 ± 2.6	-2.0 ± 1.8
45	03--4	310	9.6 ± 0.1	14.9 ± 1.8	86.0 ± 11.4	0.9 ± 2.8	14.6 ± 2.0
46	04--4	50	NA	NA	NA	NA	NA
47	04--3	134	11.9 ± 0.2	21.8 ± 15.9	276.5 ± 91.1	12.5 ± 18.3	-8.3 ± 13.1
48	04--3	81	12.7 ± 0.1	7.9 ± 2.5	142.5 ± 77.5	-3.5 ± 5.2	4.4 ± 3.1
49	04--3	66	12.9 ± 0.01	11.7 ± 1.1	69.8 ± 6.8	4.0 ± 1.3	10.9 ± 1.3
50	04--2	223	9.8 ± 0.01	18.3 ± 6.5	115.6 ± 6.6	-7.4 ± 1.5	16.6 ± 6.6
51	04--2	309	NA	NA	NA	NA	NA
52	03--2	171	12.5 ± 0.01	7.0 ± 1.5	33.2 ± 7.8	5.8 ± 1.2	3.8 ± 1.2
53	04--3	177	12.4 ± 0.1	9.0 ± 7.1	139.1 ± 27.0	-6.7 ± 4.8	4.7 ± 6.4
54	04--3	167	12.4 ± 0.01	4.4 ± 1.9	52.3 ± 62.2	3.3 ± 2.1	2.4 ± 1.4
55	04--2	50	10.2 ± 0.1	5.3 ± 0.8	96.9 ± 19.5	-0.4 ± 1.7	5.0 ± 0.9
56	04--3	156	12.7 ± 0.01	5.8 ± 0.8	208.4 ± 27.1	-4.6 ± 1.6	-2.8 ± 1.6
57	04--3	196	NA	NA	NA	NA	NA
58	04--2	174	11.3 ± 0.01	5.8 ± 1.7	313.0 ± 109.3	5.7 ± 1.7	-0.7 ± 0.7
59	04--2	164	NA	NA	NA	NA	NA
60	04--2	149	11.1 ± 0.1	5.6 ± 1.1	152.3 ± 76.0	-2.1 ± 4.1	2.8 ± 1.0
61	04--3	53	12.8 ± 0.01	11.8 ± 0.8	198.7 ± 185.1	11.8 ± 0.7	-0.3 ± 1.2
62	04--3	63	12.6 ± 0.3	4.8 ± 2.3	322.0 ± 25.1	3.8 ± 3.0	-2.2 ± 2.9
63	04--3	49	12.5 ± 0.1	3.4 ± 4.2	112.5 ± 99.5	0.1 ± 4.2	2.0 ± 1.6
64	04--4	94	11.1 ± 0.01	8.6 ± 1.7	272.3 ± 21.9	0.6 ± 3.2	-8.0 ± 1.6
65	04--3	82	12.3 ± 0.1	9.4 ± 1.3	282.6 ± 22.6	1.7 ± 2.9	-8.6 ± 2.3
66	04--3	146	12.1 ± 0.2	6.8 ± 0.5	150.6 ± 6.3	-5.9 ± 0.8	3.3 ± 0.4
67	04--3	198	12.4 ± 0.01	9.6 ± 6.1	258.2 ± 153.5	7.4 ± 8.2	-0.3 ± 2.7
68	04--3	108	13.3 ± 0.1	9.6 ± 2.4	280.5 ± 7.7	1.7 ± 1.3	-9.3 ± 2.3
69	04--3	86	12.8 ± 0.8	12.6 ± 8.4	285.8 ± 38.5	3.5 ± 4.9	-11.0 ± 8.5
70	04--2	60	12.0 ± 0.1	7.9 ± 11.7	118.4 ± 32.2	-1.9 ± 2.7	6.7 ± 12.0
71	05--2	84	12.0 ± 0.2	21.1 ± 3.0	234.7 ± 8.0	-12.1 ± 3.1	-17.1 ± 2.8
72	05--2	89	11.3 ± 0.01	13.5 ± 1.7	240.6 ± 6.1	-6.7 ± 1.7	-11.7 ± 1.5
73	05--3	330	13.1 ± 0.2	19.1 ± 3.0	192.7 ± 8.5	-18.4 ± 3.2	-4.1 ± 2.5
74	05--3	81	13.3 ± 0.1	8.4 ± 1.7	293.8 ± 95.2	5.8 ± 4.8	-3.2 ± 2.7
75	05--4	89	10.4 ± 0.1	6.3 ± 1.6	313.6 ± 6.1	4.3 ± 1.0	-4.6 ± 1.5
76	05--3	104	12.7 ± 0.01	8.2 ± 1.7	326.4 ± 57.4	7.3 ± 2.4	-2.9 ± 1.9
77	05--3	66	12.8 ± 0.2	6.2 ± 2.5	295.9 ± 22.0	2.8 ± 2.9	-5.0 ± 2.1
78	05--2	NA	NA	NA	NA	NA	NA
79	05--2	55	11.9 ± 0.4	13.6 ± 1.3	352.3 ± 3.7	13.4 ± 1.3	-1.8 ± 0.9
80	05--2	NA	NA	NA	NA	NA	NA
81	05--2	262	12.1 ± 0.01	8.2 ± 7.1	113.1 ± 23.3	-3.4 ± 4.5	6.8 ± 6.2
82	05--3	77	12.9 ± 0.1	17.0 ± 5.1	51.0 ± 13.2	9.9 ± 2.3	13.4 ± 5.7
83	05--3	68	13.2 ± 0.1	11.8 ± 12.6	187.7 ± 111.9	2.1 ± 11.0	-3.8 ± 12.6
84	05--3	120	12.1 ± 0.1	8.3 ± 4.4	228.2 ± 28.7	-4.6 ± 3.1	-5.0 ± 5.7
85	05--4	105	11.0 ± 0.1	11.2 ± 3.2	164.9 ± 13.0	-10.8 ± 3.6	2.3 ± 1.4
86	05--3	107	12.9 ± 0.01	11.6 ± 1.4	106.7 ± 6.6	-3.3 ± 1.4	11.0 ± 1.4
87	05--3	103	12.5 ± 0.4	12.5 ± 9.3	143.1 ± 64.2	-2.4 ± 12.0	5.9 ± 7.6
88	05--3	99	12.0 ± 1.5	7.9 ± 1.5	185.0 ± 169.3	7.5 ± 1.5	-0.3 ± 2.4
89	05--3	111	12.5 ± 0.1	8.8 ± 12.6	167.3 ± 98.3	1.1 ± 10.6	2.3 ± 10.9
90	05--3	85	12.8 ± 0.01	8.8 ± 11.6	229.5 ± 74.9	-0.8 ± 9.5	-0.6 ± 11.1
91	05--3	80	12.6 ± 0.1	37.4 ± 20.3	166.2 ± 15.4	-35.1 ± 19.3	6.3 ± 13.0

92	05--3	90	11.2 ± 0.2	8.5 ± 2.9	284.9 ± 63.4	3.3 ± 4.3	-5.7 ± 4.4
93	05--2	85	9.0 ± 0.1	12.9 ± 7.1	258.5 ± 22.2	-3.2 ± 7.7	-11.4 ± 4.4
94	05--3	179	NA	NA	NA	NA	NA
95	05--3	64	13.5 ± 0.1	5.0 ± 1.8	160.4 ± 56.9	-2.4 ± 1.0	2.3 ± 4.1
96	05--4	65	10.4 ± 0.5	19.9 ± 4.4	280.3 ± 32.0	5.0 ± 3.9	-18.3 ± 6.5
97	05--3	102	NA	NA	NA	NA	NA
98	05--3	124	13.1 ± 0.1	14.4 ± 1.4	195.2 ± 182.6	14.1 ± 1.6	-1.1 ± 2.3
99	05--3	NA	NA	NA	NA	NA	NA
100	05--3	49	12.5 ± 0.2	12.8 ± 10.7	190.5 ± 33.1	-10.5 ± 8.6	-1.5 ± 9.7
101	05--3	116	NA	NA	NA	NA	NA
102	06--3	180	13.2 ± 0.1	17.3 ± 9.6	242.6 ± 47.3	-3.3 ± 13.1	-12.3 ± 7.5
103	06--3	62	13.2 ± 0.3	43.2 ± 9.1	215.7 ± 2.1	-35.2 ± 8.6	-24.9 ± 3.7
104	06--2	136	10.7 ± 0.1	16.9 ± 11.6	165.0 ± 31.3	-13.5 ± 8.4	5.5 ± 11.8
105	06--4	120	11.5 ± 0.01	15.2 ± 0.8	225.1 ± 7.0	-10.7 ± 1.4	-10.7 ± 1.4
106	06--2	195	10.1 ± 0.2	15.6 ± 7.4	226.4 ± 17.1	-9.8 ± 4.1	-11.5 ± 7.3
107	06--4	55	10.9 ± 0.3	29.2 ± 3.8	239.8 ± 6.1	-14.5 ± 2.8	-25.1 ± 4.2
108	06--2	90	13.0 ± 0.5	11.9 ± 4.1	230.5 ± 52.2	-8.4 ± 7.9	-4.6 ± 1.9
109	06--3	198	13.3 ± 0.1	17.7 ± 0.2	349.4 ± 2.7	17.4 ± 0.1	-3.3 ± 0.8
110	06--3	123	12.9 ± 0.01	7.2 ± 11.7	76.8 ± 56.5	-0.4 ± 7.9	-0.2 ± 11.3
111	06--3	205	12.1 ± 0.2	21.6 ± 8.1	226.9 ± 47.2	-8.2 ± 12.7	-13.9 ± 10.6
112	06--3	91	NA	NA	NA	NA	NA
113	06--4	129	13.1 ± 0.1	13.5 ± 3.3	227.6 ± 30.5	-7.8 ± 4.7	-8.8 ± 6.1
114	04--3	142	12.6 ± 0.1	10.9 ± 0.4	294.4 ± 8.3	4.5 ± 1.6	-9.8 ± 0.5
115	05--3	97	13.1 ± 0.01	10.4 ± 2.1	237.5 ± 9.8	-5.7 ± 2.3	-8.5 ± 1.4

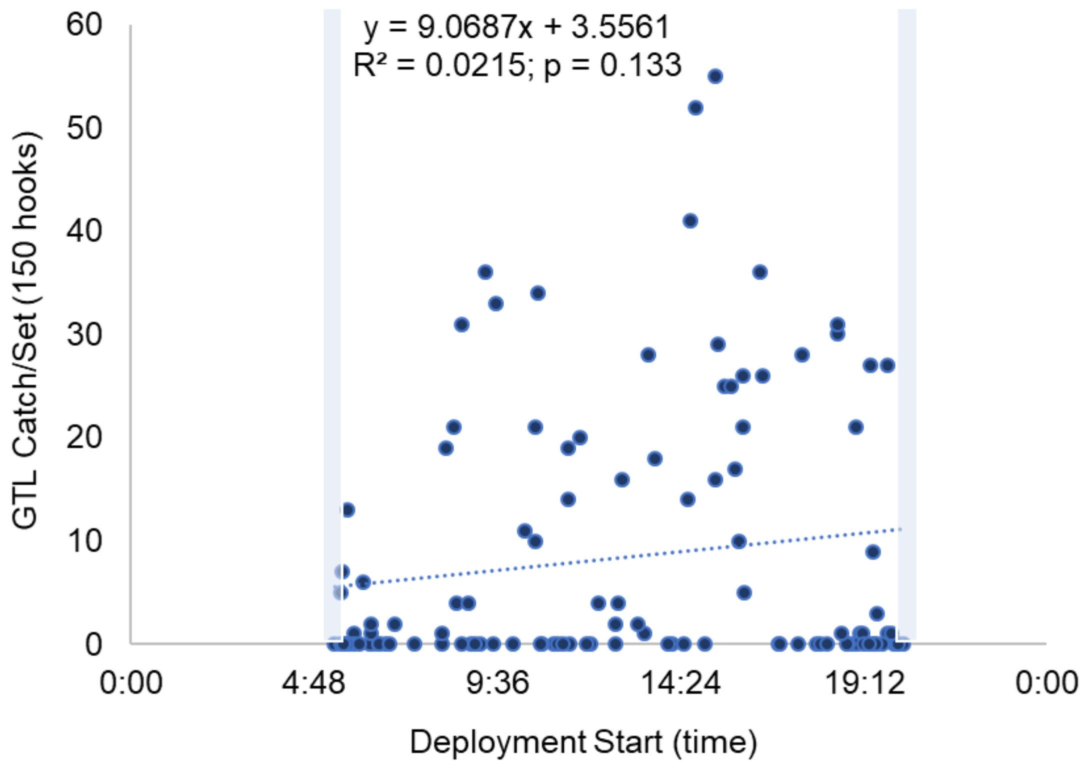
Supplemental Table 2. Taxa and number of individuals of each taxon collected by hook size in the survey.

Species	Common Name	Hook Size		Total
		Small	Regular	
Caulolatilus microps	Blueline Tilefish	1	0	1
Scyliorhinus retifer	Chain Dogfish	74	19	93
Congridae	Conger Eel	4	6	10
Anguillidae	Eel spp.	1	0	1
Lopholatilus chamaeleonticeps	Golden Tilefish	673	298	971
Myxine glutinosa	Hagfish	5	0	5
Leucoraja erinacea	Little Skate	5	4	9
Lophius americanus:	Monkfish	1	0	1
Helicolemus dactylopterus	Black bellied Rose	3	2	5
Carcharhinus plumbeus	Sandbar Shark	1	2	3
Merluccius albidus	Offshore Hake	2	0	2
Mustelus canis	Smooth Dogfish	217	301	518
Squalus acanthias	Spiny Dogfish	2	1	3
Urophycis regia	Spotted Hake	556	176	732
Paralichthyes dentatus	Summer Flounder	1	0	1
Merluccius bilinearis	Silver Hake	16	4	20
	TOTAL	***1562***	***813***	***2375***

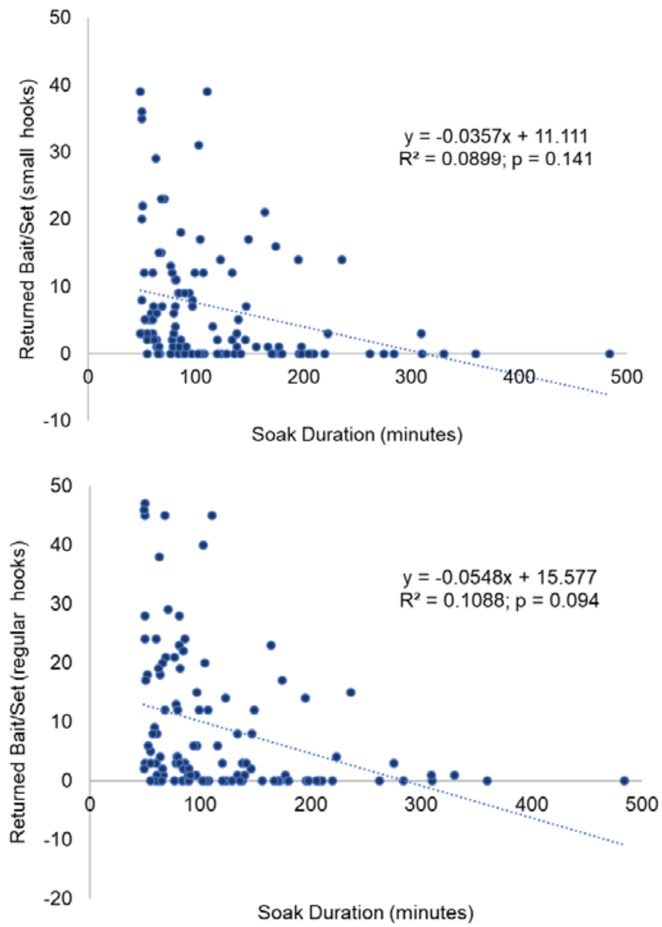
Supplemental Figure 1. Relationship between soak duration and the total number of GTF caught per set.



Supplemental Figure 2. GTF catch time of day of line deployment with sunrise and sunset depicted for July 8-19.



Supplemental Figure 3. Relationship between soak duration and the total number of returned baits per set for small (top panel) and regular (bottom panel) hooks.



Supplemental Figure 4. Cumulative distributions of small and regular hook sizes by GTF body size.