DRAFT FINAL REPORT (March 1, 2024)

PROJECT: Fishery-independent 2023 bottom longline survey for the Mid-Atlantic golden tilefish (*Lopholatilus chamaeleonticeps*) stock (Award #: 2210073)

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Key findings:

- The 2023 survey resulted in lower CPUE of tilefish *(0.042)* compared with the 2020 survey (*0.056*).
- Consistent with previous survey results, tilefish showed a core area of abundance from south of the Hudson Canyon to southern Georges Bank near Veatch Canyon.
- Depth strata 03 (54-137.9 fathoms; 99-252 m) produced the highest catches consistent with previous survey findings.
- A broader size range of tilefish were caught during the 2023 survey compared with the 2020 survey; tilefish ranged in size from 20 to 110 cm and weighed 0.1 to 17.0 kg.
- Across all strata the average proportion of empty hooks (i.e., no fish or bait) was 70%; lower than the 2020 survey (76%).
- Approximately 30% of the hooks retained bait or tilefish upon retrieval, with small hooks retaining bait at a higher frequency than industry hooks across all strata, a departure from the 2020 survey results.
- All three surveys indicated smaller hooks had higher catch rates on average than industry hooks (and large hooks in the pilot).
- Small hooks (8/0) captured a greater number of small tilefish consistent with pilot survey findings.
- The highest catch for both hook sizes was of 30-40 cm tilefish which differs from the highest catch of 40-50 cm in 2020.

***Recommendations*:**

1.0 Data from the two surveys (2020 and 2023) will provide information to track cohorts and to inform assessment model selectivity (i.e., domed shaped selectivity) for tilefish in the core region of abundance.

2.0 Data from the three surveys suggest that there is lower catchability of larger fish on small hooks but small hooks appear to have a higher catchability of smaller fish. These combined data can be used to evaluate the tradeoff between using a single hook size verses multiple hook sizes depending on the goals and utilization of a long-term survey.

3.0 Future surveys continue to sell tilefish 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.

4.0 The 2023 survey benefited greatly from the additional F/V crew participation with respect to implementation, as well as data and sample collection. Future surveys will continue to require an additional person to assist in cruise and data analyses. Considering the current implementation of the survey this could be achieved by an additional crew member.

5.0 Future implementation of the should evaluate the timing of the survey in terms of trade-offs between measuring GTF maturation prior to peak spawning and dogfish interactions, as catch of dogfish was highest in the 2023 survey (June) compared with previous surveys (2020: July; 2017: late July-August).

Background

The 2023 golden tilefish fishery-independent bottom longline survey design was developed using the results from the pilot golden (GTL) and blueline (BTL) tilefish survey conducted in the summer of 2017 and the golden tilefish survey conducted in the summer of 2020. The final reports of the 2017 and 2020 tilefish surveys can be found on the Mid-Atlantic Fishery Management Council's (MAFMC) website (http://www.mafmc.org/tilefish). 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 GTL only. The goal of the 2020 fishery-independent bottom longline survey was to derive an index of abundance for GTL 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 GTL stock could be accomplished with a reduced number of stations focused on the core region of GTL 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 GTL while also addressing considerations for optimizing a long-term GTL bottom long-line survey; (1) optimal survey periodicity (annual or biennial) and (2) hook selectivity.

The goal of the proposed 2023 fishery-independent bottom longline survey is to extend the timeseries used to derive an index of abundance for GTL stock and provide additional data to the Council to address the following considerations outlined in the 2020 survey (above). The 2023 survey design was consistent with the 2020 survey design whereby 115 stations were randomly selected to be sampled in a single trip of 14 days. It is anticipated that data from the three surveys will aid in evaluating the survey as a means to provide a fishery independent pre-recruit and adult GTL index of abundance.

2023 Survey Design

The 2023 GTL survey used a stratified random design consistent with the 2017 pilot and 2020 surveys with a target of 115 stations. The 2023 survey consisted of sampling stations representing the core fishing areas for the mid-Atlantic GTL population based on commercial catch data and the 2017 and 2020 surveys. 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) that considered GTL 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 previous survey (Table 1). 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 2023 survey had a total of 114 completed stations (Table 1).

The survey was scheduled for month of June for purposes of measuring GTL maturation prior to peak spawning while also allowing for reduced dogfish interactions and possible gear saturation issues within the survey. The survey was conducted June 19th-June 30th. F/V Sea Capture personnel included Captain John Nolan and three additional crew members. Scientific crew included Jill Olin (MTU). Captain Nolan and crew completed the survey in the absence of the scientific crew from June 23rd-30th.

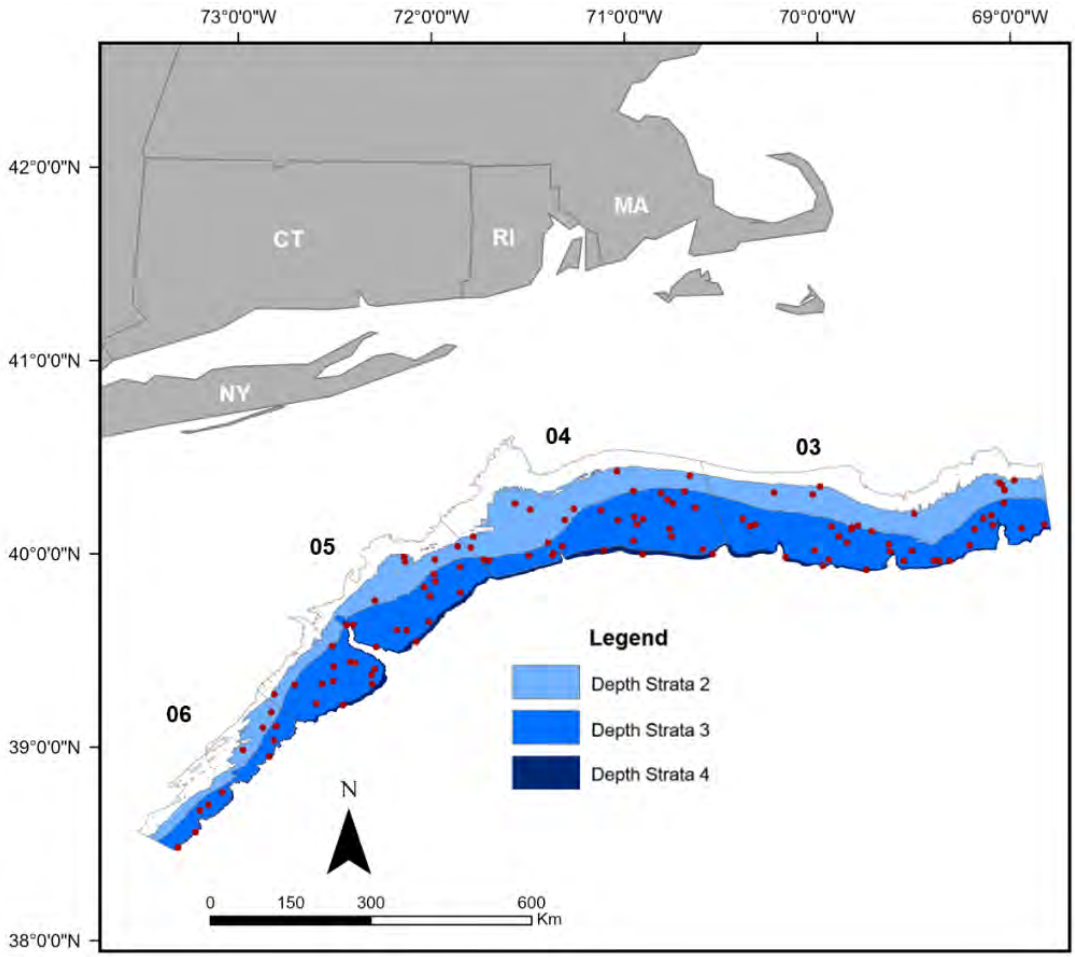


Figure 1. Stratified random sampling design for the 2023 Strata included four north-south regions (03-06) and three depth ranges (2-4). See Table 1 for the distribution and allocation of stations within each stratum.

Table 1. Distribution and allocation of stations by latitude-depth strata in the 2023 survey.

Stratum	Area (km^2)	% Total Area	# Proposed Stations	# Actual Stations
03--2	2320.7	14.3	9	8
03--3	3184.3	19.6	27	27
03--4	177.3	1.1	3	3
04--2	2167.4	13.4	10	10
04--3	2538.4	15.7	20	22
04--4	240.7	1.5	3	3
05--2	1236.1	7.6	6	5
05--3	2720.4	16.8	22	23
05--4	208.6	1.3	3	2
06--2	630.7	3.9	3	3
06--3	727.7	4.5	6	6
06--4	57.3	0.4	3	2

Gear and deployment

Bottom long-lines that consisted of one-nautical mile (1,852 m) mainline equipped with 150 evenly spaced gangions were deployed. Hook saturation was not observed during the 2017 pilot or subsequent 2020 surveys when deploying 150 gangions per line, therefore, to maintain consistency and allow for comparisons among surveys, 150 hooks were deployed per set.

Two different offset circle hook sizes, distributed at a ratio of 50-50 per each set were deployed consistent with the 2020 survey; these included small hooks (small = 8/0) and industry hooks (industry = 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, industry = 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 GTL and many small GTL relative to industry circle hooks (12/0), and large circle hooks (14/0) caught few individuals overall. Similar to the pilot survey, small hooks caught a greater number of small GTL compared with the industry hooks in the 2020 survey.

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 GTL < 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 GTL 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 and 2023 surveys, with smaller baits used on small circle hooks relative to the industry 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.

All attempts to maintain a consistent soak duration (50-minute minimum) were made; consistent with the 2020 survey. However, to accommodate the number of stations and the steam time between locations, soak time ranged from 43–307 minutes with an average soak time of 128 minutes. This average soak time was slightly longer than the average soak time recorded during the 2020 survey (range: 50–484 minutes average: 121 minutes). Similar to the 2020 survey, there was no relationship between soak time and GTL catch in the 2023 survey (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 GTL catch and the time of initial deployment (Supplemental Figure 2).

A single Star-Oddi CTD was attached to the mid-line of each set to record depth (m), temperature (°C), salinity (psu) and conductivity (mS/cm) (see summary by strata in Table 2). Two current meters were attached at the ends of each set in the 2020 survey. However current meters were not deployed in 2023 for several reasons, including effort required for tracking the meter's deployment and retrieval with reduced crew and the value/use of the output data, as evaluation of current meter data from the 2020 survey has not resulted in meaningful inferences.

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 114 sets was expressed as numbers of individuals per number of hooks deployed.

Table 2. Summary of depth (mean ± SD, range) and water parameters (mean ± SD) for the latitude-depth strata in the 2023 survey.

Strata	*n*	Depth (fa)	Depth (m)	Bottom Temperature (°C)	Salinity (psu)	Conductivity (mS/cm)
3--2	8	47.5 ± 2.6 44-53	87.9 ± 5.7 80-97	9.8 ± 2.2	30.0 ± 4.3	33.0 ± 5.0
3--3	27	72.4 ± 16.4 54-114	136.4 ± 35.4 99-209	12.7 ± 1.3	32.1 ± 3.3	37.6 ± 4.1
3--4	3	144.0 ± 4.0 140-148	257.5 ± 3.3 256-271	9.8 ± 0.4	33.6 ± 1.1	36.6 ± 1.4
4--2	10	47.7 ± 2.8 45-52	89.1 ± 5.1 82-95	11.2 ± 0.9	29.4 ± 6.2	33.5 ± 6.7
4--3	21	70.6 ± 15.7 54-113	131.0 ± 28.9 99-207	12.5 ± 0.9	30.4 ± 5.3	35.7 ± 5.9
4--4	3	151.0 ± 13.5 136-162	252.6 ± 16.3 249-296	10.8 ± 0.4	34.4 ± 0.2	38.3 ± 0.3
5--2	5	46.4 ± 2.3 44-50	86.4 ± 4.3 82-95	10.2 ± 1.6	28.2 ± 5.7	31.5 ± 5.3
5--3	24	79.1 ± 22.8 53-135	147.4 ± 44.2 99-207	12.7 ± 1.0	28.6 ± 7.9	33.7 ± 8.4
5--4	2	148.0; 165	284.5; 303.6	9.1; 9.5	33.9; 34.2	36.3; 36.9
6--2	3	47.0 ± 0.7 45-48	86.8 ± 0.8 82-88	10.7 ± 1.3	25.4 ± 12.2	28.8 ± 13.1
6--3	6	87.5 ± 34.5 62-127	142.6 ± 44.5 113-232	13.0 ± 1.0	24.5 ± 10.1	29.5 ± 11.2
6--4	2	139.0; 147.0	252; 271.5	10.3; 11.0	34.4; 35.3	38.5; 38.8

Abundance and distribution

Catch was recorded from all strata sampled during the survey. A total of 1,930 individuals were collected and included 12 species with GTL (*n* = 716), Spotted Hake (*n* = 221) and Smooth Dogfish (*n* = 805) dominating the catch (Supplemental Table 1). The 2023 survey resulted in lower catch of GTL compared the 2020 survey (*n* = 971). A single mature BTL (FL: 58.0 cm; WT: 2.8 kg) and two immature BTL (FL: 27, 29.5 cm; WT: 0.2, 0.3 kg) were caught from depth strata 03 on an industry hook in the case of the mature and small hooks in the case of immature BTL during the 2023 survey. There was a notable increase in the number of dogfish (Smooth + Spiny) caught in 2023 (*n* = 896; Supplemental Table 1) relative to the 2020 (*n* = 521) and 2017 (*n* = 9). Dogfish spp. ranged in size from 37-78 cm (mean ± SD; 59.6 ± 9.2). The increase in dogfish

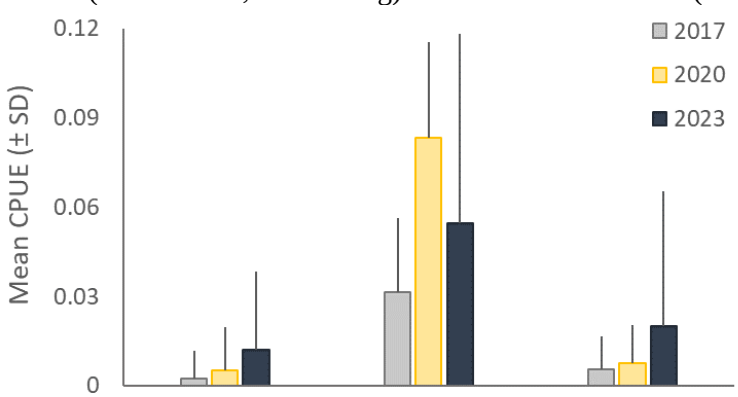


Figure 2. GTL CPUE (per hook) by depth strata for the three surveys. Data are mean (± SD).

catch may be a consequence of the timing of the survey, being conducted in June (2023) compared with early July (2020) and late July-August (2017).

Consistent with the two previous surveys, GTL CPUE was highest from depth strata 03 (99-252 m; Figure 2), with the core region of abundance ranging from the southern edge of the Hudson Canyon to Veatch Canyon on Georges Bank (Figure 3). Similar to the 2020 catch, stations in the shallowest strata (82-99 m; Figure 3) and in the eastern portion of the sampling region (E-W strata 03; Figure 3) did not catch large abundances of GTL.

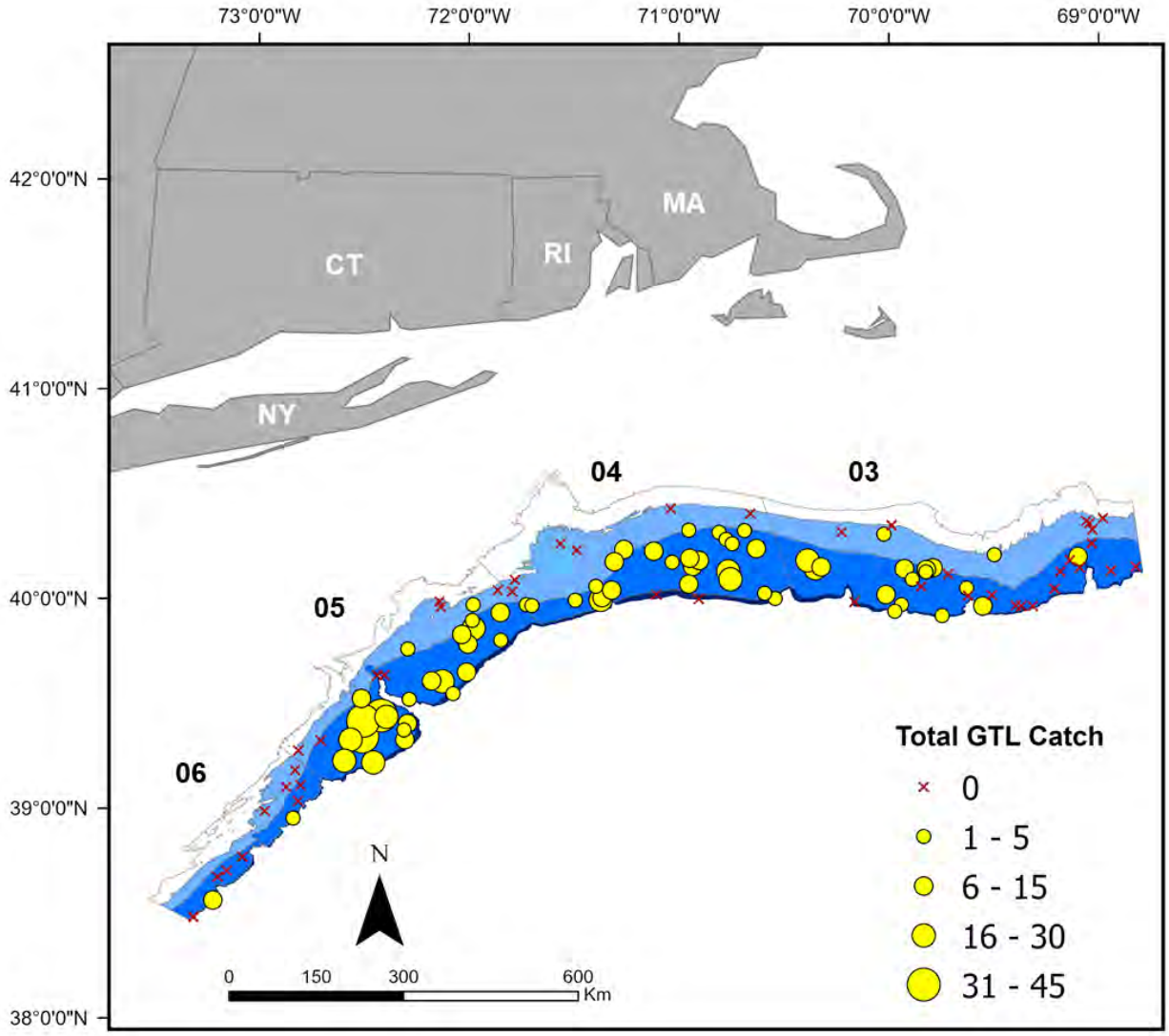


Figure 3. Station locations and distribution of GTF caught (number of individuals) in the 2023 survey.

A total of 18 stations randomly fell within the commercial fishing areas identified by Captain Nolan. These stations fell within three E-W designations and three depth strata in the following distribution: 1 (03-3), 1 (04-2), 2 (04-3), 1 (04-4), 11 (5-3), 2 (5-4). All but two of the stations (04-2, 04-4) caught GTL for a total catch of 248 individuals, constituting 34.6% of the total catch. The proportional distribution of catch between hook sizes at these stations was 70/30, consistent with the broader 2023 survey.

Size-structure and maturity

A broader size range of GTL were caught during the 2023 survey compared with the 2020 survey; GTL ranged in size from 20 to 110 cm and weighed 0.1 to 17.0 kg. The survey was dominated by catches of GTL that averaged (± SD) 35.8 ± 7.4 cm in length (Figure 4). Higher abundances of smaller GTL (30-40 cm) were caught in 99-252 m depth strata (Figure 4). Immature and mature male and female GTL were collected from all depth strata (Figure 4). In general, the proportion of immature to mature GTL was similar in all depth strata (Figure 4). The overall catch of GTL was dominated by individuals from depth strata 03 (Figure 4).

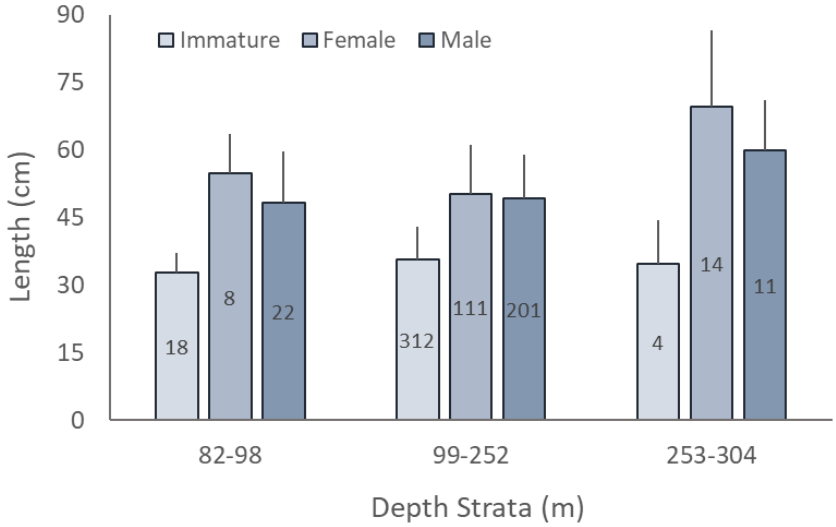


Figure 4. Catch (*n* indicated on bar) of GTL by FL. Data are mean (± SD) by sex and maturity.

Biological sampling

Similar to the prior two surveys, the 2023 survey provided an opportunity to collect and archive tissue samples for future studies. A total of 384 GTL were sub-sampled for a range of tissues, including muscle, liver and otoliths. Otoliths collected from GTL during the 2020 (*n* = 184) and 2023 (*n* = 384) surveys are currently being aged by NOAA-NEFSC Biologist Kaitlyn Rogers. Otoliths collected from the 2017 pilot survey (*n* = 438) were aged as part of Kaitlyn Dawson's MS thesis research (submitted in May 2021) with age validation from the NEFSC. Current research activities related to collected tissues include:

- Dawson, Limburg, Junker, Paterson, Nitschke, Cerrato, Frisk, Olin. Otolith microchemistry reveals spatial and temporal connectivity of juvenile Golden Tilefish (*Lopholatilus chamaeleonticeps*) in the NW Atlantic. In Prep, Transactions of the American Fisheries Society.
- Tormoen T, Ottino M, Brzeski K, Olin JA. DNA metabarcoding of stomach contents provides insight into diets of Golden Tilefish in the Mid-Atlantic Bight. In Prep, Journal of Fish Biology.

Gear Selectivity

A total number of 17,100 hooks in equal proportion between small and industry sizes were deployed in the 2023 survey (Table 3). Across all strata the average proportion of empty hooks was 70% (Table 3), slightly lower than the 2020 survey (76%). Approximately 30% of the hooks retained bait upon retrieval, with small hooks retaining bait at a higher frequency than industry hooks across all strata (Table 3), a departure from the 2020 survey results. There was no relationship between soak time and the number of returned baits for either hook size (Supplemental Figure 1). The fewest GTL were caught in depth strata 04 (Table 3). Small hooks caught 498 GTL (~70% of catch) and industry hooks caught 218 GTL (~30%

of catch), with the majority of catch from depth strata 03 (Table 3); proportions similar to catch from the 2020 survey.

Table 3. Summary of hook deployment and retrieval. Data represent the number of hooks deployed, fate of returned hook, total catch and catch of GTL by hook size for each stratum in the 2023 survey with catch of GTL by hook size for each stratum from the 2020 survey.

Strata	# Hooks Deployed	# Returned Bait	# Returned Bait SM/IND	% Empty	Total Catch	Total GTF Catch	GTF Catch 2023 SM/IND	GTF Catch 2020 SM/IND
3--2	1200	310	225/85	74	72	15	4/11	16/4
3--3	4050	613	349/264	85	375	126	81/45	159/68
3--4	450	51	24/27	89	15	2	1/1	0/0
4--2	1500	781	390/391	48	106	26	22/4	1/1
4--3	3300	833	425/408	75	335	179	147/32	254/117
4--4	450	159	78/81	65	18	2	1/1	3/0
5--2	750	509	269/240	32	50	7	6/1	0/0
5--3	3450	1082	562/520	69	692	329	222/107	234/103
5--4	300	116	71/45	61	32	26	13/13	6/4
6--2	450	299	149/150	34	7	0	0/0	0/0
6--3	900	376	211/165	58	225	4	1/3	0/0
6--4	300	41	35/6	86	3	0	0/0	0/1
Total	***17100***	***5170***	***2788/2382***	**70**	***1930***	***716***	***498/218***	***673/298***

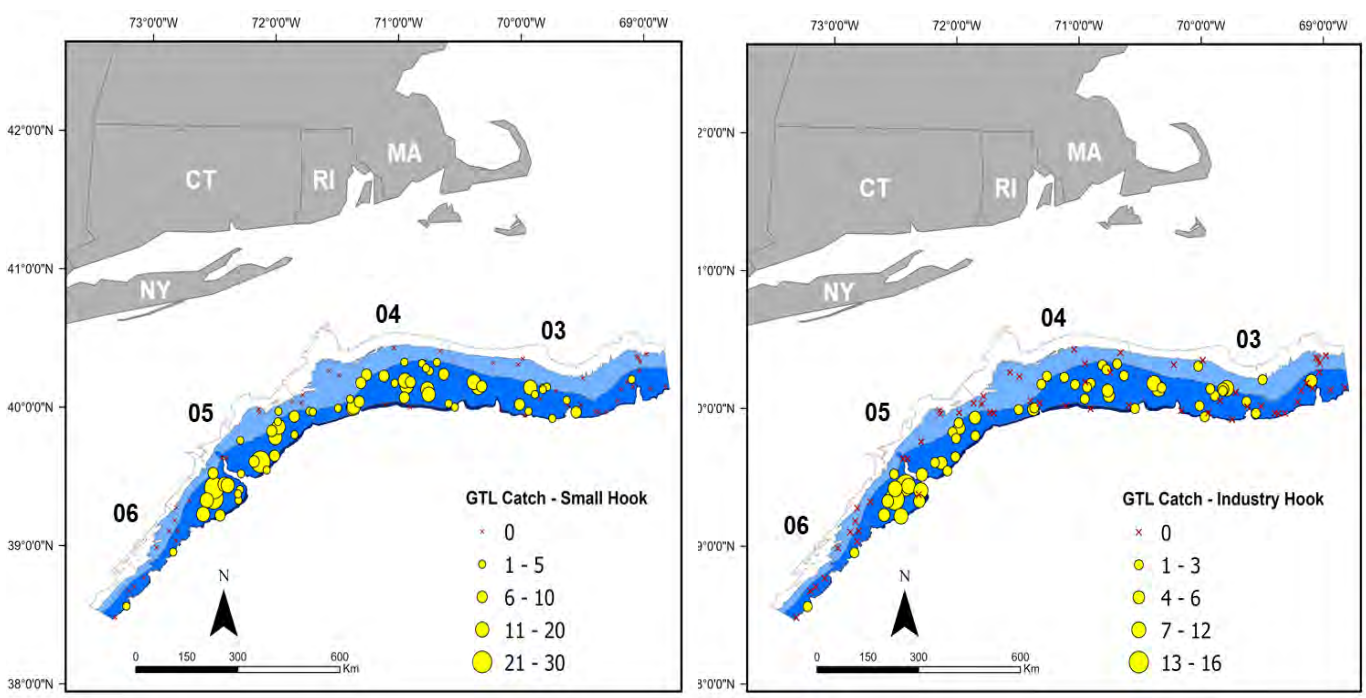


Figure 5. Spatial distribution of GTF by small (left panel) and regular (right panel) circle hooks sizes. Note the different in catch between the two hook sizes.

The distribution of catch across hook sizes was similar between the 2023 and 2020 surveys with small hooks overall catching the most GTL (Table 3). The spatial distribution of GTL catch was similar between hook sizes. The majority of GTL were caught in N-S strata 04 and 05 in depth strata 03 (Figure 5). Small hooks caught GTL that ranged in length from 20-85 cm FL while industry hooks caught GTL that ranged in length from 27-110 cm FL (Figure 6). The highest catch for both hook sizes was of 30-40 cm GTL (Figure 6) which differs from the highest catch of 40-50 cm in 2020. All three surveys showed that on average smaller hooks had higher catch rates than industry (and large in the pilot) hooks (Figure 6).

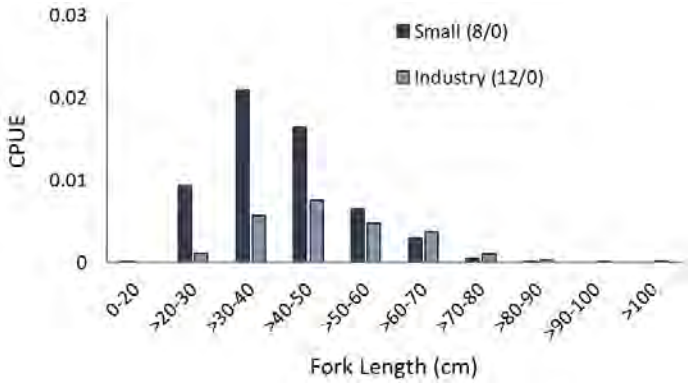


Figure 6. Length distributed CPUE by hook size.

Catch results from the three surveys suggested that selectively of the small and industry hooks could be different. Specifically, a trend whereby smaller hooks caught fewer large (> 60 cm) and a greater number of small GTL (< 35 cm) relative to industry hooks (Figure 7). Collectively, the 2020 and 2023 surveys will be important for determining the differences in selectivity between hook sizes and to inform the optimal hook size to be used in future GTL surveys. This survey illustrates the tradeoff in catch rates between the hook sizes and the differences with selectivity (Figures 7). As stated in previous reports, 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 across the three surveys are 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 and 2023 surveys do indicate that 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. A narrowly-focused survey that is conducted annually 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).

It was expected that the strong 2013-year class of GTL 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 GTL 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 7). Catch of larger GTF > 60 cm was similar between the 2020 and 2023 surveys; age estimates from otoliths will aid in identifying if these individuals result from the 2013-year class. It was not expected in the 2023 survey that a large proportion of the catch would be < 40 cm. This catch may be attributable to reduced commercial fishing efforts during COVID-19 that allowed for higher reproductive output and resultant recruitment. The 30 cm fishes collected in 2023 likely represent 2-3-year-old fishes. As stated in above, aging of fishes from the three surveys that is currently underway would help confirm selectivity differences with hook size. Considering the entire size range of GTL caught across all three surveys, small hooks caught more small fish (20-35 cm) and a similar number of large fish as industry hooks (>70 cm; Figure 7).

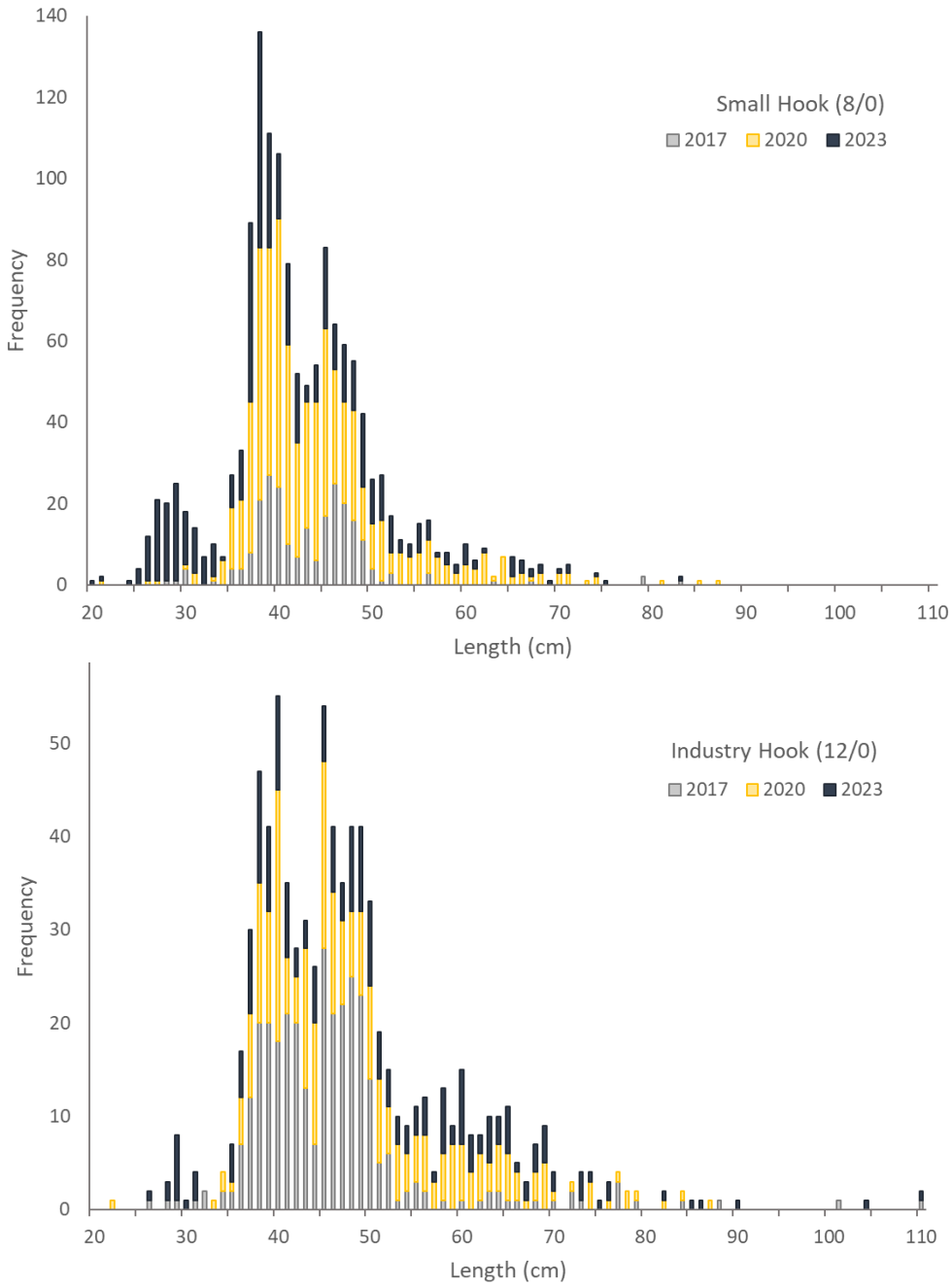


Figure 7. Length frequency of GTF by hook size from the three surveys.

The observed GTL length data from the three surveys did not follow a common statistical distribution and appears consistently in two modes between 35–50 cm FL (Figure 7). Because the data did not follow a common distribution, and appeared bi-model, 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 = 0.542, df = 1, p = 0.352).

Survey Summary

- Similar to the 2020 survey, soak duration was set for a minimum of 50 minutes. Soak duration was longer than 50 minutes at most stations due to the deployment of multiple lines at a single time (up to four). Deployment of multiple lines was necessary to accommodate the number of stations during the timeframe of the survey. There was no relationship between GTL catch and soak duration for either hook size. Fishermen experience suggests that catches occur quickly after deployment and that soak time has little effect on catch rates. We continue to recommend the standardizing of soak duration to the extent possible in future surveys. This will allow for completion of the survey in 14-days and consistency among years, but recognize that the number of and distance between stations and survey length will influence soak time.

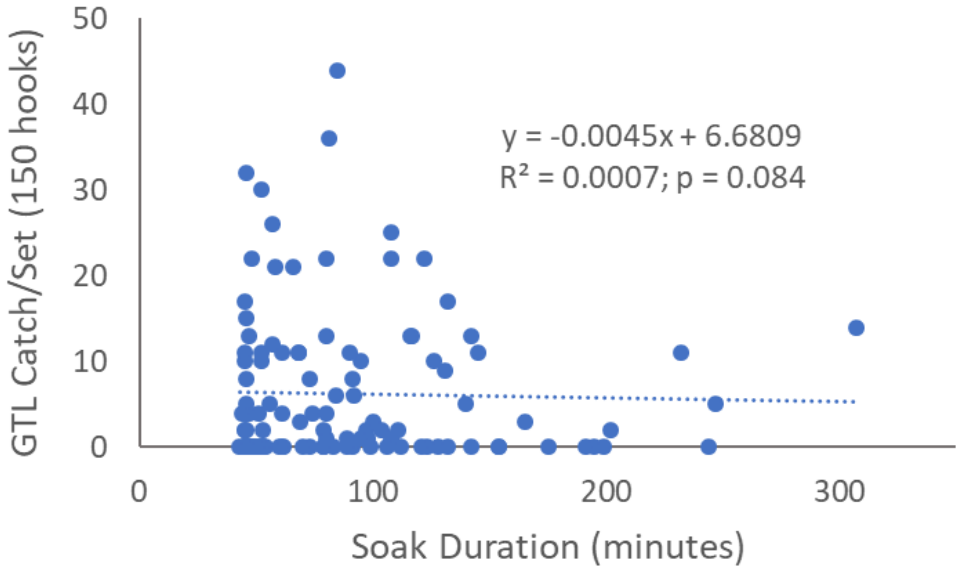
- Bait size was scaled relative to hook size similar to the 2020 survey. This differed from the pilot survey that used a consistent bait size among all hooks. We recommend continued scaling of bait to hook size in future surveys to further assess catchability of hooks and consistency among surveys.

- Bait retention across the survey was 30%, with small hooks retaining bait at a higher frequency than industry hooks; a difference from the 2020 survey. There was no relationship between soak time and bait retention for either hook size. The greater retention of bait on small hooks may result from higher catch on small hooks in general and of smaller GTL and scaled bait size. These data combined with the measure of bait retention from the pilot and the 2020 survey could be used to estimate gear saturation.

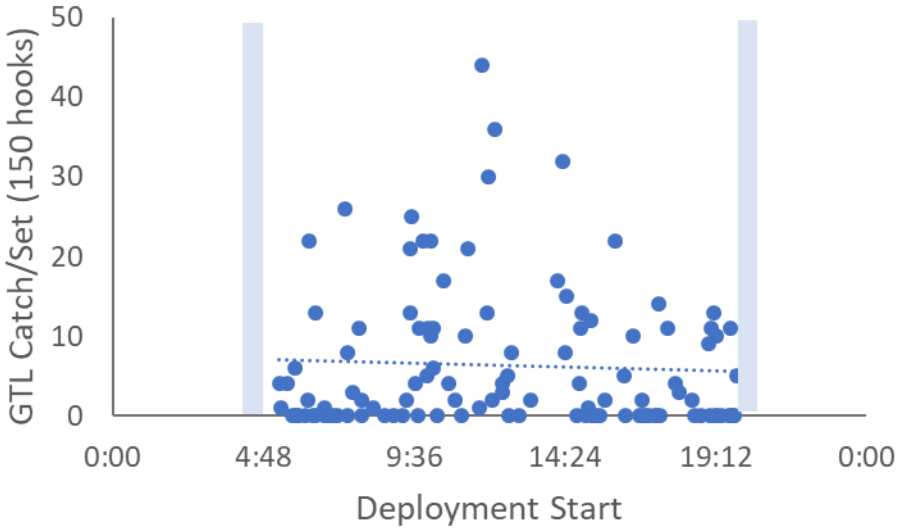
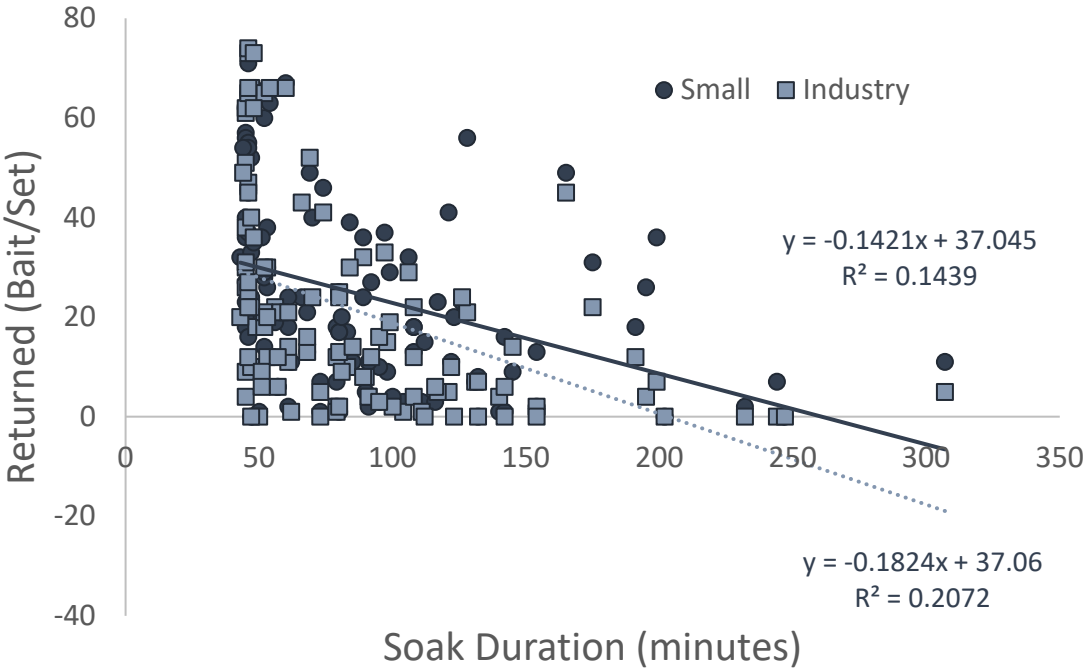
Supplemental Table 1. Taxa and number of individuals of each taxon collected by hook size in the survey.

Species	Common Name	Hook Size		
		Small	Industry	Total
Dipturus laevis	Barndoor Skate	0	2	2
Helicolemus dactylopterus	Black-bellied Rose	8	4	12
Caulolatilus microps	Blueline Tilefish	2	1	3
Scyliorhinus retifer	Chain Dogfish	35	23	58
Congridae	Conger Eel	1	4	5
Lopholatilus chamaeleonticeps	Golden Tilefish	498	218	716
Carcharhinus plumbeus	Sandbar Shark	1	0	1
Merluccius bilinearis	Silver Hake	5	4	9
Mustelus canis	Smooth Dogfish	390	415	805
Squalus acanthias	Spiny Dogfish	55	36	91
Urophycis regia	Spotted Hake	151	70	221
Merluccius albidus	Offshore Hake	5	2	7
	TOTAL	***1151***	***779***	***1930***

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



Supplemental Figure 2. GTL catch relative to the time of day of set deployment with sunrise and sunset depicted for sampling period ($y = -2.3843x + 7.5258$, $R^2 = 0.0027$, $p = 0.143$).



Supplemental Figure 3. Relationship between soak duration and the total number of returned baits per set for small and industry hooks.