Seasonal Survey for the Atlantic Sea Scallop Fishery on the Eastern Part of Georges Bank

Final Report

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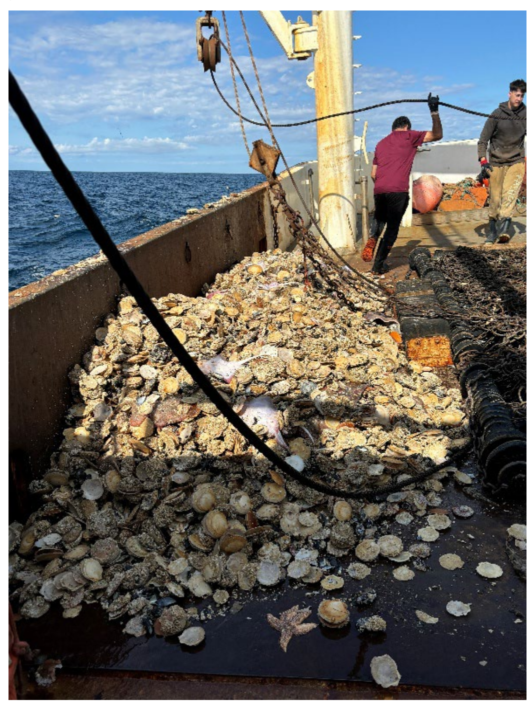

Submitted By

Luisa Garcia, Farrell Davis, Natalie Jennings and Liese Siemann - Coonamessett Farm Foundation, Inc.

Coonamessett Farm Foundation, Inc
277 Hatchville Road
East Falmouth, MA 02536

508-356-3601 FAX 508-356-3603
contact@cfarm.org

www.cfarm.org

EXECUTIVE SUMMARY

This report summarizes the data and analysis from the Coonamessett Farm Foundation (CFF) seasonal survey on Georges Bank (GB) for the 2024-2025 funding year. The survey consisted of six research trips conducted between August 2024 and June 2025 across Closed Area II (CAII) South and the Southern Flank (SF) rotational areas. Paired 15-foot uncovered and covered commercial scallop dredges were used to quantify scallop biomass by size class, meat yield dynamics, reproductive timing, health status, predator assemblages, bycatch patterns, and gear selectivity in a region with historically high scallop biomass and important flatfish bycatch.

This year the project objectives were:

1. Evaluate seasonal biomass changes of pre-recruit, recruit, and adult scallops using a dredge cover net in eastern GB.

2. Collect scallop gonad samples to investigate seasonal and spatial variations in scallop spawning on eastern GB.

3. Evaluate seasonal changes in scallop health status by macroscopically inspecting for scallop meat color, nematodes, orange pustules, and shell blisters on eastern GB.

4. Investigate relationships between predator distribution/abundance and the distribution/abundance of scallops and clappers on eastern GB.

5. Evaluate seasonal changes in the distribution and abundance of key bycatch species in relation to scallop aggregations on eastern GB.

6. Determine when yellowtail and windowpane flounder are spawning within the eastern part GB throughout gonad examination.

7. Conduct biological sampling of American lobster caught in the dredges to assess distribution, abundance, shell hardness, presence of eggs, shell disease symptoms, and damage due to the dredge

<u>Seasonal scallop biomass patterns:</u> The covered dredge was the only gear that effectively sampled pre-recruit scallops (<35 mm), confirming its importance for detecting early cohorts. Pre-recruit biomass was generally low across trips, with localized peaks in SF and CAII in August 2024 and in CAII-Ext in April 2025. Recruit scallops (35-75 mm) were more broadly and persistently distributed than pre-recruits, with the highest relative biomass observed in CAII-Ext and SF. Covered dredge estimates consistently exceeded uncovered dredge estimates in all months, particularly in CAII-Ext, where recruit biomass was highest in January and April 2025. Adult scallops (>75 mm) were widely distributed across the survey area. High adult biomass occurred in August 2024 in CAII and SF. Overall, the 2024-2025 results highlight strong spatial and temporal variability in scallop biomass, with CAII-Ext and SF emerging as key areas for recruits and adults at different times of year.

Scallop biology and health: A total of 6,553 scallops from 49 stations were used to develop a shell height-meat weight (SHMW) model. Predicted meat weights for a 120-mm scallop varied by depth, month, and meat color. Brown and gray meats consistently showed lower predicted weights than white meats. Meat weights peaked in June across all depths, with the shallow 38-fathom CAII-south station showing the highest meat weights throughout the year. The deepest 50-fathom CAII-south station had the lowest meat weights during the second half of the study, while the mid-depth 43-fathom SF station had the lowest meat weights in the first half. Scallop health indicators showed low overall prevalence of anomalies. Only 1.55% of scallops exhibited poor-quality meat and 0.51% had shell blisters. Brown meats peaked in August and October 2024 and declined in 2025; gray meats remained rare and stringy meats did not show any pattern. Shell blisters peaked in October 2024 and April 2025. These patterns indicate that during the survey period scallop health was generally good with no consistent seasonal or spatial clustering of poor-quality individuals.

Predators, natural mortality, and environmental drivers: Predator assemblages differed by gear and season, with overall higher abundances in the covered dredge. Jonah crabs were more abundant than rock crabs, peaking in August 2024, declining through winter, and increasing again in June 2025. Moon snails were more abundant than whelks and peaked in winter and spring (January and April), while sea stars showed a gear effect: the uncovered dredge primarily retained medium-large *Asterias* with relatively stable biomass, whereas the covered dredge captured dense aggregations of small *Astropecten* sp. and other sea stars, especially in January and June. Models relating scallop natural mortality to predators and environmental variables showed that, for the uncovered dredge, depth and temperature were highly significant, interacting to explain more than half of the deviance in mortality estimates, with a strong seasonal effect. For the covered dredge, depth and temperature acted as independent predictors with smaller individual effects but still significant seasonal variation. These results highlight the importance of environmental gradients and seasonally varying predator communities in shaping scallop mortality, especially for smaller size classes underrepresented in commercial gear.

Scallop and flatfish reproductive timing: Gonadal mass index (GMI) and macroscopic staging of scallop gonads indicated a strong fall spawning period in 2024, with the highest proportions of ripe and partially spent gonads and reduced GMI values in August-October. Evidence of developing and partially spent gonads in early 2025 suggests some spring reproductive activity, but comparatively high GMI values indicate that this spring event was weak relative to the fall spawning. For yellowtail flounder, gonadosomatic index (GSI) analyses supported a primary spring spawning period, consistent with previous observations for this region. Windowpane flounder exhibited a dominant fall-winter spawning signal. Moderate GSI values in August-October 2024 were followed by a sharp decline in January 2025, when over 60% of females were classified as spent, indicating peak spawning between fall and mid-winter. Spent females were present in most months (except June), suggesting low-level, extended spawning activity.

Bycatch rates and spatial distribution: Bycatch rates relative to scallop catch were low across all trips (<1.5 lbs fish per lb scallops). Yellowtail and fourspot flounder bycatch never exceeded 0.07 lbs/lb of scallops, while windowpane flounder never exceeded 0.4 lbs/lb. Yellowtail bycatch peaked in April, windowpane in February, and fourspot in April. Lobster bycatch rates were highest in October, whereas monkfish had the highest overall bycatch rates, peaking in June

(1.46 lbs fish/lb scallops). Spatially, yellowtail catches remained low and were concentrated in northern and eastern portions of the survey area; windowpane flounder were broadly distributed with seasonal concentration toward the northwest; and monkfish distributions shifted seasonally between broad coverage in high-catch months and southern location when catches were low.

Lobster distribution and dredge impacts: Lobster catches were generally low but exhibited clear seasonal and spatial trends. Most lobsters were captured in the northern and eastern part of the sampling area, with highest numbers in August and October 2024 and a pronounced increase in total weight in June 2025 due to high catches in the covered dredge and cover net. Most lobsters were female, and shell disease was rare. Approximately 60% of lobsters showed no dredge damage, 15% had moderate damage, and 19% sustained lethal injuries, with the highest incidence of lethal damage occurring in August 2024.

Gear selectivity and survey design implications: Selectivity analyses using cover net and trouser trawl SELECT models estimated L50 values between roughly 103-110 mm and showed that the covered dredge had slightly higher relative efficiency than the uncovered dredge. A GLMM of catch proportions confirmed that the covered dredge retained more smaller scallops, with the proportion of catch from the covered dredge decreasing as shell height increased. This pattern suggests that the covered dredge and cover net configuration provides a more complete representation of pre-recruit and recruit scallops by retaining individuals that would otherwise pass through the dredge or be lost during haul back and catch dumping.

Management relevance: The 2024-2025 seasonal survey demonstrates the critical value of high-frequency, fishery-independent sampling in an important scallop region that may be closed to the fleet in upcoming fishing years. By integrating size-structured biomass estimates, meat yield dynamics, spawning timing, health indicators, predator and bycatch patterns, and gear selectivity, this project provides the fine-scale, intra-annual information needed to interpret recruitment events, shifts in flatfish bycatch risk, and environmentally driven changes in productivity. These data complement observer and annual survey programs, filling key temporal and spatial gaps and providing a robust scientific foundation for future scallop specifications, bycatch mitigation, and fisheries management on Georges Bank.

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INTRODUCTION

Atlantic sea scallops (*Placopecten magellanicus*) continue to support one of the most valuable and well-managed fisheries in the United States, contributing 21.3 million pounds of wild-caught seafood valued at over $333 million in 2024 (NOAA 2025). Sea scallops inhabit a dynamic mosaic of habitats across Georges Bank (GB), the Mid-Atlantic Bight, and the Gulf of Maine, where variability in sediment transport, seasonal hydrography, and episodic recruitment events drive changes in biomass, distribution, and availability to the fishery. Management under the Atlantic Sea Scallop Fishery Management Plan relies on rotational area management and biological reference points to sustain long-term productivity while balancing bycatch and habitat considerations.

Management measures implemented through Framework Adjustment 39 reflect ongoing changes in spatial biomass patterns and emphasize the need for fine-scale seasonal information. In 2025, the Closed Area I (CAI) and CAII were reopened based on high exploitable biomass observed in recent survey data, while the Nantucket Lightship North and South and Elephant Trunk areas were closed to protect dense aggregations of juvenile scallops documented in 2024. Framework 39 also revised the seasonal bycatch closure in CAII, shifting it to November 15-May 15 to reduce interactions with northern windowpane (*Scophthalmus aquosus*) and yellowtail flounder (*Pleuronectes ferruginea*) during months of elevated bycatch and low scallop meat yields. These changes underscore the increasing importance of understanding seasonal shifts in scallop condition and size structure, predator presence, and bycatch species dynamics.

The Coonamessett Farm Foundation (CFF) seasonal survey, funded through the Sea Scallop Research Set-Aside (RSA) program, addresses these needs by collecting detailed, multi-season data on GB. Annual federal surveys provide essential fishery-independent biomass estimates, but they occur once per year and cannot capture the seasonality and spatial variability that influences bycatch, scallop meat yield, spawning cycles, predator distributions, and environmental drivers that influence the scallop fishery. Since 2010, the CFF seasonal survey has complemented these federal efforts by collecting repeated measurements throughout the year, allowing managers and researchers to track emerging trends more rapidly and with finer spatial resolution.

The incorporation of a cover net on one of the dredges towed during research trips has strengthened the survey's ability to quantify pre-recruit and recruit scallops and evaluate predator and juvenile fish assemblages that typically escape through the twine-top mesh and apron of a commercial dredge. When combined with detailed biological sampling and environmental measurements, these data provide a comprehensive picture of seasonal dynamics on GB. Annual reports from this project update species distribution maps, spawning cycles, meat quality indicators, predator-prey relationships, and bottom temperature conditions across seasons; all critical information for addressing current and future challenges in scallop fishery management.

OBJECTIVES

1. Evaluate seasonal biomass changes of pre-recruit, recruit, and adult scallops using a dredge cover net in eastern GB.

2. Collect scallop gonad samples to investigate seasonal and spatial variations in scallop spawning on eastern GB.

3. Evaluate seasonal changes in scallop health status by macroscopically inspecting for scallop meat color, nematodes, orange pustules, and shell blisters on eastern GB.

4. Investigate relationships between predator distribution/abundance and the distribution/abundance of scallops and clappers on eastern GB.

5. Evaluate seasonal changes in the distribution and abundance of key bycatch species in relation to scallop aggregations on eastern GB.

6. Determine when yellowtail and windowpane flounder are spawning within the eastern part GB throughout gonad examination.

7. Conduct biological sampling of American lobster caught in the dredges to assess distribution, abundance, shell hardness, presence of eggs, shell disease symptoms, and damage due to the dredge

GENERAL SAMPLING METHODS

Sampling design

Six research trips were conducted from August 2024 to June 2025 on eastern GB, where scallop biomass and bycatch of yellowtail and windowpane flounder have been historically high (**Table 1**, **Figure 1**). Fixed stations were located inside of the CAII (CAII southeast, CAII southwest), CAII-Ext, and Southern Flank (SF) SAMS areas. The start position for each of the 49 stations was randomly selected prior to each trip using four points 0.25 miles away from the fixed-station position.

Table 1. Trip, dates and vessels used for the 2024 seasonal survey project.

Year	Trip Month	Trip Dates	Vessel
2024	August	12th – 18th	F/V Regulus
	October	7th – 13th	F/V Beiningen
2025	January	10th – 16th	F/V Atlantic
	February	21st – 27th	F/V Endeavor
	April	22nd – 28th	F/V Concordia
	June	16th – 22nd	F/V Vanquish

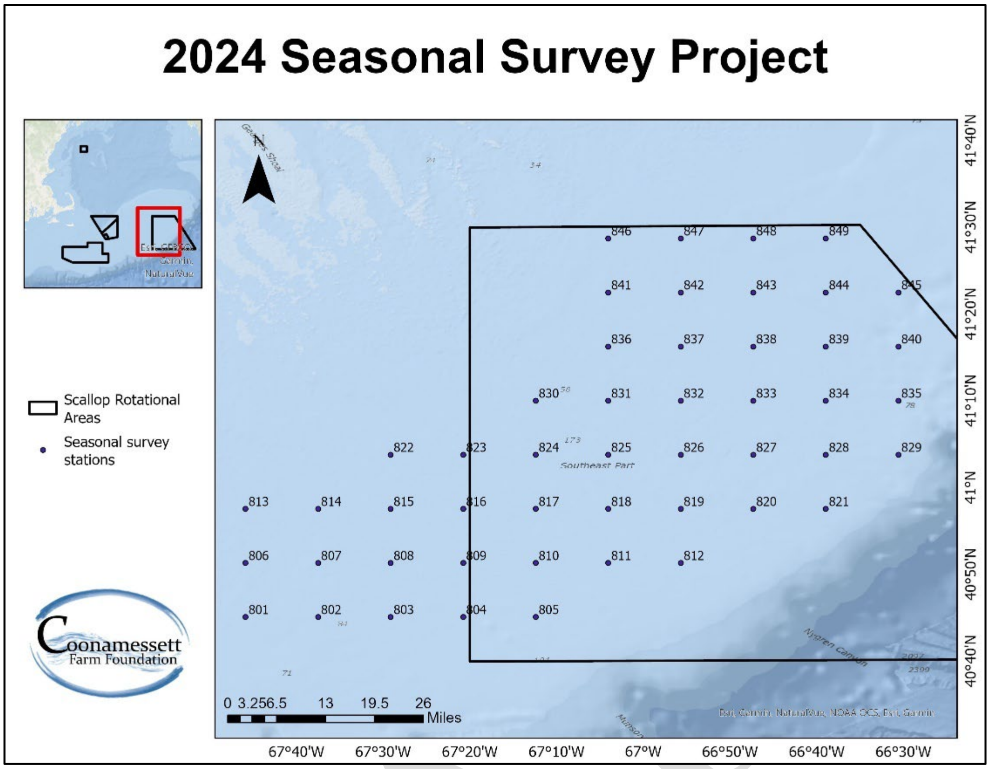


Figure 1. Survey station locations sampled for the 2024 seasonal survey on eastern GB. Stations are separated by approximately 6 nautical miles.

A covered and an uncovered 15-foot wide (4.57 m) CFF Turtle Deflector Dredge (TDD) were deployed each trip. The covered dredge employs a 45-mm mesh net over the topside of the dredge that extends from the skirt to the clubstick (**Figure 2**) and retains animals that pass through the dredge while towing at commercially representative speeds. The uncovered dredge was towed at every station while the covered dredge was towed at select stations to avoid areas with large aggregations of sand dollars or reported rocks and boulders. At stations where both dredges were deployed, they were towed simultaneously. The dredges were towed at a target speed of 4.8 knots for 15 minutes at all stations during each trip. Vessel position, speed, and heading were recorded every 15 seconds using a GPS enabled ruggedized tablet. In addition to the tow data, a Lotek data logger was affixed to the uncovered dredge to record temperature and depth every 30 seconds.

Figure 2. Picture of the cover net during the 2023 August seasonal survey trip.

Catch was processed in three gear categories: the uncovered dredge, the covered dredge, and the cover net. Catch processing was identical for each category. For each tow/gear, the catch was separated by species and weighed using a Marel 1100-series motion-compensated scale. A subset of relevant bycatch species was measured to the nearest centimeter, and all other fish species were individually counted. Winter (*Leucoraja ocellata*) and little skates (*L. erinacea*), and occasionally other skate species, were counted together and classified as "unclassified skates." **Table A1** lists the species and the number and weight caught during the project. During each trip, up to ten fish were randomly selected from the uncovered dredge to measure whole-body and gonad weights, which were used to evaluate the gonadosomatic index (GSI) of windowpane, winter (*Pseudopleuronectes americanus*), and yellowtail flounder.

The total scallop catch was quantified in bushels (bu=35.2 liters) for each tow. A one-bushel subsample of scallops was selected at random from each dredge and the cover net, and shell height (SH) was measured in 5-mm increments. For the selected basket from the uncovered dredge, all scallops were shucked and weighed. In addition, at each station, 30 scallops (or fewer if the total catch < 30 scallops) in the basket collected from the uncovered dredge were randomly set aside to collect biological data including shell height, meat weight, gonad weight, sex, reproductive stage, and meat quality. These scallops were measured to the nearest millimeter from the umbo to the shell margin and then carefully shucked for evaluating scallop health. Meat quality was assessed on a qualitative color scale (**Figure 3**), and presence of nematodes and orange pustules was noted. The presence of shell blisters, found on the inside of the scallop shells, were recorded.

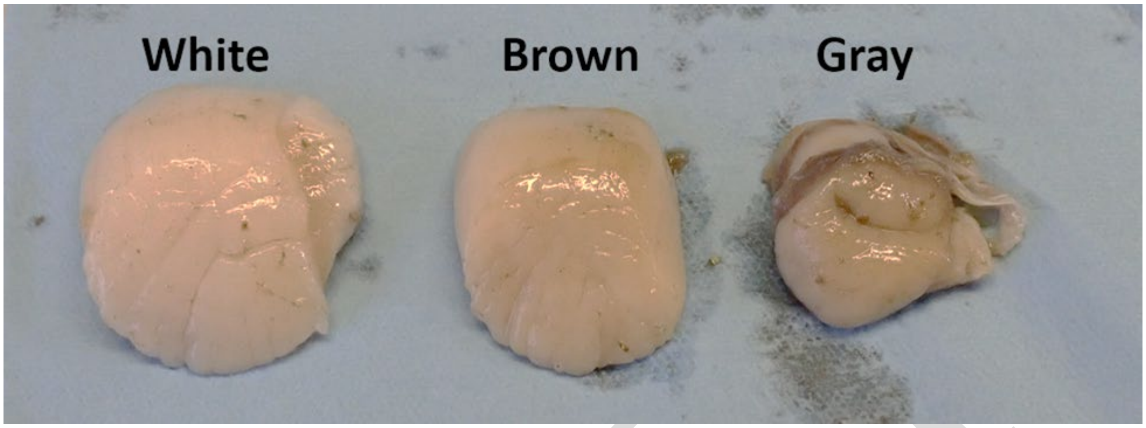


Figure 3. Image showing the qualitative scale used to classify scallops by meat color. Scallops with brown/gray meat show muscle degeneration. Scallops with salmon and white meats were combined.

Data for all individual lobsters caught in the dredges were collected by gear type. Carapace length, weight, sex, presence of eggs, shell hardness and incidence of shell disease was determined for each lobster. In addition to demographic data, the extent of damage caused by the dredge was recorded. Dredge damage was assessed on a scale from 0 to 5, with 0 indicating no damage and 5 indicating a fatal/dismembering crush by the dredge (**Table 2**).

Table 2. Classification of types of damage to lobsters caused by scallop dredges.

Valid Damage	Damage Description	Category of damage
0	No damage	**No Damage**
1	Missing an appendage, chipped carapace, (90% chance of survival)	**Moderate Damage**
2	Moderate damage to shell, slow response after 10 minutes observation (70% chance of survival)	
3	Lethal injury, still responding (less than 30% chance of survival)	**Lethal Damage**
4	Killed by dredge, still intact	
5	Killed by dredge, smashed, ripped to pieces	

Data analysis

Catch data from the covered dredge and cover net were aggregated for analysis. This was done to represent the whole catch in a similar manner to a lined dredge used in the scallop stock assessment. In this report, "covered dredge" numbers include the catch from the covered dredge and the cover net.

Scallop relative biomass by size: Scallop biomass per tow by size class was estimated based on the shell heights of the measured bushel and the number of bushels per tow. Shell heights were converted to meat weights with the equation derived from the Shell Height Meat Weight (SHMW) analysis done for this report. During all trips, the start and end position of each tow was recorded, and the minimum swept area (km^2) for each station was calculated using the dredge width (km) and the estimated tow distance (km). Assuming tows were straight lines connecting the start and end points of a tow, the following Haversine equation was used to calculate tow distance:

$$Tow\ length = Arcosine\ \Big(Cosine\big(Radians(90 - Start\ latitude)\big)\ x\ Cosine\big(Radians(90 - End\ latitude)\big) + Sine\big(Radians(90 - Start\ latitude)\big)xSine\big(Radians\ (90 - End\ latitude)\big)xCosine\big(Radians\ (End\ longitude - Start\ longitude)\big)\Big)\ x\ 6731$$

Catchability coefficients (q) of 0.4, 0.65, and 1 were used to calculate area-swept total biomass (kg/tow) estimates by month. The relative biomass of scallops (kg/km^2) for each station was calculated as:

$$scallop\ biomass\ = \frac{SB(kg)}{swept\ area(km2)} xAx \frac{1}{q}$$

To calculate the total biomass (mt) of pre-recruit, recruit, and adult scallops by month and SAMS area, the average scallop biomass (SB) per km^2 for all tows in each SAMS area was multiplied by the area (A) for each SAMS area. These calculations were done for the uncovered dredge for all stations and for the covered dredge + cover net for the stations that were sampled using this gear.

Scallop reproductive cycle: The reproductive stages of sea scallops were plotted by trip to examine seasonal changes and estimate spawning periods. Reproductive cycles were described based on macroscopic observations and gonadal mass index (GMI). Scallops were assessed using the following GMI equation:

$$GMI = \frac{GM}{SH^b}$$

where b = slope of the regression line for gonadal mass (GM) against shell height (Bonardelli and Himmelman 1995).

Bycatch crustacean and gastropod vs scallop mortality: A natural mortality (M) index was calculated as the ratio between the abundances of clappers (D) to live scallops (L), multiplied by the rate at which the shell ligament degrades:

$$M = \left(\frac{D}{L}\right)\left(\frac{52}{t}\right)$$

where a year has 52 weeks and the average length of time in weeks for the valves to separate (t) is set at 33 weeks (Merril and Posgay 1964).

For each dredge (covered and uncovered), M was modeled in relation to predator abundance (gastropods, crustaceans, and sea stars) and environmental covariates using GLMMs in the R package "glmmTMB" (Brooks *et al*. 2017) with cruise included as random effect.

Groundfish bycatch rates vs scallop meat yield: The seasonal catch rates of important bycatch species (windowpane and yellowtail flounders, monkfish, and lobsters) were calculated in relation to the scallop catch using the total meat yield from the bushel that was shucked and weighed. For this analysis, only the standard uncovered dredge was used. To calculate the total meat weight (in pounds) of scallops caught per trip, the measured bushel from each tow was expanded for the entire catch. The measured weight of bycatch species per trip (in pounds) was divided by the calculated scallop weight per trip to get a bycatch rate (fish weight/scallop weight).

Flatfish gonadosomatic index (GSI): The reproductive stages of winter, windowpane and yellowtail flounders were plotted by trip to examine seasonal changes and estimate spawning periods for each species. Reproductive stages were described based solely on macroscopic observations. GSIs for female flounders were determined following the equation:

$$GSI = \frac{WG}{WF}\, x\, 100$$

where WG = wet weight of gonad and WF = total wet weight of the fish (Bougis 1952).

Shell height-meat weight (SHMW) relationship: Scallop meat weight was modeled using generalized linear mixed models with a gamma distribution and a log link using the function “pqlmer” in R package “r2glmm” (Jaeger *et al*. 2017). Model selection was based on Akaike Information Criterion (AIC) values using the “aictab” function in R package “AICcmodavg” (Mazerolle 2019). Fixed effects for predicting meat weight included shell height, month, latitude, depth, and meat color. Survey station was included as a random effect. Predicted meat weights were estimated for white, brown and gray scallops at four stations, which were selected to include locations at different depths and areas, using the model selected using AIC values.

Spatial analysis: To illustrate spatial patterns across the sampling area, maps were created for bottom temperature, scallop biomass, and key bycatch species. Bottom temperature was interpolated using the Inverse Distance Weighting (IDW) method. Scallop biomass and bycatch species were mapped directly from tow-level data. All maps were generated in ArcGIS Pro.

Sea scallop selectivity analysis: The covered dredge is assumed to be non-selective, retaining a sample that is representative of the sea scallop population available to the gear. Tows with less than 20 scallops in any of the three gears (uncovered dredge, covered dredge, or cover net) were excluded from the analysis. The scallop catch-at-length data for each tow were analyzed using the covered/cover net and trouser trawl SELECT models (Millar 1992, Millar 1993). The covered/cover net model evaluates catch-at-length of the covered dredge bag relative to the catch-at-length of the cover net, while the trouser trawl model compares the catch-at-length of the combined covered dredge catch-at-length (covered dredge + cover net) relative to the uncovered dredge. Two trouser trawl models were evaluated, a model that calculated the selectivity parameters using pooled catch-at-length data and that calculated the selectivity parameters using individual tow catch-at-length data. To better determine if the uncovered and covered dredges were fishing similarly, a GLMM compared the scallop catches of the covered and control dredges (Holst and Revill 2009). Scallop shell height was the only covariate investigated with this model. This year, a low order polynomial of shell height was included in the model to account for non-linearity of the response and more accurately describe the mean proportion of the total catch from the covered dredge at length (Holst and Revill 2009).

RESULTS BY OBJECTIVE

Objective 1: Evaluate seasonal biomass changes of pre-recruit, recruit, and adult scallops using a dredge cover net in CAII-SE, CAII-SW, CAII-Ext and SF SAMS areas.

The covered dredge was the only gear that captured individuals in the pre-recruit (< 35 mm) size range, with the greatest relative biomass observed in the SF (**Table 3**). The highest pre-recruit biomass occurred in August 2024 for both CAII and SF, while April 2025 showed the greatest peak in CAII-Ext. Across all areas, pre-recruit biomass remained generally low throughout the sampling period.

For recruits (35–75 mm), the highest relative biomass numbers were observed in CAII-Ext and the SF, with the highest biomass observed in January in CAII-Ext (**Table 4**). Covered dredge estimates for recruits were consistently higher than uncovered dredge estimates in all months (**Table 4**). In CAII, the highest relative biomass for both dredges occurred in August 2024. In CAII-Ext, both dredges collected their highest biomass in January 2025. In SF, the highest biomass in the uncovered dredge occurred in January 2025, whereas the covered dredge catch peaked in October 2024.

For adults (> 75 mm), the area with the highest relative biomass shifted over the survey season, with estimates peaking in CAII, CAII-Ext, or SF depending on the survey trip (**Table 5**). For adults, the month with the highest relative biomass with both dredges was August 2024 in CAII; June 2025 (uncovered dredge) and January 2025 (covered dredge) in CAII-Ext; and August 2024 (uncovered dredge) and February 2025 (covered dredge) in SF (**Table 5**).

Table 3. Total scallop pre-recruit (< 35 mm) relative biomass estimates for each SAMS areas by gear type by month in eastern GB. Since the cover net has not been calibrated, three catchability coefficients (q) were used to calculate area-swept total biomass estimates by month.

Year	Month	Covered Dredge		
		q=1 (mt)	q=0.65 (mt)	q=0.4 (mt)
CAII				
2024	August	0.2	0.4	0.6
CAII-ext				
2024	August	0.1	0.2	0.4
	October	0.4	0.6	1.0
2025	April	1.4	2.2	3.6
	June	0.0	0.1	0.1
SF				
2024	August	4.9	7.6	12.4
	October	1.7	2.5	4.1
2025	January	0.5	0.7	1.2
	June	0.1	0.1	0.2

Table 4. Total scallop recruit (35-75 mm) relative biomass estimates for each SAMS areas by gear type by month in eastern GB.

Year	Month	Uncovered Dredge	Covered Dredge		
		q=0.65 (mt)	q=1 (mt)	q=0.65 (mt)	q=0.4 (mt)
CAII					
2024	August	19	7	11	18
	October	3	3	5	8
2025	January	2	6	9	14
	February	1	5	8	13
	April	0	4	5	9
	June	2	6	9	15
CAII-ext					
2024	August	2	68	105	171
	October	3	177	273	444
2025	January	12	1027	1579	2566
	February	3	117	180	292
	April	3	871	1340	2177
	June	11	49	75	122
SF					
2024	August	16	190	292	474
	October	5	485	747	1213
2025	January	52	92	141	229
	February	17	171	264	428
	April	12	49	75	122
	June	20	52	79	129

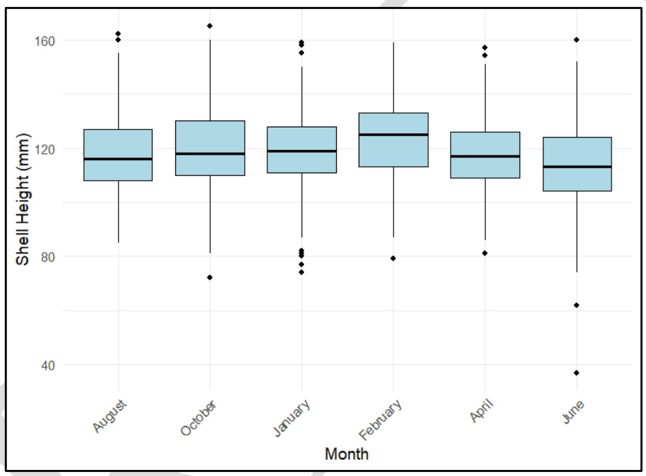
Table 5. Total adult scallop (>75 mm) relative biomass estimates for each SAMS areas by gear type by month in eastern GB.

Year	Month	Uncovered Dredge	Covered Dredge		
		q=0.65 (mt)	q=1 (mt)	q=0.65 (mt)	q=0.4 (mt)
CAII					
2024	August	2768	1511	2325	3779
	October	1913	1110	1707	2775
2025	January	875	1042	1603	2605
	February	967	1145	1762	2863
	April	692	747	1150	1869
	June	1528	466	717	1164
CAII-ext					
2024	August	1030	470	723	1175
	October	701	1571	2416	3926
2025	January	1088	2011	3094	5028
	February	806	1889	2906	4723
	April	535	1772	2726	4430
	June	1093	1035	1592	2587
SF					
2024	August	865	1383	2128	3458
	October	219	714	1098	1784
2025	January	539	752	1157	1880
	February	842	3651	5617	9127
	April	647	1591	2448	3979
	June	819	1740	2677	4349

Scallop distribution patterns varied by size class and seasons (see **Figures D1-D3** in **Appendix D**). Pre-recruits were most abundant during late summer and fall in SF (**Figure D1**). Recruits (35–75 mm) showed a broader and more persistent distributions throughout the year than pre-recruits. Consistently higher recruit densities were captured with the covered dredge, occurring in nearly the same central-southern portion of the sampling area across all trips (**Figure D2**). Adult scallops were widely distributed throughout the region and present across all months, with peak densities in late summer and fall 2024, particularly in northern and central portions of the sampling area (**Figure D3**). Overall, the updated 2024–2025 results reinforce the spatial and temporal variability of scallop biomass across SAMS areas.

<u>Shell height-meat weight analysis</u>**:** A total of 6,553 scallops were sampled at 49 stations located across the eastern portion of GB. Scallop shell heights ranged from 37 mm to 165 mm and meat weights varied from 1 g to 78 g. Temporal distributions of the collected shell heights and meat weights are shown in **Figure 4**.

a)



b)

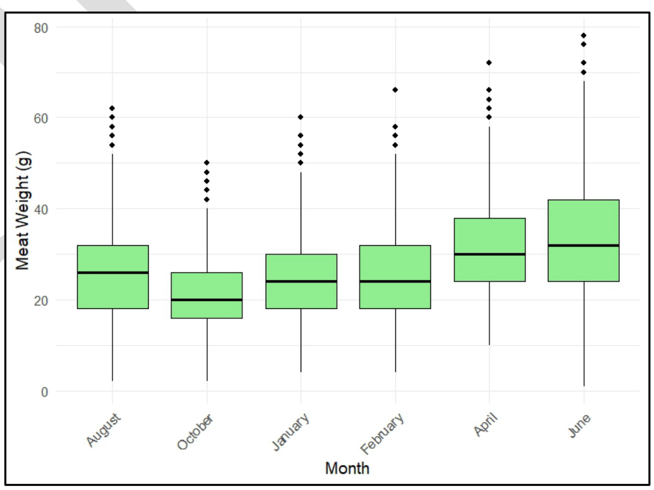


Figure 4. Temporal changes in the distributions of collected **a)** shell height and **b)** meat weight samples from eastern GB. The markers inside the boxes show the median values for each month. Boxes end at the first and third quartiles of the distribution of values for each variable, with the whiskers extending to the minimum and maximum values.

The selected model ($MW = e^{(\beta_0+\beta_1(ln\,SH)+\beta_2(M)+\beta_3(ln\,D)+\beta_4(C)+\beta_5(ln\,D*M)+\delta)}$) incorporated depth, month, meat color, and a depth-month interaction, with station included as a random intercept. Using this model, predicted meat weights for white, brown and gray scallop meats were analyzed by depth (**Figure 5**). Temporal trends in predicted meat weights for 120-mm scallops highlight the consistently lower values observed in brown meat weights compared to white scallop meats, as well as the different seasonal trends in meat weights for stations located at different depths (**Figure 5**). Meat weights peaked in June across all depths. The shallower 38-ftm (69 m) station, located in CAII-south, showed the highest meat weight for all months relative to the other depths. The deeper 50-ftm (91 m) station, located also in CAII-south, showed the lowest meat weights during the second half (February, April, and June trips) of the project period. In contrast, during the first half of the project (August, October, and January trips), the lowest meat weights were recorded at the mid-depth 43-ftm (79 m) station located in SF (**Figure 5**).

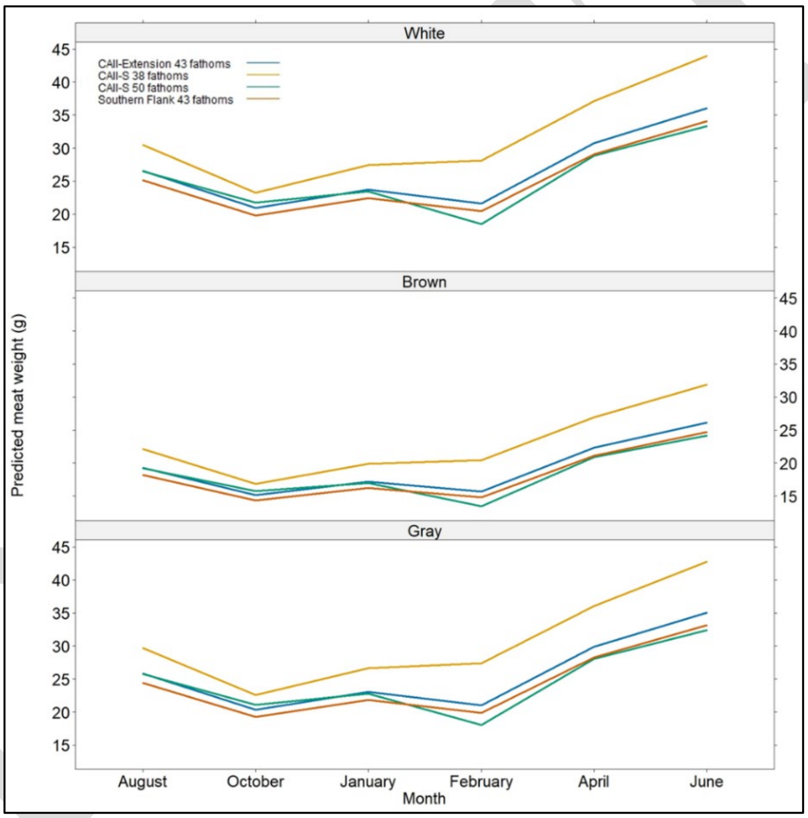


Figure 5. Estimated SHMW curves for white, brown and gray scallop meats from stations at different depths.

<u>Objective 2: Collect scallop gonad samples to investigate seasonal and spatial variations in scallop spawning</u>

Combining GMI results with macroscopic gonad stage observations suggests a strong fall spawning period for scallops, consistent with previous findings for this region and previous project years (Thompson *et al*., 2014; Garcia *et al*., 2018; Garcia *et al*., 2019; **Figure 6**). The highest proportion of ripe and partially spent gonads, together with lowered GMI values, occurred in late summer and early fall (August–October 2024), indicating peak reproductive activity during this period. Although developing gonads were observed in January and February and partially spent gonads were observed in April 2025, implying spring spawning activity, the relatively high GMI values suggest that this event was weak or incomplete. In contrast, the fall period exhibited lowest GMI values and a predominance of spent and partially spent gonads, confirming a more intense and widespread spawning phase. The presence of ripe gonads in August and October further supports the interpretation of a major fall spawning event (**Figure 6**).

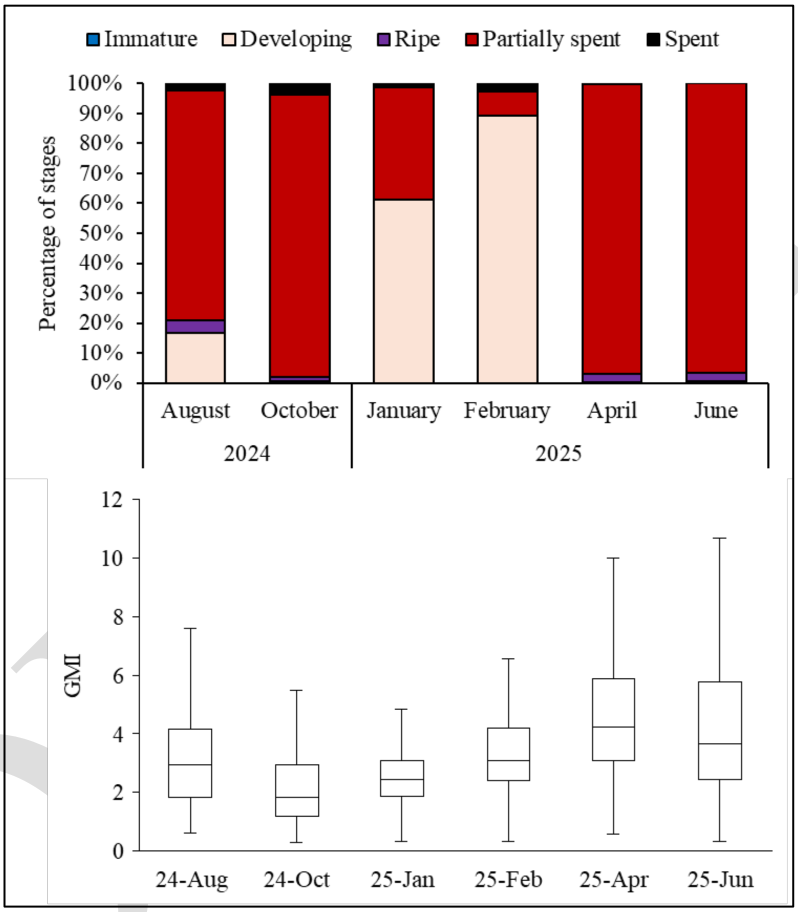


Figure 6. Seasonal changes in female scallop reproductive condition based on macroscopic gonad stage observations and GMI values during the 2024 seasonal survey on eastern GB. The stacked bars represent the proportion of females in each gonadal stage per month, while the boxplots illustrate the distribution of GMI values. Boxes denote the interquartile range (25th–75th percentiles), with whiskers extending to the minimum and maximum observed values.

<u>Objective 3: Evaluate seasonal changes in scallop health status by macroscopically inspecting for nematodes, orange pustules, and shell blisters</u>

During the SHMW analysis, researchers assessed both meat quality and shell condition of collected scallops. Overall, poor quality meats were rare, with only 1.55% of scallops exhibiting discoloration or abnormal texture, and 0.51% having shell blisters (**Table 6**). The few instances of poor-quality scallops were broadly distributed across the sampling area each month. Brown meat occurrence peaked in August and October 2024 and declined overall in 2025. Gray meats were recorded in low numbers than brown which increased or remained the same in the first 3 trips and decreased after February. Stringy meats displayed a mixed pattern, with high occurrences in roughly half of the trips. Shell blisters peaked in October 2024 and April 2025. These patterns highlight the low overall prevalence of health anomalies and the absence of consistent seasonal or annual trends in this area (**Figure 7**).

Table 6. Number of scallops analyzed by health condition and month.

Year	Month	Meat Color			Stringy meat	Shell blisters
		White	Brown	Gray		
2024	August	1165	7	1	22	5
	October	934	4	2	15	9
2025	January	1131	2	2	21	4
	February	1121	0	1	3	5
	April	1054	2	0	12	9
	June	1120	0	0	7	1

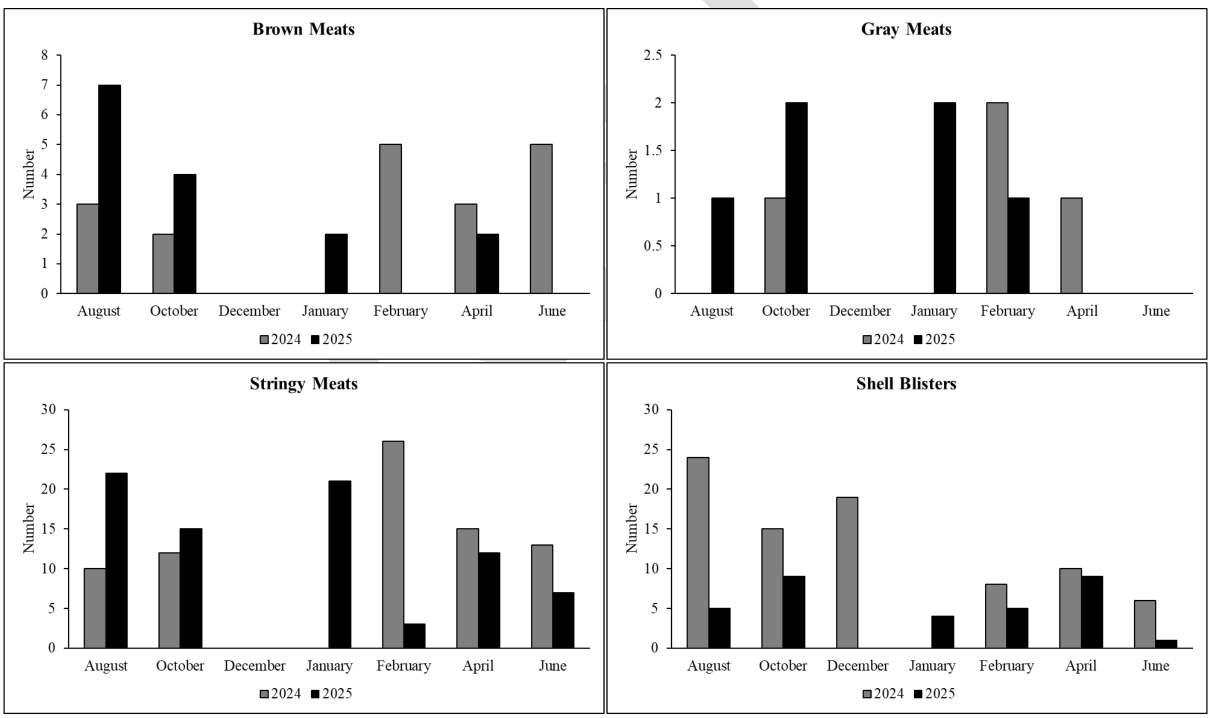


Figure 7. Monthly counts of scallops exhibiting brown, gray, and stringy meats, and shell blisters during 2024 and 2025. Bars represent the number of affected individuals per month for each health condition, shown separately by year to illustrate temporal variability and interannual differences.

Objective 4: Investigate relationships between predator distribution/abundance and the distribution/abundance of scallops and clappers

Predator data from each dredge type were analyzed separately. Crabs, gastropods, and sea stars were counted and weighed for both the uncovered and covered dredges. Predator abundance was consistently higher in the covered dredge (**Figure 8**). *Cancer* spp. showed clear seasonal patterns, with Jonah crabs dominating both abundance and biomass across all trips and gears. Catches peaked in August 2024, declined through winter, and increased moderately again in June 2025, suggesting a summer aggregation in the region (**Figure 8**). Moon snails were more abundant than whelks throughout the year, with the highest densities occurring during winter and spring (January and April trips; **Figure 9**), contrasting with the summer peak observed in crabs. Sea-star patterns also differed between gears. The uncovered dredge primarily retained medium to large Asterias with relatively stable biomass, whereas the covered dredge showed high densities of small Astropecten and other sea stars, with peak abundances in January and June. Despite their high numbers, these small individuals contributed little biomass compared to Asterias.

When comparing scallop natural mortality against predator abundance and environmental parameters, the uncovered dredge model showed that depth and temperature were highly significant predictors ($p < 2e{-16}$), indicating that natural mortality varied across combined depth-temperature conditions. This model explained 54.4% of the deviance, suggesting that environmental gradients are major drivers of mortality patterns when only larger organisms retained by commercial gear are represented. The significant cruise effect ($p = 1.11e{-05}$) highlights strong seasonal variation in natural mortality (**Table 7a**). In contrast, the covered dredge model showed that depth and temperature each influenced natural mortality independently rather than jointly (Depth: $p = 0.00150$; Temp: $p = 0.0467$), with smaller individual effects than in the uncovered dredge model. This model explained 42% of the deviance. As in the uncovered dredge model, cruise-to-cruise variability remained significant ($p = 0.00102$), reinforcing the role of seasonality on scallop natural mortality (**Table 7b**).

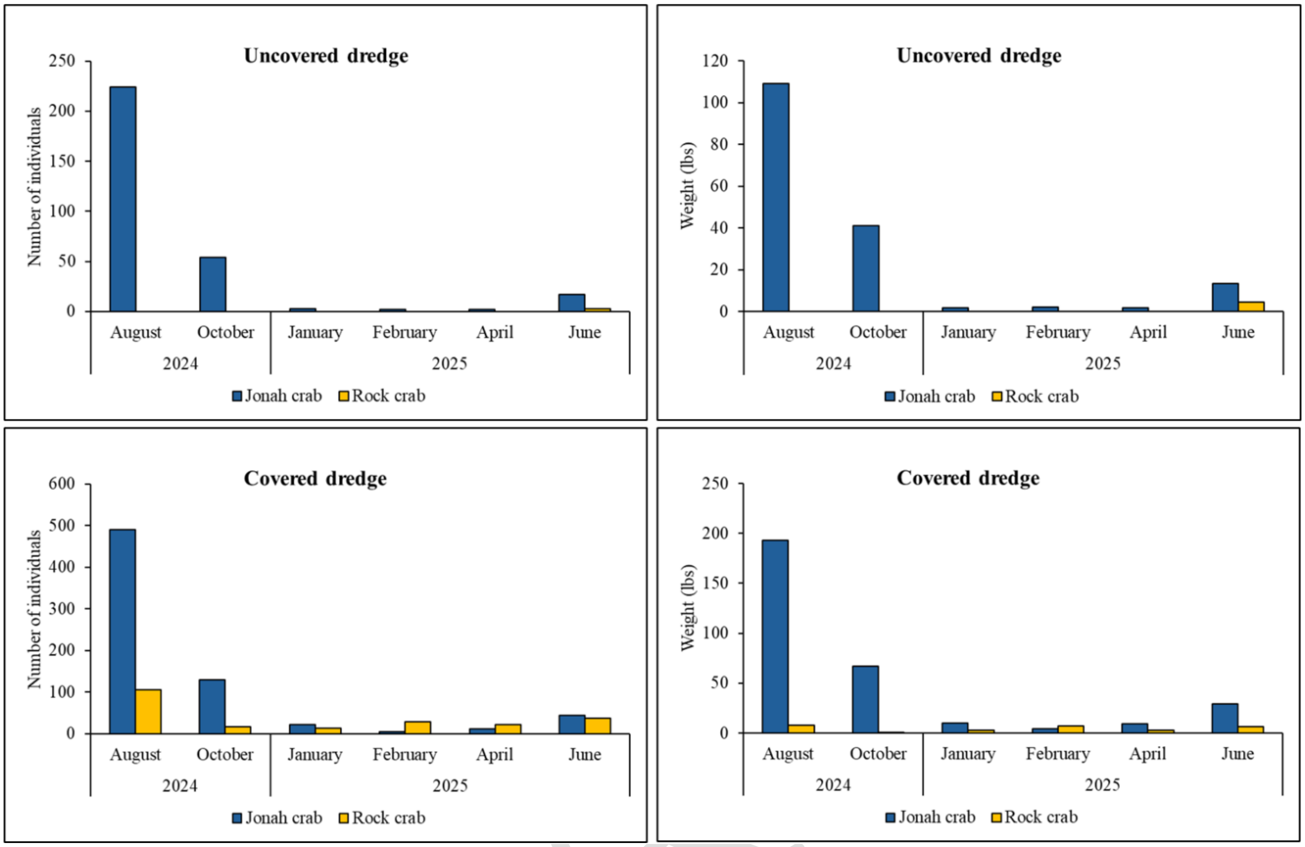


Figure 8. Seasonal trends in the number of individuals (left panels) and total weight (right panels) of Jonah crab and rock crabs caught with uncovered (top row) and covered (bottom row) dredges during the 2024 seasonal survey project.

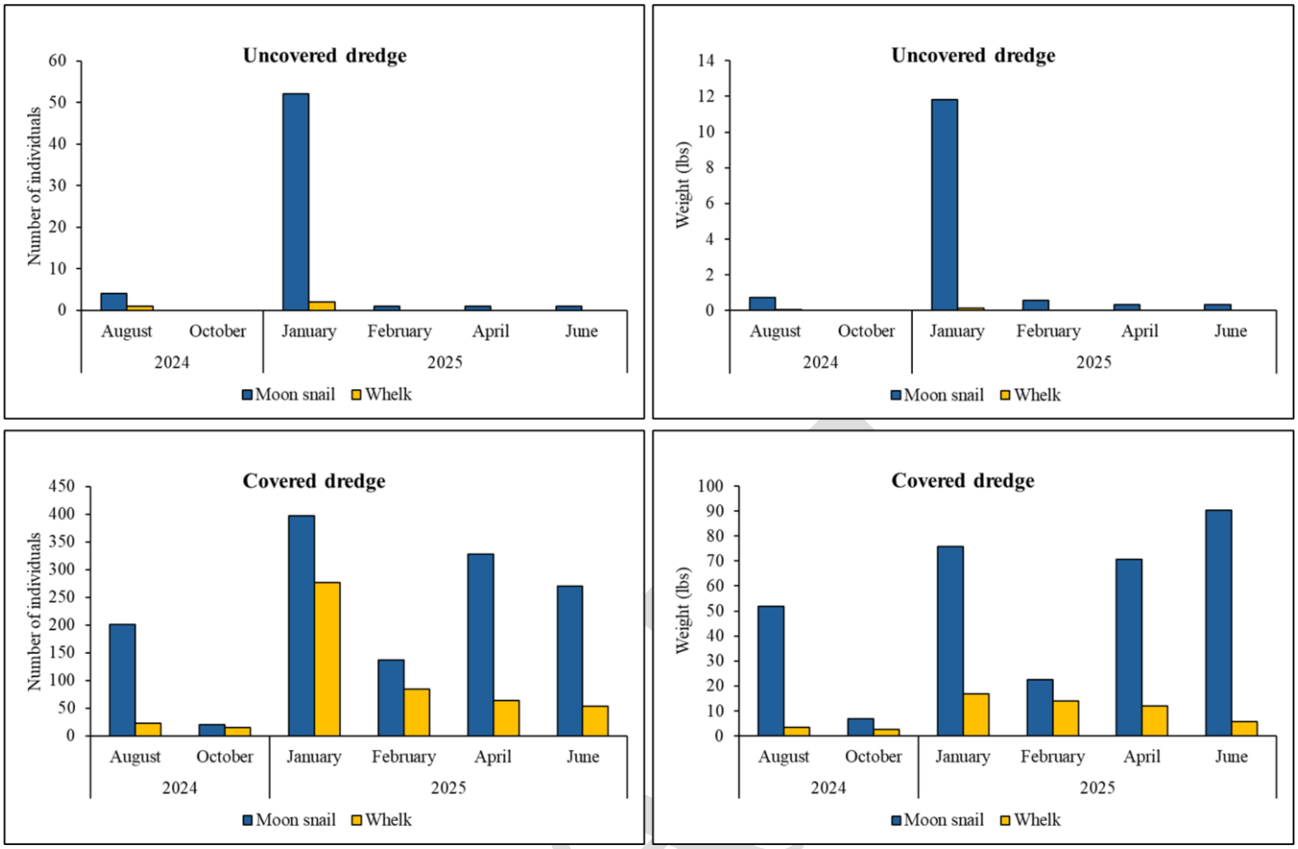


Figure 9. Seasonal trends in the number of individuals (left panels) and total weight (right panels) of moon snail and whelk caught with uncovered (top row) and covered (bottom row) dredges during the 2024 seasonal survey project.

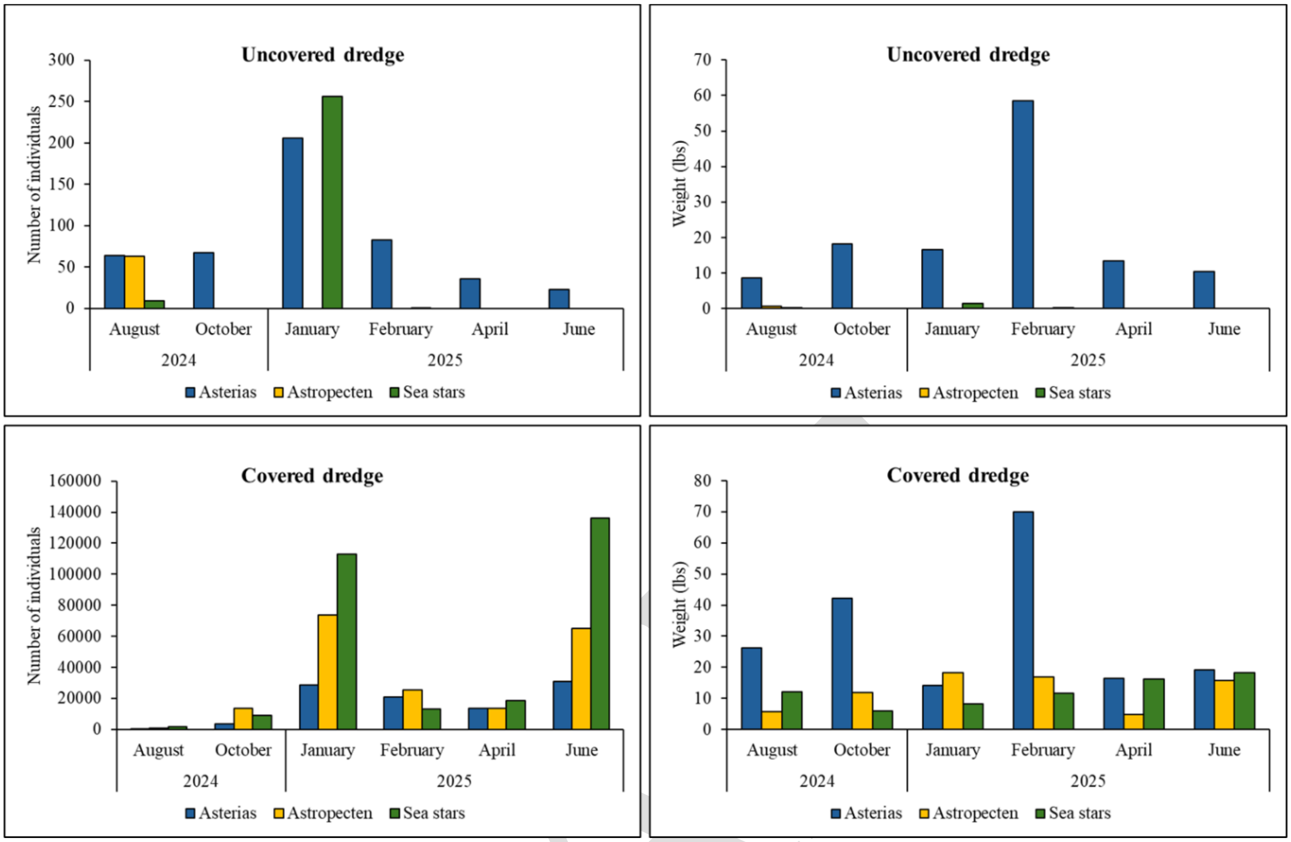


Figure 10. Seasonal trends in the number of individuals (left panels) and total weight (right panels) of Asterias (blue bars), Astropecten (yellow bars) and other sea star species (green bars) caught with uncovered (top row) and covered (bottom row) dredges during the 2024 seasonal survey project.

Table 7. Summary statistics for the relation of M, predator abundance and environmental parameters, data collected from the **a)** uncovered dredge and **b)** covered dredge.

a)

```
Formula:
nat ~ s(Depth, Temp, k = 40) + s(CruiseID, bs = "re")

Parametric coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)   -3.926      1.266    -3.1  0.00216 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Approximate significance of smooth terms:
                 edf Ref.df     F  p-value
s(Depth,Temp) 16.977  22.84 5.392  < 2e-16 ***
s(CruiseID)    4.752   5.00 5.274 1.11e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-sq.(adj) =  0.306   Deviance explained = 54.4%
-REML = -11.518  Scale est. = 0.35664    n = 273
```

b)

```
Formula:
nat ~ s(Depth) + s(Temp) + s(CruiseID, bs = "re")

Parametric coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  -3.8410     0.7484  -5.132 1.54e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
              edf Ref.df     F p-value
s(Depth)    2.810  3.509 5.264 0.00150 **
s(Temp)     3.946  4.942 2.293 0.04666 *
s(CruiseID) 4.178  5.000 3.323 0.00102 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.334   Deviance explained =   42%
-REML = -64.705  Scale est. = 0.23384   n = 106
```

Objective 5: Evaluate seasonal changes in the distribution and abundance of key bycatch species in relation to scallop aggregations on Georges Bank

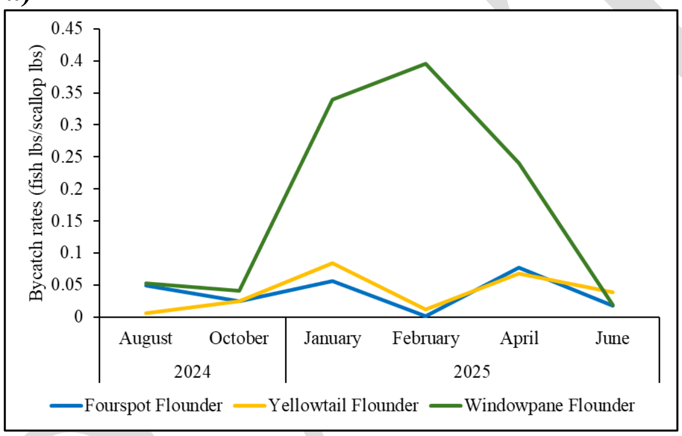
Total catches by survey month of the relevant bycatch species from the uncovered dredge are displayed in **Table 8**. The seasonal catch rates of important bycatch species were calculated in relation to the scallop catch (i.e. lbs. of fish/lbs. of scallops). The overall bycatch rates for all the commercially important species sampled during this project were low (< 1.5 lbs. of fish/lb. of scallops). Bycatch rates were never greater than 0.07 lbs. of fish/lb. of scallops for yellowtail and fourspot flounders (*Hippoglossina oblonga*), and for windowpane flounder, the bycatch rates never exceeded 0.4 lbs. of fish/lb. of scallops (**Figure 11a**). Yellowtail flounder bycatch was highest during the April trip; windowpane flounder bycatch peaked during the February trip and fourspot flounder bycatch peaked during the April trip (**Figure 11a**). The highest lobster bycatch rates were observed during the October trip (0.6 lbs. of lobster/lb. of scallops). Monkfish bycatch rates were the highest among the species that were analyzed, with the highest rate observed during the June trip (1.46 lbs. of fish/lb. of scallops **Figure 11b**). Other flatfish, like summer flounder (*Paralicthys dentatus*) and winter flounder were rarely caught during the survey (**Table 8**).

Distribution maps for selected bycatch species are presented in **Appendix D**. Yellowtail flounder catches remained low throughout the project and were concentrated primarily in the northern and eastern portions of the sampling area (**Figure D4**). Windowpane flounder were present across the entire survey area with relatively uniform spatial coverage, although in August, October, and June their catches were more concentrated toward the northwestern section, a pattern consistent with their known seasonal movements and results from previous surveys (**Figure D5**). Monkfish exhibited broader spatial variability across months; when catches were higher (August, October, and June), individuals were widely distributed throughout the survey area, whereas during January and April, monkfish were more localized to the southern portion (**Figure D6**). These patterns highlight species-specific habitat preferences and seasonal shifts within the survey area.

Table 8. Total catches by trip with the uncovered dredge for the 2024 seasonal survey project. Scallop catch is quantified in bushels and fish/crustacean in number of individuals.

Year	Month	Scallop	Summer Flounder	Fourspot Flounder	Yellowtail Flounder	Winter Flounder	Grey Sole	Windowpane Flounder	Monkfish	Lobster
2024	August	67	0	47	2	0	1	36	74	61
	October	43	6	17	4	0	0	14	44	35
2025	January	41	9	20	15	0	0	153	22	3
	February	37	8	1	2	0	0	176	0	2
	April	23	14	30	9	2	2	99	39	9
	June	40	0	11	8	2	10	8	99	21

a)



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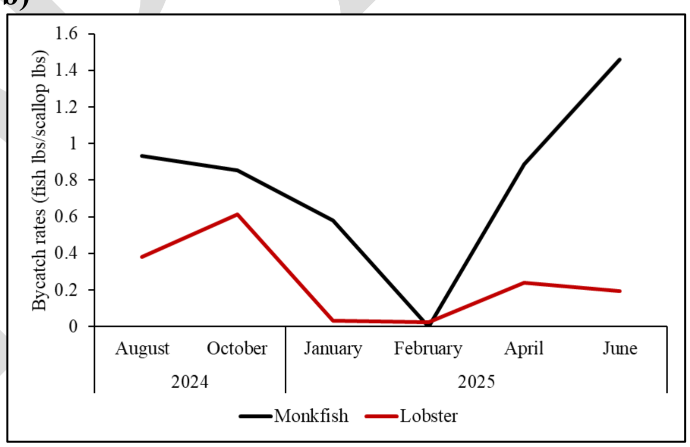

Figure 11. Bycatch rates for commercially important species, including **a)** fourspot, yellowtail and windowpane flounders and **b)** monkfish and lobster in relation to scallop catch during the 2024 seasonal survey. Only the uncovered dredge was used for this analysis.

Objective 6: Determine when yellowtail and windowpane flounder are spawning within the eastern part GB throughout gonad examination

Yellowtail flounder: A total of 86 yellowtail flounder were caught, of which 42 individuals were assessed for reproductive condition, and 92% of these were females. The highest catch occurred in January (**Table 8**, **Figure D4**). The GSI analysis suggested a potential spawning period in spring (**Figure 12**), consistent with historical yellowtail flounder spawning patterns and previous observations from CFF seasonal surveys. (Pereira *et al*. 2012, Garcia *et al.* 2018).

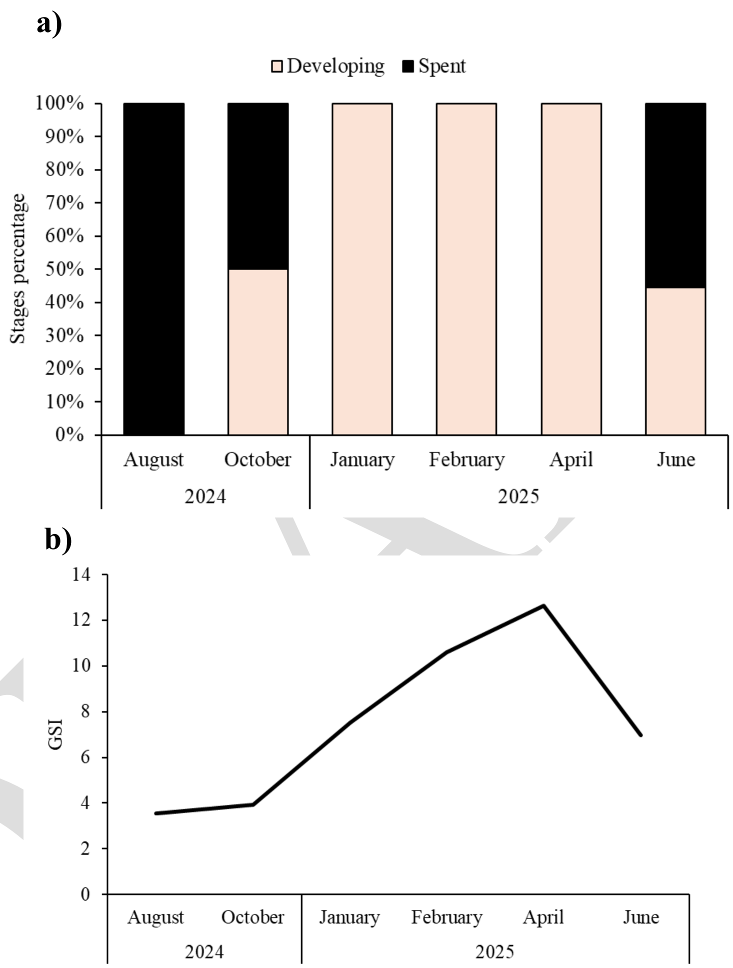

Figure 12. Seasonal changes in the GSI of female yellowtail flounder for each month during the 2024 seasonal survey on eastern GB; **a)** percentage of individuals sampled by trip spawning stage and **b)** GSI level by trip.

Windowpane flounder: A total of 919 windowpane flounder were caught, of which 438 individuals were assessed for reproductive condition, and 69% of these were females. Windowpane catches peaked in February (**Table 8**). They were caught at most stations in January, February and April (**Figure D5**). Based on the GSI values, one clear spawning period likely occurred in fall/winter (**Figure 13**). GSI values were moderate during August-October 2024, followed by a sharp decline in January 2025 that coincided with more than 60% of fish being classified as spent. This pattern strongly suggests that peak spawning occurred between fall and mid-winter. However, spent females were observed during every trip, except June, suggesting that a low level of spawning activity may occur year-round.

a)

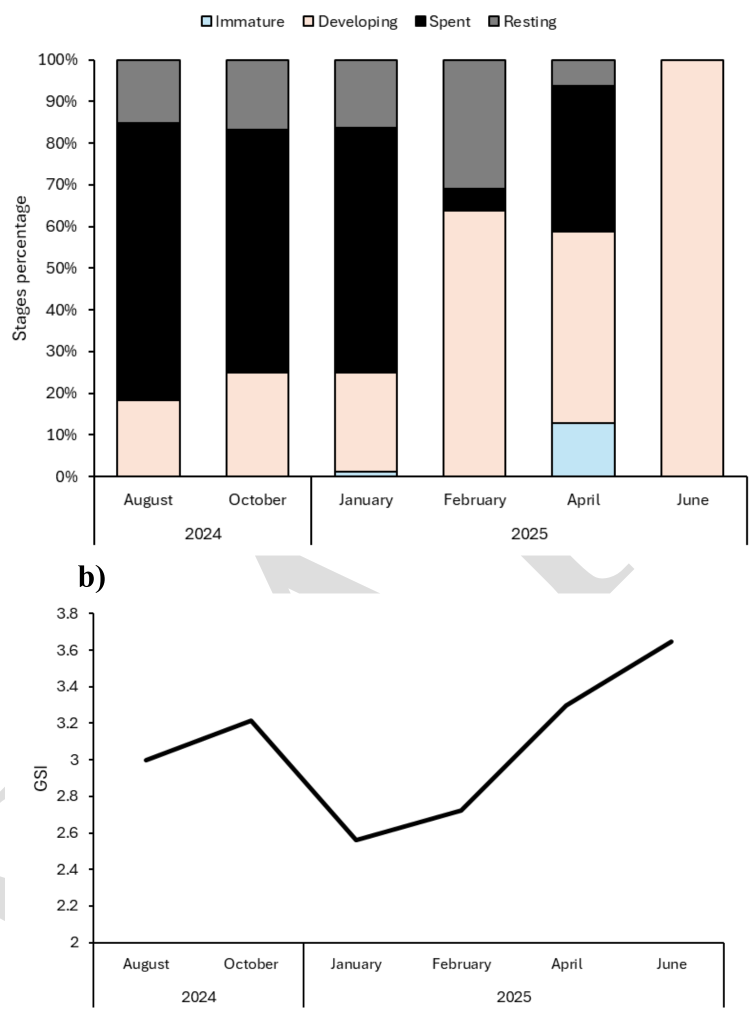

Figure 13. Seasonal changes in the GSI of female windowpane flounder for each month during the 2024 seasonal survey on eastern GB; **a)** percentage of individuals sampled by trip spawning stage and **b)** GSI level by trip.

Objective 7: Conduct biological sampling of American lobster caught in scallop dredges.

Lobster catches were consistently low throughout the 2024–2025 survey period, although catch rates varied among trips. The majority of captured lobsters were in the northern and eastern portion of the sampling area, a pattern that aligns with both historical observations and known seasonal habitat preferences in this region (**Figure 14**). Catches were highest during the late summer and fall of 2024, with 61 individuals collected in August and 35 in October in the uncovered dredge. During these months, lobsters were widely distributed across the northeastern stations, suggesting seasonal use of shallower, warmer habitats. In contrast, lobster presence declined sharply during the winter months of January and February, when only seven individuals were captured across both dredge configurations. This reduced winter occupancy is consistent with the species' well-documented movement into deeper, more thermally stable habitats during colder periods. By the spring and early summer of 2025, catches increased again, particularly in June, when the combined dredge and cover net gear captured 262.6 lbs of lobster, the highest recorded weight across all trips (**Table 9**).

Table 9. Lobster catches by trip.

Year	Month	Uncovered dredge		Covered dredge + cover net	
		Number	Weight (lbs)	Number	Weight (lbs)
2024	August	61	163.5	20	32.5
	October	35	125.2	24	85.3
2025	January	3	7.9	3	7.1
	February	2	5.4	0	0
	April	9	49.4	2	7.2
	June	22	62.3	7	262.6

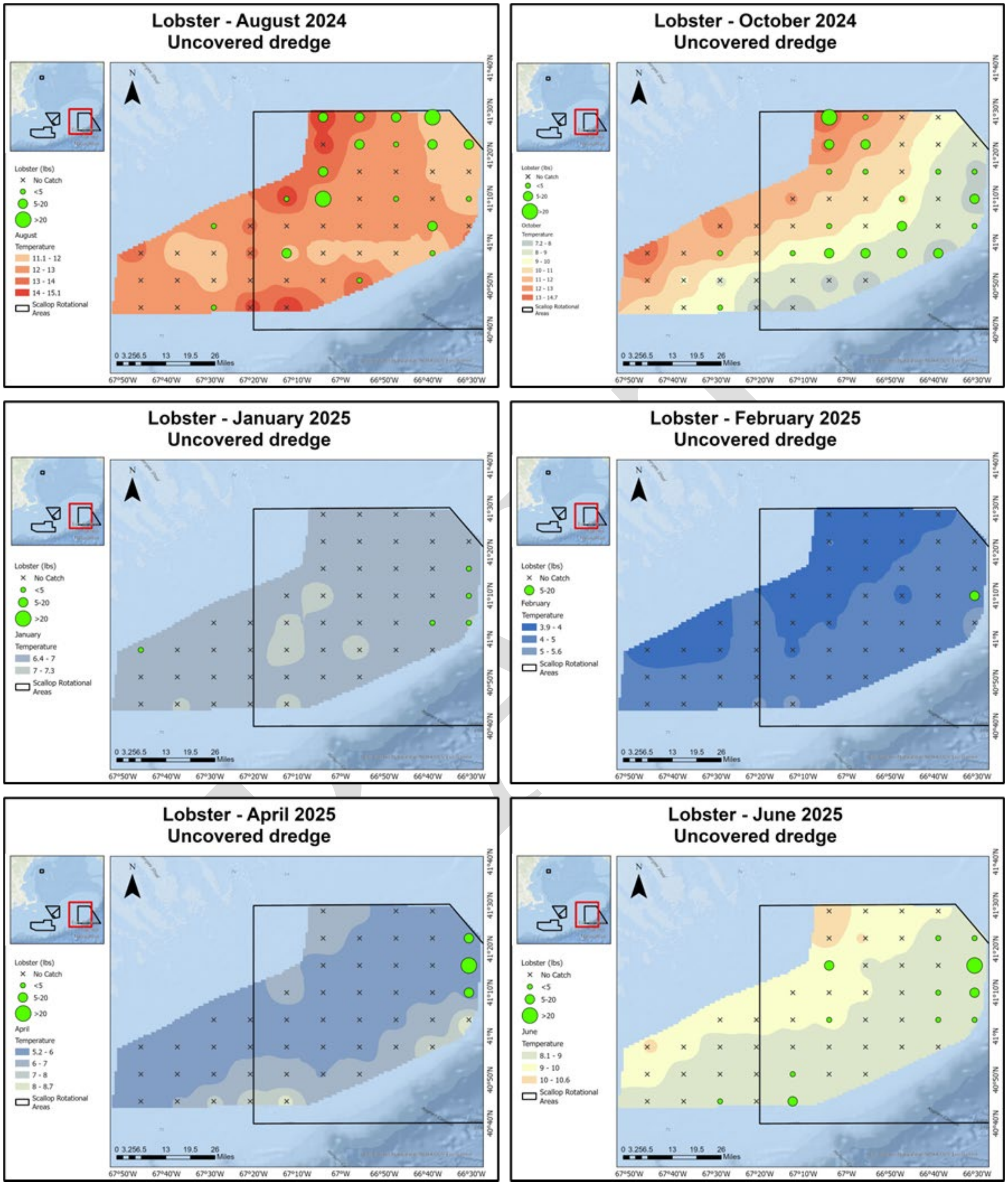

Figure 14. Distribution of lobster caught with the uncovered dredge during the 2024 seasonal survey on eastern GB shown over observed bottom temperature. Temperatures (°C) were interpolated using the IDW method and illustrated with cooler and warmer colors associated with respective temperatures.

The majority of the lobsters caught during the survey were females, with the exception of the December trip, where males constituted 53% of the catch (**Table 17, Figure 15**). Shell disease was observed in six lobsters: three during the August trip, two in December, and one in June. Of the 103 lobsters caught, 60% showed no damage, 15% were moderately damaged (e.g., missing claws or walking legs), and 19% had lethal damage (**Figure 16**). The highest incidence of lethal damage occurred during the August trip (**Figure 16**).

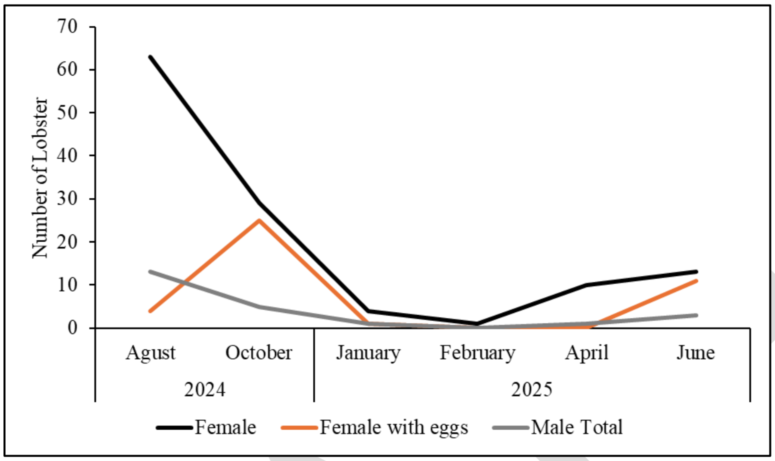

Figure 15. Catch of lobsters by trip separated by sex during the 2024 seasonal survey on the eastern portion of GB.

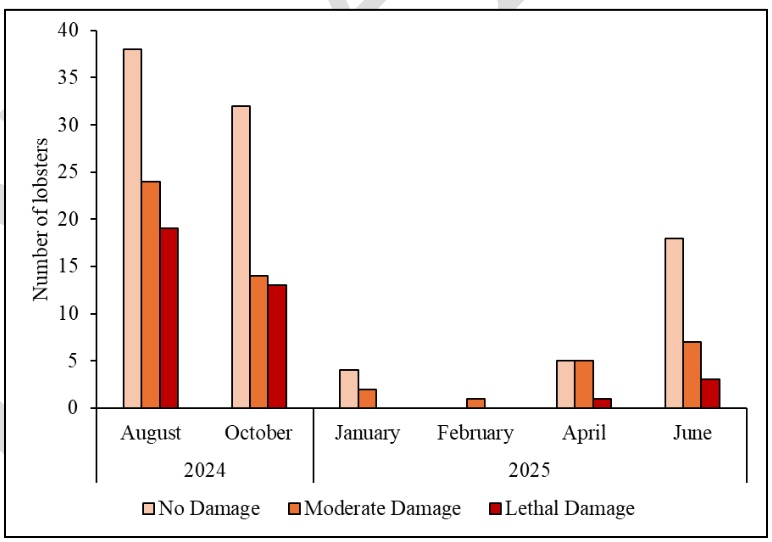

Figure 16. Dredge-induced damage to lobsters by trip during the 2024 seasonal survey on eastern GB.

Add-on objective 8: Evaluate selectivity of scallops and main bycatch species, as well as assess the seasonal distribution and abundance of pre-recruits and recruit scallops and juvenile flatfish through a dredge cover net

The predicted length at 50% retention (L50) values predicted by the SELECT models ranged from 103.33-109.72 mm (**Table 10** and **Figure 17**). For the trouser trawl models, the relative efficiency estimates (split-p) for both models ranged from 0.52-0.53, indicating that the covered dredge had a similar, slightly elevated efficiency than the control dredge.

Table 10. The estimated sea scallop retention parameters from the trouser trawl and cover net models.

	Covered/cover net Model		Trouser Trawl Model		REP Model	
	Estimate	*S.E.*	*Estimate*	*S.E.*	*Estimate*	*S.E.*
L50	95.24	0.093	108.05	0.651	111.94	1.228
SR	19.46	0.142	29.10	0.480	26.66	0.791
p	N/A		0.54	0.005	0.54	0.012
Log-Likelihood	-75.28		-97.91		-77.41	
AIC	2724.08		1372.05		517.44	

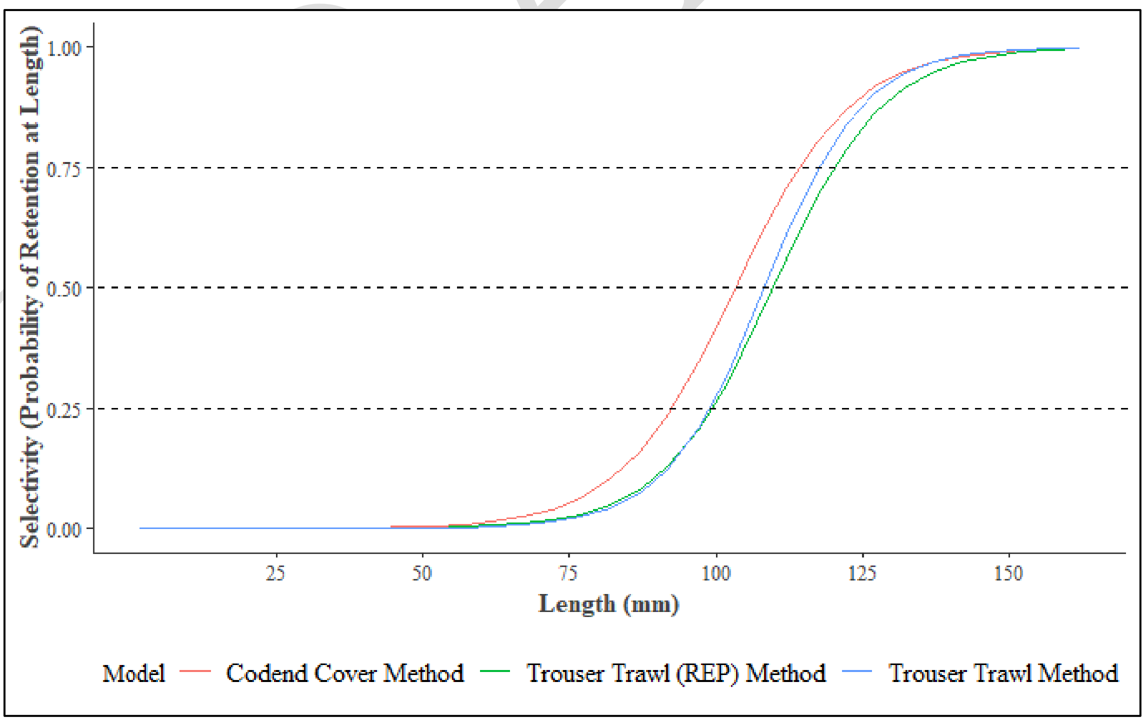

Figure 17. Sea scallop selectivity curves as generated by the trouser trawl and cover net models.

Both trouser-trawl SELECT models and the best fitting GLMM model indicate that the covered dredge was marginally more efficient with efficiency increasing as shell height decreased (**Table 11**, **Figure 19**). This may be due to a combination of factors like smaller scallops in the cover falling through dredge when the catch is being dumped and/or the cover net masking the dredge bag which prevents smaller scallops from passing through dredge bag (Millar and Naidu 1991; Millar 1993).

Table 11. GLMM modelling coefficient estimates for sea scallop catch.

Fixed Effect	Estimate	Std. Error	t-value	p-value
(Intercept)	0.126	0.040	3.173	0.0051
Length	-0.318	0.032	-9.871	2.00E-16
Length^2	-0.142	0.030	-4.677	3.90E-05

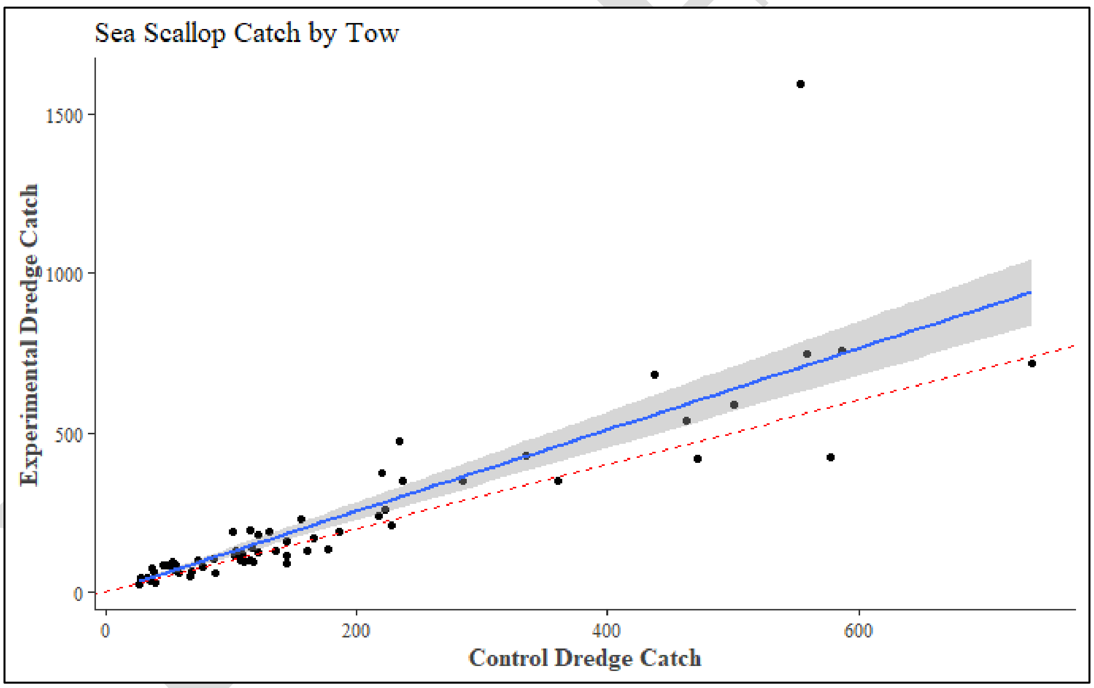

Figure 18. The model estimated proportion of the total catch (blue line) relative to the observed catch proportion (black dots) and an equivalent proportion (red dotted line).

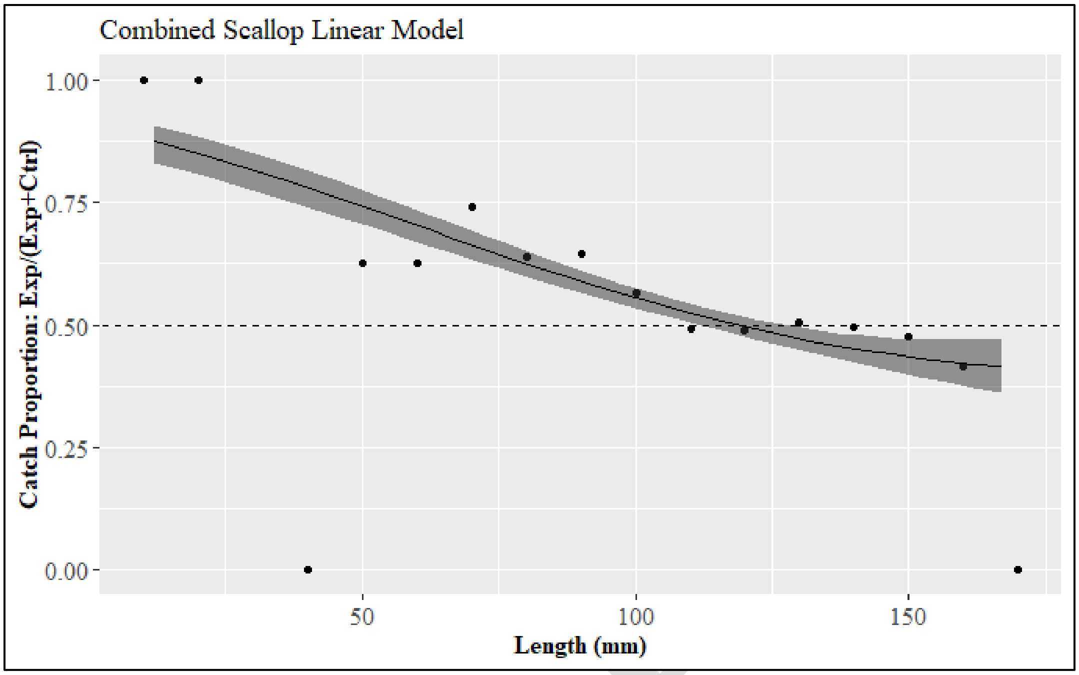

Figure 19. The model estimated proportion of the catch-at-length (black line) relative to the observed catch-at-length (black dots) and an equivalent proportion (black dotted line).

DISCUSSION

The CFF seasonal survey provides essential, fine-scale information on sea scallop population dynamics and fishery interactions with bycatch species on GB, particularly during seasons when federal survey coverage is absent. Seasonal surveys began in 2010 and have strategically evolved as management needs changed (**Figure 20**). The project was temporarily unfunded in 2014 following questions about the value of continued sampling in the same region, and this pause forced a shift to a new survey area in 2015. That relocation later contributed to renewed questions in 2020, when the project again went unfunded, because the time series was no longer continuous within a single core region. While these externally driven shifts created unavoidable gaps in spatial continuity, they also underscored the importance of maintaining the long-term, standardized dataset originally envisioned for eastern GB. In addition, during 2020, when observer coverage in CAII was absent, the survey provided the only source of seasonal data for this area. After returning to the intended core area, the survey has reestablished consistent coverage in this critical area. The project's core methodology has remained unchanged throughout its history, ensuring that the dataset remains robust, comparable, and scientifically valuable over time.

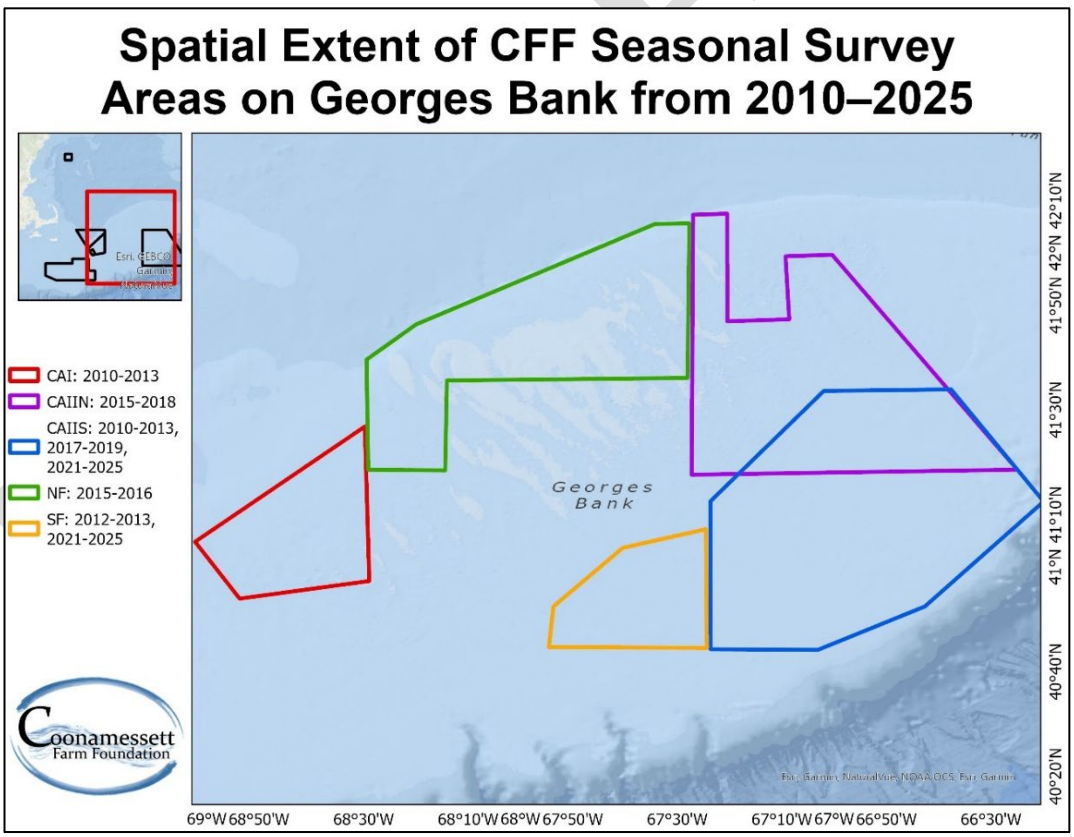

Figure 20. Survey areas sampled by the CFF seasonal survey from 2010–2025. Colored outlines show the survey areas sampled during the different phases.

Since 2017, this project has delivered a uniquely continuous dataset for eastern GB that captures intra-annual changes in scallop biomass, scallop meat yield, reproductive timing, bycatch distributions, predator-prey interactions, and environmental conditions.. For instance, the seasonal survey first documented the breakdown of the predictable yellowtail flounder cycles that previously supported the original CAII seasonal closure (August 15–November 15; Smolowitz *et al.* 2016). However, the historic late-summer peaks in yellowtail abundance have been replaced in recent years by irregular and shifting patterns, with peaks occurring in mid-summer, late spring/early summer, and winter. These findings, together with the CFF seasonal survey's windowpane flounder data, contributed to the evidence used by managers to modify the CAII seasonal bycatch closure in Framework 39. The new closure (November 15–May 15) was adopted to better align with the period of highest windowpane bycatch and lower scallop yield, and the CFF seasonal survey provided the seasonal flatfish distribution information necessary to support this decision.

Incorporating the dredge cover net remains critical for accurately quantifying pre-recruit and recruit scallops, as it consistently retains substantially more small individuals than the uncovered dredge. This enhanced gear efficiency allowed the survey to identify distinct seasonal and spatial patterns, including localized pre-recruit peaks in SF during late summer to early fall 2024 and in CAII-Ext in April 2025. Selectivity analyses support this observation, with model results showing that the covered dredge retained proportionally more small scallops than the uncovered dredge, validating its ability to more accurately represent pre-recruit and recruit size classes. Recruit-size scallops were also detected most reliably in CAII-Ext, where biomass was highest in January and April. Seasonal fluctuations in scallop biomass are strongly influenced by spawning cycle, during which metabolic energy is directed toward the production of gametes and somatic tissue weight reaches some of its lowest levels relative to shell size (Smolowitz *et al.* 1989). Our results reflect this pattern with the lowest relative biomass of individuals larger than 75 mm (**Table 5**) occurring in spring for the CAII-Ext and CAII SAMS areas, and fall for SF. These declines align with the spawning period observed in this year's data (**Figure 5**). Gonadal indices and macroscopic staging confirmed a dominant fall spawning period in 2024, consistent with findings from the prior survey year. Although some reproductive activity was detected in early 2025, GMI values suggest that spring spawning was comparatively weak or spatially limited.

Currently, scallop spawning dynamics are inferred primarily from data collected by the Northeast Fisheries Observer Program (NEFOP). Although NEFOP has historically sampled a sufficient number of trips to characterize broad reproductive patterns, observer data are inherently tied to fishing activity and may not capture seasonal biological conditions in areas with limited or prohibited effort. As a result, within-year variability in meat-yield, reproductive condition, and yield-per-recruit can be difficult to assess consistently across all scallop grounds. In contrast, the CFF seasonal survey sampled CAII both when it is open and closed, with six surveys conducted each year regardless of fishing effort or access-area status. This repeated, fishery-independent sampling provides higher temporal resolution for evaluating spawning dynamics and short-term changes in scallop condition. This data may become increasingly valuable as management explored broader implementation of electronic monitoring, which may change the nature and distribution of future observer coverage.

Predation and predator abundance factor into seasonal scallop biomass estimates. Seasonal variability in predator assemblages was pronounced. Jonah crabs dominated the predator assemblage in the sampling area and exhibited strong late-summer peaks, while moon snails and *Astropecten* spp. peaked during winter and spring. Covered dredge samples revealed much higher densities of small predators, indicating that commercial gear underestimates the abundance of small-bodied predators that would influence scallop recruitment. Models for scallop natural mortality consistently identified depth, temperature, and season as significant predictors. These findings reinforce the role of environmental variability in shaping predator-prey interactions and subsequent scallop mortality rates. Accounting for seasonal predator pulses, particularly for pre-recruits and recruits whose vulnerability is known to increase under certain temperature regimes (Hart and Chute 2003; Barbeau and Scheibling 1994), improves management's capacity to be seasonally proactive.

Environmental conditions on GB continue to vary substantially across space and time, and many marine species are responding to increasing temperatures, altered circulation patterns, shifting nutrient regimes, and changes in ocean chemistry (Kleisner *et al*. 2017). These environmental drivers influence growth, physiology, and reproductive timing. Seasonal survey data provides seasonal evidence for understanding how yellowtail and windowpane flounder adjust their reproductive cycles shift in response to environmental variability. Our multi-year observations indicate that yellowtail flounder consistently spawn in spring, aligning with recent survey years (Garcia *et al*. 2022, Garcia *et al*. 2023) and the historically documented spawning period (Pereira *et al*. 2012). The notable exception is the unusual winter spawning event recorded in 2019 (Garcia *et al*. 2021), demonstrating that atypical reproductive timing can occur under certain environmental conditions. In contrast, windowpane flounder exhibited a dominant fall–winter spawning period but also spent females throughout the year, suggesting prolonged or diffuse reproductive activity in this region (Hendrickson 2008, Garcia *et al*. 2022). Such inconsistency in timing may contribute to poor recruitment if eggs or larvae encounter suboptimal environmental conditions (Wieland *et al*. 2000).

These findings highlight the importance of collecting reproductive data at multiple points throughout the year. High frequency seasonal sampling provides managers with near-real-time information needed to understand shifting reproductive cycles and anticipate how environmental change may influence the productivity of key bycatch species. The need for finer-resolution biological data is further emphasized by recent PDT updates, which noted that the Scallop PDT was unable to generate SNE/MA yellowtail flounder bycatch projections for FY2026 because area-specific scallop catch estimates and updated discard-to-kept ratios were not available. The absence of this information directly limits the PDT's capacity to evaluate bycatch risks under different management alternatives. The seasonal survey provides precisely the type of high-resolution, repeated sampling necessary to support area-specific catch estimates, improving understanding of seasonal bycatch distributions. CAII will likely remain closed to the fleet during the 2026 fishing year, and as a result, the CFF seasonal survey will provide the only source of biological and bycatch information from this region during that period.

The 2024-2025 results demonstrate that seasonal survey data capture key dynamics, including recruitment events, shifting patterns of bycatch and predator abundance, and intra-annual spawning signals that would be missed by annual surveys alone. As scallop management enters a period marked by increasing environmental variability and operational uncertainty, the continuity of this seasonal survey is critical. Sustained sampling provides managers with the temporal resolution necessary to interpret short-term ecological changes and to incorporate reliable, fine-scale information into annual specifications. Consistent seasonal coverage greatly strengthens managers' ability to interpret short-term ecological changes.

CONCLUSIONS AND FUTURE RESEARCH

Marine environmental changes on GB continue to drive spatial and temporal shifts in the distribution, abundance, and condition of commercially important species. These changes, coupled with variable fishing pressure and access area availability, highlight the need for fine-scale monitoring throughout the year. Seasonal surveys remain a useful tool capable of detecting rapid ecological changes, such as recruitment aggregation, shifts in spawning timing, predator dynamics, and seasonal bycatch distributions, that annual surveys cannot identify.

The 2024-2025 survey year showed important patterns with direct implications for scallop management. Recruit biomass in CAII-Ext showed peaks during winter and spring, and a spring peak in SF, suggesting a potentially meaningful contribution to future exploitable biomass. Predator assemblages presented a strong seasonality, with Jonah crabs peaking in summer, and moon snails and *Astropecten* spp. peaking in winter and spring, reinforcing the importance of considering seasonal predator pressure when interpreting scallop natural mortality. Scallop reproductive data showed a dominant fall spawning period, while spring spawning was comparatively weak. Seasonal distribution data for yellowtail and windowpane flounders also supported ongoing management efforts under Framework 39 and 40 to minimize flatfish bycatch during periods of highest abundance. Together, these results demonstrate how year-round sampling capture biological processes that could be missed with annual surveys alone.

Looking forward, maintaining the continuity of this long-term seasonal dataset is essential but increasingly uncertain. With the RSA program not issuing a funding opportunity for the upcoming year, continuation of the seasonal survey will depend on alternative mechanisms, such as the Exempted Fishing Permit request submitted on September 25, 2025. Any interruption to seasonal sampling would create gaps in an 8-year time series and limit the ability to detect the short-term dynamics that influence stock biomass, bycatch mitigation, and the evaluation of management alternatives. This need for continuity is even more critical given that CAII is expected to be closed to the fleet next year, meaning the CFF seasonal survey will provide the only scallop and bycatch biological information available from this region. Without these repeated fishery-independent observations, managers would lack the seasonal data necessary to monitor recruitment success, identify emerging bycatch hotspots, detect shifts in predator pressure, or understand how environmental variability is influencing the productivity of key species in this region.

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APPENDICES

Appendix A: General

Table A1. Species captured during the 2024 seasonal survey on the eastern portion of GB. Total lengths were measured for some fish while mantle length was taken for squid.

Common Name	Scientific Name	Sample Procedure	Weight (kg)	Number Caught
American lobster	Homarus americanus	Weigh/Measure	367.4	190
American plaice	Hippoglossoides platessoides	Weigh/Measure	1.66	4
Atlantic cod	Gadus morhua	Weigh/Measure	10.73	4
Barndoor skate	Dipturus laevis	Weigh/Measure	412.42	377
Blue crab	Callinectes sapidus	Weigh/Count	0.74	11
Butterfish	Peprilus triacanthus	Weigh/Count	0.5	7
Conger eel	Conger oceanicus	Weigh/Count	0.05	1
Fourspot flounder	Paralichthys oblongus	Weigh/Measure	179.44	978
Gulfstream flounder	Citharichthys arctifrons	Weigh/Count	22.73	648
Haddock	Melanogrammus aeglefinus	Weigh/Measure	10.51	15
Illex squid	Illex illecebrosus	Weigh/Measure	0.33	2
Jonah crab	Cancer borealis	Weigh/Count	333.78	1500
Lady crab	Ovalipes ocellatus	Weigh/Count	0.11	1
Loligo squid	Doryteuthis pealeii	Weigh/Measure	0.82	4
Longhorn sculpin	Myoxocephalus octodecemspinosus	Weigh/Count	49.02	493
Monkfish	Lophius americanus	Weigh/Measure	830.07	392
Northern moon snail	Euspira heros	Weigh/Count	163.66	1488
Northern searobin	Prionotus carolimus	Weigh/Count	74.15	387
Ocean pout	Zoarces americanus	Weigh/Count	66.91	233
Red hake	Urophycis chuss	Weigh/Count	363.67	2689
Rock crab	Cancer irroratus	Weigh/Count	20.57	306
Rosette skate	Leucoraja garmani virginica	Weigh/Count	0.38	1
Sea lamprey	Petromyzon marinus	Weigh/Count	62.59	46
Sea raven	Hemitripterus americanus	Weigh/Count	9.99	9
Silver hake	Merluccius bilinearis	Weigh/Count	68.75	609
Spiny dogfish	Squalus acanthias	Weigh/Measure	74.74	47
Spotted hake	Urophycis regia	Weigh/Count	3.59	12
Squid uncl	Teuthida	Weigh/Count	0.02	6
Summer flounder	Paralichthys dentatus	Weigh/Measure	66.82	55
Torpedo ray	Torpedo nobiliana	Weigh/Count	8.2	1
Unclassified skates	Rajidae	Weigh/Count	1211757	17422
Waved whelk	Buccinum undatum	Weigh/Count	26.37	539
White hake	Urophycis tenuis	Weigh/Count	1.51	2
Windowpane flounder	Scopthalmus aquosus	Weigh/Measure	207.34	919
Winter flounder	Pseudopleuronectes americanus	Weigh/Measure	7.68	6
Witch flounder	Glyptocephalus cynoglossus	Weigh/Measure	10.76	23
Yellowtail flounder	Limanda ferruginea	Weigh/Measure	47.97	84

Appendix B: SHMW analysis

Linear mixed model fit by REML in with function pqlmer R package r2glmm

Full model
MW~ln(SH)+Month+ln(Depth)+ln(Lat)+Color+ln(SH):Month+Month:ln(Depth)+(1|Station)

Abbreviations:
SH = shell height (mm)
Lat = latitude (decimal degrees)
Depth = bottom depth (m)
Color = meat color (white, brown, gray)
Month = survey month
AIC = Akaike information criteria

	Number of estimated parameters	AIC	Delta AIC
Top model (mFull)	23	-4049.12	0
Second model (m_Lat, no color)	22	-4038.07	11.05

Summary of selected model (mFull):

REML criterion at convergence: -4095.3

Scaled residuals:

Min	1Q	Median	3Q	Max
-5.4740	-0.6419	-0.0213	0.6140	6.8384

Random effects:

Groups	Variance	Std.Dev.
Station	0.01333	0.1155
Residual	0.03010	0.1735

Number of observations: 6552
Number of groups (Station): 47

Appendix C: Selectivity

This model defines the proportion of an animal of length *l* that is caught in the uncovered dredge out of the total catch from both dredges ($\Phi_c(l)$) as:

$$\Phi_c(l) = \frac{p_c r_c(l)}{p_c r_c(l) + (1 - p_c)}$$

The probability that an animal of length *l* contacts the uncovered dredge is $r_c(l)$ and a split-parameter, p_c, describes the relative efficiency of the uncovered dredge. For most species selectivity tends to reflect a logistic function which equates to:

$$\mathrm{r}_c\ (l) = \frac{\exp(a + bl)}{1 + \exp(a + bl)}$$

For some species a Richard curve provided a better fit to the data (Tokai *et al.* 1996):

$$\mathrm{r}_c\ (l) = \left\{\frac{\exp(a + bl)}{1 + \exp\ (a + bl)}\right\}^{\frac{1}{\delta}}$$

When substituted into the SELECT model it yields:

$$\Phi_c\ (l) = \frac{p_c \exp(a + bl)}{(1 - p_c) + \exp\ (a + bl)}$$

Estimates for *a* and *b* (the logistic parameters) and the split-parameter p_c were generated by maximizing the likelihood:

$$L(a, b, pc|data) = \prod_{l=22}^{167} \left(\frac{p_c \exp(a + bl)}{(1 - p_c) + \exp(a + bl)}\right)^{C_{cov}} \left(\frac{p_c \exp(a + bl)}{(1 - p_c) + \exp(a + bl)}\right)^{C_{ctrl}}$$

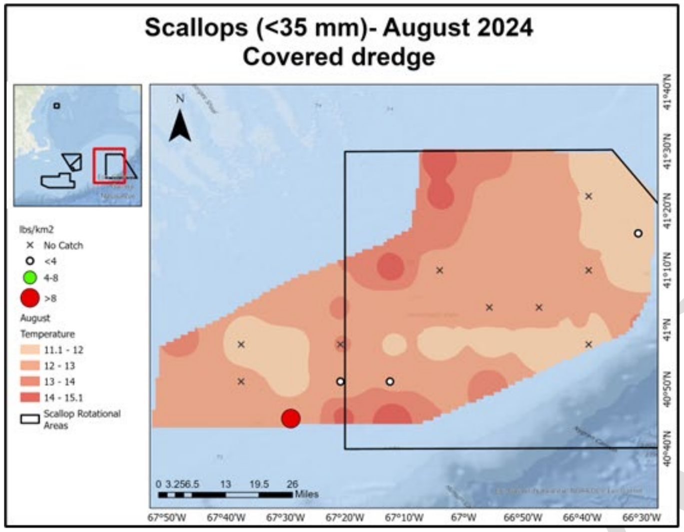
C_{cov} is the number of length *l* animals in the covered dredge and C_s is number of length *l* animals in uncovered dredge. The selection parameters L50 and the selection range (SR) are calculated with the following equations:

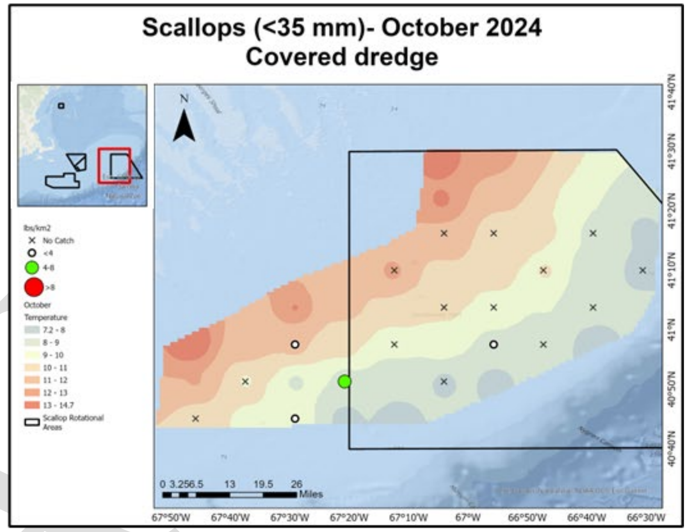
$$L50 = \frac{-a}{b} \text{ and } SR = \frac{2\ln(3)}{b}$$

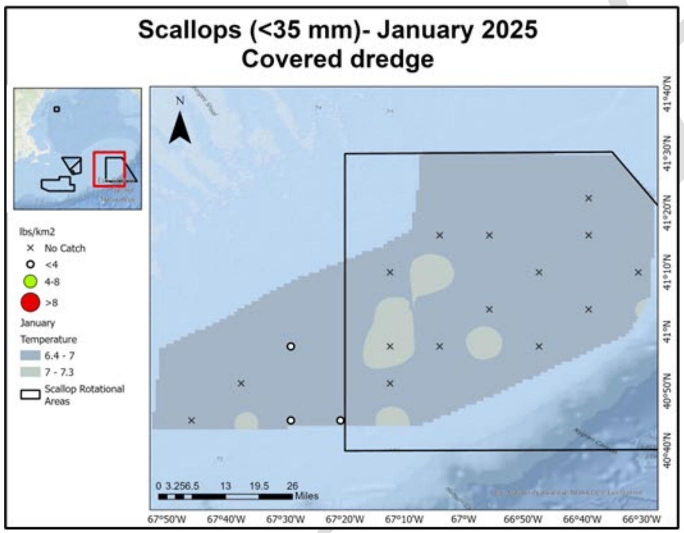
Uncontrollable factors like wind speed, sea state, animal density result in variation in selectivity estimates from tow to tow. To determine if the variation is exceeding the model predictions (overdispersion) a test is necessary when combining tows. This can be done using the replication estimate of between-haul variation (REP) combined-hauls approach (Millar *et al.* 2004). REP is the Pearson chi-square statistic for model goodness of fit divided by the degrees of freedom, the number of terms in summation minus the number of fitted parameters. The REP provides an estimate of overdispersion and the standard errors of the parameters are multiplied by the square root of REP if the null hypothesis that there is no extra variation is rejected (Millar *et al*. 2004). This approach has been used to estimate selectivity parameters of commercial sea scallop dredges paired with lined survey dredges (Yochum and DuPaul 2008).

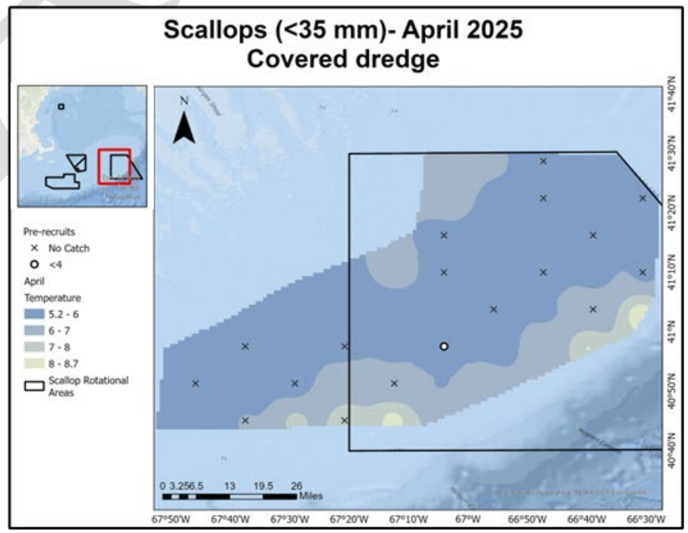
The R-Statistical Program was used to evaluate the data (R Core Team 2015). The "trawlfunction" package was used to estimate the selectivity coefficients and parameters (Millar 2009).

Appendix D: Distribution of scallops, main bycatch species and scallop predators









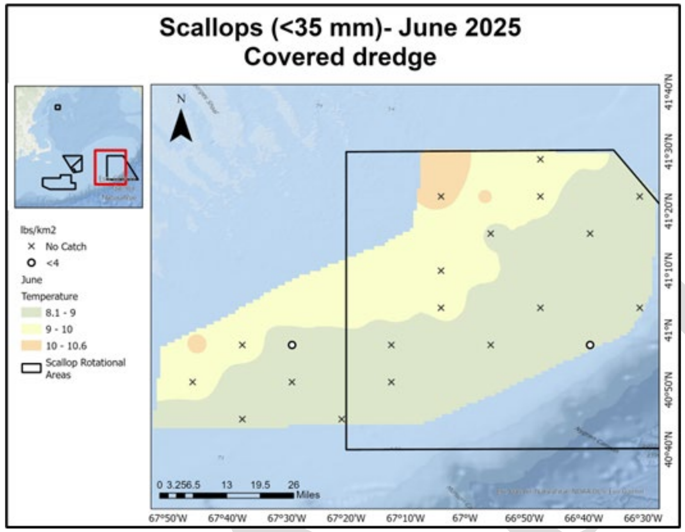
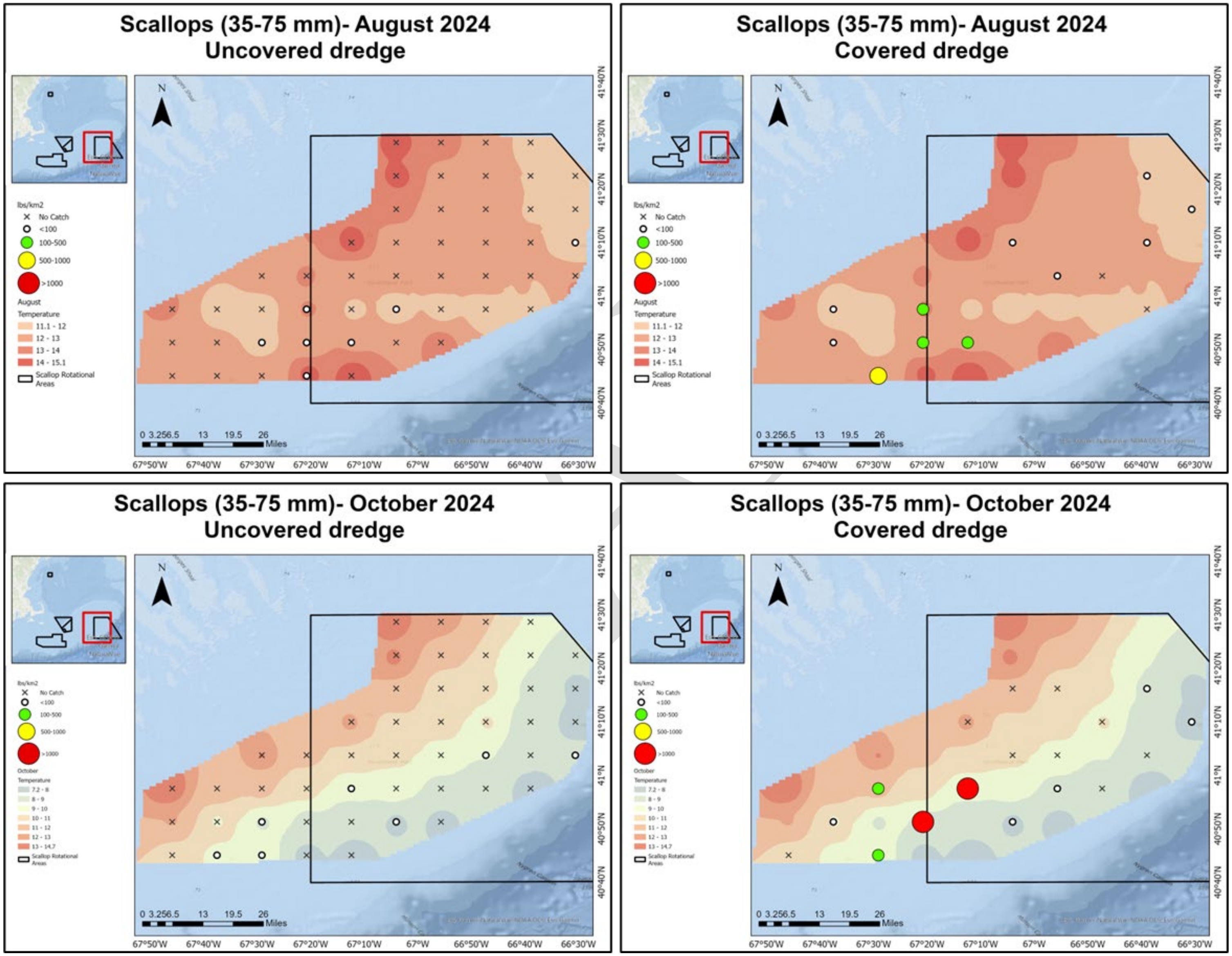
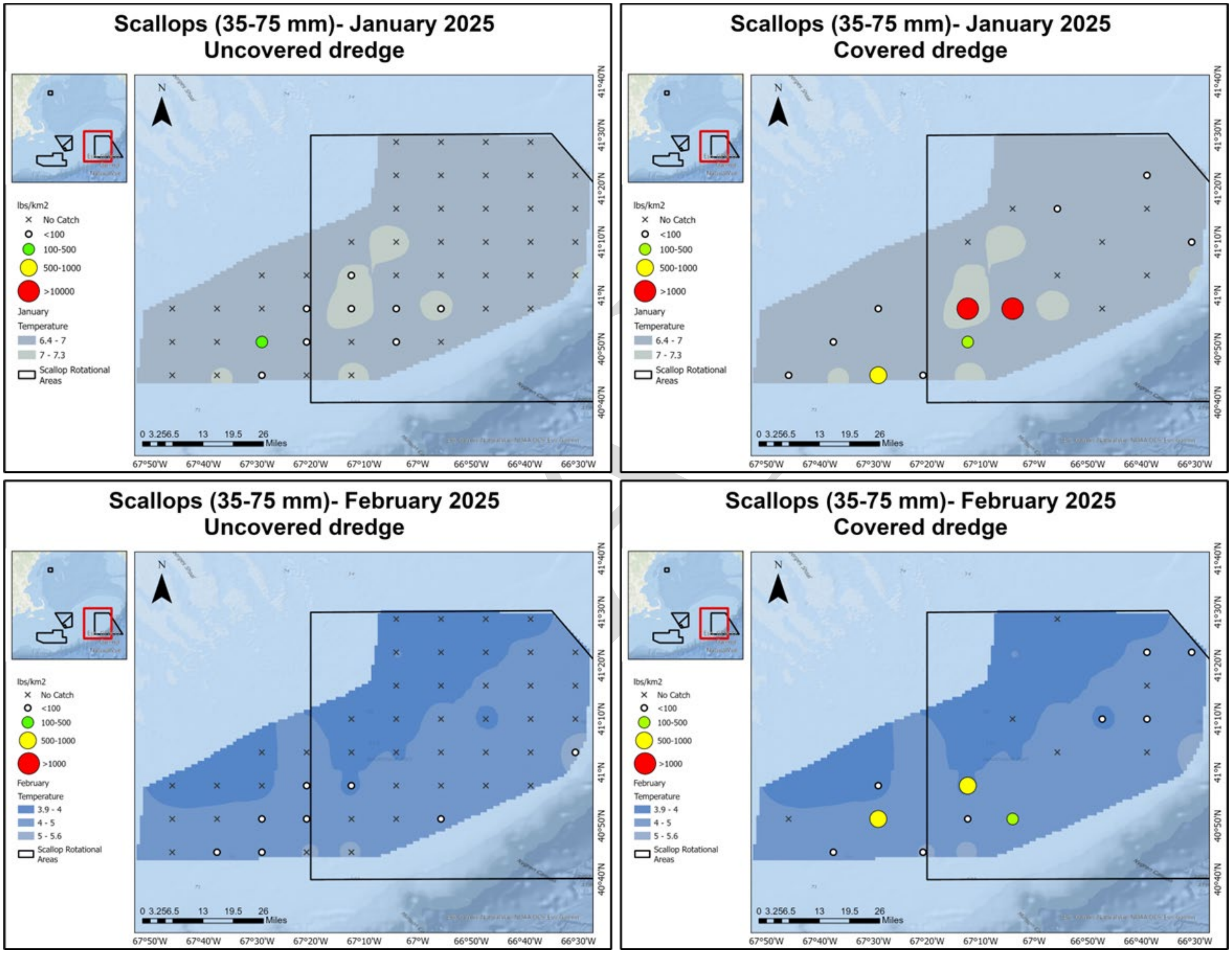


Figure D1. Distribution of pre-recruit scallops caught with the covered dredge, no catch was observed with the uncovered dredge, during the 2024 seasonal survey on eastern GB shown over observed bottom temperature. Temperatures (°C) were interpolated using the IDW method and illustrated with cooler and warmer colors associated with respective temperatures.


Scallops (35-75 mm)- August 2024
Uncovered dredge
lbs/km2
No Catch
<100
100-500
500-1000
>1000
August
Temperature
11.1 - 12
12 - 13
13 - 14
14 - 15.1
Scallop Rotational Areas
0 3.256.5 13 19.5 26
Miles
67°50'W 67°40'W 67°30'W 67°20'W 67°10'W 67°W 66°50'W 66°40'W 66°30'W
41°40'N 41°30'N 41°20'N 41°10'N 41°N 40°50'N 40°40'N
Scallops (35-75 mm)- August 2024
Covered dredge
Scallops (35-75 mm)- October 2024
Uncovered dredge
October
Temperature
7.2 - 8
8 - 9
9 - 10
10 - 11
11 - 12
12 - 13
13 - 14.7
Scallops (35-75 mm)- October 2024
Covered dredge


Scallops (35-75 mm)- January 2025
Uncovered dredge
lbs/km2
No Catch
<100
100-500
500-1000
>10000
January
Temperature
6.4 - 7
7 - 7.3
Scallop Rotational Areas
Scallops (35-75 mm)- January 2025
Covered dredge
lbs/km2
No Catch
<100
100-500
500-1000
>1000
January
Temperature
6.4 - 7
7 - 7.3
Scallop Rotational Areas
Scallops (35-75 mm)- February 2025
Uncovered dredge
lbs/km2
No Catch
<100
100-500
500-1000
>1000
February
Temperature
3.9 - 4
4 - 5
5 - 5.6
Scallop Rotational Areas
Scallops (35-75 mm)- February 2025
Covered dredge
lbs/km2
No Catch
<100
100-500
500-1000
>1000
February
Temperature
3.9 - 4
4 - 5
5 - 5.6
Scallop Rotational Areas

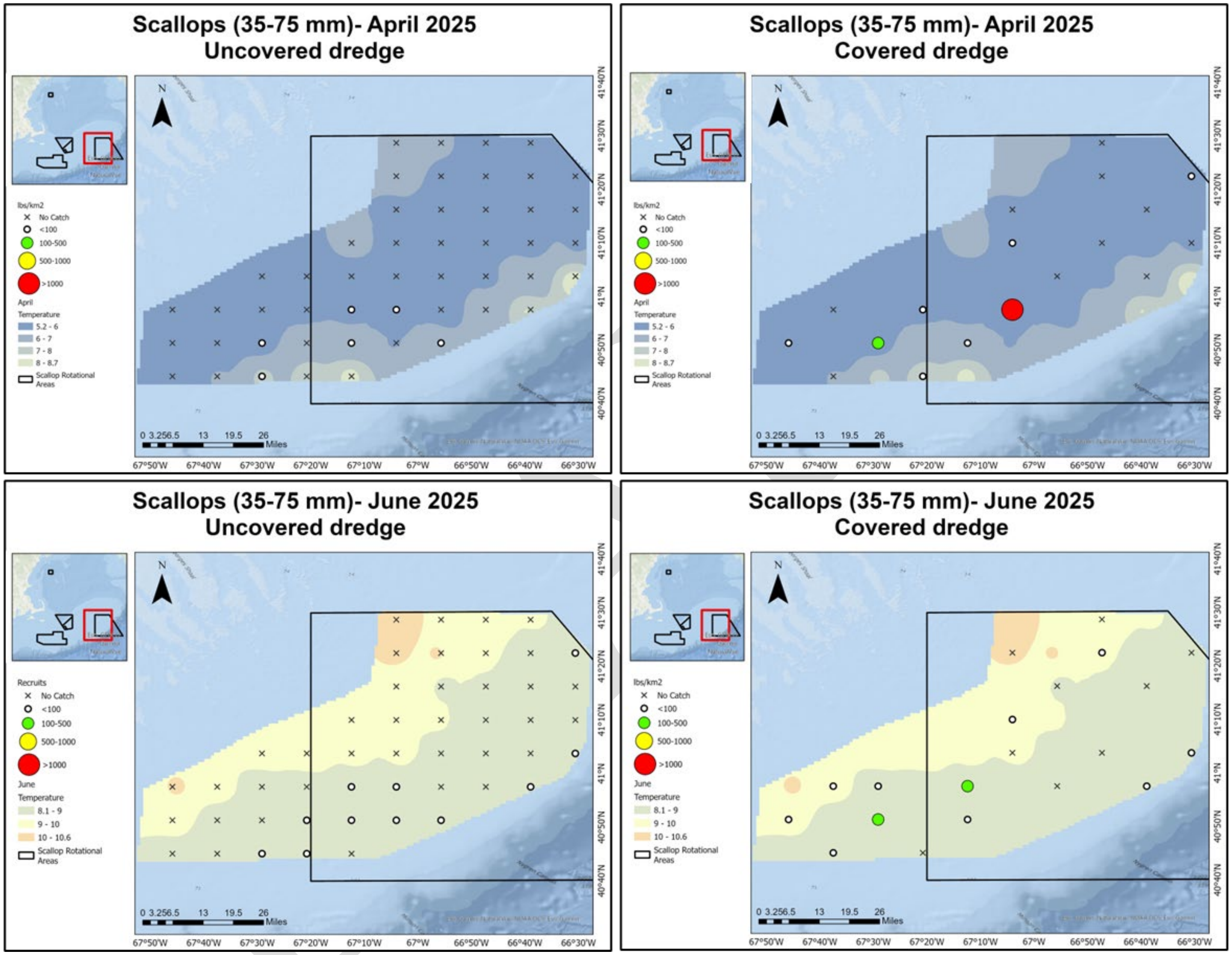
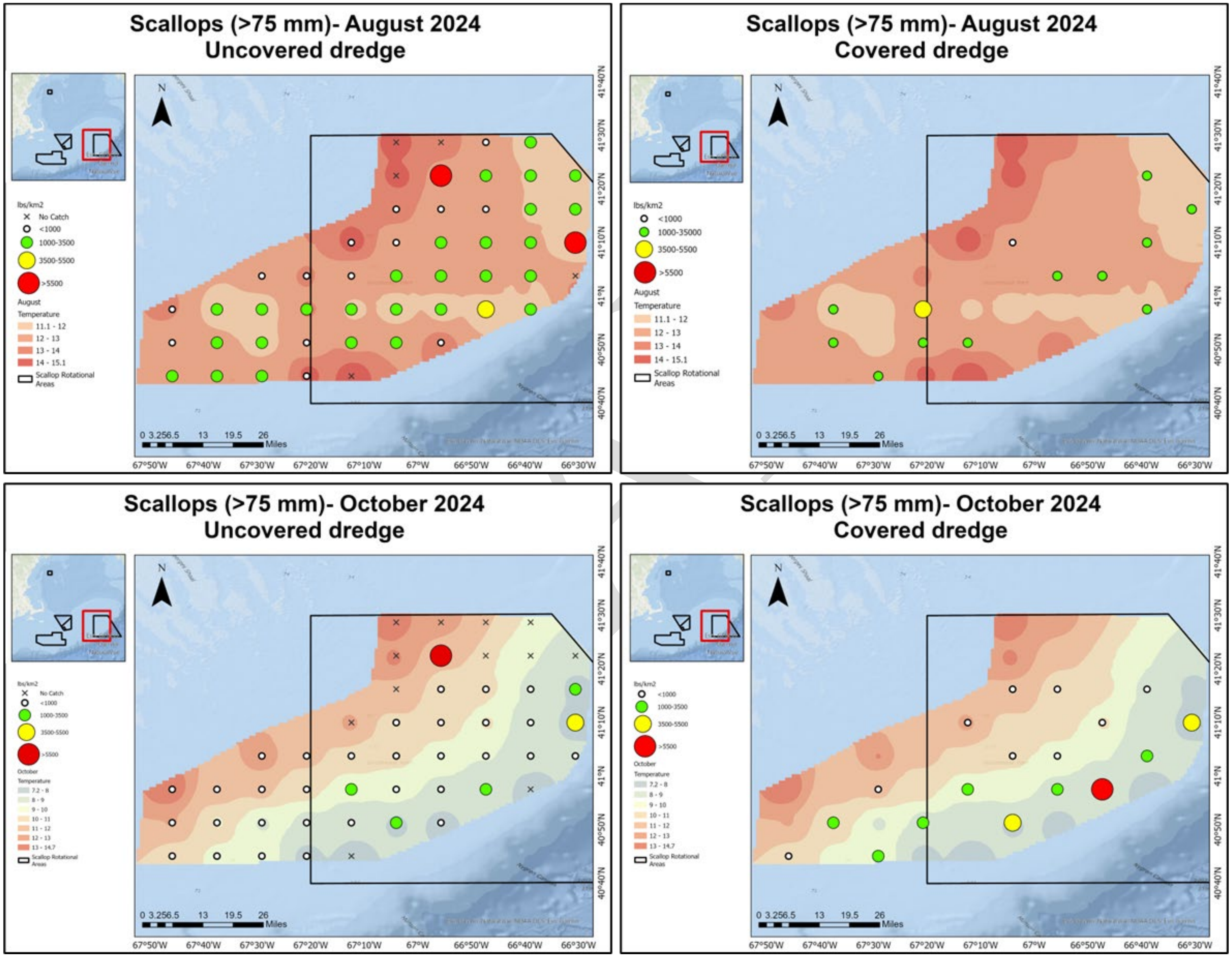
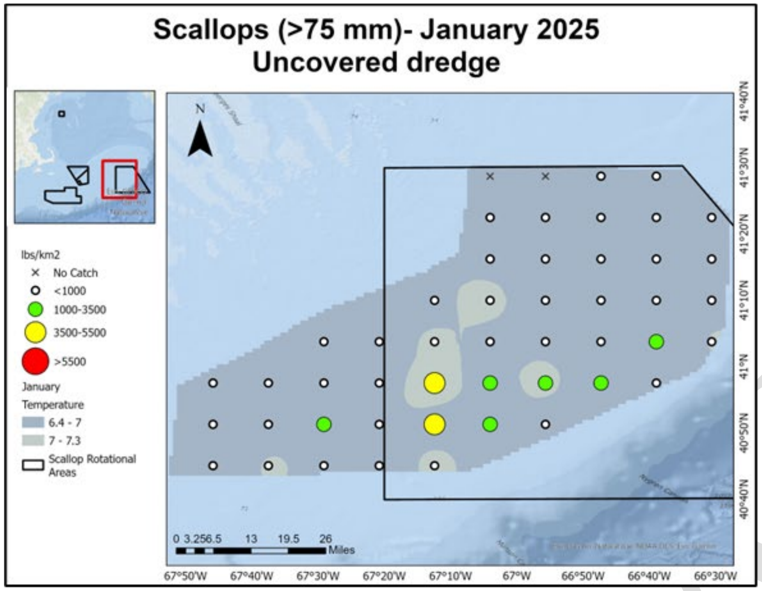
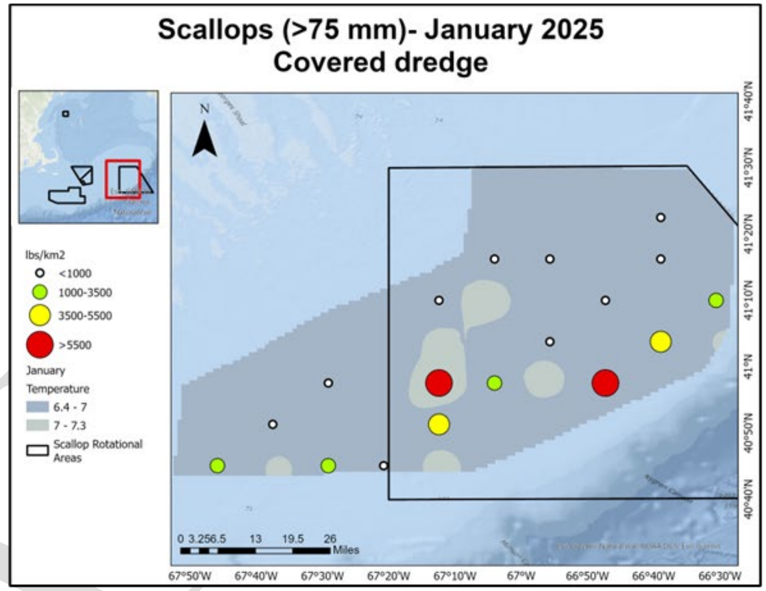


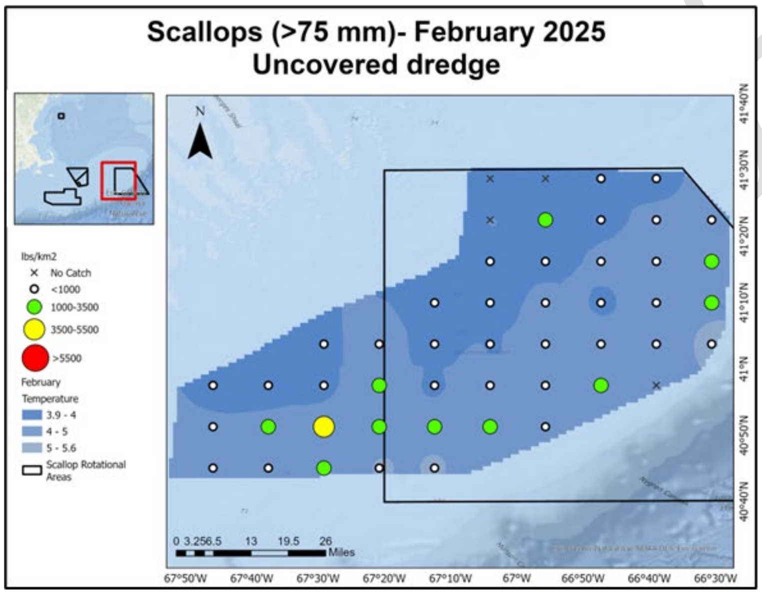
Figure D2. Distribution of recruit scallops caught with the uncovered dredge (left maps) and the covered dredge (dredge + cover net; right maps) during the 2024 seasonal survey on eastern GB shown over observed bottom temperature. Temperatures (°C) were interpolated using the IDW method and illustrated with cooler and warmer colors associated with respective temperatures.

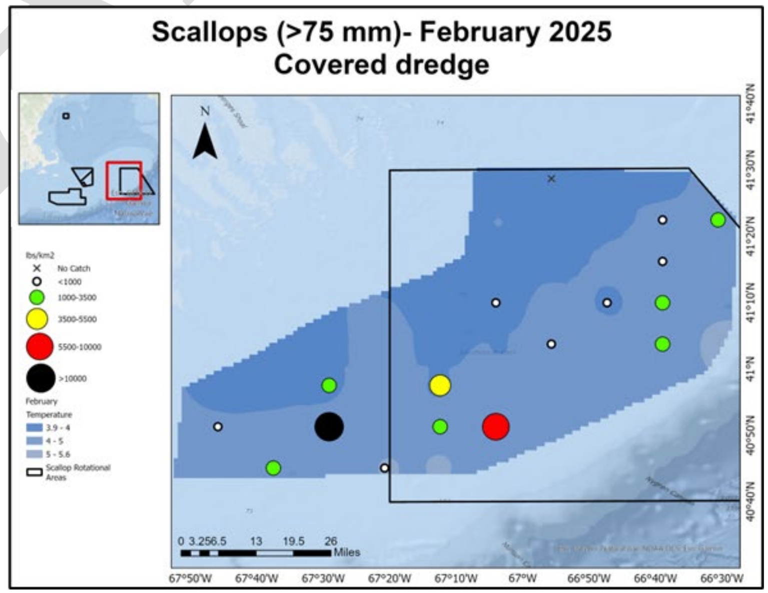


Scallops (>75 mm)- August 2024
Uncovered dredge
lbs/km2
No Catch
<1000
1000-3500
3500-5500
>5500
August
Temperature
11.1 - 12
12 - 13
13 - 14
14 - 15.1
Scallop Rotational Areas
Scallops (>75 mm)- August 2024
Covered dredge
lbs/km2
<1000
1000-35000
3500-5500
>5500
August
Temperature
11.1 - 12
12 - 13
13 - 14
14 - 15.1
Scallop Rotational Areas
Scallops (>75 mm)- October 2024
Uncovered dredge
Scallops (>75 mm)- October 2024
Covered dredge
0 3.256.5 13 19.5 26
Miles
67°50'W 67°40'W 67°30'W 67°20'W 67°10'W 67°W 66°50'W 66°40'W 66°30'W
41°40'N 41°30'N 41°20'N 41°10'N 41°N 40°50'N 40°40'N


Scallops (>75 mm)- January 2025
Uncovered dredge
lbs/km2
No Catch
<1000
1000-3500
3500-5500
>5500
January
Temperature
6.4 - 7
7 - 7.3
Scallop Rotational Areas
0 3.256.5 13 19.5 26
Miles
67°50'W 67°40'W 67°30'W 67°20'W 67°10'W 67°W 66°50'W 66°40'W 66°30'W
41°40'N 41°30'N 41°20'N 41°10'N 41°N 40°50'N 40°40'N


Scallops (>75 mm)- January 2025
Covered dredge
lbs/km2
<1000
1000-3500
3500-5500
>5500
January
Temperature
6.4 - 7
7 - 7.3
Scallop Rotational Areas
0 3.256.5 13 19.5 26
Miles
67°50'W 67°40'W 67°30'W 67°20'W 67°10'W 67°W 66°50'W 66°40'W 66°30'W
41°40'N 41°30'N 41°20'N 41°10'N 41°N 40°50'N 40°40'N


Scallops (>75 mm)- February 2025
Uncovered dredge
lbs/km2
No Catch
<1000
1000-3500
3500-5500
>5500
February
Temperature
3.9 - 4
4 - 5
5 - 5.6
Scallop Rotational Areas
0 3.256.5 13 19.5 26
Miles
67°50'W 67°40'W 67°30'W 67°20'W 67°10'W 67°W 66°50'W 66°40'W 66°30'W
41°40'N 41°30'N 41°20'N 41°10'N 41°N 40°50'N 40°40'N


Scallops (>75 mm)- February 2025
Covered dredge
0 3.256.5 13 19.5 26
Miles
67°50'W 67°40'W 67°30'W 67°20'W 67°10'W 67°W 66°50'W 66°40'W 66°30'W
41°40'N 41°30'N 41°20'N 41°10'N 41°N 40°50'N 40°40'N

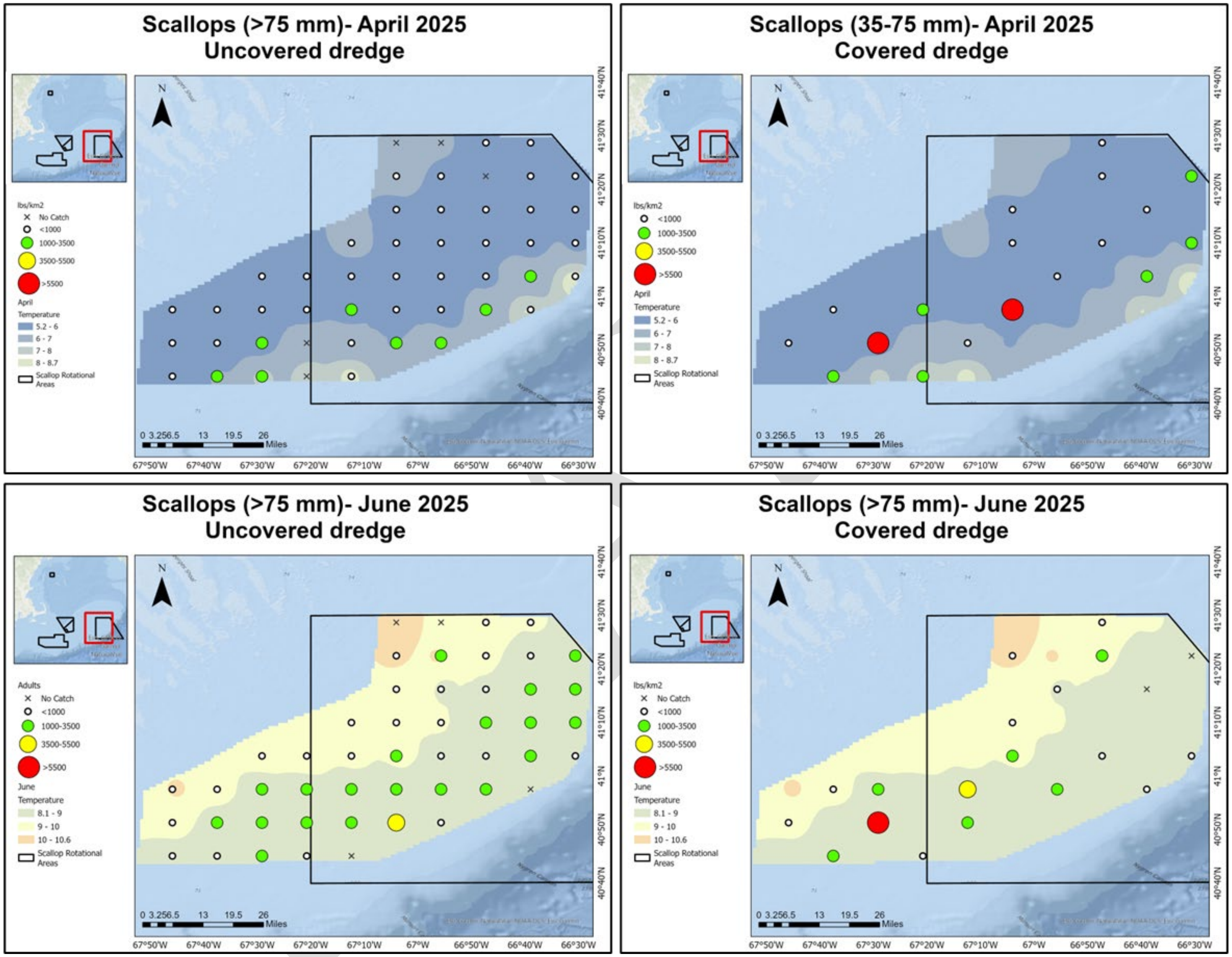


Figure D3. Distribution of adult scallops caught with the uncovered dredge (left maps) and the covered dredge (dredge + cover net; right maps) during the 2024 seasonal survey on eastern GB shown over observed bottom temperature. Temperatures (°C) were interpolated using the IDW method and illustrated with cooler and warmer colors associated with respective temperatures.

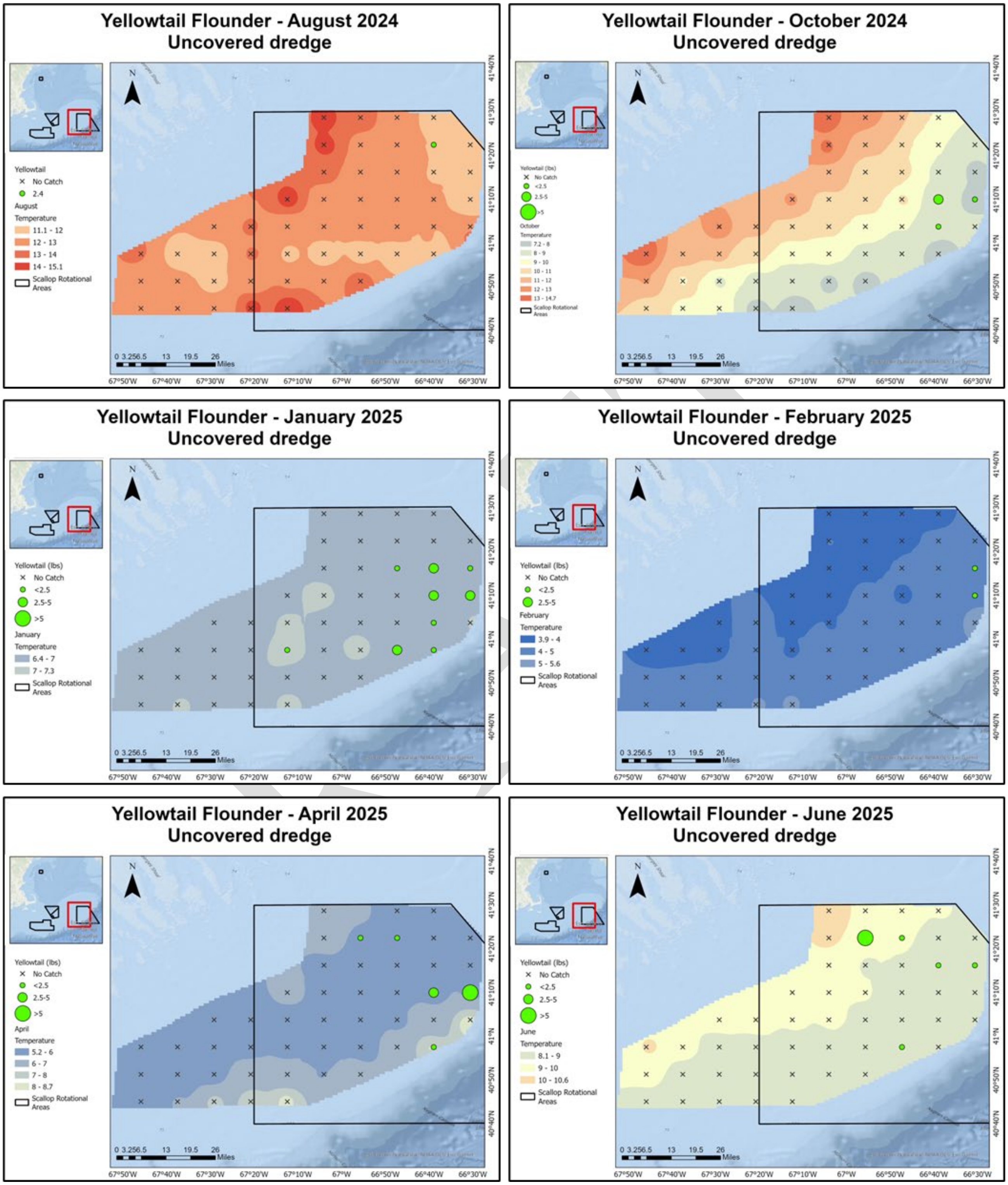


Figure D4. Distribution of yellowtail flounder caught with the uncovered dredge during the 2024 seasonal survey on eastern GB shown over observed bottom temperature. Temperatures (°C) were interpolated using the IDW method and illustrated with cooler and warmer colors associated with respective temperatures.

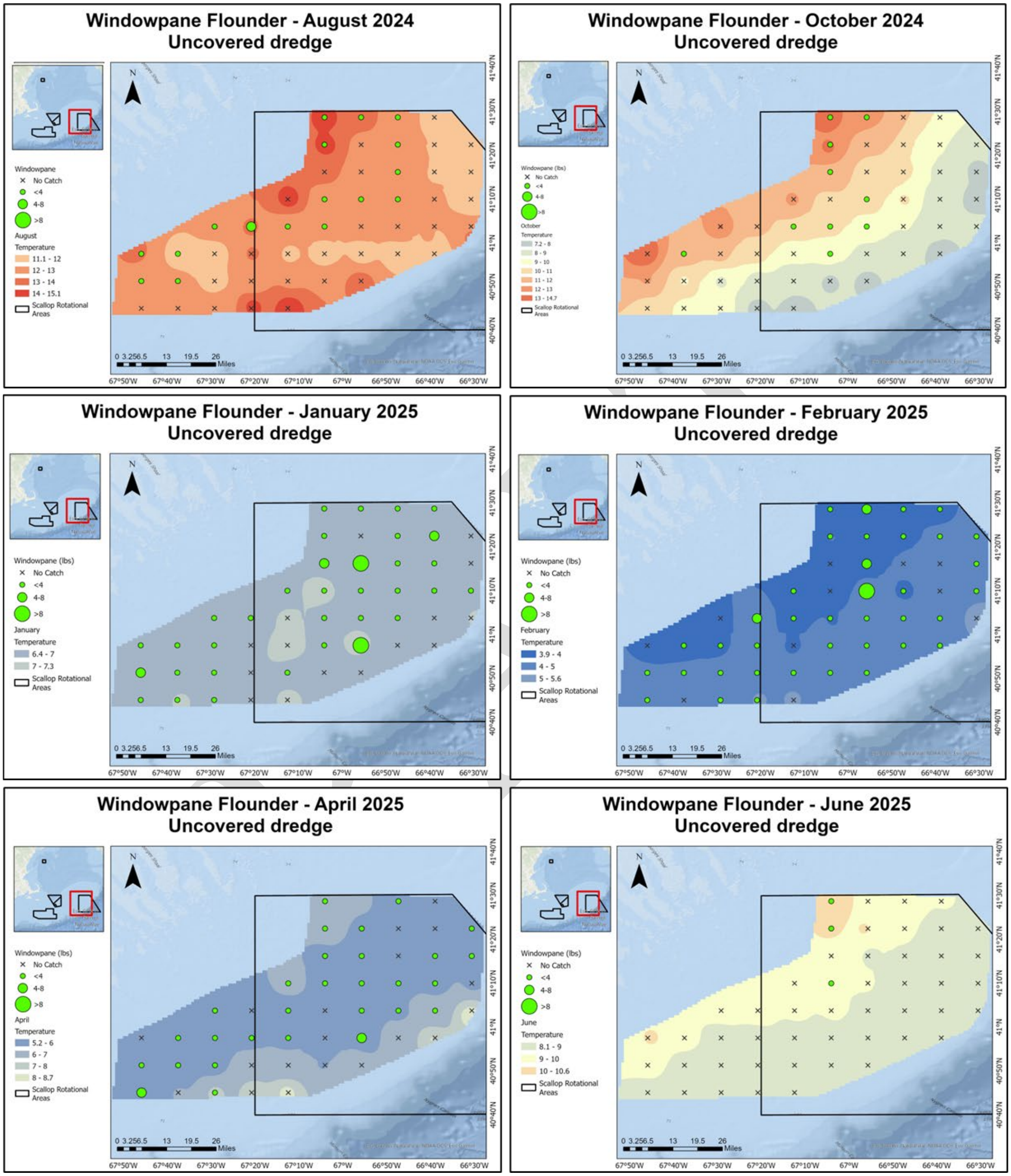


Figure D5. Distribution of windowpane flounder caught with uncovered dredge during the 2024 seasonal survey on eastern GB shown over observed bottom temperature. Temperatures (°C) were interpolated using the IDW method and illustrated with cooler and warmer colors associated with respective temperatures.

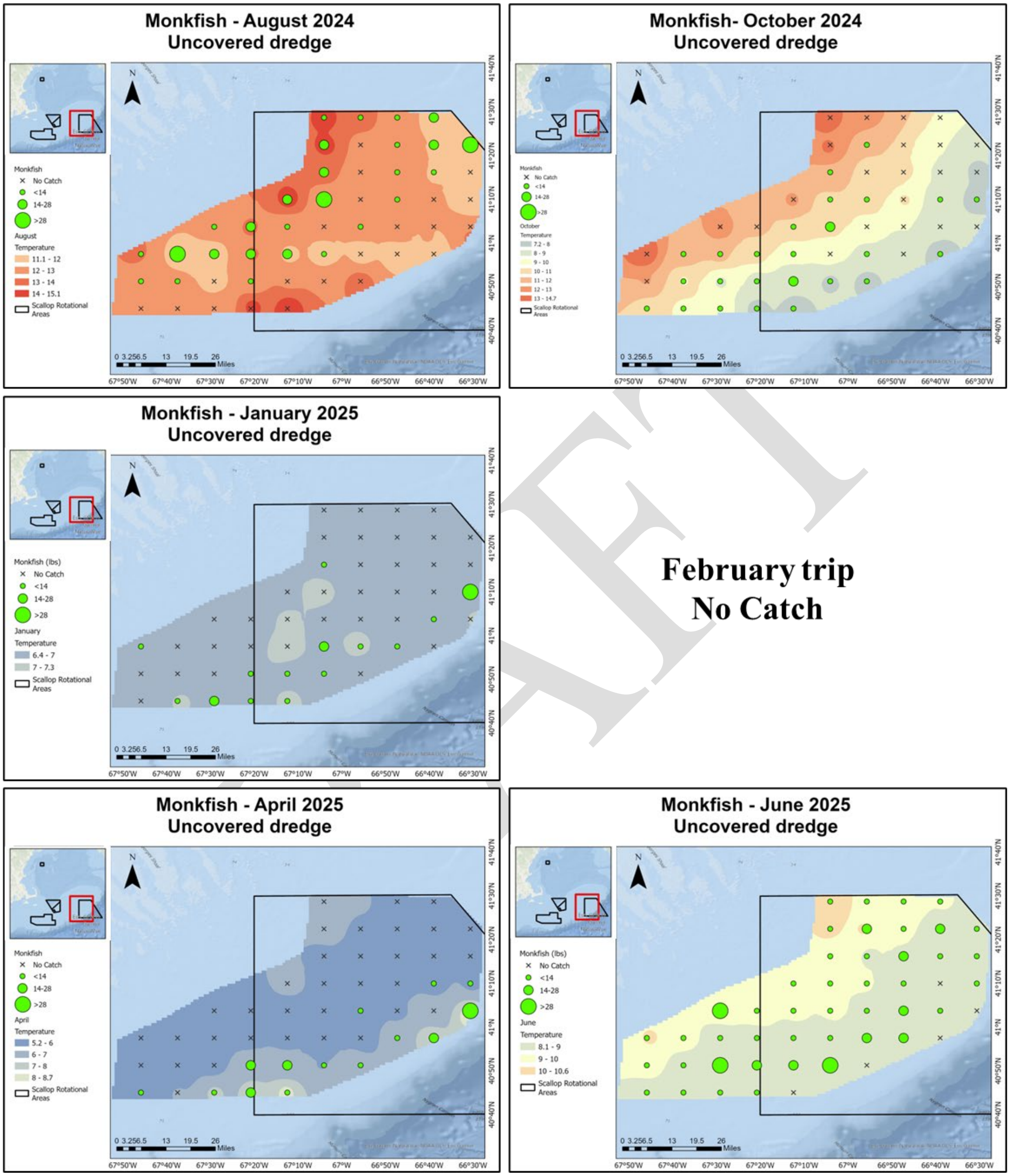


Figure D6. Distribution of monkfish caught during the 2024 seasonal survey on eastern GB shown over observed bottom temperature. Temperatures (°C) were interpolated using the IDW method and illustrated with cooler and warmer colors associated with respective temperatures.