Understanding Impacts of the Sea Scallop Fishery on Loggerhead Sea Turtles

Final Report

Prepared for the 2017
Atlantic Sea Scallop Research Set Aside Program
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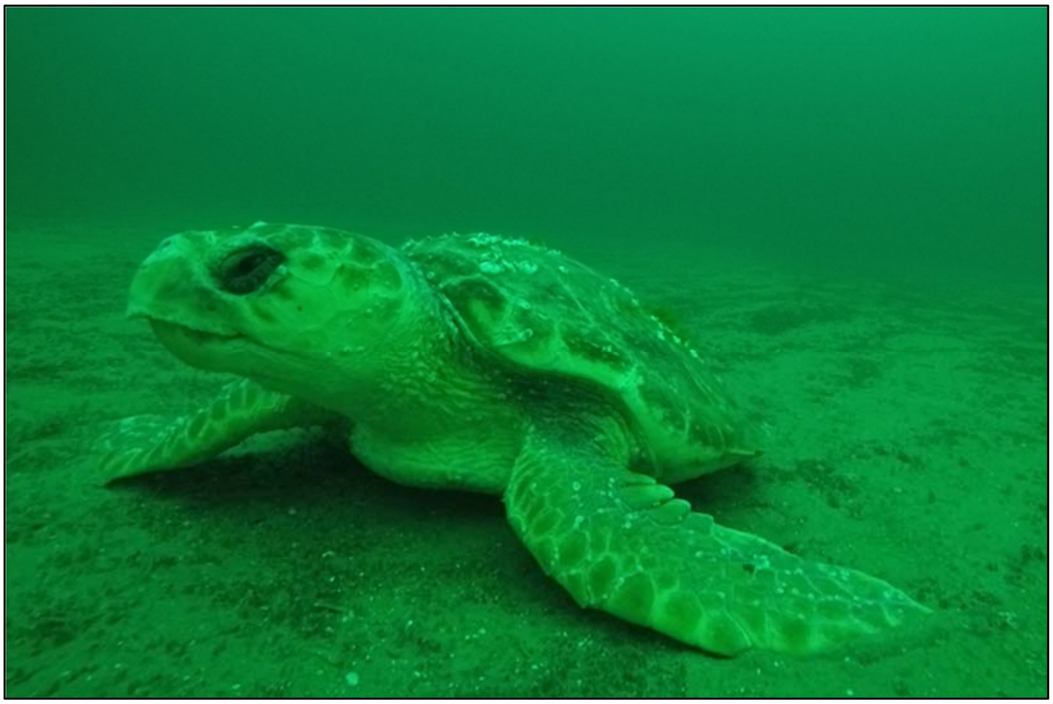

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Project Summary:

Coonamessett Farm Foundation's (CFF) 2017 project "Understanding Impacts of the Sea Scallop Fishery on Loggerhead Sea Turtles" has continued to add invaluable data to our already abundant dataset on loggerhead sea turtles. The focus of this project is to evaluate the distribution and behavior of loggerhead sea turtles to better understand their interactions with the scallop fishery. This improved understanding will help reduce turtle bycatch in scallop dredges.

We participated in three trips this summer, two funded through the scallop research set-aside (RSA) award and one trip as collaborators on the National Oceanic and Atmospheric Administration (NOAA) vessel Henry B. Bigelow. Trip 1 occurred from May 15 – 20 on the F/V Kathy Ann, Trip 2 occurred from July 5 – 19 on the Henry B. Bigelow and Trip 3 occurred from August 21 – 25, again on the F/V Kathy Ann.

During Trip 1, we focused efforts in the southern Mid-Atlantic Bight (MAB) region, tagging as far south as 36°N latitude, approximately 100 km northeast of Cape Hatteras. During this trip we tagged a total of 16 turtles (Figure 1). During Trip 2 on the Bigelow, we scouted southeastern Georges Bank, reaching Corsair Canyon in Canadian waters but found no turtles. Due to these poor sighting conditions, we travelled to the MAB and there found and tagged five turtles. Four were tagged north of the Hudson Canyon Access Area, and one was tagged in the Access Area. We then returned to Georges Bank and sighted one loggerhead and one leatherback along the southern edge but were unable to capture them. During trip 3, we scouted within the MAB scallop access areas, spotting several turtles per day; however were only able to catch and tag one. Turtles found later in the season were more active and aware of our presence, making capture nearly impossible. Across these trips, we collected lavage samples from all caught turtles, with five samples positive for nematode eggs.

Tagged turtles behaved similarly to previous years in that they continued to meander north through the summer, reaching their northernmost foraging grounds in August. Turtles foraged within all MAB scallop access areas throughout the entire summer, with the southern portion of the Megatron having the highest densities of turtles during the late spring and early summer, and the northern portion having higher densities later in the season (Figures 2 and 3).

1. Purpose

The National Marine Fisheries Service expects scallop gear to catch an estimated average of 140 loggerhead sea turtles each year, with 47% incidental sea turtle mortality (NMFS 2012). Reasonable and Prudent Measures (RPMs) are deemed necessary to minimize estimated incidental turtle mortality in the scallop fishery (NMFS 2012). This research directly addresses RPM's #3, #4, #5 and #6. There is a necessity to continually review available data to determine whether there are areas or conditions within the action area where sea turtle interactions with scallop fishing gear are more likely to occur. For the scallop fishery to maintain an exemption from the prohibitions under Section 9 of the Endangered Species Act (ESA) these RPM's, which are non-discretionary, must be implemented for the scallop fishery to continue. While not the highest research priority, this research is required under the law. In the absence of National Marine Fisheries Service (NMFS) Northeast Fisheries Science Center (NEFSC) funding, the scallop RSA is the only current source of funding available to allow the scallop fishery to continue meeting ESA requirements.

This research continues over ten years of turtle research and has evolved from a multitude of studies conducted since 2004 under Scallop RSA funding and National Marine Fisheries Service (NMFS) contracts. These projects, besides developing sea turtle excluder gear, have advanced the ability to locate, track, and observe loggerhead sea turtles through innovative use of dredge and remote operated vehicle (ROV) mounted video cameras, side-scan sonar, aerial surveys, and satellite tags. Over the duration of these past projects, this CFF/NMFS joint effort has resulted in the tagging of over 150 loggerheads, and has tracked these turtles for nearly 60,000 days. We have demonstrated exceptional success in tracking and observing sea turtles throughout the water column with an ROV and have obtained footage of sea turtles foraging on the sea floor and socializing at the surface. The data from these tags allowed for the first estimate of absolute abundance of loggerheads in the shelf waters of the east coast and has helped to define critical habitat for loggerheads. In addition to morphometric measurements, blood, genetic, and most recently fecal samples were taken from each turtle tagged to improve our understanding of the overall biology of this species and its impact to the environment.

2. Methods

At Sea Operations

CFF and NEFSC provided at-sea scientists, while Jim Gutowski at Viking Village Fisheries oversaw vessel coordination and operations of the F/V Kathy Ann. Heather Haas at NEFSC coordinated the research cruise on the R/V Henry B. Bigelow.

Turtle spotting efforts were restricted to daylight hours, between 0700 and 1800 hours. Once a turtle was spotted, the vessel maneuvered toward it and stopped when within 50 meters of the animal(s). Once the vessel was in the appropriate position, two crewmembers launched the collection boat, an open 14’ Achilles soft bottom zodiac. When the zodiac approached within six feet of the turtle, a NMFS-approved ARC twelve-foot hoop net was used to capture it. The netted turtle was then carefully brought alongside the zodiac and lifted on board with the help of the crewmember. The zodiac was brought alongside the larger vessel, and the turtle was transferred to a large rectangular net that is attached (as a brailer) to a specially rigged winch and boom to safely transfer the turtle aboard the Kathy Ann or Bigelow.

After transfer, the turtle was positively photo-identified as a loggerhead sea turtle using the Sea Turtle Species Identification Key (NOAA Technical Memorandum NMFS-SEFSC-579). We then measured the carapace, taking the curved and straight carapace lengths, and examined it to ensure that it was in suitable condition for tagging. If the turtle was approved, epibionts were removed from the carapace at the intended bonding site of the tag. The transmitters were attached with a two-part cool setting epoxy with the antenna oriented backward, at the point where the first and second vertebral scutes meet. Our NEFSC partners retrieved blood and tissue samples for on-shore analyses. Sea turtles were then lowered using the same large rectangular net over the side of the boat, with engine gears in a neutral position, in areas where they were unlikely to be recaptured or injured by vessels.

ROV protocols remained the same as previous years, as described in Smolowitz et al. 2015: "ROV operations were conducted with two tether handlers, an ROV assistant, an ROV operator, and a masthead observer. The two tether handlers deployed the ROV off the port rails of the vessel and remained on deck to pay out or retrieve the tether as needed. Commonly, the masthead observer had the best view of the turtle and ROV and coordinated the ROV operations until ROV video contact was made. Communication between the masthead observer and an ROV assistant was via the VHF radio. Once the turtle was spotted with the ROV, the operator was required to monitor the video and sonar feeds continuously. Concurrently, the ROV assistant took notes of the live video events for later review and analysis. To avoid startling the animal, which often caused it to dive, it was determined to have the ROV approach the turtle to within ~3 - 5 m while in their direct line of sight. Occasionally, the turtle would approach the ROV to investigate. When this occurred, the ROV would remain still. Otherwise, the ROV operator worked to his best ability to maintain sight of the sea turtle for the longest duration possible without disturbing its natural actions. When a turtle dove, it was followed to the best of the ROV operator's abilities, as the turtle was able to dive faster than the ROV. If the turtle was lost on a dive, operator maintained the ROV at the same heading to the sea-floor and used visual observation and the multi-beam sonar to reacquire the subject."

In coordination with another CFF RSA-sponsored project, we deployed a baited drop camera system during the August trip to test the system's ability to capture still photos and videos of the seafloor and to identify species that predate on scallop shucking discard (Figure 11). This system includes two still image Sony DSLR cameras aimed at the ocean floor that take pictures simultaneously every 15 seconds. We also added several GoPro cameras to record video footage during the drop. At lease, two GoPros were placed facing downward and one was installed on the bottom of one of the legs, its lens facing parallel to the ocean floor. We attached pyramidal crab traps to the center of the system filled with scallop guts. These traps stay closed until they reach the bottom, and then the sides opened and layed on the surface in a star pattern to expose the scallop guts to the surrounding environment. The drop camera system were deployed over the side of the vessel using the scallop winch and were subsequently retrieved via grapple of the vertical line. We remained within view of the system and retrieved the system within two hours.

Fecal Sample Analyses

All fecal samples were analyzed at Roger Williams University in the Roxanne Smolowitz lab. Analyses protocols were developed by Dr. Smolowitz specifically for identifying the presence of eggs from the nematode species *Sulcaris sulcata*. First, each sample was strained through a fine mesh tea strainer to remove large particulate matter. From each sample, a maximum of 50 ml was used. This 50 ml subsample was centrifuged to remove excess liquid. From the remaining particulate, 15 ml was taken and centrifuged again. Excess liquid was decanted, and then a flotation solution was added. This was then centrifuged a third time with a cover slip placed as a lid on the sample tube. Due to the density of the flotation solution, the centrifuging pushed the eggs to the surface in contact with the cover slip. This cover slip was placed on a microscope slide and thoroughly analyzed at 10x and 20x magnifications. All noticeable findings from the microscope were photographed (Figure 2). Currently, in collaboration with David Rudders at

VIMS, we are working on developing a method to test for the presence of nematode eggs using genetic markers. This will allow for quicker and more accurate processing of the samples. We expect this method to be in practice after the collection of samples during the 2018 field season.

Data Analysis

We continued to monitor the turtles via satellite telemetry. This included monitoring the dive behavior, along with identifying variations in seasonal home range throughout the year. This year, we again put more effort into understanding the relationship of loggerheads and the life cycle of *S. sulcata*. This included unfunded work of collecting and analyzing fecal samples from necropsied turtles that stranded along Cape Cod during the annual cold stunning season.

We also focused effort in analyzing the oceanographic data acquired through the satellite tags (Patel et al. *in review*). Specifically, we wanted to identify if loggerheads would make good oceanographic sampling platforms within the MAB. To test for this, we quantified the breadth of available data from the satellite tags, and the ability of these data to capture the signatures of important, yet difficult-to-model oceanographic features within the region, specifically bottom temperatures, the mixed layer depth (MLD), and the seasonal Cold Pool water mass (CPW).

Turtles as Ocean Observers

Excerpt from Patel et al. *in review*:

“For loggerheads to be good MAB ocean observers, they would need to be present in the MAB in times and areas with CPW and strong thermoclines, as these are strata where the water column is difficult to model accurately. We defined the MAB as north of 35.2° N, east of -76.0° W, south of 41.1° N, and west of -70.0° W (Ecosystem Assessment Program, 2012). In all cases where we compared tag data to bathymetry, we used the ETOPO1 Ice Surface Global Relief Model (National Centers for Environmental Information/NOAA). Because ETOPO1 is a 1 arc-minute global model, we expect there to be variations between actual and modelled bathymetry values due to fine scale variations in bathymetry, and we expect variation between true and modelled depth in regions of extreme bathymetric changes, such as Hudson Canyon. To account for these expected variations, we identified bottom depth as any depth value within 15% of modelled bathymetry. Temperature-depth profiles that included a temperature from the bottom were considered full water column profiles.

To identify the time period influenced by CPW, we plotted the surface and bottom temperatures from the profiles within the 30-m to 70-m isobaths region (Lentz 2017). We selected a broad temporal window (Julian day 121 to 304, 01 May to 31 October) which generally coincides with the stratified season within the MAB (Schofield et al. 2008). We defined the surface temperature as the shallowest temperature reported in the profile. Average depth of surface temperature was 2.0 m. We defined the bottom temperature as the deepest temperature from a full water column profile. We then used the time period with strong separation between surface and bottom temperatures as a temporal envelope for evaluating loggerhead distribution within the MAB.

To evaluate whether loggerhead distribution provided sampling throughout the water column, we first examined a cross section of the of the MAB continental shelf waters in an area (from 39° N to 40° N) with frequent CPW (Lentz 2017). We plotted profiles in relationship to bathymetry and longitude for profiles collected within the stratified season between 2009 and 2017. We estimated the bathymetry as the maximum ETOP1 depth at every 0.01° of longitude between 39° N and 40° N latitude. We also assessed whether temperature sampling occurred throughout the water column in the larger MAB by examining data from dives that exceed the MLD and/or reached the bottom. For each collected profile position, MLD was obtained from the HYCOM Global Analysis model (GLBa0.08). Profiles were analyzed to determine if they had reached below the MLD. All profiles reaching the bottom, were also considered to have exceeded the MLD. We examined the spatio-temporal distribution of deep sampling dives by mapping the location of full water column profiles per month. We do not show maps for profiles that went through the MLD because they were similarly distributed as the full water column profiles."

3. Results

During the 2017 tagging season we deployed 22 tags. Sixteen tags were deployed in mid-May, five were deployed in mid-July and one was deployed in late August. As of May 16, 2018, eleven tags were still transmitting. When combined across all years, we have now accrued ~60,000 transmission days with 166 satellite tag deployments. This year we deployed two tags substantially farther south than previous May trips in an attempt to capture turtles traveling within the Gulf Stream. These turtles ended up staying within shelf waters, and did not travel out of the southern MAB like other turtles that were tagged farther north (Figure 4).

We deployed a new satellite tag, Wildlife Computers SPOT 375B, on the turtle caught during the August cruise (Figures 5 and 6). This turtle did not travel farther north after tagging; however continued to meander through the southern MAB during the summer and fall months, before settling near Cape Hatteras during the winter. This turtle became active again in the late winter and has started to migrate north. While in the MAB, this turtle spent more time at the surface in temperatures at times reaching above 27.5°C. Then as temperatures cooled, this turtle spent much less time at the surface and in temperatures as low as 7.5°C. Throughout the tracking duration this turtle has only spent 6.8% of time at the surface and primarily resided in temperatures between 15° - 22.5°C. These results are slightly skewed as the majority of the data currently is from the colder months.

From the 2016 tagged turtles, we had 14 transmitters continue functioning into May 2017 or later. As a cohort, these turtles seemed to heavily overlap between years in terms of foraging locations (Figure 7). Turtles reached similar latitudes north and seemed to congregate in the northwestern section of the Megatron. Understanding foraging fidelity is an important step in predicting when and where sea turtles will be overlapping with fisheries within the MAB.

From turtles tagged during 2017, we found 5 positive for nematode eggs. Turtles that were positive for nematode eggs seemed to stay within a narrower band of the MAB, closer to the 100 m bathymetry line and the scallop access areas (Figure 8). Additionally, we collected samples from 37 stranded sea turtles during the annual necropsies in partnership with the MA Audubon Society Wellfleet Bay Wildlife Sanctuary. This included nine loggerheads, five green turtles, two hybrid turtles and twenty-one Kemp's ridley turtles. We did not find nematode eggs in any of these turtles; however we did find worms in the digestive systems of five Kemp's ridley turtles. Overall, we found a high abundance of microplastics, substantially higher than last year (Figure 9).

During the May and August cruises we also deployed the ROV to survey the bottom (Figure 10). We did not track a turtle, and in surveying the bottom we found primarily shell hash, sand dollars, crabs and scallops. During the August cruise we deployed a baited drop camera system to identify species that would be interested in the discard from shucking scallops (Figure 11). We conducted five ~2 hour deployments. We primarily identified the presence of hake quickly entering the field of view and eating the scallop guts (Figure 12).

Turtles as Ocean Observers

Excerpt from Patel et al. *in review*

"Tagged loggerheads were present in the MAB and diving to the bottom during periods with strong CPW signals. Between 01 May and 31 October (across all years), we collected 11,498 profiles in the CPW zone of 30–70m. The mean number of profiles per day throughout the whole water column in this time and area was 62.5 (± 33.7 SD). Mean surface temperature for these profiles was 22.3° (± 2.8°C SD), and mean bottom temperature was 11.0° (± 2.8° C SD).

The period of Julian day 152 (01 June in non-leap years) and ending on Julian day 277 (04 October in non-leap years) between 2009 and 2017 had large temperature differences between surface water and bottom water (Figure 13), so we used this temporal window as an envelope for strong stratification in the MAB and for examining loggerhead distribution within the MAB. Our temperature sampling within the MAB prior to 01 June is relatively infrequent due to our cruise schedule for tag deployment and also due to turtle migration patterns. We selected the end date to be prior to the autumn mixing events and to equally divide the season into 7-day bins. During this highly stratified season, 162 tagged loggerheads were present in the MAB and collected 18,790 profiles.

Examining cross sections of the MAB shelf in regions of CPW formation (Figure 14) revealed that the tagged turtles were sampling throughout the water column in June through September, particularly between 73° and 74° W. There were fewer samples west of 73°, partially because it represents a smaller area but also because the turtle distribution was centered further offshore (Winton et al 2018). East of 73° W, Hudson Canyon dropped below 80 m and we did not receive temperature data from depths greater than 80 m.

Deep sampling dives were distributed across the MAB, particularly between the 30 and 70-m isobaths. Fewer bottom dives occurred north of Hudson Canyon early (June) and late (September) in the foraging season. Loggerheads carried most data loggers through the MLD to the ocean floor. All 162 tags present in the MAB exceeded the MLD, and a total of 16,371 profiles captured this ocean feature. Most (160 of 162) tags went to the bottom recording a total of 11,591 full water column profiles. Of all the dives that did not go to the bottom (n = 7,199), two thirds (66.6%) exceeded the MLD. The dives beyond the MLD and to the bottom were widely distributed across weeks (Figure 15)."

4. Discussion

After FY2016, we planned to continue efforts in understanding the prevalence and transmission of nematodes. During the 2017 season, we were able to identify turtles positive for nematodes and again found that those caught later in the season seemed to have a higher likelihood of having eggs. However, the late season sample size was again much smaller, which limits the strength of the results. This season, however, we did not encounter eggs in turtles that died during the cold stunning season. We did find worms present in the digestive system, and these worms are still being processed to identify species. We have recently moved forward in developing a genetic test to easily identify the presence of *Sulcaris sulcata*. This method will speed up the processing time considerably. Although we did not find eggs in the stranded turtles, the high presence of microplastics was alarming. We suspect that the majority of the microplastics are harmlessly passing through the turtles; however for filter feeding animals like scallops, this could be a much larger problem that needs investigating. Additionally, it is unclear if the microplastics contain toxins that could be bioaccumulated and prove harmful to both turtles and scallops. Studies have found microplastics can accumulate in tissues outside the digestive system in vertebrate species (Lu et al. 2016).

The 2017 season included the deployment of a new transmitter from Wildlife Computers. This tag was attached in the same manner as the SMRU tags, applying a two part epoxy directly to the carapace. This tag does not record depth, but does record temperature and time at surface due to a wet/dry switch. It also transmits Argos locations, and due to the limited data output, the battery is meant to last three years. It is a smaller and less expensive tag than those we typically deploy from SMRU. This transmitter is still functioning and we have received near daily data for all parameters.

During the 2017 season we successfully continued our efforts to deploy transmitters and collect biological samples from loggerheads in the MAB. The deployment of 22 transmitters adds to our considerable dataset and ensures that our understanding of the overlap between loggerheads and fisheries is always up-to-date. This is of critical importance to guarantee that any potential future interactions will be identified quickly and managed with the least amount of impact to both the industry and the animals. It is rare to have a consistent long-term dataset of this kind and it is important to continue this research into the future. Interactions by fisheries with protected species can result in severe complications for the industry and this project is a method to preempt that potential.

Turtles as Ocean Observers

Excerpt from Patel et al. *in review*

"The evaluation of our data has identified that the temperature-depth profiles obtained from turtles within the MAB regularly captured the MLD and CPW signatures. Tag durations were such that coverage within the MAB lasted the entire summer and could be used to track the evolution of the CPW and identify the autumn turnover event. Additionally, previous spatial analyses found that loggerheads tagged within the Northwest Atlantic primarily restrict their summertime distribution to the continental shelf waters and on occasion include excursions into adjacent bays and estuaries (Winton et al. 2018). Overall, environmental data collected from turtle-borne sensors can be used to improve understanding of temperature through depth within the Mid-Atlantic Bight.

Due to the relatively large population of loggerheads and the consistent reporting from the satellite transmitters, less effort is required to obtain oceanographic data from turtles in the MAB than to obtain the same amount of data using traditional methods of shipboard CTDs, gliders and moorings. For example, one of the longest running programs within the region to collect oceanographic data is the Oleander Project, which since 1995 has contributed to at least 33 peer-reviewed publications (http://www.aoml.noaa.gov/phod/goos/oleander/index.php). This project is a partnership that started in 1977 between researchers and the MV Oleander that takes a weekly shipping route from New Jersey to the Bahamas (Rossby and Gottlieb 1998). During this transit, researchers deploy XBTs to measure temperature through depth. Since 2000, this project has yielded between 38 and 324 profiles per year, across a narrow band within the region (http://www.aoml.noaa.gov/phod/goos/oleander/index.php). Similarly, since 2009, tagged turtles have accrued an average of ~1450 full water column profiles within the MAB per year with much wider spatial coverage.

Satellite tagging of sea turtles is a relatively common method for studying the at-sea behavior of these species, and has been and continues to be employed throughout the world (Godley et al. 2008). Here we give the example of how sea turtles can be used as effective ocean observers due to their consistent annual migration and foraging behaviors, their tendencies to use a broad range of the marine environment, both horizontally and vertically through the water column and the high data output from the satellite tags. In situ data are important for improving accuracy of remote sensed ocean temperature data and climate forecasts (Reynolds et al. 2005). In the MAB, we suggest using these data to improve understanding and forecasting of the strong summer temperature stratification feature (Lentz 2017) and stochastic events like warm core rings and major storms. In other parts of the world, we expect turtles are similarly interacting with and transmitting data on the more unique aspects of those ecosystems (Polovina et al. 2000, 2004; Dodd & Byles 2003; Monzón-Argüello et al. 2012). Ocean forecast models are regularly used for management and conservation decisions; however consequences can be dire when models are wrong (Tommasi et al. 2017). We expect that the assimilation of over 18,000 temperature-depth profiles from the loggerheads will not only improve ocean models but also improve decision making for protecting and managing the many valuable species within the region."

5. Future Objectives

For the 2018 season we plan to continue catching and deploying satellite transmitters on loggerheads caught within the southern MAB in May during their migrations northward. For this season, we are not planning a late summer cruise to spend more time on analyses. During the May cruise we plan to deploy more Wildlife Computers tags to achieve longer transmission durations to better understand foraging fidelity. Although, collectively, loggerheads seem to inhabit the entire MAB during the summer months, by determining the level of fidelity for specific foraging sites we can establish more specific habitat ranges for turtles within the region. Additionally, within these specific foraging sites, we plan to analyze bottom time of the loggerheads and scallop catch data to determine if loggerheads prefer benthic habitats with specific communities of species. This could help fishermen quickly determine if loggerheads are in the area and spending time on the bottom based on the makeup of their catch. Furthermore, by determining the prey community loggerheads prefer, this could help improve understanding of the ecology of the nematode *Sulcaris sulcata*.

Data analyses during FY2018 will also include a continuation of comparing the temperature data from the satellite tags with oceanographic models. Preliminary analyses by Manning et al. has been discussed in previous final reports and steps will be taken during the upcoming year to finalize this work and move it towards publication. Oceanographic analyses will also be moved forward by collaborators at NEFSC who have received additional funding to use our collective tag data to better understand the potential habitat shifts for loggerheads under a warming climate. The MAB is expected to warm three times faster than the global average (Saba et al. 2016) and this will impact all species within the region. As has been speculated before, this could yield a northward expansion by loggerheads, resulting in more turtles foraging within the MAB and north for a larger portion of the year (Witt et al. 2010). Climate change is also expected to impact the Cold Pool water mass, a critical ocean feature for the survival of sea scallops. We plan to continue our efforts of using tag data retrieved from the loggerheads to track this water mass. Overall, we expect 2018 to again provide unique insight into the ecology of this northwest Atlantic loggerhead population, setting up a whole new set of questions requiring investigation in 2019.

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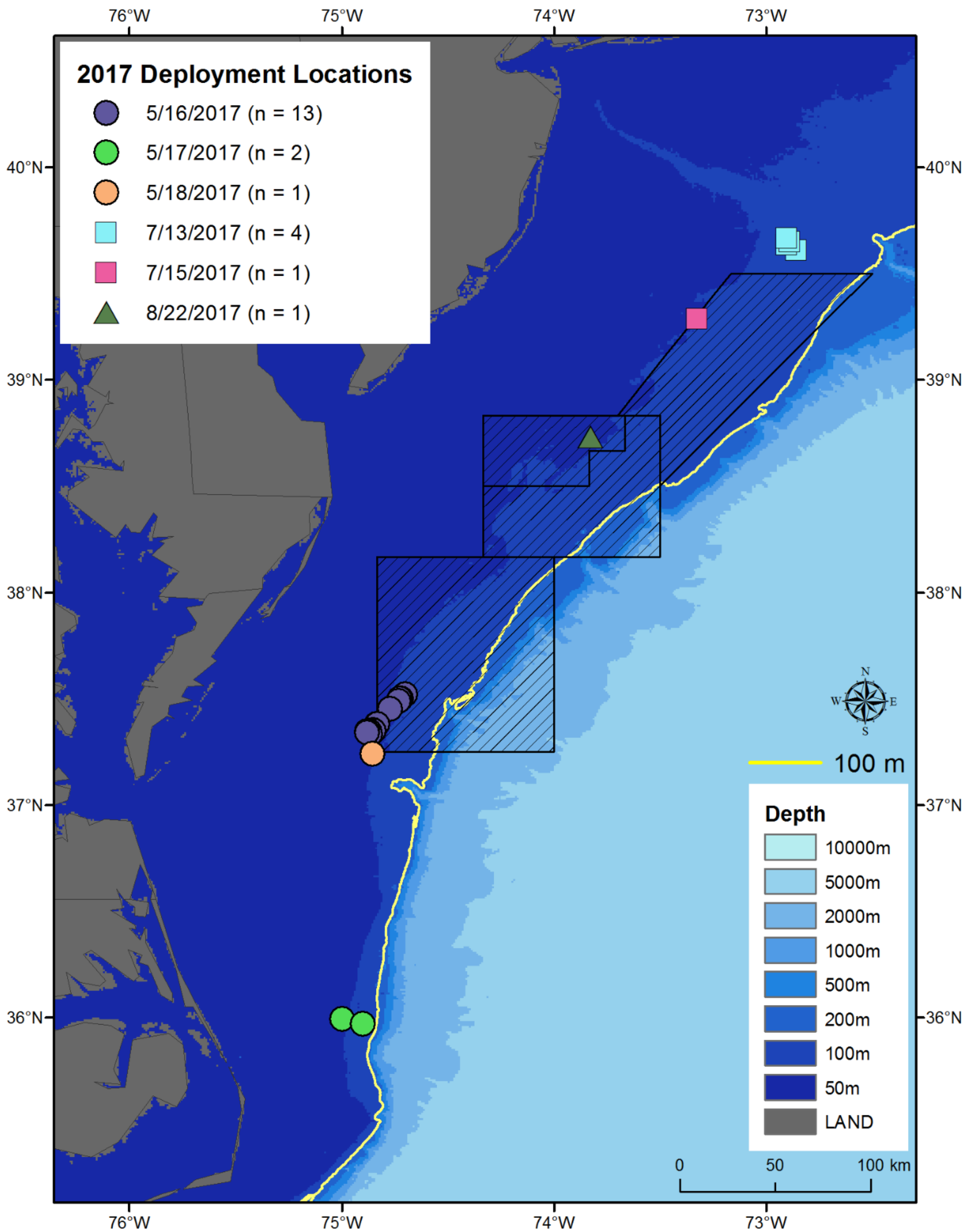

Figure 1: Deployment locations for turtle tagged in 2017.

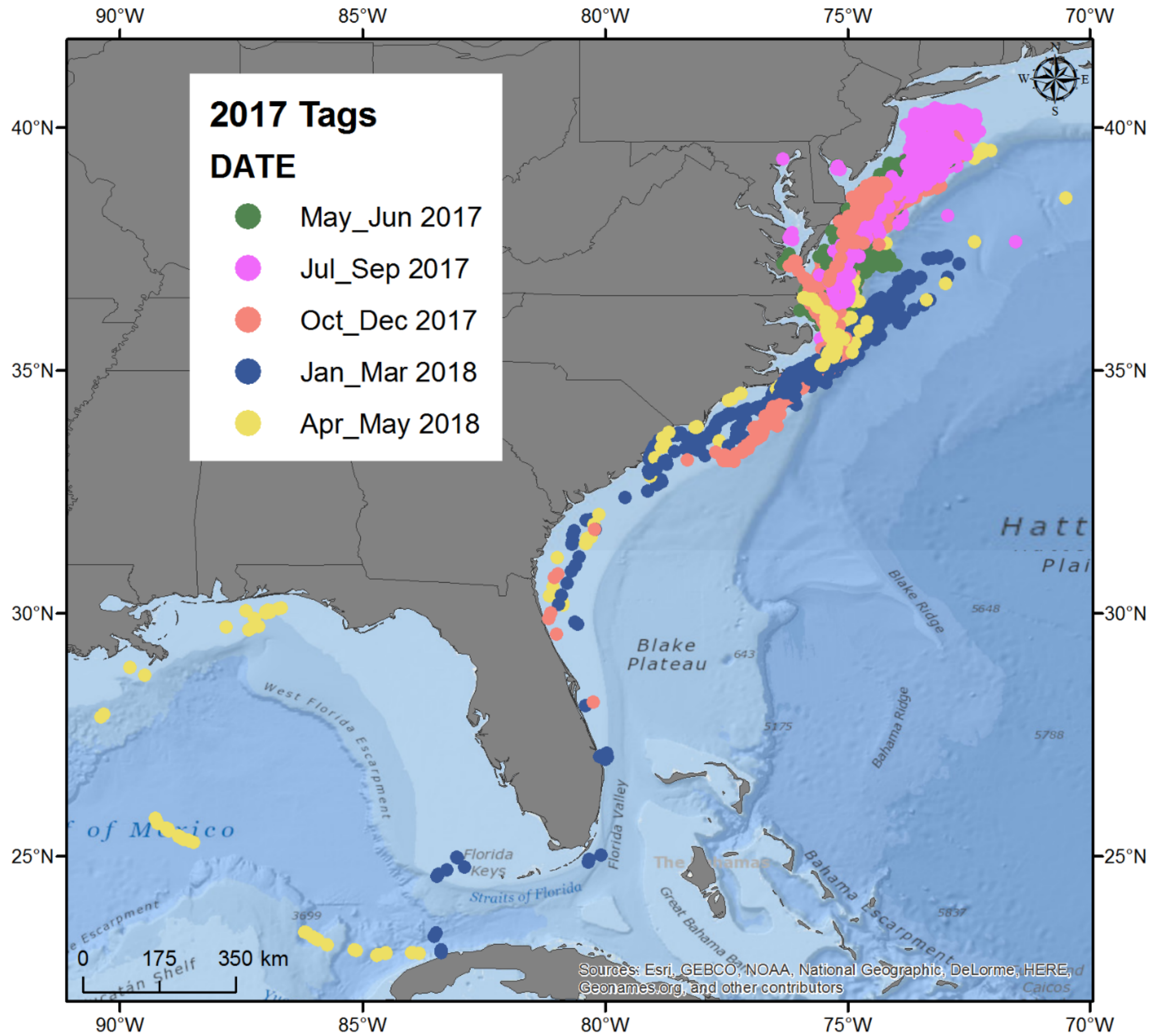

Figure 2: All locations for turtles tagged in 2017 as of May 15, 2018.

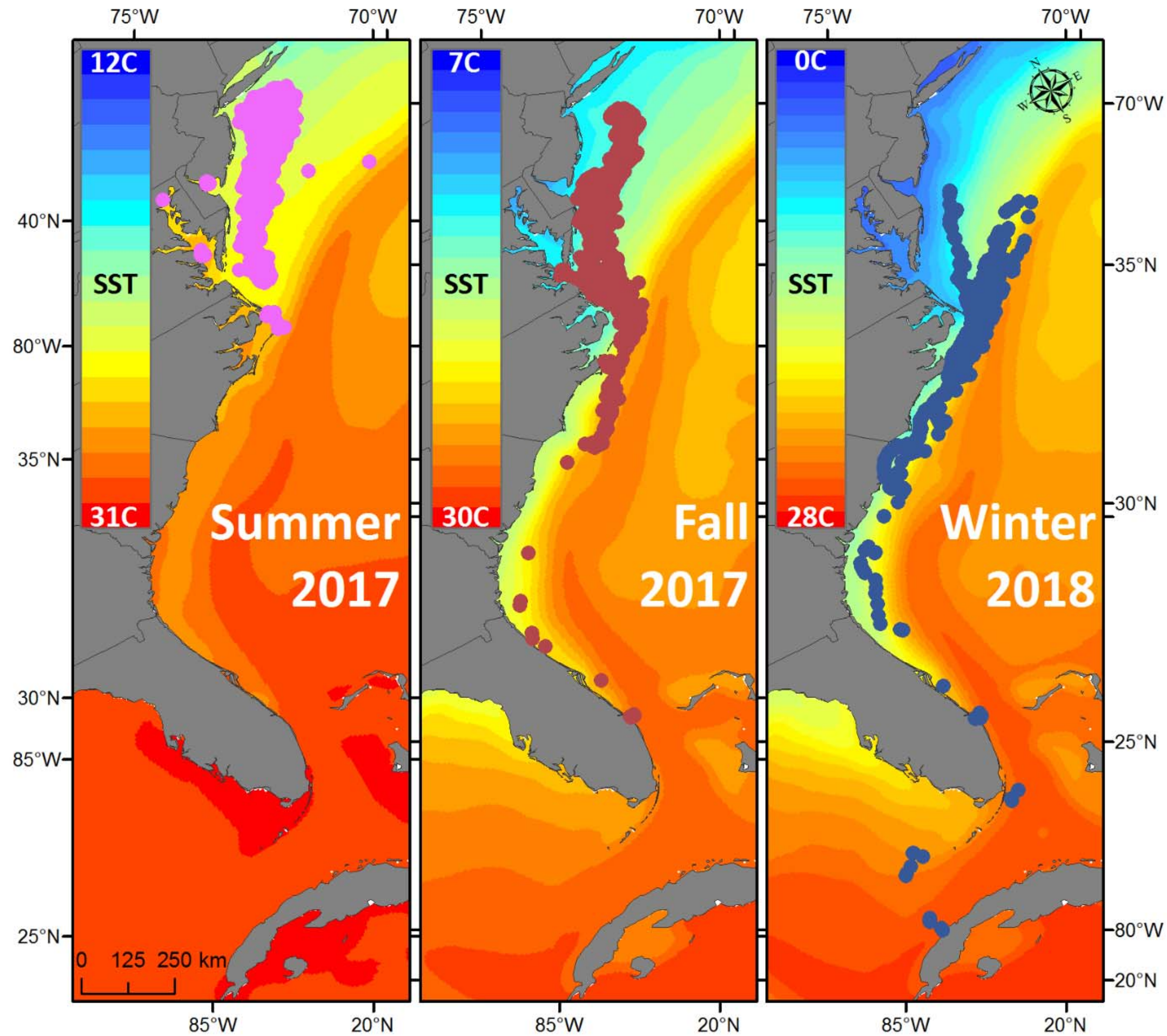

Figure 3: Mean SST during the summer, fall and winter months overlayed with corresponding turtle locations from tags deployed in 2017. Note the SST scale bars differ in each panel.

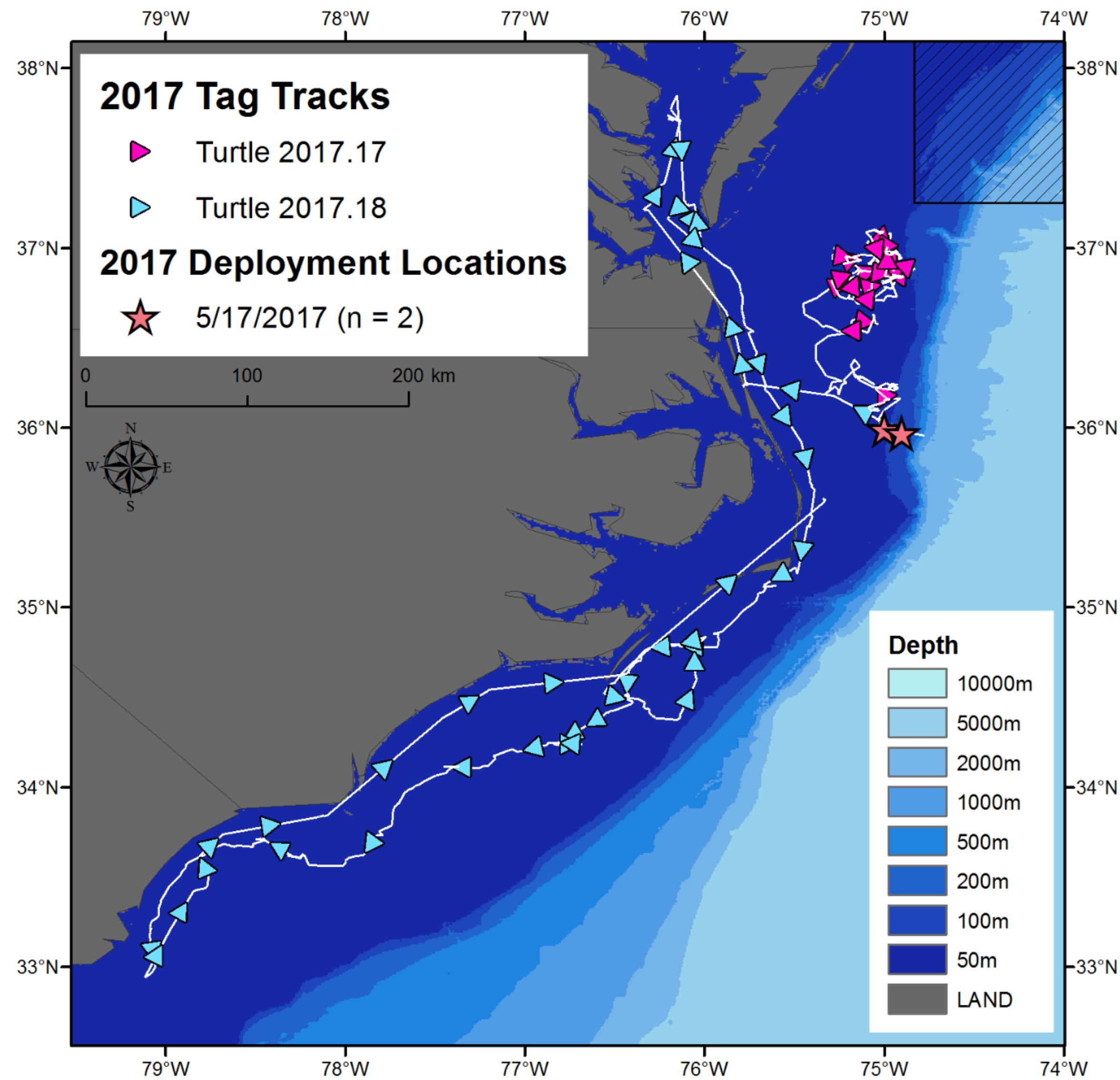

Figure 4: All locations of two turtles tagged at a southern tagging site during the May cruise.

Figure 5: Wildlife Computers tag attached to the turtle caught during the August cruise.

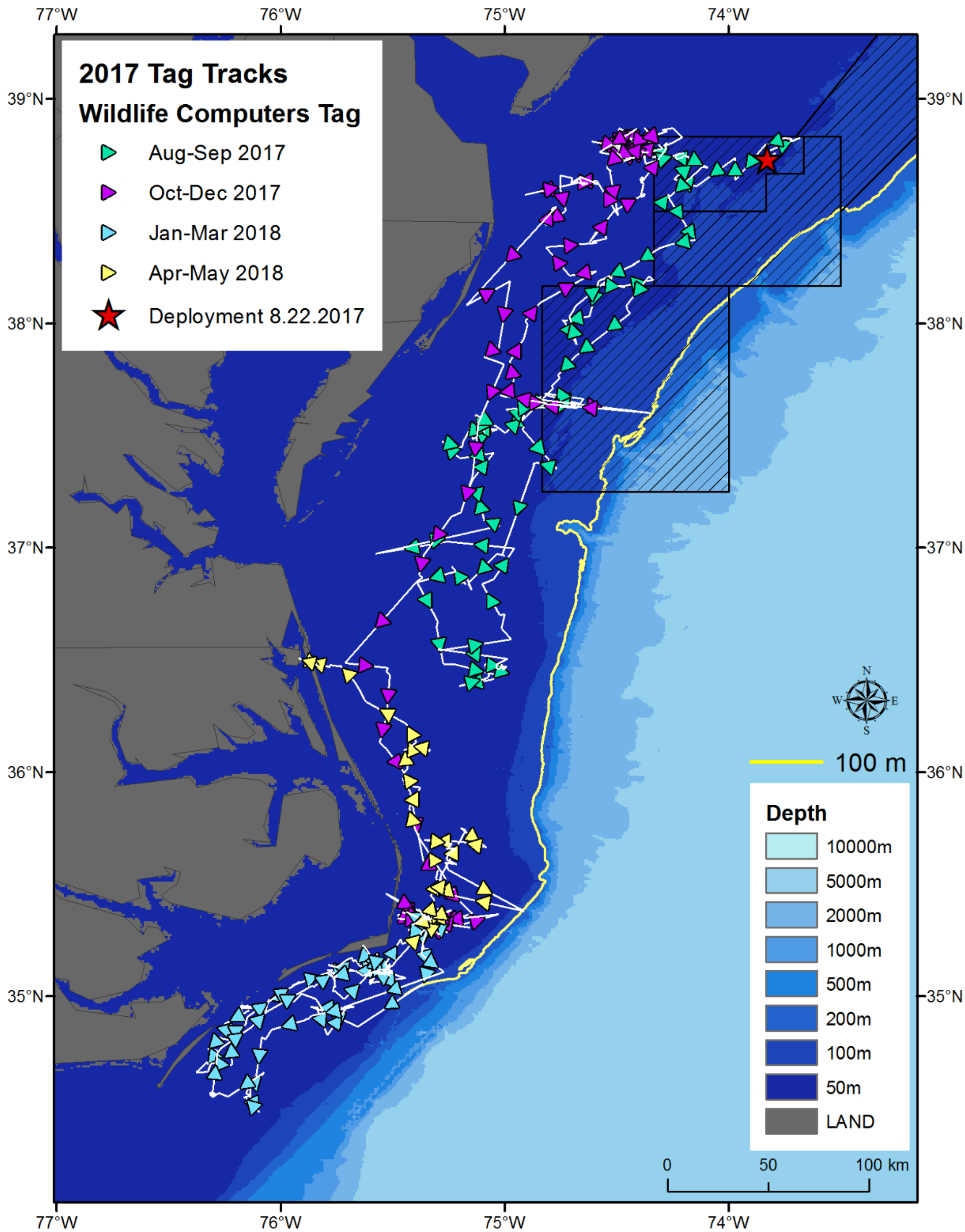

Figure 6: All locations up till May 15, 2018, for loggerhead turtle with the new Wildlife Computers SPOT 375B tag.

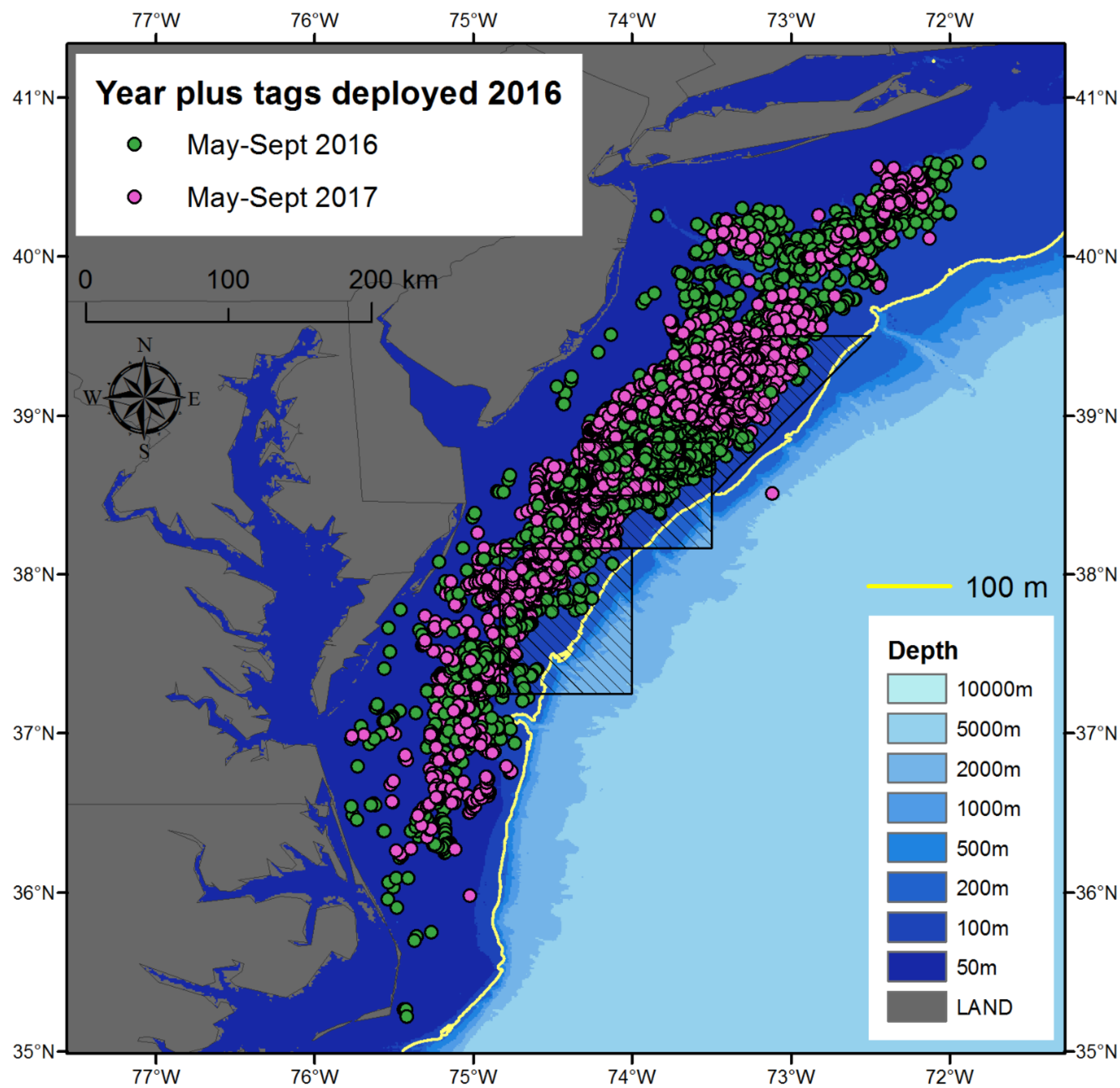

Figure 7: 2016 and 2017 summer locations for turtles tagged in 2016. Fourteen tags deployed in 2016 continued to transmit till May 2017 or beyond.

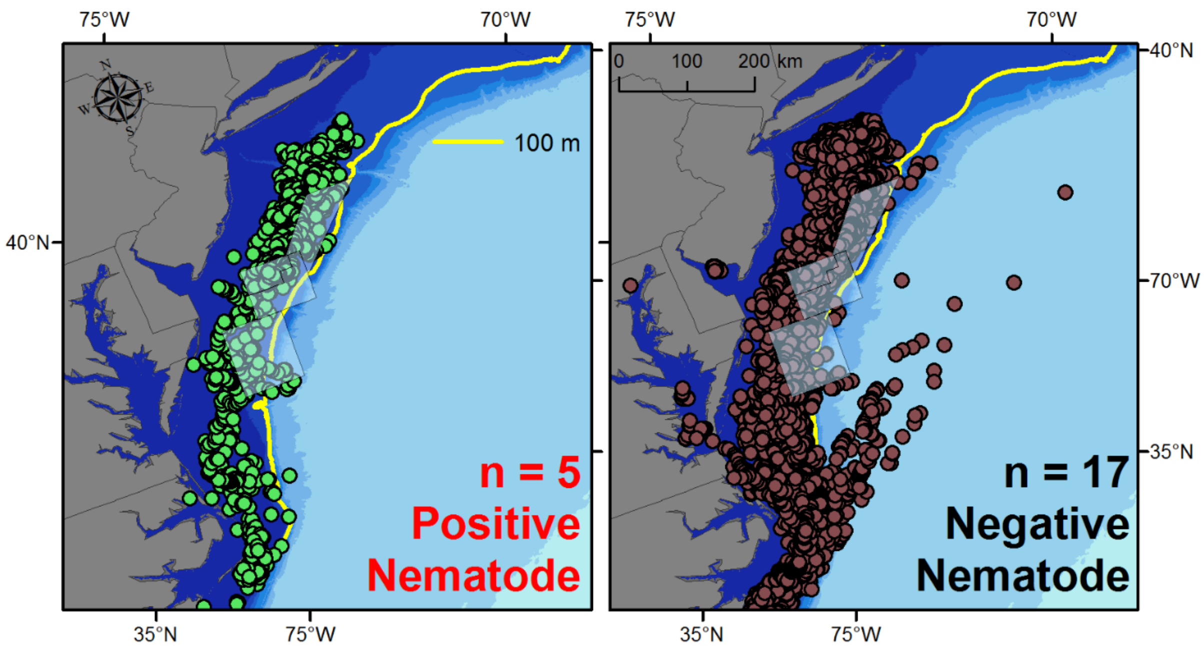

Figure 8: Locations of loggerheads within the MAB positive and negative for nematode presence in cloacal lavage samples.

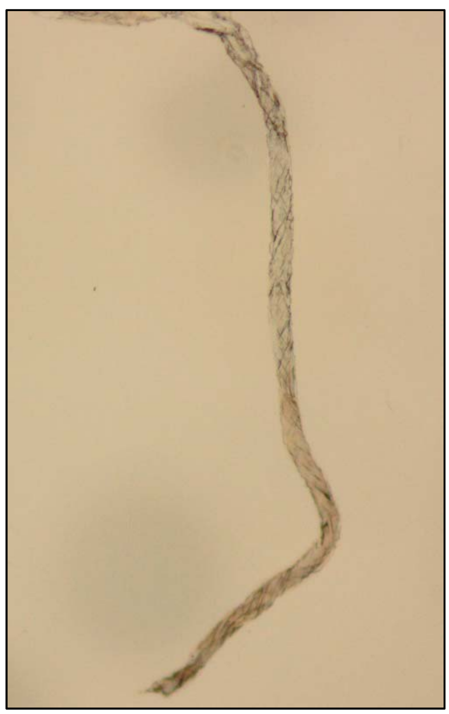

Figure 9: Microplastic found in the gut/fecal sample collected from a Kemp's ridley turtle that stranded in Cape Cod.

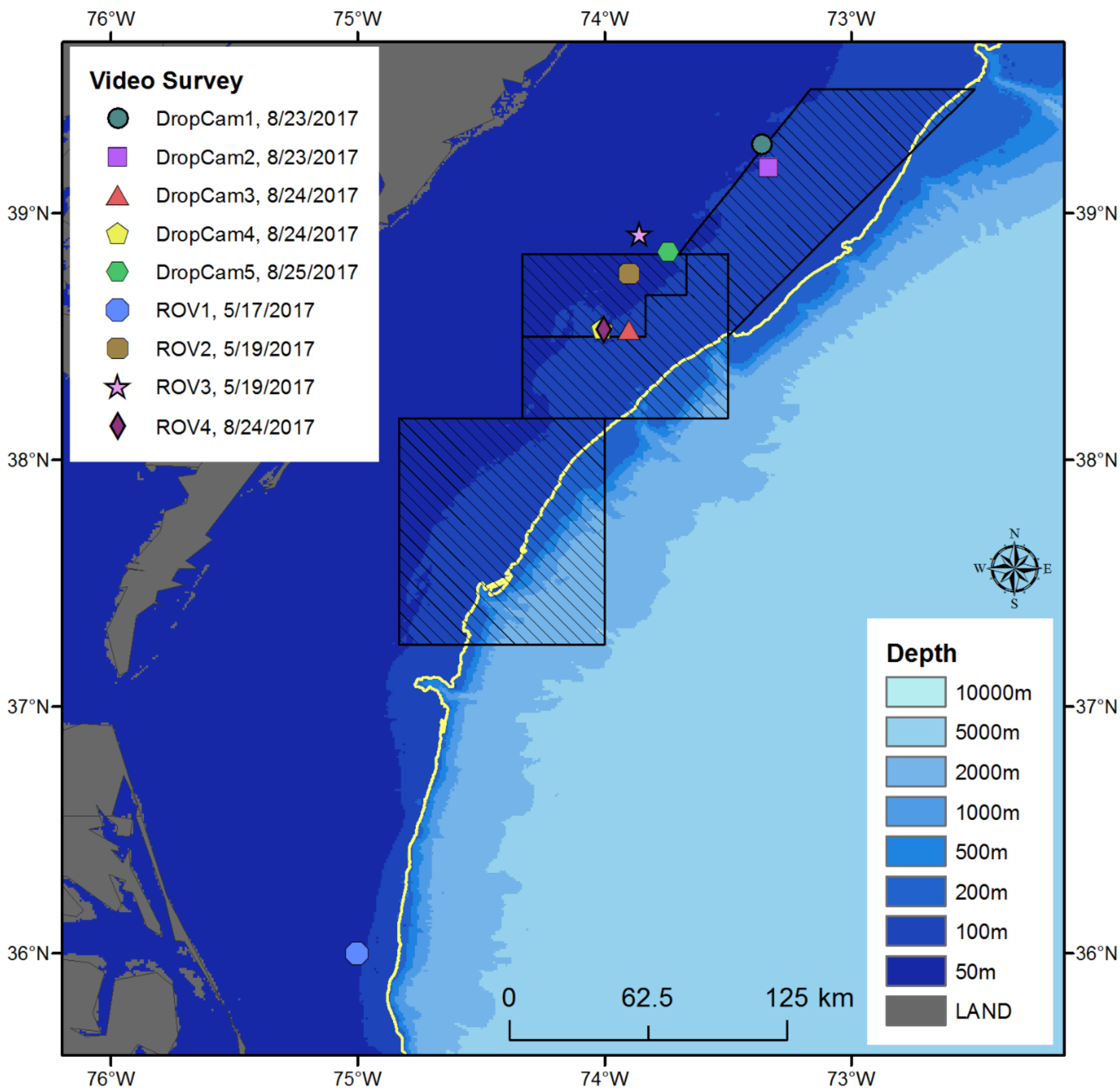

Figure 10: Locations for all video work during the 2017 sea turtle cruises. This includes ROV dives and drop camera deployments.

Figure 11: Baited drop camera system used to assess the species attracted to the discard from shucking scallops.

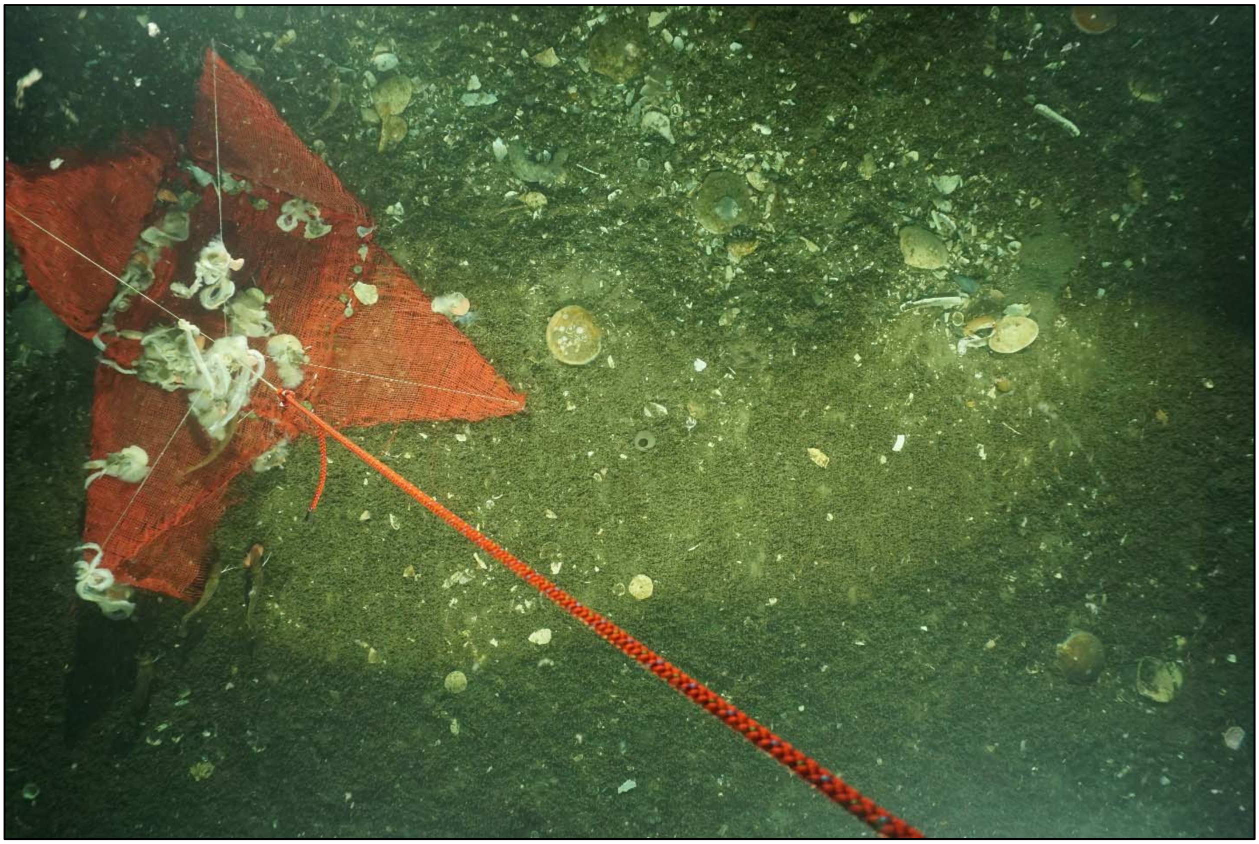

Figure 12: Image taken from the drop camera. Red crab trap is used to bring scallop guts to the bottom, and a photo was taken every 15 seconds. This image is ~30 minutes after deployment.

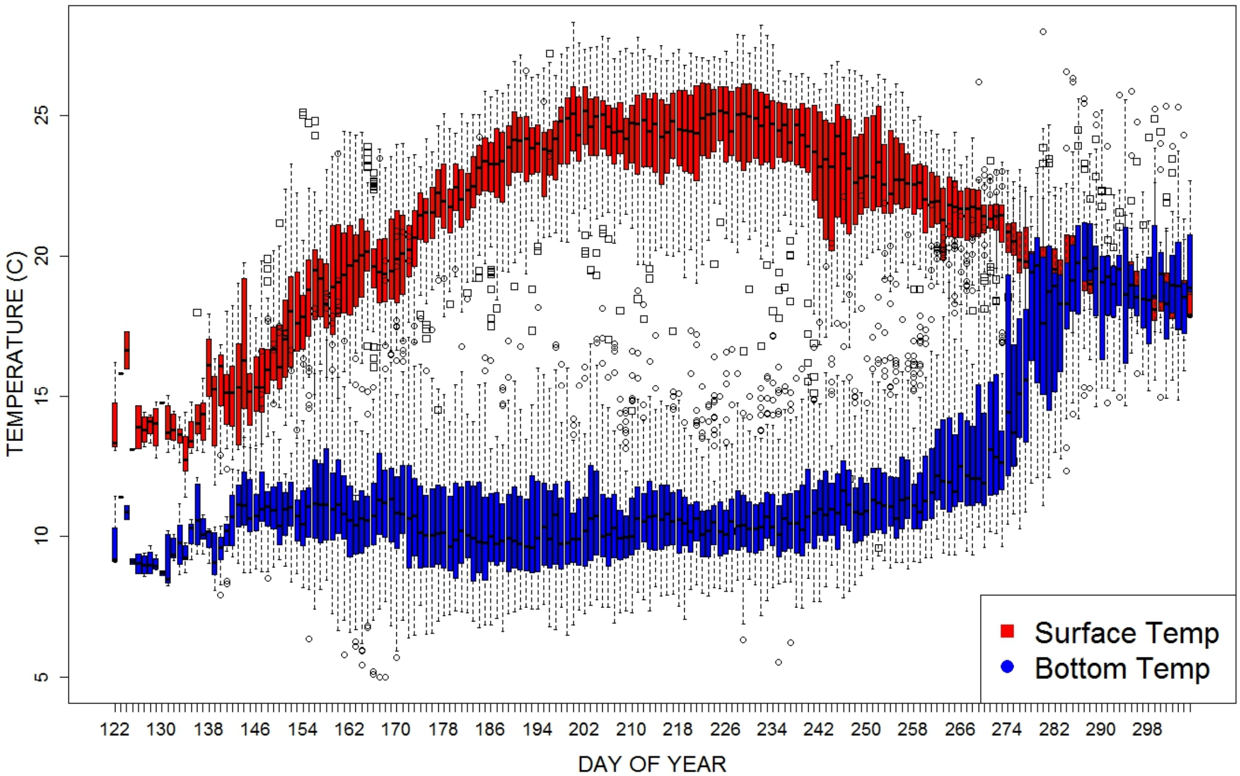

Figure 13: Daily bin of all recorded surface and bottom temperatures from bottom dives between the 30 and 70 m isobaths from May 1 to Oct 31 for all sample years, 2009 - 2017. Horizontal bars = median; box = 50%; whiskers = range of observations within 1.5 times the interquartile range from edge of the box; open circles/squares = observations farther than 1.5 times the interquartile range for bottom and surface temperature respectively.

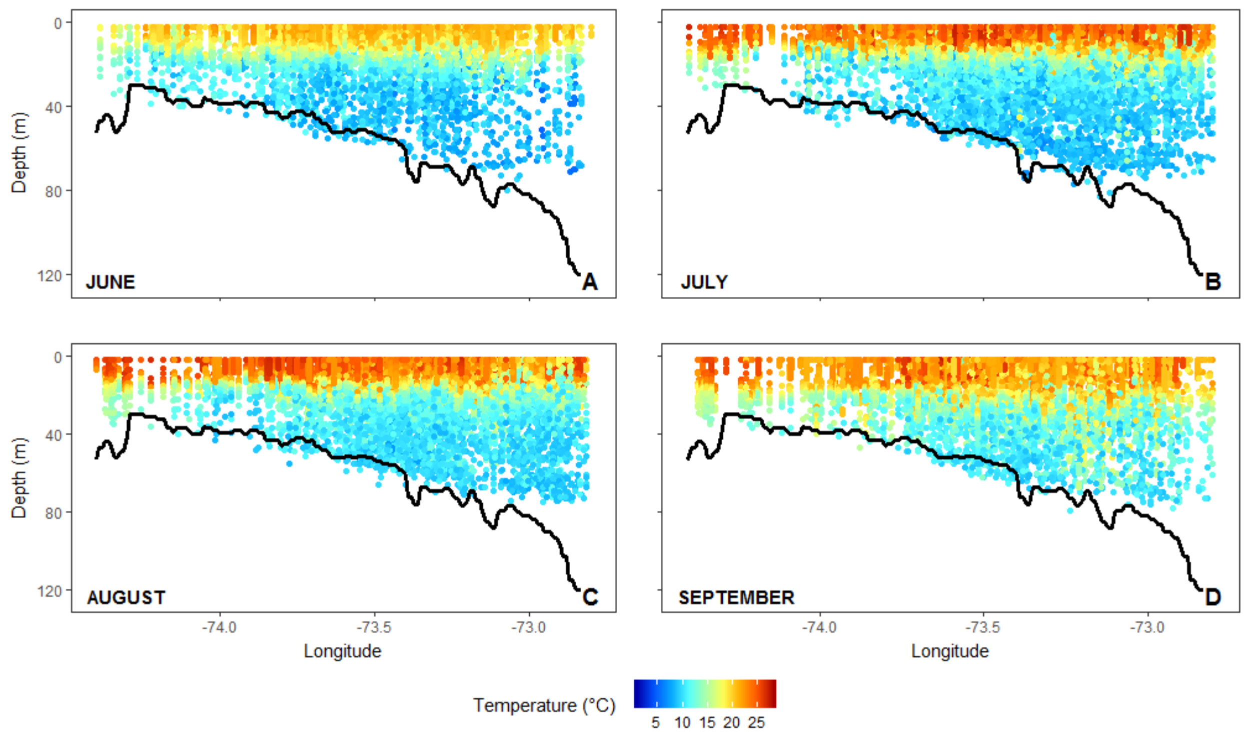

Figure 14: Temperature-depth profiles for bottom dives occurring between latitudes 39° N and 40° N along the continental shelf. This degree of latitude tends to have the largest difference in surface and bottom temperature as a result of the seasonal CPW (Lentz 2017). Left along the X axis for each graph is closest to shore. Solid black bathymetry line represents the maximum depth at every 0.01° of longitude between 39° N and 40° N latitude. A) Temperature-depth profiles for June 2009 - 2017; B) Temperature-depth profiles for July 2009 - 2017; C) Temperature-depth profiles for August 2009 – 2017; D) Temperature-depth profiles for September 2009 – 2017.

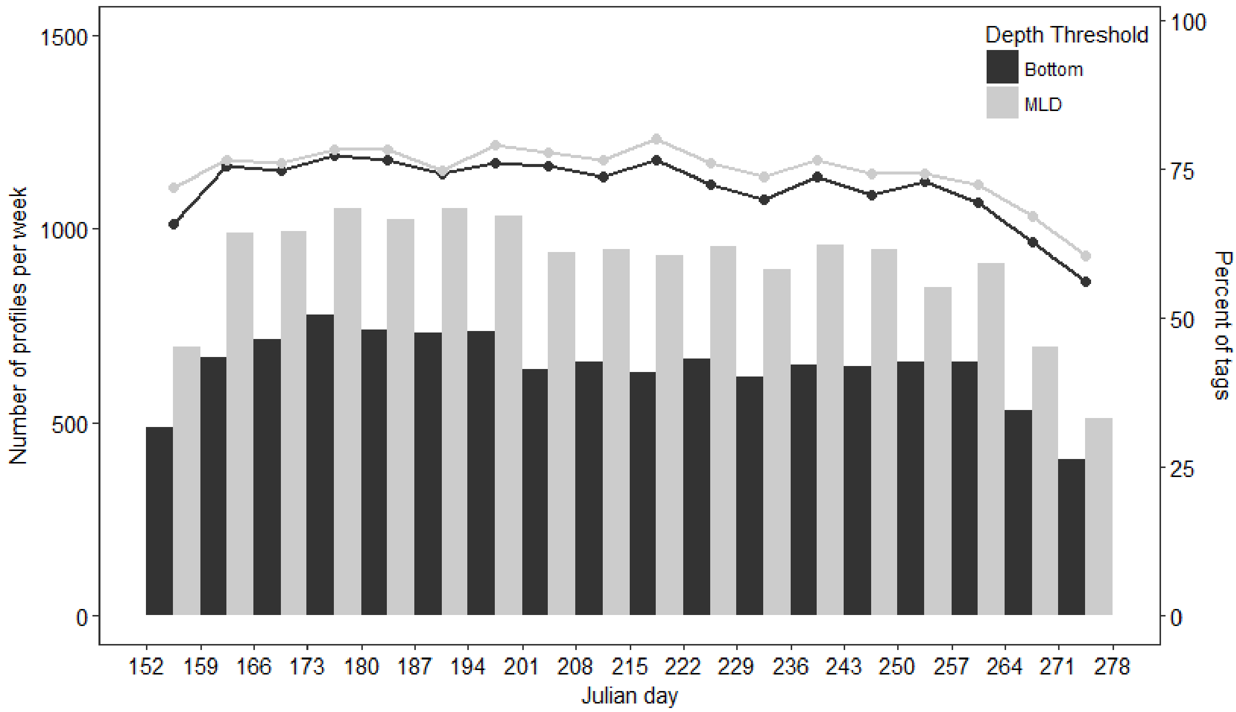

Figure 15: Bars represent total number of profiles passing through the MLD (grey) and reaching the bottom (black), and the lines represent the percent of deployed tags (*n* = 167) returning profiles which meet the two depth thresholds (MLD and depth) per week across all years, 2009 – 2017 from Julian day 152 to 277.