Improving the Understanding of Sea Turtle Entanglement in Vertical Lines

Final Report

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Submitted By
Samir Patel and Liese Siemann
Coonamessett Farm Foundation, Inc

In collaboration with:
Michael James – Department of Fisheries and Ocean Canada
Aliki Panagopoulou – The Leatherback Trust
George Maynard – Cape Cod Commercial Fishermen's Alliance
Ronald Smolowitz – Coonamessett Farm, Inc.
George Breen – Pilot

In Partnership with:
Heather Haas, Henry Milliken and Eric Matzen – Northeast Fisheries Science Center

Coonamessett Farm Foundation, Inc

277 Hatchville Road East Falmouth, MA 02536

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

www.cfarm.org

General Information

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Report Author(s): Samir Patel and Liese Siemann

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Executive Summary

The goals of this project addressed the research needs of **FY 17/18 BREP Priority I.B.1b** to reduce bycatch impacts between fisheries and protected species. Specifically, this project increased the dataset on the fine scale behavior of leatherback turtles within Massachusetts (MA) state waters, a region with a particularly high number of entanglement incidences (Sampson 2015) and provided input from fishers on their perspective on this issue. Data were acquired through a combination of research techniques to (1) understand the presence and habitat usage of leatherbacks within MA state waters and (2) the interactions they have with vertical line. To study leatherbacks, we conducted flights within Cape Cod Bay (CCB), Vineyard Sound (VS), and Nantucket Sound (NS) to find and document leatherback presence. Aerial observations during flights also helped the boat-based work of deploying camera tags on leatherbacks by locating target animals. To better understand the fishery and gear itself, we deployed cameras on vertical lines and conducted anonymous surveys with fishers.

We recorded 61 leatherback sightings and two unidentified hard-shelled turtle sightings during 21 flights over two field seasons. We deployed the camera tags on 23 leatherbacks. Fourteen leatherbacks were tagged in CCB, three were tagged in NS, three were tagged in VS, and three were tagged in nearshore waters of North Carolina (NC) for camera testing. We accrued ~62 hours of footage from cameras placed near-surface on the vertical line of active lobster trawls. Eight fishers provided responses to our survey.

Leatherbacks within MA state waters behaved differently in different regions. Within CCB, turtles were not observed foraging, and we generally sighted and tagged individuals within the southeast corner of the bay. We did not document an entanglement; however, we did film a turtle that had scars and a stiff right front flipper consistent with impacts from a constricting rope. In NS and VS, turtles were filmed foraging on jellyfish. These turtles actively dove in search of prey and foraged at a rate of approximately 3.1 jellyfish per minute. We did not document a protected species while filming along the vertical line, and fishers generally did not consider turtles to be threats to their personal gear. However, fishers did view turtles as a threats to their fishery and seemed to agree that a reduction in vertical lines overall was the most reasonable solution to the issue of entanglement.

Project Overview and Purpose

The main goals and objectives of this project addressed **FY 17/18 BREP Priority I.B.1b** to reduce bycatch impacts between fisheries and protected species. The specific goals of the project were: (1) conduct flights over regions of known high densities of buoys and sea turtles to assist in boat-based tagging and tracking methods, (2) use videography to monitor sea turtle at-sea behavior within Cape Cod nearshore waters, (3) use videography to monitor vertical lines attached to fishing gear to document potential sea turtle interactions and the movements of the line caused by ocean conditions, and (4) anonymously survey fishers to collect information on turtle-gear interactions and potential solutions.

During this research, we conducted 26 flights, both for scouting and for assisting in tagging. Overall, 79 leatherbacks and two unidentified sea turtles were spotted during the flights. We successfully tagged and characterized the in-water behavior of 23 leatherback turtles, accruing 35 hours of footage from the turtle-mounted camera tags. This included the successful tracking of 20 leatherbacks in MA state waters and three turtles in the state waters of NC near Beaufort. We also deployed a camera on the vertical lines of actively fishing lobster pots within CCB. These deployments accrued 61.8 hours of footage on lobster gear that was set primarily near Duxbury, MA at the mouth of CCB. In addition to the in-water videography, we received eight completed surveys from local MA fishers regarding their experience fishing in waters adjacent to Cape Cod.

Background

Sea turtles residing in the Northwest Atlantic region are all listed as either ESA threatened or endangered, and leatherbacks are listed in Canada's Species at Risk Act. Yet limited actions, beyond the establishment of an MA disentanglement network, have been taken to mitigate the impact of vertical lines from fisheries on this species, and there have been few studies examining the possible gear modifications to reduce risk. (**Figure 1**). In a study by the Consortium for Wildlife Bycatch Reduction between 2005 and 2009, vertical line modifications to reduce entanglement were tested to quantify their feasibility (McCarron 2009). Four types of vertical line modifications were tested: illuminated rope, sheathed rope, weak rope and time-tension line cutters. All modifications were deemed unfeasible from the

***Figure 1**: Leatherback photographed in Cape Cod Bay with rope draped over its left flipper. This turtle did not end up entangled from this line interaction. Photo credit Heather Haas, NEFSC. ESA Permit #16556.*

perspective of the fishers. Although modifying line has been a common approach at mitigating protected species entanglements, very limited knowledge is available on how and where on the line turtles entangle themselves. Improving the knowledge of sea turtle at-sea behavior while amongst vertical lines has been deemed a priority by both the Greater Atlantic Regional Fisheries Office (GARFO) and the Northeast Fisheries Science Center (NEFSC) (NMFS 2015).

With the current numbers of vertical lines permitted in coastal and offshore waters, 20 leatherbacks are reported entangled per year from Maine to Virginia, and approximately 13 leatherbacks are reported entangled in Atlantic Canadian waters each year (Hamelin et al. 2017). The numbers of vertical lines are expected to increase due to expansion of inshore and offshore aquaculture. Therefore, research is needed to improve the overall understanding of sea turtle behavior and where and how turtles entangle themselves so that appropriate mitigation methods can be developed. Understanding animal behavior is a critical component of bycatch mitigation research (e.g., Buchholz 2007, Southwood et al. 2008, Jaiteh et al. 2013, Glass and Wardle 1995, Main and Sangster 1981, Milliken and DeAlteris 2004), and a sample size closer to 100 tracked animals is required to effectively understanding fisheries interactions (Sequeira et al. 2019). Specifically, we need to identify sea turtle behaviors near vertical lines to understand why they become entangled. From previous research on loggerhead in-water behavior (see Smolowitz et al. 2015 and Patel et al. 2016), we have documented turtles interacting with line in the water. This line was the tether of an ROV, and it has a 1-inch diameter and a higher stiffness compared to vertical lines from fixed gear fisheries. During these tether-turtle interactions, the turtle did not become entangled even though its reaction to the line consisted of continuing to swim forward. This lack of entanglement was averted because we could move the tether using the ROV; however, this is a telling sign about how sea turtles may react in these types of events, leading to life-threatening levels of entanglement. It is currently unclear why certain species are more susceptible to entanglement, and leatherbacks are reported entangled over 10x more often than hard-shelled turtles (Sampson 2015). Furthermore, no data exists to identify how often turtles interact with vertical lines and do not entangle. These data would help provide information on the entanglement potential of individual fishing gear within a high-density environment of turtles.

Although sea turtle entanglements consistently occur annually in the NW Atlantic, no effective mitigation measures have been implemented for these species, and gear modifications that remove vertical line from the water column have been slow to develop. In a comprehensive assessment of Canadian fisheries interactions with leatherbacks, vertical line fisheries were included in both the highest (snow crab pot) and moderate (whelk pot and lobster pot) threat categories (Fisheries and Oceans 2012), and a more recent study also identified trap nets as a source for many entanglements in the region (Hamelin et al. 2017). In New England, July - September is the peak season for sea turtle presence within coastal waters (http://www.seaturtlesightings.org). Between 2002 and 2014, 275 turtles, including 252 leatherbacks, were reported entangled in vertical lines from Maine to Virginia, with the majority reported in MA waters near Cape Cod (**Figure 2**) (Sampson 2015). Most reported entanglements involved turtles near the surface buoy; however, it is unknown whether surface entanglements are more likely to be sighted and reported by the general public because they are more visible, whether turtles indeed become entangled near the buoy most often or do turtles work their way to the surface if entangled at depth. Additionally, as entanglements are reported opportunistically by fishers, boaters, beach walkers, and others, these numbers underestimate the total number of interactions. Unfortunately, while commercial fishers are best poised to evaluate entanglement configurations, including specific turtle-gear interactions at depth, underreporting is believed to be particularly prevalent among this group because of concerns about how entanglement information might be used.

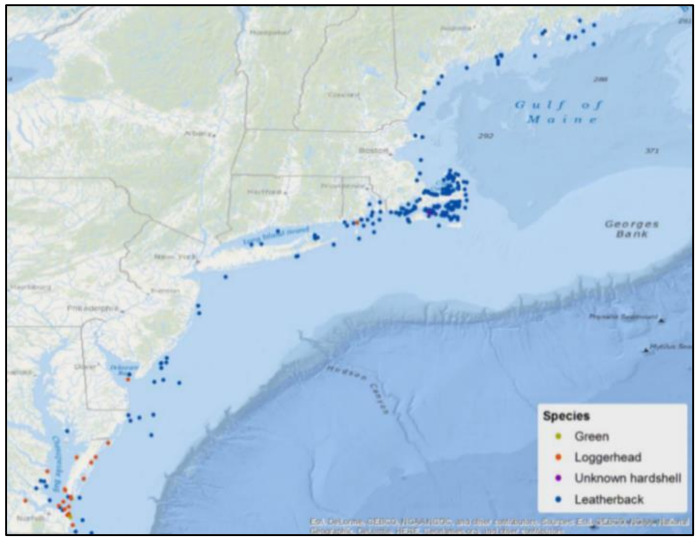

***Figure 2**: All reported locations of entanglement incidences from Maine to Virginia between 2002 and 2014 (Sampson 2015).*

Project Objectives and Approach

Objective 1: Conduct flights over regions of known high densities of buoys and sea turtles to assist in boat-based tagging and tracking methods.

Field work for tagging leatherbacks within MA state waters occurred each year in August, September and October, with flights beginning in early August as pre-surveys to scout for turtles. We developed a flight path for pilot George Breen to follow during each scouting flight to ensure consistent coverage over the regions we have identified as hot spots for leatherbacks within quick reach of accessible boat launches (**Figure 3**). These pre-survey flights allowed us to plan where field work would occur within the following weeks during good weather windows. Aerial sighting in CCB was easier, as water clarity was better than in VS and NS, and the contrast of the dark turtles on the light colored sandy bottom made it possible to track the turtles while submerged. This was more difficult in VS and NS where water clarity was worse and turtles were generally located in deeper waters.

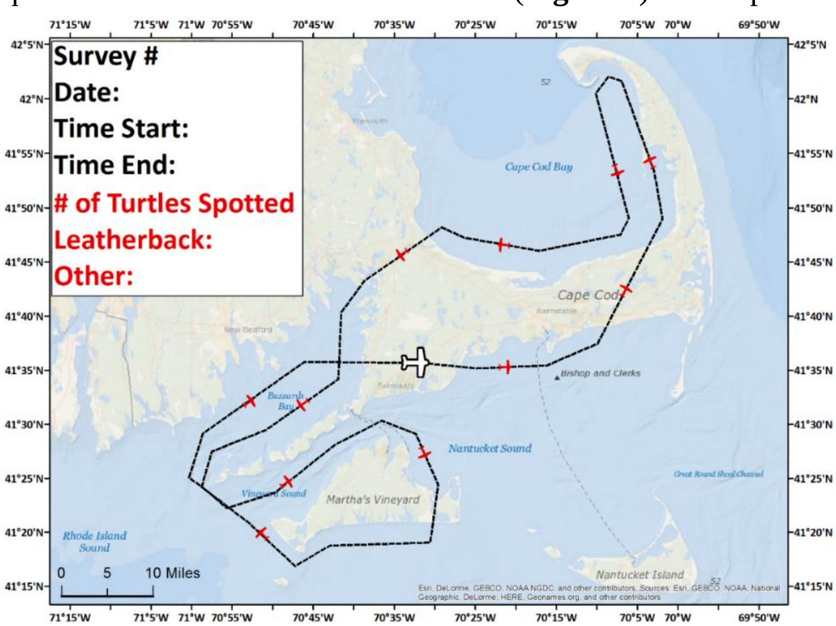

***Figure 3:** Pre-survey flight path and inset datasheet used by pilot George Breen.*

Aerial assistance was critical for consistent tracking and tagging of leatherbacks. During active field work for tagging turtles, our pilot would stay within a few miles of the boat while searching for turtles. In CCB, this included scouting along the southern and eastern edges of CCB, and in VS and NS, this meant traveling throughout VS and the northern and western portion of NS. Once a turtle was spotted by the pilot, he would radio this information to the boat, and he would keep track of the turtle's location until we had arrived at the site. Once we were at the site, he would continually update us about the turtle's behavior and orientation, prompting us to approach and tag it as he saw it rise to the surface for a breathing event. We always approached the turtle from behind because if we approached the animal head on, this could be perceived by the animal as a threat. Overall, this method worked well, particularly in areas with good water clarity.

Objective 2: Use videography to monitor sea turtle at-sea behavior within Cape Cod nearshore waters.

To collect information on the behavior of leatherbacks within MA state waters, we used a variety of custom-built camera tags specifically designed for ease of deployment on leatherbacks without capture and same-day recovery in nearshore waters. All leatherback tracking and tagging was done under NEFSC ESA permits #16556 and 22218.

The first set of tags we tested and deployed were custom built by the Nova Scotia Community College (NSCC) in collaboration with the Department of Fisheries and Ocean Canada (**Figure 4a**). These tags were built with long-term (multi-day) video recording capabilities and an integrated GPS system. Suction cups for attachment were connected to the tags using corrodible links for easy release from the turtle, and temperature-depth recorders (TDRs) and radio transmitters for recovery were attached externally. Unfortunately, due to the delicate nature of the internal components, these tags were a bit inconsistent, and we were not able to obtain any good footage while using them on turtles in MA state waters. However, they were pre-cursors to the successful long-term vertical line cameras discussed below.

Concurrently with the development of these tags by NSCC, we built tags using off-the-shelf products. We built these tags on small blocks of high density and highly buoyant foam and tested a variety of underwater action cameras with built in sensors (**Figure 4b**). We used the same suctions cups, corrodible links, and radio transmitters as those used on the NSCC tags because we found this system of attachment, release and recovery to be reliable and effective. We tested four action cameras: Garmin VIRB, Olympus Tough TG Tracker, GoPro Hero 4, and Paralenz dive camera. After testing, we determined that the Paralenz camera was the best choice for our needs as it recorded temperature and depth while having the longest battery life and deepest depth rating. Additionally, with a cylindrical design and small frontal area, this camera added the least amount of additional drag to tagged turtles. To record GPS locations, we built a simple GPS tracker using parts from www.adafruit.com. We also tested the addition of a satellite transmitter from Wildlife Computers to record GPS location and dive behavior data. The satellite tag also acted as a beacon for recovery, as tag transmissions can be received using a handheld device called a goniometer. This satellite tag also helped with existing projects to calibrate shallow depth readings with video footage to better identify when a turtle had breached the surface with data from satellite tags.

The third type of camera tag we tested on leatherbacks was the AMX tag built by Loggerhead Instruments (**Figure 4c**). This tag was designed to be an all-in-one tag with a camera, timed-release, sensors (temperature, depth, GPS, and accelerometer), and tracking technologies integrated into a single platform. Loggerhead Instruments built this tag using an iterative approach, with a simple version built first, and the results of the initial testing of the

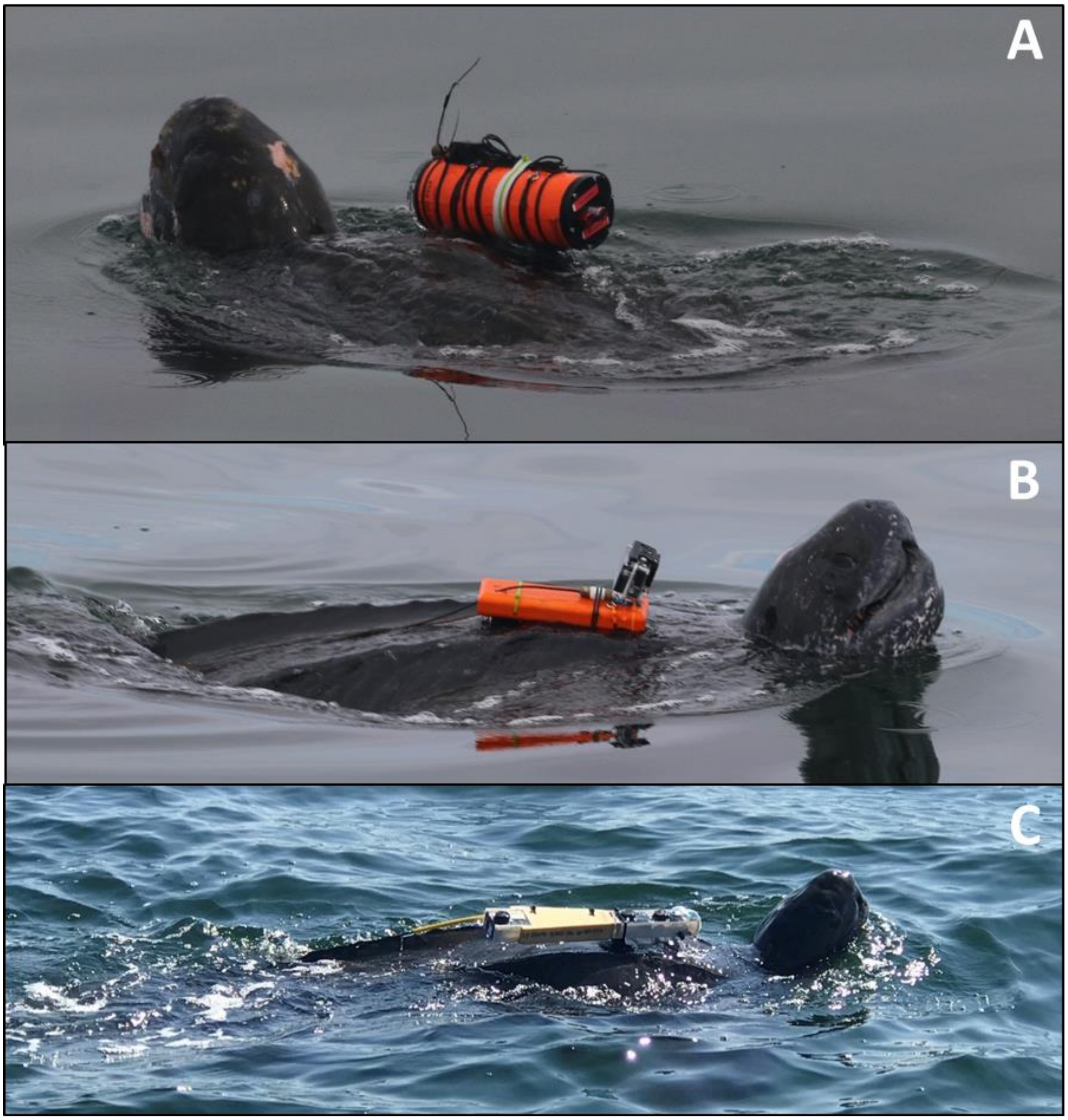

Figure 4: A) *NSCC camera tag deployed on a leatherback in Cape Cod Bay, Aug 23, 2018. B) Action camera tag deployed on a leatherback in Cape Cod Bay, Aug 23, 2018. C) AMX tag deployed on a leatherback in Cape Cod Bay, Sept 10, 2019. Photo Credits: Heather Haas, NEFSC. ESA Permit #16556, 22218.*

simple tag helped inform design and build of the final version. The simple version (AMX1) had a low-resolution black-and-white camera to maximize storage of video and no tracking beacon to minimize operational costs associated with satellite networks. After watching video footage from this camera, we determined that we required a higher resolution camera. We also realized that tracking tags using only a radio transmitter used up valuable time in the field and limited our tagging efforts to inshore waters. Consequently, the final version of the AMX tag (AMX2) incorporated a high-resolution camera and a satellite-based tracking beacon. The tracking beacon would start transmitting over the Iridium satellite system once the tag was released from the animal, sending its GPS location every 10 minutes to the user through email or a handheld receiver. This simplified and sped up recovery time due to the increased precision of a GPS location as compared to traditional radio tracking signal strength.

Video footage from each tag was analyzed using animal behavior analysis software called Observer XT. This analysis was designed based on our previous work quantifying in-water loggerhead sea turtle behavior from video footage obtained using remotely operated vehicles (ROV; Patel et al. 2016). We created a coding scheme to quantify the events recorded by the camera tags, including any events where anthropogenic items (boats and rope) were in view or interacted with the turtle (**Table 1**). We also documented the general ecology and physiology of

Table 1: *Video coding scheme used to quantify turtle camera footage.*

Behavior and Habitat Variables	Description
State Events	
Depth Zones	
Surface	Water surface in view from under or above
Mid-Water	Neither surface nor bottom in view
Bottom	Seafloor in view
Other Animals	
No Other Animals in View	No non-prey species in view
Other Turtle(s) in view	Any other turtles of any species in view
Fish in view	Any fish in view
Anthropogenic Items	
No Items in View	No fishing gear or boats in view
Vertical Line in View	Any vertical line in view
Boat in View	Any boats in view
Point Events	
Tag Start/Stop	
Tag Deployment	Tag is deployed onto turtle
Tag Recovery	Tag falls off turtle
Animal Behavior	
Breath	Turtle takes a breath at the surface
Flipper Beat	One complete flipper stroke cycle (includes upstroke and downstroke)
Foraging	Turtle is eating any prey item
Prey Item Passing	Gelatinous prey items pass by without a foraging attempt
Miscellaneous	
Only Tag Above Surface	Tag is above water surface, but turtle is submerged
Miscellaneous Items	Any additional events of note

the turtle by counting prey items, foraging events, flipper beats, breaths, and sympatric species. We compared video analysis results of water column usage (e.g. behavior underwater vs. at the surface) with TDR data obtained from the tags.

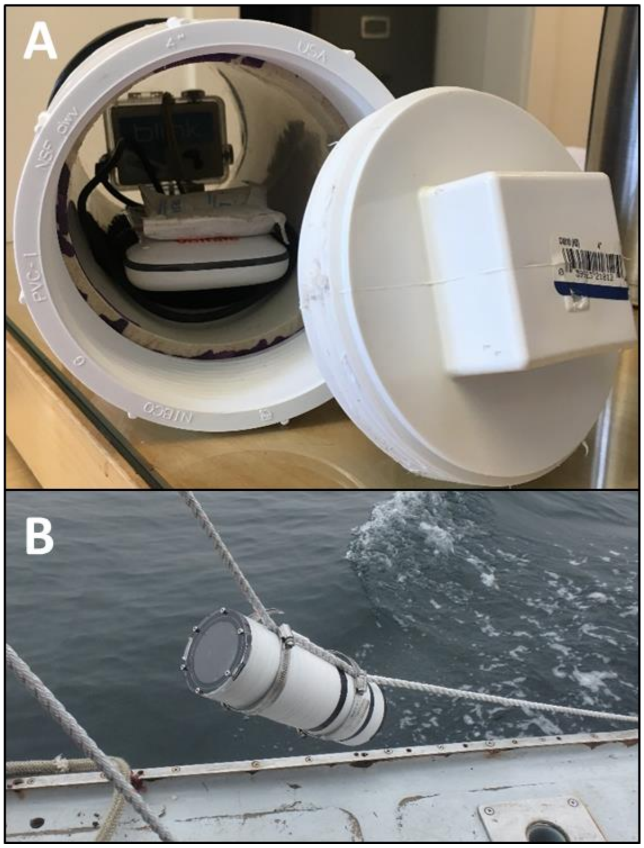

Figure 5*: A) CFF-built vertical line camera. B) NSCC-built vertical line camera being deployed on June 19, 2019 in Cape Cod Bay.*

Objective 3: Use videography to monitor vertical lines attached to fishing gear to document potential sea turtle interactions and the movements of the line caused by ocean conditions.

We designed two vertical line cameras for this project. The first was built in-house at CFF using off-the-shelf components, while the second was custom built by NSCC and was a simplified but improved version of the camera tag built for deployment on leatherbacks. The in-house camera was composed of a GoPro Hero 4 equipped with a CamDo intervalometer, to allow programmed time-lapse recordings, and a pair of external batteries to extend the recording time (**Figure 5a**). This camera system was housed in a custom built PVC housing. During bench testing, the camera recorded as programmed; however, while deployed at sea, the system did not function as well and recorded far less footage than expected. Due to this inconsistency, we asked NSCC to scale down their turtle camera tag to make a long-term recording device without additional integrated sensors (**Figure 5b**). This camera worked very well and had the battery capacity to record for 6 - 8 hours a day across three days on a single charge. Cameras were deployed on the vertical line of actively fishing lobster gear near Duxbury Beach, MA in collaboration with Tim Krusell, a lobsterman docked at Green Harbor, Marshfield, MA. Deployments lasted three days, and gear was not hauled during that period. On four out of five deployments, we attached an external TDR to collect environmental data.

Objective 4: Anonymously survey fishers to collect information on turtle-gear interactions and potential solutions.

To anonymously survey fishers, we developed a questionnaire to be distributed to fixed gear fishers working within MA state waters or nearby. The survey was 25 questions, with each question requiring less than a minute to answer (**Appendix 1**). The survey included questions on the fisher's personal demographics and general fishing practices before leading into questions involving protected-species interactions. Questionnaires were distributed by the Cape Cod

Commercial Fishermen's Alliance, and no identifying information was retained on the fishers who completed the survey. We received an Institutional Review Board permit (#1907007310) through Drexel University to administer the surveys.

Results and Discussion

Objective 1: Conduct flights over regions of known high densities of buoys and sea turtles to assist in boat-based tagging and tracking methods.

In 2018, we recorded sightings during five flights within MA state waters, yielding four leatherbacks sightings in CCB and two unidentified hard-shelled sea turtles sightings south of Martha's Vineyard. In 2019, we recorded sightings during 21 flights. This yielded 61 leatherback sightings in CCB, two sightings near Monomoy National Wildlife Refuge in the northeast corner of NS, two sightings in the northwest potion of NS, and 10 sightings in VS. In 2019, we transitioned from working in CCB during August and September to primarily working in NS and VS in October, with the ten leatherbacks in VS all sighted on the same day in late October.

Objective 2: Use videography to monitor sea turtle at-sea behavior within Cape Cod nearshore waters.

In total, we attempted to deploy a camera tag on 28 individual leatherbacks, with footage obtained from 23 of these turtles (**Table 2, Figure 6**). In 2018, we completed seven deployment attempts on six turtles in CCB using a variety of tag options to determine which camera was ideal for this work. In total, we accrued 208.1 minutes of footage from these deployments, with three deployments including GPS data and two deployments including temperature-depth data. Dive data from Turtles 5 and 6, tagged on the same day five km apart, showed that they tended to stay at depths shallower than 5 m when diving, and water temperatures averaged 19.7° C and 18.7° C respectively during the

***Table 2**: Summary table of camera tag deployments on leatherbacks.*

Turtle ID	Tag Type	Date	Duration (min)	GPS	TDR	Location
Turtle 1	GoPro Hero 4	9/23/2018	98.7	NO	NO	CCB
Turtle 2	GoPro Hero 3	9/23/2018	0	NO	NO	CCB
Turtle 3	DFO Canada Tag	9/23/2018	0	NO	NO	CCB
Turtle 4	Garmin VIRB	9/30/2018	0	NO	NO	CCB
Turtle 5-a	Garmin VIRB	9/30/2018	70.6	YES	NO	CCB
Turtle 5-b	Olympus TG-Tracker	9/30/2018	19.5	YES	YES	CCB
Turtle 6	Olympus TG-Tracker	9/30/2018	19.3	YES	YES	CCB
Turtle 7	Paralenz	5/15/2019	86.9	YES	YES	NC
Turtle 8	AMX 1	5/18/2019	68.1	NO	YES	NC
Turtle 9	Paralenz	5/21/2019	204.2	YES	YES	NC
Turtle 10	Paralenz	8/27/2019	8.6	NO	YES	CCB
Turtle 11	Paralenz	8/27/2019	198.8	YES	YES	CCB
Turtle 12	AMX 2	9/10/2019	56.8	YES	YES	CCB
Turtle 13	Paralenz	9/10/2019	37.2	NO	YES	CCB
Turtle 14	AMX 1	9/10/2019	43.6	NO	YES	CCB
Turtle 15	AMX 2	9/15/2019	67.8	YES	YES	CCB
Turtle 16	Paralenz	9/15/2019	184.5	YES	YES	CCB
Turtle 17	Para+Sat	9/21/2019	95.7	YES	YES	CCB
Turtle 18	AMX2	9/21/2019	4.8	YES	YES	CCB
Turtle 19	AMX2	9/21/2019	76.3	YES	YES	CCB
Turtle 20	Para+Sat	9/30/2019	32.9	YES	YES	CCB
Turtle 21	Paralenz	9/30/2019	0	NO	NO	CCB
Turtle 22	Paralenz	10/5/2019	157.3	YES	YES	Monomoy
Turtle 23	Para+Sat	10/5/2019	57.8	YES	YES	Monomoy
Turtle 24	AMX2	10/15/2019	36.3	YES	YES	NS
Turtle 25	DFO Canada Tag	10/15/2019	0	NO	NO	NS
Turtle 26	Para+Sat	10/25/2019	130.6	YES	YES	VS
Turtle 27	Paralenz	10/25/2019	185.1	YES	YES	VS
Turtle 28	Paralenz	10/25/2019	156.0	NO	YES	VS

deployment. Turtle 5 was tagged twice in the same day, first with a Garmin VIRB tag that only recorded video and GPS data and then with an Olympus camera that recorded video, gps, temperature, and depth. The three failed deployments that season were due to a variety of reasons, including a lost tag deployed on Turtle 2, tag malfunction on Turtle 3, and the tag immediately slipping off of Turtle 4.

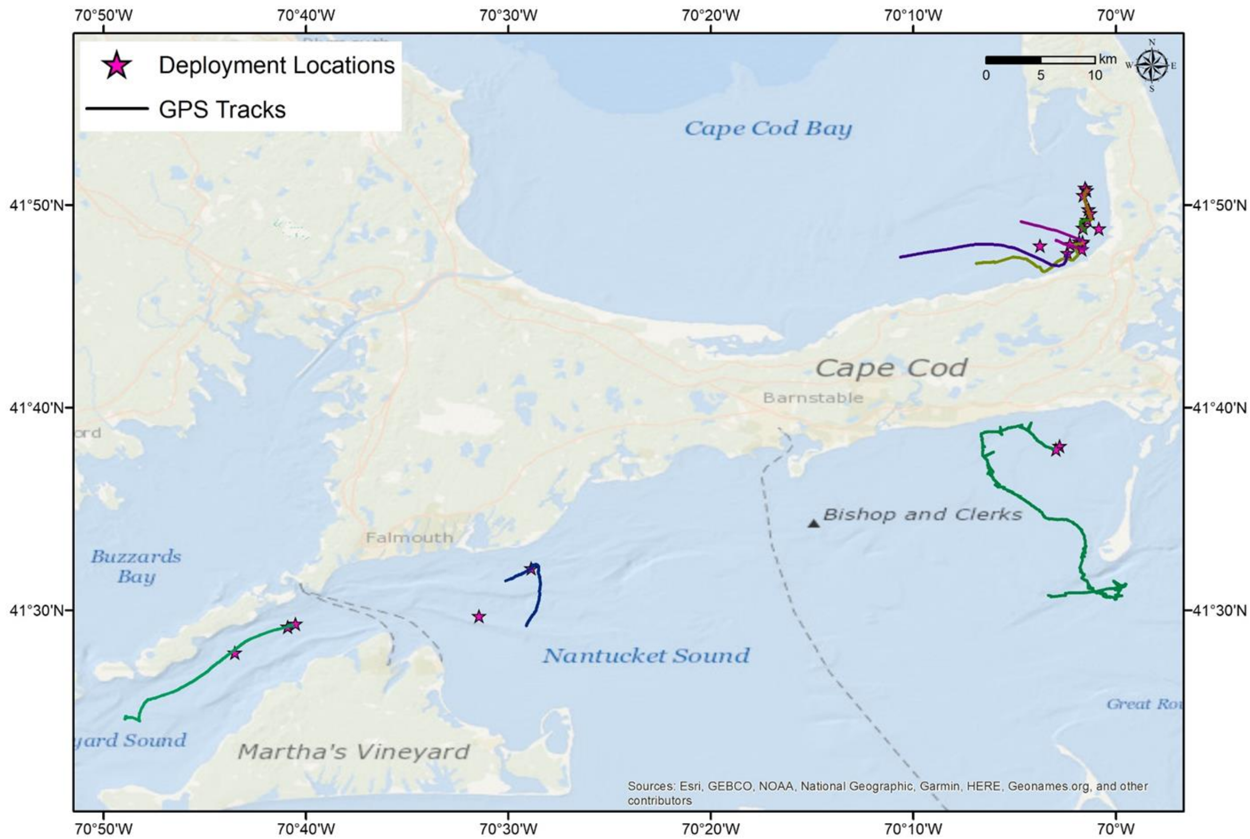

Figure 6: *Map of all tag deployments within MA state waters.*

In May 2019, we tested two new tags (Paralenz and AMX1) on leatherbacks within coastal NC waters. All three deployments were successful, and we accrued a total of 359.2 minutes of footage. Each included temperature-depth recordings, and two of them included GPS data. From these test deployments, we determined that the Paralenz dive camera provided the better video quality combined with TDR capabilities. The three turtles spent time in three slightly different habitats within a ten km radius of one another. Turtle 7 was tagged farthest from shore and travelled parallel to the coastline toward open ocean. This turtle experienced water temperatures averaging 22.7° C and dove to a maximum of 11.6 m. Turtle 8 was tagged and remained within a small cove, and as a result, never dove below 2 m due to the shallowness of the area; this turtle experienced water temperatures averaging 27.9° C. Turtle 9 was tagged in the same cove, but ventured out, travelling parallel and very close to shore, and dove to depths of 8.4 m within waters averaging 24.9° C.

Later in 2019, we had 17 successful deployments in MA state waters out of 19 attempts. The two failed deployments were due to an inability to secure the tag on Turtle 21 and tag malfunction on Turtle 25. For all successful deployments, we recorded temperature and depth, and we recorded GPS data on 13 deployments. We started this series of tag deployments in CCB, from late August through the end of September. We accrued 807 minutes of footage in CCB, primarily in the southeastern corner of the bay. These turtles experienced ocean temperatures averaging (± SD) 19.5° ± 2.1° C and dove to only a maximum of 12.1 m, primarily due to the shallowness of this portion of CCB.

In October 2019, we shifted effort to NS and VS, first tagging two turtles in the northeast corner of NS, in an area west of Monomoy. Then we tagged two turtles in a northwestern portion of NS, and finally we tagged three turtles in the northeastern portion of VS. In total, we accrued 723.1 minutes of footage from these October deployments, all with temperature-depth data recorded and all but one with GPS data recorded. These turtles experienced much cooler water temperatures, averaging 16.7° ± 1.2° C, and the maximum dive was twice as deep as those in CCB, reaching 24.3 m. For all tracked turtles within this study, recorded ocean temperatures were of a similar range to those documented by leatherbacks satellite tagged in MA state waters and tracked through NW Atlantic shelf waters by Dodge et al. (2014).

Detailed behavioral analysis using Observer XT yielded varying results depending on the category. With the exception of Turtle 17, on which the camera was placed farther back on the carapace, the most consistent results were related to presence of anthropogenic items and other animals in view and breaths and foraging events, because water clarity and camera angle did not reduce our ability to identify these events. Anthropogenic items and animals in view were only counted when they were within very close proximity of the turtle. Identifying the location of the turtle in the water column was more difficult, as water clarity, camera angle, and image quality reduced our ability to consistently determine if the turtle was near the surface or bottom. This skewed results toward labelling turtles as within mid-water. For most deployments, the water column information was supplemented by the TDR data. Flipper beats could only be counted when at least one front flipper was in view of the camera, and this was not consistently the case. For some turtles, a larger flipper stroke would enter into camera frame, but the more routine strokes did not. Furthermore, as we noticed with Turtle 21 (details below), front flippers may not always beat synchronously. As a result, getting an accurate count of flipper beats was not possible for all turtles.

In total we coded 2,097.3 minutes of footage, with each deployment averaging 87.4 minutes. Turtles averaged 19.1 ± 15.6% of deployment time near surface, 65.0 ± 24.6% of time within mid-water and 22.7 ± 19.8% of time with the bottom in view. In two instances, vertical line was document to be within view, with the turtle avoiding contact each time (**Figure 7**). We documented 104 instances when a boat was in view, and many of these instances were due to the turtle surfacing for a breath near our research boat. Fish were associated with 12 turtles, and for four turtles, the fish were present and swimming in front throughout the entire deployment (**Figure 8**). During recordings from other turtles, fish would come in and out of view, likely swimming alongside, under, or behind the turtle out of view of the camera. We counted 1,715 breathing events, 10,915 flipper beats, and 1,323 prey items passing the turtle. We also counted 1,068 instances when the tag was out of the water while the turtle was submerged, indicating a pause at the surface either prior to a breath or prior to a dive or a short resting period.

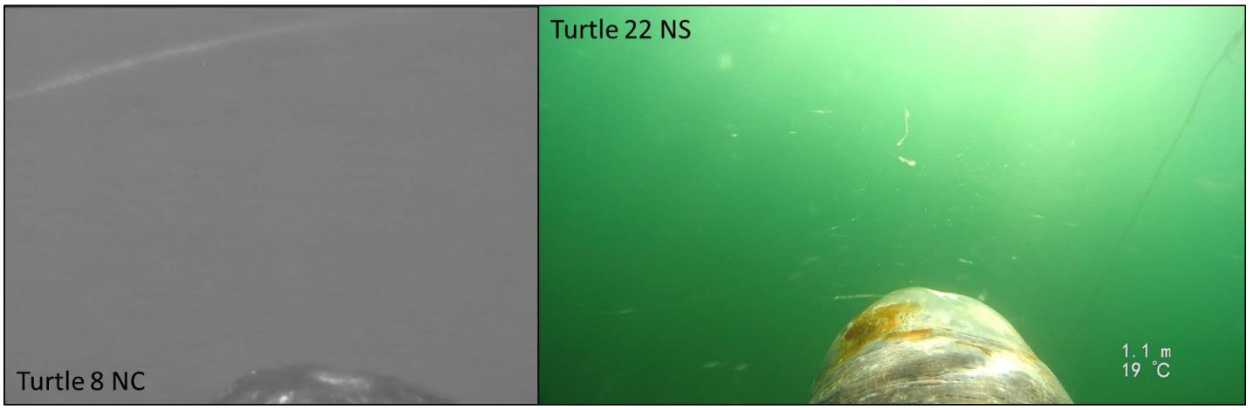

Figure 7: *Turtles passing rope in the water. Turtle 8 seemed to duck under this anchor line and Turtle 22 didn't seem to react to the presence of this vertical line. ESA Permit #16556 and 22218.*

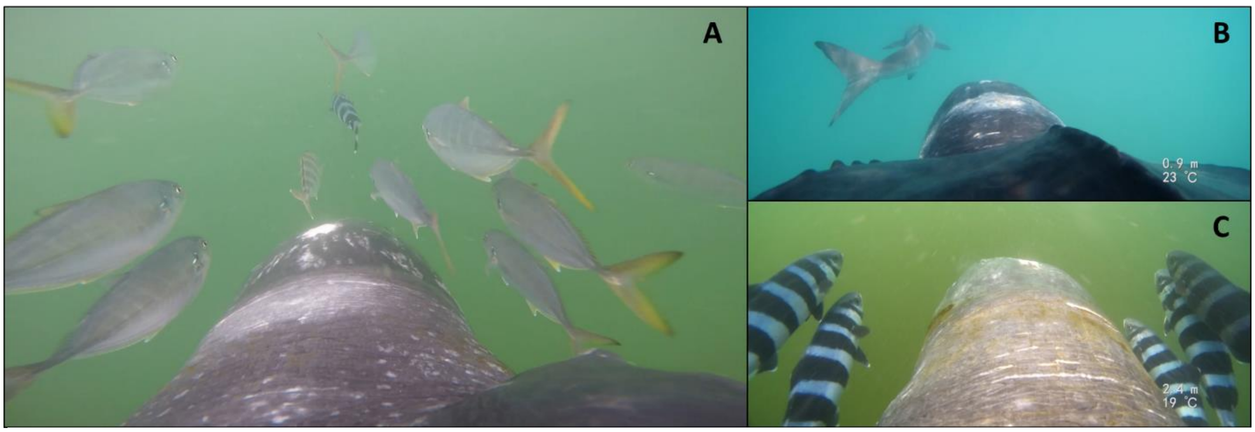

Figure 8: *A) Turtle 1 in CCB had the most fish associated with it. B) Turtle 7 in NC had a cobia swimming with it nearly the entire deployment. C) Turtle 13 had several pilot fish tucked very close to its head during the deployment. ESA Permit #16556 and 22218.*

Regionally, turtles varied in their behavior. Those in NC tended to spend more time near surface, but this was heavily skewed by Turtle 8 remaining within a shallow cove that was less than 2 m deep. Turtle 8 spent 65% of time with surface in view, while turtles 7 and 9 spent 30% of time near surface. This trend matched the TDR data, with Turtle 8 spending 91% of its time above 1 m depth, while Turtles 7 and 9 spent only 15% of their time above 1 m of depth and 32.2% of their time above 2 m depth (**Figure 9**). This was unexpected as there were far more boats present during the deployments in NC than in MA state waters, and we predicted that boat presence would cause turtles to remain submerged. In NC, there were 65 instances of boats in view, while in MA there was only 39 instances. Turtles in CCB averaged 16.6 ± 14.0% of dive time with the surface in view, while those in VS and NS averaged 14.1 ± 6.8% of deployment time near the surface. The TDR data also indicated that turtles in CCB spent more time near surface; however, TDR data indicated more time near the surface than what was identified in the video footage. Specifically, turtles in CCB spent 58.1% of dive time above 2 m and those in VS and NS spent only 25% of dive time above 2-m depth. This may be indicative of both the behavioral and habitat differences between the regions, with turtles in VS and NS actively diving to forage within deeper waters, while those in CCB seemed to be actively swimming in a particularly shallow portion of CCB.

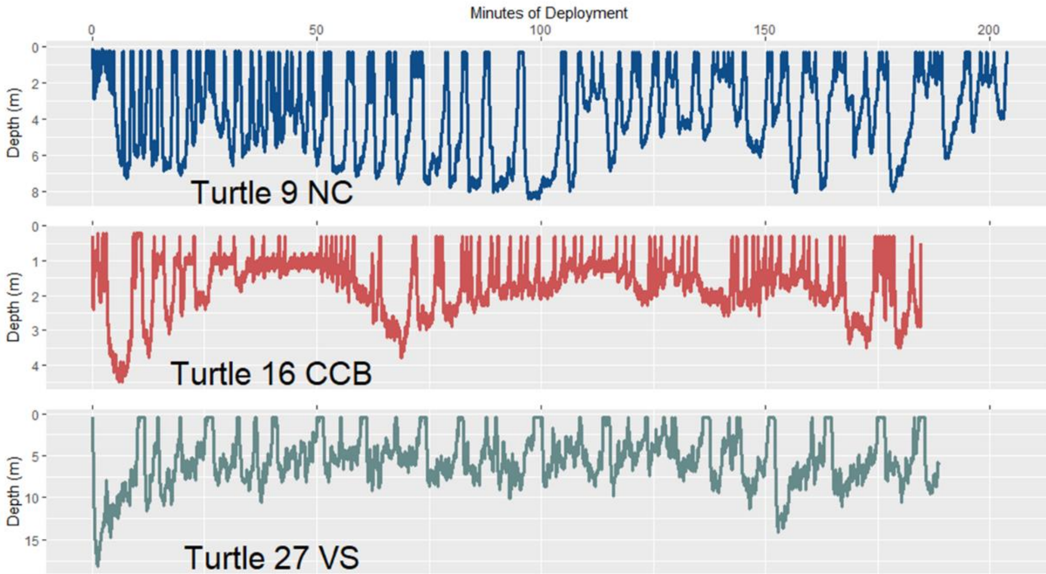

Figure 9: *Example of dive behavior from TDR data from turtles in each region. Note depth axis varies for each turtle.*

Although events related to foraging, breathing, and other animals in view were among the most easily and consistently identified, the presence of potential prey items was not always linked to foraging behavior. Active foraging behavior was only identified for turtles in VS and NS. In all regions, we identified potential prey items passing the turtles including large cannonball jellyfish in NC (Murphy et al. 2006). In CCB, ctenophores dominated the potential prey items passing by the turtles (James et al. 2006; Wallace et al. 2006). Interestingly, even though turtles in VS and NS were regularly foraging, they also let many prey items pass by with some even hitting them in the face (**Figure 10**). It was unclear why they chose certain jellyfish over others; however, without a direct view of the face and mouth, turtles could simply have been chewing as they passed these prey items. Overall, turtles in VS and NS ate an average of 187.4 ± 92.0 jellyfish per hour of footage, which was substantially higher than recorded by Wallace et al. (2018) for leatherbacks filmed foraging in eastern Canadian waters (16 jellyfish per hr). This may be due to the size of prey in each region. Wallace et al. (2018), using leatherback average head diameter of 23 cm for reference, measured foraged prey to be 27.7 cm in diameter on average. In our study, leatherbacks were frequently foraging on prey much smaller than their head, likely requiring less time to chew and swallow between feeding events. Similar to Wallace et al. (2015), foraging turtles in NS and VS typically first swam deep and then turned towards the surface to forage on their way back up through the water column. However, foraging events were also very opportunistic, with turtles occasionally foraging between breaths while at the surface. From an energetics perspective, and again similar to Wallace et al. (2015), breathing did not seem correlated with active foraging. Turtles in CCB averaged 0.82 ± 0.3 breaths per minute, while all other turtles averaged closer to one breath per minute (NC = 0.93 ± 0.1 breaths/minute and NS/VS = 1.0 ± 0.3 breaths/minute). Although turtles in NC spent more time above 2-m depth, it did not necessarily mean they took more breaths or that being at shallow depths was indicative of a recent or impending breathing event.

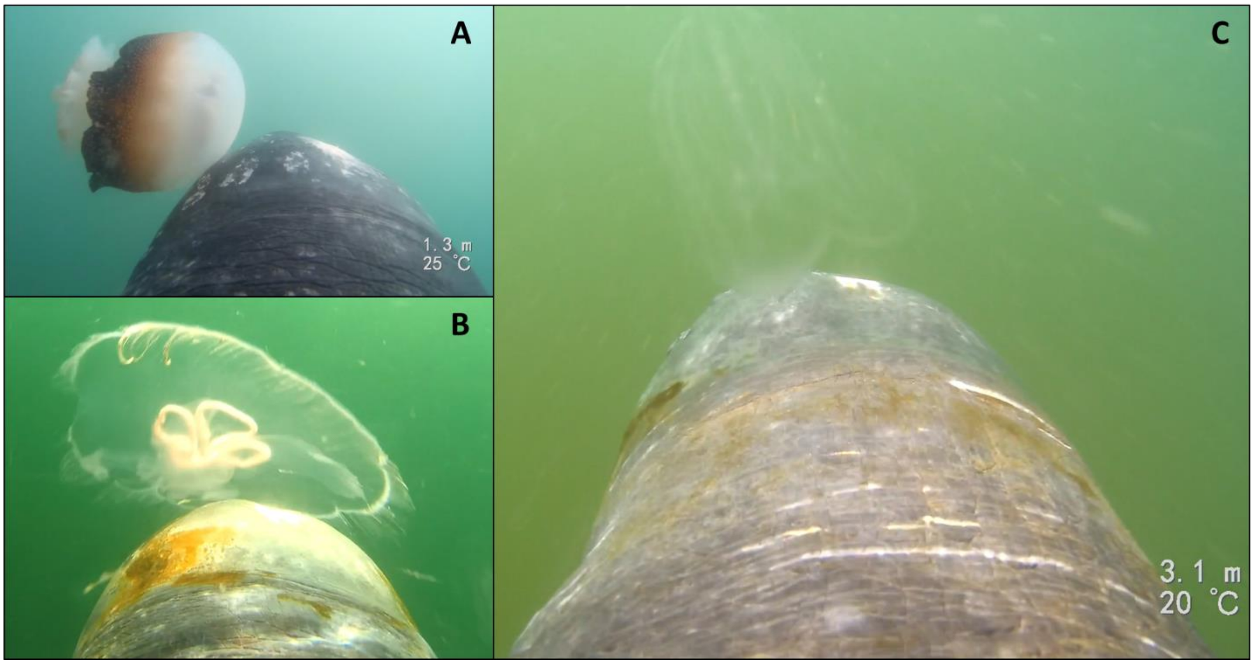

Figure 10: *Prey items passing very close to the face and head of tracked leatherbacks. A) Turtle 9 in NC let this cannonball jelly fish bounce off of its head. B) Turtle 22 in NS swam directly into this moon jellyfish. C) Turtle 13 in CCB did not attempt to forage on any ctenophores that passed. ESA Permit #16556 and 22218.*

In addition to the two instances of turtles passing rope in the water, we also documented a turtle (Turtle 21) with substantial scarring around its neck and right front flipper. These scars were likely caused by an entanglement or some sort of constricting line around its neck and right front flipper (**Figure 11**). This turtle was spotted, followed, and filmed in the southeast corner of CCB on September 30, 2019. The right front flipper was relatively immobile and remained low as the left front flipper produced more typical swim strokes. This turtle was initially pursued for camera tag deployment; however, after noticing the scarring and irregular swim strokes, the pursuit was halted and filming of the turtle was done from a distance using a pole-mounted action camera held from the research boat. It was unclear how recent this injury occurred, and perhaps this turtle will regain mobility in its right front flipper with additional healing. For now, this turtle was clearly restricted in its movements, putting it at risk of lowered foraging success and reduced ability to properly undertake a seasonal southward migration typical for leatherbacks tagged in MA state waters (Dodge et al. 2014).

Objective 3: Use videography to monitor vertical lines attached to fishing gear to document potential sea turtle interactions and the movements of the line caused by ocean conditions.

In total we recorded 3,708.8 minutes of footage along a vertical line. On average, each recording was 337.2 minutes. We conducted a total of five deployments, two in 2018 and three in 2019. The two in 2018 both occurred in August, while in 2019, the first occurred in June, the second in July, and the final one in October. The first two deployments were much shorter (1 – 3 hrs) due to malfunctions with the camera systems. The next three deployments worked as planned, with the camera recording for over six hours a day for three consecutive days each time. As a result, we accrued footage from 11 separate days, two from the first two deployments and nine from the next three.

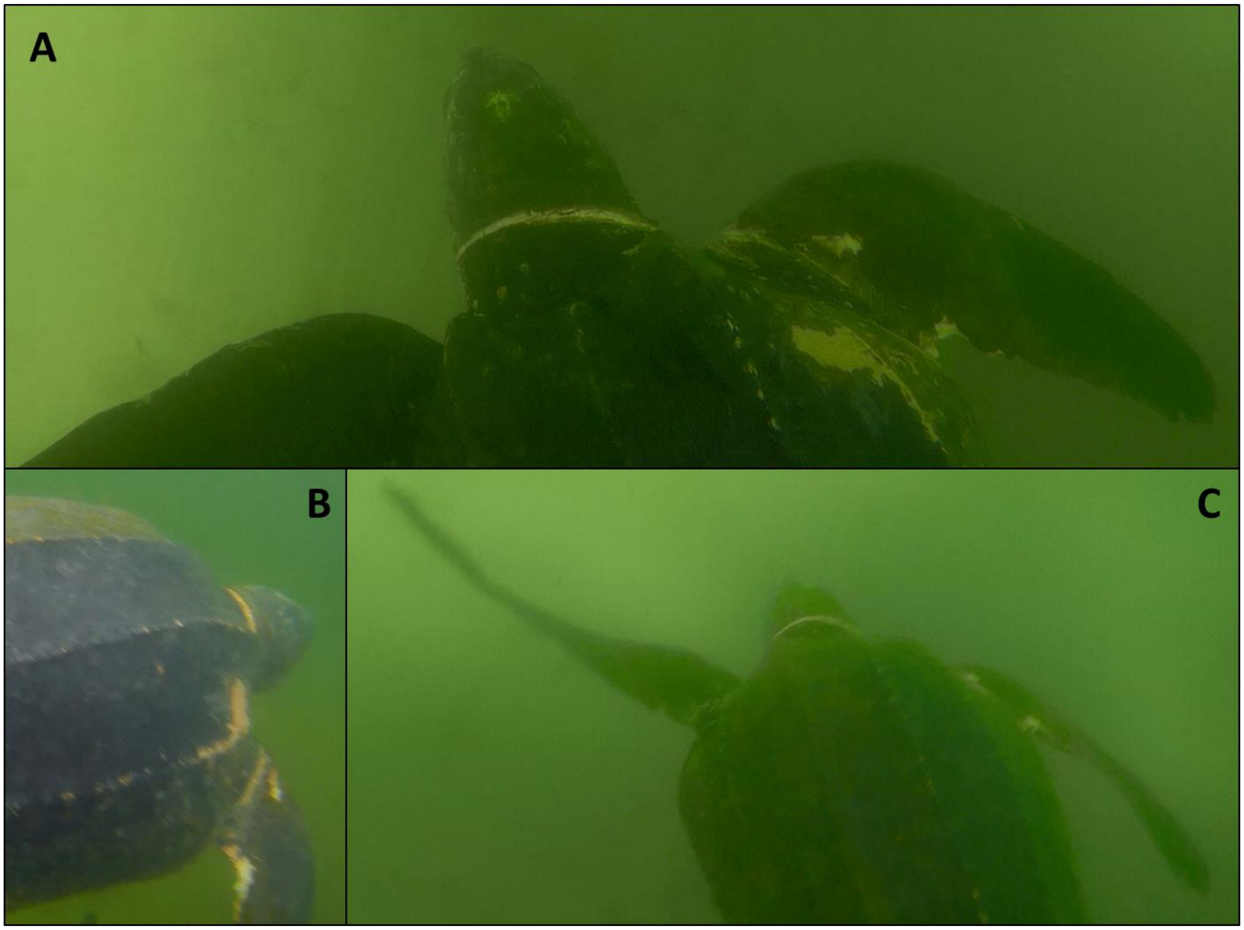

Figure 11: *Images of Turtle 21. A) Top view of scars on neck and right front flipper. B) Side view of scars on neck and right front flipper. C) Difference in swim stroke between the left and right front flippers. ESA Permit # 22218.*

Overall we did not see a protected species pass within the camera field of view. We saw fish congregated around the vertical line during the fourth and fifth deployments, with the fifth deployment having fish in view for nearly the entire time (**Figure 12**). In the fourth deployment, a large school of fish swam through the frame, and the entire school took nearly 40 seconds to cross through the field of view. Fish filmed in the fifth deployment were generally very small and some were potentially very early year classes. During the fifth deployment, we also documented a consistent stream of ctenophores flowing through the field of view, with some getting temporarily stuck on the vertical line. The vertical line itself was clean during the first four deployments, but was very fouled in the fifth, likely attracting the fish. During deployments three, four and five, the vertical line was in the camera frame through nearly all of the deployment. However, day two of deployment three, there were long periods when the line was out of view. During deployments one and two, the line was rarely in view, and this may be due to the different camera system that was used.

According to the TDR data that was acquired from the first four deployments, the cameras stayed within the top two meters of the water column and did not show any noticeable changes in depth associated with changing tides. Temperature during deployment one was ~15°C and during deployment two it rose to ~20°C. During deployment three, temperatures were the coolest, ranging between 10° - 15°C, and during deployment four they rose to between 15° - 20°C.

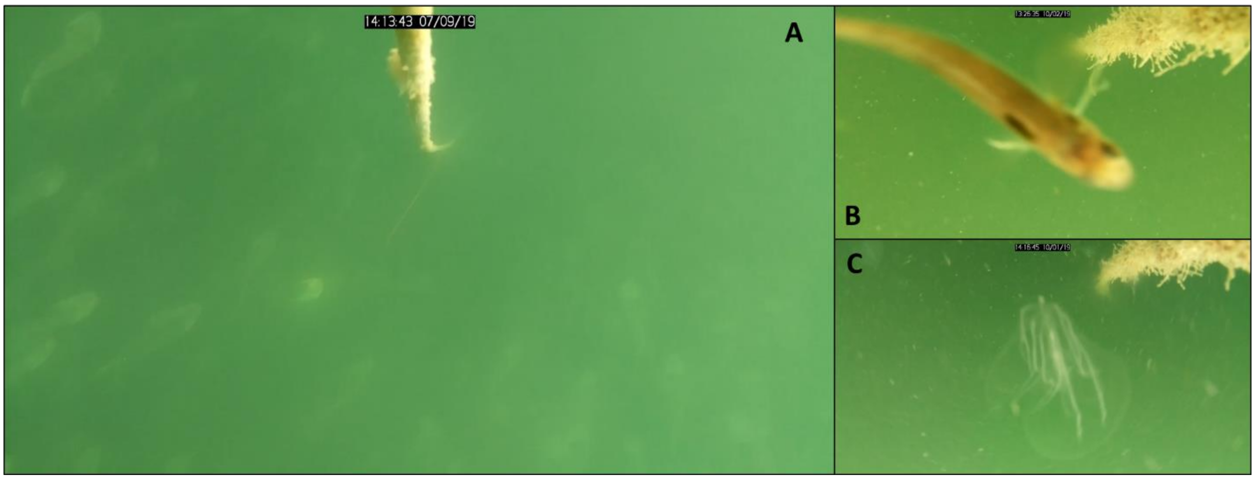

Figure 12: *Images from the vertical line camera. A) Large school of unidentified fish passing through frame during deployment four. B) Small fish remained near the vertical line throughout deployment five. C) Ctenophores regularly passed through the frame during deployment five.*

Objective 4: Anonymously survey fishers to collect information on turtle-gear interactions and potential solutions.

In total we received eight completed surveys. Seven out of eight respondents were boat owners with 15 – 45 years of experience and one was a crew member with three years of fishing experience. All respondents worked on fishing boats using pots. Most respondents used modern trawls with baited pots to fish for lobster, conch or black sea bass. Gear was soaked for between 30 minutes to 8 days depending on respondent and was set primarily in the Outer Cape Management Area. The next most common fishing ground was Management Area 2. One respondent worked in the Offshore Area and another worked in Management Area 1.

Two respondents had experience with a sea turtle entanglement, and both fishers seemed to resolve the entanglement on their own. One respondent had an entanglement in the Outer Cape region 25 years ago using gear that did not have sinking rope or buoys attached with weak links, and he seemed to suggest these more modern components to fishing trawls would have been worse for the turtle but did not include details on why. The other respondent dealt with the entanglement in Management Area 1, and disentangled a turtle from another fisher's gear. For his own gear, he uses whale-release rope (Novabraid with the South Shore sleeve every 40 ft that breaks at 1700lbs).

All respondents did not think sea turtles impacted their personal fishing at all, while there were mixed responses about sea turtles as a threat to the entire fishery. Four fishers responded that turtles were not a threat at all to the fishery, three responded that turtles were a limited threat, and one responded that turtles were a big threat and that the fishery could be shut down due to these protected species interactions. As recommendations, two respondents suggested reducing vertical lines either by increasing trawl sizes or incentivizing fishers to stop using single pots. One respondent suggested training and legally allowing fishers to disentangle turtles themselves. This respondent indicated that fishers usually contact the gear owner about entanglements rather than the appropriate entanglement network. This suggests that fishers are usually handling entanglements on their own.

Conclusions:

With the consistent annual entanglements of leatherback sea turtles with vertical lines from fishing gear within the NW Atlantic, it is imperative that research is conducted both from fisheries and ecological perspectives to reduce these harmful interactions. Although it is clear that removing vertical lines in their entirety provides the most complete solution to ending entanglements (Moore 2019), currently it is not a realistic approach due to the many limitations of ropeless fishing gear and the overall financial harm to fisheries caused by widespread closures. As a result, improving the ecological understanding of the species threatened by vertical lines may provide critical information to improve development of fishing gear solutions or management protocols to reduce entanglements. For this project, we took the ecological approach of focusing research effort on leatherback sea turtle habitat usage within MA state waters, a region with known high incidences of entanglements (Sampson 2015). We also included fisheries perspectives to provide additional context for understanding the impacts of entanglements on the fishing industry.

Overall, we could not identify whether turtles were at more risk of entanglement based on their documented behavior, and although we did identify two instances of vertical line in view from the turtle camera tags, we did not spot and track turtles within areas having a high density of fishing gear. Leatherbacks in MA state waters behaved considerably differently depending on what side of Cape Cod they were inhabiting. Those in CCB exhibited a unique behavior for nearshore sea turtles because they did not forage and spent a considerable amount of time in very shallow water (< 5m depth). These turtles may have been in a searching phase for either food or a way out of CCB. Telemetry studies conducted in collaboration with the Southeast Fisheries Science Center have identified that these turtles do eventually find their way out of CCB and take a southward migration during the fall months, similar to those tagged in NS and VS (Dodge et al, 2014). For turtles in VS and NS, the prey seemed abundant and foraging activity was consistent, with 3.1 foraging events documented per minute, with an additional 362 prey items passing the turtles. This behavior seemed more consistent with documented leatherback behavior in nearshore habitats (Wallace et al. 2015; 2018). In both regions where we deployed tags, vertical line was not very abundant, and we did not identify turtles reacting to obstructions in the water. Water clarity, however, did vary, with image quality in CCB greatly reduced at times resulting in clear footage limited to only the turtle's neck (**Figure 13**). Poor water clarity may play a larger role in entanglements, as turtles may not have time to react to an object in the water if they cannot see it.

Figure 13: *Low visibility in CCB during deployment on Turtle 13. ESA Permit #22218.*

Although we did not document a direct entanglement, we did film what could have been the resulting damage to a turtle from an interaction with a constricting rope. This turtle had noticeable scars on its neck and front right flipper. Flipper movements were also clearly limited in this turtle, with the right front flipper displaying limited mobility compared to the left flipper that did not have any scarring. The long term ramifications of this type of injury are unclear, as we don't know if this turtle was recently released from the constricting rope or if the scarring was much older. Either way, the reduced swimming ability was noticeable and this may have a larger impact on the turtle's ability to forage, reproduce, or make the long distance southward migration common for leatherbacks in the region (Dodge et al. 2014). In whales, the energetic impacts from an entanglement are severe, with North Atlantic right whales potentially delaying reproduction by years after a single entanglement event (van der Hoop 2017). In leatherbacks, entanglements are known to elicit a severe stress response (Hunt et al. 2016); however, the long term consequences are still unknown.

From the perspective of the fishers, it seemed apparent that they generally thought protected species entanglements were a concern to their fisheries and that reducing vertical line was a reasonable solution. The fishers we surveyed presented two options for reducing vertical line density, either increasing trawl sizes or incentivizing fishers to stop using single pots. The direct understanding that a reduction in vertical lines would help mitigate entanglements was a clear indication that management options aimed at this tactic could be accepted by the fishing industry. Efforts are underway to develop fishing gear that removes the vertical line from the water column and instead places it on the sea floor with the fishing pot or gillnet in an apparatus with a timed or remote release (Moore 2019). This could be the ideal solution; however, technological and financial limitations will prevent this option from both working consistently and reaching widespread adoption in the near future. Up till now, fishers also seemed to manage entanglements on their own, so training and empowering them to legally disentangle sea turtles may provide the quickest option for relieving fisheries pressures on these species. Currently, to protect sea turtles from vertical line interactions, more immediately practical solutions are required until all vertical line are removed from the waters. Studies, like the one completed for this project, provide the data needed to develop effective solutions that can be implemented quickly and with the support of fishing communities.

Literature Cited:

Buchholz, R. 2007. Behavioural biology: an effective and relevant conservation tool. Trends Ecol. & Evo. 22(8), 401-407.

Dodge, K.L., B. Galuardi, T.J. Miller and M.E. Lutcavage. 2014. Leatherback turtle movements, dive behavior, and habitat characteristics in ecoregions of the northwest Atlantic Ocean. PLoS ONE 9(3): e91726. doi:10.1371/journal.pone.0091726.

Fisheries and Oceans. 2012. Assessment of leatherback turtle fishery and non-fishery Interactions in Atlantic Canadian waters. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2012/041.

Glass, C.W. and C.S. Wardle. 1995. Studies on the use of visual stimuli to control fish escape from codends. II. The effect of a black tunnel on the reaction behaviour of fish in otter trawl codends. Fisheries Research, 23(1), 165-174.

Hamelin KM, James MC, Ledwell W, Huntington J, Martin K. 2017. Incidental capture of leatherback sea turtles in fixed fishing gear off Atlantic Canada. Aquatic Conservation: Marine and Freshwater Ecosystems. 27(3):631-42.

Hunt KE, Innis CJ, Merigo C, Rolland RM. 2016. Endocrine responses to diverse stressors of capture, entanglement and stranding in leatherback turtles (*Dermochelys coriacea).* Conservation Physiology. 4(1).

Jaiteh, V.F., S.J. Allen, J.J. Meeuwig and N.R. Loneragan. 2013. Subsurface behavior of bottlenose dolphins (*Tursiops truncatus*) interacting with fish trawl nets in northwestern Australia: implications for bycatch mitigation. Marine Mammal Science, 29(3), E266-E281.

James MC, Ottensmeyer CA, Eckert SA, Myers RA. 2006. Changes in diel diving patterns accompany shifts between northern foraging and southward migration in leatherback turtles. Canadian Journal of Zoology. 84(5):754-65.

Main, J. and Sangster, G. I. 1985. Trawling experiments with a two-level net to minimise the undersized gaboid by-catch in a Nephrops fishery. Fish. Res. 3, 131-145.

McCarron, P. 2009. Maine lobster industry field testing of experimental vertical and groundlines. Consortium of Wildlife Bycatch Reduction, Maine Lobstermen's Association.

Milliken, H.O. and DeAlteris, J. T. 2004. Evaluation of a large-mesh panel to reduce the flatfish bycatch in the small-mesh bottom trawls used in the New England silver hake fishery. North Amer. J. Fish. Manag. 24(1), 20-32.

Moore MJ. 2019. How we can all stop killing whales: a proposal to avoid whale entanglement in fishing gear. ICES Journal of Marine Science. 76(4):781-6.

Murphy TM, Murphy SR, Griffin DB, Hope CP. 2006. Recent occurrence, spatial distribution, and temporal variability of leatherback turtles (*Dermochelys coriacea*) in nearshore waters of South Carolina, USA. Chelonian Conservation and Biology. 5(2):216-24.

NMFS. 2015. Sea Turtles and Vertical Lines in the Northeast Region Issue Statement and Research Needs. http://www.greateratlantic.fisheries.noaa.gov/Protected/research/st/

Patel SH, Dodge KL, Haas HL, Smolowitz RJ. 2016 Videography reveals in-water behavior of loggerhead turtles (*Caretta caretta*) at a foraging ground. *Front Mar Sci* 10.3389/fmars.2016.00254.

Sampson, K. 2015. Sea Turtle Entanglement at the GARFO Aquaculture Workshop

9/28/2015.
Sequeira AM, Heupel MR, Lea MA, Eguíluz VM, Duarte CM, Meekan MG, Thums M, Calich HJ, Carmichael RH, Costa DP, Ferreira LC. 2019. The importance of sample size in marine megafauna tagging studies. Ecological Applications. 29(6):e01947.

Smolowitz, R.J., S.H. Patel, H.L. Haas and S.A. Miller. 2015. Using a remotely operated vehicle (ROV) to observe loggerhead sea turtle (*Caretta caretta*) behavior on foraging grounds off the mid-Atlantic United States. J. Exp. Mar. Bio. Eco. 471, 84-91.

Southwood, A., K. Fritsches, R. Brill and Y. Swimmer. 2008. Sound, chemical, and light detection in sea turtles and pelagic fishes: sensory-based approaches to bycatch reduction in longline fisheries. Endang. Spec. Res. 5(2-3), 225-238.

van der Hoop J, Corkeron P, Moore M. 2017. Entanglement is a costly life-history stage in large whales. Ecology and evolution. 7(1):92-106.

Wallace BP, Kilham SS, Paladino FV, Spotila JR. 2006. Energy budget calculations indicate resource limitation in Eastern Pacific leatherback turtles. Marine Ecology Progress Series. 318:263-70.

Wallace, B.P., M. Zolkewitz and M.C. James. 2015. Fine-scale foraging ecology of leatherback turtles. Front. Ecol. Evo. 3(15): 1 – 15.

Wallace BP, Zolkewitz M, James MC. 2018. Discrete, high-latitude foraging areas are important to energy budgets and population dynamics of migratory leatherback turtles. Scientific reports. 8(1):1-4.

Appendix 1

QUESTIONNAIRE #:

FISHERMEN SURVEY

Opening Statement

Thank you for participating in this survey. It should take approximately 10-15 minutes to complete.

This survey is part of a Bycatch Reduction Engineering Program research project (BREP), funded by NOAA Fisheries aiming to improve our understanding of sea turtle entanglement in vertical lines within Massachusetts state waters.

Filling out this survey represents your agreement to contribute to this research. Your participation is voluntary, and you may choose not to respond to any of the questions included in the questionnaire. No personal information is requested, and all responses will remain anonymous and will only be presented in aggregated formats, as part of a report for the BREP program and academic publications.

If you have any questions about this project, please contact Dr. Aliki Panagopoulou directly at (267) 231-6640 and/or the Project PIs, Drs. Samir Patel and Liese Siemann at (508) 356-3601.

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Demographics

First, a few questions about you and your fishing activity:

1. Gender: Male ☐ Female ☐ Other ☐

2. Age (years):
    a. Under 18
    b. 18 – 24
    c. 25 – 44
    d. 45 – 64
    e. 65 and over

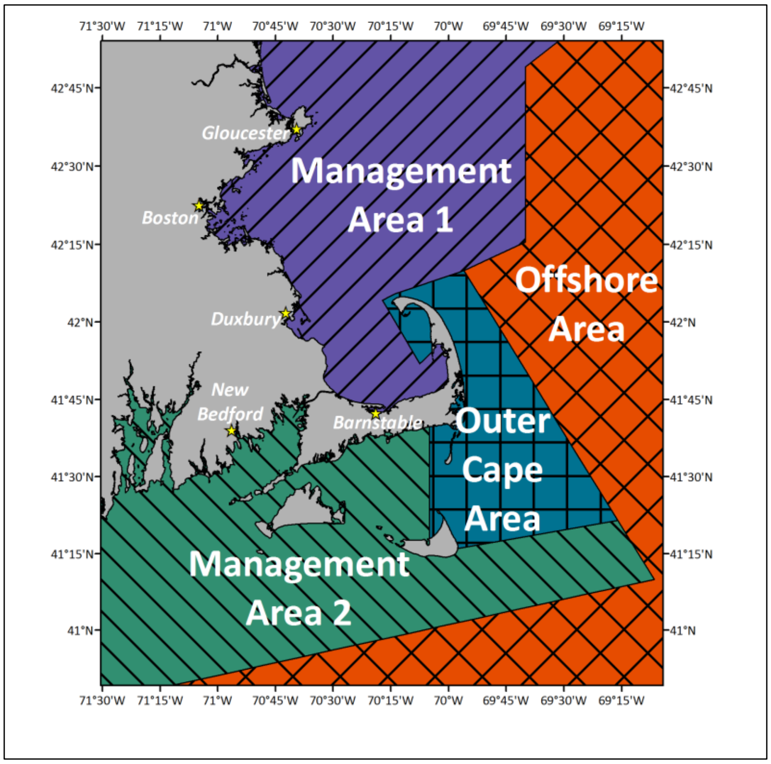
3. How long have you been a fisherman (approximate number of years)? __________

4. Are you a
    a. Fishing vessel owner
    b. Skipper (captain of a fishing vessel, but not owner)
    c. Working on a fishing vessel

   d. Other (please specify)__________

5. About the boat you are working on:
   a. Boat Length (feet): ____
   b. Engine Power (In HP, otherwise please clarify): ____
   c. # of people working on the boat (incl. you): ____

6. In which areas do you go fishing? (see map)



Management Area 1 ☐

Management Area 2 ☐

Outer Cape Area ☐

Offshore Area ☐

7. At what depths (in fathoms) do you place your gear? ________________________________

8. On average, how long do you leave your gear in the water before checking it? ____________

____

____

9. Do you use:

Do you use:	Individual pots/traps	Yes ☐	No ☐
	Trawls	Yes ☐	No ☐
	Bait	Yes ☐	No ☐
	Buoys	Yes ☐	No ☐

10. What type of gear do you use **most often**?____

    a) What are your main target species when using this gear? __________________________

    ____

Interactions with turtles and other species

Next, there are some questions about your interactions with sea turtles and other species:

11. Do sea turtles ever interact with the vertical lines attached to your gear? Yes ☐ No ☐

If **no, go to question 21.**

If **yes**:

12. Where do these incidents occur?

Management Area 1	☐
Management Area 2	☐
Outer Cape Area	☐
Offshore Area	☐

13. How many in the last 12 months? (Use attached guide for identification)

Leatherbacks	1 – 5 ☐	6 – 10 ☐	11 – 15 ☐	16 + ☐ (How many? _____)
Loggerheads	1 – 5 ☐	6 – 10 ☐	11 – 15 ☐	16 + ☐ (How many? _____)
Kemp's ridleys	1 – 5 ☐	6 – 10 ☐	11 – 15 ☐	16 + ☐ (How many? _____)
Greens	1 – 5 ☐	6 – 10 ☐	11 – 15 ☐	16 + ☐ (How many? _____)
Unknown	1 – 5 ☐	6 – 10 ☐	11 – 15 ☐	16 + ☐ (How many? _____)

How certain are you on species identification?

Leatherbacks	Very sure ☐	Fairly sure ☐	Not sure/Uncertain☐
Loggerheads	Very sure ☐	Fairly sure ☐	Not sure/Uncertain☐
Kemp's ridleys	Very sure ☐	Fairly sure ☐	Not sure/Uncertain☐
Greens	Very sure ☐	Fairly sure ☐	Not sure/Uncertain☐

14. How many of these turtles got entangled on the line? Give approximate estimates for each species

Leatherbacks _____ Loggerheads _____ Kemp's ridleys _____ Greens _____

15. Of the entangled turtles, how many: (Give approximate estimates, use guide for species identification if needed)

a) Escaped or were released with injuries
Leatherbacks _____ Loggerheads _____ Kemp's ridleys _____ Greens _____

b) Escaped or were released uninjured
Leatherbacks _____ Loggerheads _____ Kemp's ridleys _____ Greens _____

c) Died
Leatherbacks _____ Loggerheads _____ Kemp's ridleys _____ Greens _____

16. Have you ever watched a turtle become entangled? Yes ☐ No ☐
If **yes**, please describe incident, including final outcome:

____

____

____

17. Have you ever watched a turtle become UN-entangled (i.e. free itself)? Yes ☐ No ☐
If **yes,** please describe how:

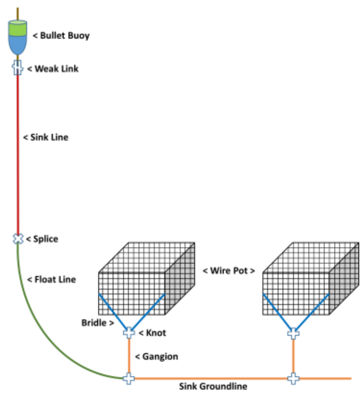
____

____

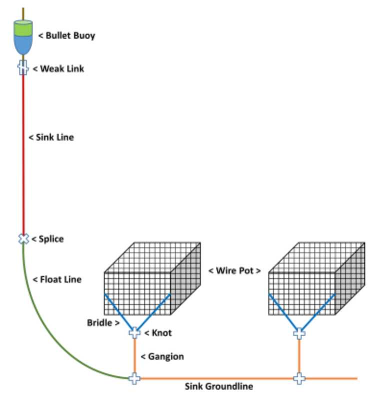
____

18. On what part(s) of the pot/trap configuration do they get entangled on? Please mark on the figures below where entanglements occur most frequently (per species, if applicable)

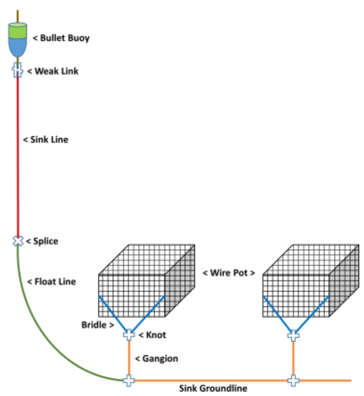
Leatherbacks



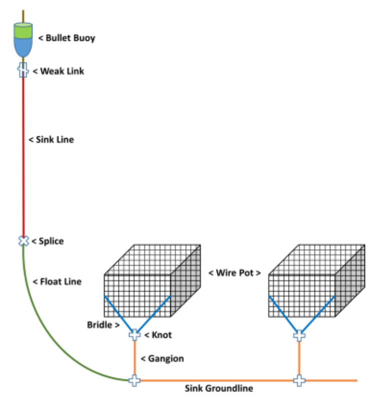
Loggerheads



Kemp's Ridleys



Greens



19. Did any of these entanglement incidents cause damage to your gear? Yes ☐ No ☐

20. If **yes**, can you please describe what damages were caused? ____________________________

____

____

21. Do animals other than sea turtles interfere with your pots/traps and their configuration?
    Yes ☐ No ☐

22. If **yes,** which?
    a. Whales ☐
    b. Dolphins ☐
    c. Other marine mammals (Seals, Sea lions, porpoises, etc) ☐
    d. Humans ☐
    e. Sea birds ☐
    f. Other (Please specify) _____________ ☐

23. Overall, how much do you think sea turtles interfere with your fishing activity?

    ☐ A lot ☐ A little bit ☐ Not at all ☐ Don't know/Unsure

24. Overall, how much of a threat do you think turtles are to the local fishery?

    ☐ A big threat ☐ A limited threat ☐ No threat ☐ I don't know/Unsure

25. Do you have any recommendations on how to reduce entanglement of turtles on vertical lines? If yes, what would these be? Feel free to use additional page if you want to write more or make appropriate drawings to explain what configurations might be appropriate.

____

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This is the end of the survey. Again, thank you very much for agreeing to participate !

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