Sea Turtles and Vertical Lines in the Northeast Region
Issue Statement and Research Needs

National Marine Fisheries Service
Greater Atlantic Regional Fisheries Office (GARFO) and Northeast Fisheries Science Center (NEFSC)
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Sea turtles are documented entangled in vertical lines of fishing gear. Reducing injury and mortality from these interactions is a priority for the Northeast sea turtle program (covering Maine through Virginia). NMFS's GARFO and NEFSC, and a representative from Fisheries and Ocean Canada, discussed this issue in December 2014 to develop a plan for reducing these interactions. A brief summary of pertinent information is presented below, followed by a matrix of gear research ideas.

Background

- Sea turtle vertical line entanglement reports are opportunistic, and the entanglement numbers are an underestimate as not all entanglements are reported. In waters off the Northeast United States, the primary species entangled is the leatherback sea turtle, but loggerhead and green sea turtles have also been documented. Since the Sea Turtle Disentanglement Network was formed in 2002 and through 2014, there have been 275 entanglements in vertical lines (NMFS unpublished data 2015). The turtle is usually documented entangled around the neck and/or front flippers. The majority of entanglements are reported in Massachusetts, where leatherbacks are more commonly entangled than other species. Chesapeake Bay also has a large number of interactions. Interactions with hard-shelled turtles occur more frequently in the mid-Atlantic. Leatherback entanglements in vertical lines have also been documented in Atlantic Canadian shelf waters (M. James, pers. comm. 2015).

- Entangled animals are generally observed at the surface; however, this may be due to this being the part of the gear easily seen by opportunistic reporters. In the Northeast United States, most of the animals reported are anchored in the gear, rather than free swimming with trailing gear. However, there are examples of turtles dragging gear. Entangled animals often exhibit injuries from the constricting line, but post-release mortality is not known. In most cases, the specific gear associated with the vertical line is not known. When the gear has been confirmed, it has been lobster pot (81 entanglements), whelk pot (32), fish pots (11), crab pot (10), research pot (2), whelk/lobster pot (1), and aquaculture gear (1). Line materials and buoy types were varied and represented most of the common types found in these fisheries.

- Leatherback behavior data can help ascertain how and why turtles entangle in vertical lines. Broad scale movements from satellite tags have been obtained for 27 leatherback turtles in Massachusetts and 2 in Florida (Dodge et al. 2014, K. Dodge, pers. comm. 2015). Consistent with historical surveys and opportunistic data, Dodge et al. (2014) found that leatherbacks primarily occupy the United States continental shelf from summer through fall. The range was least extensive in summer with turtles preferring the Northeast shelf (moving between southern New England and Virginia/North Carolina), while the fall range expanded to increase use of the mid-Atlantic bight before migrating south. When compared to other parts of their range, leatherback movements are relatively slow and sinuous when off the Northeast United States; presumably, the animals are foraging (Dodge et al. 2014). Based on time-at-depth data for the

Northeast shelf (15 tags), leatherbacks spent over 60% of their time in the top 10 m of the water column and over 70% of their time in the top 15 m (Dodge et al. 2014). An animal-borne camera showed a turtle diving and then looking up, with jellyfish silhouetted in the light from the surface (K. Dodge, pers. comm. 2015). While foraging subsurface, the turtle moved in closely to examine seaweed, suggesting reliance on visual cues over relatively short distances for identifying potential prey.

- Leatherback behavioral research is also conducted off Canadian waters. Based on 24 free-swimming leatherbacks tagged from 2008-2013, Wallace et al. (2015) found these leatherbacks primarily occupied the upper 30 m of the water column and had shallow 4-6 minute dives. Leatherbacks are visual predators and appear to locate prey in the photic zone. They capture prey at the bottom of a dive or on the ascent, rarely capturing prey on the descent; presumably they use the light from the surface to silhouette their prey (Wallace et al. 2015). As such, it is possible that sea turtles may move towards objects other than prey (e.g., buoys) that are silhouetted in the water column.

- Northeast Fisheries Observer Program (NEFOP) effort on pot gear has historically been very low (well under 1%). However, in 2014, observer days in pot fisheries were allocated throughout New England and the mid-Atlantic (http://www.nefsc.noaa.gov/fsb/SBRM/2014/Proposed_2014_Observer_Sea_Day_Allocation_05222014_rev.pdf). There was one dead leatherback take observed in lobster gear off Rhode Island in 2014. Pot gear observer coverage is expected to continue in the future.

Research Needs

The following matrix presents a suite of ideas to reduce sea turtle and vertical line interactions, with notes on the operational feasibility and conservation benefit of each modification. The matrix text represents previous discussions and is not meant to reflect a consensus. Note that Atlantic large whales also entangle in vertical lines, and many gear modifications have been investigated to reduce these entanglements. These modifications are included in the Atlantic Large Whale Take Reduction Plan's gear research matrix (see http://www.greateratlantic.fisheries.noaa.gov/whaletrp/plan/gear/Gear%20Research%20Matrix_Oct%202010_final.pdf). The sea turtle matrix was based upon this large whale gear research matrix, as some of the previously tested ideas may apply to sea turtle bycatch reduction, and discussion at a 2008 workshop on sea turtles and vertical lines on fixed gear fisheries (http://www.greateratlantic.fisheries.noaa.gov/prot_res/seaturtles/doc/Vertical%20Line%20Workshop_2008-web.pdf).

In addition, a number of data and research needs exist to better understand the interactions between sea turtles and vertical lines, and while not inclusive of everything that needs to be done on the issue, a few of the (non-bycatch reduction) data and research needs are noted below.

- Leatherback behavior - additional trials with new technologies: Technologies (camera tags, time-depth recorders, autonomous underwater vehicles, etc.) exist to help us better understand the 3-D behavior of animals, and how they are interacting with their environment. However, trials with these technologies are limited. More trials are needed and should be targeted in gear

dense areas to be most effective. Animal-borne underwater cameras have become very cost-effective for conducting this type of work. AUVs can be used to get a wider view of the habitat.

- Leatherback behavior - field studies: Conduct behavioral studies in additional areas to reduce bias. For example, more information is needed for the Gulf of Maine.
- Habitat sampling: Include habitat sampling in behavioral studies to better understand how habitat influences sea turtle behavior.
- Acoustics and visual acuity: Conduct additional research on turtle hearing and visual sensitivity to better inform the potential use of acoustic or visual deterrents.
- Gear details: Work with states to obtain information on gear configuration, density, and description (e.g., buoy colors) to better understand the likelihood of interactions. Further, work with NEFOP to ensure all pot gear details that would help better understand the gear in which sea turtles become entangled are collected by observers.

Literature Cited

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:e91726.

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

Gear modification ideas to reduce sea turtle entanglements in vertical lines
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Activity	Description	What it does	Operational Feasibility	Bycatch Reduction Potential[1]
Stiff line				
Hard lay line	Modify vertical line to be less likely to wrap around head/appendage	If line cannot wrap, it may pose less of an entanglement risk	•If whole line is hard lay, may not lay flat on deck/not coil which could result in safety issues •Hard lay in part of line near buoy may be more feasible	•Stiffer line may reduce potential interactions •Depending how stiff the line is, entanglements may still occur
Sheaths over line			•Would need to be removed to pass line through hauler •May interfere with effectiveness of whale plan (i.e., will weak links operate properly if lines sheathed?) •May result in chafing of the line, depending on sheathing material •Potentially could be used in upper part of line near buoy •May be feasible for marker buoy lines in aquaculture gear as these lines are not hauled	•Reduction potential promising as PVC or similar sheathing would not be able to wrap •Sheathing only part of the line may shift entanglement to depth (i.e., below the sheathing) rather than at surface, increasing mortality and decreasing documentation/reporting
Rubber coating			•Coating may stiffen line, and stiff line may not lay flat on deck/not coil which could result in safety issues	•Stiffer line may reduce potential interactions •Depending how stiff the line is, entanglements may still occur
Chain			•Links of chain would need to go through hauler •Would need to see design to better assess feasibility	•Chain may be likely to wrap
Shock corded poles (like tent poles)			•As gear needs to be broken down to haul, would take additional time to fish •Not feasible in a commercial setting. May be feasible in shallow waters on a calm day	•Hard pole may reduce potential interactions
Pressure stiffening line			•Line stiffens at depth but becomes flexible at surface, reducing potential handling issues •Idea raised but never developed or tested	•Stiffer line may reduce potential interactions •Depending how stiff the line is, entanglements may still occur
Tensioning endline with sub-surface flotation			•Requires additional anchoring weight •Would need to rig a sizeable sub-surface buoy with a surface pick-up buoy. Hauling and setting procedures would need to be modified to accommodate added weight and buoy arrangement.	•A tensioned line may reduce potential interactions •Subsurface buoy may shift entanglements below the surface, increasing mortality and decreasing reporting
Other line modifications				
Sinking line/leaded rope	Require sinking line in buoy line and/or surface system	Reduces amount of floating line in water column	•Operationally feasible under most conditions	•Benefit likely low •Entanglements documented in floating and leaded line •Sinking and floating lines configure similarly so would have the same entanglement potential
Slippery rope	Modify vertical line such that would be less likely to stay wrapped around head/appendage	May allow turtle to shed gear more easily	•Idea raised but never developed or tested	•May reduce potential interactions •Uncertain how slippery the rope would have to be reduce entanglements
Breakaways				
Time-tension cutters[2]	Device in the buoy line that will release the buoy line from the bottom gear after a predetermined load and time period have been exceeded	Cuts the buoy line away from the bottom gear if load is exerted on the line for a time longer that the device is set to accommodate	•Difficulties with hauling line through hauler •Might work with single trap system	•Benefits unknown •If entanglement is subsurface, may improve survival by allowing animal to surface/breathe •If line is broken, would be difficult for animal to shed gear if entangled •If animal breaks line and swims away with gear, would be difficult to relocate animal for disentanglement and could lead to post-release mortality
Weak links	Gear modifications (e.g., hog rings, off the shelf links, rope of appropriate breaking strength, etc.) that allow the release of the buoy or weighted device from the line. Designed so the remaining line will slide through baleen in a large whale's mouth as the forward momentum of the whale and the weight of the gear causes the link to part.	Allows the release of the buoy, flotation, or weighted device from the line in a way that when released, the remaining line will not have a knot on its end	•During development for whale plan, tested breaking strength over 100 days at sea measuring forces in different fisheries •Development incorporated feasibility of retrieving gear with given breaking strength. Lower breaking strengths may not be able to be hauled. •Breaking strength would need to be lower to be effective for turtles and may not be feasible in the fishery	•Benefit likely low •Doubtful turtle would break weak link if entangled
Thwartable bottom link	Device located at the bottom of a buoy line that will act as a weak link until the gear is ready to be hauled. At that time the device is switched from a weak link mode to a strong link mode, allowing the gear to be hauled.	In the "weak link mode", allows release of buoy line from the bottom gear if load exerted on the buoy line reaches a predetermined value	•To be effective for turtles, breaking strength in the 'weak link mode' would need to be so low that it may not stand up to every day weather and sea conditions	•Benefits unknown •If entanglement is subsurface, may improve survival by allowing animal to surface/breathe •Doubtful turtle would break weak link if entangled
Removing buoy line from water column				
Galvanic time release	Holds the buoy and the buoy line on the bottom for a predetermined length of time. Then releases the buoy allowing it to float to the surface.	The time release deteriorates in sea water at a predictable rate. It is used as a latch, holding the buoy and buoy line at the bottom until it has deteriorated.	•Evaluated for whale plan •Gear conflict with both fixed and mobile gears •Release was unreliable	•Removes vertical line from the water

Green: Operationally feasible; High conservation benefit
Yellow: Operational feasibility unknown; Conservation benefit unknown or limited
Red: Operational feasibility low or technology unavailable; Conservation benefit low or unlikely

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Mechanical time release	Holds the buoy and the buoy line on the bottom for a predetermined length of time. Then releases the buoy allowing it to float to the surface.	Small mechanical timer set to release after a set period of time. It is used as a latch, holding the buoy and line until timer releases.	•Gear conflict with both fixed and mobile gears •Not tested	•Removes vertical line from the water
Acoustic release	Holds the buoy and the buoy line on the bottom until a signal is received. Then releases the buoy allowing it to float to the surface.	Eliminates vertical line from water column until time to haul the gear	•Evaluated for whale plan •Didn't work reliably •Gear conflict with both fixed and mobile gears	•Removes vertical line from the water
Lineless fishing	Use grapple to haul gear	Eliminates vertical line from water column	•Tested, but not feasible •Gear took longer to haul •In certain sea conditions, gear is almost impossible to haul •Gear conflict with both fixed and mobile gears	•Removes vertical line from the water
Buoy system modifications				
Two buoy system	Surface buoy at one end and smaller buoy at other. Passes through a pulley attached to the bottom gear. The buoyancy force of the smaller sub-surface buoy reduces the effective scope of the line between the surface buoy and the bottom gear.	Essentially reduces the scope of the buoy line during conditions requiring less than the total amount available	•Some preliminary fieldwork under non-commercial conditions conducted •Results indicated that the arrangement would require additional weight to keep the gear stationary	•Relationship between scope of the line and entanglement risk is not known
Reduce the length of line between buoy and highflier	Highflier and tide ball are held close to each other until it is time to haul the gear	Reduces the horizontal line at the surface	•Need to develop technology •Operational feasibility is unknown	•Reducing line in water would reduce entanglements, but most reported entanglements do not involve this part of the gear so benefit may be limited
Whale-free buoy[3]	Gradually transitions from a limp buoy line to a stiff buoy	Allows buoy to flow around an appendage	•Needs further testing •Potentially operationally feasible	•Gear would slide off animal rather than entangle •Benefit unknown
Visual deterrents				
Buoy modifications - color and/or shape	Buoys that can be better seen by sea turtles and/or minimize potential attraction	May allow turtle to avoid gear	•Buoy color easy to change	•Uncertain if turtles are targeting different colors or confusing buoys with prey •One anecdotal report that turtles bite white buoys more than black
Lighted line	LEDs/light sticks to increase probability the animal will see the rope	May allow turtle to avoid gear	•Being tested in other fisheries •May have issues with hauler	•If leatherbacks feed on ctenophores at night, they may be attracted to luminescent rope •Uncertain if turtles would avoid line even if they could see it
High visibility line	Rope that can be better seen by sea turtles	May allow turtle to avoid gear	•Glow rope technology under development •Colored rope available	•If leatherbacks feed on ctenophores at night, they may be attracted to luminescent rope •Uncertain if turtles would avoid line even if they could see it •Colors not visible after ~30 ft depth so wouldn't make a difference to turtles at that depth
Acoustic deterrents				
Low frequency pingers	Emit pings in frequency that sea turtles can hear	May allow turtle to avoid gear	•Questions on the feasibility or suitability of using on the large number of lines in the water (i.e., level of noise, expense)	•Research on acoustical deterrents and turtle hearing needed in general •Not a priority for vertical lines

[1] Bycatch reduction potential will also likely depend on behavior of turtle when encountering the line (e.g., roll vs other escape behavior).

[2] Developed by Blue water Concepts, LLC.

[3] Developed by MIT Sea Grant - http://seagrant.mit.edu/cfer/whalefreebuoy/whalefreebuoy.html

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