**Project 3 Final Report**

# Perspectives of Gulf of Maine Lobster Fishermen on Reducing Large Whale Entanglements

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## Introduction

The endangered North Atlantic right whale, *Eubalaena glacialis*, has a current population of approximately 526 individuals (Pettis and Hamilton, 2015). Entanglement in fishing gear has been identified as one of the main threats to this species (Kraus et al 2005), causing an average of observed mortality of 1.5 individuals per year from 2001-2010 (Waring et al 2008; Waring et al 2010; Waring et al 2013). Ropes recovered from entangled right and humpback whales found along the east coast of the United Stated and Canada have been identified as lobster pot/trap gear and gillnet gear in 80% of the cases in which the gear type could be determined (Johnson et al 2005). The four parts of fixed fishing gear most commonly involved in entanglements were found to be: buoy line (also known as the vertical line), groundline, floatline, and surface system lines (Johnson et al 2005). An analysis of 626 right whale photographs taken from 1980 to 2009 suggests that at least 83% had been entangled at least once and 59% had been entangled more than once (Knowlton et al 2013). These authors also found that the percentage of animals observed each year with rope on the body increased significantly during the study period, implying that it is becoming more difficult for whales to free themselves from fishing gear.

The Atlantic Large Whale Take Reduction Plan, intended to reduce the incidental mortality and serious injury of North Atlantic right, humpback, and fin whales, informs regulatory actions for commercial trap/pot and gillnet fishing activity in the region (NMFS 2002). The plan addresses fixed gear fisheries from Maine to Florida. All trap/pot fishermen in northern inshore state waters of Rhode Island, Connecticut, Massachusetts, New Hampshire, and Maine must comply with measures to reduce the risk of fishing gear to whales, including: rigging without the buoy line floating at the surface; hauling gear at least once every 30 days (no wet storage); marking surface buoys; rigging buoys, floatation devices, and/or weights attached to the buoy line with a weak link having a breaking strength no greater than 600 lbs; fishing groundline made of sinking line; and gear marking. Some exceptions to these rules apply within an exemption zone approximately equivalent to 2nm offshore from the nearest landmass in Maine state waters. Fishermen are also encouraged to maintain knot-free buoy lines. Restricted Areas (Cape Cod Bay, Stellwagen Bank Jeffrey's Ledge, and Great

South Channel) have additional restrictions on weak links and the number of traps and endlines per trawl during certain times of the year. In 2015, additional regulations were implemented that include expanded gear marking, a seasonal closure off of Massachusetts, and a minimum number of traps per trawl based on area fished, in order to reduce the overall number of vertical lines (NMFS, 2015).

Since 2005, the Consortium for Wildlife Bycatch Reduction ("Bycatch Consortium") has been testing modified fishing gear such as abrasion-resistant groundlines, glow rope, weak rope, stiff rope, red rope, and time-tension line cutters with lobstermen and in the lab, has modeled whale entanglement scenarios using computer simulation, and has supported research to learn more about right whale visual perception. The purpose of these projects has been to identify ways to reduce interactions and entanglements involving lobster fishing gear and whales, while maintaining practical fishing methods and lobster catch rates. Many of these projects have been conducted in collaboration with lobstermen, specifically by testing modified fishing gear.

The Maine Lobstermen's Association (MLA), a member of the Bycatch Consortium, has engaged lobstermen in conversations to identify innovative yet practical fishing gear and methods that have potential for preventing large whale entanglements. As past bycatch reduction efforts have shown, fishermen's understanding of the problem is important for identifying solutions and adopting new techniques (see, for example, discussion of shrimp trawl fishermen and the adoption of sea turtle exclusion devices (TEDs) in Tucker et al [1997]). Cooperative fisheries research has many benefits, including: helping fishermen and scientists become more informed and appreciative about each other's expertise; making fishermen more likely to accept the credibility of scientific observations; and promoting the likelihood of lasting partnerships (Hartley and Robertson 2006). Recognizing this, the MLA and the Bycatch Consortium organized a series of meetings over several years to 1) develop a common language between scientists and lobstermen for communicating the problem of right whale entanglements, 3) discuss past bycatch mitigation research and results, and 4) provide opportunities for lobstermen to offer their insights on fishing practices and potential bycatch mitigation techniques. Ultimately, the goal was to increase the involvement of fishermen in understanding the entanglement problem while soliciting their input into identifying sustainable solutions. This report presents the results of these outreach activities.

## Outreach with Fishermen

### *Creating a Common Language*

The first goal of the Bycatch Consortium and MLA was to create a resource for scientists, lobstermen, policy makers, and other interested parties that explained the diverse range of fishing gear and techniques used throughout the Gulf of Maine. In 2010, lobstermen were invited to participate in one of 39 meetings held along the coast of Maine to characterize the fishing gear and techniques used by their community (Table 1). Meetings were held in all lobster management zones (Figure 1)

as well as in New Hampshire and Massachusetts; over 150 active lobstermen in total attended these meetings. Fishermen were asked to document (draw and label) the individual components and rigging of their lobster gear. The MLA collected drawings from 115 lobstermen. The descriptions and drawings included the size and number of traps, weight and ballast, brand, size, and length of lines, types of flotation devices, and methods of rigging gear.

**Table 1**. MLA outreach meetings to characterize fishing methods and discuss whale bycatch mitigation.

| Date | Meeting Location | Date | Meeting Location |
|---|---|---|---|
| 2.23.10 | Zone B, District 2-7 | 5.13.10 | Zone E, District 9-10 |
| 3.5.10 | Zone B, District 2 | 5.13.10 | Zone C, District 2 |
| 3.15.10 | Zone G, District 6-7 | 5.19.10 | Zone F, District 1 |
| 3.22.10 | Zone G, District 1-3 | 5.20.10 | Zone F, District 5 |
| 3.23.10 | Zone D, District 3 | 5.26.10 | Zone D, District 1-2 |
| 3.25.10 | Zone F, District 8-9 | 5.27.10 | Zone F, District 7 |
| 4.5.10 | Zone A, District 1-2 | 6.1.10 | Zone C, District 9 |
| 4.5.10 | Zone A, District 3-4 | 6.2.10 | Zone D, District 12 |
| 4.6.10 | Zone A, District 5-6 | 6.7.10 | Zone D, District 11 |
| 4.6.10 | Zone A, District 7-8 | 6.16.10 | Zone G, District 4-5 |
| 4.6.10 | Zone B, District 5 | 8.7.10 | Zone C, District 2 |
| 4.7.10 | Zone C, District 1-2 | 12.14.10 | Zone A, District 6 |
| 4.7.10 | Zone C, District 3-4 | 12.15.10 | Zone D, District 3-4 |
| 4.7.10 | Zone C, District 5 | 1.25.11 | Zone B, District 5 |
| 4.8.10 | Zone D, District 7 | 3.31.11 | Zone G, District 1-3 |
| 4.8.10 | Zone D, District 6 | 2.11 | Massachusetts Lobstermen's Association Annual Weekend |
| 4.9.10 | Zone D, District 8-10 | | |
| 4.29.10 | Zone G, District 8-9 | 2.11 | MLA Directors Meeting |
| 4.30.10 | Zone G, District 10-11 | 3.11 | Maine Fishermen's Forum |
| 5.4.10 | Zone D, District 10-11 | 4.11 | Massachusetts Lobstermen's Association Delegates Meeting |
| 5.5.10 | Zone D, District 5 | | |
| 5.6.10 | Zone F, District 2 | 4.11 | New Hampshire Regional Meeting |
| 5.11.10 | Zone E, District 5-8 | | |

Lobstermen were also asked to describe their fishing area's environmental conditions, including tides, currents, and bottom habitat; the length of the active fishing season; depths fished; the average soak time; the number of traps per trawl; number of buoy lines (endlines); vessel size; and number of crew members. Some of these characteristics change over the course of the season, so lobstermen documented how, when, and where they change.

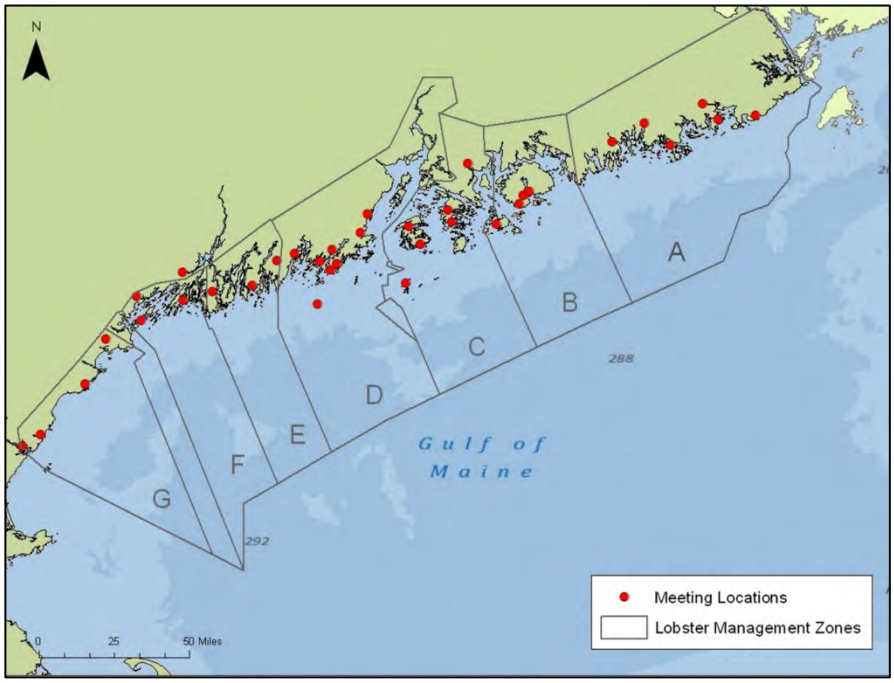


**Figure 1**. *Meeting locations in Maine to collect data on gear configurations.*

After this information was collected and summarized, it was reviewed for accuracy by lobstermen, including the MLA's Board of Directors. A 33-page illustrated report was produced with in-depth descriptions of the fishing gear and techniques used in each Zone of the Gulf of Maine (McCarron and Tetreault 2012, Appendix E). This report collected lobstermen's knowledge about the fishery, illustrated the diversity of fishing methods in the Gulf of Maine, and disseminated terminology for gear with people and groups interested in the lobster fishery. It is especially important for use in evaluating the relative impacts of potential gear or regulatory changes involving fishing gear, by giving scientists, fishermen, and fisheries manager a common understanding about the range of fishing techniques used in the region. To date, more than 700 copies of the report have been distributed to lobstermen, marine mammal and fisheries scientists, government officials, students, and businesses.

*Sharing Bycatch Knowledge*

The second goal was to communicate the problem of right and other large whale entanglements in fishing gear, and share the mitigation research carried out to date. In February and March of 2012, the Bycatch Consortium and the MLA hosted seven half-day meetings in Machias (Zone A), Bar Harbor (Zone B), Bucksport (Zone C), Rockland (Zone D), Boothbay (Zone E), Yarmouth (Zone F), and Biddeford (Zone G) entitled

"Understanding Interactions between Whales and Lobster Gear". A total of 40 lobstermen, scientists, Maine DMR staff, and reporters attended the meetings. The Bycatch Consortium and the MLA presented slideshows explaining the purpose of the Consortium and summarized its research related to large whale entanglements and lobster fishing gear (Table 2). The MLA and the Consortium also hosted a half-day meeting at the 2012 Maine Fishermen's Forum entitled "How do whales get entangled in fishing gear? Using reverse engineering to understand whale entanglements". The Bycatch Consortium and the MLA presented slideshows similar to those given at the Zone meetings. These were supplemented with insights from two lobstermen who had attended the Bycatch Consortium's 2011 whale entanglement reverse engineering workshop. Lastly, information booths stocked with project reports, videos, and images were set up by the Bycatch Consortium and the MLA at the Maine Fishermen's Forum and the Massachusetts Lobstermen's Association Annual weekend in 2012.

**Table 2**. Presentation topics given at each outreach meeting by the Bycatch Consortium and the MLA.

- Right whale status and vertical line rule update
- What is the Consortium for Wildlife Bycatch Reduction?
- Field testing experimental ropes and gear (glow rope, stiff rope, weak rope, etc.)
- Characterizing lobster gear in the Gulf of Maine
- Making sinking groundlines more workable
- What can we learn from entangled whales? The dynamics of whale entanglements
- Insights from ropes and whale injuries
- Insights from disentanglement efforts and necropsy cases
- What happens when a right whale swims into fishing gear? Using models to simulate entanglements
- Reviewing right whale entanglement case studies and the gear removed from whales

*Feedback from Lobstermen*

Based on presentations given during these meetings and information shared by lobstermen about their fishing experiences, they were asked to provide feedback on fishing practices they thought might reduce the risk of gear to whales. Lobstermen identified two main challenges in considering this topic. First, they highlighted that they mainly work alone and therefore develop their fishing strategy independently, including the number of traps fished, gear rigging, gear deployment and when and where they fish. Therefore, many were not comfortable discussing their fishing strategies, particularly if they believed these might be used to develop general recommendations that might dictate how other lobstermen should fish in the Gulf of

Maine. Second, a recurring observation among lobstermen was that their gear configurations have been optimized through trial and error over many years. Most lobstermen reported that their current fishing practices are used for ease of operation, to maximize catch, and to ensure the safety of themselves and their crew. Individualism and the belief that fishing practices have been perfected make it challenging to garner support for discussion about new gear or fishing techniques. Lastly, lobstermen expressed frustration with the ongoing regulatory process surrounding the protection of large whales, which has caused changes to the fishery, including weak links, gear marking, and the unpopular requirement to use sinking groundlines.

Although discussions about fishing ropes and their role in whale entanglements covered both vertical lines and groundline, the Final Report for Bycatch Consortium Project 2 ("*Review of Sinking Groundline Performance in the Maine Lobster Fishery, with Recommendations for Improving its Fishability*") discussed groundlines in far more detail.

## Results

Lobstermen identified a number of ideas during these meetings for avoiding or reducing the severity of whale entanglements. These are not presented as the consensus view among lobstermen, but rather a list of the different ideas that emerged.

1. Maximize the number of traps per endline to reduce the total number of endlines in the water.
2. Minimize the length of floating groundline between traps
    a. Use sinking rope whenever possible, even inside the exemption line
    b. Maximize the gear-setting speed when deploying traps to keep groundlines as taut as possible on bottom
3. Minimize entanglement risk from the surface system
    a. Limit the amount of scope on the vertical line
    b. Limit the length of rope fished between flotation devices in the surface system
    c. Incorporate smaller, weaker ropes on the top third of the buoy line
    d. Deploy only the flotation devices in a surface system (such as highflyers, polyballs, tide buoys and toggles) necessary to haul the gear based on the conditions fished; avoid using redundant flotation as a precaution against losing gear
4. Minimize the use of knots and coils on the vertical line
    a. Use splicing rather than knots
    b. Use lengtheners to add and remove scope of buoy line when shifting gear rather than coiling or shanking rope which could interfere with the efficacy of the breakaway
5. Reduce gear density through trap reductions

6. Investigate the use of stiff line or taut line
7. Reduce ghost gear through a variety of operational guidelines for sinking groundlines

Maximize number of traps per endline to reduce vertical lines

*Rationale*
An analysis of fishing gear involved in 45 right and humpback whale entanglements found that vertical lines were commonly involved in entanglements of large whales (Johnson et al 2005). When researchers were able to identify the type of line retrieved from entangled whales, in 56% of the cases it involved vertical line. Given that vertical lines pose a serious threat to whales, eliminating the number of vertical lines would be expected to reduce the risk of whale entanglements. NMFS also believes that reducing the number of vertical lines, particularly in areas of high whale density, could reduce serious injuries and deaths of large whales from entanglements in fishing gear (NMFS 2012).

*What would this change involve?*
There is a broad range of gear configurations fished throughout the Gulf of Maine. In many inshore areas shorter strings of gear are fished, largely consisting of singles, pairs and triples, generally with one endline. In the Massachusetts Outer Cape fishery, singles are also fished with one endline. In other inshore areas including Cutler, Boothbay, Casco Bay, Kittery, and most areas of New Hampshire and Massachusetts, longer strings of gear are fished. The Maine, New Hampshire and Massachusetts offshore fisheries all deploy much longer trawls of 10 to 40 traps, each.

For a lobsterman fishing a total of 800 traps, a change in gear configuration can significantly alter the number of endlines. The more traps on a trawl, the fewer the number of vertical lines in the water (Table 3).

**Table 3**. Total number of endlines based on gear configuration (traps/trawl).

| Configuration | # Vertical Lines with 1 Endline | # Vertical Lines with 2 Endlines |
|---|---|---|
| Single | 800 | -- |
| Pairs (2) | 400 | -- |
| Triples (3) | 267 | -- |
| 4 trap trawl | 200 | -- |
| 5 trap trawl | 160 | 320 |
| 6 trap trawl | 133 | 266 |
| 8 trap trawl | 100 | 200 |
| 10 trap trawl | 80 | 160 |
| 15 trap trawl | -- | 106 |
| 20 trap trawls | -- | 80 |
| 25 trap trawls | -- | 64 |
| 40 trap trawl | -- | 40 |

Table 3 shows that lobstermen fishing singles can reduce vertical lines by 1/2 going to pairs, and by 1/3 going to triples. Lobstermen fishing triples can reduce the number of vertical lines by ¼ going to four-trap trawls. However, a triples lobstermen trawling up would need to fish more than six traps on a trawl with two endlines in order to see any reduction in vertical lines. Two important considerations here are that, first, increasing the number of traps/trawl from <5 to $\geq$5 can have no net reduction in vertical lines, because longer trawls require the addition of a second endline. However, if a lobsterman is already using two endlines but then adds more traps/trawl, there may be an incentive to increase the strength of the endlines used, which might reduce the chance that an entangled whale can break free of the gear (Knowlton et al., 2015).

Many factors must be considered when contemplating trawling up gear such as tides, bottom currents, bottom habitat, depth, level of fishing congestion, boat traffic, vessel size and equipment, personal safety, lobster catch, and the culture and traditions of the local fishery. Many of these factors will limit the number of traps that can be safely and effectively trawled up. Lobstermen who have been most successful in maximizing the number of traps per endline are typically lobstermen who have a minimum vessel length of 32 feet, fish with one or more crew, fish in areas of mud or gravel bottom, fish in areas of high boat traffic, or fish in deeper offshore waters. Lobstermen also identified issues related to the width of the vessel and the type of hauling equipment aboard the vessels as factors that can limit the number of traps per trawl that can be safely fished.

When fishing trawls of ten or more traps, lobstermen are seldom able to fish with only one endline. This is due to the high likelihood of losing an endline because of gear congestion from other lobstermen, boat traffic (particularly in Massachusetts, New Hampshire and southern Maine from April through September) or from chafing and hang-downs. A second endline also provides lobstermen with an alternate way to haul the gear if ocean or weather conditions make it challenging to haul from one end. Trawls fished with sinking rope are extremely difficult to recover if buoy lines become unavailable, because groundline that rests on the seafloor makes it virtually impossible to locate using a bottom sounder, particularly in areas with uneven, rugged bottom.

Lobstermen identified a variety of specific reasons for fishing singles, pairs and triples:

- Ability to target rocky bottom, holes, crevices more strategically to maintain lobster catch levels
- Variable bottom habitat (such as boulders, rock outcroppings and holes) makes it impossible to effectively set longer trawls on the sea bed, especially in inshore shallow water
- Deploying more traps in a larger number of areas minimizes competition between traps
- Smaller vessels can't handle large strings of traps on deck
- It is safer for lobstermen who fish alone because the gear fits more easily on deck, and it is safer and more manageable to redeploy the gear and manage the rope on deck
- In areas with a high density of fishing effort and gear, especially those with variable bottom type, lobstermen are more likely to set gear over one another, increasing the probability of gear tangles and trap loss. However, these conflicts can be minimized when lobstermen consistently set gear in the same orientation in relation to the tide.
- Singles are necessary in areas around islands to maintain safety due to rugged, shallow, and rocky bottom habitats.

*Supporting evidence*
Reduction in the total number of vertical lines has potential to reduce the incidence of whale entanglements, but the number of variables that factor into entanglement risk are many, and while the measure makes intuitive sense, it is difficult to predict its impact.

Even though vertical lines have been identified more than other parts of gear in whale entanglements (Johnson et al 2005), it may not be the case that they constitute the most risky part of lobster pot gear. Vertical lines may just be easier to recognize,

because buoys or high-flyers are attached. Other lines don't always have distinguishing characteristics. For most entanglements, it is impossible to determine the gear part involved; Johnson et al (2005) were not able to identify 44% of the gear involved in entanglement events.

Reduce floating line between traps on bottom to reduce rope profile

*Rationale*
Groundline is also known to entangle whales. In cases in which gear retrieved from whale entanglements could be identified, Johnson et al (2005) found that 28% involved groundline. Since 2009, government regulations require that any groundline used in the Gulf of Maine outside the exemption line must be negatively buoyant. While the National Marine Fisheries Service has determined that the fishery inside this line poses minimal risk to whales due to the lack of whales sighted in the these waters, entanglements have been known to occur in these inshore waters. Where positively buoyant groundline is still allowed, lobstermen nevertheless recommended shortening its length between traps to reduce the profile of the rope in the water column.

*What would this change involve?*
In 2003, the Maine Lobstermen's Association partnered with the Maine Department of Marine Resources (DMR) to conduct an underwater observation of floating groundlines in each lobster management zone. This study provided a baseline of the length of groundline typically fished between traps in inshore waters (ranging from 10 to 14 fathom), and documented the underwater profile of many commonly used lines, including how their how arcs change according to gear configuration (Stockwell and Summers, 2008).

The DMR further investigated the concept of fishing neutrally buoyant or low profile lines through field work in 2005 and 2006. This work documented the arc height of low profile versus floating line with varying lengths of line through experimental gear deployments. While overall the study showed that the arc of low profile lines was less than that of floating line, it also measured the difference in profile of floating line with differing lengths of line between traps (Table 5).

**Table 5**. Average and Maximum Heights for Float Rope and Low Profile Rope (Stockwell and Summers, 2008).

| Rope Type | N | Length (Fa) | Avg arc height (m) | Max arc height (m) | Avg arc height (ft) | Max arc height (ft) |
|---|---|---|---|---|---|---|
| Float rope | 72 | 18 | 5.28 | 11.89 | 17.33 | 39.20 |
| | 72 | 10 | 2.99 | 7.48 | 9.8 | 24.54 |
| | 72 | 6 | 2.37 | 3.80 | 7.78 | 12.50 |
| Low Profile rope | 72 | 18 | 0.21 | 0.90 | 0.68 | 2.97 |
| | 72 | 10 | 0.23 | 0.63 | 0.75 | 2.07 |
| | 72 | 6 | 0.43 | 0.97 | 1.42 | 3.20 |

This research demonstrated a reduction in the arc of the floating line as the length of groundline is decreased. A significant reduction in the arc of the rope in the water column was achieved by shortening groundlines from 18 to 10 fathoms; the average height of the arc was reduced by 43% (from 5.28 to 2.37 meters), and the maximum arc height was reduced by 37% (from 11.89 meters to 7.48 meters). While there are many variables which affect the arc height of groundline including region deployed and tautness of the line depending on how it was set, overall, these observations indicate that lobstermen could reduce the amount of floating groundline in the water column by reducing the length of line fished between traps. A reduction in the amount of rope in the water column could be achieved by reducing the length of floating groundlines to 10 fa between traps.

*Supporting evidence*

Lobstermen and the Maine Department of Marine Resources have indicated that because the Northern Gulf of Maine is rocky and has extreme tides, some flotation is needed in groundlines for fishing safety and operational feasibility (Stockwell and Summers 2008). A lower profile line would be more likely to chafe on a rocky bottom or hang down. Some lobstermen did indicate that in general, shorter groundlines can be successfully fished in shallower, nearshore areas. In deeper waters however, they stated that longer lengths of groundline are needed to safely haul at depth and successfully fish longer trawls.

Right whale dive profiles tracked in the Gulf of Maine have shown that they forage very close to or right against the seafloor (Marsh 2005), and there are many photographic records of right whales with mud on their mouths (S. Kraus, pers. comm.). M. Weinrich and D. Wiley also used information from archival tags on humpbacks in the Great South Channel to show that the whales often dive to the bottom and then propel themselves along the seabed on their sides or upside down

with their mouths open (NMFS 2005). This suggests that reducing the profile of the floating line may not avoid the risk of entanglement in groundlines to foraging whales, but could reduce it. However, it has also been suggested that whale foraging inshore, in rocky habitats, may differ from that observed further offshore. Additional research is still needed to examine whale behavior in inshore waters.

Minimize risk from endlines and the surface system

*Rationale*
Right whales frequently feed at or just below the surface of the water (Baumgartner, Mayo et al. 2007). The surface system of lines has been involved in large whale entanglements (Johnson et al 2005). Lobstermen suggested reducing the amount of surface gear by fishing the minimum amount of rope necessary for the endline and the minimum amount of rope necessary between flotation devices in the surface system and deploying only the flotation devices in a surface system (such as highflyers, polyballs, tide buoys and toggles) necessary to haul the gear based on the conditions fished.

*What would this change involve?*
Lobstermen noted that they observe some lobstermen in their areas fishing more rope between flotation devices at the surface than necessary to successfully retrieve gear under local conditions. For example, in some instances lobstermen fish 15 fathoms of line between the marker and main buoys, and many suggested it could be reduced to 5 fathoms. Lobstermen also said that the diameter of rope on the top 1/3 of the endline connected to the buoy is larger, and therefore stronger, than necessary. Many lobstermen use 3/8" diameter rope when the strain on this portion of the line could actually be handled with 7/16" or even as small as 5/16". This would reduce the strength of the rope near the surface system.

One of the challenges lobstermen face is keeping the surface system of their gear visible over the range of the tidal cycle. A variety of methods are employed to achieve this depending on the strength of the tides and bottom currents. Lobstermen may use one or more toggles several fathoms below the buoy, or smaller buoys referred to as tide or marker buoys, located 5 to 15 fathoms distant from the main buoy. These buoys help maintain the main buoy at the surface, but primarily serve as a way for lobstermen to gaff their gear without fighting the strain on the line from tides and currents.

In offshore waters, lobstermen use more flotation to keep the surface system from submerging, typically using two bullet buoys or a polyball. These configurations generally require the use of a second, smaller marker buoy attached by line to the main buoy. Lobstermen fishing outside 12nm are required to mark the ends of their trawls with highflyers. Highflyers are large, metal markers that require significant flotation to stay above the surface, such as a polyball plus a marker buoy. Federal regulations allow for the use of floating line at the surface if more than one buoy is

attached to a single buoy line or if a high flyer and a buoy are used together on a single buoy line.

Lobstermen suggested shortening the length of endline to minimize the risk due to the amount of rope in the water column. Lobstermen typically add "scope", or additional line length, to a buoy line in order to account for tides and currents. However, there is a lot of variability in how much extra rope is fished based on different determinations among fishermen. It may be possible for many lobstermen to shorten the lines they are using and still fish safely and effectively.

Lobstermen seemed to think that shortening the line in the surface system could significantly reduce whale entanglement risk because many believe it is disproportionately involved in entanglements because of skim feeding behavior in right whales. However, in areas with strong tides and currents that require more rope to keep the surface system visible, this alteration may not be advisable.

*Supporting evidence*
It is known that whales get entangled in the surface system of fishing gear, although the risk of surface system gear may be overestimated because it is the easiest to identify (Johnson et al 2005). There is no information on how the amount of gear at the surface may impact the risk of gear to whales. Nevertheless, if the change is simple and possibly even reduces operational costs by using ropes of lesser diameter, it is advisable to implement wherever possible given no consequence to fishermen while potentially benefitting whales.

<u>Minimize the use of knots and coils</u>

*Rationale*
Federal regulations encourage, but do not require, lobstermen to fish buoy lines without knots (NMFS 2002). It is hypothesized that a knotted rope may get stuck in the baleen of a whale, while a knotless rope would be more able to slide through it, and therefore be less prone to causing an entanglement. Obstructions on the line can also be created when a lobsterman coils his rope, creating a shank below the buoy.

*What would this change involve?*
Lobstermen often use splices instead of using knots when configuring gear, a procedure that is easier on land than during fishing. The operational challenges of splicing while fishing often make fishermen prefer using knots rather than splices. Maintaining knotless lines becomes challenging over the course of the fishing season because the circumstances requiring lines to be joined together increases in frequency. Lines are often cut by other lobstermen due to gear conflicts, and over the course of the fishing season endlines are combined for redeploying gear out to deeper

waters. Much of this gear is shifted during the colder months of the year, in the dark, creating an additional challenging to splicing rope. Creating shanks is an alternative method to shortening gear when shifting it from deep to shallower water, instead of replacing the entire endline with a shorter rope or removing a lengthener.

Lobstermen proposed alternative methods of tying ropes together instead of using knots, such as an eye splice tuck, that could be managed on a working vessel. This method of tying lines together would minimize the bulge on the line, and therefore the obstruction if a whale encounters the line. A common concern lobstermen had about decreasing the use of knots was the belief that knots reduce the strength of rope, increasing the likelihood that the rope will break at the knot if encountered by a whale. Many lobstermen also identified coiling rope into shanks as potentially unsafe for whales, because it may cause entanglement and could render the weak link ineffective. Lobstermen suggested discouraging the use of this method to shorten and lengthen endlines. However, shanks require less investment in rope, and less gear that needs to be transported and handled on deck.

*Supporting evidence*
There have been discussions at Atlantic Large Whale Take Reduction Team meetings to determine whether knots should be prohibited in buoy lines and for the attachment of the toggle gangion to the buoy line (ALWTRT 2003). It was decided that it was not operationally feasible to make this a requirement. However, there is no conclusive evidence to suggest that knots increase entanglement probability. There is also no information as to whether reducing the amount of gear at the surface, by eliminating shanks, would reduce entanglement risk to whales.

<u>Reduce number of traps deployed</u>

*Rationale*
Less fishing gear should result in a lower probability that whales will encounter gear and therefore become entangled in it. The assumption is that trap reduction would also result in a reduction in the number of fishing lines.

*What would the change involve?*
To reduce the total amount of gear, the number of traps deployed would need to be restricted by trap limits or by reducing the number of lobstermen fishing. Many lobstermen believe their incomes would decline if they fished fewer traps because they use a portion of their traps to investigate lobster migration. Lobstermen also said that if they had to fish fewer traps, they may deploy them in smaller strings of singles, pairs, or triples to maximize the catch of each trap, leading to more endlines in the water. Of course, in many areas new regulations would prevent them from reducing the number of traps/trawl (NMFS, 2005). Some lobstermen suggested having seasonal trap limits during periods where the risk of interactions with whales is high, while allowing a full complement of traps during the rest of the year.

There are areas in Maine that have implemented reduced trap limits, thereby minimizing the amount of gear in the water. In Zone B, Swans Island lobstermen implemented an island conservations zone in 1984 and are limited to 475 traps, which is a 40% reduction per lobsterman in that zone. In 2000, Zone E lobstermen voted to implement a 600-trap limit, which is a 25% reduction. In Zone D, Monhegan Island lobstermen in 1998 established a conservation area and have a winter fishing season, and a trap reduction to 300 traps, later increased to 400 traps based on lobstermen's claims that they were not able to make a decent living under the 300 trap restriction.

*Supporting evidence*
Assuming that reducing the total amount of gear deployed results in fewer endlines in the water column, there should be a reduced risk of entanglement to whales (NMFS 2013).

Deploy lines under tension

*Rationale*
It has been hypothesized during Atlantic Large Whale Take Reduction Team meetings that a line with increased stiffness or under high tension may reduce the number of entanglements in vertical lines, because of lower entangling properties.


poly ball

*What would the change involve?*
Lines come under high tension when polyballs are used at one end of the buoy line and an anchor at the other, especially in extremely strong tides and currents. This practice already exists in eastern Maine (typically east of Schoodic Point), where lobstermen face unique environmental challenges due to extremely strong bottom currents and tides. To deal with strong tides, they deploy polyballs paired with a tide buoy for grappling, to mark their gear at the surface. Polyballs provide more flotation than Styrofoam bullet or acorn buoys fished elsewhere, as well as preventing the surface system from being pulled underwater.


danforth anchor

Confounding the problem of strong tides is the speed of the bottom currents, which are capable of moving under-weighted lobster gear great distances along the bottom. In order to keep the lobster trawls where they are set, lobstermen deploy heavy Danforth anchors, mushroom anchors, railroad ties or similarly weighted devices at the end of their buoy lines. They also sometimes weigh down individual lobster traps fished as singles, pairs, or triples with bricks, window weights, cement or other ballast.

Other lobstermen who fish in areas of strong tides and currents, including offshore lobstermen in deep water areas and those fishing around the Outer Cape, also report deploying gear in a similar fashion.


mushroom anchor

To deploy lines under tension, lobstermen would have to use a combination of a large flotation device, anchors, and short vertical lines. Another possibility is to use ropes of harder lay, but these are more difficult to coil on deck and are not popular in this region's trap fishery.

Lobstermen from areas outside eastern Maine do not consider the use of a polyball in combination with an anchor as a viable fishing option, and do not believe that fishing this sort of gear would result in the desired "stiffening" of the line in their local fishing areas. The polyballs would provide too much flotation and create an excessive amount of drag on the gear. Any strong wind or running tide would cause the gear to move significant distances along the bottom. The use of anchors or extreme amounts of ballast in traps to offset this tendency is considered unnecessary and extremely dangerous to the hauler, on deck and when setting back gear. Lobstermen also said that using larger floats and weights would not create the line tension desired, because that tension comes from the large tides and strong currents more than the characteristics of the gear.

Instead of using larger floats and weights, lobstermen recommended maximizing line tension by shortening the scope of vertical line, coupled with using adequate ballast to hold traps on the bottom. Most lobstermen reported that this was already the standard configuration and that the lines in the water were already very taut. Lobstermen also cautioned that when lines are under extreme tension, lobstermen must deploy multiple flotation devices in the surface system in order to be able to gaff the gear for hauling. This strain on the line also increases risk of injury if a rope snaps due to chafing or hang-downs.

The overall conclusion by lobstermen with regard to creating lines under extreme tension as seen in eastern Maine is that in the absence of strong tides, anchoring gear is unlikely to achieve the same level of tension on the line.

*Supporting evidence*
Tests conducted by Baldwin et al (2012) suggest that a higher tension line may not reduce the risk of injury to whales. They found that lines under tension may cause lacerations through the sawing action of the rope against the point of contact. The results of these experiments did not completely eliminate the potential benefits of using a higher tension line or a stiff line, but indicate a high risk of injury using rope diameters typically used in this fishery and at high tension. In addition, ropes of harder lay, such as those used in the Western Australian rock lobster fishery are known to entangle whales (How, Coughran et al. 2015).

## Conclusion

Modifying fishing practices is difficult because many lobster fishermen report their current methods are already optimized to maximize target catch, are as simple as they prefer them, and are safe for vessel and crew.

Lobstermen did however identify a range of approaches for altering fishing methods that could serve as a basis for future research into potential gear modifications to reduce the risk of whale entanglements in lobster gear. Table 6 briefly summarizes these, which were discussed above in more detail. One of the techniques has been under examination by the Bycatch Consortium (stiff rope), but generally these ideas may not be testable in the field. The Bycatch Consortium's Virtual Whale Entanglement Simulator (VWES), a computer program that models interactions between right whales and fishing ropes, may be a useful alternative tool for evaluating these mitigation techniques suggested by lobstermen. (See: http://www.bycatch.org/project/modeling-right-whale-entanglements).

**Table 6**. Methods suggested by lobstermen in the northeast US to mitigate lobster gear entanglement risk to large whales.

| Mitigation Method | Scientifically Tested? | Regulated? | Potential to reduce entanglement risk |
|---|---|---|---|
| Maximize the number of traps per endline to reduce the total number of vertical lines | No | Yes. New rules for the minimum number of traps per trawl was implemented by NMFS under the ALWTRP (NMFS 2015) | Fewer endlines in the water column may reduce entanglement probability, although many other factors are involved |
| Minimize the length of floating groundline between traps to reduce rope profile | No, although shortening the length of groundline reduces the profile of the line (Stockwell and Summers 2008) | No.<br>Lobstermen are not regulated on the amount of rope fished between traps. | Probably preferable than having the line higher in the water column, although entanglement prone right and humpback whales do sometimes feed at the sea floor |
| Minimize risk from surface gear | No | No | Shortening the length of line, if practical, sounds like a sensible measure that may reduce entanglement risk |

| | | | |
|---|---|---|---|
| Minimize the use of knots and coils | No | No, but reducing the number of knots is encouraged by NMFS | Assumption is that knots increase the probability of entanglements in baleen. However, knots also create a point along the line with reduced breaking strength that can also facilitate whales breaking free of gear |
| Reduce the number of traps | No | No | Less gear and rope in the water should decrease the likelihood of entanglement risk. |
| Deploy lines under tension | Examined by the Bycatch Consortium (Baldwin et al 2012), and in this report (Project 1 - *Evaluation of Western Australian Stiff Rope Fishing*) | No | Might decrease entanglement risk but could potentially increase entanglement severity (Baldwin et al 2012). Even if advisable, it is not clear how fishing for lobster using ropes of higher tension could be reproducible in areas outside ones that have conditions similar to downeast Maine. |

Gear modifications made in the interests of reducing endangered species bycatch are most effective for fishermen and wildlife when they result through collaborations involving stakeholders, especially fishermen. In the case of North Atlantic Right whale entanglements, the input of fishermen is rarely sought outside of the formal Take Reduction Team process. Regular engagement and cooperative research should be used to increase transparency and accountability of the research and regulatory process. During our meetings, lobstermen reported that they still feel a lot of distrust towards researchers and managers because of historically being left out of research and management decisions. This is unfortunate, because many of the most practical and sustainable solutions emerge as ideas proposed by fishermen themselves, making their participation critical for bycatch reduction efforts (Werner et al, 2006). Support for collaborative research, including with some of these suggestions proposed by lobstermen, remains a critical need as the incidence and severity of right whale entanglements is not decreasing despite many years of regulated changes to lobster and gillnet fishing practices.

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