#10d

Coonamessett Farm Foundation
Supporting scientific research activities in agriculture, aquaculture production, and fisheries research
277 Hatchville Road • East Falmouth, MA 02536
Tel: (508) 356-3601 • Fax: (508) 356-3603
Website: www.coonamessettfarmfoundation.org

An alternative approach to reduce whale mortality from entanglements: the development of an inexpensive GPS radio buoy

Critically endangered North Atlantic right whales continue to perish at an alarming rate, with the majority of recent right whale deaths attributed to entanglement in fixed gear (Van der Hoop et al. 2012, Kraus et al. 2016). There is an immediate need for feasible solutions to minimize whale mortality from entanglements. Because the most important factor for successfully releasing an entangled whale and minimizing whale mortality is being able to get a trained team on site as quickly as possible, we are proposing a two-pronged approach to address this urgent need: 1) develop an inexpensive GPS buoy that can be easily integrated into existing pot-fishery buoy configurations and 2) increase the number of people, including fishermen, trained in disentanglement response.

One of the main factors affecting response time is accurate location information. Therefore, Coonamessett Farm Foundation (CFF), in collaboration with the engineering firm Prescott Consulting, is developing an inexpensive budget GPS radio buoy system, the bsBuoy or budget smart buoy. This device will provide an early notification and near-real time location data of active whale entanglements in the vertical buoy lines of commercial fishing gear to improve overall disentanglement network response efficiency and in turn potential whale mortality. Additionally, we expect the bsBuoy to be affordable and feasible for fishermen. We are currently seeking additional funding for the next stage of bsBuoy development.

Large whales routinely become entangled in vertical lines. From 2007 to 2017, 357 large whale entanglements were documented, with 20% of those whales found dead (Morin et al. 2018). Actual entanglement numbers are undoubtedly much higher. Researchers have estimated that over 80% of endangered North Atlantic right whales have been entangled in fishing gear, and 10-25% of North Atlantic right whales and humpback whales acquire new entanglement scars each year (Knowlton et al. 2012). Yet because entangled whales are currently discovered by chance, a small percentage of entangled animals are documented and even fewer are freed of gear.

A practical and reliable solution to mitigate these entanglements has been elusive. Current research efforts are focused on changing the color of fishing lines to make them more visible to right whales (Kraus et al. 2014, Kraus & Hagbloom 2016), creating very loud whale pingers to startle whales (Pirotta et al. 2016), making fishing lines easier to break by reformulating rope materials or incorporating weaker hollow sections along the line (SSLFA 2017, Knowlton et al. 2017), and developing 'ropeless' systems (NMFS 2010, Baumgartner et al. 2018). Yet each of these solutions have major drawbacks, and none are likely to be ready for widespread use in the near future. Although ropeless systems with pop-up buoys, and no permanent vertical lines, would potentially offer the greatest protection to marine megafauna, these solutions are currently very expensive, operationally impracticable, and most likely unreliable. Long-standing conflicts between fixed bottom gear (pots and gill nets) and mobile gear (dredges and trawls) would be exacerbated without a surface buoy or other system to mark the relative location of fixed gear for mobile gear fishermen. Furthermore, at the current rate of development it is unclear if these systems will be in place in time to reverse the decline of the North Atlantic right whale population.

Consequently, CFF is developing an alternative system that would provide an alert to all relevant stakeholders if whales become entangled in fishing gear, thus reducing the larger consequences of an entanglement, especially mortality. With a small grant from the Marine Mammal Commission (MMC17-223: Development and testing of an inexpensive GPS radio buoy system for early notification of whale entanglements), we have designed and built a prototype of the bsBuoy, with materials costing under $100. Radio buoys are routinely used for tracking gear in the pelagic longline, purse seine, and fish aggregation device fisheries (FAO 2016). Unfortunately, the cost of these commercially available buoys makes them prohibitively expensive for widespread use in fisheries with large numbers of buoys per individual vessel like the New England lobster fishery. The goal is to make available inexpensive bsBuoys to fishermen as an economical solution for monitoring their gear to reduce both the response time for disentangling marine protected species and the creation of new ghost gear. Moreover, bsBuoys will be tailored to the specific needs of the New England pot fisheries and the associated entanglements, and we expect the bsBuoy to have limited impact on established fishing practices.

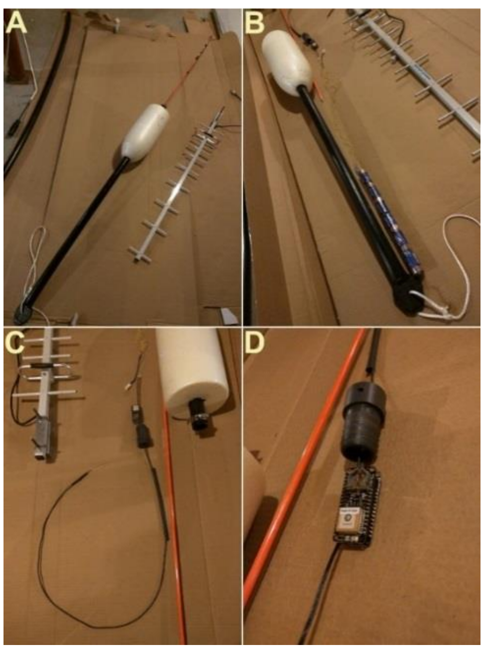

Figure 1: The prototype bsBuoy. (A) The assembled bsBuoy shown with a Yagi antenna. (B) The underwater counterweight that can hold a series of C batteries. (C) The antenna made out of coax cable. (D) The custom PVC plug and Adafruit Feather board.

The prototype bsBuoy currently consists of a 4-foot polyethylene pipe that can pass through the center of a typical commercial lobster buoy (**Figure 1A**). The pipe is filled with batteries, which serve as a counterweight to keep the antenna upright (**Figure 1B**). A sleeve-dipole antenna, made by folding back the shield of a coax cable for a precisely tuned length, is sealed and taped to a fiberglass rod (**Figure 1C**). The coax cable passes through a sealing gland to an off-the-shelf Adafruit Feather© board with an integrated 915 MHz LoRa radio and stacking GPS module (**Figure 1D**). It can easily be programmed via a USB connection to a standard computer and using open source software like Arduino IDE. Because the bsBuoy unit can be placed in a lobster buoy, mimicking the existing center stick, we expect handling to be similar to traditional buoys.

The bsBuoys will emit radio signals at preset intervals to provide gear locations under normal conditions, and fishermen will be able to utilize their vessel chart plotter to map their bsBuoy locations. Automated detection of line breakage or displacement of gear, a critical feature of the system for locating and tracking entangled animals, will be accomplished by tracking buoy locations relative to the locations immediately after the gear is set (**Figure 2**). By providing the depth and the length of rope each time the gear is set in a new location, the fishermen can establish a watch circle (the circumference traveled by an anchored buoy or vessel) unique to each bsBuoy. When a bsBuoy moves outside of the geometrically defined geofence (the watch circle with a buffer to account for GPS errors, scope and depth estimation errors, tides etc.), an automated message would be sent to alert the gear owner. If the bsBuoy moves outside of the geofence rapidly, i.e. above typical surface current speeds, indicating a likely entanglement event, an additional alert would be sent to the disentanglement network.

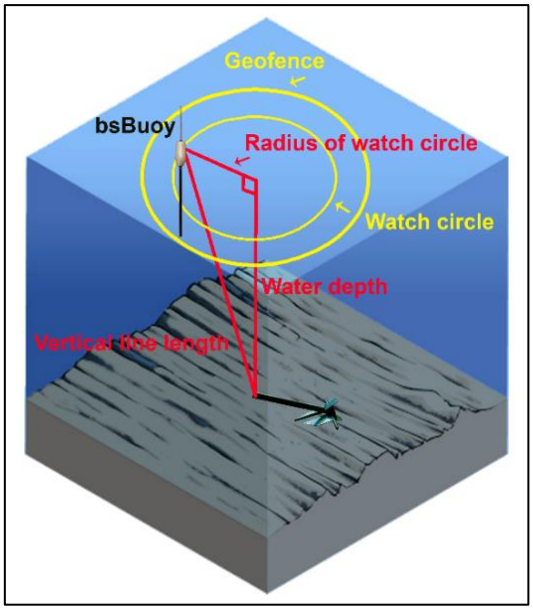

Figure 2: Detection of line breakage or gear displacement based on the length of the vertical line and water depth. Detection algorithm will be based on the geometry of right triangles coupled with built-in margins for error based on GPS accuracy, line length measurements, and tides.

The whale identification algorithm and communication protocols to and from the buoys will be developed in close collaboration with the disentanglement network and other state and federal agencies. An ideal system would seamlessly integrate with the current hotline, sending notifications only if a buoy is confirmed as attached to a whale. Although the bsBuoy will not eliminate entanglements, by providing accurate locations and immediate notification to the disentanglement network, this system could greatly reduce the entanglement duration to <12hr, which has been considered a negligible amount of time regarding long-term stress impacts and mortality (Van der Hoop et al. 2017).

With additional funding, we plan to build more buoys and test them on local commercial pot gear to resolve any operational issues. Through this collaboration with fishermen, we will evaluate bsBuoy robustness, functionality, and ease of handling during regular fishing operations. Because cost efficient mass production has been an essential consideration in the design and development of the bsBuoy, we also plan to transfer the finalized schematics to a custom printed circuit board to remove redundant components and reduce costs.

If the bsBuoys and the accompanying network operate as intended, the system has the potential to substantially reduce whale mortalities due to entanglements by providing trained teams with regular location updates as long as the buoy is attached to the whale. An expanded network of trained teams could be developed by training and equipping fishermen to respond to entanglements.

Furthermore, any recovered buoys would furnish data on the gear type, the location where the gear was set, and the distance the whale traveled after becoming entangled. All of these data, which are currently not available, are critical for understanding and minimizing future whale interactions with fishing gear. The integration of wireless communication technologies would enable the buoy to be read quickly and easily by passing patrol vessels or aircraft. This feature could support the development of difficult to enforce management systems, for example limiting and enforcing the number buoy lines or traps per trawl, by linking buoy data with unique identifiers.

Literature Cited

Baumgartner M, Moore M, Knowlton A, Werner T, and Kraus S. 2018. Development plan for rope-less fishing. https://ropeless.org/wp-content/uploads/sites/112/2018/02/12.-Baumgartner_Ropeless-_Development.pdf.

Food and Agriculture Organization of the United Nations (FAO). 2016. Expert consultation on the marking of fishing gear. FAO Fisheries and Aquaculture Report.

Knowlton AR, Hamilton PK, Marx MK, Pettis HM, and Kraus SD. 2012. Monitoring North Atlantic right whale Eubalaena glacialis entanglement rates: a 30-yr retrospective. Marine Ecology Progress Series 466: 293-302.

Knowlton A, Werner T, and Kraus S. 2017. Whale release ropes. https://www.greateratlantic.fisheries.noaa.gov/protected/whaletrp/docs/2017%20April%20Meeting%20Docs/knowlton-alwtrt_2017__1_.pdf

Kraus S, Fasick J, Werner T, and McFarron P. 2014. Enhancing visibility of fishing ropes to reduce right whale entanglements. BREP 1: 67-75.

Kraus SD, Kenney RD, Mayo CM, McLellan WA, Moore MJ, and Nowacek DP. 2016. Recent scientific publications cast doubt on North Atlantic right whale future. Frontiers in Marine Science 17 https://doi.org/10.3389/fmars.2016.00137.

Kraus SD and Hagbloom M. 2016. Assessments of vision to reduce right whale entanglements. Final Report for NOAA Grant NA09NMF4520413.

McCarron P. 2009. Maine lobster industry field testing of experimental vertical and groundlines. Consortium of Wildlife Bycatch Reduction, Maine Lobstermen’s Association. https://www.greateratlantic.fisheries.noaa.gov/prot_res/GrantsResearchProjects/reports/NEA/Appendix%20D.pdf

Morin D, Salvador G, Higgins J, and Minton M. 2018. Gear analysis and protocols; 2007-2017 preliminary additional gear analysis. https://www.greateratlantic.fisheries.noaa.gov/protected/whaletrp/trt/meetings/Jan%202018/2018_alwtrt_gear_update.pdf

National Marine Fisheries Service (NMFS). 2010. Concept paper on ALWTRT proposal to open a management area presently closed to trap/pot fisheries to stimulate development of ropeless [buoy lineless] fishing. https://www.greateratlantic.fisheries.noaa.gov/whaletrp/trt/meetings/Mid-Atlantic_Southeast_ALWTRT_Materials/Final%20Lineless%20Concept%20Paper%20Nov2010.pdf

Pirotta V, Slip D, Jonsen ID, Peddemors VM, Cato DH, Ross G, and Harcourt R. 2016. Migrating humpback whales show no detectable response to whale alarms off Sydney, Australia. Endangered Species Research 29: 201-209.

South Shore Lobster Fishermen's Association (SSLFA). 2017. Co-Existing: Working with best available Science within the Commercial Lobster Fishery to Implement Thoughtful Solutions that Minimize the Frequency and Severity of Right Whale Entanglements. https://www.greateratlantic.fisheries.noaa.gov/protected/whaletrp/docs/2017%20April%20Meeting%20Docs/haviland_presentation.pdf

Van der Hoop J, Corkeron P, Moore M. 2017. Entanglement is a costly life-history stage in large whales. Ecology and Evolution 7:92-106.

Van der Hoop JM, Moore MJ, Barco SG, Cole TVN, Daoust PY, Henry AG, McAlpine DF, McLellan WA, Wimmer T, and Solow AR. 2012. Assessment of management to mitigate anthropogenic effects on large whales. Conservation Biology 27: 121-133.