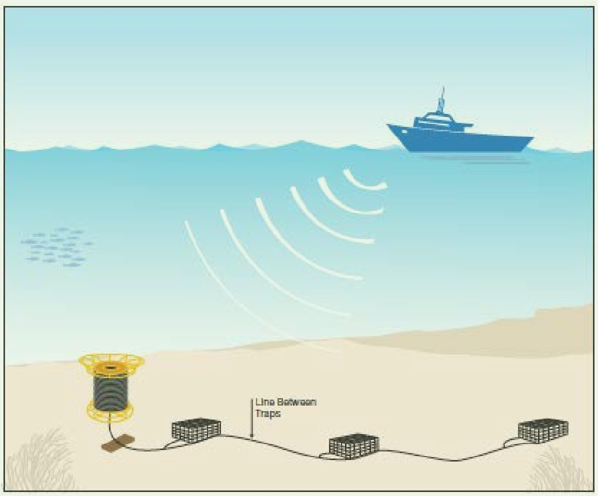
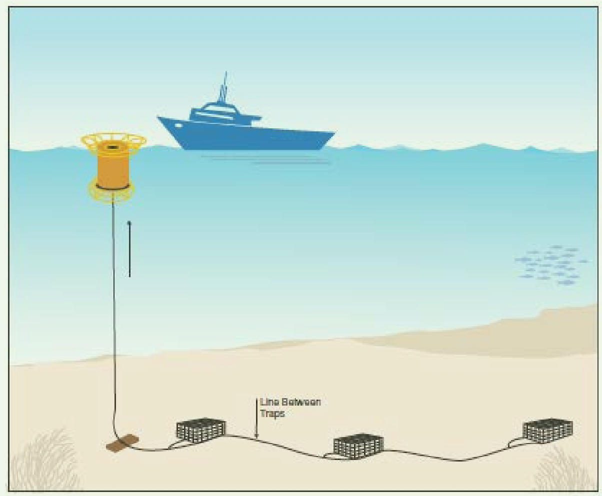
Ropeless Systems and Whale Release Ropes: A Technical Brief for the Fishing Industry





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Consortium for Wildlife Bycatch Reduction

Anderson Cabot Center for Ocean Life at the New England Aquarium

Overview

Entanglement in ropes and nets is a leading cause of mortality and serious injury to large whales worldwide. Among the most vulnerable is the North Atlantic right whale (*Eubalaena glacialis*), which numbers fewer than 350 individuals and inhabits coastal waters from Florida to northeastern Canada. Current entanglement rates are unsustainable if this species is to avoid extinction.

Decades of using fishing closures and modifications to fishing gear have not shown progress in reversing the threatened status of this species, but instead, population numbers and calving rates are falling while the incidence and injury severity have been increasing. Part of the problem is that many of the mandated gear changes lacked any scientific evidence that they work as intended. A complete review of these measures is available in these reports:

> FAO. 2020. Report of the Expert Meeting to Develop Technical Guidelines to Reduce Bycatch of Marine Mammals in Capture Fisheries. Rome, Italy, 17–19 September 2019. FAO Fisheries and Aquaculture Report No. 1289, Rome. https://doi.org/10.4060/CA7620EN
>
> FAO. 2021. *Fishing operations. Guidelines to prevent and reduce bycatch of marine mammals in capture fisheries.* FAO Technical Guidelines for Responsible Fisheries No.1, Suppl. 4. Rome. https://doi.org/10.4060/cb2887en

These publications review two gear modifications for trap fisheries for which there is evidence that they will mitigate the problem: whale release rope and ropeless, or on-demand/pop-up systems. Both are being advanced by regulators in the U.S., Canada, and elsewhere, and the purpose of this document is to provide information to assist the industry in their evaluation of potential solutions.

Whale-release Rope

Whale-release rope is a pot or gillnet vertical line that has a virgin breaking strength of 1700lbf (7562N) or less, which is weaker relative to what is currently used in the northeastern U.S. and Canada. Scientific evidence indicates that whale-release rope, if integrated throughout the entire endline, would reduce North Atlantic right whale (NARW) serious injuries and mortalities from entanglements (Knowlton et al., 2016). Historical records show that the incidence and severity of NARW entanglements correlates with an increase in the breaking strength of ropes used in northwest Atlantic pot fishing, specifically linked to the adoption of co-polymer ropes which replaced ones manufactured with weaker synthetic fibers--such as polypropylene--and before that natural fibers that were even weaker at similar diameters.

It is possible to manufacture ropes with the diameter used by lobster fishermen to have a maximum breaking strength of 1700lbf, but it can be difficult or expensive with the machinery used by manufacturers. An alternative approach is to splice or tie in “weak links” at various points along the length of the rope. One link is the so-called South Shore sleeve, a 3-6 foot segment of braided rope produced by Novabraid that can be integrated into typical three-strand fishing ropes. This is achieved by cutting the three-strand rope and inserting the bitter ends into each end of the sleeve at a side-cut until they meet in the middle (see video here: https://www.youtube.com/watch?v=3eRqat5TMBA). A small length of the sleeve is tucked into the rope at both ends to help ensure the rope will not pull out of the sleeve. In lab tests, the sleeves break on average at 1600lbf (Figure 1).

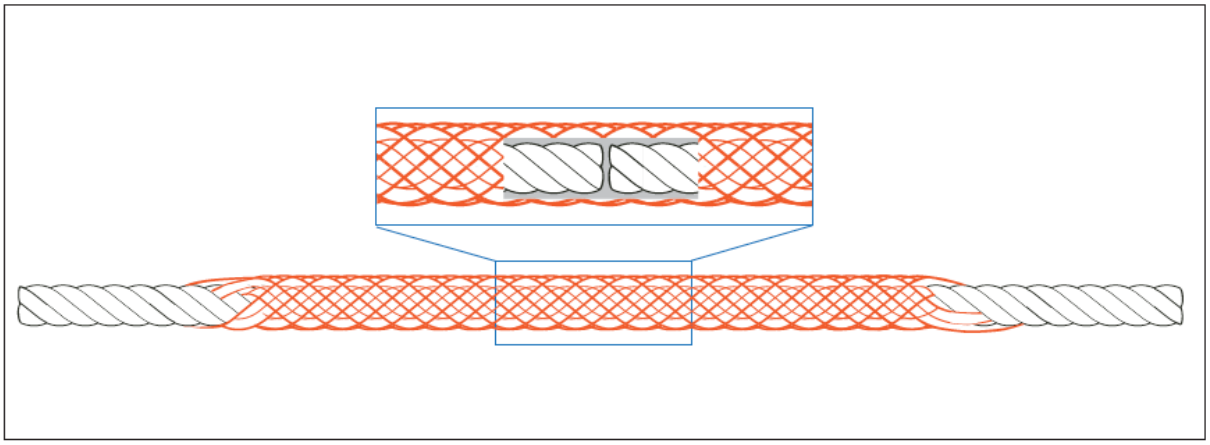

Figure 1. The "South Shore Sleeve" tested by lobster fishermen off the eastern U.S. The diagram shows the sleeve (colored orange) integrated into a typical three-strand vertical line that has been cut so that it can be inserted into the sleeve (M. Riley, NEAq).

To be effective, a rope can have reduced breaking strength throughout its length or contain weak points at different locations. The benefit of both types of these ropes to whales should be realized unless the weak links are somehow nullified. This might occur if too few weak points are incorporated into the rope. For example, a single weak point could become lashed securely on the body of a whale or placed above the point where the whale hits the rope and not allow the rope to part from the counterforce from heavy bottom gear. To improve the likelihood of weak ropes functioning as intended, a rule of thumb when using braided sleeves rope is to insert a “weak link” every 40ft. That length was derived from the average length of a NARW. By spacing the placement of weak inserts at a distance of one NARW body length, the rope likely would part below the whale as it swims or thrashes, reducing the chance of it trailing heavy gear, or above the whale as the surface buoys are pulled subsurface creating another counterforce. If too few links are used then there is a greater risk that a long, trailing line would create drag on a moving whale, endangering its overall health. Furthermore, right whales occur at all depths of the ocean, from the seafloor to the surface, and despite claims that the higher risk is at the surface, it is well known that right whales occur and feed at depth where gear occurs. It is therefore important to design weak ropes so that they can produce the desired effect at all depths where entanglements can occur by locating weak spots at multiple locations (</= 40’), or having the entire length of the rope consist of this reduced breaking strength.

Some fishermen have suggested putting a knot in a rope a simpler way to reduce its breaking strength. Tying a knot into a rope creates a weak point in the rope that reduces its breaking strength by approximately one-half. It can therefore serve the purpose of inserting a weak point in the rope that might break at 1700lbf or less, however NOAA Fisheries and some whale scientists recommend that knots not be used because of the increased possibility that the knot can lead to ropes causing damage to baleen or becoming lodged within it, and lower the probability of ropes sliding through the mouth or off the flippers or fluke (NMFS 1997). The presence of knots may also be more likely to increase the probability of catching in other parts of the rope that could hinder the whale's ability to shed the entangling gear.

Weak ropes using the braided sleeve have been tested in the northeast Atlantic by many lobster pot fishermen. Loads measured on lobster pot vertical lines both in the field with lobster fishermen and using computer engineering models have shown that they generally fall well below 1700lb during typical fishing operations (including hauling), and can be reduced further through basic changes to fishing practices. For example, avoiding excessively fast hauling speed especially in rough seas, increasing the length of groundline between the first and second traps in multi-trap trawls, and hauling as directly as possible over the buoy line so that it is as perpendicular as possible to the surface of the water are operational changes that can reduce tension (Knowlton et al., 2018). Vertical lines are certainly prone to breaking under high strain, such as when hang-downs occur, and undesired parting occurs even when stronger ropes are used. It may be that in instances when ropes break either from passing vessels snagging them or from whale entanglements, that the shorter time between an encounter with a rope and when it breaks might reduce the distance in which the gear could be dragged and therefore fishermen may be more successful relocating their gear for retrieval.

Lab and field tests of vertical lines with braided sleeves showed that they broke at just below 1700lbf and are feasible during normal fishing activity as only 11.8% of experimental endlines were reported broken or missing in comparison to 8.5% of control endlines. After 35 hauls, there was almost no reduction in breaking strength of the sleeves, while control lines lost approximately 9% of their virgin breaking strength after fewer than 15 hauls. Furthermore, several fishermen in Massachusetts report using the sleeves through three seasons and continue to fish with them integrated into their buoy lines. Ropes with braided sleeves or ropes manufactured entirely with a reduced breaking strength also pass easily through current deck haulers.

It takes approximately 2-3 minutes to splice in a single sleeve, although with practice and the use of a splicing fid tool this time can be reduced. Each 6-foot sleeve costs just over US$2 to acquire at present but this can be cut in half and be just as effective at a 3-foot length, and requires no other modification in rigging in order to haul it onto the gunwale or perform any other fishing operation using existing equipment or operational practices. More instructions on using weak rope inserts for those interested in testing them, and evaluation reports, are available from the Consortium for Wildlife Bycatch Reduction (www.bycatch.org).

To comply with the Canadian regulation that all fixed gear fisheries in Atlantic Canada must use weak rope by the fall of 2022, many fisheries have been testing the best way to do so using their gear configurations and considering the conditions in which they fish. Among the fishing groups that have evaluated whale release rope are the Massachusetts South Shore Lobstermen's Association, the Grand Manan Fishermen's Association, the Coldwater Lobster Association, fishers in the Bay of Fundy (LFA 35), the Acadian Crabber's Association and APPCA, and the Area 19 Snow Crab Fishermen's Association. In addition, other types of weak links or rope have been tested in other fisheries.

Ropeless Fishing Systems

In ropeless fishing, pot ropes are dispensed with or secured at depth until bottom gear is ready to be retrieved. At that point the ropes are brought back to the surface using a timed or acoustic release for inflating a buoy or bag, or detaching surface gear secured to bottom gear by a short rope. Ropeless systems were initially tested in the 1990s and are fished commercially in Australia. During the past few years, many companies and engineers have emerged with new prototypes. Many evaluations of these systems are underway in Canada and the U.S.

The basic configuration for all types of ropeless systems consists of an on-board deck box for running the communication system, a transducer that is hull mounted or placed in the water for communication with the bottom gear, and a timed or acoustic release that when activated releases a float bag or buoy line and buoys so that they float to the surface for retrieval. With acoustic releases, each unit has a proprietary signal belonging to one fisher that only they can release. Ultimately, the goal is to also make this gear detectible at the surface by other fishers to reduce the risk that they will incidentally set their own gear on top of them or become incidentally trawled up.

In addition to the systems listed here, more inexpensive but less reliable techniques include use of a galvanic timed release to lash ropes and buoys to bottom-set gear, or dispense with vertical lines and instead grapple for groundlines, the ropes that connect pots together at the seafloor. Grappling without buoys is illegal in many pot fisheries, but it does occur in some areas, as does diving.

Ropeless fishing is the only technique for which there is solid evidence that it would eliminate whale entanglements. No lines in the water means no entanglement risk. It is possible that groundlines and the short segments of ropes that secure surface gear at depth can entangle a whale, but the threat is considered minimal to that posed by vertical lines.

Some key components that distinguish the ropeless systems that exist or are in development are as follows:

Hauling mechanism. Some designs use inflatable bags or buoys, with or without vertical lines, to bring pots at the bottom back to the surface. Others stow the vertical line on top of the pot (or first pot in a multi-pot string) or within a container at the end of the string. A third design uses an inflatable spool around which the vertical line is coiled when at the seafloor.

Depth duty. Units are designed for fishing different depths.

Timed versus on-demand acoustically triggered releases. Bottom set gear may be released to the surface at a preset time using a digital timer or galvanic release, or by an acoustically activated signal transmitted from the vessel. Some companies, such as Teledyne (http://www.teledynemarine.com/benthos/), do not make ropeless systems but sell acoustic releases that can be incorporated into some of the systems.

Pricing. Prices can range from several hundred dollars for a timed shallow-water release to thousands for a deeper water acoustically released unit. Manufacturers do point out however that with increasing demand prices will drop both from a higher scale of production and refinements to the technology.

Geo-tracking. Units include different computer or cell phone-based software so that where the gear is set and other information can be recorded.

During trials and operation of this gear fishermen and researchers report some gear sets becoming entangled during retrieval, however the incidence seems to decrease with refinements and experience using these systems.

What follows is a brief overview of the different systems currently in use or undergoing testing. Their focus is mainly on lobster pot (trap) fisheries however some target crab fisheries. Not much evaluation has been carried out in gillnet fisheries, but the benefit may be less because net panels would still be suspended in the water creating entanglement risk.

FLOTATION SPOOL SYSTEMS

FioBuoy (https://fiomarine.com/)
The line is coiled around a positively buoyant spool. Units operate at maximum depths of 100m or 200m. The rope can be released using a digital timer or acoustic release.

Figure 2. Fiobuoys. At left the 100m unit with digital timer. At right the 200m one with an acoustic release and deckbox.

Its lowest priced model, which is triggered to surface by means of a pre-programmed exact time/date, rated to 100m depth, is approximately USD $2.8K, or $6.4K using an acoustic signal. The company claims it is developing a new model that will sell for $2K.

Fiomarine has been making its fiobuoys for many years and has a long track record of successful applications with the military and industry. Its engagement with the fishing industry is more recent.

The fiobuoy has been evaluated in the following fisheries: California Dungeness crab; California rock crab; California spiny lobster; Scottish brown crab; Scottish langoustine prawn; Scottish European lobster; South Atlantic sea bass; and American lobster.

<u>WHOI Flotation spool</u> (for more info: www.bycatch.org)
Commissioned by the Consortium for Wildlife Reduction, the WHOI flotation spool was designed for offshore gear at the extreme depths of the northeastern U.S. offshore lobster trap fishery. Smaller units could be produced using the same design.

Product specifications:

Maximum diameter	32" (of cheeks located at either end of the spool)
Height	43"
Weight	130lb empty; 340 lb with 900m of ½" diameter line
Operational depth	450m
Buoyancy	>180lb buoyancy (spool and line weight approximately equal to the 180lb anchor used in the fishery

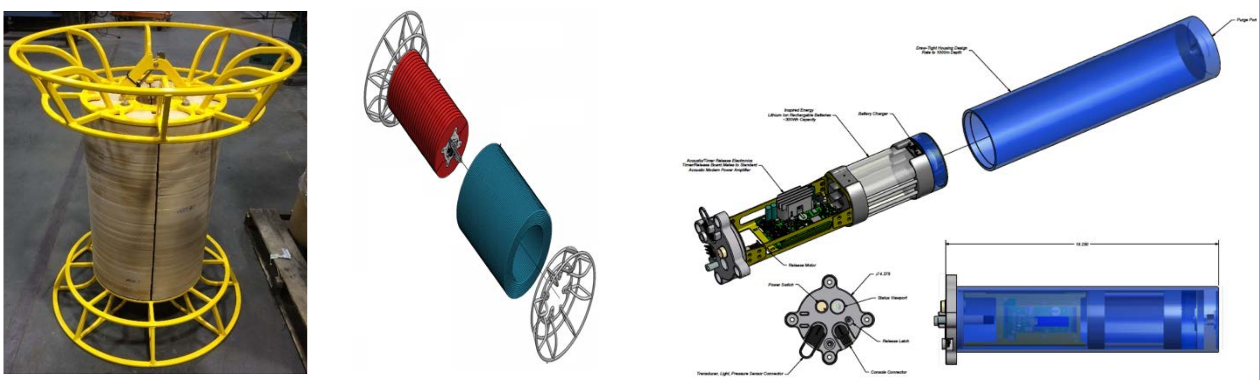

Figure 3. The "pop-up" flotation spool. The center image shows the unit dismantled to facilitate rope coil (blue) replacement, part of the original design that now can use at sea recoiling. At right is a diagram of the acoustic release that is inserted into the center of the spool.

Trials aboard an offshore lobster boat by a mid- to offshore fisherman off Massachusetts with researchers from the Consortium for Wildlife Bycatch Reduction resulted in reliable retrievals, and the fisherman has developed a technique for recoiling the spool at sea, as needed. Only three prototypes exist at present, and each cost approximately $30K to produce.

Figure 4. Spool being hauled on board.

INFLATABLE BAG/BUOY SYSTEMS

Rapid Riser (https://www.ropeless.us/)
A frame is attached to a lobster pot. Within it, an acoustic release (2) activates a tank of compressed air (3) which inflates a bladder (1) to provide sufficient flotation for the unit to return to the surface. No ropes are necessary for a single pot.

Figure 5. The Rapid Riser.

The Rapid Riser has been tested so far to a maximum depth of 300’. Units are not yet priced commercially but research ones run $8250 for the acoustic components and $3625 for the trap assembly, which includes a SCUBA cylinder. This pricing is for the shallower version; a deeper water unit is priced at $8250 + $4620. The company also offers a deck-based gas recharging station for $2745.

SMELTS (https://www.smelts.org/lobster-raft)
Like the rapid riser, SMELTS devices use compressed air from a tank to fill a bag that brings the pot or string of pots to the surface. Each unit costs $7-8000, and a deck box with transducer for communicating with the release would be priced separately and supplied by another company.

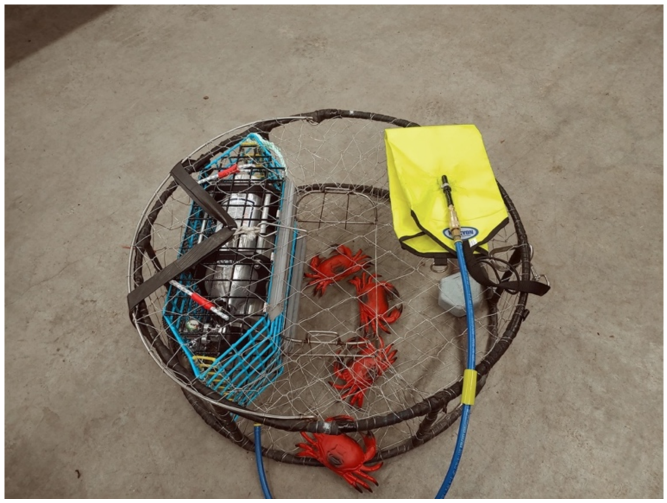

Figure 6. A SMELTS crab raft wireless trap with the bag uninflated.

The company reported that its gear has been tested with crab and lobster fishermen but did not specify which ones.

POT-STOWED ROPES

Edgetech (https://www.edgetech.com/product-category/acoustic-releases-transponders-command-control-systems/)

The Edgetech system was developed primarily for offshore, with the first pot of a multi-pot string consisting of the cage in which the vertical line is stored, and buoys fastened to the top of the trap. The release operates at a maximum depth of 500m, and has a one-year battery life. The company's cell phone app *Trap Tracker* software lets a fisher know where the gear was set and also where it rests on the seabed.

Figure 7. The Edgetech trap in which the vertical line is contained at the seafloor.

A release with with a 48 inch long cage is priced at $4500. The rest of the communication systems cost $4000 for the deck box and $4500 for a hull mounted transducer.

Evaluations of this system have been carried out in the Northeast Atlantic lobster pot fishery and the California Dungeness crab pot fishery.

Ashored

This is a newer company that produces a system with a design similar to that of Edgetech. Its list price is $9000 per “ROC Fishing Starter Kit”, a “rope containment and release module,” and $2500 for each additional MOBI (includes cage, lid, release, 3 key plates, and 2 hard buoys). Releases can be activated using a digital timer or acoustically triggered release.

Figure 8. An Ashored ropeless cage.

Although the system may still be largely in the development phase, tests have been reported to have occurred at least with First Nations fishers in New Brunswick, and the Passamaquoddy Recognition Group.

Desert Star (https://www.desertstar.com/)
Instead of a cage, Desert Star contains ropes and buoys inside a mesh bag, designed with the input of fishers and the New South Wales Government (NSW) in Australia. The bags and floats packed into the bag are recalled to the surface using a *Desert Star* acoustic release, and in the event of a malfunction the line holding the bag closed is attached to a galvanic release that slowly corrodes in seawater so that the gear can eventually be retrieved. The NSW system has been fished to a maximum depth of 115 fm using 180 fm of rope. The bag is tethered 10fm above the trap which measures 6' x 5' x 2' 6 in.

Snow crab fishermen in the Gulf of St. Lawrence have modified the design so the bag opening faces downward rather than upward in relation to the sea surface.

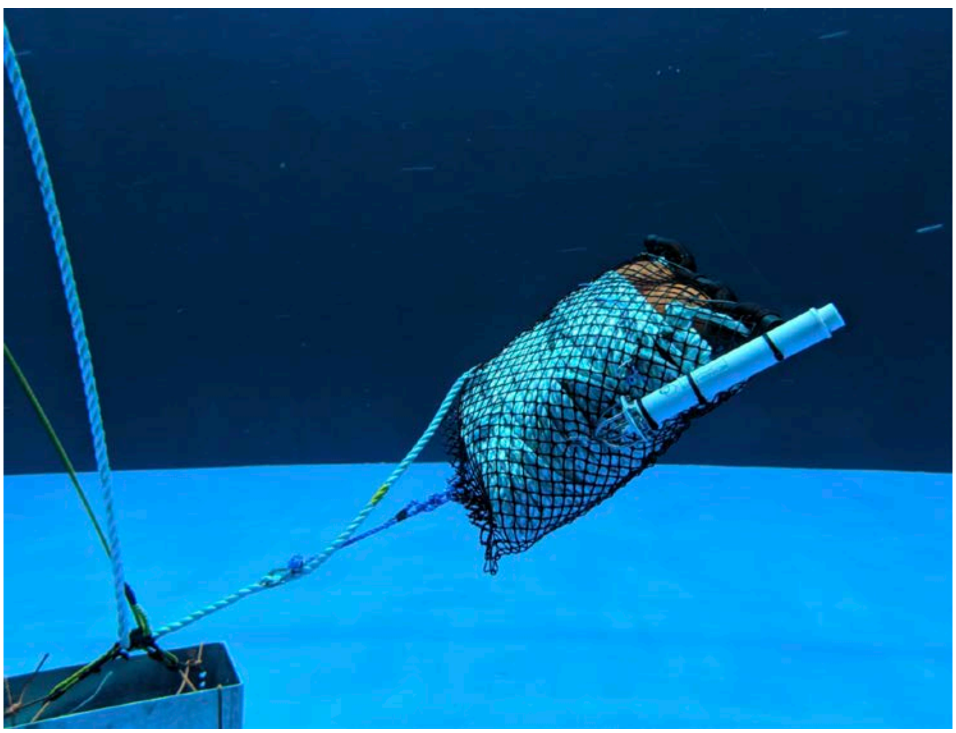

Figure 9. The Desert Star mesh bag and release at depth.

The Desert Star system is fished by two commercial fishermen in Australia, and has been evaluated by the Gulf of St. Lawrence snow crab fishery, among others, such as the Coldwater Lobster Association fishing in Canada's LFA 34, southwestern Nova Scotia, and the Grand Manan Fishermen's Association.

Lobster Lift (https://www.lobsterlift.com/)

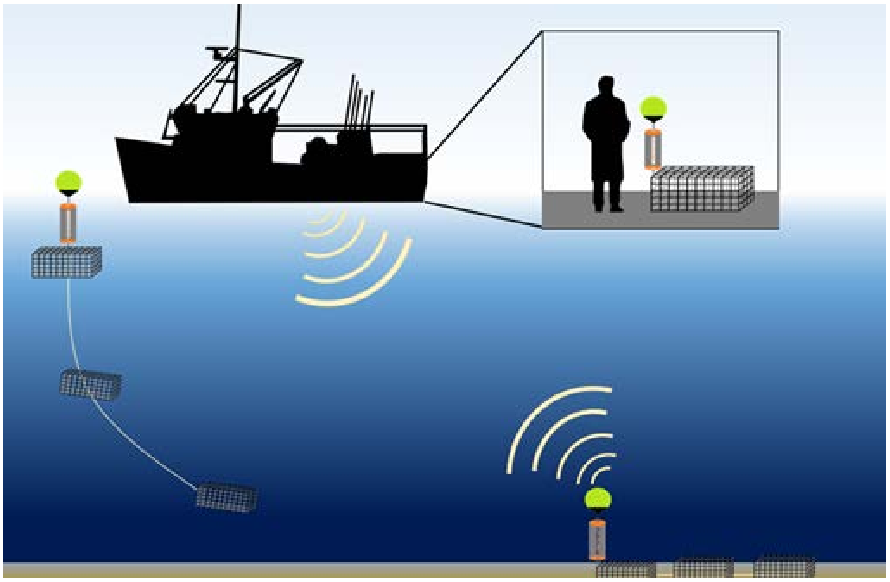

Figure 10. A diagram showing the Lobster Lift system.

The system is designed for lobster pot fishing. It operates with a deck box and includes a gear marking system. Based on the company's diagram on its website, the underwater flotation device is connected directly to the first pot. It is intended to be operational to a maximum of 300' and three-trap pot strings. The target price for the underwater release and buoy lift system is $600/unit. An additional $1000 would be required for deck-based communications.

Sub Sea Sonics (https://www.subseasonics.com/ropeless-fishing)
The Sub Sea Sonics system uses a timed release that can be set in 15-minute increments with a six-month battery life. The hauling rope rests atop the first pot. The current design envisioned a single trap fished at a maximum depth of 500'. A release is priced at $300 and includes a system for marking its location.

Trials off California retrieved pot gear successfully in 123/129 (95%) of trials. In three of the trials the rope became tangled, two failures were related to a battery issue for a single unit, and the other was unidentified. This is typical for many of these systems which tend to show a reduction in failures upon greater familiarity with the gear and small refinements to it.

Figure 11. The Sub Sea Sonics system.

Fisheries in which this system has been evaluated: California Dungeness crab; California spiny lobster; California rock crab; East Coast black sea bass; American lobster; East Coast whelk; and European lobster.

Evaluating New Gear

Both modifications—whale-release ropes and ropeless fishing—are being legislated for implementation in the eastern U.S. and Canada. We can envision an immediate use of whale release ropes, at least in low duty fisheries (closer to shore, shallower water, lower bottom gear weight) while continuing to advance ropeless fisheries to work out challenges such as avoiding gear conflicts when surface buoys that mark their location are no longer used.

Any fisher interested in testing gear of course is free to work independently, but they should also consider being part of a more structured evaluation. Independent assessments are often greeted with suspicion as highly biased, fairly or unfairly. The advantages of carrying out evaluations with researchers include a collaborative learning environment and contributing unbiased results to government, the fishing industry, and other researchers. Researchers also design studies that produce statistically robust results, and not simple comparisons that may produce results from random variability.

Attached as appendices are examples of data sheets formulated for testing whale-release rope and ropeless spools at sea. They are provided as a guide to the kind of information that can be collected to produce useful qualitative and quantitative results when evaluating new fishing gear. Please note that they include collecting information on typical (business as usual) fishing configurations to provide a source of comparison with experimental treatments.

To fund trials, there are at least two existing sources in the U.S. and Canada: the NMFS lending library (eric.matzen@noaa.edu) in the U.S. and the Whalesafe Gear Adoption Fund in Canada (https://www.dfo-mpo.gc.ca/species-especes/mammals-mammiferes/whales-baleines/gear-equipement/index-eng.html). Independent researchers may also know of funding sources and be interested in developing joint proposals for submission to these donors. It is timely to contribute information on using these technologies in the current environment of interest in supporting the evaluation of these gear modifications, and governments looking for input from the industry on if and how best to implement them.

Acknowledgments

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References

Knowlton, A.R., Robbins, J., Landry, S., McKenna, H.A., Kraus, S.D., and Werner, T.B. 2016. Effects of fishing rope strength on the severity of large whale entanglements. *Conservation Biology, 30*(2): 318-328.

Knowlton, A.R., Malloy, R., Jr., Kraus, S.D., and Werner, T.B.. 2018. "Development and evaluation of reduced breaking strength rope to reduce large whale entanglement severity." Final Report to the Office of Energy and Environmental Affairs, State of Massachusetts, under MMARS# CT EVN 0607160000 000 000 3938: 66pp.

NMFS. 1997. Environmental assessment and regulatory impact review of the Atlantic Large Whale Take Reduction Plan and implementing regulations. NMFS Department of Commerce, National Oceanographic and Atmospheric Administration. Gloucester, MA, NMFS. 97 pp.

APPENDIX – Examples of field testing logsheets

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Buoyless Spool Field Testing

Anderson Cabot Center for Ocean Life at the New England Aquarium

Name: ___________________ Vessel: _______________________

Spool Serial #: ______ Spool fixed to: end trap or anchor, approximate weight (lbs): ____________

Trawl Configuration Same trawl as last deployment? Y or N if yes, skip to Setting section
Number of traps: ___________ Weight of a non-end trap (lbs): ________ Safety endline length (ft): __________
Groundline length (ft): __________ Buoy type: (polyball, highflyer, or both)
Endline - diameter______ manufacturer____________ and buoyancy ________
Groundline - diameter _______ manufacturer ___________ buoyancy_______

Setting
Date: ___________ Time: __________ Sea State - wind: _______ direction: ______ wave: _______ temperature: ______ Current: __________
Coil size on spool (m): __300__ Depth (fathom): ________
Location (latitude/longitude) spool end: ____
Location (latitude/longitude) safety endline end: ____
Slope Inclination (1- no slope, 5- steep slope): 1 2 3 4 5 Sediment type: (Circle all that apply): Rock, Mud, Sand

Retrieval
Date: _______ Time: _______ Sea state (provide wind, direction, wave, temperature and current): ___________________________
Weather during soak (calm, storm, etc.) ___________________ Successfully deployed and retrieved? (Y/N) if not why?
________________________ how did you retrieve it: safety endline or grapple
Deployed on first command? (Y/N) if no how many? ______ Total time to re-deploy (time from being hauled on deck to being ready to re-deploy) (mins): _______ Retained Catch (lbs): _______ Spool damage/wear and tear (1- none, 5-severe): 1 2 3 4 5

Notes/Design Recommendations:

This section is provided to indicate any reoccurring issues and to provide your input. Please report gear loss, frequent difficulties, computer application problems, gear changes, recommendations to improve spool design/ recoiling and any other notable information. Please provide as much information as possible.

Field Log Sheet - Weak Rope Example

Contact Name: ______________________ Phone:______________________ Vessel:_________________________

Experimental Trawl #:___________________ Control Trawl #:___________________

Initial Trawl Configuration:

Endline length (ft):______________ Number of pots on trawl:_____________ Date first set:_______________

Distance between pots (ft):______ Weight of a single pot (lbs):__________ Buoy #/type (polyball?, foam?):___________________

*NOTES/GEAR CHANGES SECTION: AS APPROPRIATE, PLEASE REPORT ANY ROPE BREAKS, GEAR LOSSES, LIKELY EXPLANATION FOR GEAR LOSS, GRAPPLING TO RETRIEVE LOST GEAR AND OUTCOME (SUCCESSFUL? REPLACE SLEEVE?), AND CHANGES MADE TO TRAWLS (# OF POTS, SPLICES ADDED, ETC.) - SEE INSTRUCTIONS

Date Hauled	Location (latitute/longitude)	Depth (ft.)	Endline Hauled	Sediment Type Rock, Sand, Mixed	Control Endline Hauled	Notes/Gear Changes
			A B	R S M	C D	
			A B	R S M	C D	
			A B	R S M	C D	
			A B	R S M	C D	
			A B	R S M	C D	
			A B	R S M	C D	
			A B	R S M	C D	
			A B	R S M	C D	
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			A B	R S M	C D	
			A B	R S M	C D	

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