An evaluation of at-sea field trials of a ropeless lobster fishing method in LFA 34.

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Summary

Concern over entanglements of endangered North Atlantic right whales (*Eubalaena glacialis*) in fishing ropes/gear has resulted in the development of alternative methods to reduce the vertical lines (ropes) in the water while fishing for lobsters. Coldwater Lobster Association, a lobster fishermen's association based out of Yarmouth, Nova Scotia, conducted a field trial to evaluate a "ropeless" fishing method developed by Desert Star Systems. The goal was to assess the advantages and limitations of this technology and determine if ropeless lobster fishing gear could be successful in Lobster Fishing Area 34.

The captains and crews of three fishing vessels participated in the study, out-of-season in the fall of 2018. Following several days of on-shore classroom training, at-sea trials were conducted. Three aspects of ropeless fishing were examined: (1) the acoustic release system of communication between the boat and the gear on the sea floor, (2) the rope bag containment systems that stored floats (buoys) and buoy line which could be released on demand to send the rope to the surface and (3) the Ropeless Fishing™ app, a virtual marking system to allow harvesters to see the GPS coordinates where other harvesters have set their trawls to avoid gear overlay.

During one of the deployments, an acoustic release device failed because of flooding (1 of 26 units) but overall the releasers operated at the appropriate time. There were difficulties in making contact between the fishing vessel and the acoustic release on the bottom, particularly in rough weather. In these cases, multiple attempts to position the boat close enough to the device to establish contact were necessary. There were a number of issues with the rope bags and the ability to locate the floats as they rose to the surface. Overall, there was a 16-30% failure rate associated with the releases. In some cases, a tidal current dragged the float and buoy line under the water before it could be retrieved. When the rope bags were not tightly packed, some snarls occurred. A few times the rope bags failed to open after the acoustic release fired because a release cord snagged. The design of the rope bag will have to be improved before it could be adopted for general use. The system of alerting other harvesters to the locations of trawls was tested by deploying trawls in close proximity to others. Initially trawls were deployed half a mile from others and, over the day, the distances were reduced to about a quarter mile apart. None of the 22 trawls deployed that day were overlaid with others. This system only worked in areas where Wi-Fi coverage was available, however.

There are some major problems with the ropeless fishing system. The absence of a safety line (buoy and buoy line at the end of a trawl being deployed) means that it would take considerable time to retrieve a trawl that has taken a fisherman overboard. The extra time it takes to locate the acoustic release at the end of a trawl, get the buoy on board and repack the rope bag would add 10-20 minutes to the time it takes to handle each trawl. By these estimates, it could add 3 or more hours per day if 20 trawls are being fished. Considerable time searching will be required if a trawl is moved by a storm or dragging fishing gear because of the limited acoustic communication range. Extra equipment would have to be purchased and crews would have to be properly trained on the technology and the overall concept before they could engage in ropeless fishing. Having all of the harvesters in LFA 34 switching to a ropeless system could take 10 years. If area closures are expected to be temporary, it might be less costly for individual

boats to simply stop fishing for the duration of the closure rather than taking on the expense of purchasing the ropeless technology and gear and perhaps never using it. Coldwater Lobster Association, or other fishermens' associations, may wish to consider obtaining a stockpile of ropeless equipment that could be rented out to harvesters should an area be temporarily closed. The cost of such an endeavor would require financial assistance from government and possibly environmental NGOs.

The significant capital costs of the equipment and training required to adopt a ropeless fishing ability may not be warranted in lobster fishing areas where only occasional and short-term closures associated with North Atlantic right whale presence are likely. Due to the additional hauling and redeployment time, problems with the current dragging floats underwater, and the inability to access Wi-Fi to operate the Ropeless Fisher™ app in much of LFA 34, ropeless fishing may not be viable in LFA 34 at this time.

Introduction

North Atlantic right whales (NARW, *Eubalaena glacialis*) are considered endangered by both the Canadian Species at Risk Act (SARA) and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (Anonymous 2018a). The current population estimate is that there are 411 whales and of these, only about 71 are reproductive females (Anonymous 2018b). Of the 12 right whales that died in Canadian waters in the summer and fall of 2017, 2 were confirmed to have died as a result of entanglement with fishing ropes. An immediate response to this situation in 2018 was the temporary closure of a number of fishing areas, particularly in the Gulf of St. Lawrence, by the Department of Fisheries and Oceans Canada (DFO). Some of the areas (28 grids in the Gulf of St. Lawrence) have been closed for some time and on 6 November 2018 an additional 30 grids were newly closed (Anonymous, 2018c). This last set of fisheries closures was in response to the sightings of three and six NARWs roughly mid-way between the southern tip of the Magdalen Islands and the northern tip of Prince Edward Island. These whales will likely begin their annual southward migration before winter as they are not expected to remain in the Gulf of St. Lawrence over the winter. On their southward migration in late Fall, and on their northern migration in May, it is possible that NARW could be sighted travelling through some regions of Lobster Fishing Area (LFA) 34. If so, this may result in the temporary closure of some sections of LFA 34 to lobster fishing. Area closures are intended to remove the likelihood of a whale being entangled in rope and the attached fishing gear in the event of a confirmed sighting of a NARW during the fishing season.

NARW are large bodied baleen whales that principally feed on copepods during the summer. The food supply during the summer and fall in the Grand Manan Basin, Roseway Basin and Western Gulf of St. Lawrence attracts the whales to these areas. Many aspects of their life history and distribution patterns are not well known. For example, various sources place their longevity at 30, 50 or more than 75 years. Females become sexually mature around ten years and can give birth every two to six years. It is estimated that a female may give birth as few as five to six times during her lifetime. This low rate of reproduction means that it will take a long time for the population to recover. The NARW population has the biological potential to increase by 4% per year. Unfortunately, the abundance since 1990 only increased by 2% per year, then began to slightly decrease and there has been a population decline of possibly 40 whales in the last year (Anonymous 2018b). Anthropogenic mortality has limited the recovery of the NARW population (Corkeron et al., 2018). The accidental entanglement and death of any of the breeding females will further slow and reduce the chance of a population increase. Deaths caused by fishing gear entanglements or ship strikes, especially of reproductive females, will reduce the NARW population below its current level of about 411 animals and only 71 breeding females (Anonymous 2018b). There is a very real possibility that the NARW will become extinct. It will be possible to increase the NARW population to a safe level but this will require extreme measures to protect them. Large whales are charismatic animals. Large segments of the public in both Canada and the United States will support conservation measures to help protect them and keep the species from going extinct.

While feeding, NARWs can dive to the bottom (at least 110 fathoms: Baumgartner and Mate, 2005) and stay underwater for 20 minutes or more. Three quarters of NARW entanglements involved the head or mouth region as the point of gear attachment (Cavatorata et al., 2005). This implies that while feeding, the whales are becoming entangled in ropes that go from the fishing gear on the sea floor to buoys on the water's surface. Once the rope has been caught in the whale's baleen, it can then be wrapped around the body and flippers as the whale roles to try to free itself. Using scarring patterns, Knowlton et al. (2012) estimated that 83% of the NARW have been entangled once, 59% entangled more than once and each year about 15% of the population becomes entangled. These figures do not include times that NARWs brushed against ropes or were entangled briefly and no scarring occurred. Ropes in the water are presenting a significant hazard to NARWs.

Kraus et al. (2014) have demonstrated that near the surface, red and orange coloured rope may be better avoided by NARWs that black or green ropes. At depth, however, where there is less light and thus less contrast between the rope colour and the background illumination, colour may not be that useful in helping the whales avoid the ropes. Moreover, the placement of the eyes on the sides of the head suggest that the whales may not be able to see very well directly in front of them, making avoiding ropes more difficult.

Another approach to reducing whale entanglements in fishing and other gear in the ocean is to adopt a ropeless strategy. Ropeless fishing methods will involve placing the fishing gear on the sea floor along with a mechanism to release a float (buoy) that will bring a buoy line up to the surface on demand for retrieval. Thus, fishing rope would only be vertical in the water column when the harvester is nearby and intending to raise the gear to the surface.

On-demand releases of bottom mounted buoy and buoy line systems have been proposed to greatly reduce vertical ropes in the water associated with lobster and crab fishing. Large pieces of scientific equipment have been deployed using a system where the device is attached to a floatation collar and held to an anchor by an acoustic release device. Upon receiving a specific acoustic signal, the device detaches from the anchor and the equipment floats to the surface for retrieval. In this case, the anchor remains on the sea floor and no ropes are involved. To alter the system for ropeless fishing purposes, the acoustic release device releases a float and buoy line of sufficient length and strength to reach the surface, be retrieved by the fishing crew, and used to haul up the anchors and traps. The advantage of this system is that the floats and ropes are only released when the harvester is present and vertical rope is only in the water for a very short period of time.

In the fall of 2018, Coldwater Lobster Association of Yarmouth, Nova Scotia, conducted a field trial of an acoustic release fishing technology to assess if it could be adopted in Lobster Fishing Area 34 (LFA 34). There are 975 lobster fishing licenses in LFA 34 and it is one of the most lucrative fishing areas in Canada. LFA 34 covers an area of 8,500 square miles off the western coast of Nova Scotia. The late November to May lobster fishing period is characterized by winds and rough seas, often few daylight hours, periods of low visibility and cold temperatures. Many of the harvesters fish close to shore but others sail two hours or more offshore to their fishing areas. Except during severe weather, the harvesters go out on a daily basis in December and May and three times a week in the intervening months. The work is physically demanding and dangerous. Each captain has to have made a large capital investment in the license, fishing boat, electronics, and fishing gear and cover the operating costs of a crew, fuel, insurance, etc. The Desert Star System acoustic release technology (ropeless fishing) system was used in the field trials. The trials were financially supported by the both the Atlantic Fisheries Fund (AFF) and Coldwater Lobster. Three fishing vessels participated in the study. The captains and crews underwent three days of on-shore classroom training prior to conducting at-sea trials. The following assessment of Desert Star System's ropeless fishing system was prepared using notes and related information from the manufacturer, field data forms and verbal reports from the captains and crews during the trial period, and especially observations made during three days at the end of the trial period when the gear was deployed under close-to-natural fishing conditions. The Desert Star System has three major components: the acoustic release system (ARC-1XD units and the surface station), the underwater float and rope containment (rope bag) and the ability of the gear location marking system (Ropeless Fisher™ app) to distinguish the ends of the trawls to ensure that gear overlay can be prevented. These will be assessed separately along with other issues such as the strength of tidal currents, bottom topography, water depth, visibility of the floats, and Wi-Fi dead zones. Other general aspects associated with ropeless fishing such as other types of ropeless gear, relations with the regulators, and implementation considerations will be presented.

1. The acoustic release system.

The system consists of a topside control unit (STM-3 deck box), a hull-mounted transducer, an over-the-side transducer and individual acoustic releases (ARC-1XD) that function by releasing a submerged float and rope system. Communication between the deck box and the submerged acoustic release is via a series of coded acoustic signals. The signals are 4 millisecond pules between 34 and 42 kHz that have a coded pattern. There are two modes of operation to activate a release: an individual release mode in which the signals are only recognized by a specific release device and a broadcast release mode in which all of the acoustic releases that the harvester owns (and are within range of the acoustic signals) will be activated.

In the individual release mode, the code related to a specific ARC-1XD is selected on the deck box. The transducer will emit a coded signal that will initiate an acoustic response by the ARC-1XD. This signal will provide information on the direct distance between the boat and the acoustic release and the battery status. The harvester can then position the boat closer to the acoustic release, optimally ending up directly above it. When the boat is closer to the ARC-1XD, the harvester issues a release command on the deck box. Upon receipt of this command, the release device acoustically acknowledges receipt of the command and when is has fired, releasing the float and rope. This released signal indicates to the crew when they should be on the look-out for the float(s) so that they can maneuver the boat to retrieve the buoy line and haul in the trawl.

In the broadcast release mode, the ARC-1 XD releases as soon as it detects the signal from the deck box and it does not acknowledge when it has released the float(s) etc. This can result in the floats coming to the surface some distance from the boat. The range of the broadcast release signal is limited by the maximum detection range of the acoustic releasers, which is approximately 200 fathoms.

The hull-mounted transducer sends out a cone of sound that is about 60º wide. In the trial, all three boats mounted the transducer in the hull such that it was aimed straight down. The diameter of the cone of sound that reaches the sea floor is equal to the depth of the water. Most of the attempted contacts with the ARC-1XD units were made using the hull-mounted transducer. The over-the-side transducer produces an omnidirectional signal that has a slightly lower amplitude than that of the hull mounted unit but ensonifies (the area receiving the sounds) a greater area of the bottom.

The sensitivity of the deck box system can be adjusted to take background noise (acoustical and to a lesser extent electrical noise) into account. The first step is to measure the noise level detected by the transducer connected to the deck box. In relatively quiet conditions, the sensitivity of the system is set to 120 dB [re 1 µPa] as this provides the greatest operating signal-to-noise range between the deck unit and the acoustic release unit. In a noisy environment, the sensitivity can be lowered (= detection threshold raised) to up to 150 dB [re 1 µPa]. This will reduce the communication range between the deck unit and the acoustic release but will limit interference allowing the surface station to have a clear communication channel with the ARC-1 XD units.

The release mechanism on the ARC-1XD units uses a plastic lever that is held in place by a fusible nickel-chromium wire stretched across two metal posts. The fuse wire is threaded through a small opening near the top of each post and held in place by a screw that is tightened using an allen key. Upon receiving a release command from the deck box, an electrical current is passed through the wire, a direct short occurs, and the wire melts, thus freeing the lever arm. The end loop of a small diameter release cord is held in place by the lever arm until the arm swings down, thus releasing it. This system operates at a mechanical advantage (like a wheelbarrow) such that the pull on the releasing rope can be much greater than the pressure on the fuse wire by the lever arm. Even so, the manufacturer recommends that the force of the releasing rope be no greater than 40 pounds, a 2x safety factor as the fuse wire could break if a force of 80 pounds is applied to the releasing rope. The operation of this lever arm and release cord and the re-arming of the ARC-1XD will be covered in the section on the rope bag.

The burn-wire release mechanism has the disadvantage that the direct pull on the release lever should be limited to 40-80 pounds. The advantage of this type of release is that there are no moving parts going from the inside of the acoustic release device to the outside. This removes the problem of having to seal a drive shaft against the external water pressure and it is not necessary to provide a motor or solenoid along with the additional battery power to run them. Some other manufacturers of acoustic release devices use motors or solenoids to operate the release mechanism but their units are typically three to four times more expensive.

Observations

Twenty-three at-sea trials were conducted during which 130-140 retrieval attempts were made. Of these, 94 retrieval attempts were documented in detail. Several “non-releases” were observed and documented. One release failure was caused by an ARC-1XD unit becoming flooded with sea water. Two retrievals were unsuccessful because the ARC-1 XD did not fire and melt the fuse wire. It was later discovered that the fault was likely caused by interference from electrical noise that was present in the inverter of the boat’s power system. Six ARC-1XD units could not be interrogated on the first try (individual mode). Four of these were successfully fired using the broadcast mode and one using the individual mode during attempts made over an hour later or the next day. One ARC-1XD unit that could not be interrogated was raised using a safety line. This failed interrogation may have been due to a problem with positioning the boat close enough to the release unit. One captain reported that when the waves were rough (7 to 9 feet) he would have to line up the boat over the trawl end five or six times before communication was established with the ARC-1XDs.

Interrogation with the ARC-1XD while the boat motor was in gear was generally not possible as it was determined that it was too noisy. Similarly, depth sounders also had to be turned off while producing the acoustical communication codes. The problem with the depth sounders is that many of them produce short pulses at 50 kHz. When sounds are created as short duration pulses, frequency side bands develop and these will present acoustic energy at lower and higher frequencies. When these pulses overlap the communication signals between the deck unit and the acoustic release, they essentially change the code by adding additional digits. Interference between the acoustic signals of different companies will not likely be a problem.

The captains reported that interrogations of the ARC-1XD began at ranges of 130 m to 50 m with the linking to the ARC-1XD being achieved at ranges of 100 to 30 m. For both measures, values of 50 m or less were commonly reported. The measures of the distance when the interrogations began are really the distances at which the captains expected to locate the ARC-1XD s, based on the GPS locations of the gear they wished to raise. The individual mode is better than the broadcast mode, in part because while operating in the individual mode the floats are likely to be closer to the boat when they surface. Moreover, the individual release mode gave the captains and crew an expected time of when the buoy(s) would be expected to surface. In the broadcast mode, there is no timeline of when the buoy(s) would be expected to surface and, when the tide is strong, it would be harder to gauge if the buoy(s) had been dragged under buy the current.

There was one observation of a fuse wire breaking while the rope bag was being prepared for deployment. Rearming took 2.5 minutes, in part because the fuse wire and tools had been put away in the cabin. There were no observations of a break in the fuse wire of any of the deployed ARC-1XDs that had not been fired.

There was a consensus among the captains that the acoustic release equipment worked well overall. The time to locate an ARC-1XD takes longer than regular lobster fishing operations whereby a captain would simply look for a larger buoy or highflyer that was set to mark his/her gear. One captain noted that it was difficult to keep his attention focused on the plotters and operate the deck box (which was located six feet away from the wheel because of space limitations) while maneuvering the boat to locate the ARC-1XD. As the captains gained experience with the acoustic release system, they felt more comfortable positioning their boat using the GPS locations of the ends of their trawls as a starting point and then used previous ARC-1XD locations that day to judge the likely drift during initial deployment. The added time required to search and locate the ARC-1XD is a concern. There is also the question of when the captain should give up when the connection is not made with the ARC-1XD unit at one end of the trawl and try to raise the acoustic device at the other end of the trawl, or simply search for another set trawl or begin to grapple. In some cases, particularly after storms, the trawls may have moved quite some distance and this would make locating them particularly difficult to impossible.

The manufacturer has considered the potential for the acoustic signals from the through-the-hull transducer to adversely affect the hearing of nearby marine mammals (Flagg, 2018). Using the over-the-side transducer, the interrogation signal was recorded in shallow water in a harbour. A hydrophone connected to a digital recorder were used. The interrogation signals are a series of 6, 4-msec pulses over 3.6 seconds that are spaced by 4.5 seconds. The hull-mounted system produces a cone of sound that faces downwards, in the same manner as a depth sounder. The over-the-side system presents sound in an omnidirectional pattern which would result in relatively high sound levels beside the boat as well as underneath but the levels are a few dB lower. Harbour porpoises (*Phocoena phocoena*) have the most sensitive hearing thresholds at 30-40 kHz of all marine mammals. The detection threshold for a long tone at 30-40 kHz is 45 dB re 1 µPa (Kastelein et al., 2015). When a short signal duration of only 4 msec is taken into account, the detection threshold would be expected to be raised by about 16 dB to 61 dB re 1 µPa. The maximum sound level of the through-the-hull transducer is 197 dB re 1 µPa at 1 m. At 10 m, the level will drop to 177 dB re 1 µPa. This level is about 116 dB above the detection threshold of a porpoise. If a porpoise was swimming under the boat when the interrogation signals began, they would be exposed to loud, short duration clicks that, in human terms, would resemble a very loud finger snap or a toy “cricket” held very close to the ear. While this would likely disturb the porpoise, it is unlikely to cause permanent hearing loss, especially as the porpoise could swim away and would only be exposed to a few such clicks at most. This analysis is different than the one used by M. Flagg (2018), but both come to the conclusion that the use of acoustic release devices are unlikely to cause hearing loss or “noise pollution” problems with marine mammals.

Of the documented 94 tests of the ARC-1XD system, although there 12 operational failures recorded, only one unit failed completely (flooded). By another measure, of the 26 ARC-1XD units involved in the trial, one failed due to flooding. The other ARC-1XD s were retrieved and worked properly in later trials. The electrical noise problem from the boat’s inverter was corrected. The major problem was in bringing the boat close enough to the ARC-1XD unit to communicate with it.

Major problems

If a fishing trawl has drifted farther than expected from the GPS locations of the first and last anchor, been moved by a storm, or a dragger fishing vessel, it will be difficult, and certainly very time consuming, to locate the ARC-1XDs and retrieve one’s gear. Searching would entail steaming in an ever-widening circle around the last known position until contact was made with an ARC-1XD.

In very rough weather, when a boat is pitching around it may not be possible to use the hull-mounted transducer because the direction it is aiming will be continually changing. This will especially be a problem in shallower water because the diameter of the ensonified area on the sea floor is equal to the depth. Like a flashlight beam, the closer the source is to the target, the smaller the area that can be seen.

Locating the ARC-1XD units will take longer than locating surface buoys and high-flyers. This will add at least a few minutes to the beginning of every trawl recovery. The total extra time per day will be significant.

Replacing the burn wire and rearming the ARC-1XD when it is dark and cold could take some time. Replacing the burn wire has been compared to "threading a needle" and would be difficult in inclement weather with winds, a rocking deck and cold fingers in rubber gloves. The total extra time per day it could take to do this task could be significant.

Potential improvements

One improvement that was presented by the developer, M. Flagg, would be to aim the hull-mounted transducer forward, perhaps by as much as 60º. This angle provides better coverage to be able to locate the direction of the ARC-1XD using the distance measure and the direction of the boat. With the 60º outgoing signal cone, the ARC-1XD units would be detected when farther away because the area of the bottom that was ensonified by the hull transducer would cover a greater area on the bottom than if the cone was aimed directly below the boat.

Another potential improvement presented by M. Flagg would be to redesign the hull-mounted transducer so it could be switchable between three directional modes: a 60º cone pointing downwards, a 60º cone pointing forwards at 45º to 60º and an omnidirectional 360º pattern.

With additional software and connections to a GPS receiver, it may be possible to create a program that would allow locating an ARC-1XD using the distance between the ARC-1XD and the boat and the GPS position of the boat. By combining a number of distance measures with the GPS locations, in theory it should be possible to triangulate the positon of the ARC-1XD unit.

2. The rope bag containment system

The design of the rope bag was developed initially by commercial fishermen in New South Wales, Australia, with insight from Desert Star Systems. The same prototype for the rope bags was followed for the purposes of this trial. The captains and crews modified the rope bags and/or cages as snags were identified as the trials progressed.

A rope bag is used to house the ARC-1XD unit, hard plastic float(s) and the buoy line that can be two to three times the water depth. The bag, made of plastic oyster mesh, varied in size depending on the depth the harvester was fishing (greater depths require more buoy line). The bag is lined with polyvinyl chloride (PVC) piping to help maintain its shape and, has a hinged wire lid that is kept closed by a thin release cord that goes to the acoustic release mechanism of the ARC-1XD. The ARC-1XD unit is attached to the external side of the bag such that the transducer end is upright and slightly above the top (approximately 5 inches). The lower end of the ARC-1XD is attached to the external side of the bag with the release mechanism pointing downward (Figure 1). The buoy line runs from the anchor at the end of the trawl, into the bottom of the bag where it is coiled and stuffed tight and attached to one or two float buoys. The distance between the anchor and the rope bag should be about 2 fathoms. This is to keep the anchor and rope bag from fouling each other during deployment and to keep the bag as close as possible to the sea floor. The release cord has a loop that circles the release arm of the ARC-1XD, then runs over a protective cage of two crossed rods (Figure 2), through some rings fastened to the side of the bag, and over the wire lid to a bungee cord that provides the tension needed to keep the lid closed. When the ARC-1XD fires, the lever releases the end of the release cord thus in turn releasing the wire lid and enabling the buoys to float to the surface along with the buoy line. The rope bag is attached to the buoy line near the anchor by a separate short rope and clip.

During the initial trials, as the captains and crew were becoming familiar with the technology, a rope bag with an ARC-1XD was attached to one end of the trawl and a "safety" line (rope and buoy) was left on the other end of the trawl to ensure that no gear was "lost". Later, rope bags with ARC-1XDs attached were deployed at both ends of the trawl, without a safety rope and float. Ropeless lobster fishing will require a rope bag at each end of the trawl. This will give the harvester a second chance to retrieve the trawl if the buoy line of the first rope bag fails to reach the surface.

The rope bag has to be repacked and the ARC-1XD rearmed on the open deck after each trawl is recovered. During recovery, a crewman takes the surfaced float(s) away from the hauler and begins to coil the rope as it comes up. After the rope bag and anchor are brought on board, the anchor is moved to the holder at the back of the deck, and the coil of buoy line is brought to the same side of the deck as the anchor holder. The rope coil is then turned upside down and one of the crew can begin to repack the rope bag. Handfuls of coiled rope are stuffed into the bag and packed down by pushing from above. Finally, the float(s) are stuffed into the top of the bag on top of the buoy line. The next step is to pull on the bungee cord to provide slack so the release cord can be threaded over the lid of the bag, through the guidance rings, over the ARC-1XD's protective cage and looped around the release lever. Then the fuse wire to hold down the release lever if put in place. It is possible for one crew member to do this task however it would be easier and faster if one person held the bag and release cord while the other crew member stuffs the bag and then replaces the fuse wire. The electronics of the ARC-1XD unit are always on and do not need any changes or adjustments during rearming or redeployment. During deployment of the trawl, the rope bag is pulled off the deck just after the second anchor. The rope bag has to be robust enough to withstand being dragged across the stern of the boat and bounced off the deck into the water.

Figure 1. A rope bag ready to be deployed. The white ARC-1XD is strapped to the left side of the bag. The blue release cord (blue arrow) runs through two rings (yellow arrows) and around the wire lid (black arrow) to a bungee cord (red arrow).

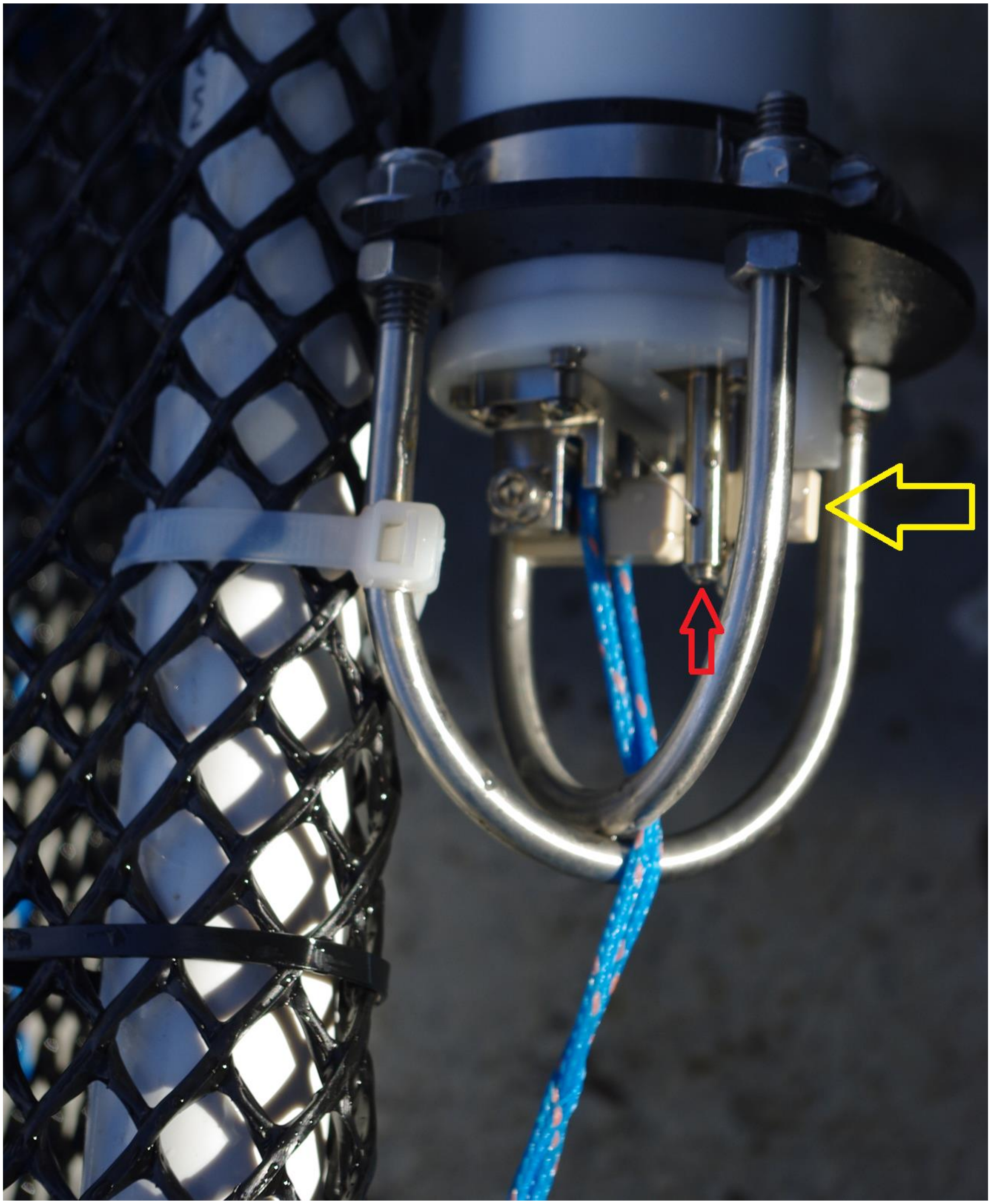

Figure 2. The release mechanism of the ARC-1XD acoustic release device. The device is armed and the loop at the end of the blue release cord is around the release lever (yellow arrow). One of the two posts that holds the nickel-chromium fuse wire across the release lever is identified by the red arrow. The release cord must run through the opening of the bent rod protective cage on the far side of the rope bag so that the release cord is pulled straight down.

Observations

There were a significant number of problems with the rope bags. The captains reported a general failure/problem rate of about 30%, but not all of these were fully documented. Using the documented (fully described) data prepared by the captains, there were 12 bag failures and two losses in 88 deployments – a 16% failure rate. The overall failure rate is 16-30%. Failures included:
- floats remaining in the bag due to snagging of the releasing cord;
- the rope becoming snarled as it exited the bag;
- the float coming out when the bag bounced over the deck during deployment;
- a broken tie down pressed against the release arm of the ARC-1XD so it could not open;
- the wire lid catching on another part of the bag and not opening up;
- one rope bag was lost when the rope attaching it to the buoy line was broken as it went over the hauling block and it fell overboard; and,
. one rope bag was lost (and never seen) during recovery.

The release cords occasionally snagged on the ARC-1XD release lever post or one of the rings they had to pass through after being released. There is a design problem associated with the release cord operation. The ARC-1XD has to be attached to the rope bag so that the transducer end is at least a few inches above the top of the bag as is floats upright in the water. This is to ensure that the bag and rope do not block the acoustic signal from the boat. This results in the release lever opening "upside down" at the other end. When the lever arm is opened after the ARC-1XD fires, the loop in the cord at the free end of the release cord has to move downward and then through a series of rings attached to the outside of the bag, change direction by 180º to run up and over the wire lid to the bungee cord that pulls the release rope toward the bottom of the rope bag on the other side. The pull from the bungee cord and the upward pressure on the wire lid from the floats, drags the release rope through the rings. The two bent rods that form a protective cage over the release mechanism form a cross a few inches from the release lever. If the release cord is passed through the opening of the protective cage that is on the opposite side of the bag, the release cord is pulled straight down (Figue 2). In one case, the release cord was threaded through the protective cage on the bag side of the ARC-1XD. This meant that the loop on the end of the release cord was pulled sideways and it caught up on the side of the release arm. This fault was due to human error during the rearming procedure. In other cases, knots or taped knots associated with the loop at the end of the release cord caught on one of the guidance rings on the outside of the bag. The tension from the bungee cord and the steep angle change as the cord passed through the ring were enough to snag the cord. This problem was lessened during the trials by replacing the initial small diameter rings with rings of a larger diameter. Some of the guidance rings broke away and had to be replaced before repacking the rope bags. This type of repair was done on the deck in a few minutes but spares and the appropriate tools had to be handy.

Coldwater Lobster Association tested different sized rope bags and one rope cage prototype. The smaller bags were designed to hold less buoy line while the larger bags could hold more rope and two larger floats. The larger bags were unwieldy to handle. One of the releases using a larger bag resulted in a snarl of the buoy line and the float did not reach the surface. It was suggested that the bag was not packed tight enough and the some of the rope could have floated up between the coils before the floats were released, thus causing the snarl. This problem may be lessened by packing the rope tightly in the bags. As such, the size of the bag will have to match the desired lengths of buoy line. In one case, additional rope was added when it was discovered that the first rope only filled the bag just past halfway. In that case, it took 9 minutes to fill the bag because additional rope was added, a ring had to be replaced on the outside, and it took another 4 minutes to rearm it. Too much rope in a bag will put too great a strain on the wire lid and in one case an 11-inch float popped out while the release cord was still intact.

There was a suggestion that the roughness on the inner side of the plastic mesh of the bag might be a benefit that reduces snarling. The inner surface would offer some resistance to the rope floating out and thus the rope higher up in the bag would be released first. That may reduce the probability of some lower portions of the rope floating above other coils and causing a snarl.

The shape and size of the wire lid will have to be adjusted to accommodate different numbers and sizes of floats. If the lid is too small, the floats can be ejected during deployment.

The time it took for the floats to reach the surface after the ARC-1XD fired varied with depth and current. The surfacing times were from 20 seconds to 3 minutes, but this sometimes included the time it took to confirm visual sighting of the floats after they surfaced. The float(s) from one 200 fathom bag reached the surface near the boat in 1.1 minutes.

The time that the floats stayed on the surface varied greatly. During the day when the currents were running stronger, some floats were dragged under the surface without ever being seen. The time that the floats remained on the surface ranged from as short as 30 seconds up to 3.25 minutes. In one case the first pass to retrieve a float missed and the float sank before the boat could get back for a second try. In another case, the crew observed a float and long length of buoy line on the water's surface. The buoy line slowly straightened out as more rope was dragged under and after about 2 minutes, the float was also dragged under. On other days none of the floats were dragged under.

The floats were usually spotted quickly when they surfaced close to the boat. They were harder to spot when more than 50 m or so away, especially when waves were present. Under poor light conditions, fog or snowy conditions, the task would become more difficult. This will primarily be an issue when floats are being dragged under by currents and observation time is limited. When the floats are surfacing, all of the crew must be on the lookout in order to view a full 360º around the boat.

When a single float is being used, if the slack rope has been pulled under, it is difficult to retrieve. There can be a strong pull by the submerged rope which makes it difficult to lift the float and rope into the hauler. Two floats would aid in retrieval and lifting the line into the hauler on the boat but if the floats have to be smaller to fit into the rope bag, they may be dragged under sooner than would be the case for a single, larger float.

The buoyant force of an 8-inch hard plastic float is about 9 pounds and that of an 11-inch float is about 25 pounds. The underwater lift by the floats and buoy line combined may require using a 90-pound anchor rather than the usual 50 pound anchor. If the tidal current near the bottom is strong enough, the resistance offered by the rope bag, and its buoyancy, may lift a lighter anchor off the bottom. Placing a 90 pound anchor in the anchor holder at the stern will be more dangerous than the lighter anchor, particularly when the deck is rocking.

The average time taken to haul the ropeless gear was reported as 23.3 ± 7.1 minutes (range is 7 - 44 minutes, 54 samples, Figure 3) while for the controls the average time was 18.5 ± 2.0 minutes (range is 15 – 20 minutes, 6 samples). This does not include times when the attempt was temporarily abandoned or grappling was performed.   It can take an additional 5 or more minutes to locate the ARC-1XD and initiate the release of the buoys.

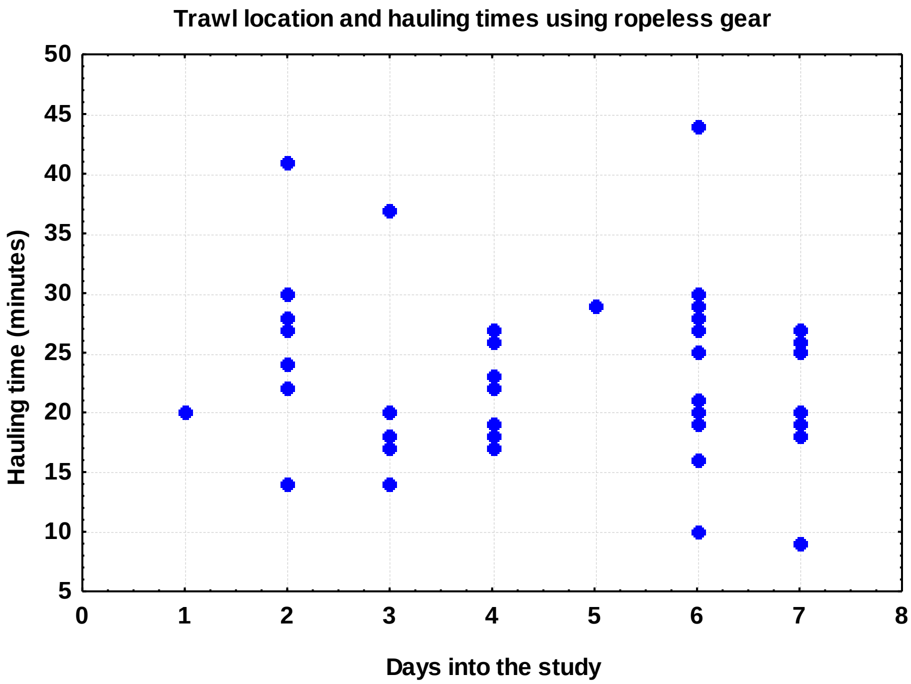

Figure 3. The time taken to locate and haul trawls using the ropeless fishing equipment did not change with experience. The average time is 5 minutes longer than for traditional gear with floats.

In a separate section on the data sheet questionnaire the captains estimated the time added to recovering and redeploying each trawl. While some provided specific times, most reports presented a range of times. The low estimate of additional time is 13.6 ± 7.0 minutes (range is 7 to 20 minutes, sample size is 12) while the higher estimate is 30.0 ± 25 minutes, (range is 9 to 90 minutes, sample size is 8). One key observation made from the field data sheets was that the additional gear handling time estimates did not become shorter as the captains and crews had greater experience with the system (Figure 3).

During some trials a crewman repacked the rope bag and rearmed it while the captain and the other crewman lifted the trawl. In these cases, only a few extra minutes were required to locate, lift and redeploy a trawl but this left only one crewman to handle the lobster pots as they came up. In most cases, however, the rope bag was repacked and rearmed after the trawl had been lifted. When the buoy line was coiled as it first came in, the repacking of the bag went much quicker, unless the coils fell apart while being moved to the other side of the boat and had to be sorted before being put back in the bag. Overall, it seem likely that the ropeless system will require 10-15 additional minutes per trawl, comparted to the present system with floats. This time could be slightly reduced if an additional crewman was hired but this would be an added expense for the captain.

Location and retrieval of the floats was occasionally a problem. The tendency for the floats to be pulled under when the current was strong is a major issue. While it is not possible to determine why a float was not seen after it was released, it could be that some of them never reached the surface or were pulled under before they were seen. Most of these problems occurred on Oct. 29th. The maximum current predictions for the nearby Grand Manan Channel were 3.2 knots at 11:36 on Oct. 29, 2.8 knots at 12:23 on Oct. 30 and 2.3 knots at 13:19 on Oct. 31 (Anonymous, 2018e). The inability to locate the floats released from 4 net bags on Oct. 29 coincides with the time of the high tidal current. On the two following days, there was not a problem with the floats being dragged under. The maximum tidal currents predicted for the Grand Manan Channel were lower on those days.   During the LFA 34 fishing season, the maximum Grand Manan Channel currents exceed 3.0 knots on 21% of the days (Anonymous, 2018e). While those measures will not apply directly to much of Area 34, it is clear that on days with high tidal flows there will be a problem with some floats being dragged under, some possibly before they surface. Maximum tidal current predictions are not available for LFA 34.

The captains found that it was difficult to keep track of all of the systems/screens while locating the ARC-1XD s. There are several screens to attentively watch while putting the motor in and out of gear and changing direction etc.

Acoustic contact between the deck unit and the ARC-1XDs has to be "line-of-sight". That is, if an ARC-1XD is some distance away and behind a ridge, the signal will be blocked. This is not likely to be a problem because the fishing vessel will typically be above the end of the trawl with the "acoustic cone" pointing directly downward when it comes within contact range.

Major problems

There is a serious safety issue to consider when evaluating ropeless fishing. During deployments of the lobster trawls, if a crew member was caught in the ropes and dragged overboard, and the deck crew could not stop the deployment and hook the rope in the hauler, it would take a very long time to retrieve the trawl. This scenario would be of particular concern on "dumping day" (opening day of the season) when crew may get distracted and enter no-go zones because of space limitations on the deck.

Deploying ropeless fishing gear on "dumping day" would require major changes, and likely one or two trips back to shore because it would not be possible to stack as many trawls and the associated rope bags on board at once.

The rope bag itself will have to be extensively modified in order to be implemented in a commercial lobster fishery. A 16-30% failure rate is unacceptably high and the repacking and rearming the ARC-1XD takes too much time. There were at least three instances that required grappling in which the acoustic release system at each end of a trawl failed to operate properly. The testing conditions on the latter trials were close to the natural weather conditions that will be experienced during the fishing season in LFA 34. The field-trial days were not as long and it was not as dark and cold as it will be in the winter (LFA 34's regular fishing season).

Assuming that the ropeless fishing only adds 10 minutes to the retrieval and redeployment of a trawl, that would add 3.3 hours to the time taken to haul 20 trawls. When trawls are being hauled daily, this would be a significant burden.

In a 2-knot current, the flow rate is about 30 fathoms per minute. During a deployment, if it takes 5 minutes for the first anchor to reach the bottom, the location could be up to 150 fathoms from the marked GPS location. In a severe storm, a trawl can be moved considerable distances. If that were to happen, finding the trawl again would be extremely time consuming because the harvester would have to bring the boat within a few hundred meters of the ARC-1XD before contact could be established. This could lead to a greater amount of lost/abandoned gear than would be the case for the present fishery.

Sighting the floats will be a problem in high waves and when the visibility is limited by darkness, fog, or snowy conditions. When the floats remain on the surface, sighting difficulties will add time to the recovery of the trawl. On days when the floats are being dragged under by a tidal current, either the trawl will have to be grappled or the ropes left in the water and searched for again at slack tide (or the next day). If the area has been closed due to the presence of NARW, leaving rope in the water may not be an option. An extreme restriction would make it necessary not to attempt to haul trawls on days with strong tidal currents. Stronger currents occur in clusters. There could be a number of consecutive days when retrieving trawls would not be permitted (in an extreme case) or would be hampered by not attempting float releases (or having to take more time to search and grapple) for a few hours at mid-tide. For example, Figure 4 shows the tidal currents for the nearby Grand Manan Channel from the start to the end of the lobster season in LFA 34. There are 11 groups of days when the maximum currents exceed 3.0 knots and some of these peaks last for a week or more. Clearly, actual data of current strengths in LFA 34 and the behaviour of floats and buoy lines would have to be obtained in order to determine when this will be a problem. At the very least, there will be some days, and possibly a number of consecutive days, when floats being dragged under will be a concern.

Potential improvements

One modification that was briefly trialed involved using a rectangular wire frame cage (slightly smaller than a lobster pot) rather than the more flexible rope bag. One entire end of the cage acted as the hinged flap to contain the floats. The release cord mechanism was similar to that used in the rope bags. The cage was relatively sturdy and easier to handle and stack prior to redeployment. It would be possible to put a false bottom in the cage that could be moved up and down to accommodate different lengths of rope depending on the depth being fished and one or more floats could be used. If the ARC-1XD unit could be properly protected, this cage could be placed on the deck under a lobster trap and be the last unit off the deck, just after the anchor leaves.

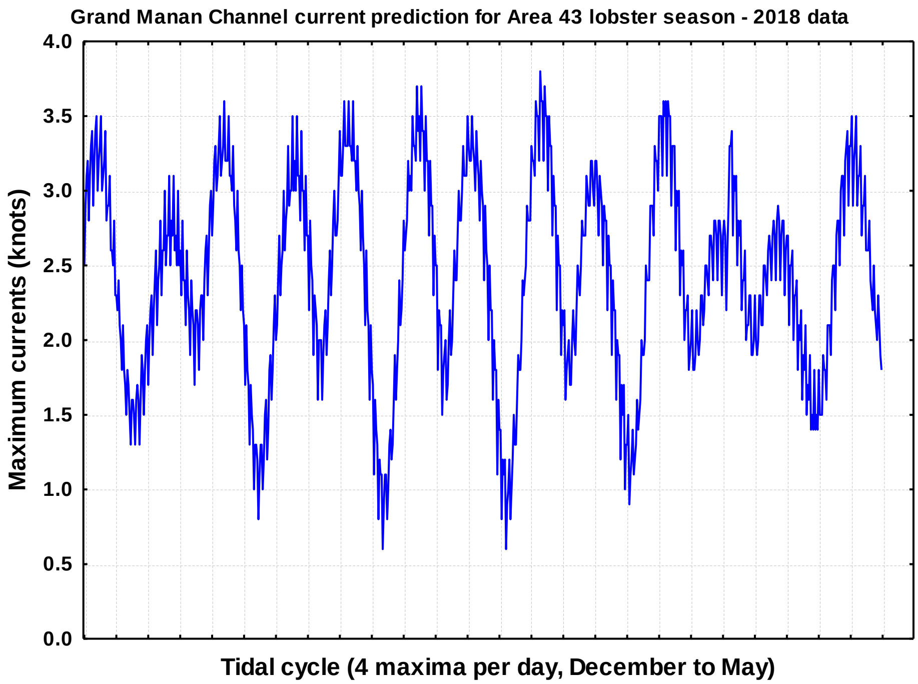

Figure 4. Maximum tidal current predictions from December to May in the Grand Manan Channel that is nearby to LFA 34 (Anonymous, 2018e). Similar data are not available for LFA 34. All values have been made positive.

With a wire frame cage, a simpler release mechanism may be possible. The release cord could be tied directly to the free edge of the lid and run via a single pulley down to the trigger apparatus of the ARC-1XD (a U-shaped pathway). That would remove the need for some of the guidance rings and the pulley could be attached to a bungee cord to maintain tension on the release cord after the system is armed. Also, if the cage could be opened at each end, it would be possible to pack the floats and then the rope as it is brought on board by the hauler. This would avoid having to coil the rope and then turn the coil upside down before packing the bag. In this case, a different rope holder would have to be used because the rope holder being recovered would be at the other end of the buoy line being raised. It would be important to keep accurate track of the serial numbers of the acoustic releases because they would change with each deployment. The individual serial numbers are required for the deck unit to make contact with the soaking ARC-1XD unit when operating in the individual mode.

A plastic frame rope cage that was purpose built to house the float(s), rope and the Acoustic release device might also work. By using molded plastic, it would be possible to better protect the acoustic release mechanism from damage and the routing of the release cord could be made more secure. It would also be easier to change the volume of the cage to accommodate different lengths of rope.

One suggestion for improving the ease of rearming the ARC-1XD units was to change the tool needed to tighten the fuse wire in place from an allen key to a nut driver. This would be easier to fit over the end of the screw than inserting a small allen key.

The developer, M. Flagg, suggested changing the nickel-chromium fuse wire from a spool to a number of precut straight lengths that had a paper tab on one end. The paper tab would be easier to hold when gloves are worn and make it easier to thread the fuse wire through the holes in the vertical posts on each side of the release lever, a process that is similar to threading a needle.

3. Gear location marking system

Desert Star Systems have developed a "Ropeless Fisher™" application for Android smartphones that permits other harvesters and enforcement officials to locate the GPS positions of deployed trawls. When within Wi-Fi range of shore, the harvester can communicate the locations of the start and end of each trawl as they are deployed. By keeping track of the gear number, the harvester can also keep track of the serial numbers of the ARC-1XD units that will be needed to communicate with them to recover the trawl. Other harvesters or enforcement officials are thus alerted to where trawls are and can avoid overlays. The trawl locations are colour coded so that the harvesters can distinguish their trawls from those of other harvesters. Each harvester has the capability to determine the visibility radius to others. That is, they can limit the ability of other harvesters to detect their trawls to a set distance from the other harvester's boat. Thus, only other harvesters that are close to the trawls will be able to detect them on their smartphones. It is possible that enforcement officials could be granted access to information about the owner of each trawl.

The system takes note of the real time location of the observer's boat. For the observers, their real time location is displayed on the screen so they can determine how far they are from the deployed trawls (their own and those of other harvesters). It is also possible to limit ownership information: other harvesters would not know who owns the trawl while that information could be made available to the regulators, i.e., DFO fisheries officers. If the trawls are deployed in areas with no Wi-Fi access, the locations of the trawls would be uploaded once the harvester returns to port or an area where Wi-Fi is established. This system will not provide real-time data in offshore areas of LFA 34.

<u>Observations</u>

During a day-long trial, all three boats operated in a single area and deployed and lifted trawls progressively closer to each other. The first deployments were made within a half mile and then the distances were reduced to about a quarter mile. This was designed to mimic normal fishing practices when boats are operating within sight of each other. The boats all had Wi-Fi reception and the trawls were marked as they were deployed. Twenty-two trawls were deployed and recovered without any overlay problems. The Ropeless Fisher™ app worked well under these conditions.

Major problems

Farther offshore and in other areas of Wi-Fi dead zones, the system would not work. In these areas it would not be possible for harvesters to know where trawls have been deployed that day. When boats are returning to harbour, the trawl locations can be uploaded as soon as they can obtain Wi-Fi contact. The next day, other harvesters would be able to see trawl locations of the previous day but not the locations of the trawls that had been lifted and redeployed on that day.

Potential improvements

Satellite communication systems, such as Iridium, could likely be used to convey the trawl location information close to real time when the boat is out of Wi-Fi range. Large sections of LFA 34 are outside of Wi-Fi range and the Ropeless Fisher™ app would not be able to operate real time without some type of satellite communications.

Refinements to the amount of information that can be gathered about a particular trawl can be made. For example, it should be possible to provide Fisheries Officers with information about the owner of a trawl while other harvesters would only gain information about the location of the trawl. It would be very difficult to provide Fisheries Officers with the specific serial numbers of the individual ARC-1XD units. These serial numbers would be required for them to be able to retrieve a lobster trawl for inspection purposes.

4. Regulator issues

A ropeless fishery operation will mean that it will not be possible for regulators to identify the locations or owners of trawls using surface buoy markings. It is possible that they could interrogate the ARC-1XDs on the trawls to determine the owner of the gear but would not have the release codes needed to bring the floats to the surface.

A significant technical issue would arise if there was a regulatory need to be able to bring the trawls to the surface to check the tag numbers on the lobster traps. With access to the individual harvester’s codes, the officers could retrieve the trawls. To do this they may have to run through the serial numbers of the individual acoustic release devices owned by that harvester in order to eventually make contact with the ARC-1XD they are attempting to activate . This would also require the enforcement personnel to be fully trained on the recovery and redeployment methods, and have the tools and supplies to rearm the ARC-1XD units. A very important aspect would be to be able to inform the harvester that their trawl had been lifted and the new GPS locations of the start and end of the trawl.

Adopting a ropeless fishery will require changes to some fishery regulations and procedures. A concern was expressed that it typically takes a year or more to modify fishery regulations. As a ropeless fishery was rolling out, there would need to be a mechanism to permit some temporary relief from some regulations that were incompatible with the new methods. The example of officers being able, or required, to lift trawls to check tag numbers on traps would apply to this situation.

For ropeless fishing methods to be adopted, some license conditions would need to be changed or modified. Initially, ropeless fishing practices might have to be conducted under an "experimental fishery" set of regulations. This would avoid conflicts between the new gear and old regulations. As an experimental fishery, fishing could continue while the new regulatory changes were being considered by DFO. Moreover, the DFO protocols for closing and opening areas will have to be refined. For example, should the single spotting of a NARW automatically lead to closure, and if so over how large an area and for how long?

5. Other ropeless fishery equipment prototypes

Three other types of ropeless fishing gear are being developed. It should be noted that the following information is only a brief overview and does not include recent findings.

1. Timed release devices

International Fishing Devices Inc. (Anonymous, 2017) use the timed erosion of a galvanic timed release device to free a buoy that will float to the surface along with a buoy line to bring up the gear (Anonymous, 2017). Unfortunately, the timing is not accurate enough to predict within a few hours as to when the buoy would rise to the surface and the harvester may not be in the area at that time, thus leaving a vertical rope in the water. A similar difficulty exists with devices that release the buoy at a predetermined time using a clockwork mechanism.

2. Bottom-stowed spooled rope (Parton et al., 2018).

In this system, a buoyant spool that holds twice as much rope as is needed to get to the surface is attached to an anchor at the end of a trawl. A motor-driven acoustic release device typically is used to release the spool which can then float to the surface. The core of the spool is the floatation device. Scientists at the Woods Hole Oceanographic Institute are working on a spool system that will hold 300-500 fathoms of rope (Parton et al. 2018). In their system, the rope is in the form of a pre-wound self-supporting line cartridge. The cartridge is inserted over the floatation core of the spool and metal end caps cover both ends of the spool to protect the rope. The spool weighs up to 340 pounds in air and the metal end caps are 42 inches apart. The spool is kept on the bottom using a 180-pound anchor. The acoustic release removes a clamp on the rope allowing it to unspool as it floats to the surface. After retrieval, the buoy line is stowed in a barrel and taken to shore to be rewound into a rope cartridge. This is done because it is too difficult to accurately rewind the rope onto the spool at sea.

There are some aspects of this type of system that would not fit well with the harvesters in LFA 34. Having to take pre-wound spools on board and store the buoy lines for return to land would take up too much space on the boat. The heavier weights of the full spool and anchor would make handling on board difficult and dangerous. The motor-driven acoustic releases are much more expensive than the burn wire systems. When completely unspooled, the rope would be taught which would make it heavy to gaff the buoy and lift it out of the water. The time taken to locate the buoy device on the bottom would likely be the same as for the Desert Star system. The spool system does not seem to be a good alternative to the rope bag approach for LFA 34.

3. Inflatable buoy (SMELTS, 2018).

In this concept, an inflatable buoy (using compressed gas cartridges) is attached to the last lobster trap in a trawl or an anchor a few fathoms away. Upon interrogation using an acoustic release system, the buoy inflates and has enough lift to bring the trawl to the surface. There is no buoy line involved. The buoy can be quite large and thus would be more visible than the 8- or 11-inch yellow plastic floats.

The SMELTS animation (SMELTS, 2018) indicates that the buoy would be capable of bringing four lobster traps to the surface. Once at the surface, however, the first trap would have to be hauled on board before the rope could be placed in the hauler unless the rope between an anchor and the first trap could be brought on board. There is no information provided concerning the rearming time. The time taken to locate the acoustic release device on the bottom would likely be the same as for the Desert Star system.

6. Implementation issues

Going ropeless is a different fishery that has the potential to present a substantial learning curve for the majority of the fishing fleet in LFA 34. It will require both technical and practical training for both the captain and the deck crew and the know-how to troubleshoot when issues arise. As such, the switch to ropeless fishing would take some time.

Having a local technician available to repair and assemble the electronic equipment on the vessels is a must. This individual would also need to have spare deck boxes, transducers, and ARC-1XD units on hand for harvesters to purchase and/or rent if their equipment was being serviced.

Each lobster trawl would require two acoustic releases and rope bag units. This is to reduce having to grapple for the trawl if the first acoustic release-rope bag system fails. To outfit 20 trawls, the initial capital costs of purchasing 40 ARC-1XD units, 40 net bags and a deck box could be over $ 125,000, less if high volume purchasing results in lower costs of the ARC-1XD units. In LFA 34, if an area of 30x30 nautical miles was closed that would affect about 100 boats. The total capital costs to them to purchase and install the ropeless fishing equipment could be as much as $ 12,500,000.

While large orders of equipment would result in somewhat lower prices, the costs would still be significant. Desert Star Systems estimated that the company would need approximately three months to set up a production line to produce a large number of ARC-1XDs. It would also take a number of years for the harvesters to fully adopt ropeless fishing. In addition to the capital costs and time needed to produce a sufficient number of acoustic releases etc., it would take time to train the harvesters to use the new equipment. It is likely that individual harvesters would have to be faced with an area closure before many would invest the money and time to adopt the new technology. For many harvesters, the choice would have to be between not fishing at all or going ropeless. In that situation it may be financially advantageous not to fish, assuming that the area closure would be temporary. Lower revenue boats may not be able to afford to purchase the ropeless gear.

The added time associated with deploying and hauling ropeless trawls could be a serious impediment to adopting ropeless fishing. Having more traps per trawl may be a partial answer, but there are practical limits to having very long trawls. Few harvesters are likely to adopt ropeless fishing in a completely voluntary manner. The potential for not being able to find the floats when there is a substantial tidal current, the added time to locate, haul and redeploy the trawls and the substantial capital costs that would be in addition to their current operation, make ropeless fishing an undesirable alternative to current practices.

If a transition to ropeless fishing were to be implemented in LFA 34, it could take upwards of ten years before the fleet was converted. The delays in implementation would be associated with the time required to mass-produce the necessary technical equipment, the time to train the local trainers on the new fishing methods and the time required to train all the harvesters. It would likely take a few years for some fishery regulations to be changed to accommodate the new methods. Lastly, there could be hold-ups in the delivery of the ropeless equipment due to competition from harvesters in other LFAs, particularly those in the Gulf of St. Lawrence where longer and more regular closures are likely to occur.

Harvesters in LFA 34 have not been subject to fishery closures as a result of NARWs being spotted in the area with the exception of a one-day closure on the last day of the season in May 2018 when a NARW was spotted near the Roseway Basin. A few whales will likely transit the area on their northward and southward migrations so it is possible that portions of LFA 34 would be subject to a temporary closure. NARW have not been known to frequent the waters in LFA 34 other than when in migratory transit so the probability of large area closure of Area 34 is unlikely at this time. Small areas, however, may be subject to closure if NARW are seen there as there will be a greater effort of keeping track of the whales in the future.

From the perspective of an individual harvester, one has to consider whether it would be worth their while to purchase the ropeless equipment and keep it on reserve in case the area where they fish was subjected to a temporary NARW closure. During the months of December and May, which tend to be the most lucrative lobster fishing months in LFA 43, a harvester may wish to consider having the ropeless technology on-hand as sitting out those months would be a severe financial burden. It would, however, not be politic for a ropeless harvester who fishes in one area to move into another area some distance up or down the coast that was closed to regular fishing gear.

One option for consideration would be to have a fishermen's organization such as Coldwater Lobster Association invest in ropeless fishing gear to have on-hand to train harvesters on how the technology works. Should a section of LFA 34 be temporarily closed to regular fishing practices, the gear could be rented to harvesters that chose to fish in the closed area. This would permit some harvesters to continue to fish in temporarily closed areas, but would exclude others who were not trained or did not have access to the limited amount of available equipment.

Some harvesters noted that in response to NARW presence, fishing areas were closed while the shipping industry only had to slow down. Slowing large vessels presents additional financial costs to the shipping industry but that is much less of an impact than the lobster harvesters would experience as a consequence of an area closure. The fishery closure costs of

NARW protection should not be borne by lobster harvesters alone. If a reserve pool of ropeless fishing equipment were to be created, it would be appropriate for government and perhaps NGOs to provide financial assistance in such an endeavor.

Desert Star Systems have invested significant time and expertise in the development of a ropeless fishing system to combat the ever-increasing concern of whale entanglements in fishing rope/gear. Mr. Flagg's participation in this pilot, and other recent field trials in Atlantic Canada, has provided valuable insight to both the technicians of Desert Star Systems and the harvesters themselves. To go forward, however, there would need to be some formal agreements between potential purchasers (i.e., DFO, fishermen's associations and/or individual harvesters) and the company before a large-scale production of acoustic release devices could go forward.

It is likely that many lobster harvesters in the central Gulf of St. Lawrence will face prolonged closures due to the presence of NARW. These areas in particular, are unlikely to exhibit the same environmental issues observed in LFA 34 with the tidal current dragging floats underwater once released from the rope bags. While it would be advantageous for harvesters in LFA 34 to have ropeless technology on-hand, it would be more reasonable to wait and see what develops in other areas. The significant capital costs of the equipment and training required to adopt a ropeless fishing ability may not be warranted in lobster fishing areas where only occasional and short-term closures associated with North Atlantic right whale presence are likely. Due to the additional hauling and redeployment time, the number of days when the current is dragging floats underwater, and the inability to access Wi-Fi to operate the Ropeless Fisher™ app in much of LFA 34, ropeless fishing may not be viable in LFA 34.

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