

Preparations for Ropeless Fishing with the ARC-1 System

DRAFT 16MAY18















Dear fisher, pilot project coordinator, fisheries manager or regulator,

Ropeless fishing holds the promise that permanent vertical buoy lines associated with pot and trap fisheries could be substantially removed from the water column, making these waters safer to marine mammals and navigation in general. Realizing this potential and managing the new technology in such a way that it also benefits and improves the business of lobster and crab fishers is possible but will require effective cooperation between fishers, fishery associations, fisheries managers and regulators.

Flexibility translates to profitability for fishers and ropeless fishing success

We are fortunate that a reference point for successful conversions to ropeless fishing exists, even though only on a limited scale, with southern rock lobster fishers in New South Wales, Australia. This experience taught that success is best achieved when fishers are given maximum flexibility in the implementation and operation of a ropeless fishing system to suit their particular circumstances.

Consequently, the ARC system for ropeless fishers consists of a simple yet reliable release mechanism that can be used in many ways, boat electronics with options for computer controlled individual or 'flip a switch' broadcast release as might best suit a fishing operation, and a simple virtual gear marking Android app that takes the place of visual buoy spotting and helps prevent gear overlay or conflict.

This technical flexibility provided to fishers however must also be supported by operational and regulatory flexibility and advantages to fishers investing in ropeless technology. In NSW, where a quota rather than an effort control system is in place, regulations allow for the use of 'submerged headgear' in the lobster fishery. This is the essential legal starting point. As significantly however is that fishers can by and large design their traps as they wish, operate singles or trawls, use short or long set times and so on. This flexibility has resulted in a gradual shift to the use of larger traps with longer set times. Ropeless technologies has supported these shifts and made fisher's business more profitable. For example, 'submerged headgear' has meant safety from ship strikes and theft, making these long set times a realistic proposition and resulting (in combination with the large traps) in very high CPUE.

Conditions in your fishery will be quite different, but regulatory flexibility must be granted to fishers to experiment and optimize towards a profitable application of ropeless technology. Here, if an effort control regime limits individual trap size and count for example, consider limiting the total volume of all traps instead, resulting in fewer but larger high-yielding traps with long soak times. And, if a fisher has removed the hazard to marine mammals by using ropeless technology, they should be allowed to continue fishing during time area closures.

Getting started

We have now seen that ropeless fishing will generally be introduced through pilot programs in which a number of fishers are outfitted with boat gear and some releases. These efforts may be financed by government or private (NGO) funds, and a pilot project coordinator is typically appointed to manage the pilot group, collect fisher feedback, prepare for the trial use and so on. The coordinator should in turn interface with fisheries managers to obtain experimental fishing permits, and share results of these efforts which then might become a basis for regulatory changes. Meanwhile, beyond providing equipment, Desert Star and myself support the pilot programs by offering an on-site class to the pilot

group, conducting initial boat inspections, advising on boat installations and release bag design, and ultimately supporting the first at-sea operations on each boat to make sure the equipment is operated and functions as intended.

Getting ready will require a number of preparations, and the purpose of this document is to advise the preparations needed for a successful pilot program. Please read it. Notice the many embedded links providing additional information, citations, instructional videos and interviews with fishers. Review and depending on your role in a pilot program, please consider the following:

Fishers: Please learn how the system works, and how it's been used in NSW. See what gear is needed on the boat, what you already have and what equipment or boat modifications will be needed. Determine if the NSW operation is the right way for your fishing operation, or if something should be changed. Advise your coordinator.

Pilot project coordinators: Please get this information out to your fishers and follow up with them. Ask for their idea, and from them develop starting points for the group and decide what individual variations might be needed. Very importantly, check on the boat installations. For example, some boats that are also engaged in a longline fishery may already have a hydraulic line hauler to re-fill a release bag with rope. In other cases, this equipment may have to be procured and installed. Review the issue of gear overlay in ropeless fishing, and the suitability of the Ropeless Fisher app as a tool to coordinate fishing activities and gear placement among fishers in your association.

Share this document also with fisheries managers, determine initial conditions needed in experimental fishing permit and advise managers of the regulatory changes or relief your association will be seeking for fishers that use ropeless technology.

Fishery managers and regulators: Review this information to learn how the technology works in general and how it has been applied in NSW. Consider submerged gear reporting requirements, and see if the Ropeless Fisher app is a suitable starting point for this. Review the chapter on marine mammal acoustic safety and allow operating conditions that are safe for the animals but also realistic for fishers. Prepare to support the fishers by advocating regulatory changes that make ropeless fishing a realistic and profitable activity.

Having been involved with ropeless fishing since 2011 and the very start of experiments of the NSW group, I am looking forward to working with you to build a practical and robust ropeless system for your fishery.

Marco Flagg

CEO, Desert Star Systems LLC



The Desert Star Systems provided components for a ropeless fishing system including (1) the STM-3 deck box for remote control, (2) the ARC-1XD acoustic release, (3) the through-hull transducer to range to and command the ARC-1XD while underway, (4) an 'over the side' transducer for various test functions and as backup, (5) a set of small tools and supplies to re-arm and service the ARC-1XD.

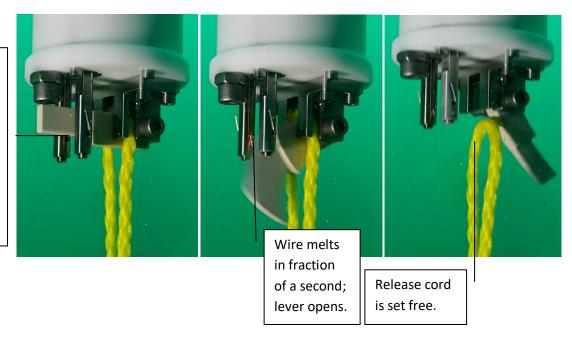
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1. Basic operation of the ARC-1XD Release Mechanism

The ARC-1XD acoustic remote release mechanism is at the core of the ropeless system. The release mechanism is very simple, and therefore reliable. Upon receipt of an acoustic command from the deck box on your boat, the ARC-1XD discharges a large capacitor through a nickel-chromium resistance wire that is strung between two titanium posts. The wire melts or evaporates in a few thousands of a second, setting free a lever. The lever now opens and releases a cord that is strung over the top of your release bag. Here are some pictures and a video of this action.

Lever is held close by nickel chromium wire across top surface.
Replace the wire to re-arm the mechanism.



Click this link for a brief video of the release action

- ✓ The ARC-1XD 'fusible link' release mechanism is very simple, with only a single moving part (the lever). This simplicity translates to reliability. There isn't much that can go wrong.
- ✓ The mechanism also lasts a very long time. All metal parts are titanium which will not corrode. ARC-1XD after their sixth year of use in NSW remain in good condition.
- ✓ Consider the ARC-1XD acoustic release mechanism a component in your customized and optimized ropeless fishing system. You have much flexibility and can use it many ways.
- ✓ The reliability of your ropeless fishing system will depend on your implementation of the other components, principally the bottom stored rope release bag, your operating conditions such as biofouling potential, your overall method of operating the system and your preparedness when a snag hits and you must grapple.

2. Ropeless Fishing System Operations Overview

The release mechanism itself is very simple. But, how does this mechanism translate to a full ropeless fishing system? Please click the next video link to get an overview of the system operation on the F/V Seeking in NSW. Please consider this a starting point only, as your optimal gear configuration or fishing method may be quite different.

Ropeless Fishing System Operation on F/V Seeking

Here are a few observations about the general operation of the system as used in NSW:

- ✓ The system uses standard hard floats, here two linked by about 2m (6') of rope to better keep one on the surface in high currents. These hard floats (generally 20cm or 8" diameter) are inexpensive, easy to spot and easy to mark. Irawlworks model 551 is a suitable choice.
- ✓ Polypropylene floating rope is used. That helps float the rope out of the bag and to the surface. The NSW folks use 10mm haul rope with at least 2430 pounds breaking strength, enough to haul the big traps there.
- ✓ There is also additional slack rope, 8mm polypropylene. It keeps slack in the rope for a while after the hard floats pop up in high current. You can grapple them before they get pulled under by the current.
- ✓ The system uses a standard winch to haul the trap using the rope trailing the floats. The empty rope bag is unclipped after it surfaces. The haul rope stays clean all the way to the trap, so winching is not interrupted.
- ✓ The F/V Seeking crew feeds the rope from the winch into a big blue barrel. Floats are first and are placed next to the barrel. The barrel is then filled with the slack and then the haul rope. The winch is standard as would be used for any trap hauls.
- ✓ To refill the release bag, the crew uses a very fast snood or line hauler. It can run 200 fathoms of rope in 30 seconds. This two-step hauling and bag filling operation might be combined into a single step. We'll get back to that later.
- ✓ The release bag is placed some distance above the trap. F/V Seeking uses 10 fathoms of rope between the trap and the bag. It could be more or less for you. There are several reasons and we will get back to it in detail.

In the next section we'll look at the manufacturing of the release bag, and some modifications you might consider.

3. Installing the STM-3 Deck Box

The STM-3 deck box contains the sonar electronics that ranges to and commands the ARC-1XD acoustic releases. The STM-3 is mounted in a waterproof (when closed) or splash resistant (when open) Pelican case. It's instrument panel can also be removed from the Pelican case and then mounted in a console or against a bulkhead of your boat. Keeping the STM-3 in the Pelican case is convenient for temporary use and portability. But, bulkhead or console mounting makes for a much cleaner installation and is recommended for permanent use.



Permanent installation of the STM-3 deck box (F/V Seeking): The STM-3 instrument panel is removed from the Pelican case and mounted on a bulkhead of the boat (left). The through-hull and the over-the-side sonar transducers are wired to the box and selectable via a toggle switch. An industrial PC (black box on right) runs the DB-ARC control software.



The ARC-1XD releases are controlled via the control screen and keyboard mounted in the wheel house.

Note: ARC-1XD release control is currently via the DB-ARC Windows application as shown here. An integration of the control capability into the 'Ropeless Fisher' app running on an Android tablet is planned. Communication between the tablet and STM-3 deck box will be wireless via Bluetooth.





Installation on F/V Andree-Dean. The control display is installed in a console at the steering position. The STM-3 deck box is inside the console and remains mounted in its Pelican case for easy swap-out.

STM-3 Deck Box Electrical Connections

- ✓ Through-hull sonar transducer plugs into SONAR #1 connector.
- ✓ Over-the-side test & backup sonar transducer plugs into SONAR #2 connector.
- ✓ USB connection to a PC running DB-ARC control software
- ✓ Optional USB connection to a GPS receiver, for auto-recording of ARC-1XD positions
- ✓ Optional 110-250 VAC power connection. The STM-3 also has an internal re-chargeable battery

3.1. Through-Hull Sonar Transducer Mounting

The ARC-1XD on your traps are interrogated and commanded through ultrasonic signals not unlike the pings from your boat depth sounder. And, similar to a depth sounder, a hull mounted transducer is required. The transducer is of the through-hull variety, meaning that a 50mm diameter hole is cut in the hull and the transducer is sealed into that hole. This transducer is made to our specifications by Airmar, and housed in their P319 housing. The installation instructions are available here. Please study them closely.

A critical installation consideration is the 'dead rise angle' or pointing angle of the transducer. The transducer has a flashlight like circular beam covering 60 degrees at full performance (-3dB points) and about 90 degrees at reduced performance (-10dB points). The transducer should be pointed either straight down at the sea floor, or where possible tilted somewhat forward at an angle of about 15 degrees to concentrate the search area for the ARC-1 ahead of the boat.

You may be able to achieve straight-down pointing (zero dead rise angle) by mounting the transducer on the keel of your boat. This is the most common situation in NSW where fiberglass hull boats with an integrated keel are used. But, in many other cases keel mounting is not practical and the v-shape of the hull means that the transducer would point somewhat to port or starboard. If the dead rise to port or starboard is too extreme (>30-45 degrees), then there may even be no 'sonar illumination' directly under the boat and you would have to run a course to the side rather than directly over your traps for effective communication. This is not desirable.

In those situations, the transducer should be mounted on a fairing block that compensates for the hull angle and points the transducer in the desired direction. Again, our recommendation for ideal pointing is 15 degrees forward. But, a zero-dead rise is a good and well tested solution as well.

<u>If hull mounting is not at all possible for the pilot program:</u> Each system is also supplied with an 'over the side' transducer that can be lowered over the side of your boat. This transducer is caged, and a lead weight can be attached to keep the transducer submerged even if your boat is underway at a limited speed. However, the combination of a cable running across your deck and the need to remove the transducer from the water before cruising at high speed makes this a very limited solution. Use it only as a last resort!



The over-the-side transducer (left) and the through-hull transducer (right). The through-hull transducer allows ranging to and commanding the ARC-1XD releases while your boat is underway. The over-the-side transducer has limited such capability when lowered over the side and weighted. But it should only be used as a last resort.

4. Design and Operation of the 'Bottom Stored Rope' Release Bags

Bottom end of 10mm haul rope; linked to trap via 5-20 fathoms of rope. (Bag floats 5-20 fathoms above trap)

Release cord (released by ARC, opens top of bag to set floats free) . Cord is routed through shackles and tensioned by bungee on other side of bag.

ARC-1XD Acoustic Release (supplied by Desert Star Systems)

Bag material: 20mm plastic oyster mesh (made by Nylex) Stainless steel float retainer with 3/4" (16mm) PVC pipe hinge. Retainer is constrained by release cord

Two 8" (20cm) hard floats with depth rating well exceeding max. fishing depth (made by Trawlworks and others)

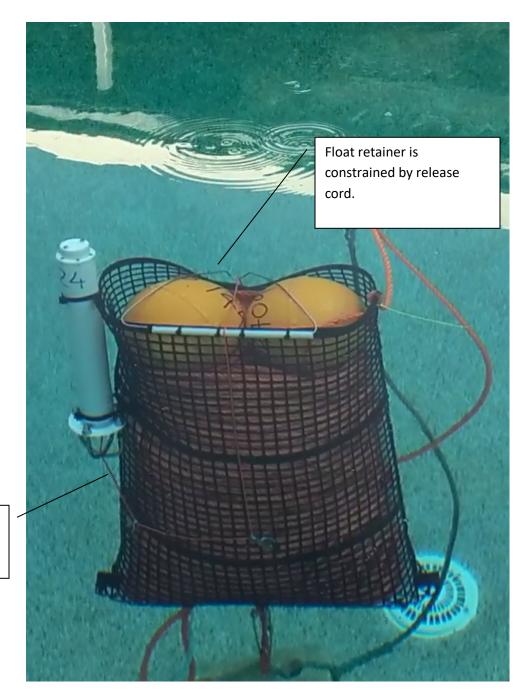
Rest of bag is filled with approx. 90 fathoms of 8mm rope. It provides slack to recover in high currents.

110 fathoms of 10mm polyprop rope. This bag is designed for fishing at up to 110 fathoms. A smaller bag design should be used for shallow water fishing.

U-Shaped PVC pipe keeps bag shape

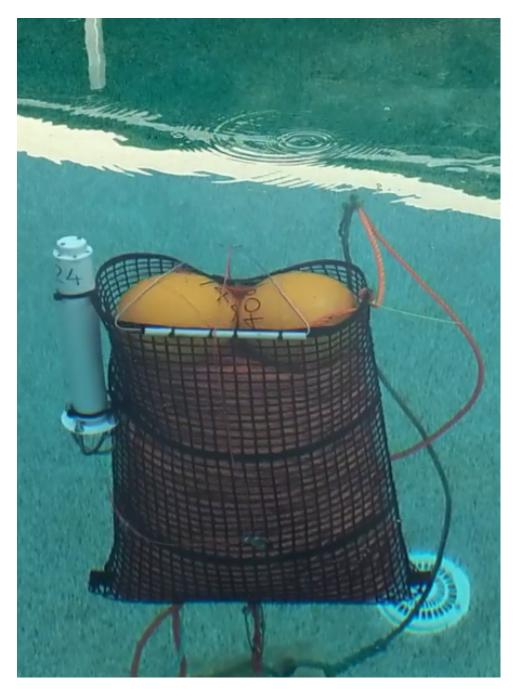
Clip to tie bag to haul rope

Click this link for a series of videos detailing the manufacture of the bags

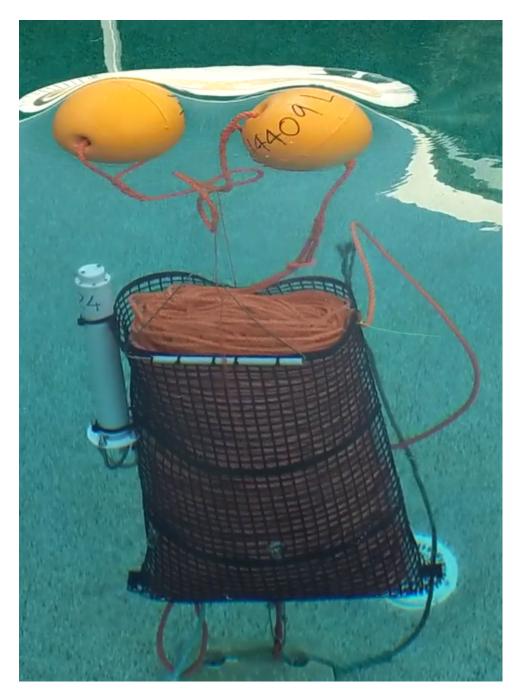


Release cord is held in place by ARC-1 mechanism.

Before release: ARC lever arm is closed, holding the release cord in place. Release cord constrains the stainless-steel float retainer in the closed position.



Release: Upon receipt of the release command from the boat, the ARC lever opens. The release cord is set free and pulls out, allowing the float retainer to open driven by the floation force of the floats.



After release: The floats surface, trailing first the slack rope (8mm) and then the haul rope (10mm). Once the trap is hauled, the bag will be completely empty of rope, and the now empty bag will only be attached to the haul rope by the bottom clip. The bag will be unclipped from the haul rope upon surfacing and set aside for re-fill. The haul rope is not blocked and feeds through the winch all the way until the trap surfaces.

Click this link for a video of the pool test of the bag

4.1. Modifications of the 'Bottom Stored Rope' Release Bag

The release bag as described here is designed for high-current fishing in waters up to 110 fathoms deep. It thus contains 110 fathoms of strong, 10mm diameter polypropylene haul rope and about another 90 fathoms of 8mm slack rope that is used to maintain slack until a surfaced float can be grappled (within seconds to a minute typically), preventing the floats to be pulled under in strong currents.

This bag however may be much too large if you are fishing in shallow water, and it should then be scaled down. Here are design recommendations:

- 1. Size your bags appropriate for the depth range of fishing. Use enough haul rope to reach the winch from the deepest fishing location.
- 2. Splice the stronger haul rope to weaker slack rope as needed for your currents. Have enough slack rope to be able to grapple the pop-up float before it gets pulled under by strong currents.
- 3. Tamp down the rope with a broom or similar when filling the bag, so the rope will not be loose.
- 4. The bag must always be filled with enough rope to keep the hard floats at the top in such a way that the bag does not fold over the floats. The stiff plastic mesh may 'set' in a given fold in coldwater. In particular if the bag is deflected in high currents, the floats may not pull out if there is too much of a fold. See the pool test for a properly filled bag. Filling the bag to the right level may require a bit more or less rope for each bag, depending on manufacturing and rope size tolerances.
- 5. The ARC-1XD must always be attached to the side of the bag in such a way that the sonar transducer endcap is above the bag so that the signal is not shielded.
- 6. The ARC-1XD must be attached so that the tip of the lever points away from the bag. Jamming may happen if the mechanism is rotated so that the lever is parallel to the bag.
- 7. Use 2mm or 3mm polypropylene release cord, with a loop spliced into each end (no knots!)
- 8. Route the release cord through the ARC-1XD cage such that the force on the cord is always straight up from the ARC, and not at an angle. This is to prevent jamming.
- 9. Use two 316 stainless steel chain links to route the release cord first to the center of the flat side of the bag and another two 316 stainless steel chain links to route the cord over the top of the bag, centered on the retainer, and down the other side to a bungee tensioner.

Avoiding snags



Snagged lever: The lever arm is pointing parallel to the bag, not away from the bag. This resulted in the release cord snagging the lever arm, preventing it from fully opening and releasing the release cord. Lesson: Make sure the ARC-1XD is mounted to the bag such that the tip of the lever arm points away from the bag.



Not enough rope in bag: The mesh is folding over the floats, and the plastic may 'set' in this configuration after a prolonged time in cold water. If the current is high and the bag is 'leaning over', the floats may not exit the bag. Lesson: Fill each bag with enough rope to keep the floats unobstructed at the top. Be sure to tamp down the rope during the fill process such as with a broom. The rope lay needs to be tight in the bag.



Enough rope in bag: The floats are near the top of the bag, and the mesh isn't folding over the float. These floats can be expected to exit the bag even when the bag is swept near horizontal in strong currents.

A smaller bag



An example of a smaller bag design with less rope, and two stacked hard float bubbles, for shallower water fishing with smaller traps. This bag does not use a hinged stainless-steel float retainer. Instead, the release cord constrains the floats directly. See NSW Dept. of Primary Industry Operation Manual for ARC-1XDf for details.

4.2. The Release Bag Refilling Process and Boat Equipment Needed

Refilling the release bag must be done efficiently and quickly. The goal is to perform this process at the same or better speed than normal servicing of your traps or trawls so that a release bag recovered from one trap is used for the re-deployment of the next trap and so on. In NSW, bag refilling is done using hydraulic snood haulers (line haulers) normally used in tuna longline fishing. The <u>Alstain Sheetmetal</u> hauler can haul 200 fathoms of line in 30 seconds, and its rollers are suitable for the 8mm and 10mm polypropylene rope used in that fishery.

<u>Lindgren Pitman</u> also offers such line haulers, although we have not seen them in operation for this purpose. In general, however, any sufficiently fast line hauler capable of handling the diameter rope you use should suffice.



An Alstain Sheetmetal snood hauler (line hauler) employed to refill a release bag. The fill speed is 200 fathoms in 30 seconds. Click this link for a video of the release bag fill operation. Note that a random rope lay is used. Rope coiling is not advised as it puts tension in the rope and may cause snags.

An alternative bag refilling method

The NSW bag refilling method is a two-step process. First, the slack and haul rope coming off the winch is fed into a barrel for intermediate storage. Second, the bag is re-filled using the snood hauler from the rope that's now in the barrel.

An alternative would be to feed the rope directly from the winch back into an empty release bag rather than into a barrel. This method however means that the 'top' and 'bottom' end of the rope are reversed during each trap haul. This has at least two implications: First, the buoys must be set up to unclip and be clipped onto the other end of the rope. Second, since the rope direction is reversed on each haul, using a combination of heavier haul rope spliced to thinner slack rope is not possible. The entire rope length must be of sufficient strength for hauling.

5. Ropeless Fishing System Operation

Now it's time to look at the operational considerations for ropeless fishing.

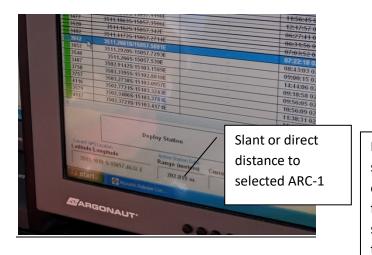
- Section 5.1. discusses gear safety and loss prevention. Experienced fishers consider submerged gear on the seafloor not 'potentially lost', but 'safe'. See some of the fishermen interview videos linked at the end of this document. Yet, this safety requires that you have a robust and well practiced action plan when the ultimately inevitable scenario of a snag, of gear moving by bottom trawlers or otherwise or of a release failure does occur.
- Section 5.2. explains how to avoid gear overlay. With ropeless fishing, there is no surface
 marker buoy. So, virtual gear marking is used instead. Learn how this works and the changes
 that will be needed to coordinate fishing activities in your fleet as compared to traditional buoy
 marking.
- Section 5.3. reviews your options of individual release mode, which gives you better control including for fishing in strong currents but requires computer operation, or broadcast mode which is more efficient and works at the flip of a switch.

5.1. Gear Loss Prevention Strategy

The ARC ropeless fishing system keeps the haul line and buoys stored in the bag at the bottom, thereby minimizing risks of catch or gear theft, ship strikes, heavy weather, marine life entanglement etc. But, as with any system there is also a risk of failure to release. For this reason, the system has built-in redundancy. If used right you have several options to recover your gear even when automatic pop-up fails. Please review and implement the recommended methods to achieve this redundancy and provide robust equipment recovery options.

Methods to recover a 'lost' release

- 1. The ARC-1 provides acoustic ranging information to your boat. If the floats do not pop up, use the ranging to establish the precise location of the trap.
- 2. If a trap may have been moved such as by a bottom trawler, search the area while interrogating the release. Once ranging is established, you can find the new location.
- 3. If an ARC-1 does not reply to interrogates due to a defect, use your depth sounder to locate the release bag. The float bubbles make for a prominent sonar target and show up well if the bag is floating some distance above the trap.
- 4. If automatic release does not work (a snag has occurred), grapple for it after identifying the location. The release bag floating above the trap or anchor provides good purchase for a grapple. In combination with a good position from either acoustic ranging or a sonar target, experienced fishers generally grapple successfully on first try.







High visibility pop-up buoys: High visibility buoys are another important consideration to minimize gear loss. 8" (20cm) diameter orange hard floats (depth floats) float almost entirely above the waterline and are thus visible from a long distance. Select a color that clearly stands out against the background and allows the pop-up buoys to be spotted quickly after pop-up.

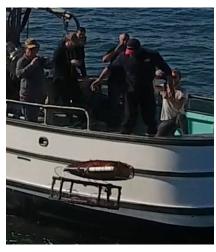
Selecting the scope between trap or anchor and the release bag

To aid recovery of lost gear, it is essential that the release bag is not tied directly to the trap or anchor (in case of a trawl), but with some scope (rope length) in between. This provides both a target for your depth sounder and purchase for your grapple. Select the amount of scope that will work best for you. Fishers in NSW use between 10 and 20 fathoms of rope between the release bag and their large traps. The optimal amount of scope may be different for you. Consider the following:

- ✓ Keep scope small enough so that marine life entanglement is not a likely factor.
- ✓ In shallow water fishing, keep release bag closer to sea floor to avoid the high-energy zone in heavy weather.
- ✓ Keep scope big enough so that the release bag will not become entangled in the trap or anchor even if the trap should roll.
- ✓ Keep scope big enough to clearly distinguish the release bag from seafloor features on your depth sounder.
- ✓ Keep scope big enough for reliable grappling.



Correct Configuration and Deployment: The trap is already submerged, and scope between trap and release bag prevents entanglement of the release bag with the trap, provides a good depth sounder target and provides good purchase for grappling in case needed.



Incorrect Configuration and Deployment: There is almost no scope between the trap and the release bag. They release bag is not clear of the trap and may become entangled with the trap. There will not be a good depth sounder target. Grappling will be difficult.

5.2. Avoiding Submerged Gear Overlay with Virtual Gear Marking

In normal pot and trap fishing, static buoys at the surface serve to mark gear locations and prevent overlays or conflict between gear. In this traditional system, other fishers will see your gear but only when within visual range, providing some combination of secrecy of your trap locations and protection against gear conflict. Ropeless Fisher is a free Android app that runs on your smartphone or tablet and serves a similar function but with virtual gear marking. You press a button as you deploy a trap, or when starting and ending a trawl, and the gear location is recorded. You can always see your gear on the map, no matter where you are. But, you define a *visibility radius* for others. If a different fisher is within that radius, they will see your gear location to avoid gear overlay. Outside of the radius, your gear will not be indicated. Ropeless Fisher works with a cloud database. When you have internet connection, the latest database information with other fisher's gear is downloaded to your device, and your locations are uploaded to the database. When off-line, you can still mark gear and see nearby gear locations that have been stored in your device but you will not receive updates.

The method has advantages over physical gear marking:

✓ You can decide from what distance your virtual gear markings are visible to others.

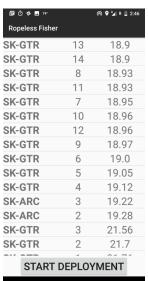
- ✓ You will see gear locations at night or in poor weather where a physical market buoy might be missed.
- ✓ You always have a complete record of all your gear locations.

But you must consider these limitations:

- > Gear deployed by other fishers since you left internet connection or before they reached internet connection after setting gear will not be visible. You must use other methods such as VHF communications between boats to coordinate.
- > The virtual marking and awareness is limited to users of Ropeless Fisher. A fisher who might not use ropeless fishing and does not use the Ropeless Fisher app would not be aware of your gear locations and might set their gear on top of yours.

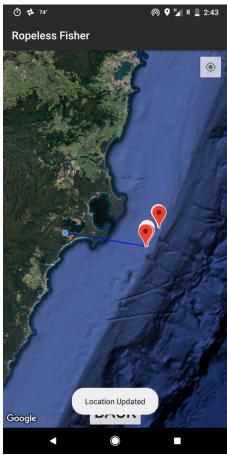
How to use Ropeless Fisher





- Start on the gear definition screen after selecting either a Single or a Trawl deployment. Filed values are remembered, and you only have to change what changed since your last deployment. That is normally just the gear #.
- Enter the name for the **Fishery** you are operating in, such as here MRY for Monterey, California. All data sharing is limited to a specific fishery. Make sure all fishers use the same fishery name.
- Enter your **Name**. This identifies you and can also be your boat name or your fishing license number. All fishers should use the same convention.
- Enter the **Visibility** radius for your gear (nautical miles). Other users of the Ropeless Fisher app will only be able to see your gear if they are within the specified radius from its location. So, you can protect your locations by selecting a small radius. Or you could choose to use a very large radius to let other fishers know that you already have gear in this area.
- Enter the **Soak Time**. Normally you will select gear and use the Release button when you have recovered a trap to indicate it is no longer there. The Soak Time value will auto-clear your gear marking after the specified number of days, in case you forgot to clear it yourself.
- Enter your **Gear #**. This identifies your specific trap or pot. You might use a short two or three-digit number that relates (via a table kept secret) to the acoustic release code of your ARC-1.
- Before you hit **Deploy**, watch the GPS position including the Last Update. It should be within the last second or two, to make sure your virtual position accurately reflects the location where you sunk your trap.
- The gear list screen shows you all gear in the vicinity including the owner (left), the gear number (center) and the distance of the gear from your current location in nautical miles. In this example, we are seeing trap

- locations of the vessel F/V Seeking (SK), also specifying if the trap is equipped with a galvanic timed release (GTR) or an acoustic release (ARC).
- If the gear doesn't belong to you, you will only see it if you are within the gear owner specified visibility radius.
- You can select any gear and then obtain course information to that gear. If it is your gear you can then release (remove) it.
- You can hit the START DEPLOYMENT button to mark a new trap, pot or trawl.





- The Map View shows gear in your vicinity.
- You can zoom in and out, such as here for a set of traps offshore Huskisson, NSW.
- Your traps will be marked in green, traps of other owners in red.
- You can click on a trap to get more information.
- Your (boat)
 location is marked as a blue dot. Here we watched the traps after having returned to shore.

Additional Information about Ropeless Fisher and Virtual Gear Marking

• Ropeless Fisher distribution: Ropeless Fisher is available free of charge and may be used by anyone who has a need to know submerged gear locations: fishers, fishery enforcement, other ocean users etc. The application is currently distributed as an. apk file for android devices with GPS functionality. Please contact Desert Star Systems for a free copy. Based on feedback from coordinators during the pilot programs, we may move the app to Google Playstore or assign distribution tasks to fisheries associations or regulators. A consideration here is that a database may become 'polluted' with fake gear locations when distribution of the app is unlimited and uncontrolled.

- **Source code access:** Desert Star will make the source code available free of charge to fisheries departments, fishery associations and other organizations that may wish to inspect the code or develop their own fishery specific virtual gear marking application.
- **Fisheries Enforcement version:** An 'fisheries enforcement' version of Ropeless Fisher is a possibility but we have not implemented it yet. Such a version, with limited distribution, might show all gear locations in a given fishery independent of the location of the observer. Fisheries enforcement might thus see gear locations not only when on site but also from the offices.
- Release Commanding with Ropeless Fisher: The ARC-1XD acoustic releases are currently commanded and ranged to using the DB-ARC software, a Windows application that is installed on a notebook or industrial computer linked to the STM-3 deck box via a USB cable. To reduce system complexity, we are planning to add release commanding and ranging functions to Ropeless Fisher. This will eliminate the need for a Windows PC. Communication between the Android tablet or smartphone and the STM-3 deck box will be wireless via Bluetooth.
- Acoustic Gear Marking: A proposed alternative to virtual gear marking is to equip traps with an acoustic modem that reports to passing boats equipped with a corresponding interrogator. In fact, since an acoustic release includes acoustic modem functions to command and range to the release, such a capability could be implemented in the ARC-1XD through a software upgrade. However, in our experience acoustic gear marking will not be sufficiently reliable. Underwater sound propagates for only a limited <a href="https://doi.org/10.2016/journal-jou

5.3. Choosing Individual or Broadcast Release Mode

The ARC-1XD supports two release modes: Individual or broadcast release. During the pilot program, you will be ableto experiment with either mode. If broadcast interrogate is preferred, a simplified and lower cost deck box (STM-4) and acoustic release (ARC-2) may be used. Here is how both modes work.

Individual Release Mode

Individual release means that you select the specific ARC-1XD release in advance of its release. This is done in the DB-ARC software running on the Windows PC connected to the STM-3 deck box. After you have selected the specific release by clicking on a list of all your releases, this release will be activated by acoustic command. Once it has activated, you will get ranging information and battery status. Activation is typically initiated as you are done working one trap and are now moving to the next one. You will normally start seeing ranging information before you arrive on location, and so can use it to position the bat directly above the release. You will now issue the RELEASE command, which is

acknowledged meaning it is time to look for the buoys to pop-up. Buoys ascend at a typical rate of two fathoms per second.

Individual release is typically used with larger traps or trawls in deeper water where you want to be sure of a trap or trawl position and position the boat directly above before the floats pop up. This is in particular of advantage when operating in high currents, where slack rope after pop-up will allow you to hook the floats before they get pulled under by the current. Thus, you can operate in even stronger currents than might be possible with static surface buoys.

An application example for individual release is in the NSW rock lobster fishery. Here, the East Australian Current can run strong for weeks and even months at a time, making fast hooking of the floats with slack rope a significant productivity enhancer. Fishers there now operate in currents in excess of two knots, compared to a maximum limit of 0.75 knots when using GTR or static surface buoys. Fishing depths are from 60 to 110 fathoms.

Broadcast Release Mode

Broadcast release means that the STM-3 deck box is commanded to transmit a fisher specific, not a release specific, release code continuously once every 5 to eight seconds. The ARC-1XD releases as soon as it detects that code, causing the floats to pop up. This method is faster and less complicated, causing floats to pop up ahead of the approaching boat. Once a trap is re-set the release will not trigger again for a set period (one hour for the pilot programs). This blackout is designed to prevent immediate retrigger in response to the ongoing broadcasts once a trap has been set again.

The limitation of the broadcast method is that there is no feedback from the submerged release other than the float pop-up, and floats may pop-up while your boat is still some distance (up to about 350m) away. Thus, if there is a snag of the floats, there is no indication that the release is in fact nearby. (However, with the ARC-1XD you can then switch to individual release to get a report of its presence and distance, allowing you to identify the location for grappling). When operating in high currents, the floats may also get pulled under as rope slack is exhausted but the floats have not been hooked yet.

An application example for broadcast release is in the New Zealand scampi fishery where pilot testing is scheduled to start in the summer of 2018. Small, open boats are used in that fishery and operation of a computer to command individual releases is considered not practical. But, the fishing is also in more shallow water and strong currents are not an issue.

Which operating mode to choose?

In some cases, the choice of broadcast or individual release mode may be dictated on the outset by environmental or operational circumstances. For example, very high currents may dictate use of individual release to capture floats before they become submerged. Or, a fishing fleet of small, open boats may make the computer operation required for individual release impractical. Perhaps a fishery must use small singles that are serviced a rate of one every few minutes or faster and so individual

release is too labor intensive. In most cases, the choice should be an outcome of the pilot program evaluation however, where both modes should be tested. An ultimate choice of broadcast mode exclusively can save equipment cost, as the lower priced STM-4 deck box and ARC-2 release can then be used. However, the following questions should be answered to satisfaction if broadcast mode is to be recommended for a fleet:

- A release operating only in broadcast mode, eg. ARC-2, will <u>not</u> provide acoustic feedback. If a float snag occurs, the failure of floats to pop up are not readily distinguished from moved or lost gear such as due to ground trawler interaction. Is the remaining method of lost gear localization by depth sounder search robust enough to minimize gear loss to acceptable levels?
- > Are ocean currents generally low enough so that floats getting pulled under is not a concern?
- While lower cost, the ARC-2 is a non or only partially serviceable design. It has a re-chargeable lithium-ion battery that may wear out after 3-10 years. This means the release has a lifetime limit. This compares to the ARC-1, which can be serviced by skilled fishers, technicians or the factory. It has no hard life limit and endurance of ten years is expected and 20 years quite possible. Is the lower cost ARC-2 a good trade-off considering the above?

6. Scaling Up

A common question about acoustic interrogated ropeless fishing technology is if the system can be scaled up from the hundreds of releases now used in NSW to potentially hundreds of thousands of devices operated by thousands of fishers in a large fishery such as the Atlantic Canada, Maine and the New England states. And, at such a scale would the system operation and its acoustic signaling harm marine mammals? Both questions are addressed here.

6.1. Large Scale Use of the ARC-1

The ARC acoustic releases rely on underwater ultrasonic signaling and ranging. The system is designed to support use in large numbers, but there are limitations. An understanding of the basic communication protocol helps illuminate.

- 1. The signals from the boat's through-hull are concentrated in a cone not unlike that of a flashlight shining at the seafloor. The cone spans 60 degrees at full performance (>50% power) and 90 degrees at reduced performance (>10% power). Further, the range of the signals is limited to 350m, by making the ARC-1 insensitive to weaker signals that may have come from more distant locations. This fundamental design of the use of a cone and rejection of weak signals means that interference will not happen between boats more than about 350m apart.
- 2. When operating in broadcast mode, the releases never transmit.
- 3. When operating in individual interrogate mode, a release will only reply when interrogated by the boat.
- 4. An array of releases on the seafloor will be quiet with no sound emissions unless interrogated.
- 5. Each release has its own equipment specific PIN number plus a 'fisher specific' PIN number for broadcast release. A release will not reply or act unless addressed through its individual or fisher specific PIN number.

Scale Limitations

Based on the above, the system operates under these limitations.

- 1. **Interference between boats limited to 350m:** Interference between multiple fishing boats operating at the same time will not happen if they are more than 350m apart. If closer than 350m, signals may collide and potentially cause unreliable operation.
- 2. **Up to 32,700 fishers per fleet:** Since there is a limit of 32,700 fisher specific PIN numbers, only this number of fishers may operate in a given area. However, the same codes may be assigned to fishers in a different region as there would not be a chance of interference.
- 3. **No limit on releases operating in broadcast mode:** Any number of releases may be assigned to a fisher. Releases operating in broadcast mode will only receive and not transmit signals. Thus, there is no limit on the number of releases per fisher or overall in a fishery when operating in broadcast mode.
- 4. **Up to 32,768 releases using individual release per fishery:** There are 32,768 equipment specific PIN numbers. Thus, individual release is limited to 32,768 ARC-1 operating in a shared fishing area.
- 5. If the reservoir of fisher specific or individual PIN numbers is exhausted, it can be expanded: The next step us is 524,200 fisher specific PIN plus 524,288 equipment specific PIN. This change would slow communication by about 16% and emit about 16% more sound energy into the water per release cycle.

6.2. Marine Mammal Safety of the ARC-1 Signaling System

Hearing is an important sense of marine mammals. While the hearing range of large baleen whales only barely extends to the 34kHz-42kHz frequency range utilized by the ARC-1, many other cetacean species exhibit high sensitivity in this frequency range. Acoustic systems operating around marine mammals may cause harm to animals by either causing temporary (TTS) or permanent (PTS) 'threshold shifts' i.e. hearing loss.

Is the ARC-1 system at risk of causing hearing loss cetaceans or other marine animals? The short answer is that the signals emitted by the STM surface station and the ARC-1 releases (when operating in individual release mode) are roughly comparable to those of a commercial grade depth sounder as might be found on a fishing vessel operating at a lower frequency such as 33kHz or 50kHz. And similar to a depth sounder, the risk to marine mammals in most realistic operational scenarios is minimal.

In July 2016, NOAA Technical Memorandum <u>NMFS-OPR-55</u> established Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing. The memorandum uses the following approach:

- 1. Marine mammals are divided into hearing groups. This is table ES1 in the memorandum, which you find reproduced in table 1 below.
- 2. For each hearing group, PTS onset acoustic thresholds are stated in the memorandum table ES3. These thresholds are cumulative exposure of the animal to the sound, not intensity levels. Thus, higher intensity sounds with shorter exposure time may be equivalent to a lower intensity sound but with longer exposure time. Overall, some animals such as baleen whales in the LF

- hearing group are very noise tolerant and are thus assigned high thresholds. Others, such as harbor porpoises in the HF hearing group are found to have a much lower noise tolerance and are thus assigned a low threshold.
- 3. Sound that is emitted from a device is weighted per table ES2 depending on the frequency of transmission as compared to the assumed audiogram of an animal in one of the hearing groups. For example, the 38kHz transmissions of the ARC system are assigned a weighting of -13.85dB for the LF hearing group, because baleen whale hearing only barely extends to this range and is much attenuated. For harbor porpoises and others in the HF hearing group, the ARC-1 transmissions are assigned a weighting of OdB because they are in the frequency range where the animal's hearing is most sensitive.

We are applying the above guidance to establish safe distances from the transmitter (i.e. the boat or transmitting ARC-1) for the animals in tables 2 and 3. The safe distances depend on the following:

- 1. The intensity of the transmissions. The through-hull boat transducer has a focused beam within which the sound is relatively intense at 197 dB re. 1μ Pa at 1m distance from the transducer. The over-the-side transducer for the boat or the ARC-1 transducer have a more omni-directional beam pattern and the sound intensity is lower at 192 dB. Thus, we provide two tables with safe distances for the through-hull transducer (table 2), and with safe distances for the over-the-side transducer or the ARC-1 (table 3).
- 2. The exposure time of the animal to the sounds. Shorter exposure means that higher intensity sound can be tolerated, and the safe distance is thus less. We are providing three categories. (1) One second is the minimum safe distance for a case when an animal happens to intersect the boat just as a transmission occurs. Chances are, the animal will have gained some distance by the time of the next transmission. (2) Five minutes is for a scenario where an animal might linger around a boat or location of a release just as it is being operated. Typically, the fishing boat will have moved on after five minutes. (3) Continuous exposure is a scenario where a fleet of fishing boats is constantly (day and night) transmitting such as to broadcast release traps, and animals in the area cannot gain distance from these transmissions. This is a very unlikely worst case, but also produces the greatest 'safe distance' meaning system operation will be unconditionally safe if animals in that hearing group are at the specified distance or more from a transmitter.
- 3. The duty cycle of the boat or ARC-1 transmissions. The boat and ARC-1 use a very efficient coding scheme that minimizes the duration of transmissions and thus the amount of acoustic energy that is put into the water per unit of time. Typically, an STM-3 deck box on a boat or an ARC-1 will only transmit for 0.004 seconds in each second. Thus, even for a five-minute trap or pot recovery including many acoustic ranging cycles between the boat and the release, the cumulative active transmission time is only 1.2 seconds. This reduces the 'cumulative sound exposure' of the animals dramatically and means that the system can be safely operated at much closer proximity to the animals as compared to a system of similar sound intensity but emitting sound continuously or at a much higher duty cycle.
- **4.** The decay of signal intensity with distance from the transmitter. Sound naturally attenuates with distance from the source. Music playing gets fainter with distance from the speaker. The standard model for sound attenuation underwater is called spherical spreading loss. This implies that sound travels in all directions and inverse proportional to the surface area of an expanding balloon, the sound intensity at twice the distance from the source will be 1/4th. This model assumption is made in the safe range computations for tables 2 and 3.

Hearing Group	
LF	Baleen whales
MF	dolphins, toothed whales, beaked whales, bottlenose whales
HF	true porpoises, <i>Kogia</i> , river dolphins, cephalorhynchid, <i>Lagenorhynchus cruciger</i> & <i>L. australis</i>
PW	Phocid pinnipeds (true seals)
OW	Otariid pinnipeds (sea lions and fur seals)

Table 1: Marine mammal hearing groups for the purpose of safe range computations. Corresponds to memorandum table ES1.

Hearing Group	PTS onset Threshold (dB)	Frequency Weighting W(f) (dB)	Weighting Adjusted Exposure Limit E(f) (dB)	1 sec exposure (m)	5min exposure (m)	continuous exposure (m)
LF	199	-13.85	212.98	0.01	0.17	2.95
MF	198	-0.14	199.34	0.05	0.84	14.20
HF	173	0.00	174.36	0.86	14.84	251.92
PW	201	-7.58	209.33	0.02	0.27	4.50
ow	219	-9.76	229.40	0.00	0.03	0.45

Table 2: Species dependent safe distances from boat through-hull transducer

Hearing Group	PTS Threshold (dB)	Frequency Weighting W(f) (dB)	Weighting Adjusted Exposure Limit E(f) (dB)	1 sec exposure (m)	5min exposure (m)	continuous exposure (m)
LF	199	-13.85	212.98	0.01	0.10	1.66
MF	198	-0.14	199.34	0.03	0.47	7.98
HF	173	0.00	174.36	0.48	8.35	141.66
PW	201	-7.58	209.33	0.01	0.15	2.53
OW	219	-9.76	229.40	0.00	0.01	0.25

Table 3: Species dependent safe distances from boat over-the-side transducer or ARC-1XD release

Summary

Tables 2 and 3 shows that per the NOAA guidance document, the ARC acoustic release can be safely operated in quite close proximity to marine mammals. The one limited exception is the HF hearing group of animals including true porpoises. Here, the acoustic transmissions fall into the sensitive portion of the animal's audiogram and these animals have been found to have a low noise tolerance. Still, as long as exposure is limited to five minutes or less, system operation is safe at distances of 15m or more from these animals. If use of the system in some areas should become very intense so that animals cannot escape exposure to acoustic transmissions from boats or responding releases, then system operation should be paused if porpoises are sighted within about 150m.

7. The Economic Viability of ARC-1 based Ropeless Fishing

Economic viability is of course an absolute requirement for the implementation of a ropeless system. NSW fishers have achieved economic viability and are purchasing ARC systems not due to mandates, but independently to improve their fishing business. The reasons for system purchases are very fisher specific. This chapter looks at how to minimize the cost of ARC ownership and maximize the benefit for your business.

Cost minimization

Minimize purchase cost: The purchase cost of ARC-1 releases ranges from U.S. \$1550 if purchased at quantities of 100 or more to \$1995 if purchased at quantity of 9 or less. We recommend that you pool purchases within your fishery association to obtain the lowest price. An alternative might be a very large quantity 'strategic purchase' by a national fisheries management body negotiated at a lower price.

Maximize equipment lifetime to obtain a low annualized cost: The ARC-1 has no hard limit to its lifetime or endurance. The housing is made from non-corrodible Delrin plastic and all metal components are titanium. The device is also fully serviceable, so substantial value is maintained in virtually all circumstances including housing flooding. In NSW, equipment has now reached six years of fishery use and a recent inspection found equipment to be in good condition. Practice good maintenance, and you should see equipment life of ten or even 20 years. To minimize cost, you can fully service ARC-1 yourself with the right training. Now, consider the annualized cost of the equipment. Assuming \$40 annual cost for a battery change and small repairs and a \$1600 acquisition price (quantity 50-99 bracket), the annual ownership cost over a ten year life is \$200. If you achieve a 20 year life, cost is \$120 per year.

Minimize equipment loss: A properly run ropeless system will be robust against equipment loss, employing multiple 'lines of defense' to minimize the loss of traps.

- ✓ The release bags are well designed and tested, minimizing snag potential
- ✓ There is sufficient scope between trap and release bag to prevent entanglement during deployment and allow a grapple to reliably get purchase between the trap and the bag
- ✓ For individual release mode, the pre-deployment release test function is used to make sure the release is functional
- ✓ The automatic trap GPS location recording function is used to provide an error free record of location.
- ✓ The deployment is consistent every time, trap in first, bag following once the rope is paid out.
- ✓ You have tested your depth sounder for its capability to detect a release even if the acoustic communication should fail.
- ✓ You have practiced searching for a trap using acoustic ranging when it has been moved such as by a ground trawler or a storm.
- ✓ You have practiced your grappling skills and will be able to reliably and quickly grapple a trap and release bag.

Using the above defenses, you should be in a position to consider your traps and releases to be safe when submerged, never lost. What loss rates are achievable? Seeking Fisheries in NSW has lost approx. 15 releases out of a growing inventory of 100-150 units over six fishing seasons. That's a loss rate of roughly 2%-3% per year. They are attributing most losses to ground trawlers. Another fisher has also seen very few (or no?) losses, but encountered a high snag rate after extending soak times and eventually running into biofouling problems. His nonetheless low loss rate is on account of reliable depth sounder locating and grappling. A third fisher experienced very high loss rates, thought to be in general on account of not having the best defenses as outlined above.

If you can limit your gear loss to no more than 3% of inventory per year, then the annual cost of losses is about \$48 per release you own.

Benefit Maximization

The goal is to make the benefit of the use of the ARC-1 system exceed its cost. We learned in NSW that these benefits are very fisher specific.

- Maximize the revenue or value of catch per season per release equipped vertical line that is being used. In NSW, it's around \$5000 per year. If your annualized cost per release is on the order of \$200, it accounts for 4% of revenue earned and may be more than offset by other advantages you gain. On the other hand, if you are generating only \$400 revenue per season for each release, than the \$200 annualized cost may be much too large a share of your revenue and very hard to offset. There are number of ways you might maximize revenue per vertical line. In NSW, very large and high yielding traps are used. An alternative is to 'trawl up', using strings of traps with a release on one or both ends. As with submerged buoys themselves, these modifications may require regulatory changes. Your pilot project coordinator and fishery association should interface with fisheries management for this purpose, using the insights gained from the pilot project.
- Request fishing access to time area closures. With ropeless technology, you have substantially eliminated the entanglement risk to marine mammals. Consequently, you should be allowed to keep fishing during time area closures. Making ropeless fishing commercially viable will require a good look at current regulations and revisions in light of the advantages but also requirements of the new technology. The pilot coordinator should work closely with fisheries management to affect these changes first through experimental fishing permits and based on results through responsive regulatory changes.
- Improve the efficiency of trap servicing in high currents. NSW fishers have to contend with the East Australian current, which can run strong and submerge static buoys at the surface for weeks or even months at a time. Use extra rope in your bag to hook floats after pop-up while there is still slack. This has allowed NSW fishers to access their deep traps in over 2 knots of current, up from 0.75 knots. Trap servicing has become far more efficient and reliable. Seeking Fisheries has reduced time at sea (per engine hour meter) from about 1000 hours per year to about 400 hours per year while landing a larger quota.

- ✓ **Reduce losses due to theft, ship strikes, weather.** Your submerged trap and release at the sea floor is much safer from these hazards. Ship strikes are essentially eliminated, and theft would take a much greater and more obvious effort. In sufficiently deep water, your trap will be safe from storms as there is no buoy in the high energy surface zone.
- ✓ Productively use time previously spent patrolling your fishing grounds. If theft or ship strikes are a concern, you might now spend time to patrol your fishing grounds. With the gear safely submerged, use that time otherwise. NSW fisher Steve Rosskelly now pursues inshore mud crab fishing and other fisheries with time freed up from patrolling, adding revenue to the business.
- ✓ **Better use of traps as live storage.** With access to your catch more reliable, you may be able to use your traps to some extent for live storage, timing your fishing to coincide with best market demand and prices. Perhaps you will need larger traps that will continue fishing for a longer period and need less frequent servicing. Permission to optimize your trap size and design as needed, and allowing longer set times are experimental fishing or regulatory chnages that your coordinator might request from fisheries management in order to make ropeless fishing viable.
- ✓ Cost savings from longer set or soak times. If the above changes allow longer soak times while upholding fishing yield, you may experience significant cost reductions in boat time and cost and labor.
- ✓ **Go fishing on your schedule.** The safety of submerged gear may give you greater control over your time. There may be no need to recover gear ahead of an approaching storm, or when whales move into an area, affecting a closure. Better control over your time and fishing activities should reduce cost by improving efficiency, reduce risk, and make time for family and time off.

Every fishing operation is different, and only some of the listed benefits may apply to you while there are perhaps other benefits not listed here. Look at ropeless fishing from a 'big picture perspective', not for example just focusing on additional equipment cost or time burdens incurred, but how the technology may on balance improve your business and what changes might be needed to obtain the greatest possible benefit.

Below are links to video interviews, giving the NSW fishers perspective on ropeless fishing.

Steven Rosskelly, Forster Fishcorp, Forster, NSW

Scott Westley, Seeking Fisheries, Sussex Inlet, NSW

Mal Gorry, Seeking Fisheries, Sussex Inlet, NSW