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Hackaday Prize Dream Team Ghost Gear Research Report

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for Conservation X Labs

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Overview

At a high level, the problem area is known as abandoned, lost, or otherwise discarded fishing gear (ALDFG) retrieval. This fishing gear is known as ghost gear, and falls into the wider scope of marine debris. Ghost gear has a tremendous impact on nature: leading to deaths of marine animals and harming the marine ecosystem. Additionally, it has an economic cost to the fisheries.

The goal of the Conservation X Labs Dream Team Challenge is to reduce "**soak time**", that is the time that fishing gear has to be left in the water unnecessarily.

[source Design Brief Conservation X Labs Dream Team Challenge. Available at: https://cdn.hackaday.io/files/8533365075872/design-brief-conservationxlabs-dream-team-challenge-wp.pdf (Accessed: 1 July 2020)]

This time increases the chance of snag or loss. There are several **gear types**, the challenge addresses specifically two types: **pots or longlines**.

[source Fishing Gear and Risks to Protected Species (2020). Available at: https://www.fisheries.noaa.gov/national/bycatch/fishing-gear-and-risks-protected-species (Accessed: 1 July 2020)]

A key insight that will guide the development of our solution will be that **the technology must match the pace of fishing**. Meaning, the solution will have to not be intrusive to their normal operations, it will need to be robust - as to not cause more ghost gear, and it must not use any additional time for which it would not have a return on. A preliminary user discovery interview conducted in Nigeria touched on these points as well.

In this research report, a better understanding of the problem will be given by touching on the following topics: Problem, Impact on Species, Root Cause Example, Barriers, Classification of Fishing Gear, Existing Solutions, and End-Users.

Problem

Causes

Ghost gear’s capacity to entangle, injure and kill hundreds of species of marine animals on a large scale makes it a serious concern requiring urgent action.

There are several causes of ghost fishing gear:

- Damage and/or loss of gear through adverse weather conditions
- Snagging on marine environments
- Gear conflict (incidents where fishing vessels or their gear interact with each other, either accidentally or intentionally, causing damage)
- Gear abandoned at end of life due to lack of net disposal facilities or the high cost of disposal lack of ability to retrieve lost gear
- Abandonment to avoid detection when fishing illegally
- Human error

[source 1 1. Macfadyen, Graeme;Huntington, Tim;Cappell, R. Abandoned, lost or otherwise discarded fishing gear. FAO Fisheries and Aquaculture Technical Paper 523 523, (2009). - Accessed 30 June]:

Soak Time

Soak time is one of the variables that is defined and changed to optimize the fishing operations. There are several studies that relate the influence and effects of different soak times and the catching efficiency of the gear. For the fishermen it is important to establish the optimal time that the gear needs to be in the water. Usually this time depends on its type and the target species, but that time increases if any of the following situations occurs:

1. The gear is lost. When that happens it becomes **ghost gear**. This represents 10% of the world's ocean plastic.
2. The gear is badly located.
3. The gear has already caught the desired amount of fish, but is left in the ocean until the time arrives to retrieve the gear.

Economic Cost

Ghost gear is particularly damaging because it continues to execute its purpose of capturing fish well after being lost to fishers. This results in four areas of cost:

- Decreased harvests
- Habitat damage
- Navigational hazard
- Replacement gear

[source: https://www.nature.com/articles/srep19671 (accessed 4 July)]

Impact on Species

Figure 01: This female right whale died off the Canadian coast this summer after dragging crab traps for days. NOAA/NEFSC/PETER DULEY

All marine life can be affected by entanglement of ghost gear and bycatch. This includes species such as sea turtles, seals, sea birds. Of particular interest are Right Whales, as they are one of the world's most endangered whales. Shockingly, 82% of North Atlantic right whales have become entangled at least once [source 22 from here - Ghosts Beneath the Waves — World Animal Protection (report here) (Accessed June 30)].

The North Atlantic Right Whales were hunted to near extinction in the 1750's for their oil, meat and bones. Now they become entangled in fishing gear, ultimately leading to death. The population is decreasing rapidly, so much so that they may be functionally extinct by 2040 if more effort is not done to save them. [source: https://www.biologicaldiversity.org/species/mammals/North_Atlantic_right_whale/index.html (Accessed July 3)]

We can compare the North Atlantic Right Whale to its Southern Hemisphere counterpart. These Right Whales rebounded to 15,000 animals, a population growth of 6% annually. Their primary cause of death is old age in their 80s. Compared to the North Atlantic Right Whales, the Southern Hemisphere Right Whales do not migrate through busy areas. [source: https://e360.yale.edu/features/already-on-brink-right-whales-are-pushed-closer-to-the-edge (Accessed July 3)] The North Atlantic Right Whales swim through shipping lanes and fishing gear. This comparison shows the impact that the industrialized ocean is having on Right Whales.

Root Cause

Flow Chart

The diagram below shows the root causes of unnecessary soak time, and what can be the effects of this.

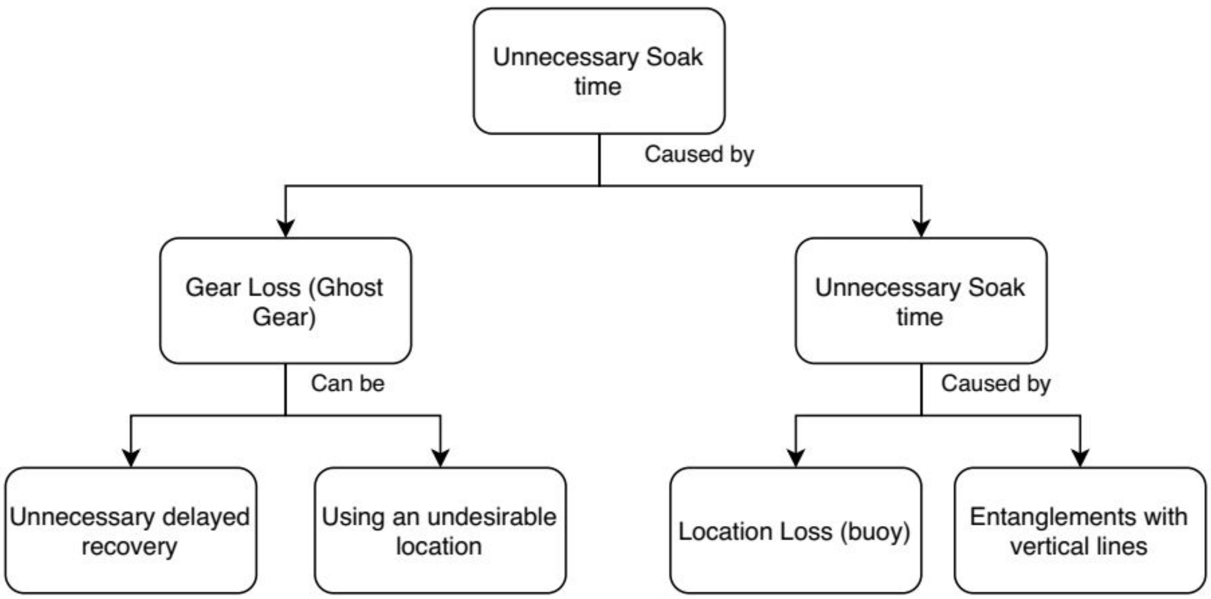


Figure 02: Root Causes

Case Study: Lobster Fishing

As an example case, the recent history of lobster catch in eastern North America illustrates a root cause for the increase in ghost gear.

Since 2000, lobster catch in the U.S. has increased. The reason for this increase is more offshore fishing than nearshore fishing. Offshore fishing is a more industrial endeavour, using larger traps, set in deeper water, and using stronger ropes. The vessels for offshore fishing are often twice as large as the lobster dayboats frequenting nearshore fishing. (source: https://www.pewtrusts.org/en/research-and-analysis/articles/2019/04/25/time-is-running-out-to-save-right-whales (Accessed June 30)) As the commercial fishing industry was expanding, the growing lobster catch resulted in more vertical ropes in areas where Right Whales are found. (source:

https://www.pewtrusts.org/en/research-and-analysis/articles/2019/03/07/saving-endangered-right-whale-demands-new-approach (Accessed June 30)). To give a sense of scale to the lobster fishing industry, in 2018, 147.6 million pounds of lobster were landed coastwide, representing a $630 million ex-vessel value. (source: http://www.asmfc.org/species/american-lobster (Accessed June 30))

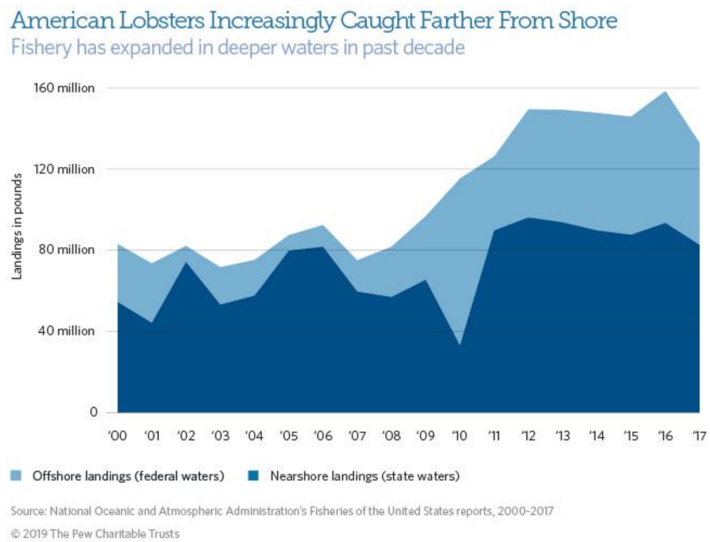


Figure 03: Lobsters fished offshore vs nearshore over time (source: https://www.pewtrusts.org/en/research-and-analysis/articles/2019/04/25/time-is-running-out-to-save-right-whales (Accessed June 30))

The Gulf of Maine / Georges Bank stock is not overfished. Rather, the stock abundance has increased since 1979 and at an accelerated pace since 2007. Current stock abundance is at an all-time high and recruitment has remained high between 2008 and 2013. (source: http://www.asmfc.org/species/american-lobster (Accessed June 30)). The population of lobster is not disappearing, instead it is the location that has changed.

The way we determine stock size is by catch-per-unit-effort, also known as catch rate. It is frequently the single most useful index for long-term monitoring of a fishery. Catch rates by boat and gear categories, often combined with data on fish size at capture, permit a large number of analyses relating to gear selectivity, indices of exploitation and monitoring of economic efficiency. (source: http://www.fao.org/3/Y2790E/y2790e02.htm#TopOfPage (Accessed July 1))

The location has changed due to warming sea surface temperatures. This forces the lobster to higher latitudes than previously. Although ocean temperatures worldwide have risen 0.12 deg C each decade since 1980, this is not the case for offshore in the U.S. Northeast region (where the lobsters are). From 1982 to 2006, the sea surface temperatures in that region increased by twice the global rate, according to the National Climate Assessment. The Gulf of Maine is a hotspot, where it's predicted the sea surface temperatures are warming faster than anywhere else on the planet, to an estimated possible between 2 - 4 deg F by the end of the century

(2020). (source: https://www.climate.gov/news-features/climate-and/climate-lobsters (Accessed June 30))

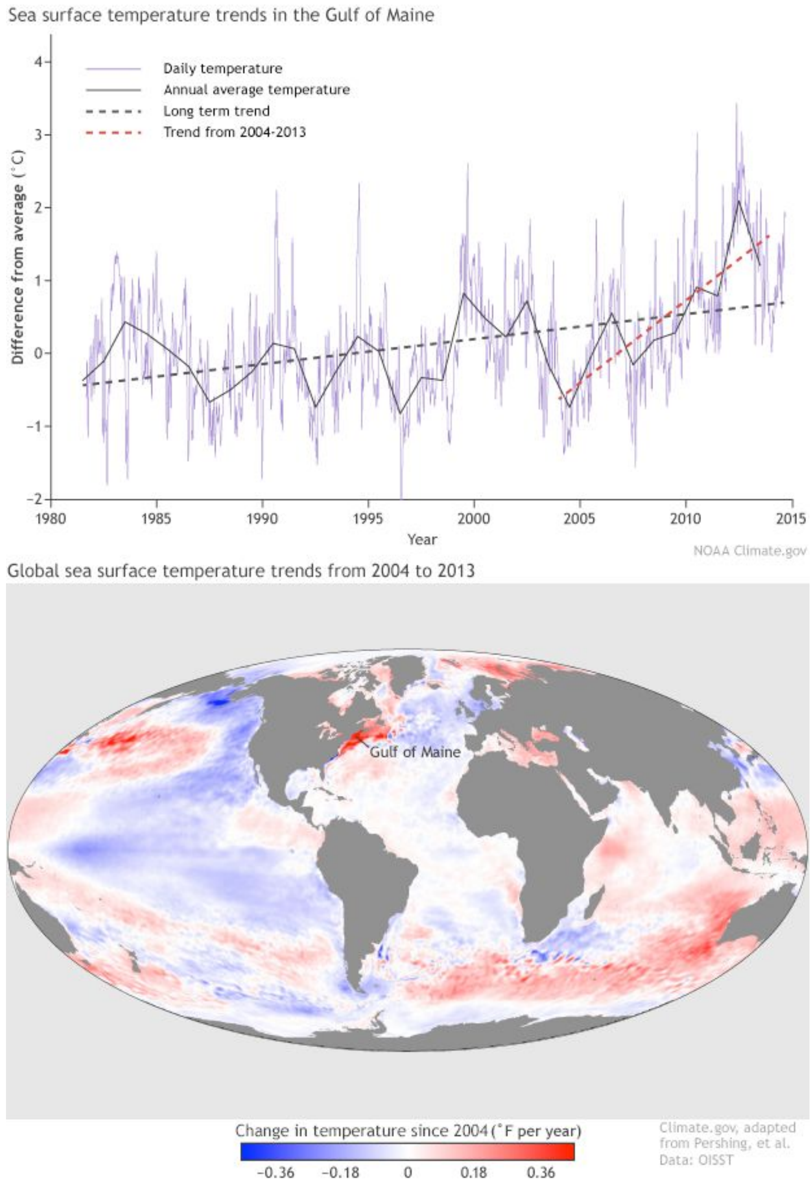


Figure 04: Sea surface temperature trends and map of change (source: https://www.climate.gov/news-features/climate-and/climate-lobsters (Accessed June 30))

This increase in sea surface temperature is why lobsters are moving. Lobsters are stressed after 20 deg C, where they then experience respiratory and immune problems, leading to shell disease and less chance to successfully reproduce. (source: https://www.climate.gov/news-features/climate-and/climate-lobsters (Accessed June 30))

Classification of Fishing Gear

Types of Gear

There are two different types of gear: pots and longlines. Longlines can be bottom longlines or pelagic longlines.

Traps and pots are submerged three-dimensional wire or wood devices that permit organisms to enter the enclosure but make escape extremely difficult or impossible. Their target species are fish (scup, black sea bass and eels), crustaceans and mollusks (crabs, lobsters and whelk). Traps and pots use vertical lines that run from them to a buoy in the surface, and this creates a risk of entanglement for turtles and marine mammals.

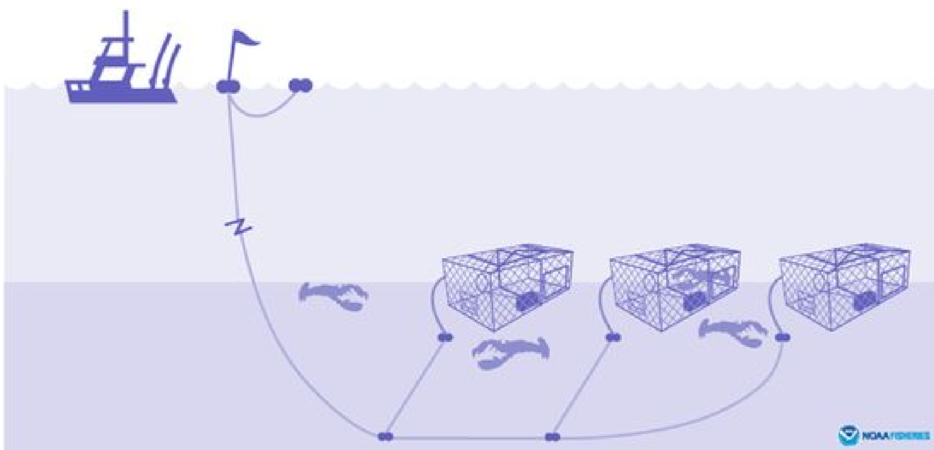


Figure 05: Traps and pots illustration.

[source Fishing Gear: Traps and Pots (2020). Available at: https://www.fisheries.noaa.gov/national/bycatch/fishing-gear-traps-and-pots (Accessed: 1 July 2020)]

Bottom longlines are a type of fishing gear that uses baited hooks attached to a mainline weighted to the seafloor with buoy lines marked by flags on either end. Their target species are sharks, halibut, flounder, sole, and other groundfish. They create a risk of entanglement with the vertical lines and hooks.

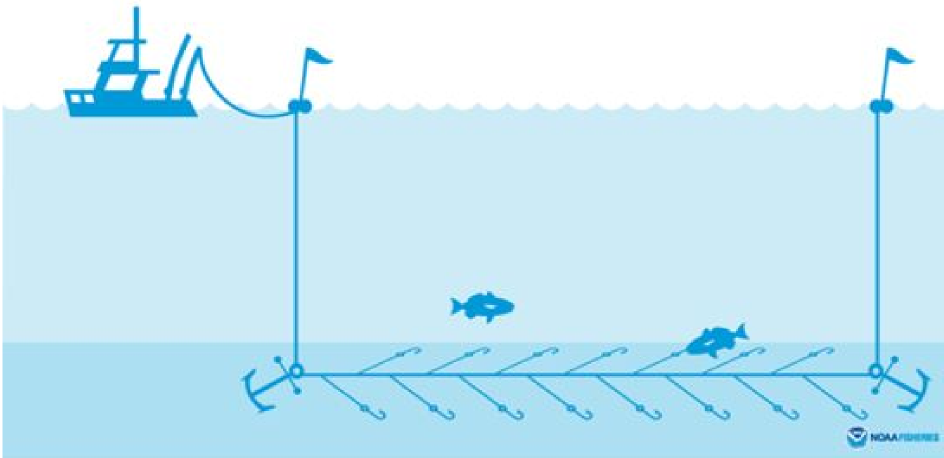


Figure 06: Bottom longline illustration.

[source Fishing Gear: Bottom Longlines (2020). Available at: https://www.fisheries.noaa.gov/national/bycatch/fishing-gear-bottom-longlines (Accessed: 1 July 2020)]

Pelagic longlines are a type of fishing gear that consist of a mainline, gangions, and baited hooks. Their target species are tuna, swordfish and other Pacific billfish. They create a risk of entanglement with the vertical lines and hooks.

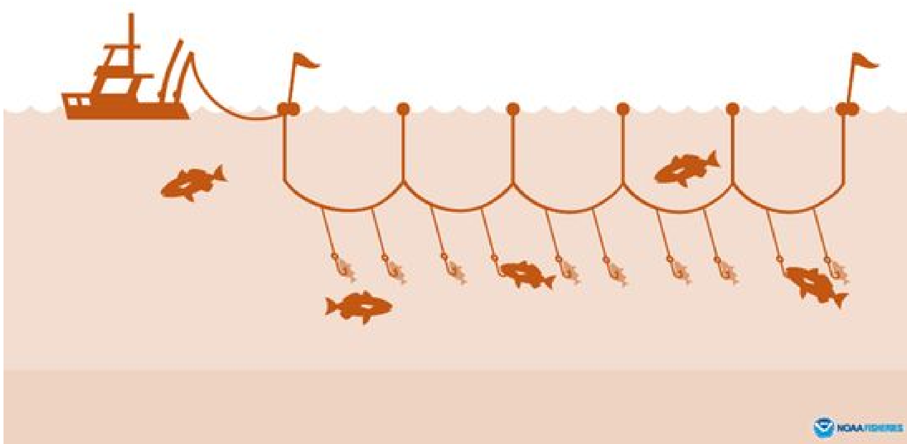


Figure 07: Pelagic longline.

[source Fishing Gear: Pelagic Longlines (2020). Available at: https://www.fisheries.noaa.gov/national/bycatch/fishing-gear-pelagic-longlines (Accessed: 1 July 2020)]

All the mentioned types of gear create a **risk of entanglement** with the animals in the surrounding environment. All of them contain a main vertical line attached to a buoy, but also they create a risk (to a lesser degree) with their hooks (longlines) and groundlines (traps and pots). The figure below illustrates the risks caused by the types of fishing gear.

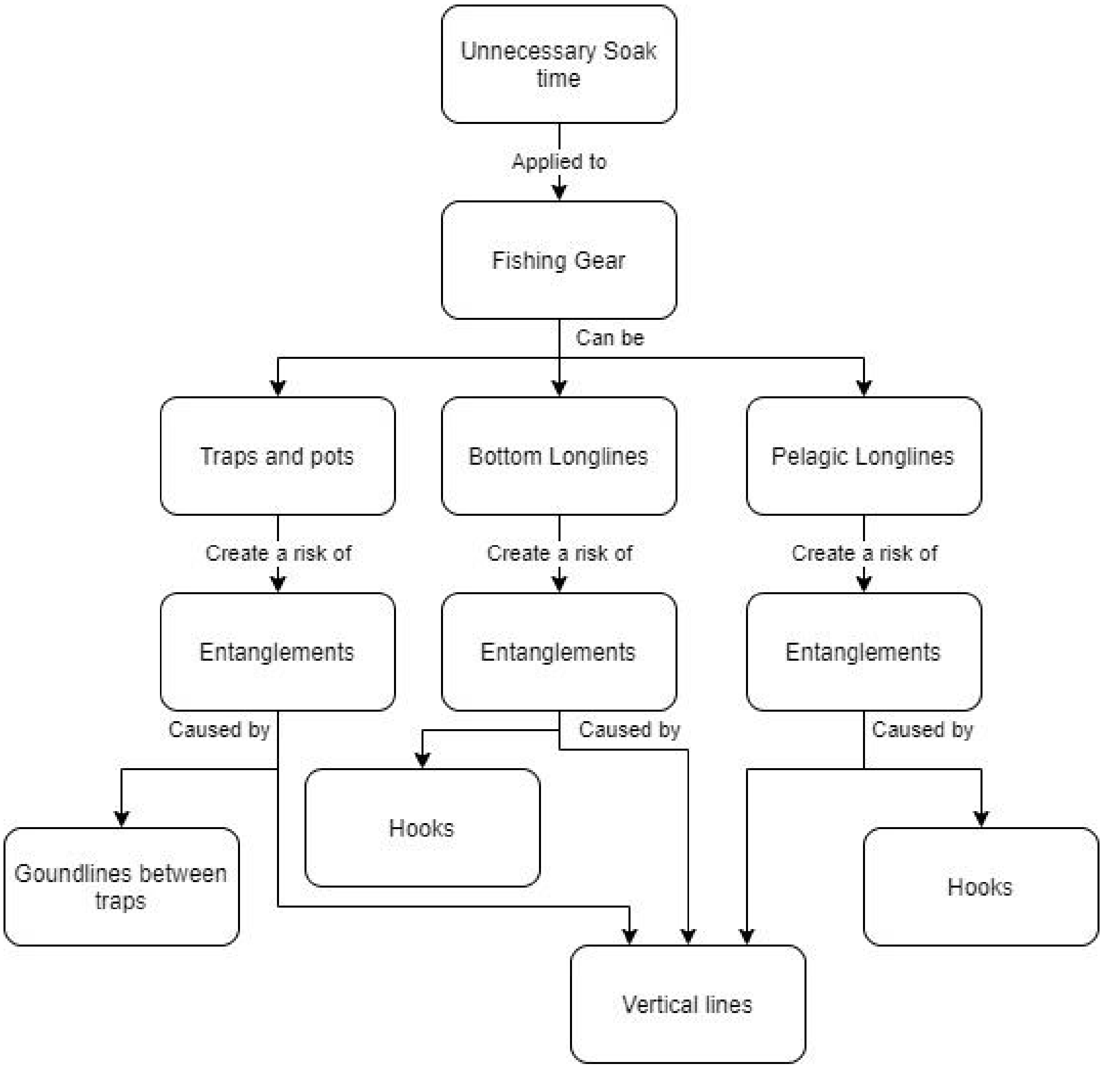
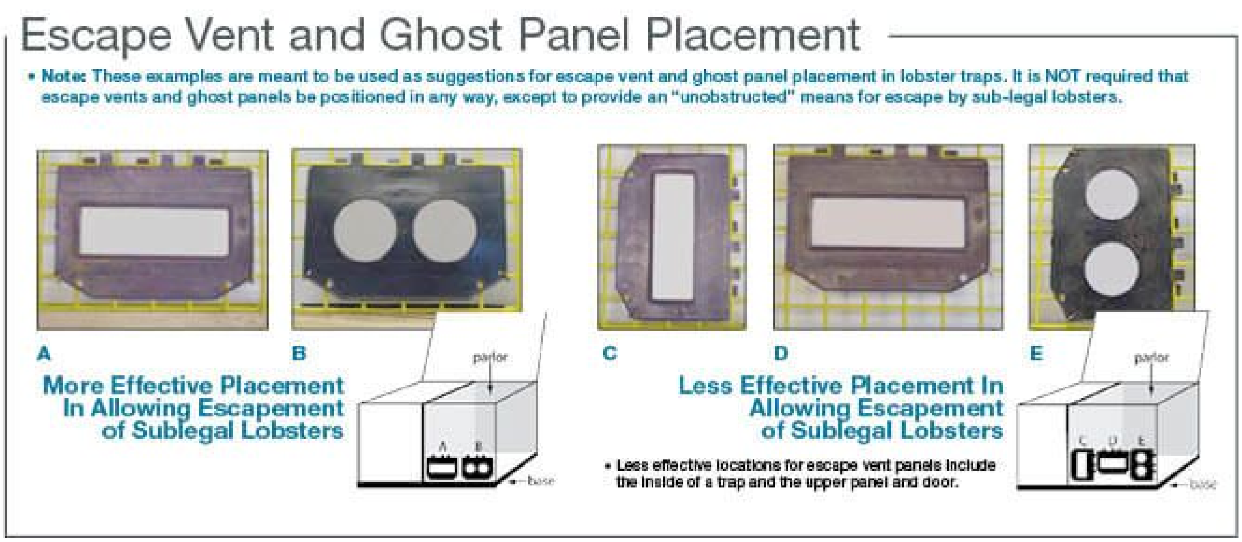


Figure 08: Gear types and their associated risks

How Traps Work

The below images, from this source (http://www.eregulations.com/massachusetts/fishing/saltwater/lobstercrab-trap-requirements/) show the inner workings of a trap. Bait is placed inside the trap, which lures the lobster in. If the lobster is too small, then it can escape through an escape vent. Lobsters then try to leave the trap by travelling through a funnel. This leads them into an area that is challenging to escape from, and is usually where the catch will be found when retrieved.



source:
http://www.eregulations.com/massachusetts/fishing/saltwater/lobstercrab-trap-requirements/
(Accessed July 3)

Barriers

When we consider the scale and impact of this problem, this question arises: **Why hasn't more technology been adopted for these problems already?** The report, *Technologies for Improving Fisheries (2018)* shares relevant insights towards this. The most pertinent examples from the report are included below.

1. **Lack of drivers**

"Many fisheries lack drivers for monitoring, such as legal mandates or strong economic incentives. Moreover, monitoring programs are difficult to implement for a number of reasons: fishermen who have been fishing without restrictions may resist being held accountable to fishery regulations; the costs of monitoring may seem prohibitive; privacy concerns may drive opposition to monitoring; and prosecutorial systems may not generate sufficiently severe penalties for infractions, making monitoring seem futile."
[source: Technologies for Improving Fisheries (2018)
https://www.edf.org/sites/default/files/oceans/Technologies_for_Improving_Fisheries_Monitoring.pdf (Accessed 1 July)]

2. **Legal mandate required**

"A legal mandate to monitor is often a critical component in implementation and can result in fishery managers and fishermen working together, but this alone is often not enough. Stakeholders generally need to be incentivized to adopt a monitoring system beyond the threat of punishment, which is often ineffective or even non-existent in certain contexts; ownership of the idea that monitoring will lead to better fishing is obviously preferable, and this can be achieved by using participatory processes to co-create monitoring goals and design monitoring systems. Demonstrating and otherwise communicating the benefits of monitoring for fishermen—often in the form of higher fish prices, increased catches and increased sustainability—can help to achieve stakeholder buy-in."
[source: Technologies for Improving Fisheries (2018)
https://www.edf.org/sites/default/files/oceans/Technologies_for_Improving_Fisheries_Monitoring.pdf (Accessed 1 July)]

3. **Positive outcomes**

"Positive outcomes of monitoring can reinforce buy-in and willingness to participate in improving fisheries accountability. For example, if fisheries monitoring strengthens fishermen's rights by ensuring that no illegal fishing is taking place, and that scientific data are being used to manage the fishery, participants will likely approach monitoring in a positive manner."

[source: Technologies for Improving Fisheries (2018) https://www.edf.org/sites/default/files/oceans/Technologies_for_Improving_Fisheries_Monitoring.pdf (Accessed 1 July)]

4. **Benefits exceed costs**

“It is important to strive to ensure that the benefits exceed the costs of implementing a particular monitoring program. Many fisheries probably cannot afford to implement an intensive monitoring system that involves the use of cameras in integrated systems that generate highly detailed data for management.”
[source: Technologies for Improving Fisheries (2018) https://www.edf.org/sites/default/files/oceans/Technologies_for_Improving_Fisheries_Monitoring.pdf (Accessed 1 July)]

Existing Solutions

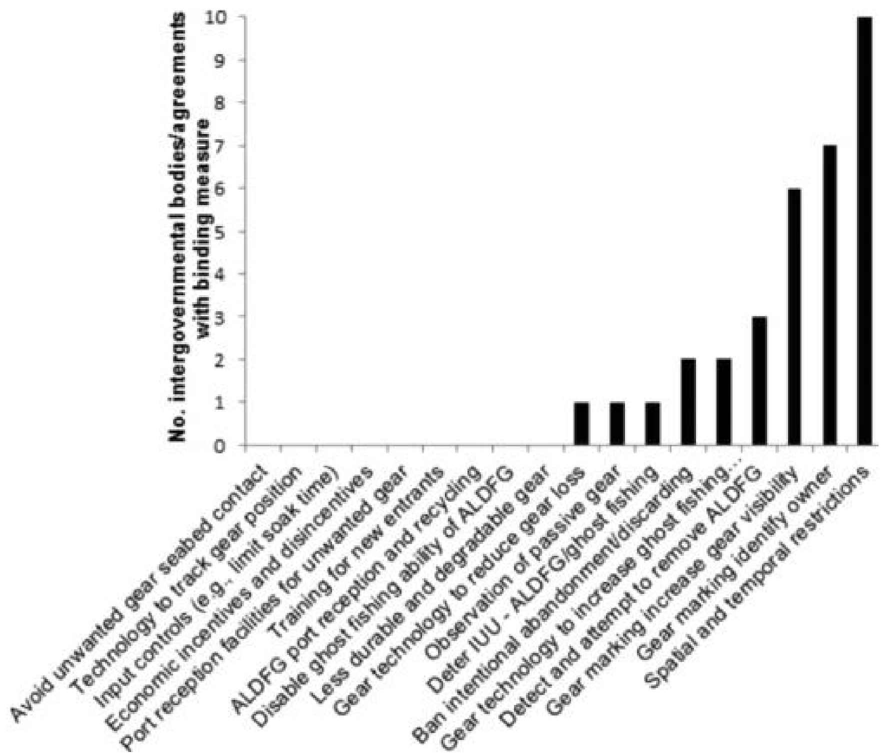
Overview

The challenge proposes 3 possible solutions:

1. Notify the gear has been deployed in an undesirable location.
2. Communicate that the fishing gear has moved to a different location, to avoid it becomes ghost gear.
3. Notify that the target species has been caught.

[source Design Brief Conservation X Labs Dream Team Challenge. Available at: https://cdn.hackaday.io/files/8533365075872/design-brief-conservationxlabs-dream-team-challenge-wp.pdf (Accessed: 1 July 2020)]

A 2015 study by Gilman, showed that established techniques to reduce the impacts of ghost gear are not widely implemented. The categories in this study give insight into potential technical solutions to reducing ghost gear impacts. [source: Eric Gilman, "Status of International Monitoring and Management of Abandoned, Lost and Discarded Fishing Gear and Ghost Fishing," Marine Policy 60 (October 1, 2015): 225–39, https://doi.org/10.1016/j.marpol.2015.06.016.]



In the broad perspective, here are a variety of technological solutions from the Technologies for Improving Fisheries Monitoring report.

CHALLENGE/NEED	TECHNOLOGICAL SOLUTIONS	SPECIFICS
IUU fishing of highly migratory species and transboundary stocks	Satellite imagery VMS data AIS data	Global Fishing Watch, Eyes on the Sea, Camio, Data Science for Social Good
Catch limit compliance - self reported	Electronic logbooks on tablets Smartphone apps	TNC e-Catch, DeckHand Apps: Abalobi, mFish, FACTS, FishBrain, iSnapper, FishAngler
Catch limit compliance - monitored	Low-cost cameras with data loggers	Flywire, ShellCatch
Effort limit compliance	Electronic logbooks on tablets Smartphone apps GPS trackers Low-cost VMS	TNC e-Catch, DeckHand Apps: Abalobi, mFish, FACTS, FishBrain, iSnapper, FishAngler PDS trackers, Remora trackers, SatLink artesanal VMS
Compliance with spatial restrictions (MPAs, TURFs, SPAG closures, etc)	GPS trackers Low-cost VMS	PDS trackers, SatLink artesanal VMS, Data Science for Social Good tracking and alert software, Camio tracking and alert software
Compliance with seasonal restrictions	GPS trackers VMS	PDS trackers, Remora trackers, SatLink artesanal VMS
Reducing bycatch of ocean wildlife	Cameras Satellite imagery AI for detecting wildlife in images Acoustic monitoring of marine mammals	Flywire, ShellCatch, GoPro Planet Images, CVision SA Instrumentation
Illegal access to fishery	Radar GPS trackers VMS	Marine Monitor (M2) radar PDS trackers, Remora trackers, SatLink artesanal VMS
Seafood fraud	DNA scanning Blockchain ledgers	Conservation X DNA scanner, FishCoin
Fisher ID and vessel registry	Electronic registries	FINNS, FishTrax (web-based)
Compliance with size limits	Cameras AI software for image processing Web-based length quantification	Flywire, Shellcatch, TNC system, CVision, Poseidon
Data management	Hardware to integrate data from multiple sensors Databases with user friendly interfaces	Nautilus, Olrac Akvo, Hydroswarm
Predicting illegal activity	Machine learning	Google TensorFlow
Incentivizing data collection and sharing	Blockchain ledger	FishCoin

[source Technologies for Improving Fisheries Monitoring. Available at: https://www.edf.org/sites/default/files/oceans/Technologies_for_Improving_Fisheries_Monitoring.pdf (Accessed: 1 July 2020)]

In the sections below are additional solutions of interest that have already been developed.

Ropeless Fishing Gear

Ropeless fishing is a technique that removes the vertical line that is a part of different types of gear and leads to a buoy on the surface. The fishermen have a visual reference of the gear's location, and also helps to retrieve the gear from the water.

[source Consortium, R. and Consortium, R. (2020) Background – Ropeless Consortium, Ropeless.org. Available at: https://ropeless.org/background/ (Accessed: 1 July 2020)]

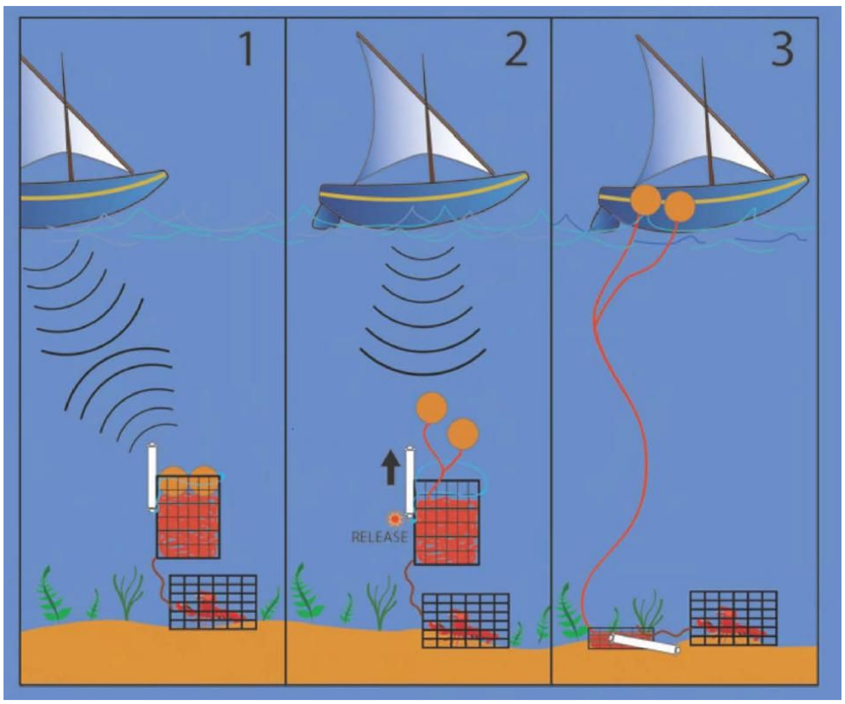


Figure 09: Step-by-step depiction of a pop-up, or 'ropeless' system.

[source Simke, A. (2020) *New 'Pop-Up' Fishing Gear Could Reduce Whale Entanglements*, *Forbes*. Available at: https://www.forbes.com/sites/ariellasimke/2020/03/14/new-pop-up-fishing-gear-could-reduce-whale-entanglements/#1095fdb02b8c (Accessed: 2 July 2020)]

How effective is the solution?

A ropeless gear solution helps to reduce the entanglements. The challenge addresses specific types of fishing gear (pots and longlines), and all of them create a risk of entanglement because of the use of vertical lines. The principal objective of a ropeless gear solution is to remove the mainline that goes to the surface. Since the entanglements directly create ghost gear, and that gear represents 10% of the ocean's plastic, a ropless solution directly reduces the soak time.

[source Design Brief Conservation X Labs Dream Team Challenge. Available at: https://cdn.hackaday.io/files/8533365075872/design-brief-conservationxlabs-dream-team-challenge-wp.pdf (Accessed: 1 July 2020)]

The ropeless solution evaluated in the report includes a remote localization system. This functionality is a key benefit. Most of the ropeless solutions include a remote localization system.

[source Ropeless Workshop Report. Available at: https://ropeless.org/wp-content/uploads/sites/112/2018/03/Ropeless_Workshop_Report.pdf (Accessed: 2 July 2020)]

This type of system is useful for the fishermen when the buoy is released. An underwater system is useful to keep track of the localization at all moments. This aspect is required by Fishery Inspectors, and any viable, long term solution needs to take them into account.

[source Desert Star Systems LLC Technical Proposal Topic Ropeless Fishing. Available at: https://static1.squarespace.com/static/5c49f2807e3c3a3eb6d75875/t/5c5b7494085229ad86f5cec5/1549497513314/Desert+Star+Systems+LLC+-+Technical+Proposal+-+Topic+9-2-04+Ropeless+Fishing.pdf (Accessed: 2 July 2020)]

Products and Projects:

1. 5112 Ropeless Fishing System.

[source 5112 Ropeless Fishing System (2020). Available at: https://www.edgetech.com/product/5112-ropeless-fishing-system/ (Accessed: 1 July 2020)]

2. Pop-Up Buoy Recovery System.

[source System and Inc., D. (2020) Pop-Up Buoy Recovery System | Ocean News and Technology, Ocean News and Technology. Available at: https://www.oceannews.com/offer/pop-up-buoy-recovery-system (Accessed: 1 July 2020)]

3. Ropeless Fishing studies and experiences from Desert Star Systems [15]
4. The Ropeless Workshop Report from the Woods Hole Oceanographic Institution (2018)

[source *Ropeless Conversion* | *Desert Star Systems* (2020). Available at: https://www.desertstar.com/es_MX/ropeless-fishing/considerations (Accessed: 2 July 2020)]

From the last experiences of Desert Star Systems with pop-up gear tests, **the fishermen manifested two main concerns**:

1. **The technology must match the pace of fishing** that they are currently able to achieve, Any increase in time caused by the new technology creates an increase in working hours to achieve the same income.
2. **The release and recovery system must be robust**, if the buoy doesn't pop up the system creates losses of income and creates more ghost gear.

[source Simke, A. (2020) *New 'Pop-Up' Fishing Gear Could Reduce Whale Entanglements*, *Forbes*. Available at: https://www.forbes.com/sites/ariellasimke/2020/03/14/new-pop-up-fishing-gear-could-reduce-whale-entanglements/#1095fdb02b8c (Accessed: 2 July 2020)]

Weak Links

Weak links are an existing solution of attachments from lines to buoys that can break under a certain amount of force. Related to this solution are bio-degradable options for ropes and traps. See below for images detailing weak links, these images are from (source: NOAA Atlantic Large Whale Take Reduction Plan - Supplements https://www.maine.gov/dmr/science-research/species/lobster/documents/plansupplements8-14.pdf).

Weak Links & Anchoring Techniques

Why Are Weak Links Required?

Weak links are intended to allow the release of the buoy, flotation or weighted device from the line in a way that when they release, the remaining line (that was connected to these devices) will not have a knot on its end. An eye left on the line made by splicing, tucking or hog rings is acceptable. Splices are not considered to be knots.

All weak links must be placed as close as operationally feasible to each individual buoy, flotation or weighted device. Each management area has specific weak link breaking strength requirements. See regional trap/pot and gillnet guides for more information.

Weak Links For Buoy, Flotations or Weighted Devices

1) HOG RINGS

Figure 1

Hog rings can be used to form an eye in the end of a line that will function as a weak link (Figure 1). Up to 7 may be used to create a 600 pound weak link and up to 5 for a 500 pound weak link. Hog rings can be distributed (from 6" to 12") without significantly affecting the strength.

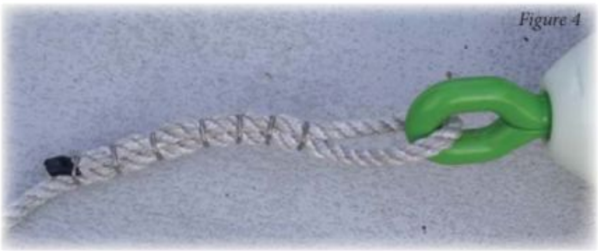
Figure 2

A variation of this technique (Figure 2) is to connect a weak link from a short length of line. The line is formed into a loop with its ends overlapped and hog ringed to each other. Five hog rings form a suitable 600 pound link while 4 are sufficient for a 500 pound weak link. For this weak link to function properly, the loop must move freely where it attaches to both the buoy, flotation, or weighted device and the line.

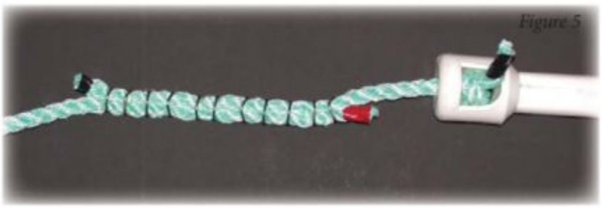
Figure 3

A line may also be passed through a plastic swivel two times (Figure 3), not forming a knot, and hog ringed back on itself with up to 3 hog rings.

USING HOG RINGS TO ACHIEVE A SUITABLE WEAK LINK



When threading the buoy line only once through the buoy becket/spindle, up to 7 hog rings may be used to create a weak link no greater than 600 lbs, and up to 5 hog rings used to create a weak link not exceeding 500 lbs.



A buoy line can be laid alongside a short lead and hog-ringed to form a weak link. 11 hog rings produced a breaking strength of 345 lbs as tested by the NOAA Fisheries Gear Team.

To produce a weak link from a short length of line, the line is formed into a loop with its ends overlapped and hog-ringed to each other. Five hog rings form a suitable 600 lb weak link, while four are sufficient for a 500 lb weak link. The buoy line can be passed through the loop only once, then spliced, hog- ringed or tucked back on itself to make a knotless connection.

A buoy becket-type weak link can be made using no more than 7 hog rings to create a weak link less than or equal to 600 lbs, and no more than 5 hog rings to create a weak link less than or equal to 500 lb weak link. When using this hog ring buoy becket-type weak link, the buoy line must pass through the hog-ringed eye only once and be tucked, spliced or hog ringed back to itself, making a knotless eye.

GILLNET FLOATLINE WEAK LINKS

Several methods of incorporating weak links into a gillnet floatline are shown below. The first two methods create a weak link by utilizing Rope of Appropriate Breaking Strength.

The first picture shows a weak link jumper spliced into the floatline. The overhand knot in the jumper reduces its strength to about 60% of its original strength. For example, putting an overhand knot in a piece of 5/16" polypropylene that has an original tensile strength of 1710 pounds will make the rope fail with a load of about 1025 pounds.

The second picture shows a weak link tied into the float rope with the fisherman's knots. These knots also reduce the strength of the rope to about 60% of its original strength.

Another alternative shows an off the shelf weak link rigged into the floatline.

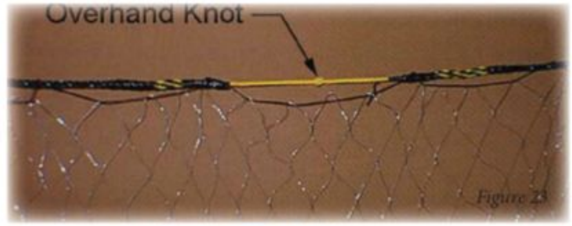


Figure 23

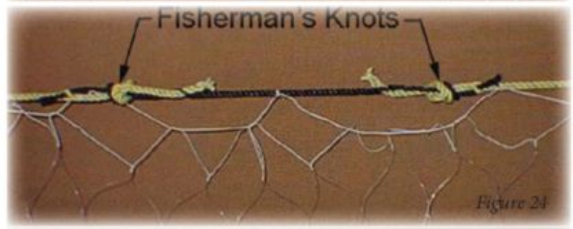


Figure 24


Figure 25


Figure 26

GILLNET ANCHORING TECHNIQUES

At the right is an example of a burying anchor (designed to hold to the ocean bottom through the use of a fluke, spade, plow or pick) that meets the requirement of the holding power of a 22-pound Danforth–style anchor. Note, dead weights do not meet the requirements for burying anchors.

For More Information Contact the NOAA Fisheries Greater Atlantic Gear Team

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www.greateratlantic.fisheries.noaa.gov/whaletrp

Note: The following sections were provided to us by Sam Kelly from Conservation X Labs

Gear Marking

Identify ownership and increase visibility. Being able to trace an owner back to lost gear reduces likelihood of intentional dumping/abandonment and identify practices that lead to unintentionally lost gear. It may also present an opportunity to increase the traceability of seafood and limit the capacity.

Coded Wire Tags (CWT)

Used in juvenile salmon – laser etched ID, detected by specialized readers (T-Wands) and read under microscope. Single study for tracing origin of fishing gear (ropes in fixed gear) Krutzikowsky et al (2009). $18USD per km of rope (0.25c per tag) and likelihood of identifying tag is 90%. Concluded too expensive due to depths.

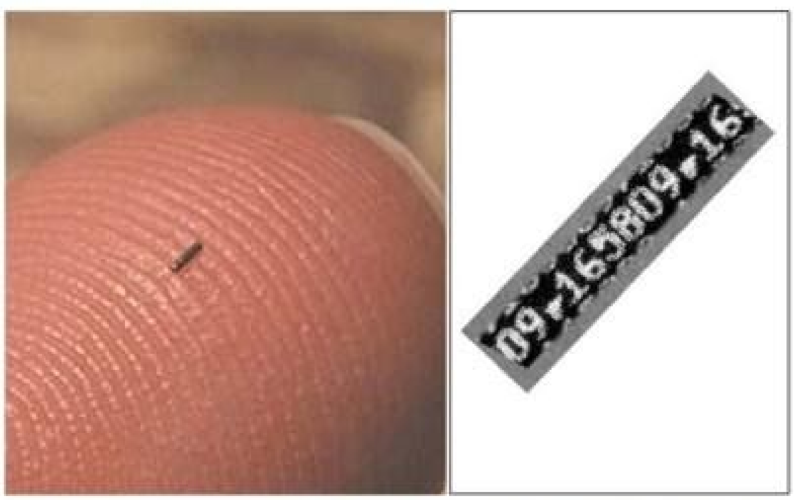

Figure 10: The standard coded wire tag (1.1 mm x 0.25 mm) as it appeared in a fingertip

[source New Technologies for Marking of Fishing Gear. Available at: http://www.fao.org/fishery/docs/DOCUMENT/ec-marking/Inf3.pdf (Accessed: 5 July 2020)]

Passive RFID Tags

Can carry 2 KB of data, but can be advanced and add GPS, time etc.

Applications:

- PIT Tags (Passive Integrated Transponder)

- NOAA supports research for advanced gear marking technologies
- Rope Tagging – BioMark Inc. (Boise, ID)
    - All readable for inshore gillnet and lobster pot, only 54% offshore lobster pot
    - NOAA supported research on “Super Smart Tape”
- Capacity monitoring
    - Amount of gear is limited in fisheries so tags are ascribed to permit numbers and they are starting to incorporate RFID
    - GPS Location is read when the RFID is scanned – allowed better recording of areas where fishing occurs

Technical and functional parameters	Passive RFID tag	Active RFID tag
Power source	From reader	Internal
Tag battery	No	Yes
Availability of power	Only when within reader’s range	Continuous
Required signal strength from reader	High	Low
Signal strength to reader	Low	High
Detection range	Short (<3 m)	Long (100 m or more)
Sensor capability	Very limited	Yes
Data storage	Very limited	Yes
Multi-tag readability	Limited	Yes
Tag size	Small	Large
Tag cost	Low	High

Figure 11: Cable-tie style tags typically used in lobster pots in Maine, USA.

Figure 12: The quarter-size RFID tag used for crab pots by Quinault Indian Nation (NWIFC, 2015).

[source New Technologies for Marking of Fishing Gear. Available at: http://www.fao.org/fishery/docs/DOCUMENT/ec-marking/Inf3.pdf (Accessed: 5 July 2020)]

Technology to Track Gear Position

Tracking the location of gear position involves the use of smart buoys that can communicate long distances to fishermen. The use of this gear transcends fishing techniques but is most commonly used in pelagic fisheries such as longlines and seine nets where FADs are used.
For example, Japanese Pelagic Longlines can be 70NM in length. They have radio buoys for retrieval with GPS, sonar and solar panels incorporated. FADs are another common use for tracking buoys - 75% of purse seine nets now use FADs (Lopez et al 2015) (including tuna – half (Miyake et al., 2010). There is growing fear of ecological impact (Davis et al, 2014) of FADs but there is now 105,000 drifting FADs (primarily for tuna purse seine) (Baske et al 2012). The top five manufacturers put out 47,500-70,000 buoys a year.

AIS (Automatic Identification System)

AIS is an automatic ship position and tracking system widely used by ships.

Classes:

- Class A – 20-25NM
- Class B – 7-8NM
- Search and Rescue Transmitters (SARTs) (3-4NM)

- Aid to Navigation (ATON)
- Shore-based stations
- S-AIS (Satellite AIS)

Figure 13: The AIS Class B drift marker designed by Aanderaa Data Instruments AS (www.aadi.no) that was primarily used for tracking oil spills.

[source New Technologies for Marking of Fishing Gear. Available at: http://www.fao.org/fishery/docs/DOCUMENT/ec-marking/Inf3.pdf (Accessed: 5 July 2020)]

Only 1% of the 1.3 million fishing vessels carry a Class A system. There are several unused data slots that could be used for marking fishing gear (and presumably other things). There are restrictions within the US about using AIS for non-vessel purposes.

Use VHF frequencies: Ch. A: 161.976 MHz, Channel B: 162.025 MHz

Companies:

- SeaFi – hold the record for longest transmission without satellite or cellular network
- AADI AIS Drifter Buoy – can be received from Class A and Class B AIS receivers and shore-based stations. Rechargable battery lasts 7 days.
- Em-Trak - $500
- SRT Marine Technology - $500
- True Heading AS - $500

- Matsutec - $200
- Quark-Elec Online AIS Store: (includes “SeaCall” which can be used for Skype) $50-700

NOAA is experimenting with virtual buoys (AIS transmitter in different location send location of e-buoy, so that boats can see vessel)

Figure 14: Examples of radio buoys for longlines from Kato Electronics Co. Ltd (Kaohsiung, Taiwan). Antenna not included. From: http://www.radiobuoy.com .

[source New Technologies for Marking of Fishing Gear. Available at: http://www.fao.org/fishery/docs/DOCUMENT/ec-marking/Inf3.pdf (Accessed: 5 July 2020)]

Radio Buoys

Two types: 1) Constantly transmit 2) Only transmit when called (Sel-Call)

Companies

- Kato Electronics: KTR-17/18, range: couple of 100 NM, emit signals with 30 sec repetition 3 min rest
- Dong Yang Engineering: PRSC-30 lasts 10x longer. Only emits signal when it receives signal from owner vessel
- Marine Instruments AS: Satellite Communication Buoy

Type	Year	Signal detection/ transmission	Detection range	Power	Notes
Radio buoys	mid 1980s	Constant transmission Radio Detection Finder (RDF)	100	Battery	Detectable by other RDFs and radars
Select call radio buoys	late 1980s	RDF (no constant transmission)	200	Battery	Detectable by other RDFs and radars
Radio GPS buoys	mid 1990s	RDF (no constant transmission) + GPS position	700-900	Battery	First expansion of FAD fishing grounds
GPS tracking buoys	late 1990s	GPS position (continuous emitting)	1000	Battery	First with info on battery status and SST
Echo-sounder buoys	2000s	Inmarsat satellite connection + light when approached	Virtually unlimited	Battery	First echo-sounder readings
2nd gen. echo sounder buoys	mid 2000s	Satellite connection	Virtually unlimited	Solar panels	First with info on current speed and direction
3rd gen. echo sounder buoys	2012	Satellite connection	Virtually unlimited	Solar panels	Multi-frequency transducers

- Buoy for the **location and tracking** of the FAD.
- **Iridium** satellite communications. Global coverage.
- **Flat rate** on communications for cost-effectiveness
- **Easy to use,** perfect for those starting to use FAD on their tuna fishing operations.
- Competitive price.
- The buoy reports data on **GPS position, water temperature and battery level**.
- Set-up of different operation modes through telecommand:

Figure 15: An example of a solar-powered satellite FAD buoy from Marine Instruments AS with some advertised features (www.marineinstruments.es).

[source New Technologies for Marking of Fishing Gear. Available at: http://www.fao.org/fishery/docs/DOCUMENT/ec-marking/Inf3.pdf (Accessed: 5 July 2020)]

Finding Lost Gear

Pingers/Transponders

Used to recover ghost/lost gear

Gearfinder 700 – An acoustic recovery system

Deepsea Launcher System – Acoustic Release System for fishing gear

Passive Sonar Reflectors

Devices that are engineered to enhance or reduce acoustic signal.

SonarBell (Subsea Asset Location Technologies) – Previous military tech, material creates a signal significantly greater than a solid reflecting sphere. Works frequencies 8-140kH

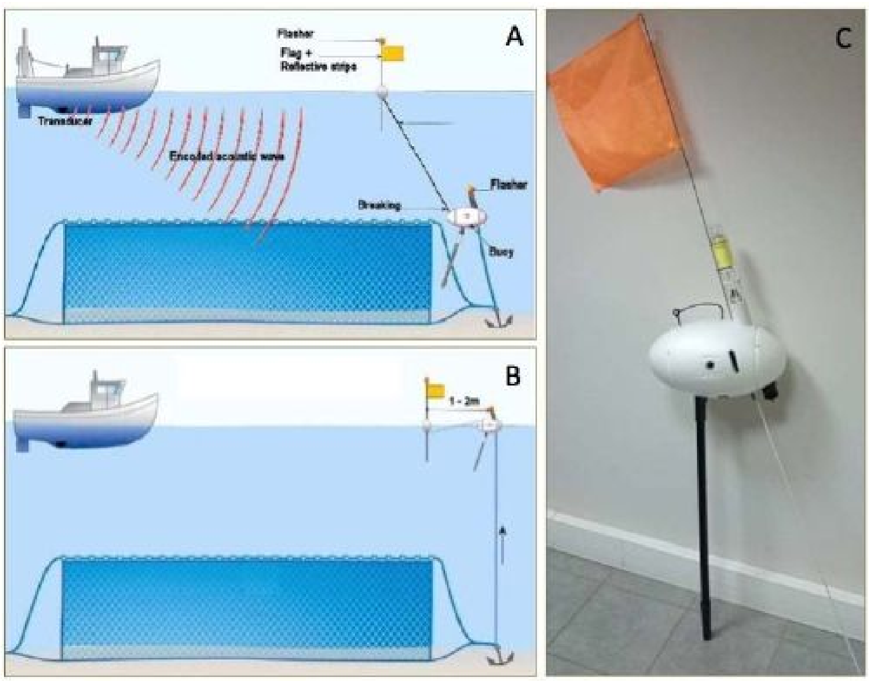

Figure 16: The Deepsea Launcher System (DLS) from Scatri of France. A. The gillnet in fishing condition (the buoy submerged 15-40 m the surface. B. The buoy emerged from underwater during retrieval. C. The buoy. From http://www.scatri.com.

[source New Technologies for Marking of Fishing Gear. Available at: http://www.fao.org/fishery/docs/DOCUMENT/ec-marking/Inf3.pdf (Accessed: 5 July 2020)]

End-Users

Preliminary Discovery Interview Conducted

Discussed with one of the famous tribe of fishermen in Nigeria about which gear they use the most. He prefers the passive gear because it does not need to be dragged, pulled or towed to capture fish. The catch is recovered by simply removing the gear from the water after a time period. No energy is expended on towing, pulling or dragging of gear. This is the simplest gear employed for fishing. The requirements are line and baited hook. Hooks vary enormously in shape, size, type of point, thickness of wire and type of end of the shank.

User Benefits

Who are your users? Who is willing to pay for the solution?
The principal users are the **fishermen**. The Ropeless Workshop Report from the Woods Hole Oceanographic Institution (2018) discusses the following benefits for the fishermen:

1. Never buy end lines again for some ropeless approaches.
2. Significant reduction in lost gear.
3. Gear position is still apparent using technology, but gear identity only known by gear owner and enforcement.
4. Less gear movement from current and tidal drag on end lines and buoys.
5. Fewer interactions with vessels.
6. Some ropeless options may be safer to retrieve
7. Gear identity and location can be monitored remotely
8. Better information for regulators (for example fishing effort)

[source Ropeless Workshop Report. Available at:
https://ropeless.org/wp-content/uploads/sites/112/2018/03/Ropeless_Workshop_Report.pdf
(Accessed: 2 July 2020)]