LONG-LINING POT GEAR FOR WHALE ENTANGLEMENT BENEFIT?

(i.e stringing multiple pots together with groundline to reduce the number of vertical lines in the water—with or without ropeless gear)

Information From Marine Mammal Experts (pages 1-5), Followed By Input From Fishermen (pages 6-12) and attachments p. 14-47

Compiled by Fran Recht, PSMFC October 2019

Marine Mammal Experts Karin Forney, NOAA SWFSC, Dan Lawson, NMFS Protected Resources Division, Doug Sandilands, SR3 Sealife Response, Rehab, Research, and Jenn Tackaberry, Cascadia Research Collective, provided this input.
(Their information has been re-ordered and combined to group similar topics)

With thanks to Jenn Tackaberry and Tim Werner, New England Aquarium for the attached papers.

Question: *As the idea of ropeless or pop-up gear moves forward and/or management measures are being thought about (that might call for reducing lines in the water when risk is higher) people are thinking that the costs and logistics seem to dictate that pots be long-lined together. What are the concerns/benefits for operations and whale entanglement?*

Fewer Lines Versus More Severe Injuries

- Overall there is a complicated calculus needed, which weighs the relative impact of longline gear on the nature of injuries that may occur given entanglements, vs the relative benefits of reduced instances of entanglement vs the relative impact on detection rates of entanglements vs the potential for launching successful disentanglement efforts (and that may not be exhaustive). While there are a number of questions that need further consideration, I believe there is ample room for progress evaluating what role longlined fixed gear could play.

- reducing the amount of the vertical line will likely reduce the chance of individuals coming into contact with line across species.

- While the reduction in vertical line would likely reduce entanglement risk because there is less line in the water, multiple pots on a long line can create a different entanglement hazard if the bottom line ends up suspended above the sea floor, and any entanglement that does result is more likely to be serious/fatal than single pots. This is because whales that get tangled strings of multiple pots (e.g. spot prawn gear) often get anchored, and - if not discovered and disentangled in a timely manner - this can lead to death from exhaustion, inability to surface/breathe, or (even after release) capture myopathy

- it is common sense to expect the weight of gear could/would lead to more severe injuries and constraints on movements of individuals entangled in many cases, although there may be times the weight of gear could help provide resistance to break free. I

It is possible to look at (and I am doing some work here) the relative rate of serious injury/mortality as determined through our marine mammal stock assessment reports between single trap vs. longline gear to gain some inference specifically relative to management goals combing the significance of injuries and reduced entanglement probabilities (need to try and factor in groundline too), but that may not tell the full story.

What could be ideal is if we could find a balance with a shorter string (and/or lighter gear) that could minimize the risk of increased injuries that ultimately could lead to net benefit by also reducing the overall number of entanglements. I like the idea that one fishermen suggested (which was use much lighter pots in between the heavier pots).

- perhaps it would be worthwhile to categorize the injuries and health parameters of well documented cases of anchored whales vs similarly entangled free-swimming whales to gain an understanding of the consequences of a switch to a gear type that could result in more anchored whales.

When the US east coast lobster fishery switched from singles or very short trawls to longer trawls they also switched to heavier gear that resulted in more severe injuries - which was an unforeseen and unintended consequence.

Groundline:

- I would strongly recommend that if the fishery switches to long-lining that they mark the ground line differently than buoy lines to be able to determine if entangling line came from ground line or buoy line

- Regarding use of floating ground line: at the moment I think I would seriously consider trading in a decrease in cumulative risk of so many vertical lines with the additional risk of entanglement in ground line from the perspective of reducing the number of entanglements, unless/until I saw evidence of regular entanglement in the groundlines. While I don't assume the risk of entanglement in a groundline is nil, I do assume it is less that the vertical line, unless that floating groundline is really rising high in the water column. We currently have fisheries that longline fixed gear that have been involved in entanglements, and there are not many cases where we have identified the groundline as being involved (I assume these lines are all floating lines currently).

- I believe the risk of entanglements in floating groundline is going to increase as gear is set shallower, so it is prudent to consider that this may not be appropriate for shallow gear (current longlined fixed gear fisheries are typically deeper). I don't know what an appropriate depth cut-off would be - that seems like a worthy avenue of further consideration.

- I agree that the scope of the ground line is an issue, especially inshore areas or where prey has been documented within 20-30ft of the bottom (I do not know the behavior of krill or common bait fish along the West Coast at different times of year- before/after if/when stratification occurs in different areas).

However, I would suggest neutrally buoyant line (found to be a few inches above the subsurface) vs. floating line (up to 26ft above the subsurface- likely influenced by the scope of the ground line and how far apart the traps end up along the bottom) (McKernan et. al 2002, attached). The McKernan paper compares sinking vs. neutrally buoyant vs. floating over different substrates. I think neutrally buoyant line would be a better step, because if we move to floating ground line, then we are just mimicking the steps of the East Coast and likely the fisheries will have to change their gear again like they did in MA when fishermen were forced to move to sinking ground line a decade ago (2009).

- Some of us have expressed that sinking groundline can be an issue for species that may be coming into contact with the substrate. This stems from species and foraging methods found on the East Coast. A study which we did soon after the transition from floating to sinking groundline in MA, found that this change might reduce the chance of juvenile humpbacks from coming into contact with groundline, but an issue for bottom feeding humpback, with reproductive females coming into contact with the bottom at a higher rate while they are lactating, then when they are pregnant. Bottom feeding occurs over sand/gravel areas where sandlance is the primary prey species, at least half the population uses this feeding method. It occurs during the day and night and their flukes, flippers, and open mouth come into contact with the substrate.

I know there are large numbers of sandlance around the WA/BC boarder, but I have not heard of them being the primary prey species for humpbacks in the area nor have seen markings on the whales suggesting they are using this feeding method. A recent paper also found right whales coming into contact with the substrate more often than once believed, which they did not take into consideration when putting the rule into effect.

With that said, I think defaulting to floating ground line puts us in the same spot the East Coast lobster fishery was over a decade ago; it won't prevent all entanglements and a provides an avenue for other people to point out that over 15 years ago there was evidence of needing to reduce the amount of floating line to help prevent large whale entanglements.

If the fishery does not want to make the jump to sinking or neutrally buoyant line, I would suggest, as an added level of protection, to do a similar technical report as McKernan et. al 2002 to acknowledge that fact the folks tested how the different ground line works in different habitats and provide results showing in what areas is it possible vs. not possible due to the safely of the fisherman or the increased loss of gear due to the environmental conditions in different regions.

- There is a need to have neutral or sinking line connecting the pots if such an approach is considered. Based on humpback whale feeding patterns when they forage on schooling fish in shallow nearshore waters, any line that is floating above the sea floor would definitely be a substantial risk.

Impact On Detection Rates

- based on my experience with whales entangled in longlined fixed gear, one should expect that entangled whales in longlined fixed gear will be fairly constrained on their ability to move. This could lead to easier detection of an entangled whale (in places where people are looking), as it is often time difficult to tell a whale is entangled when swimming freely. What isn't clear to me is how the prospect for more serious injuries and maybe a shorter time to mortality would factor in.

Would a whale that died sink and take the surface gear with them? This is worth some more consideration.

Disentanglement Success

- based on my experience, it is often easier to respond to and deal with whales that are entangled in longlined fixed gear. They don't swim away while responders are mobilizing, and during disentanglement efforts, so easily. The issue is that the whale has to be seen and reported - and we know that there are vast areas on the coast (an/or during certain times of year as well) where detection of any entanglement may be far less certain than other places, and response capabilities are far more limited. Use of longlined fixed gear may ultimately warrant further consideration more in some areas/times of year where detection and response are more promising than others.

- disentangling anchored whales is often easier than free-swimming whales but certainly not always. When the flukes or other body parts are held deep underwater - and especially in water with poor clarity – removing life threatening gear is difficult and can sometimes be just as or more dangerous than disentangling a free-swimming whale (whose flukes are more likely to come close to the surface).

Measure to Reduce Potential Impacts

- There are additional features that could theoretically be implemented in concert with longlined fixed gear to reduce potential impacts. These could include:

  - break away/weak links in various places;
  - weak lines (because you may not have to haul the vertical lines so fast all the time to tend all the gear)
  - most if not all of the ropeless/pop-up gear concepts.

In fact it probably increases the feasibility of any and all of these ideas when the number of lines that have to be worked decreases, both physically for the fisherman as well as economically. It's at this point I would generally have to turn to fishermen to help describe what/why they think any of these ideas, and the prospects for using longlined fixed gear in general, are feasible from their perspectives.

Operations and Enforcement:

- There is an issue regarding conflicts with other users. Certainly folks would have to adjust and be aware of areas where folks are fishing longlined fixed gear to avoid them. I do believe that fishermen can work this out - perhaps using some particular buoy configuration could signal the presence of a string.

But in areas where vessel traffic is high – this approach might really reduce the conflict there and the amount of gear lost/moved due to vessels dragging them/cutting buoys off.

Enforcement of current pot limit management by States with longlined fixed gear must be addressed. Seems like there are possible technological fixes, although they might be a little too far from the norm to easily/quickly implement.

But I can't imagine that a collective and well intentioned brainstorm between fishermen, managers, enforcement couldn't come up with some bright ideas in the meantime if there were incentives to do so.

Attachments (at end of document):

Excerpt on long-lining from FAO report 2018: Expert Workshop On Means and Methods For Reducing Marine Mammal Mortality In Fishing and Aquaculture Operations

Excerpt on longlining from Werner and Press 2016: Global Assessment of Large Whale Entanglement and Bycatch Reduction in Fixed Gear Fisheries

McKiernan et. al 2002, Massachusetts Division of Marine Fisheries: A study of the Underwater Profiles of Lobster Trawl Ground Lines

LONG-LINING DUNGENESS CRAB POT GEAR
(to reduce vertical lines in the water for the potential benefit of whales?)

IDEAS AND CONCERNS
INPUT FROM WEST COAST FISHERMEN

With thanks to fishermen:
Zed Blue, Cody Chase, John Corbin, Bob Eder, Bob Maharry, John Mellor.
Note that comments are arranged by state and are not in order.

With thanks to Sheila Garber for the attached paper on long-lining technique by Barry Fisher from 1970

Question: *The long lining of gear has been mentioned both as a way of reducing the number of vertical lines in the water and/or to make pop-up or ropeless gear more feasible from a cost and operations perspective. What are your concerns about long lining and what are ideas that could make it feasible or at least worth further consideration?*

WA fisherman:
In my opinion outside of 20 fathoms Longlining is a far superior method of pot fishing. I've longlined for brown King crab in Alaska. We would longline 50 pot strings thereby reducing our number of vertical line to 1/25 of the number of vertical lines in single pot fishing. With a pot longline instead of having small foam buoys you can use flagpoles, hardballs (the orange hollow balls you generally see on trawl nets) and flashing lights. These setups are much more noticeable for easy avoidance of passing ships. They are more expensive but that would be offset by needing 1/25 of the amount involved in single pot fishing.

I personally believe that Longlining would drastically reduce the number of lost pots as well. When a buoy setup is chopped of by a propeller of a passing ship in a single pot configuration that individual pot is usually lost. In a longline configuration you can lose the buoy setups on both ends but still drag for the ground line that connects all the pots on the bottom.
In a perfect world Longlining pots is faster, cheaper, reduces the chance of whale entanglement, reduces the likelihood of ship strikes and makes it easier to recover lost gear.

The hard part is application in our current fishery. First off with the number of permits and pots allocated to those permits the density of gear is so high that I think the first day of the season we would have a coastwide snarl immediately from longline strings crossing each other. In the Aleutian brown crab fishery we had about 7 boats participating along a 300+ mile chain of islands.

Longlining Dungeness pots would require a DRASTIC reduction in the number of pots fished. I'm not confident that it could still be economically feasible for the same number of vessels to participate under an extreme pot reduction.

Vessels would need to upgrade their hydraulics, davits and blocks to compensate for the tension of a longline. Line bins would have to be fabricated to store the groundline on deck taking up working area on smaller vessels. Non-Steel vessels are much more likely to sustain damage particularly wood boats.

Inside of 20fms pots can become buried in the sand due to turbulence from large waves. I can't imagine how hard it would be to maintain a position while pumping out 50 individual pots that are all connected. The shallower you go the more likely your pot is going to get buried outside of 15fms it's not very common to have to pump your gear. Inside of 10fms it's very common after a storm. In extreme cases I've had pots that were mildly buried in 25fms outside of river mouths after large storms.

At previous meetings I have suggested mini longlines of two pots off of one buoy setup. We would have pot rigged as a traditional single pot setup with a groundline running from that pot to one additional pot. We'd need fleet input on what that length should be in case the individual needs to pump both pots. I recall WDFW enforcement being opposed to regular longlines but unopposed to 2 pot longlines. These could be applied with the same equipment we currently own, reduce vertical lines by 50%, and enable the same number of vessels to operate with full allocation of pots preventing economic hardship. This would require fleet support but seems much more realistic in an immediate application than Ropeless technology or large longlines. This would only need to be implemented when there is heightened concern of whale interaction.

From my understanding our goal is to keep this public resource economically viable for the participants while minimizing our impact on the environment and wildlife. As an individual I would love to engage in large scale Longlining but as a realist I feel that two pot Longlines would be the best tool during times of elevated concern.

OR Fisherman:
I have talked with many about longlining. The general feelings are that depending on how many pots are in a string changes the dialogue. Most of the areas that you fish are just full of gear. If you longline many pots, say 20 or more, you won't know where strings of gear are and they will get crossed and tangled. This could lead to enormously more derelict gear problems. Also, when fishing close to shore, where pots tend to get stuck in the sand during storms, they will not be retrievable once sanded in. There has been talk lately of longlining 2 pots per string. This definitely helps with knowing where the gear is but no matter how

many pots are tied together, when a whale entangles it, he now has more pots he is anchored to.

The idea of less vertical lines in the water is now challenged by the most recent humpback entanglement in CA last week. It is the off season when the only gear out there is derelict gear and he still gets tangled. Not sure what to think about that.

OR Fisherman:
Longlining crab pots was once done by a few fishermen. It is very dangerous, but some chose to do it especially in deep water. Not all boats and not all crews can longline effectively or safely. It was outlawed many years ago for several reasons, one of which was gear conflicts with other single (traditional) crab pots as well as other fisheries. The rule change was done at the ODFW Commission level (there may be some reference to long lining crab pots in Tri-State (PSMFC) or wording of the Magnuson Act (NMFS) or some other Federal program as well. Caren Braby or Kelly Corbett at ODFW in South Beach could fill you in. There has been some consideration to “pairs” of pots (two) per line. Even that will be much more risky on deck at sea.

OR Fisherman:
Concerns:

If have 2 or 3 pots or more, there will be an increased chance of killing an entangled whale over one pot.

Lack of institutional knowledge about how the fishery worked in the past. The gear conflicts with single pot fishers caused it to be closed down.

Ideas to Make Things Work:

Two or 3 traps on a buoy is possible, but that could actually be harder to dovetail into present fishery. It might be better to not have overlap – rather than having one pot/one buoy and long lining overlapping or being fished close to one another, it might be more workable to separate things out to better know where other pots are (and in any case assuming knowledge of how currents etc. affect buoy locations etc.). They are not very compatible.

To avoid the chaos of entangling other’s gear, don’t mix them.
i.e. if as is thought, Humpback whales are most prevalent from April to November and most are found in 50-100 fathoms, then perhaps could start the season normally and then comes April… no single buoy pots would be allowed outside X depth, only longline.

Then would have to have all gear laid in the same orientation—easiest might be on longitude lines, i.e. gear would have to be laid parallel to each other at known intervals… e.g. of 1/10th of a minute … so don't get gear entangled. This has worked with the halibut fleet with several 100,000s of hooks on longlines in very specific areas… this separation has worked well.

It might be better to consider a system of longlining 25 or 50 pots like was done in the past, with buoy at each end (e.g. at 50 pot would have 4% of the of the lines in the water that is there now). It would set out the most pots you could have and have a different tag.

It may be easier to begin messing around with pop-up gear – if long-lining made things more cost-effective.

Floating groundline was used since if it wouldn't wear out from chaffing or interfere with catchability of traps (block tunnels, foul triggers).

Such a system could work with smaller as well as larger boats. His experience is with 40' boat. He never lost gear, though one time had to grapple for it when buoy was cut probably by tug in deep water.

Even on small boats need a back deck that would fit at least 20 pots. You could use the heavier pots at each end of the string, with lighter pots between them.

This would be easier on fishermen and, of course, use much less polypropylene. Moving conventional single-pot gear in deep water is hard work. Stacking traps containing 100 fathoms of wet line and multiple buoys is a back breaking experience. Trailing that line out behind the moving boat (while avoiding any tangles) requires skill, speed, and intense effort.

OR fisherman
Long lining pots was way before my time but I'm not opposed to it but from what I've heard when guys did it is both good and bad. Sounds like very few operations did it and there was conflict (tangling of gear) between the boats that did. I'm not sure how it would work for the little boats like mine but possibly making it ok in deep water 70 fa out maybe could be an ok thing to do.

CA Fisherman
Longlining could be useful in the DC fishery, in the spring time (not in the beginning of the season or peak—it would be very difficult to do with so much effort).

Could help with whale entanglement risk in springtime and could enable pop up gear to work economically (would need a lot fewer of these if long-line the pots).... if in collaboration with fishermen that technology could ever be made to work reliability— and would have to make sure everyone knows where everyone else's pots are.

With long-lining would want a trap reduction as well… to limit how many could be fished in an area. Need trap reduction—would have to be a whole other conversation around this -- has to be equitable. Has to be sufficient for people who have small amount of pots to make a living.
Make it somehow that people couldn't fish over each other. Everyone would have to set out the same direction. Would probably have to have a different colored buoy to mark upper end and lower end i.e. it would tell you that 'this string stretches to the N of me'.

Fishermen would also have to leave a fair amount of space between someone your strings and someone else's strings when you set since the pots don't necessary set out straight. You would have to change gear (would have to buy all new traps) —Would need to fish all lighter traps with double triggers on tunnels… so they function, no matter which way they fall if they fall on would have to buy all new traps. There would be an anchor on each end so the buoy line stays fixed in place. In longlining hooks for black cod fishery, their buoys have light and radar reflectors. Probably want these to be used too.

You could fish this gear with a small boat. Would be like other fishing—would still have to stack pots. Would need containers to hold the groundline rope, but not a problem. Could figure out how to do this..how to not get into a propeller.

In terms of how many traps on a string—would depend on depth.
The spacing of each trap would have to be far enough apart so as not to be pulling several traps at a time.

It would be similar to fishing gillnets… learn how to fish with each other—like in Bristol Bay where you have to stay in your river area for a length of time or on the east coast where lobster pot fishermen have areas.

Would want sinking ground line and pretty strong rope for the groundline so it wouldn't break while haulting. Wouldn't want line floating around. Crab are fished in mud and sand… so don't see much problem with chaffing or snagging. If a rope is chaffed or worn would see this while handling the rope and can cut off worn end and resplice.

The breakaway swivels and yale sleeves would make even more sense if longling traps, since if an entanglement occurs they could help the entangled whale break free instead of potentially being anchored.

CA Fisherman
Concerns:

Idea might not be accepted by others who have more power or for fishermen who it wouldn't need to work for since they don't fish late in season.

You could put a lot of time and effort into working up an idea, applying for an experimental permit and it gets shot down, so the hard work is not worth it.

Comes up slower, reset times a bit slower—but might give opportunity to fish when otherwise can't due to lines in water.

When they used to longline – people got hurt, especially with gear in deeper water (but all fishing is a risk)

Another concern is the part of the fleet who are not vested in trying to figure things out. Change is hard and it's easier to say no, not try to make it work.
He realizes that their ideas may need to be modified. They're just coming up with ideas and willing to try them out.

Positives:

Could continue to crab fish when the risk is higher— otherwise there may be no other alternative—and gear is in gear shed and people aren't crabbing.

By having only 2 pots would result in a 50% reduction in lines and you could see the next buoy so other fishermen would see where the gear is set and know that there is another pot between the first buoy and the second buoy. This would be simpler and more reliable than trying to set on longitudinal lines—as everyone could see the next buoy. Removes argument about increase gear conflicts.

Has a few other fishermen who want to work with him on this (he has a smaller boat approx. 50'). Has been talking about this with other CA in various ports since last summer.

He thinks this could work for vessels of all sizes; people who want to make it work. Not a big boat/small boat controversy. Would get participation from those who want to fish.

Wants to pursue experimental fishing permit for next spring.
Whales don't entangle in pots, they entangle in lines, so reducing lines is the only way he sees to keep things going and not tangle whales

Could potentially use lighter additional pot(s).

Would have to work out ground line details. Don't want bumps or gullys in the ground line… so would potentially take some gear changes.

Would have to lengthen and shorted rope as necessary if fishing in deeper or shallower water—as people should be doing anyway and following best management practices –no knots, no snags, everything clean.

The rigging and operation would be as follows:
The posts would be spaced with groundline so many feet apart so that when you're pulling the pots you would not have two pots handing on the line at the same time (which increases the danger)

This EXAMPLE is for a 2 pot long-line fished as an example in 30 fathom depth: When fishing 30 fathoms depth—throw first pot then 50 fathom of rope on bottom then the other pot.   When retrieving, you grab your buoy, throw line in block get the first pot. The first pot is in the boat getting rebaited since you have 50 fathoms of line, when you haul up 2nd pot.

Reset—would slow things down initially, until system learned, but rather have to slow down a little bit and still fish.

(If you go deeper or shallower, length of groundline would change).

Attachment

B. Fisher, Oregon State University, 1970. A long-line (set-line) crab pot system.

ATTACHMENTS

Regarding Longlining

Attachments are provided in order of date (from the newest to the oldest)

Food and Agriculture Organization of the United Nations

FIAO/R1231 (En)

FAO Fisheries and Aquaculture Report

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Report of the

EXPERT WORKSHOP ON MEANS AND METHODS FOR REDUCING MARINE MAMMAL MORTALITY IN FISHING AND AQUACULTURE OPERATIONS

Rome, 20–23 March 2018

From page 47 of the full report

Minimize ratio of vertical lines to units of gear

Concept: In pot fisheries that use groundlines to attach strings of pots, having fewer buoy lines per pot strings reduces the number of vertical lines in the water, likely reducing the probability of large whale entanglements.

Relevant fishing gear: Pots

Target marine mammals: Mysticete whales

Summary from evidence: One modeling study suggested a reduction in but not elimination of entanglement risk. Any risk reduction must be quantifiable to ensure the persistence or recovery of the marine mammal population of concern. "Trawling up" in the U.S. prompted some fishermen to increase their vertical line diameter, resulting in higher breaking strengths which increase entanglement risk and the and severity of entanglements to large whales.

Safety/operational considerations: Increasing the weight of pots to be hauled can lead to more frequent haul line partings and therefore more derelict gear.

Economic concerns: Trawling up may reduce the length of vertical line that a fisherman needs to purchase but may also cause them to purchase more expensive, larger diameter ropes. Derelict gear that might result from this practice can cause lost revenue from lost target catch and gear.

Description: In the U.S., NOAA Fisheries mandated that in some pot fishing areas, fishermen "trawl up" to maintain fishing effort but reduce the number of vertical lines. Trawling up reduces the ratio of endlines to bottom gear, to maintain the same fishing effort but with fewer vertical lines in the water.
One study (Kite-Powell et al, *unpublished*) showed encounter probabilities in the northeastern U.S. would be reduced. However, whales still become entangled, and the bycatch reduction from a vertical line reduction is uncertain, including whether it reduces entanglements to a level that avoids extinction and promotes recovery. Because of this regulation, some lobster pot fishermen report they have increased the diameter of buoy line they use, which would likely decrease the probability that whales would break free of gear. This technique is only applicable where pot fishermen use multiple pots connected by a groundline. Increasing the number of pots/string will increase groundline length, and groundlines are another source of whale entanglements. The assumption in US fisheries, however, is that sinking groundlines do not pose a risk to whales.

Global Assessment of Large Whale Entanglement and Bycatch Reduction in Fixed Fishing Gear

FINAL REPORT
NOAA Award Number: NA15NMF4630357

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Date: March 31, 2016 (Award Period: 10/01/2015 - 12/31/2016)

Page 11-14 of full paper:

TECHNIQUE: Minimize ratio of vertical lines to units of gear deployed

What is it? Reducing the overall number of vertical lines used in a pot or gillnet gear fishery without reducing bottom gear. This includes "trawling up", a term used by the US National Marine Fisheries Service (NMFS) in the northeastern US to describe a pot fisher who uses fewer buoy lines per number of total pots, by attaching more pots/trawl (pot string) in a single deployment (NOAA 2015). It can also involve using fewer buoy lines/gillnet string, as described in a study carried out in Mexico to reduce sea turtle bycatch (eg Peckham et al, 2016). A lower number and density of vertical lines is presumed to reduce overall entanglement risk by reducing the probability that whales will encounter ropes.

General observations. Although mathematically entanglement risk reduction should result by applying this method, how closely the theoretical corresponds to actual reductions in entanglement risk is unknown. Increasing the number of traps/trawl to $\geq$5 would have no net reduction in vertical lines in the Gulf of Maine lobster pot fishery because "trawls" with 5 or more traps require the addition of a second endline (Tetreault and McClellan, 2015). Deploying more traps per buoy line might result in pot fishers increasing the diameter of these ropes to handle the additional bottom weight of the gear, and heavier ropes are considered more of an entanglement risk to large whales (Knowlton et al 2016). Heavier gear might also lead to an increase in rope parting and consequently the possibility of more derelict gear. In a pot fishery that has strings of pots connected with groundlines, the entanglement risk from vertical lines might be offset by an increase in the length of groundlines, although if these are negatively buoyant and rest on the seafloor as most are in the eastern US by law, entanglement risk in the water column should be minimal. Both vertical lines and groundlines entangle whales (Johnson et al 2005), and the impact of US government regulations requiring the use of sinking groundlines in pot fisheries off has yet to be determined (Pace et al 2014).

Evidence? Intuitively, this technique should reduce entanglement risk if vertical lines are mostly involved in entangling whales relative to horizontal lines (such as groundlines and longlines) or gill net panels. Nevertheless, rarely do we know which component of the entire gear set caused the initial entanglement.

Any examples that have shown it to work as a deterrent? We know of no examples that have shown conclusively that this technique leads to reduced entanglement risk. Reducing the number of buoy lines in a Mexican gillnet showed significant reductions in sea turtle entanglements (while recording similar target catch per unit effort although with reduced catch value) (Peckham et al 2016), however apart from involving a different group of animals, the component of the gear would almost certainly have involved the net panels and not the ropes.

Is there any basis for continuing to consider implementation of this technique or to carry out further investigation of it? It has already been implemented in the northeastern US. There is intuitive support for reducing the number of endlines/unit of gear, so especially where the threat is high and entanglements in vertical lines are known to occur, it is worth investigating further.

Species/taxa specificity. This technique would apply to any species in which entanglements are known to occur in vertical lines.

Under what circumstances would it be most effective? Circumstances in which it might be feasible are those in which the fishery can incorporate more gear per vertical line. In some part of Maine (USA), more complex and rocky sea floor topographies challenge the ability of fishers to deploy multiple traps that may not come to rest in the correct orientation or result in lines getting hung up on rocks. There may be limitations on the use of this technique for smaller vessels, which are less well equipped for hauling and handling heavier bottom gear that would result from increasing the number of traps/trawl.

Where could an experiment be done? A fishery that optimally meets the following criteria: (1) there are high entanglement rates in vertical lines; (2) it is possible to distinguish between the components of gear involved in the initial entanglement (vertical vs other ropes or nets) using gear marking; and (3) there is sufficient observation of entangled whales to record the gear involved. Possible areas worth considering are the eastern US and the California Dungeness crab fishery, although long-term monitoring is a more likely approach.

Actual or potential downsides. As indicated above, fishers cannot precisely target fishing sites if traps are now part of a longer trawl than previously used, there is the potential for more severe entanglements resulting from fishing with heavier bottom gear that might involve a change to larger diameter ropes, more ghost gear could result if multi-trap trawls use only one vertical line as opposed to one on each end where the second line is used as a back-up haul line if the first becomes unavailable, and greater physical disturbance to benthic habitats might eventuate by using more groundlines that rest on the sea floor while the gear is set and hauled.

Research gaps/priorities. Validation that the concept shows actual reduction in entanglement risk would be useful. In different fisheries, it is important to understand the relative risk of vertical lines to other gear components, as well as if lowering the risk from vertical lines might be offset by other fishing changes made in response. Specifically, along the US east coast to what extent does "trawling up" lead to adopting ropes of larger diameter that might increase entanglement incidence or severity? It would be useful to record changes in scarring rates through monitoring the impact of this measure, while controlling for other variables, as well as gear marking schemes that distinguish between vertical and horizontal ropes. Results from the northeastern US should be monitored to inform other areas in which it potentially might be used.

TECHNIQUE: Sinking/neutrally buoyant groundline

What is it? Having the line that connects traps to one another be negatively or neutrally buoyant so that it lays on or near the seafloor versus up in the water column (NOAA 2007). *Variability.* The performance of these ropes depends on the configuration of gear, how it is deployed, and oceanographic conditions such as seafloor substrate, tides, and currents. When ropes are taut in between traps they may not rest on the bottom. Chains are used in Canada between traps, although it has nothing to do with preventing whale entanglements. A fisher will sometimes use sinking ropes or chains as a preferred fishing method, such as in Alaska demersal longlines and gillnet leadlines.

General observations. Fishers have communicated a number of concerns regarding the use of sinking groundlines. Among these are poor handling on deck; tension during hauling due to the rope becoming lodged under rocks; limited "play" in ropes under tension leading to snapped lines and dangerous handling conditions; loud noise when run through the hauler; weakened sections of line resulting from chafing on the seafloor; and a higher difficulty in predicting when the rope is nearing the end of its operational life (Ludwig et al 2015). Probably the most significant consequences involve a higher risk of personal injury when hauling these ropes and the increased expense of needing to replace these ropes more often than float ropes. Neutrally buoyant lines were eventually removed from consideration by the ALWTRT in favor of sinking groundlines because the former were shown to still frequently occur high enough in the water column such that entanglement risk would not necessarily be reduced.

Evidence? Groundlines used in the northeastern US lobster pot fishery are known to entangle whales (Johnson et al 2005)--although in what proportion to buoy lines remains undetermined--and the assumption is that the encounter risk is reduced by keeping them at the seafloor. Nevertheless, some whales do feed at or near the seafloor so it cannot be assumed that the risk is entirely eliminated. No experimental or monitoring data has shown that this technique prevents entanglement in groundlines, although the ALWTRT generally assumed it would be beneficial. Since the regulatory requirement went into place in the northeastern US (NOAA 2007) no monitoring data shown the efficacy of the measure.

Any examples that have shown it to work as a deterrent? No.
Is there any basis for continuing to consider implementation of this technique or to carry out further investigation of it? Intuitively it should reduce entanglement risk but to what extent remains unknown. Monitoring its use in the northeastern US and further investigation is warranted.

Species/taxa specificity. We assume all great whales occur at the sea floor frequently enough to suggest that this should apply across all species of great whales.

Under what circumstances would it be most effective? The technique would be more appropriately used in areas with light currents and tides where positively buoyant groundlines (specific gravity <1) are more likely to rise into the water column. Sea floors that have rugged or rocky bottom types make their use less practical.

Where could experiment be done? [See this section under "Minimize ratio of vertical lines to units of gear deployed."]

Actual or potential downsides? When grappling is required, which occurs when buoy lines are lost, it is made more difficult because the rope sits on the bottom rather than forming a loop above it. This can potentially result in more lost gear. Ropes degrade more quickly from siltation and abrasion, particularly under the crushing force of the hauler, requiring more frequent replacement (Allen et al 2008). It is also conceivable that ropes would be less visible to whales that could become entangled in them while feeding at the sea floor. (See additional fishing concerns, above.)

Research gaps/priorities. A useful gear-marking scheme is needed that can identify the rate of groundline entanglements.

A Study of the Underwater Profiles of Lobster Trawl Ground Lines

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David M. Peters, Commissioner

Division of Marine Fisheries
Paul J. Diodati, Director

Abstract: Massachusetts Division of Marine Fisheries (DMF) contracted a commercial lobsterman to deploy 5-pot lobster trawls in coastal waters to allow DMF SCUBA divers to measure the profile in the water column of the lines attached to - and connecting - the traps. Three different neutrally buoyant lines were observed as well as a floating line and a sinking line. Laboratory testing and underwater monitoring showed that neutrally buoyant lines have a much lower vertical profile than floating line and are similar in performance to sinking line. All three neutrally buoyant lines were negatively buoyant and were observed in contact with the sea floor. Independent laboratory testing of these lines bore this out with the specific gravities measuring greater than that of seawater. The deployment of trawls with all floating line also yielded useful measurements of the maximum heights achieved by floating groundline. Average heights within each trawl rigged with floating line were, 8-, 16-, and 18-feet. Replacement of floating line with negatively buoyant line will reduce the probability of whale entanglements.

I. Background. The Massachusetts Division of Marine Fisheries since 1997 has aggressively regulated fixed gear fisheries in Cape Cod Bay Critical Habitat during winter and early spring months when right whales are expected to be present. Since that time, lobstermen setting gear in the Critical Habitat area during winter and early spring have been subjected to state and federal gear restrictions to minimize risk of whale entanglement in their gear.

Two primary components of lobster gear pose a risk of entanglement: buoy lines that connect the set of pots to a buoy at the surface, and the "groundline" (or "mainline") to which each pot is attached with a short piece of line known as a "gangion". Only sinking groundline has been permitted by Massachusetts and federal regulation since 1997 for lobstermen fishing in Critical Habitat from the beginning of January through mid-May. As a result of DMF's adoption of the settlement agreement to end the *Strahan v. Durand* litigation filed in federal court in January 2001, new Massachusetts regulations will prohibit the use of floating groundline year-round beginning in January 2003 in Cape Cod Bay Critical Habitat. In 2004, this restriction will be extended to all waters west of the Critical Habitat in Cape Cod Bay south of 42 degrees 5 minutes (Figure 1). This area includes fishing grounds along the Plymouth, Kingston, and Duxbury shorelines.

The lobster industry prefers to use groundlines that float for several reasons. Floating line, typically comprised of polypropylene, is less expensive than sinking line, typically comprised of nylon. When fished over uneven and hard substrate, floating line is less subject to abrasion and to parting, thus reducing gear losses. When buoy lines that mark the ends of the trawls are cut off, floating groundlines allow fishermen to more easily retrieve trawls by towing a grapnel hook perpendicular to the trawl hoping to hook onto the trawl mainline. Finally, floating line can be used as a visual target for depth sounders when searching for lost pot-trawls with lost buoy lines. Most electronic sounders are capable of displaying a floating arc of line above the substrate.

DMF observations in 1997 using a remote operated vehicle (ROV) demonstrated that use of floating lines for groundlines produced arcs of line between traps that were 10- to 18-feet above the substrate. This elevation was higher than previously believed (Appendix 1- Report by DMF's H.A. Carr to NMFS). DMF’s position is that the most effective strategy to reduce entanglement is to lower the profiles of groundlines by prohibiting the use of floating line in that portion of the gear.

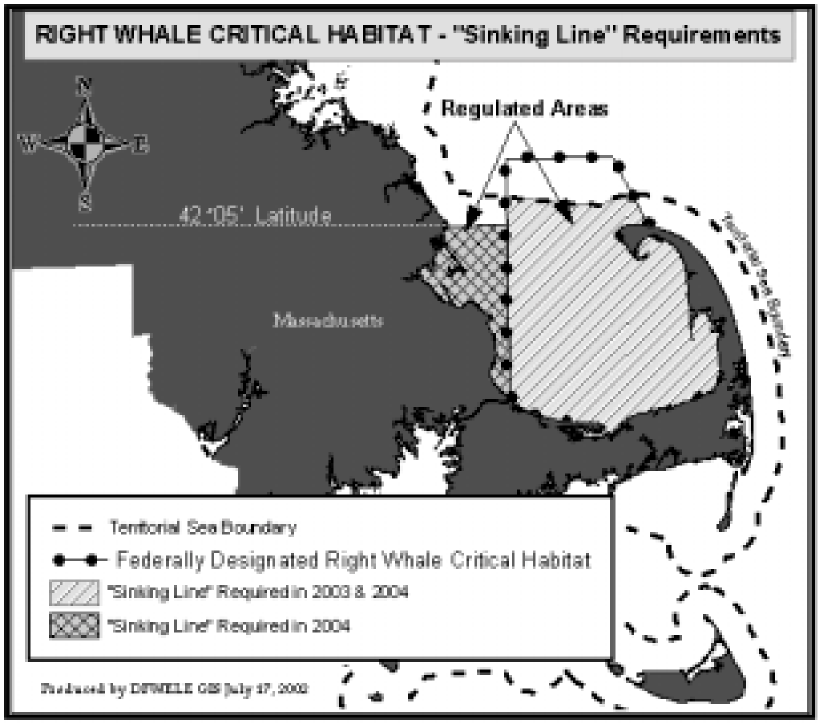

Figure 1. Map depicting groundline requirements in Cape Cod Bay effective January 2003 and beyond.

Several cordage companies now manufacture a new line type, marketed as "neutrally buoyant" line. Neutral buoyancy (in theory) allows the line to remain closer to the ocean floor than floating line (reducing vertical profile) while minimizing bottom contact and consequent abrasion (avoiding risk of gear loss). NMFS and DMF personnel distributed spools of this line to fishermen for testing under field conditions during 2000 and 2001. Reports from Massachusetts fishermen collected by DMF and forwarded to NMFS Fisheries Engineering were mostly favorable.

To further promote the use of neutrally buoyant line, NMFS Fisheries Engineering Program staff, working with Maine lobstermen, produced video footage of lobster gear rigged with various groundline types including neutrally buoyant line. This video has been instrumental in convincing some fishermen about the risk posed by floating line and the potential for neutrally buoyant line to become a viable alternative groundline.

II. Statement of the Problem. The field use of neutrally buoyant line and the NMFS video were seen as progress toward adoption of this line by the lobster industry. However, DMF noted that elevations of "typical" lobster trawl groundlines underwater were inadequately documented. More precise data were needed to demonstrate the reduction in entanglement risk and the practicality of replacing floating groundlines (including mainlines and gangions) with non-floating lines. Also, comparisons among various "neutrally buoyant" line products were needed to measure the variability of performance in the laboratory and in the field. Finally, DMF and other state agencies sought high quality underwater photos and film as part of the ongoing outreach program to overcome resistance to the further restriction on use of floating groundlines.

III. Study objective. To measure the profile and document the utility of various configurations of floating, sinking and neutrally buoyant lobster trawl groundlines.

IV. Methods.

A. Field Study of *in situ* lobster trawls. DMF contracted a local lobsterman to rig, set, and fish various 5-pot lobster trawl configurations. A lobster trawl is defined as a multiple set of traps attached in series by a single line. Fishing locations were chosen by the lobsterman within a single site in southwestern Cape Cod Bay. The site was within 1/2 mile of the east end of the Cape Cod Canal in depths of 30 to 50 ft.

The only variation among the gear configurations was the line type used in the ground lines and gangions. Lobster pot dimensions and characteristics, as well as setting protocols were identical. Buoy lines were comprised entirely of sinking line, and where possible the condition of the lower half of the buoy lines was documented. If the line was wrapped around the trap or other obstruction on the ocean floor (e.g. boulders), that condition was noted.

DMF provided three different neutrally buoyant lines to the contracted fisherman: Everson (7/16 in diam); Anacko (3/8 in diam); Poly-steel Atlantic (3/8 in diam). The contracted fisherman rigged all gear per DMF specifications and set the gear at times and locations as specified by DMF. The contractor was required to maintain gear at locations specified and not move the gear without permission from DMF. The contractor was required to occasionally maintain the gear by hauling and re-setting to ensure the gear was properly functioning. The contractor was encouraged to actively fish the traps at the prescribed locations and was allowed to retain all lobsters that met Massachusetts' regulations. The contractor was responsible for removing the gear from the water after the completion of the study and was allowed to keep all lines used in the study. DMF used its own vessels as diving platforms to perform the underwater work.

The first trial used five trawls and focused primarily on a comparison among the three neutrally buoyant line types to measure the variation among manufacturers (Trawls A, B, and C). Two additional trawls were fished for contrast: a trawl rigged with all sinking groundlines (both the mainline and the gangions - Trawl D) and a trawl rigged with all floating groundlines (mainline, Crowe 3/8”; gangion, Crowe 5/16” - Trawl E). This trial was conducted over smooth substrate.

The second trial was designed to determine if various gangion line types (floating vs. neutral line) would result in changes in mainline elevation. For visual presentation, this trial was replicated in two habitats: cobble, and boulder bottom habitats . Each of these replicates included trawls rigged with all floating groundline (Trawls H & K). Unlike the previous trial involving three neutral line products, this second trial used just one neutral line product type: Everson 7/16" line. Trawls F & I consisted of floating groundlines and floating gangions. Trawls G & J were made of neutral groundlines and floating gangions.

Trawl descriptions for each trial were:

Trial #1 - Set on smooth bottom:

Trawls A, B and C: Three different *neutrally* buoyant groundlines with *neutrally* buoyant gangions.
Trawl D: *Sinking* line groundlines with *sinking* gangions.
Trawl E: *Floating* line groundlines with *floating* gangions.

Trial #2A - Set on cobble bottom:

Trawl F: *Neutral* groundlines with *neutral* gangion.
Trawl G: *Neutral* groundlines with *floating* gangion.
Trawl H: *Floating* groundlines with *floating* gangion.

Trial #2B - Set on boulder bottom:

Trawl I: *Neutral* groundlines with *neutral* gangion.
Trawl J: *Neutral* groundlines with *floating* gangion.
Trawl K: *Floating* groundlines with *floating* gangion.

Two DMF SCUBA divers worked together to document line profiles. During the trials the methodology of underwater measurements varied. During the first trial, the first diver measured and recorded the line heights at the mid-point between traps along the mainline with a 10-ft. PVC pipe marked at one foot intervals with permanent marker. Values were recorded on an underwater writing slate. The second diver was independent of the first and swam along the trawls and filmed the line along the ocean floor. In the second trial, the two divers worked in tandem with diver #1 holding the metered PVC pipe behind the groundlines to allow diver #2 to film both the line and the meter stick held by the diver (Figure 2). In those instances when groundline height exceeded the limits of the 10-ft. marked pipe, the diver estimated the distance from the top of the pipe to the line (Figures 2, 3, and 4). DMF staff viewing the video images visually corroborated these estimates.

Equipment: The following equipment was purchased to conduct the study:

- (2) Aeris Diver Propulsion Vehicles - the scooters were used to move between trawls, greatly increasing the efficiency of the divers.
- Sony DCR VX2000 Digital Video Camera - broadcast quality digital video camera with still photo capability.
- Light & Motion Bluefin Housing with Lights and Wide-angle lens - Professional video housing designed specifically for the DCR VX2000 camera. Special wide-angle lens provides 100 degree field-of-view, allowing close focus in poor visibility.
- Dry suits to minimize diver exposure to cold water during winter months.
- Communication equipment: Diver to diver and diver to surface communication equipment included an OTS Surface Communication Station and Divator Full Face Mask with Buddy Phones.

- PVC Pipes custom marked in 1 ft. increments

B. Laboratory Specific Gravity Tests. Northwest Laboratories of Seattle verified the buoyancy characteristics of all lines used in the study (Appendix 2).

V. Results

Specific Gravity Tests. Northwest Laboratories of Seattle performed measurements on three different lines sold as neutrally buoyant line, two sold as floating line, and one sold as sinking line (Appendix 2). The specific gravity results are presented below:

Table 1. Results of specific gravity tests on the study groundlines by Northwest Laboratories of Seattle.

Product	Type	Apparent Specific Gravity
Everson Co. 7/16”	Neutral	1.056
Anacko 3/8”	Neutral	1.064
Poly-steel Atlantic 3/8”	Neutral	1.055
Hy-Line 7/16”	Sink	1.167
Crowe 3/8” (mainline only)	Floating	0.880
Crowe 5/16” (gangion only)	Floating	0.890

The apparent specific gravity is an estimate of the specific gravity of the line itself, not including anything filling spaces between threads of the line (such as air). The experimental results should be compared to a sea water specific gravity of 1.023. Lines with values less than 1.023 float; those above 1.023 sink. The values for the three neutral lines are close to those of seawater at 15ºC. In colder, deeper water, the specific gravity of seawater is slightly higher than 1.023.

B. Groundline Profile Measurements. Gear was set by the contractor during October 2001 and fished regularly. The gear was filmed on December 28, 2001, January 4 and 24, 2002.

<u>Trial #1: Comparison among three neutral line products used in the groundlines with contrasting sinking line and floating line trawls</u>. All three neutral buoyant line products performed similarly with groundlines observed in contact with the substrate or within inches of the bottom (Table 2, Figures 5 and 6). Video footage showed the sinking line (Hy-line 7/16") groundline appeared to be in more continuous contact with the substrate than the three "neutral" line types.

The trawl rigged with all floating groundlines was found wrapped around a large metal object (gallows frame), and the contracted fisherman was unable to haul the gear to the surface. This trawl was under heavy strain and not in a “natural configuration.” The lines between the first four pots were pulled extremely taut and measured just 2 - 2.5 feet off bottom, much lower than expected. However, the line between the fourth and fifth traps was slack because these traps had shifted closer together allowing the line to arch up into the water column approximately 25 feet. The contracted fisherman suspected a scalloper inadvertently dragged the gear into this position.

<u>Trial #2: Comparison of the effect of neutral line gangions vs. floating line gangions on trawls rigged with all neutral groundline, and a trawl rigged with all floating line set as contrast.</u> This trial was conducted in two habitats: cobble and boulder bottom (Tables 3A and 3B). During the two trials there

was only a one-inch difference between the trawls rigged with the neutral vs. floating gangions. On the cobble substrate the average maximum mainline height was 2-inches for the trawl with floating line gangions (Trawl F) and 3-inches for the trawl with neutral gangions (Trawl G). On the boulder substrate the result was similar: the average maximum mainline height was 5-inches for the trawl with floating line gangions (Trawl I) and 4-inches for the trawl with neutral gangions (Trawl J).

The two trawls rigged with all floating groundlines (Trawls H and K in Tables 3A and 3B) demonstrated similar profiles. These two trawls featured elevated mainlines that were no lower than 4 – 5 feet above the ocean floor. The arcs created by the floating line between gangions rose to an average of 18.5 and 16.3 feet for the two trawls, respectively.

VI. Discussion and Conclusions. Floating, neutral, and sinking groundlines used in the inshore lobster fishery were demonstrated to behave differently underwater. Neutral line produced by three different manufacturers showed no difference among the profiles observed in the field. These observations are verified by their specific gravities (1.055, 1.056, and 1.064) as calculated in the laboratory. The specific gravity of the sinking line (1.167), as measured by the contracted laboratory was substantially above that of the neutral lines while both floating lines measured lighter than sea water (0.880 and 0.890) as expected.

Neutrally buoyant lines were observed in contact with the substrate or within inches of the bottom, while sinking line appeared to be in more continuous contact with the substrate and was never measured above the bottom. The neutral line products appear to afford the same protection to whales as sinking lines based on their similar low profiles.

For trawls rigged with neutral line mainlines, no increase in the mainline elevation was seen to be caused by deploying floating line gangions (Figure 6). Some fishermen had suggested that floating line gangions might serve to buoy the neutrally buoyant mainlines. We did not observe any effect caused by the use of floating line gangions.

The floating line trawls set for contrast purposes serve as a vivid example of the threat of entanglement posed by arcs of floating groundlines in the water column. The line-drawing image produced for this report by state graphic artist David Gabriel (Figure 7) provides a much different but more accurate profile than those portrayed in a schematic drawing from a previous study by Wiley et al. (1997) (Figure 8). That previous study featured the groundline appearing as a near "bell-shaped curve" between traps, with the line in contact with the substrate near each trap. In contrast, we observed the mainline continuously elevated above the substrate. The minimum height of the mainline was at the vertical gangion connection between the bridle and the mainline. The maximum height was usually at the midpoint between gangions and averaged approximately 16 feet above the substrate.

In summary, both laboratory-testing and field-testing demonstrated that neutrally buoyant line is actually negatively buoyant. Neutrally buoyant lines rigged with lobster gear featured low vertical profiles, remaining at or within inches of the bottom regardless of substrate. Use of floating line gangions did not noticeably alter the profile of the neutrally buoyant mainline. However, the one line product marketed as "sinking line" (Hy-Line 3/8") did have a higher specific gravity than the neutrally line products, and this line was observed to be in more continuous contact with the substrate.

Floating line was observed to be very high off the bottom, between 4.5 to 25 feet. The line quickly rose in height from the gangion to form a uniform height between gangions, as opposed to the gradual bell shape often depicted. Sinking line was always observed to be on the bottom.

Neutrally buoyant line offers an effective alternative to sinking line, and may be less subject to wear and parting due to its slight elevation and less contiguous contact with the bottom. This information, combined with images of the line underwater, fishermen's experience with the product, and the dramatically high profile of the floating line, will provide substantial encouragement for industry members to accept the future restrictions on this gear.

VII. Acknowledgements. We acknowledge the following for their contributions to this project: Commercial lobsterman Gary Ostrom for his work rigging, setting, and maintaining the gear; DMF field biologists and SCUBA divers Bob Glenn, Terry O'Neil, Paul Caruso, Neil Churchill and Matt Camisa for their efforts on and in the water; DMF Fishery Supervisor Vin Manfredi for his video editing work; Program Coordinator Melanie Griffin provided editorial assistance; State graphic artist David Gabriel provided artwork for the report. Scott Landry of the Center for Coastal Studies provided components of the line drawing depicting the floating line arcs.

National Marine Fisheries Service supported this research through its funding of DMF's Right Whale Conservation Program. Support came from the Protected Species Branch at the Regional Office in Gloucester, in close consultation with John Kenney and Glenn Salvador of the NMFS Fisheries Engineering Program.

TABLE 2: Results from Groundline & Gangion Arrangements for Five Trawls set on Sand and Cobble Substrate					
TRAWL	**A**	**B**	**C**	**D**	**E**
Mainline Diameter	7/16 "	3/8 "	3/8 "	3/8 "	3/8 "
Manufacturer	Everson	Anacko	Poly-steel Atlantic	Hy-Line	Crowe Rope
Mainline Buoyancy Properties	Neutral	Neutral	Neutral	Sinking	Floating
Gangion Diameter	7/16 "	3/8 "	3/8 "	3/8 "	3/8 "
Gangion Buoyancy Properties	Neutral	Neutral	Neutral	Sinking	Floating
Maximum Gangion Elevations					
Average Maximum Gangion Elevation	*Not Measured*	*Not Measured*	*Not Measured*	*Not Measured*	*Not Measured*
Maximum Mainline Elevations Between Gangions	0",0",2",4"	0",2",4",1"	0",0"	0",0",0",0"	2',2',2',25'
			(2 traps missing)		
Average Maximum Mainline Elevation	*2 inches*	*2 inches*	*0 inches*	*0 inches*	*7.8 feet (93 inches)*

TABLE 3A: Results from Groundline & Gangion Arrangements for Three Trawls set on Cobble Substrate			
TRAWL	**F**	**G**	**H**
Mainline Diameter	7/16 "	7/16 "	3/8 "
Manufacturer	Everson	Everson	Crowe Rope
Mainline Buoyancy Properties	Neutral	Neutral	Floating
Gangion Diameter	7/16 "	7/16 "	7/16 "
Gangion Buoyancy Properties	Neutral	Floating	Floating
Maximum Gangion Elevations	2",1",2",4"	1',2',1.5',1'	5',4',4',4.5'
Average Maximum Gangion Elevation	*2 inches*	*1.4 feet*	*4.4 feet*
Maximum Mainline Elevations Between Gangions	8",3",0",0"	3",2",2",2"	14',20',14',26'
Average Maximum Mainline Elevation	*3 inches*	*2 inches*	*18.5 feet (222 inches)*

TABLE 3B: Results from Groundline & Gangion Arrangements for Three Trawls set on Boulder Substrate			
TRAWL DESIGNATION	**I**	**J**	**K**
Mainline Diameter	7/16 "	7/16 "	3/8 "
Manufacturer	Everson	Everson	Crowe Rope
Mainline Buoyancy Properties	Neutral	Neutral	Floating
Gangion Diameter	7/16 "	7/16 "	5/16 "
Gangion Buoyancy Properties	Neutral	Floating	Floating
Maximum Gangion Elevations	2",3",2",2"	1.5',2',2',1'	5.5',5.5',5.5',3'
Average Maximum Gangion Elevation	*2 inches*	*1.4 feet*	*4.9 feet*
Maximum Mainline Elevation Between Gangions	4",4",2",3"	5",5",3",6"	14',16',20',15'
Average Maximum Mainline Elevation	*4 inches*	*5 inches*	*16.3 feet (197 inches)*

Figure 2. DMF Diver Bob Glenn measuring the maximum height of the gangion (~5.5 ft) on a trawl rigged with all floating groundline.

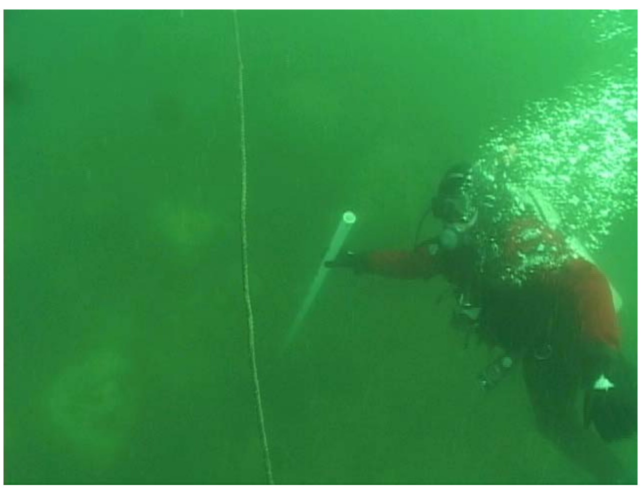

Figure 3. Topside view of DMF SCUBA diver measuring floating mainline arc.

Figure 4. Diver preparing to lower the 10-foot PVC the pipe to measure groundline arc (arcs ranged from 14 – 26 feet on trawls set in their natural position).

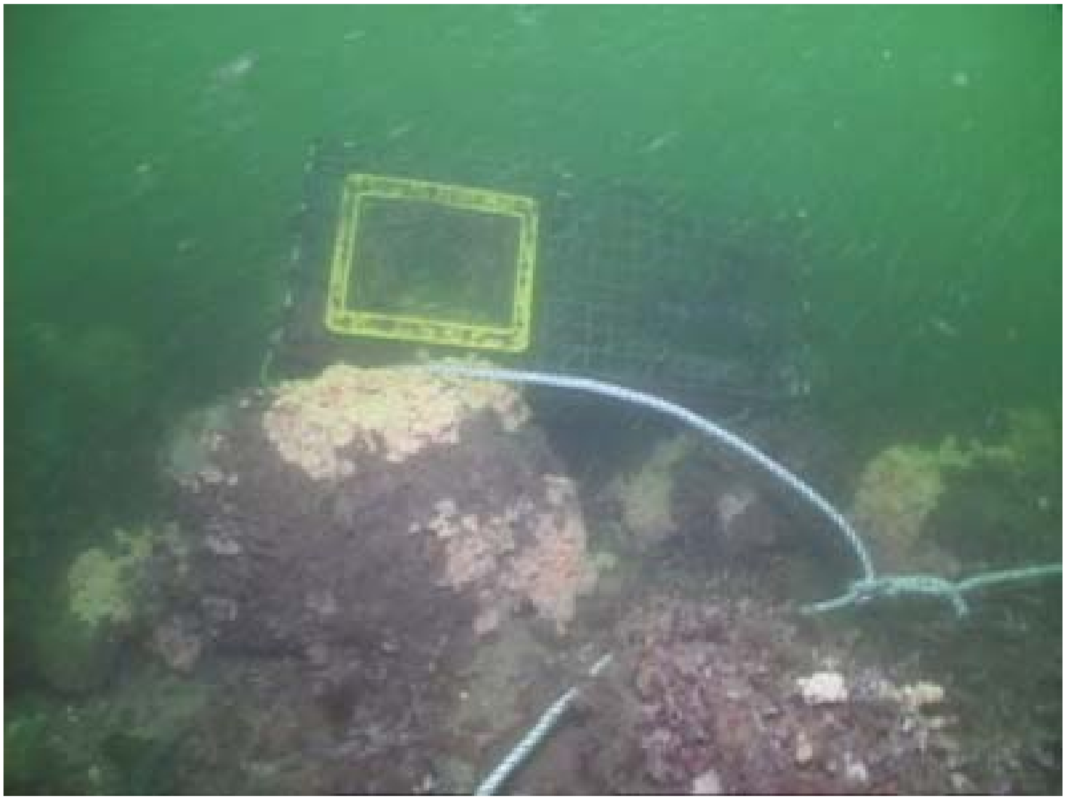

Figure 5. Groundlines composed of all neutral buoyant line were observed in contact with the substrate on all substrates fished including the boulder bottom as shown.

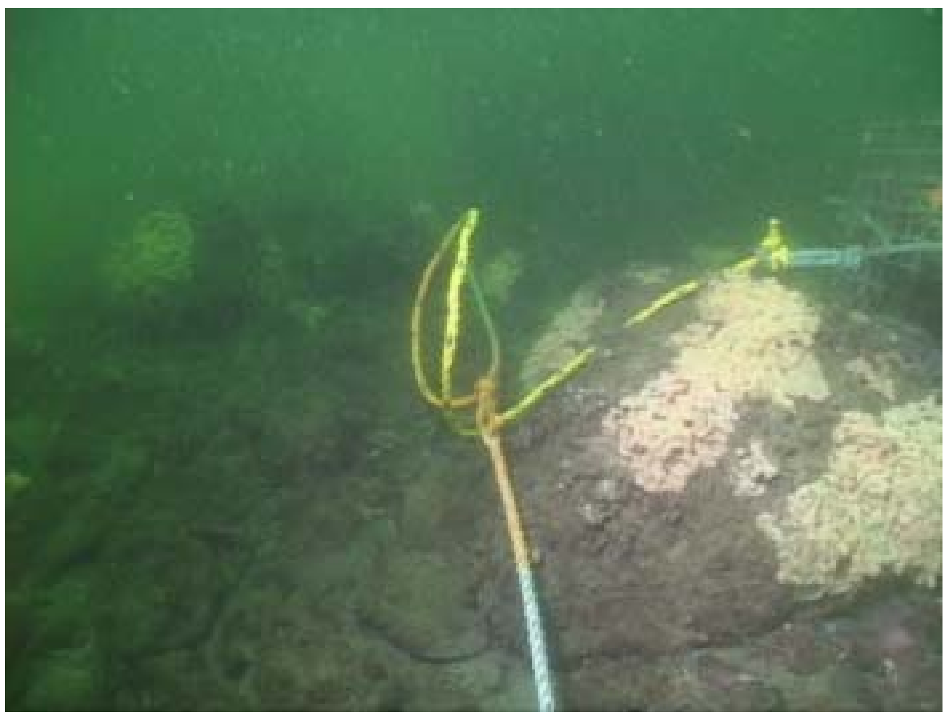

Figure 6. Use of floating line gangions had no effect on the measured height of the neutral buoyant mainline.

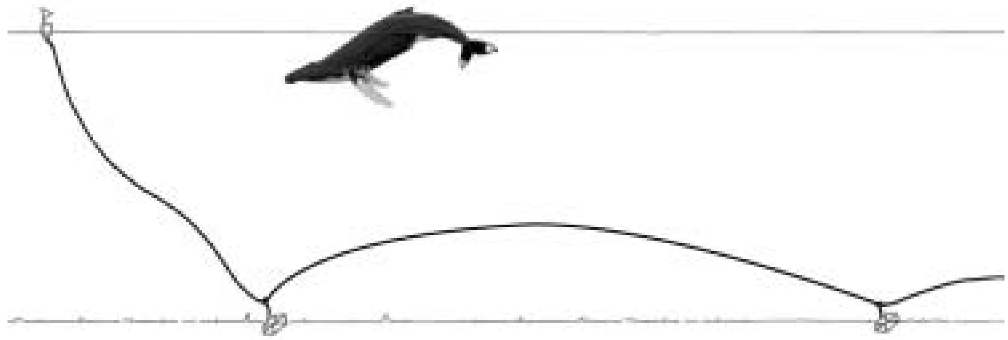

Figure 7. Schematic drawing of lobster trawl rigged with floating groundlines. This depiction demonstrates the elevated mainline reaching 16 ft., vertically suspended gangions, and the 90 ft. distance between traps (Humpback whale illustration courtesy of Scott Landry of Center for Coastal Studies & gear illustration by David Gabriel).

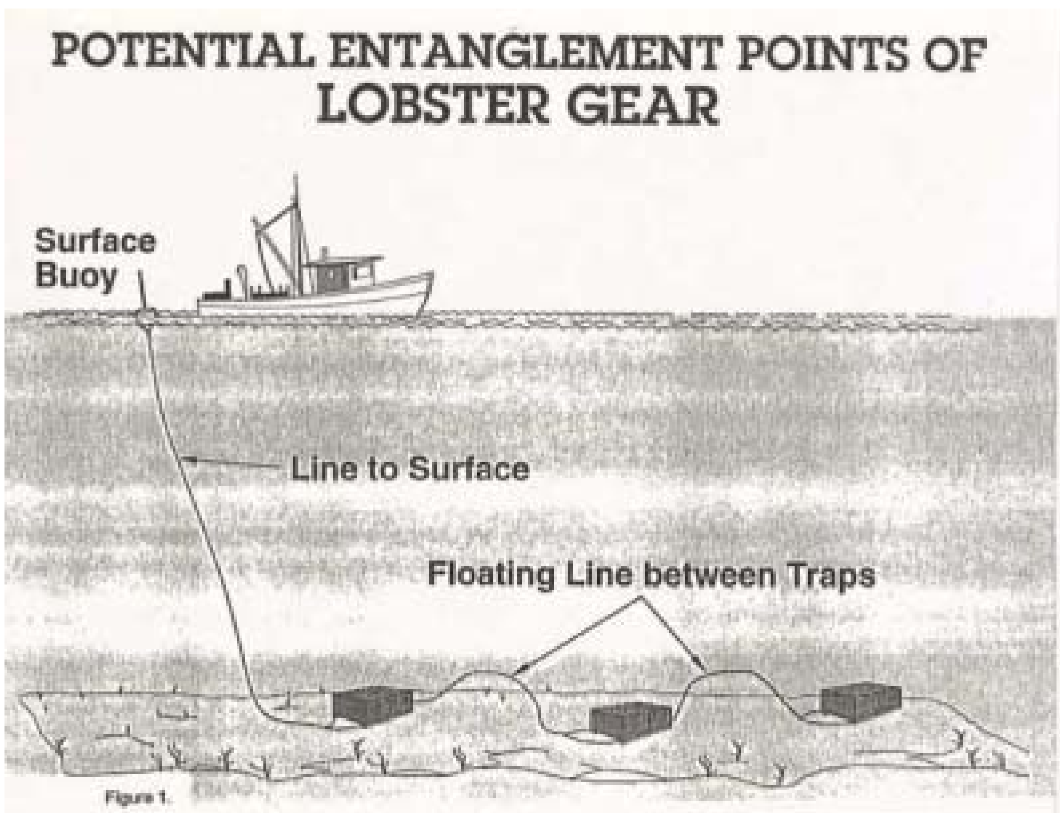

Figure 8. (below) Reprinted illustration depicting trawl with floating groundline from report by Wiley et al. (1997)*. This depiction did not properly characterize the extent of the groundline elevation because the distance between traps was short; lines were depicted tied between traps without gangions, and the lines were depicted in contact with the ocean floor.
**Development and operational testing of snag-free fishing gear for use in reducing right whale entanglement and mortality,* by David N. Wiley, Ron Smolowitz, William Adler, and Robert MacKinnon. A report to The Massachusetts Environmental Trust, 33 Union St., 4th floor, Boston, MA 02108.

Appendix 1

1998 Report by DMF's H. Arnold Carr documenting groundline height observations of *in situ* lobster trawls (2 pp.)

In Situ Observations of Lobster Gear

H. Arnold Carr
Massachusetts Division of Marine Fisheries

Introduction: In situ observations of lobster gear was undertaken in waters located off the New England coast. Some of the gear is found in or adjacent to waters deemed critical habitat for endangered marine mammals such as the Right Whale. Attached to this summary is a cruise report and a video script of a 16 minute summary tape of these activities.

Purpose: To ascertain the in situ functional attributes of commercial lobster trawl gear so as to determine the potential to entangle marine mammals and to provide an understanding toward possible approaches to mitigate this potential. A lobster trawl is defined as a multiple set of traps attached in series by a single line.

This investigation is considered part of a primary response resulting from a series of meetings with NMFS and the commercial fishing community. The meetings discussed the potential for entanglement of Right Whales in commercial lobster and gillnet gear and avenues of possible mitigation. The gear is sometimes abundant in areas deemed critical habitat for this species. This investigation addresses the issue of how this fishing gear lies in situ; determining this will greatly assist ascertaining the means to reduce entanglement of endangered marine mammals.

Methods: A team of biologists, gear technologists and commercial fishermen combined with remote operated vehicle (ROV) equipment gathered on commercial lobster vessels off the coast of Massachusetts and Maine. The team observed static commercial fishing gear set under commercial conditions. Commercial lobstermen voluntarily provided vessel support.

Results: The ROV was deployed at sea for four days. One day was spent in Massachusetts Bay and the other days off the Maine coast. All of the observations were made on lobster gear. In Massachusetts Bay multi-pot trawl (lines) were surveyed; the trawls consisted of more than 10 pots per trawl, but only 2-3 pots or traps were observed on each trawl because of the normal restriction of the ROV tether length. Off the Maine coast, single traps and the more common paired traps were observed as well as trawls of up to three traps. Paired trawls, a trawl with two traps, were the most common.

The trap lines, a line or combination of lines in series that attach the buoy to the bridle of the first trap, consisted of: a) sinking line held up off the bottom by a buoy (or toggle) attached on the line in the midwater column; or b) sinking line on the buoyed end of a buoy line and floating line on the trap or deep part of the buoy line. These result in the line having a vertical configuration near the water surface and just off the bridle of the trap nearest the buoy line. The buoy line did loop where the two lines met and the magnitude of the loop related to the scope and lengths of the respective lines. The vertical configuration of the line near the sea bottom is declared important nearer the sea bottom in order to prevent the line from entangling on very rocky bottom.

One of the objectives of the survey was to view sinking and floating groundlines that connected the traps in a trawl. Observations in each dive proved that the sinking line did what it was intended to do: it was usually right on the bottom, but in a few instances it was up to six inches above the substrate. Several makes of floating line were observed. In Massachusetts Bay, one trawl observed was set with a taut floating groundline. The groundline, that was observed by the ROV, was consistently 10 feet off the seabottom.

The attitude of the floating groundline may also relate to the way it was rigged to the buoy lines.

Two experiments were conducted with pair traps. The experiments involved different types of groundlines - some floating varieties and a sinking type - set between two traps in each experiment. The first experiment set the paired traps “loose” where the second trap in the trawl is pushed overboard just before being pulled by the groundline attached to the first trap. The maximum altitude (off the sea bottom) of each 10 fathom groundline (as measured by the ROV) was as follows:

Superhaul (sinking)	0 feet
Polysteel (floating)	6 feet

Orange poly (floating) 10 feet

The second experiment involved first setting the trawls "loose" and then setting them "tight". Tight is described where the second trap is pulled off the vessel by the first set trap in the trawl.

Loosely Set		Tightly Set	
Superhaul (sinking)	0 feet	Superhaul (sinking)	0 feet
Polysteel (floating)	12 feet	Polysteel (floating)	16 feet
Yellow poly (floating)	10 feet	Yellow poly (floating)	18 feet

The second set, which was more tautly made than the first set resulted in floating groundline altitudes higher than the "loose" set trawls. The observers speculate that this may be result of a "rubber band" effect of the first trap pulling the second closer to it. Other variables may contribute, too. These would include depth, current speed and direction, and trap design and size. The "rubber band" phenomenon warrants further investigation and it should be done with paired trawls as well as 10-20 pot trawls.

Concerns:

- The loop of the line in a composite (consisting of floating and sinking lines) buoy lines. This loop gives a larger exposed profile to the buoy line.
- Knots in the buoy line especially where the sinking and floating line connect
- Toggles or buoys placed on the buoy line within the water column
- Knots in the buoy line where the buoy is attached
- Knots in the groundline
- The method of attachment of the gangion or bridle
- Floating line and its off bottom configuration even when apparently set taut.

Note: These results are a product of cooperative research undertaken by a team of investigators from the Maine Department of Marine Resources, Massachusetts Division of Marine Fisheries and NMFS and Maine and Massachusetts commercial lobstermen.

30 January 1998.

Appendix 2

Results from contracted laboratory of Specific Gravity Tests on lines deployed during this study (2 pp.)

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Report To: Commonwealth of Massachusettes
Division of Marine Fisheries

Date: April 24, 2002

Attention: Melanie Griffin

Report On: Specific Gravity

Lab No. E76036

SUBMITTED: Six (6) Rope Samples

IDENTIFICATION:
A: Everson 7/16"
B: Anacko 3/8"
C: Polysteel Atl.
D: Hy-line
E: Crowe 3/8"
F: Crowe 5/16"

ANALYSIS:

Procedure:

Samples were dried for 24 hours @ 80° C and subsequently weighed. The samples were then immersed in salt water from Puget Sound, with a specific gravity of 1.023 at 61° F, for 96 hours. Samples were agitated to remove any air bubbles.

Samples were then weighed, to the 0.01 of a gram, while immersed in the salt water. The samples were removed from the water and placed on a non-absorbent counter top, allowing the surface water to drip off. Any visible surface water was removed with a damp cloth. The specimens were again weighed at this saturated-surface-dry condition. The specific gravity was calculated in the following ways:

A = Weight of oven-dry test sample in air.
B = Weight of saturated-surface-dry test sample in air.
C = Weight of saturated test sample in water.

Bulk specific gravity (saturated-surface-dry) = B/(B-C)

Apparent specific gravity = A/(A-C)

Sample	Weight (g) Oven-Dry **A**	Weight (g) Sat. Surface-Dry **B**	Weight (g) Saturated in Water **C**
#A	55.76	67.56	2.94
#B	41.67	58.22	2.52
#C	41.91	56.95	2.18
#D	53.13	72.41	7.59
#E	27.11	38.76	-3.71
#F	24.98	32.31	-3.08

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Commonwealth of Mass.
Page -2-
E76036

Sample	Bulk Specific Gravity (Saturated-Surface-Dry)	Apparent Specific Gravity
#1	1.046	1.056
#2	1.045	1.064
#3	1.040	1.055
#4	1.117	1.167
#5	0.913	0.880
#6	0.913	0.890

Note: Samples #E and #F floated. All others sank.

This report applies only to the actual samples tested. Northwest Laboratories does not certify, warrant or guarantee any products manufactured by others. Samples discarded within two months unless otherwise requested in writing by you.

NORTHWEST LABORATORIES, INC.

Omar Simon, Chemist

bjc

A Long-Line (Set-Line) Crab Pot System

CIRCULAR OF INFORMATION 630
JULY 1970
AGRICULTURAL EXPERIMENT STATION
OREGON STATE UNIVERSITY
CORVALLIS

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AUTHOR: R. Barry Fisher is Associate Professor of Fisheries, Oregon State University.

ACKNOWLEDGEMENT: Supported in part by National Science Foundation Institutional Sea Grant GH 45.

A Long-Line (Set Line) Crab Pot System

R. BARRY FISHER

Preliminary investigation by the Department of Fisheries and Wildlife indicates that a long-line crab pot retrieval system has definite advantages over the individual pot retrieval method currently in use on the Oregon coast. The comparative study is part of a research project established to determine the relative merits of the two retrieval systems.

The most obvious advantage of the long-line system is in the area of cost economy. Using this method crab pots do not need weights and individual buoys, and in depths greater than 15 fathoms, additional savings can be realized on warps. Smaller, lighter gear can be used successfully because the pots are anchored by the holding strain of the line anchors as opposed to the insertion of heavy weights in the individual pots. Old crab pots can be used simply by cutting out the weights and inserting double opposing triggers.

Fishing conditions in the Dungeness fishery on the Oregon Coast generally do not require large pots except in "bumper" fishing periods. Smaller pots of approximately 36 inches with ½-inch frames can be used instead of the 42-or 44-inch pots with ¾-inch frames, substantially reducing per pot costs. The savings which can be realized by using the lighter gear is apparent from the following comparison. In Newport, 42- or 44-inch pots made of ¾-inch frames and 80- or 90-pound weights, with individual warps and buoys, cost approximately $42 to $45 per pot, completely rigged. Thirty-six-inch gear made of ½-inch frames, with no weights, would cost approximately $22 to $26 per pot.

For ease in handling, the lighter pots should have the lid bar mounted exactly halfway across the top of the frame. One lid-retaining hook on a large rubber band harness should be used rather than the two lid-retaining hooks common on larger pots.

Lighter-weight pots will not sink in as readily and, as a result, they can be set into bottom that is too soft to be fished with the conventional heavier pots. Because the gear is anchored and the holding power of the anchors is greater than the unanchored but weighted pots, the long-line gear will not "walk" as much in bad weather as there is no constant surge on the buoy line going to the surface.

The trials that have been run with this gear on a Newport crabber have demonstrated that it can be run as fast, if not faster, than individual pots. During trial runs with the power block running in the wrong direction for long lining, a crew inexperienced with the long-line system consistently managed to break out the anchor line, run 10 pots, and reset the gear in 10 minutes. It seems apparent that with the power block running in the right direction this hauling rate could be increased.

If a boat were to fish the entire string of crab pots in a long-line system, and the engine, clutch and throttle, and remote steering control were mounted by the power block, it would be possible to eliminate a boat puller. When fishing long-line gear, the helmsman steering the boat to individual buoys becomes unnecessary. The boat can be controlled from the power block and changes in course, speed, etc., can be made at the power block.

If gear becomes stuck, it is still possible to "blow it out" by running a hose down the line as is done with traditional gear. When a pot on a long line is stuck, both ends of the gear are hauled from each end up to the stuck pot. The ground lines are then cut, buoys are attached, and the pots are left until gear can be brought in to blow them out. However, the probability of gear sticking or sinking into the bottom is greatly reduced with lighter pots fished on long lines.

One hazard in using this gear is the possibility that a sunken log or other submerged obstruction might snag the ground line. If this should occur and the first end hauled is snagged and cannot be broken loose, the vessel should proceed to the other end of the line and attempt to retrieve the gear. However, even with a difficult snag probably only the one pot caught will be sacrificed because the gangeon is of less strength than the ground line and will part.

If a large number of boats adopt the long-line system, fishermen will have to exercise care to assure that one string is not set across another. However, boats fishing individual pots will not normally interfere with long-line gear. In the event that buoys are cut off and/or lost, gear can be easily retrieved by dragging a grapple since the set location is known and the long line covers such a large area.

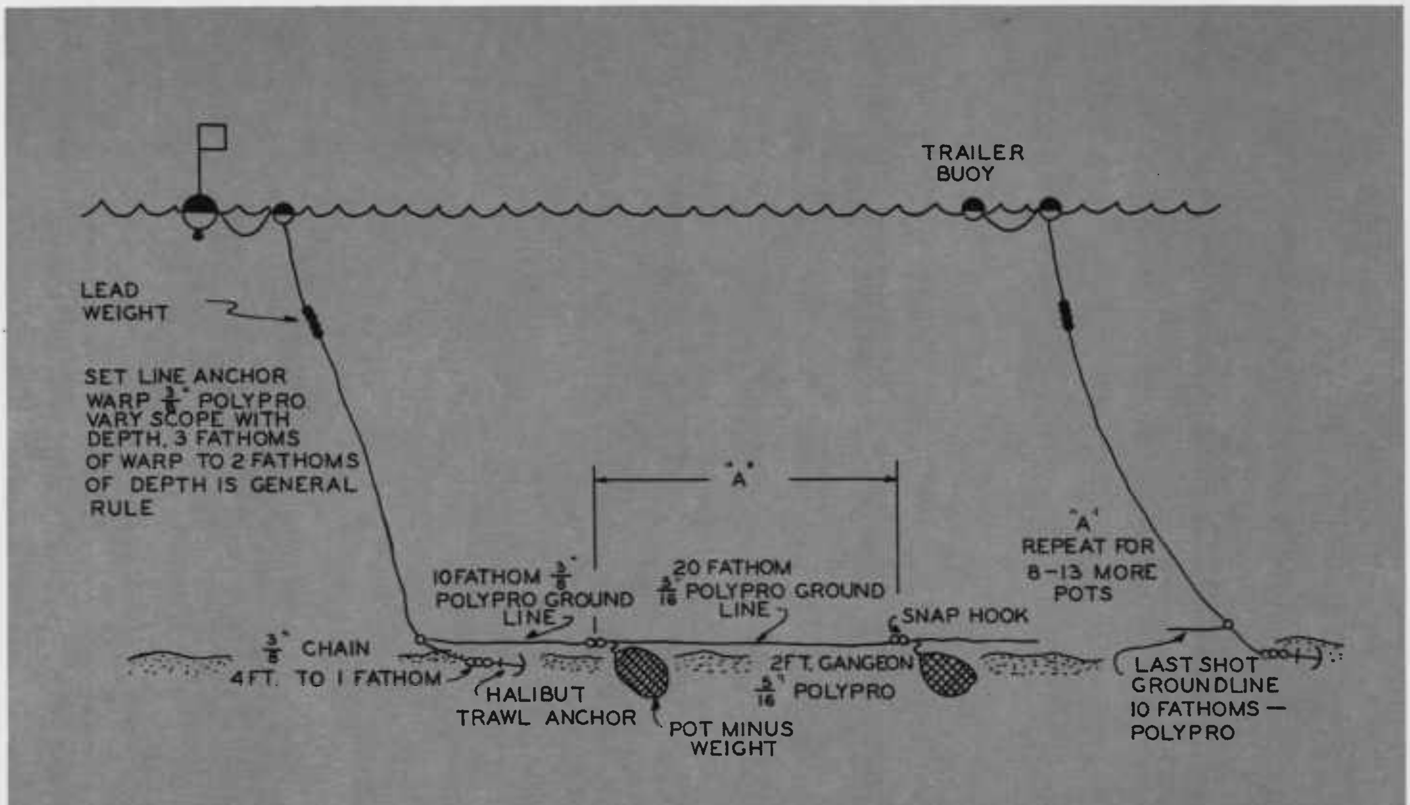
The long-line system should be considered for deep-water fishing where long buoy warps become items of considerable expense and in areas with soft bottom. Gear also can be set close on the beach because the superior holding power of the anchors allows fishing in those areas where individual pots would wash ashore.

The Department of Fisheries and Wildlife at Oregon State University is planning further research and exploratory fishing with the long-line crab pot system during the 1970-71 crab season.

Rigging the Gear

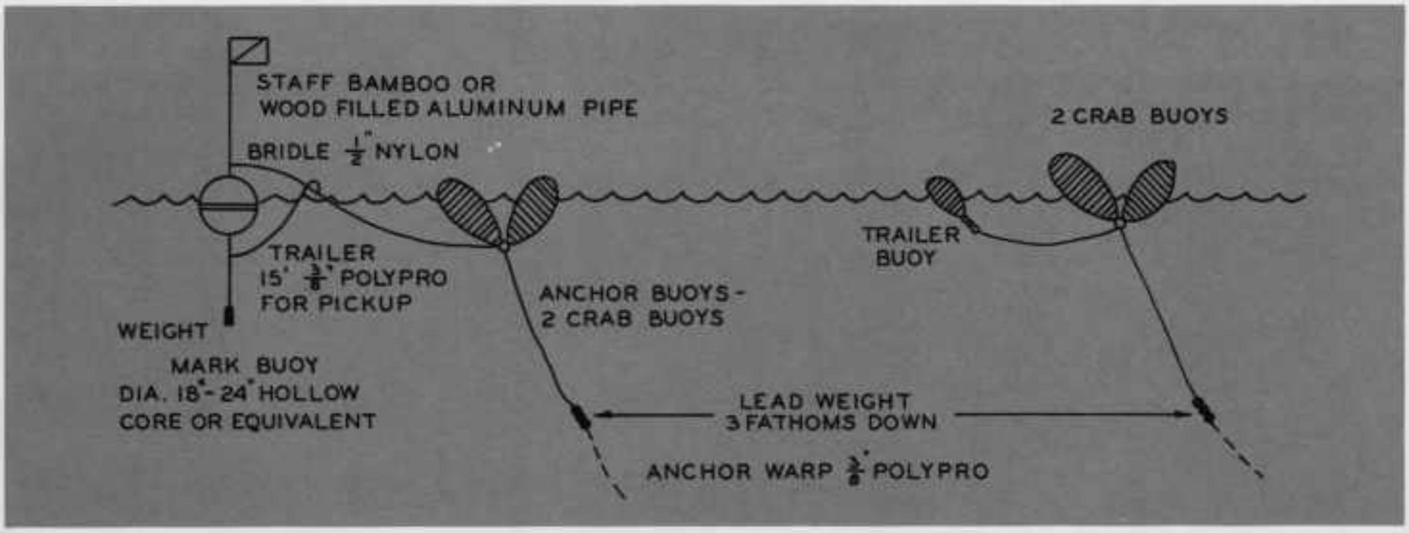
The illustrations on the following pages present a method of rigging a long-line crab pot system. The sketches first present an overall view of the gear and then show specific details of the individual equipment. Personal preference may indicate different-sized lines than are recommended. Also, the length of line between pots is a matter of individual preference and may differ in various local fishing situations.

Figure 1. Overall sketch of Long-Line Crab Pot System.



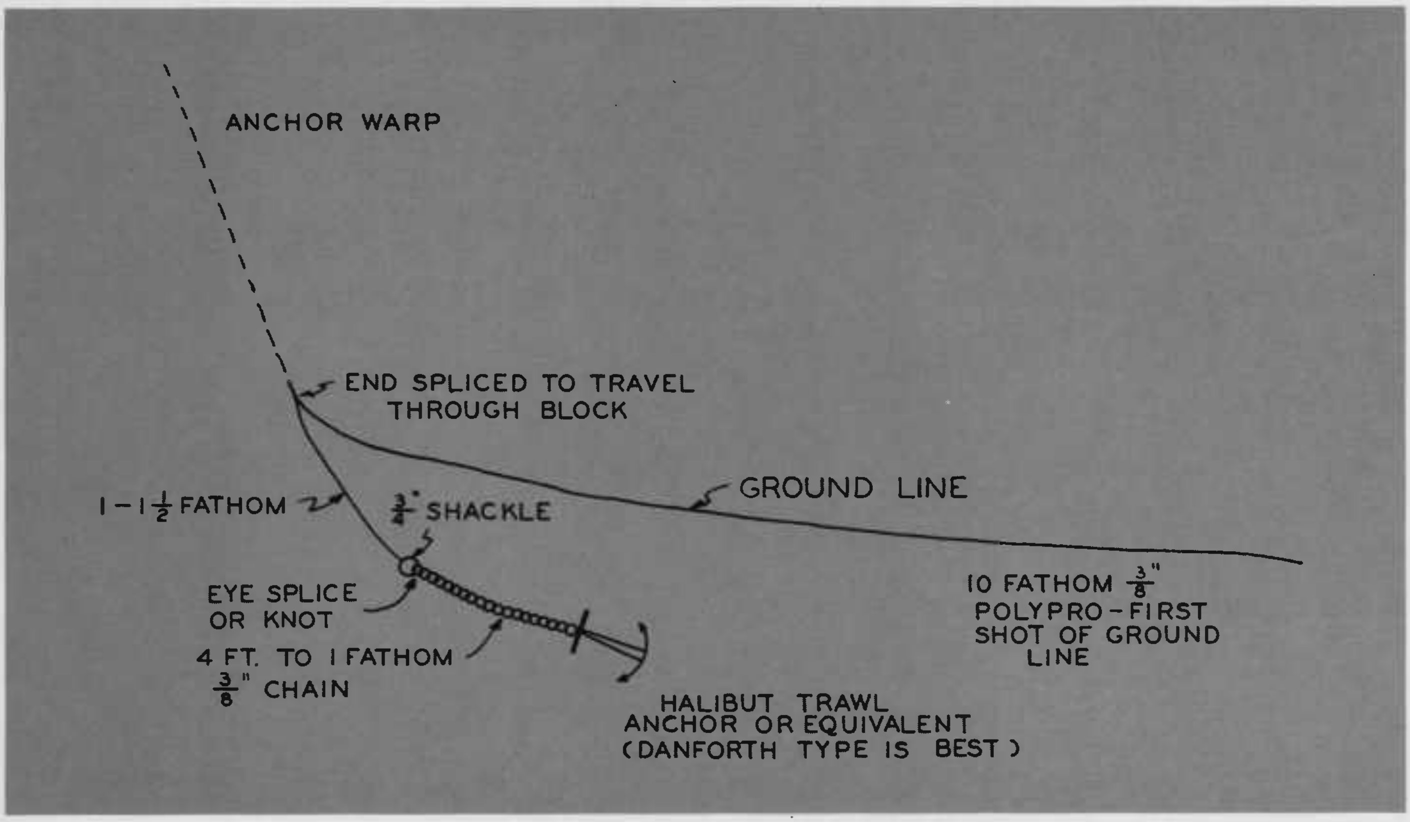
The long-line crab pot system is buoied and anchored at both ends to keep the string tight and straight. Large buoys and ample scope on the anchor lines will ensure retrieval even in conditions of strong current. Braided or hard-laid polypropylene in 3/8-inch diameter should be used for anchor warps and the ground line and a 3/8-inch swivel should be used between every three to five pots to prevent line kinking. Swivels of larger diameter may slip in the power block. It may be helpful to make the ground line of a different color than the anchor warp so that the tail end of the anchor line can be slipped off the block and the ground line can be kept on the block when the first end of the gear is hauled. Ten to twenty pots constitute a string for initial fishing; subsequent experience may dictate strings with more pots.

Figure 2. Buoys.



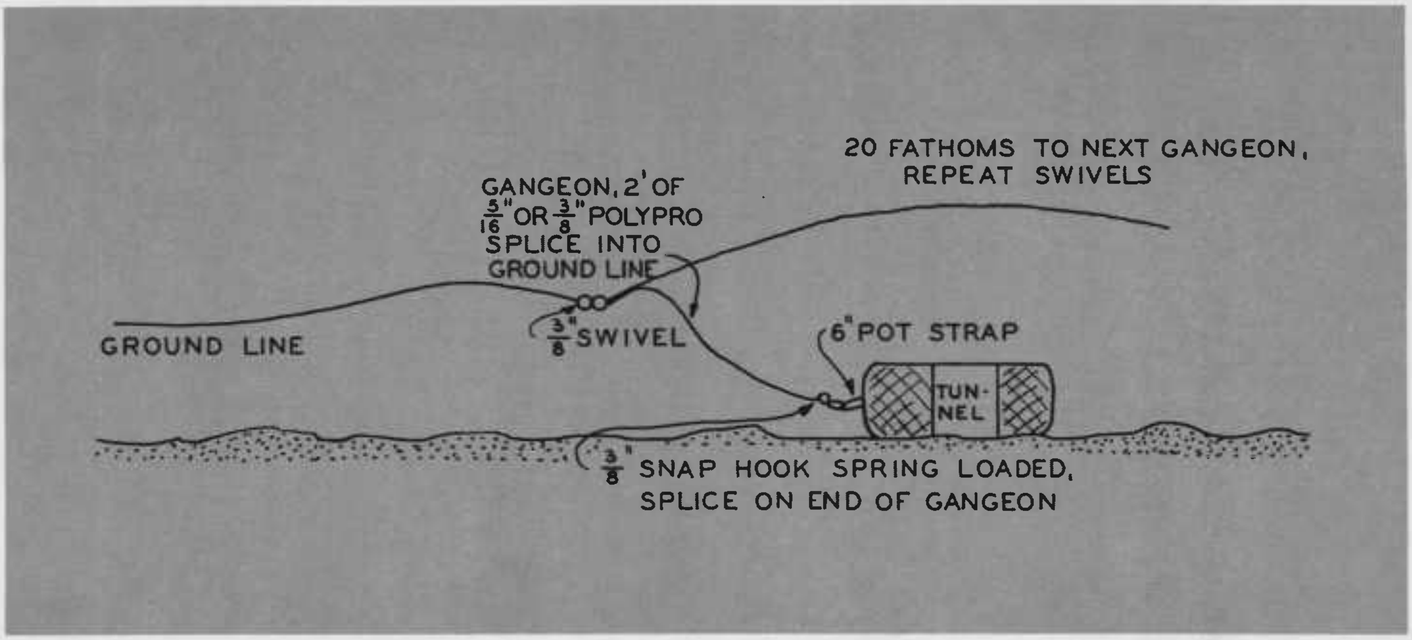
The buoy system used in long-line gear should have enough flotation to allow retrieval in any current conditions. Trailer buoys should be used on both ends to ease grappling and boarding under adverse conditions. Also, buoys at either end mark the spread of the long-line gear. The flag buoys can be made of slabs of polyfoam lashed to the staff or covered with webbing which is then seized to the buoy staff. The flag buoys should be bridled and weighted so the marker flag remains upright for easy visibility.

Figure 3. Anchor and ground line securing details.



The anchor line should be rigged the same on both ends. A shot of chain is used on the end of the anchor line to ensure positive holding of the anchor. The anchors should have good holding qualities (at least the equivalent of a halibut trawl anchor).

Figure 4. Gangeon and gangeon fastening details.



The ground line should run for at least 10 fathoms from the anchor end to the first pot to ensure that the anchor is well away from the boat before the first pot comes up. From the first pot on, the pots should be spaced 20 fathoms apart. Experience may dictate shorter or longer shots than 20 fathoms, but this appears to be an effective distance to cut down overlapping fishing radius between pots and at the same time economize on line. Short gangeons of two feet apparently work best. The pot straps should be approximately 6 inches long. The combined length of 2-foot gangeons, snap hooks, pot strap, and the height of the pot represents a length that most boats can handle at the maximum lift position of the power block ram.

Pot Rigging

Pots are rigged so they will fish regardless of which side falls to the bottom. Figure 5A shows the double triggers rigged so the bottom triggers fall open by force of gravity. The tunnels in new gear should be built to allow the same tunnel slope on each side. Figure 5B shows the single-lid cover harness which is practical for easier pot handling. New long-line pots should have the lid cover bar made halfway across the top to facilitate handling with the single-lid cover retaining harness. Figure 5C shows rigging details of the gangeon. The gangeon should be two feet in length with one end spliced into the ground line and the other end spliced into a ⅜-inch spring-loaded snap. The springs must be lubricated from time to time with heavy grease. The splice on the snap end of the gangeon should be seized into the small end of the snap to hold it in place (welding the links of chain onto the snap, as shown in Figure 5D, right, is not recommended as heat from the weld causes the snap springs to become stiff). Figure 5D illustrates the snap being attached to the six-inch-long pot strap. Hold the end of the strap in one hand,

Figure 5A. Double triggers rigged so bottom triggers fall open by gravity.

grasp the back with the other, and push it on. To unhook the snap, the lower part of the hinged snap bar is depressed and the pot strap is pulled out. The pot straps should be mounted halfway up the side brace.

A piece of ½-inch or ⅜-inch concrete reinforcing rod is fastened into the pot for anode or "eating" purposes to counteract electrolysis. Anodes of this type are inexpensive and can be replaced easily. The anodes are welded to furnish a good ground.

Figure 5B. Single-lid cover harness. New longline pots should have lid cover bar made halfway across the top to ease handling with single-lid cover retaining harness.

Figure 5C. Rigging details of gangeon. Gangeon should be two feet in length with one end spliced into the ground line and the other spliced into a 3-inch spring-loaded snap.

Figure 5D. Snap being attached to six-inch-long pot strap.

Rigging the Vessel

The power block and ram or davit must be rigged high enough to allow the pots to be swung in and lowered to the dumping box.

The power block should have both fairleads mounted on it and must be set to run in a clockwise fashion. Figure 6 shows a block rigged for long lining. A hinged, folding platform three feet long by two feet wide is anchored to the rail as a ready base for the emptied and rebaited pots (Figure 6-1). The platform is mounted four to six inches below the rail to hold pots inboard in rough weather, and is stowed flat against the bulkhead in a vertical position when not in use. Approximately two feet is allowed between the dumping base and the front end of the pot platform (Figure 6-2).

A spur fairlead six to eight inches high and curving slightly inboard is mounted at a distance of no more than six feet forward of the vessel's propeller. This fairlead keeps the ground line clear of the propeller when running the gear and will also keep it inboard in the event it is lost from the power block sheave while running the gear.

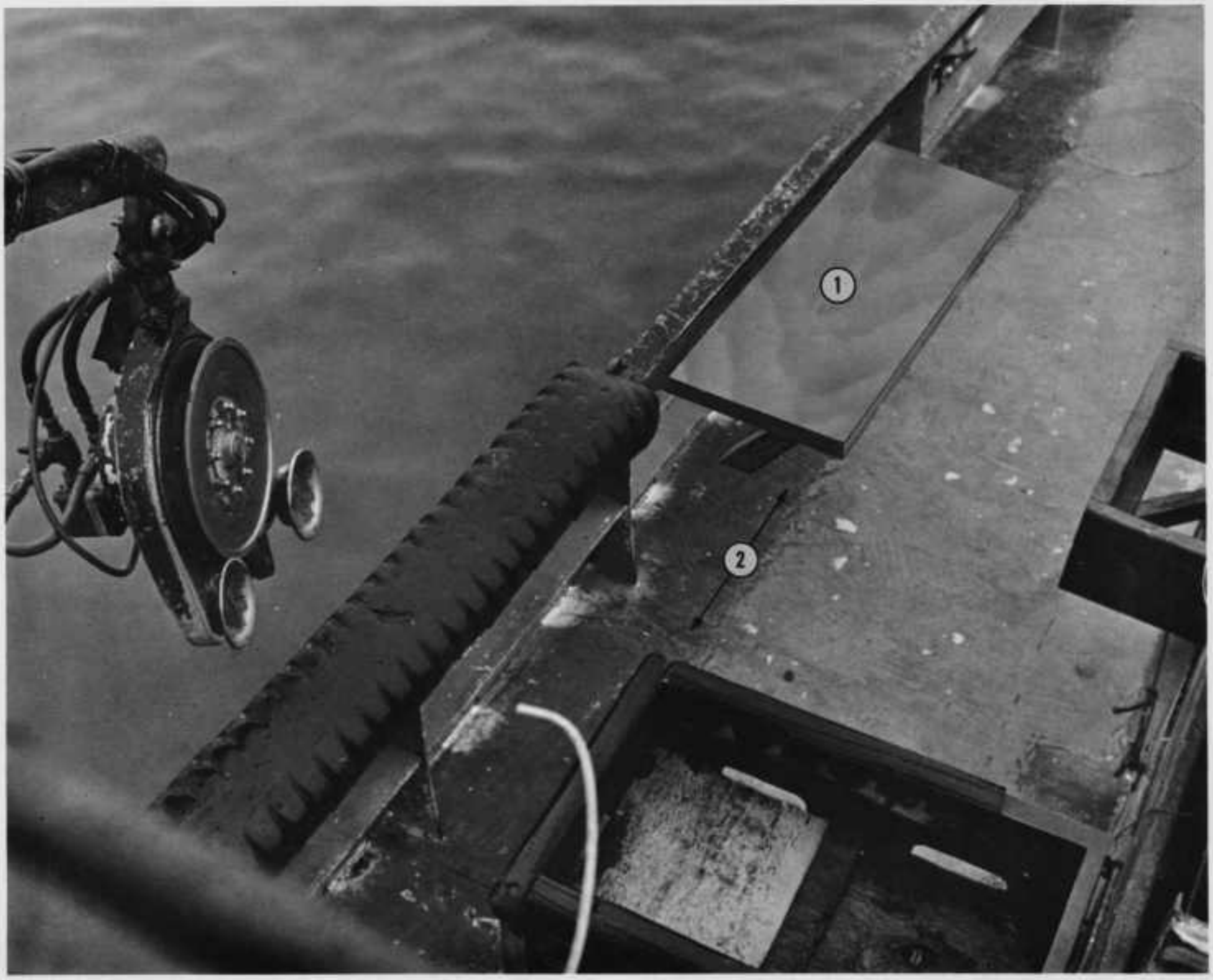


Figure 6. Block rigged for long lining. A folding platform is anchored to the rail as a ready base for pots.

Setting the Gear

Long-line gear must always be set tight and straight to prevent bows or loops and to insure full holding potential from the anchors. Coil the ground line in a fish box or other large box with the top and bottom end free outside the box for attaching the anchors. Gangeons and snaps are laid in the coils so the ends are all free outside the box and in sequence to allow easy snap-on of pots.

The pots to be set are stacked on the stern; buoys, anchors, and ground line gear is placed next to the stern rail. In setting the gear the top buoy is launched over the stern and the vessel steams ahead in the direction of the set. The anchor is bent on and dropped overboard when the first buoy line is run out.

The first part of the ground line is run out under a slight strain.

When 10 or 12 coils of line are left in the box before the first gangeon, a pot is snapped on. After the ground line has run out down to the first gangeon, the first snapped-on pot is held on the stern until a good strain is maintained to insure setting the gear tight and straight.

Continue setting the string, snapping on pots and holding each one long enough to tighten the ground line. After all the gear has been run out, bend on the other anchor. Slow the vessel and tow the gear tight and straight, then release the anchor and run out the last buoy line.

Running the Gear

The gear should always be hauled close into the wind or current, whichever is stronger, with the wind maintained on the hauling side of the vessel. The buoys are gaffed and brought aboard. Lay the anchor warp in under the forward fairlead, around the block and down around the after fairlead. Then throw the buoy overboard and "under-run" the anchor warp with the vessel. The ground line should be either a different color polypro or should be marked, so that when the anchor comes to the block the line leading to the anchor can be slipped from the sheave and the power block will then continue to haul the ground line. Continue to jog the vessel ahead so as to maintain only a slight tension on the gear. The course should be parallel to the ground line as it leaves the water.

As the first pot comes to the block, it is boarded and the gangeon unsnapped from it. The after boatpuller then leads the gangeon clear of the power block, snaps the spare pot onto the ground line and pushes it overboard.

After each pot is snapped on and pushed overboard the after boatpuller lifts the ground line clear of the fairlead to allow passage of the pot by the stern. The ground line is then flipped inboard of the fairlead again so that it will remain clear of the propeller. If the ground line slips off the block, it is retained by the fairlead and can be placed back on the block.

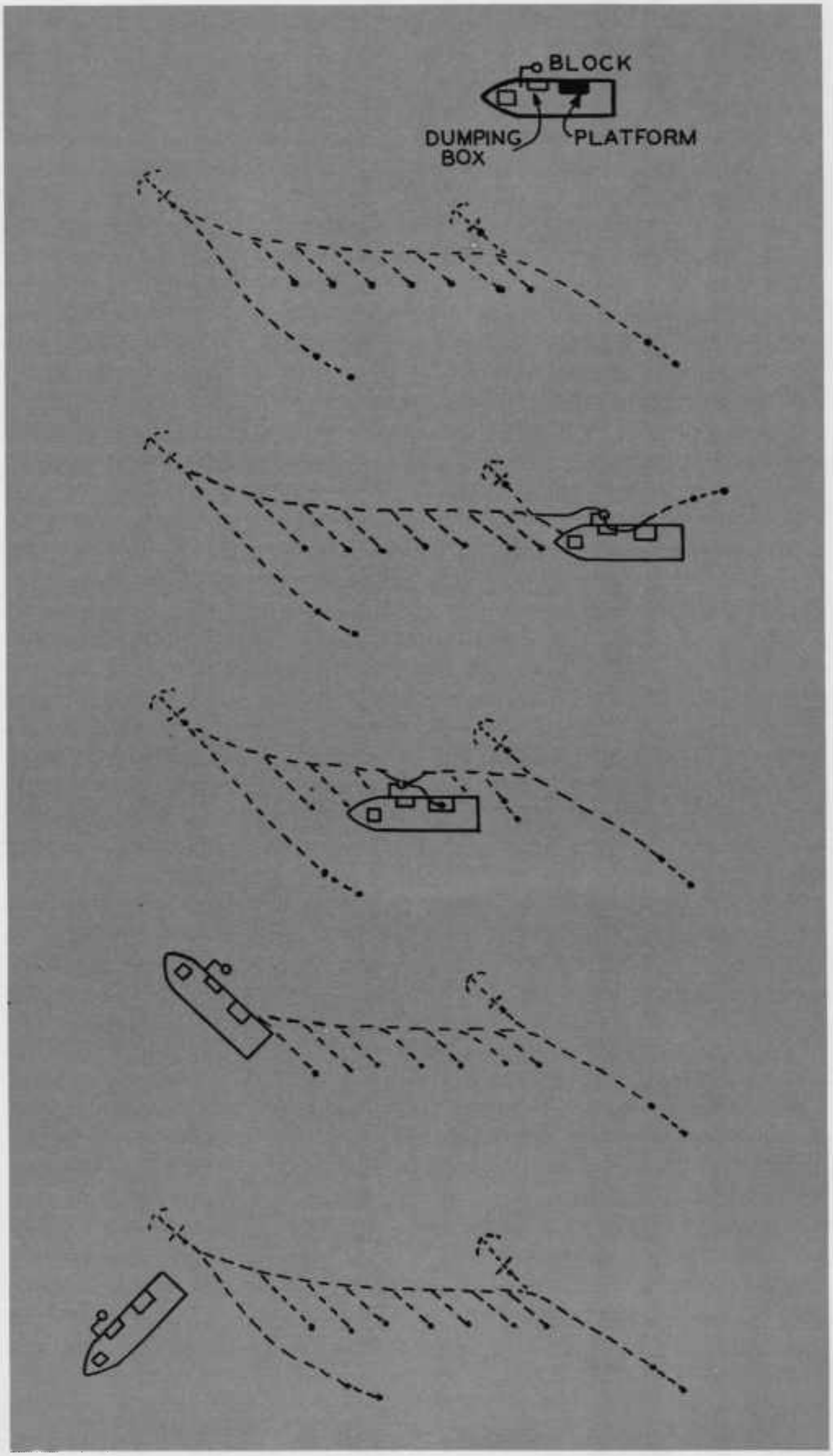
The boarded pot that has been unsnapped from the ground line is emptied and rebaited by the boatpullers as the vessel continues down the line. As soon as the pot is emptied and rebaited, the after boatpuller shifts it to the platform, clearing the dumping box for the next pot.

The vessel continues down the string with the boatpullers unsnapping full pots as they come aboard and replacing them with empty, rebaited pots. Only slight tension should be kept on the gear as the line is run. After all the pots have been retrieved the vessel continues to run the ground line until it arrives at the second anchor warp. At this point the block is shut off and tension is held on the anchor warp. The line leading to the anchor is passed around and clear of the power block and stern fairlead and the vessel then jogs against the gear until a good tension is put on the string to straighten and stretch it.

After the gear is pulled straight and tight, the anchor warp is released from the power block. The buoy line is slacked out under soft tension to maintain straight and tight gear until the gear is reset.

The sketch in Figure 7, next page, illustrates the sequence of events in running the gear.

Figure 7. Running the gear.



1. Gear in water, boat approaching the end buoy. Note that the gear is to be pulled into the current.

2. Anchor coming to block. Buoy let go astern. Vessel approaching first long-line pot.

3. Midway through the gear, anchor warp and buoy out and set again.

4. Vessel at end of string, all gear out, steaming out and tightening the gear in the direction of the current.

5. Gear completely set, vessel proceeds to next string.