Project 2 Final Report

Review of Sinking Groundline Performance in the Maine Lobster Fishery, with Recommendations for Improving its Fishability

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Background and Objectives

The Atlantic Large Whale Take Reduction Team (TRT) process, established under Section 118 of the Marine Mammal Protection Act, has convened scientists, whale conservationists, biologists, managers and fishermen annually since 1996 to discuss strategies to reduce the risk of whale entanglement in fixed fishing gear. Despite an array of regulatory actions beginning in 1997, which included introducing buoy weak links and line usage requirements, seasonal and area restrictions, and gear marking requirements, large whale entanglements continued to occur in fixed gear. In 2003, the TRT agreed to implement a regulatory requirement intended to reduce the risk associated with groundlines, and then subsequently address the risk associated with vertical lines. Vertical line rules were published in June 2014.

Beginning April 5, 2009, regulations under the Atlantic Large Whale Take Reduction Plan required lobstermen in Maine to rig traps on a trawl with sinking rope as part of a suite of broad-based gear modifications. NMFS issued its final rule in 2007 to require the use of sinking groundline, known as "whale rope" by many Maine lobstermen, in Northern Inshore State Trap/Pot Waters, which includes the state waters of Rhode Island, Massachusetts, New Hampshire, and Maine.

The sinking groundline rule reflects the premise that whales swimming or feeding at or near the ocean floor could encounter floating rope used to link traps in a trawl; thus the use of a heavier sink rope that lays on the ocean floor is mandated to reduce entanglement potential. This approach was first implemented in right whale critical habitat areas in Massachusetts where right whales are known to aggregate and feed.

The federal rule defines groundline as "the line connecting traps in a trawl" and sinking groundline as line that "does not float at any point in the water column." The rule also designates coastal areas exempt from the provisions of the rule (NMFS

2007). The exemption line established along the Maine coast allows floating groundlines to be fished in 70% of state waters. In its 2007 Final Environmental Impact Statement (FEIS) NMFS concluded "right whales are unlikely to spend substantial amounts of time in the coastal waters of Maine" and that adopting the exemption line "would provide an adequate level of protection to endangered large whales." (NMFS 2007 FEIS, page 3A-9; http://www.greateratlantic.fisheries.noaa.gov/whaletrp/eis/) (Figure 1).

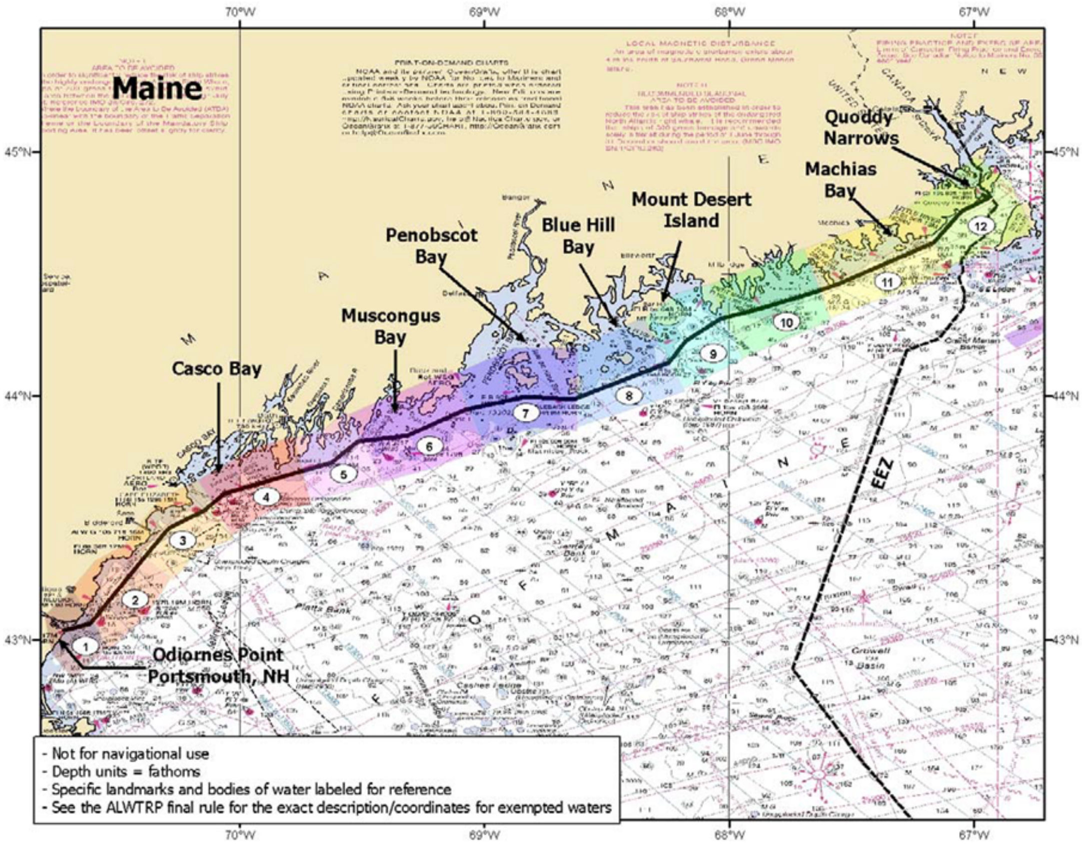

Figure 1. Maine Whale Rule Exemption Line – *Chart depicting the nearshore exempted area for Maine, outside which sinking groundlines must be used. Detailed charts available through the Atlantic Large Whale Take Reduction Plan: Outreach Supplement to the Maine Exemption Line at www.nero.noaa.gov/whaletrp/plan/outreachsup.html.*

The federal government funded several economic assistance programs for lobstermen to mitigate the cost of purchasing sinking rope needed to replace floating groundlines. In 2004, the first gear exchange program in Massachusetts conducted by the International Fund for Animal Welfare (IFAW) removed some 715,000 pounds of floating groundline from the fishery. The Gulf of Maine Lobster Foundation (GOMLF) conducted a four-year groundline exchange program, which removed over two million pounds of used floating groundline from the Maine lobster industry from 2007 to 2011, by issuing vouchers to be used towards the purchase of replacement sinking line. In 2010, the Commercial Fisheries Research Foundation conducted a groundline conversion program for offshore (Lobster

Management Area 3) and Rhode Island (Lobster Management Area 2) lobstermen, issuing vouchers to offset the cost of over 1,450,000 pounds of new sinking line.
In Maine, the industry standard for groundline has been floating rope. Maine's coastal marine habitat is characterized by large areas of hard substrate consisting of cobble, rock, boulder and ledge; strong tides and bottom currents. Float rope is not prone to chafing nor getting caught under rocks as it moves with the tides and currents. Chafed rope leads to an increased loss of gear due to weakened rope breaking off, and rope that is caught under rocks is extremely dangerous for lobstermen to haul.

Surveys and anecdotal reports from Maine lobstermen have revealed that the sinking groundline rule has significantly impacted those who fish in areas where the groundline comes in contact with the rocky ocean floor or "hard bottom," or in areas with strong tides and bottom currents. Sinking rope does not last as long when used for groundline, and must be replaced much more frequently than floating line if it is to be fished reliably. Some lobstermen in these areas have made modifications to how their gear is rigged and fished, or have abandoned prime fishing grounds in order to reduce gear loss. Many have broken multi-trap gear into smaller trawls or single traps in order to continue fishing on challenging hard bottom, resulting in more vertical lines in the water column. Others have reported personal injury or vessel damage as a result of using sinking groundline, and a few have left the fishery altogether due to the untenable expense required to purchase or replace sinking groundline and lost traps. Besides the need to replace gear, lobstermen suffer reduced fishing effort owing to the temporary removal of pots. Fishing sinking groundlines therefore greatly increases operational costs, can pose a safety hazard, and contributes to gear loss that as ghost gear can also entangle marine life.

These issues with sinking groundline mean that lobstermen retire rope earlier than when using float rope, or will continue to fish rope to save money, putting their own safety at risk. Under both scenarios there is an economic cost either from the need to replace ropes more frequently or increased gear loss.

The purpose of this project was to determine ways to enhance the performance of sinking groundline, involving three approaches:

1. Reviewing previous research and lobstermen's experience with sinking groundlines;
2. Recording directly from lobster fishermen of the Gulf of Maine the practical challenges they encountered in converting to sinking groundline;
3. Producing visual observations of actively fished sinking groundline to gain insights into chafing and how it might be reduced.

1. Review of previous research and experience with sinking groundlines

Defining Sinking Groundline

NMFS defines sink line as “line that has a specific gravity greater than or equal to 1.030, and, for groundlines only, does not float at any point in the water column” (NMFS 2007, FEIS, p. 57180). Used as groundline, each length of sink rope between two traps (in Maine, referred to locally as tailer warp, trailer warp or spreader, depending on configuration and location) typically ranges from 8 to 25 fathoms in length, and comes into direct contact with the substrate between the traps. On the seafloor of coastal Maine, rocky outcrops commonly occur interspersed with flat sandy or muddy substrates, posing problems for gear configured as pairs of traps, triples, or even more numerous multiple-trap trawls. Ropes resting on rocky bottoms are prone to “chafing” or abrasion as it moves with tides and currents, and becoming “hung down” or lodged under rocks that make hauling difficult and sometimes dangerous.

Floating rope, on the other hand, has a specific gravity of less than 1.03 in seawater, which makes it desirable as groundline for lobstermen fishing in rocky bottom habitat. It floats above the ocean floor and allows the lobsterman to retrieve gear without the rope coming into contact with the substrate. Floating groundlines are still commonly used by Maine lobstermen fishing a variety of trap configurations inside the coastal exempted area.

Rope manufacturers produce an array of floating and sinking lines for the lobster industry. The primary materials in sinking rope are polyester or nylon/Dacron in combination with varying ratios of float-rope fiber such as polypropylene, polyethylene, or a co-polymer of the two called Polysteel©. Occasionally, lead is added to a positively buoyant fiber rope to make it sink, but such rope is not commonly distributed in the Northeastern US.

Most rope used in the Maine lobster fishery is three-strand twisted cordage, and manufacturing techniques include blended and co-extruded fibers offered in a range of diameters and tightness, or “lays,” resulting in a wide spectrum of sink rope options. Responding to requests from the lobster fishing industry, manufacturers have created sinking rope that ranges from a specific gravity of 1.03--the lowest density allowed under regulations, often called “neutrally-buoyant” line--to a heavy rope with a specific gravity of over 1.3, consisting mainly of polyester. Nevertheless, these are manufacturing specifications at the time of production, and actual fishing conditions, in which ropes are subjected to infusion of sediments and the forces of tides and currents, can modify their profile.

Several rope manufacturers produce brands of sinking rope that vary in diameter, weight, length of coil, breaking strength and lay of sink rope, which are sold through the major marine suppliers to the Maine lobster industry. Costs vary based on the source of rope and the distribution area, but generally are based on coil weight. On a per unit basis, the best sink rope can be nearly twice the cost of float rope. Despite their generally higher breaking strengths, lobstermen report more frequent part-offs with sink rope compared to float rope. Lobstermen use trial and error to help guide selection of sink rope to use on their groundlines, but often simply purchase the rope that their supplier has in stock, or that is the least expensive available. Many lobstermen assume that all sinking rope brands will chafe, causing the rope to weaken and potentially break when it comes in contact with sharp, rocky substrate, and therefore believe it is not worth investing in stronger ropes that are more expensive.

Table 1. Sink rope brands and makes available in Maine (as determined in 2013). *Break strength is as reported by manufacturers.

Rope Manufacturer	Common Name	Diameter (inches)	Break Strength (lbs)*
Anacko	Coastline	11/32"	--
	Coastline	3/8"	--
	Coastline	7/16"	--
Everson	Everson Pro 3-strand	11/32	3020
	Everson Pro 3-strand	1/2"	5740
	Everson Pro 3-strand	3/8"	3620
	Everson Pro 3-strand	5/16"	2460
	Everson Pro 3-strand	7/16"	4990
	Everson Pro 4-strand	1/2"	--
	Everson Pro 4-strand	7/16"	--
Hyliner	EZ Haul	12-thd (3/8")	4000
	EZ Haul	6-thd (5/16")	2450
	EZ Haul	9-thd (11/32")	3300
	Hyliner sink	12-thd (3/8")	3300
	Hyliner sink	15-thd (7/16")	4000
	Hyliner sink	6-thd (5/16")	4000
	Hyliner sink	9-thd (11/32")	2450
	Steel Liner	1/2"	4000
	Steel Liner	11/32"	2450
	Steel Liner	3/8"	--

	Steel Liner	5/16"	--
	Steel Liner	5/8"	4000
	Steel Liner	7/16"	4000
Korean rope	Danline sink	3/8"	3650
	Danline sink	7/16"	6350
	Manline	1/2"	6350
	Manline	3/8"	3650
	SteelPro	1/2"	7700
	SteelPro	7/16"	4530
Orion	SuperHaul	11/32"	--
	SuperHaul	3/8"	--
	SuperHaul	7/16"	--
Polysteel Atlantic	Esterpro "Hot Shot"	1/2"	--
	Esterpro "Hot Shot"	1/4"	1450
	Esterpro "Hot Shot"	11/32"	3720
	Esterpro "Hot Shot"	5/16"	2450
	Esterpro "Hot Shot"	5/8"	10,950
	Esterpro "Hot Shot"	7/16"	4700
	HydroPro	1/2"	5000
	HydroPro	11/32"	2450
	HydroPro	3/8"	--
	HydroPro	5/16"	1450
	HydroPro	5/8"	10,950
	HydroPro	7/16"	4700
Portuguese rope	Cotesi	1/2", 7/16", 3/8"	--
Tytan	Dacron outside of PET	11/32"	--
	PET outside of Dacron	3/8"	--
	Tytan (reverse) RVS	1/2", 7/16", 3/8", 5/16"	--
	Tytan (sink) SLR	1/2", 7/16", 11/32", 5/16"	--
POPULAR FLOAT ROPE (HYLINER) FOR COMPARISON		*3/8"*	*2248*

Summary of Previous Work

Hundreds of lobstermen have collaborated over the past decade in groundline research or survey efforts, providing vessel platforms for field investigations, fishing modified gear, maintaining logbooks, and participating in conferences and workshops. Involving lobstermen is critical for effectively communicating information to the industry about the regulatory process as well as the findings of each study, and provides incentives for other individuals to get involved with subsequent research efforts. By communicating directly with individual lobstermen and promoting discussion among groups of lobstermen, researchers and managers have learned about many modified practices undertaken to get more life out of sinking groundline.

Regional organizations have leveraged significant resources to examine the challenges posed by sink rope used as groundline in the lobster industry. This section presents a summary and references of these research projects, information that is intended to benefit not only lobstermen but also managers and rope manufacturers.

Table 2. A summary of information listed chronologically within each category, on the properties, modifications and experience of sinking groundline in the lobster fishery.

Study/Presentation	Sponsor	Results/Outcome
GROUNDLINE PROFILING		
A Study of the Underwater Profiles of Lobster Trawl Groundlines; *In Situ* Observation of Lobster Gear	Massachusetts Division of Marine Fisheries (DMF) (2002)	• divers measured profile of neutrally-buoyant trawl lines • lines were observed to be in contact with substrate
Underwater Gear Groundline Profile Work	Maine Department of Marine Resources (DMR) (2003)	• preliminary assessment of ROV equipment and techniques for *in situ* documentation • thorough documentation of *in situ* gear and bottom-types along the entire Maine coast over 27 days (fall)
Modified Groundline Project	Maine DMR (2004a, b)	• various modifications to traditional floating groundline were successful in reducing the profile of the line • all ropes chafed when in contact with substrate
Reports to the Consortium for Wildlife Bycatch Reduction	Maine Lobstermen's Association (MLA)	• review of several experimental and sinking groundline rope

	(2005, 2006, 2008)	testing initiatives • summary of outreach conducted with industry
Determining Effect of Eastern Maine Bottom Currents On Groundlines	GOMLF (2007)	• current is strong enough 1m off bottom in certain areas that float groundline profile was 6ft or less on 20-trap trawls
GROUNDLINE LIFE		
Scale Modeling of Fixed-Fishing Gear to Compare and Quantify Differently Configured Buoyline and Groundline Profiles: An Investigation of Entanglement Threat	Massachusetts DMF (2005)	• both buoyline and groundline profiles are variable in nature due to many influences • modification measures to reduce entanglement risk vary geographically • reducing scope in buoyline has greatest promise of risk reduction
Reducing Damage to Sinking Groundlines by Adjusting Lobster Gear Hauling Equipment; Extending the Life of Sinking Groundline: Observations and Experiments, Richard Allen	Massachusetts DMF, with Dick Allen, consultant (2009, 2012)	• modifications to the hauling system may prolong the life of sinking groundline, particularly in deep-water trawls • a Crosley-style net-lifter should be tested by the offshore lobster industry
Sinking Groundline Information Exchange For Lobstermen and Rope Manufacturers	GOMLF with industry and manufacturers (2010)	• inexpensive sink rope may be desirable over high-priced rope which lasts less than a year • sink rope that is too strong to recover when hung down is a safety concern
GROUNDLINE TRACKING/GEAR LOSS		
Collaboration to Track Sinking Groundline Use	GOMLF with MLA and Downeast Lobstermen's Association (2009)	• participating lobstermen recorded challenges as a result of the switch to sinking groundline • 1/3 of participants lost

		traps during the first year of use
Trap Tag Replacement Affidavit Investigation	GOMLF with MLA (2011)	• tag replacement forms were parsed for trap loss ’09-‘11 • 38,000 traps (avg) were declared lost each year • boat traffic was reported as the #1 cause; whale rope was #2
BREAK STRENGTH TESTING		•
Break Strength Testing – A Preliminary Look at Retired Sinking Groundline	MLA (2011 Maine Fishermen’s Forum)	• preliminary break strength tests showed that used sinking groundline was 20-60% weaker than new rope • visual examination may not be enough to determine whether rope has weakened to the point of breaking
GEAR SURVEYS		
Lobster Pot Gear Configurations in the Gulf of Maine	MLA (2012)	• comprehensive depiction of the various gear configurations along the entire Maine coast and offshore
Final Report to National Marine Fisheries Service on the “Maine Fishing Gear Exchange and Research Program”	Maine DMR (unpublished)	• gear surveys conducted by Maine DMR in 2009-2010 • inventory of gear configuration by zone, season and distance from shore
GEAR MODIFICATIONS		
Sinking Groundline in the Maine Lobster Fishery, 2009-1010 – Documenting the Experience	MLA (2011 Maine Fishermen’s Forum)	• traps lost as a result of sinking groundline are second only to traps lost due to boat traffic • region-specific modifications may prolong the life of sinking groundline

Groundline Profiles

In the early years of the TRT, there was great interest on the part of the fishing industry to maintain the use of floating groundlines. The Maine Department of Marine Resources (DMR) and Massachusetts Division of Marine Fisheries (DMF) conducted baseline studies to document how floating groundlines appeared *in situ* and how certain modifications to floating groundline could lower their profile (McKiernan et al 2002; DMR 2004). At locations within both Maine and Massachusetts, underwater remotely operated vehicles (ROVs) or diver-held cameras were used to document the arc of floating and modified floating groundlines between traps. The height of the arc off the bottom of the ocean floor was measured, allowing researchers to correlate height with rope composition, length and deployment method. The footage in Maine also showed the extremely jagged and rocky bottom the rope was designed to avoid.

DMR and the Maine Lobstermen's Association (MLA) extensively tested modified groundlines and other experimental ropes as alternatives to the floating groundlines commonly used (Estrada 2006; Maine DMR 2004a, 2004b; MLA 2005, 2007, 2008). Previous investigations by DMR focused on neutrally buoyant ropes that would hover just above the ocean floor. This work led to the development of a "low profile" rope that might avoid contact with the seafloor yet not produce a high arc in the water column. Using pressure sensors, other experimental ropes were evaluated that would remain only slightly above the seafloor, including by splicing sections of sink line into the float line or adding lead weights to float line. This work did not proceed beyond the pilot stage, largely due to uncertainty about the entanglement risk posed by a low profile ropes. Many scientists hypothesized that a rope hovering at the height of the trap could pose more of a risk to whales feeding along the bottom than float rope. Producing a clear definition of low profile rope and establishing manufacturing standards proved challenging because the height of the rope in the water column will vary depending on oceanographic conditions, substrate, and how the gear is deployed. Feedback on other experimental sink ropes including barium sulfate rope and a Teflon coated braided rope conducted by the MLA with the Consortium for Wildlife Bycatch Reduction revealed functionality challenges with hauling and/or rigging the rope. Although durable and fishable by the lobstermen who tested it, the sample of braided polyester rope was expensive to produce at over $8/lb.

GOMLF conducted a pilot study looking at the effect of strong ocean currents and tides in Downeast Maine on floating groundline, using pressure sensors to measure the rope profile between traps in a 20-trap trawl (Ludwig 2010). It found that a trawl groundline rigged with the co-polymer float rope Polysteel© rarely arced more than two meters off the bottom, a relatively low profile compared to some gear configurations rigged with pure polypropylene sinking groundline.

Operational Life of Sinking Groundline

In addition to the Maine-based efforts mentioned above, in 2004 the Massachusetts DMF used scale models of fixed-fishing gear to compare, quantify and investigate buoyline and groundline profiles, and to address their relative entanglement risk (Lyman and McKiernan 2005). In ensuing years, Massachusetts DMF conducted extensive lab tests, simulating conditions found in the offshore lobster fishery (Lobster Management Area 3), aimed at reducing damage to sinking groundlines by adjusting lobster gear hauling equipment. Abrasion from sediment intrusion into the fibers of the sinking groundline was observed, but the primary cause of rope wear was caused by the vessel's hauling equipment. Many factors contributed to the level of wear from the haulers, including angles, material and smoothness of the sheaves, block and fair-lead, size of hauling drum, and spacing between the sheaves. Adjustments to one or more components of the hauling system were demonstrated to improve the life of sinking groundline. Though recommendations from this work were geared towards offshore lobster boats, many of the findings are also relevant to lobstermen fishing in inshore areas (Allen et al., 2008). A detailed summary of this work, *Extending the Life of Sinking Groundline: Observations and Experiments,* is presented in Appendix A.

2. Documenting Lobstermen's Experiences

Several efforts were undertaken to document the lobster industry's experiences with sinking groundline. These efforts do not represent scientific studies, but an industry-led effort to share experience on the operational, economic and safety challenges encountered when fishing sinking groundlines.

Groundline Surveys and Gear Loss

In 2009, GOMLF in collaboration with the MLA, documented some day-to-day experiences of lobstermen fishing with sinking groundlines. Fifty-five lobstermen completed a preliminary questionnaire, and 12 completed logsheets tracking their experience with 400 trap-hauls. A trap haul is defined as the haul of any trap attached to at least one other trap with sinking groundline. The responses indicated that gear was lost in 62% of trap hauls on hard, rocky, boulder bottom.

An individual Maine lobsterman is limited to fishing a maximum of 800 traps. Every Maine lobster trap fished must possess a unique tag, renewed annually. Until 2009, lobstermen had a 10% replacement tag allowance (80 trap tags) to replace tags if gear was lost. In 2009, Maine discontinued its replacement tag allowance and instead began requiring lobstermen to complete an affidavit to document the amount of gear lost and the circumstances of the loss in order to obtain replacement tags. This provided the first insight of actual trap loss for the industry.

GOMLF and MLA reviewed the affidavits completed by lobstermen over a three-year period, from 2009 to 2011, to investigate the number of traps reported as lost. More than 26,000 traps were reported lost due to sinking groundline, second only to boat traffic, which claimed more than 50,000 traps. With an average rigged trap costing $100, assuming that sinking groundline explained the 26,000 traps lost, Maine lobstermen had $2.6 million in trap replacement costs as a result of using sinking groundline over that three-year period. That does not include income lost while the trap is being replaced and not catching lobsters. The most significant sinking groundline losses were reported in Maine's eastern and mid-coast areas, in Zones A through D. Figures 2-4 provide a summary of the results.

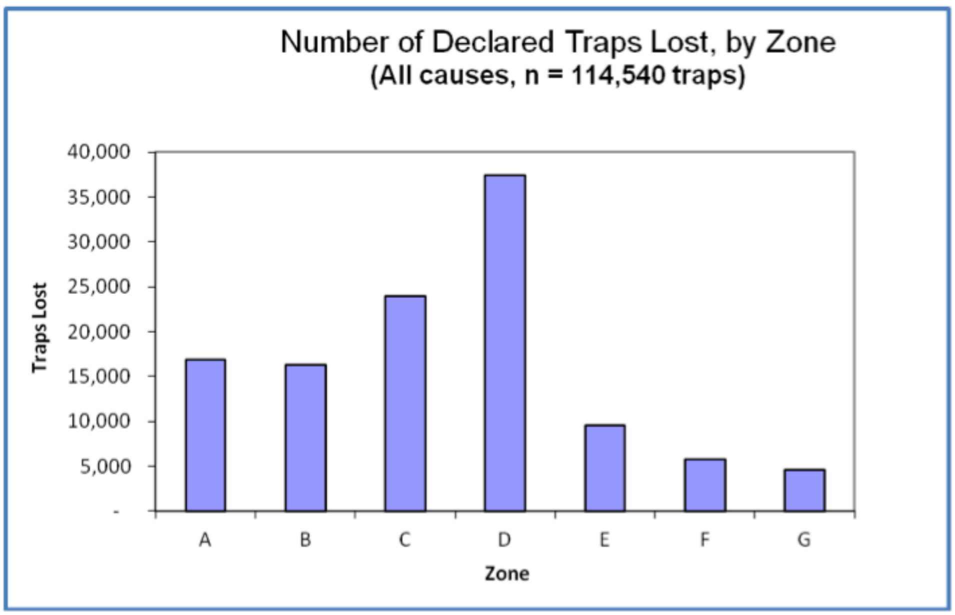

Figure 2. *Number of declared traps lost by zone (2009-2011).*

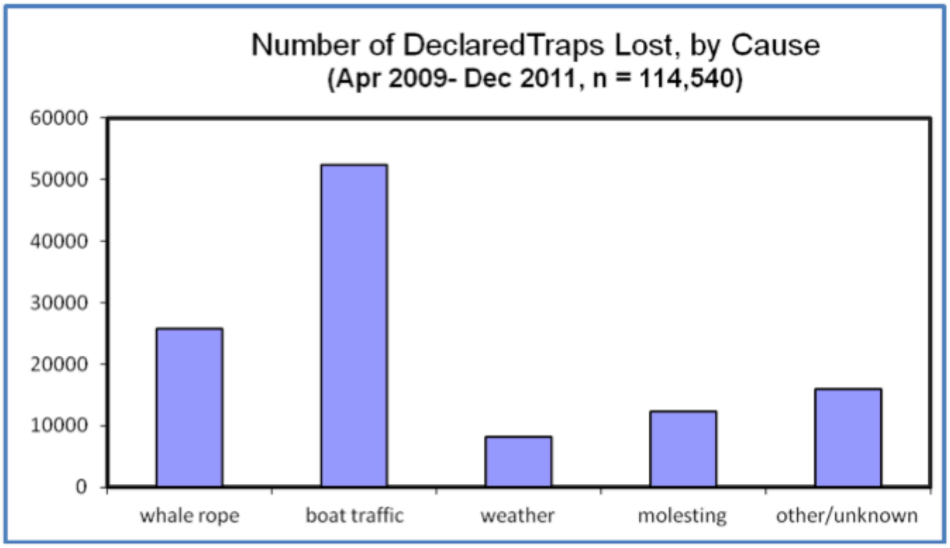

Figure 3. *Declared traps lost by cause. Trap loss was ascribed primarily to four main causes.*

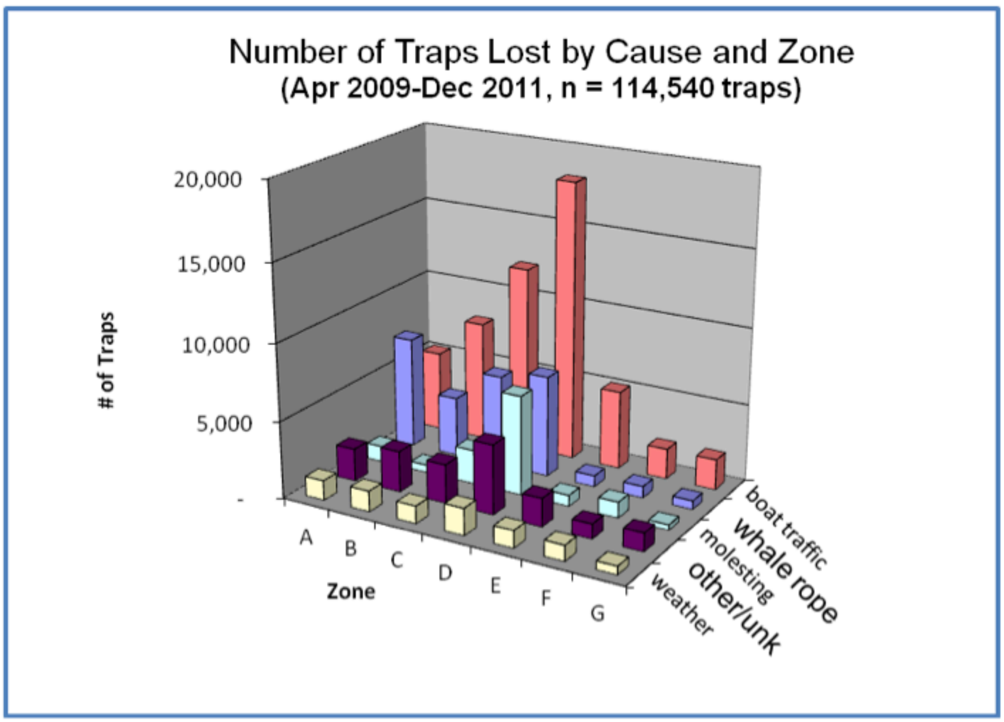

Figure 4. *Traps lost by cause and zone. Sinking groundline was reported as the leading cause of lost traps in Zone A, consistent with where lobstermen report the most challenging conditions of using sinking groundline.*

Operational Challenges of Sinking Groundline

As documented from industry feedback since the groundline rule went into effect in 2009, the challenges presented by sinking groundline pertain primarily to seafloor type. For fishermen setting gear in deep water on sand or mud, abrasion on and inside the rope is exacerbated by the duration and strain of hauling the line through the hauler (Mass DMF, 2009; Allen, 2012). For those working in waters with rocky sea floors, the sinking line can become lodged under ledges or boulders by the forces of currents or tides ("hung down"); or can chafe and weaken as it comes in contact with the substrate (Figure 5). Regional differences in bottom type probably therefore require different approaches to improve the performance of sinking groundline.

Figure 5. *A portion of sinking groundline that parted after only three hauls, compared to new rope behind it.* (*Photo L. Ludwig*)

Issues reported by lobstermen when using sinking groundline include poor handling on deck; tension during hauling due to hanging down; limited to no stretch or flexibility under tension leading to snapped lines and dangerous boat handling conditions; intense noise when run through the hauler; weakened sections of line due to chafing on bottom; and more difficulty in predicting when the rope is nearing the end of its operational life. Many lobstermen have documented their experiences by taking photos that show situations atypical when using floating groundline. One of the most unusual experiences occurred when a lobstermen from Little Cranberry Island entangled a 20-lb lobster between the 2nd and 3rd trap of a triple (Figure 6), remarking that sinking groundline "does everything you don't want it to do." Other examples include snared boulders, bent davit arms, and wrapped traps (Figures 7-9).

Figure 6. *Lobster caught in sinking groundline. (Photo B. Fernald)*

Figure 7. *Bent davit. (Photo C. Moore)*

Figure 8. *Lobster trap wrapped in sinking line. (Photo J. Alley)*

Figure 9. *Boulder wrapped in sinking line. (Photo J. Alley)*

There have been accounts from several lobstermen of sustaining injuries when hauling with sinking groundlines. As early as 2007, *Commercial Fisheries News* reported on a dangerous incident in Massachusetts where a lobsterman's gear hung down in rocks so firmly that it tore part of his wheelhouse away. In 2011, an experienced Maine lobsterman lost the thumb of his working hand as it was caught by the sink rope being hauled under tension (Richard Carver, *pers. comm.*). Others have reported losing a thumb or finger to sinking groundline, or nearly losing an eye or damaging exposed areas of the head and face due to trap runners exploding off the bottom of a trap as it reached the rail, because the sinking groundline wrapped around the trap and squeezed off the runner. Still others have reported incidents in which the block has given way under the strain of the sinking line, such that it swung freely in the direction of a lobsterman's head.

Lobstermen report that more traps are lost when using sinking groundline than floating rope, and to compound the problem, they are less likely to recover lost traps. While traps are nearly impossible to locate using their echo-sounders, lobstermen are often able to pinpoint the location of lost traps rigged with floating line because that line can be picked up by their electronics and the gear can then be recovered by dragging a grappling hook through it. In contrast, a trap rigged with sinking rope lost in a rocky area cannot be easily located using the vessel's electronics.

The experience of lobster fishermen in the Gulf of Maine is that sinking groundline has a negative impact on their bottom line, including lost income and increased operational costs. It is more expensive than floating groundline, and it needs to be replaced more often. Furthermore, there is increased time and labor required to remove weak areas of the line caused by chafing, and rigging of replacement traps. The groundline exchange programs fortunately defrayed the initial purchase price of sinking groundline for lobstermen by buying back floating line through vouchers which could be used towards the purchase of replacement sink rope.

Creating Dialogue

In June 2010, GOMLF hosted a one-day workshop for lobstermen and rope manufacturers to exchange information on the types of sinking groundline being fished in various areas of the coast, and to share information on successful techniques for fishing with it (Pelletier et al 2010). An additional goal was to facilitate a direct dialogue between lobstermen and rope manufacturers to improve understanding of how the rope is fabricated and used, as well as brainstorm possible manufacturing improvements. Samples of used, frayed groundline were brought in by the eight participating lobstermen to help inform discussions with manufacturers. The consensus of the group was to work towards creating a cost-effective sinking rope that would last at least three years.

The 2011 Maine Fishermen's Forum featured a special session that brought together lobstermen, scientists and rope manufacturers to discuss their collective experience with sinking groundline. Over 50 lobstermen from Maine, New Hampshire, Massachusetts and Canada attended, learned about the properties of sink rope from a cordage engineer, and contributed ideas and priorities for further research.

As part of the forum session, 39 lobstermen also completed a brief questionnaire to document their experience fishing sinking line (Appendix B). Fishermen provided feedback on their biggest challenges, changes to fishing practices, as well as successes and strategies that have worked. Nearly 70% reported that the least challenging conditions of using sinking rope occurred when it was fished on mud, gravel or soft bottom. One-third reported that they ended up shortening the length of groundline, and one-fourth reported relocating gear to areas with less rocky sea bottom. One lobsterman reported his biggest trap loss in a single month (60), which he attributed to the use of sinking rope. More than half of the respondents reported that their biggest challenge in fishing sink rope was hang-downs on long sets, and one-third reported excessive wear of the rope.

As part of the three-hour session, the MLA hosted lobstermen from three discrete regions of the Maine coast and the offshore Area 3 fishery to present synopses of fishing practices they have adopted to increase the lifespan of their sinking groundline. Participants shared rigging and deployment issues, and offered individual solutions in managing the challenges encountered when fishing with sinking groundlines. Lobstermen discussed unique approaches to prolong the life of sinking groundline, and issues common to many of them that included wear or chafe problems near to the lead trap. A full summary is included as Appendix C, *Maine Fishermen's Forum Sinking Rope Meeting Summary*, and Appendix D, *Examples of Rigging Modifications for Sinking Groundline*.

<u>3. Conducting research on sinking groundline chafing</u>

Since the sinking groundline rule took effect in the Gulf of Maine, the Maine Lobstermen's Association (MLA) has regularly heard from lobstermen about frequent chafing observed between the first and second traps in a trawl. This chafing has been reported to occur at a greater rate than on other sections of the same groundline. The Consortium for Wildlife Bycatch Reduction (Bycatch Consortium) and the MLA decided to investigate the problem by recording viideo of the interactions between the groundline, trap, and substrate.

Methodology

Ken Baldwin, Director of the University of New Hampshire Center for Ocean Engineering, was contracted to design and build a lobster trap for housing video cameras. He conducted a review of potential materials to determine the best video camera, lighting, housing, battery life, and placement of the gear in a typical lobster trap.

An in-house test at the UNH Ocean Engineering Lab pool, using their video equipment was conducted. To determine the best placement of cameras for recording groundline activity from the experimental trap, Baldwin and UNH graduate students outfitted a lobster trap with four cameras tethered to a live feed monitor. Representatives from MLA, the Bycatch Consortium, and Bluewater Concepts (BWC), a research and development firm based in southern Maine, observed the test and provided feedback to the UNH engineers. The tethered video equipment was then deployed for testing by Blue Water Concepts (BWC) on the Piscataqua River. The field trial was conducted to adjust camera placement so as to maximize the likelihood of capturing groundline movement throughout a tidal cycle.

The tethered trap was dropped directly from the dock in the Piscataqua River and then recovered. The cameras were adjusted for optimal target area focus, and then deployed from a lobster boat in the river but farther from the shore. Based on these trials, it was determined that three GoPro cameras with a supplemental Rescue 2200 battery inside an Ikelite underwater camera housing with Aqualite external lighting camera units should be deployed inside the trap. Cameras were positioned to record frames out the front (bridle-side), top and one side of the trap.

The configuration of the cameras inside the trap is shown in Figures 12 and 13. The front camera was positioned to observe the groundline, the side camera was placed to capture any potential movement of the groundline back towards the trap based on lobstermen's accounts of lobster traps being hauled up wrapped in sinking rope, and the top camera oriented to observe any potential interaction between the vertical line and the groundline since the two ropes connect together at the gangion. The trap entries for lobster were covered so that the trap was not fishable. Additional bricks were added to the trap to counteract the buoyancy of the underwater housing cases.

The groundline between the first and second trap was marked with different colors of duct tape every foot, in varying color patterns. This was intended to identify the section of line being observed in the video. Different combinations and types of paint and tape were tested and it was determined that duct tape was the most likely to adhere to wet rope, remain on the rope for at least four hours, and provide adequate contrast for observation in the videos.

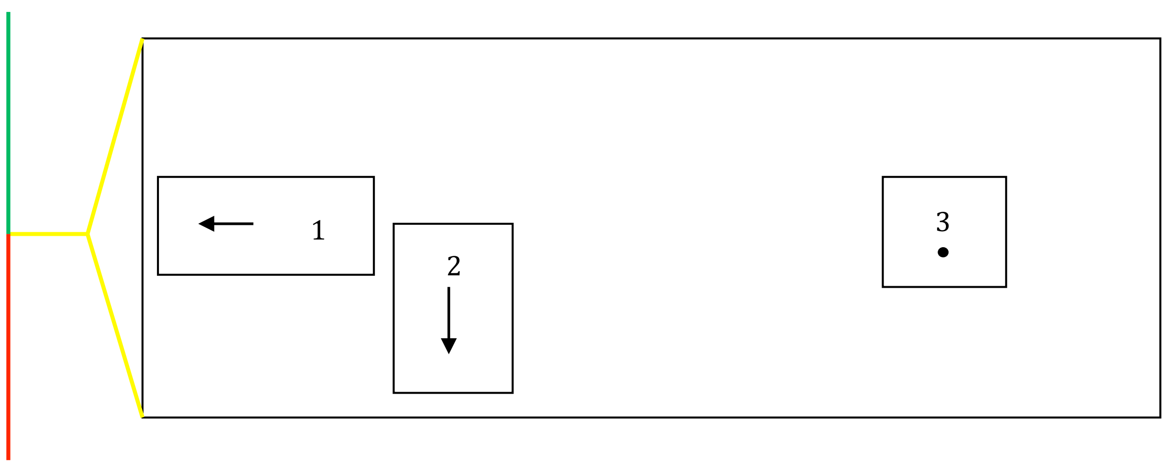

Figure 12. *Experimental trap, as seen from above. Arrows indicate direction of camera lens. Camera 1 was positioned to look out at the groundline, Camera 2 looked out the side of the trap, and Camera 3 was positioned to shoot upwards for capturing vertical line movement. The bridle and gangion are shown in yellow and the groundline is in red. The vertical line is in green. In areas of Downeast Maine where anchors are fished, the anchor is tied in at the end of the vertical line, just before the gangion.*

Figure 13. *The experimental trap with three cameras mounted inside and additional lighting.*

The experimental trap was field tested for a day by BWC in the Piscataqua River, with assistance from the MLA. The lobster gear was configured as a pair, with the experimental trap as the lead trap, which is the first trap after the buoy line and the first to be hauled. During the field trial, the experimental trap was spray-painted orange on the top edge of the front of the trap to see if, and where, the rope may be chafing against the trap. However, no transfer of the paint from the edge of the trap to the buoy line was observed.

As part of the trial, a self-recording load cell was attached to the vertical line just below the buoy, and a RiverRay Acoustic Doppler Current Profiler (ADCP) was deployed off the side of the lobster boat on a catamaran to record ocean currents. Deployment of these instruments was made to acquire data under Project 1, *Evaluation of Western Australian Stiff Rope Fishing.* The original testing-day plan involved multiple drops of the gear to provide sufficient experience installing, deploying and operating all of the electronic equipment. However, due to very strong current and wind, both the trap and buoy submerged completely and could not be recovered until a few hours later when the tide shifted. In the end, the team had a total of two practice deployments.

Three lobstermen were contracted to deploy the gear under actual fishing conditions; one each from Biddeford Pool (southern), Cushing (mid-coast), and Beals Island (Downeast), Maine. These locations were selected to sample a range of substrates and tidal/current conditions. To mimimize travel time and expenses, testing was carried out for three consecutive days at each site, even with inclement weather. Deployments were made two hours prior to a tide change and removed two hours after the tide change. Table 3 lists the information recorded at each location and on each day. Wind and sea conditions were observed and recorded and sea floor type obtained from vessel captains.

The experimental trap was deployed on September 27, 28, and 29 and October 16 out of Biddeford Pools in Zone G; on October 3, 4, and 5 out of Cushing in Zone D; and on October 10, 11, and 12 out of Beals Island in Zone A. The fourth day was added to the southern Maine trials due to equipment failure on a previous day.

The experimental protocol each day included replacing the lobsterman's first trap with the experimental camera-equipped trap, splicing or knotting in the load cell directly below the buoy, and marking the groundline with duct tape. Three *GoPro* cameras were placed in the front, side, and top positions throughout the field trials, and there was no conscious effort to use the same camera in the same position throughout the trials. The boat was anchored for two hours before the tide change until two hours after the tide change.

The New England Aquarium analyzed the video data from the three cameras. Following a preliminary analysis of the footage, MLA staff and two lobstermen were asked to add their reviews and interpretations of the images recorded.

Table 3. Information recorded during deployments of trap equipped with video cameras.

Location	Southern				Mid-coast			Downeast		
Date	9/27	9/28	9/29	10/16	10/3	10/4	10/5	10/10	10/11	10/12
Weather	Sun, light wind	Rain, fog, light wind	Rain, 20 knot wind from the N	Sun/overcast, 20 knot wind from the NW	Rain, fog, 5-10 knot wind	Heavy rain after 2, 5-10 knot wind from NE	Fog	Rain, fog, 5-10 knot wind	Sun, 26 mph wind	Rain, fog, 25 knot wind from NW
Seas	2-3ft	3 ft	4-6 ft, large swells	[not recorded]	2-3 ft	2 ft	[not recorded]	small	Sheltered area, small	[not recorded]
Bottom type (per vessel captain)	Rocky	Rocky	Sand, Mud	Rocky, Boulder	Hard mix (gravel, rock, cobble)	Rocky	Mud	Gravel, Sand, Mud	Sand	Gravel, Sand
Traps/trawl	3	3	3	3	2	3	5	3	5	10
Weights	3 bricks	3 bricks	3 bricks	3 bricks	3 bricks	3 bricks	3 bricks	12 cement wedge, 4 lb ergo/steel	12 cement wedge, 4 lb ergo/steel	12 cement wedge, 4 lb ergo/steel
Buoys	1 5x11	1 5x11	1 5x11	1 5x11	1 6x14	2 6x14	2 6x14	1 9x12	1 9x12	1 9x12 and polyball
Depth (ft)	102	94	55	103	108	66	54-60	100-106	20	18
Vertical line length (ft)	200	200	100	200	132	132	132	180	180	180
Ground line length between first and second traps (ft)	60	60	60	60	72	72	72	66	66	66

Results: Description of site deployments

Biddeford Pool: Southern Maine

September 27

The first day of testing took place out of Biddeford Pool in Southern Maine in water that was 102 feet deep with a rocky bottom. A three-trap trawl, with the experimental trap as the lead trap, was deployed two hours prior to the tide change with a 200-foot vertical line. Due to an inadequate fastening system, the front camera landed facedown and immediately shut off, producing no usable video. The side camera took two still images and then stopped recording. The top camera video was of poor quality and did not capture any rope. Due to the poor results achieved on of this day, a fourth field day at this site was added to the trials to be conducted after all the others were complete.

September 28

Testing was again carried out near Biddeford Pool in water 94 feet deep with a rocky bottom. The gear configuration remained the same as on the previous day. The quality of the video shot by the front camera was fair to excellent, and the groundline was visible throughout the 4 hr and 53 min duration of video recorded. The camera recorded video showing the intersection where the gangion, groundline and vertical line are tied together (Figure 14).

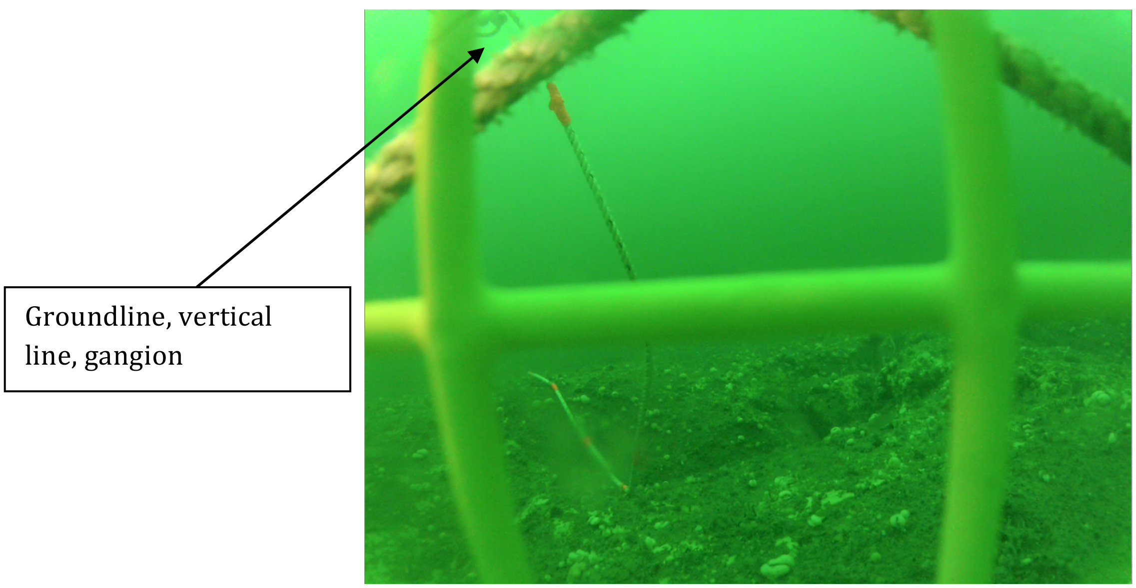

Figure 14. *Still image from the front-facing camera (at 63 min) showing the groundline with orange markings and the groundline, vertical line, and gangion tie-in in the upper left.*

From the tie-in, at least six markers can be seen on the groundline during the video. The groundline can be seen laying on the substrate between markers five and six (or six feet from the gangion and vertical line). The bottom section of the vertical line was *Manline* floating rope, which appears to be elevating part of the groundline. Throughout the video, the groundline moves back and forth in front of the camera and is pulled up and down by the vertical line. That movement causes the groundline to rub against the substrate at the point where it first encounters the bottom. The remainder of the groundline is slack, but remains primarily stationary, with some slight movement towards the trap. The side and top cameras did not provide any additional information.

September 30
The experimental trap was deployed out of Biddeford Pool furing rain, 20-knot winds, and seas up to 6 feet. The gear was deployed onto a mud/sand bottom in 55 feet of water. The experimental trap was the lead trap in a three-trap trawl with 100 feet of vertical line. The quality of the video from the front and side was very poor, possibly due to the weather and loose sediment on the bottom, and for an undetermined reason the top camera did not record any feed that day. The groundline was visible in the right side of the video recorded by the front-facing camera, and up to four markers were visible on the line. The groundline makes contact with the bottom between the fourth and fifth markers, and is shown being pulled up and down by the vertical line and side-to-side, most likely due to the movement of bottom currents or tide. The extent of line movement is pictured in Figure 15.

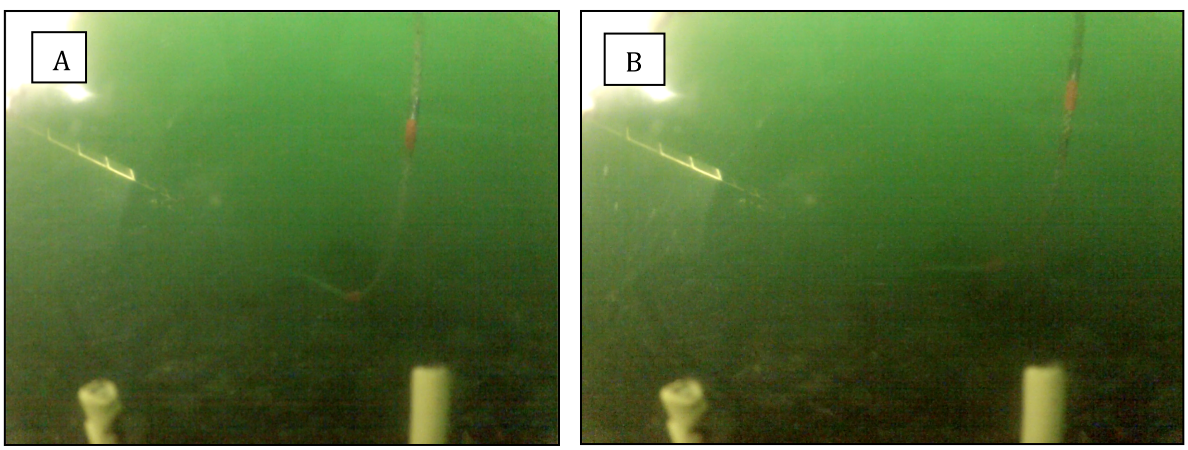

Figure 15. *Two screen captures of groundline movement. The line moves from the ground in A to the right and up in B.*

October 16
A three-trap trawl was deployed on a sunny day in 13 feet of water on rocky bottom. Two hundred feet of vertical line was used and 60 feet of groundline separated the traps. All of the video on this day was excellent. The front video shows the groundline laying over a large boulder and moving back and forth. There is significant movement of the groundline over the boulder (Figure 16). The vertical

line can also be seen in the Top camera video. It frequently moved in and out of the video frame (Figure 17).

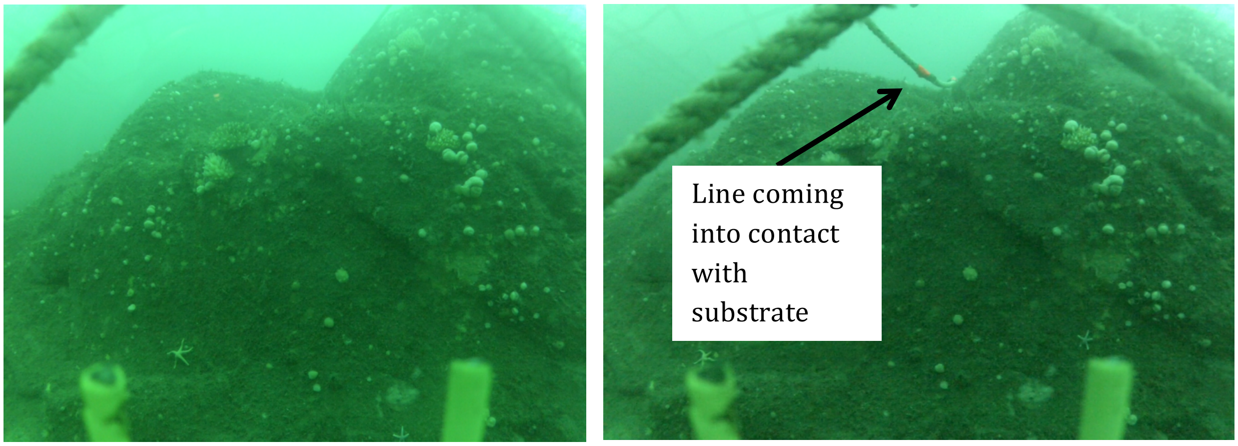

Figure 16. *A) The groundline rubbing against the boulder on the right side of the image. B) Groundline moved significantly toward the middle and the line slack has increased.*

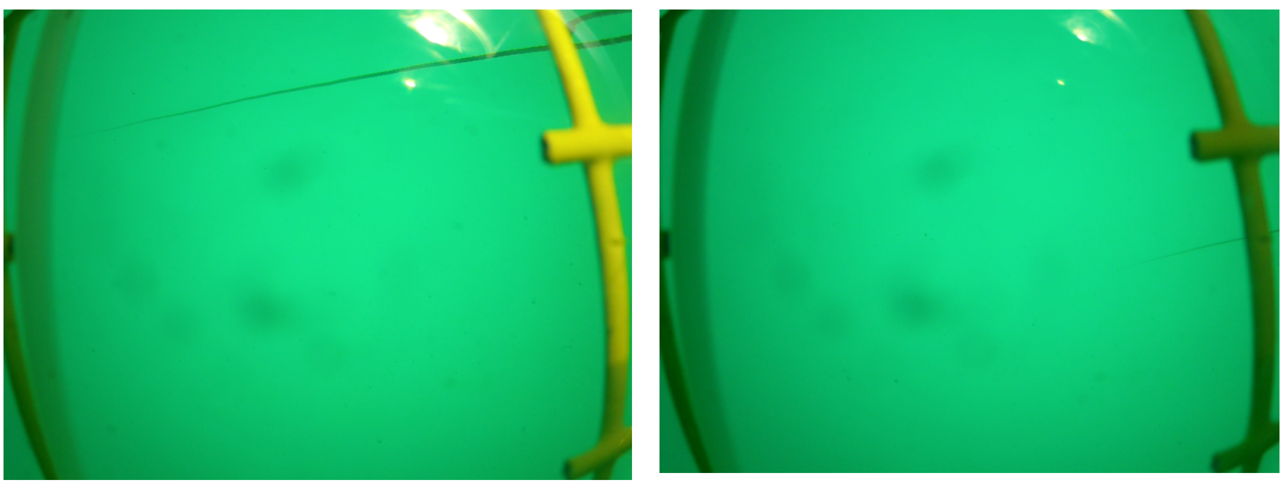

Figure 17. *The vertical line as recorded by the top camera.*

Cushing: Mid-Coast Maine

October 3

The experimental trap was deployed out of Cushing, mid-coast of Maine at a depth of 108 feet, and on a bottom consisting of gravel, rock, and cobble (as reported by the captain, although the video shows a lot of sand and mud). The experimental trap was the lead trap in a double, attached to a 132ft vertical line. The weather was a mixture of fog, rain, with 5- to 10-knot winds. The seas were reported to be two to three feet. All of the video from this day was of poor quality. The groundline was visible in the video shot with the front-facing camera, but the interaction between the line and the ground cannot be seen (Figure 18). Nevertheless, it was possible to observe a lot of movement of the portion of the groundline nearest to the trap in multiple directions (vertically in the water column, as well as side to side). This high degree of movement and contact with the substrate would cause chafing.

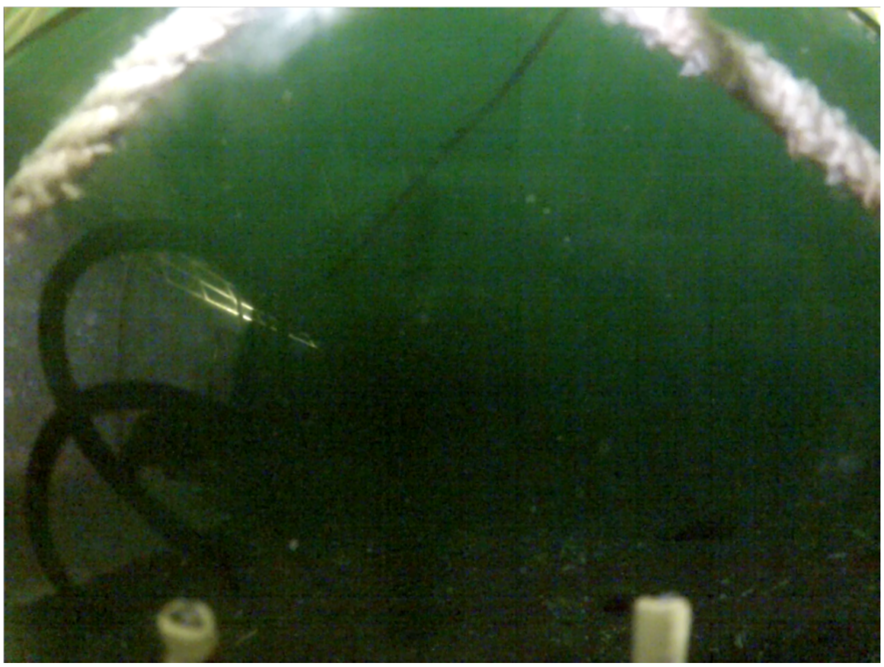

Figure 18. *Best image obtained of the groundline from the front-facing video camera. No contact with the ground can be seen due to the image quality. The dark lines are shadows from the battery extension cords connected to the camera.*

October 4

The second day of testing off Cushing was carried out in heavy rain and 2-foot seas with 5- to 10-knot winds. The experimental trap was deployed in 66 feet of water on rocky bottom with a 132ft vertical line. The videos shot from the front and side cameras were of poor quality, while the top video was fair (Figure 19). The third marker on the groundline, which was seen moving back and forth vertically in the water column, was captured by the front camera, but only for a few minutes. The