Appendix V: ME DMR Vertical Line Research Initiative

Beginning in the summer of 2018, ME DMR received a grant from the Section 6 Species Recovery Grants to States program to assess the use of vertical lines throughout the Gulf of Maine region. Portions of the resulting data have been instrumental in the development of the ME DMR Plan to reduce the risk of entanglement for right whales in Maine fixed gear. Over the next year, as new draft and final rules for the Atlantic Large Whale Take Reduction Plan are proposed and finalized, ME DMR will use the following data as a basis for the development of weak point options in the fishery. This work will be done in collaboration with the fishermen and other relevant industry stakeholders. The primary objectives of this work will be to:

1) Collaboratively develop and test gear modifications that break at or below 1700lbs and can be integrated into existing gear to minimize the impact on the fishery
2) Work with NMFS to include these options on a list of approved modifications that will meet a weak point regulation
3) Field test a variety of modifications with the fishing industry, including manufactured weak points that could go through the hauler

<u>Volunteer Gear Survey</u>

In the summer of 2018, ME DMR sent out a gear survey to fishermen throughout the Northeast region to assess their use of vertical lines and received over 800 responses through online, paper, and phone-based options. One of the pieces of information from that survey that has been used in the development of this proposal is the variety of rope diameters used in different segments of the fishery, including by distance from shore. While there is a spread of diameters used in Maine, survey responses show the most prevalent diameter of rope used in the lobster fishery is 3/8”, followed by 7/16” (Figure 1). The data also show the relative use of diameters of line greater than 3/8” increase with distance from shore (Figure 2).

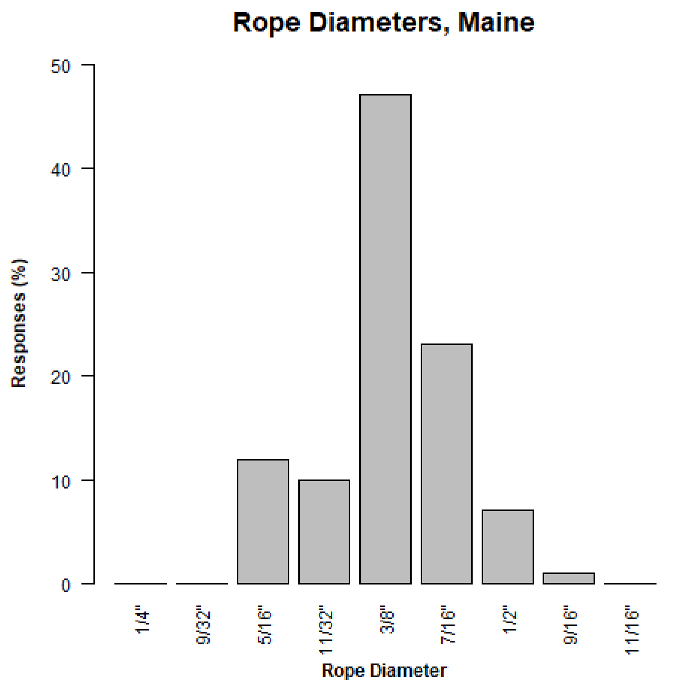

Figure 1. *Percentages of Maine based responses from the volunteer gear survey that use different diameters of line. Respondents could choose more than one diameter if their line contains multiple diameters or if their rope use differed by area. The most prevalent gear in the Maine lobster fishery is 3/8" rope being reported by 47% of respondents.*

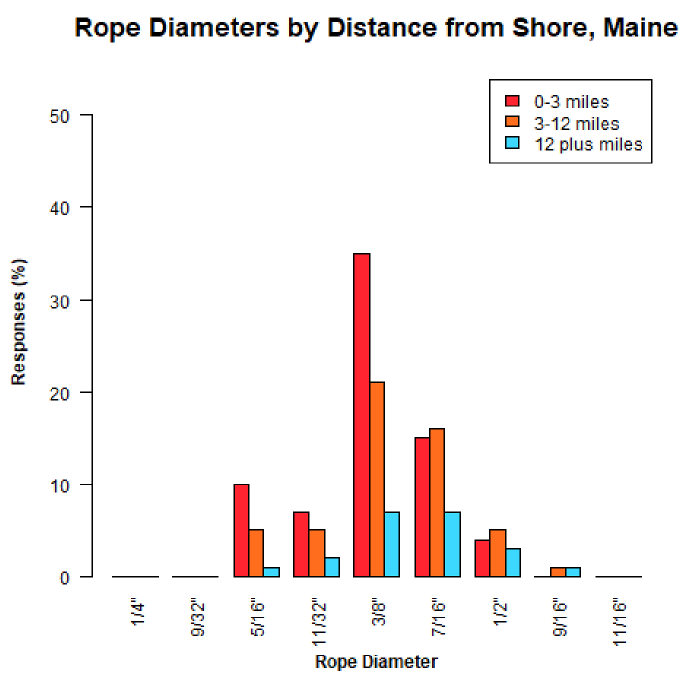

Figure 2. *Rope diameter use by distance from shore from the Maine responses to the volunteer gear survey. The proportion of ropes greater than 3/8" increases as gear moves offshore.*

Functional Breaking Strength

The second effort of this project included collecting donated vertical lines from fishermen throughout the region. The goal was to break a variety of ropes and capture the spectrum of functional breaking strengths for vertical line configurations used in the fishery. These data could be used to determine what configurations of vertical lines in the fishery are already weak, or break at or below 1700lbs, as well as provide a way to determine the benefit gained by requiring weak points in the vertical lines.

Whole vertical lines were collected from fishermen in addition to information about where the line was fished, rope types, rope diameters, age of rope, gear configuration, etc. A total of 215 samples were broken on the Tinius Olsen tensile testing machine housed at the DMR lab in Boothbay Harbor. These samples included the knots and splices that were used to tie ropes together to make up the vertical lines, as well as clear or unmodified pieces of rope. The ages of the rope generally ranged from two to six seasons fished, but went up to as many as twelve seasons (Figure 3). Figure 4 shows the results of the breaking strength tests. The sample sizes generally represent the relative occurrence of a certain diameter in the fishery. Knots and splices reduce the breaking strength of rope, which is of importance since less than 5% of lines fished in the fishery are used without a modifying link of some kind (Figure 5). When a line of two different diameters knotted or spliced together was tested, the smaller diameter broke 100% of the time and the knot or splice always stayed with the larger end if it did not unravel. These results show that, of all of the diameters tested, 5/16” can be considered to meet the threshold of breaking at 1700lbs, especially with the addition of a knot. While many of the larger diameter ropes did break below 1700lbs with some regularity, the type of knot or splice used would have to be identified to be able to add these diameters to a list of weak points which break at or below 1700lbs. Results of a two-way ANOVA suggest that rope diameter, modifications to the rope (splices and knots), and age or seasons fished all have a significant effect on the breaking strength of the vertical line (Table 1). It should be noted that the relationship between the diameter of rope and the breaking strength is regardless of material used since all types of ropes that are used in the lobster fishery are represented in the dataset (Figure 6).

Table 1. *Results of two-way ANOVA showing the significant relationship between breaking strength of line and rope diameter, modifications, and age.*

Rope Breaking Strength ~ Rope Diameter + Rope Modifications + Seasons Fished

	f–value	p–value
Rope Diameter	13.8	< 0.0001
Rope Modifications	29.3	< 0.0001
Seasons Fished	11.9	< 0.0001

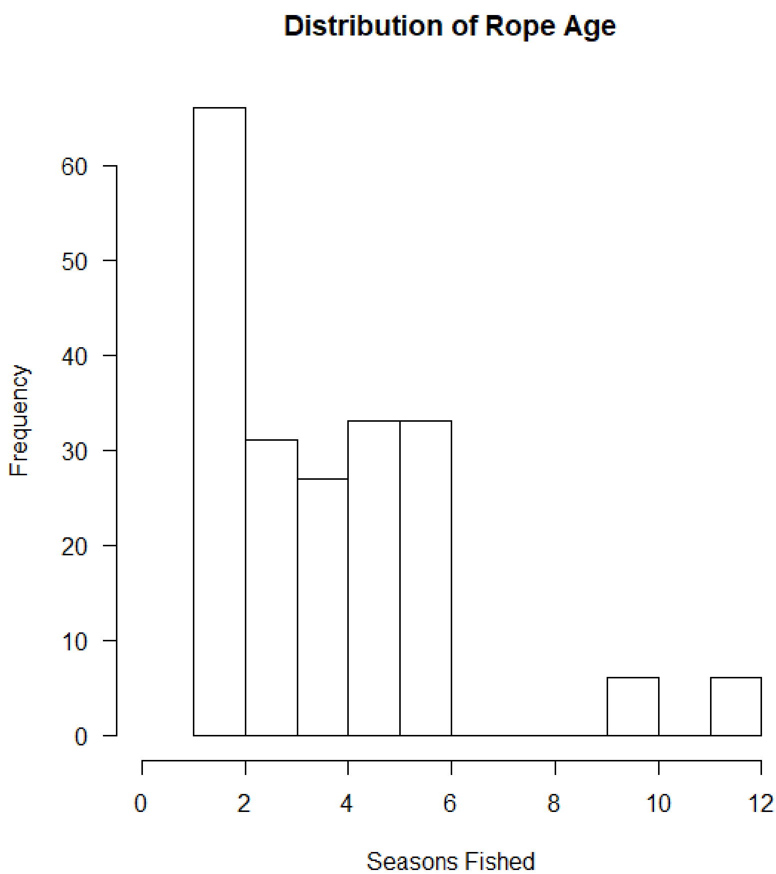

Figure 3. *The distribution of the ages of vertical lines that were donated for breaking strength testing. While some went up to as many as 12 seasons fished, the majority of donated lines had been fished between two and six seasons.*

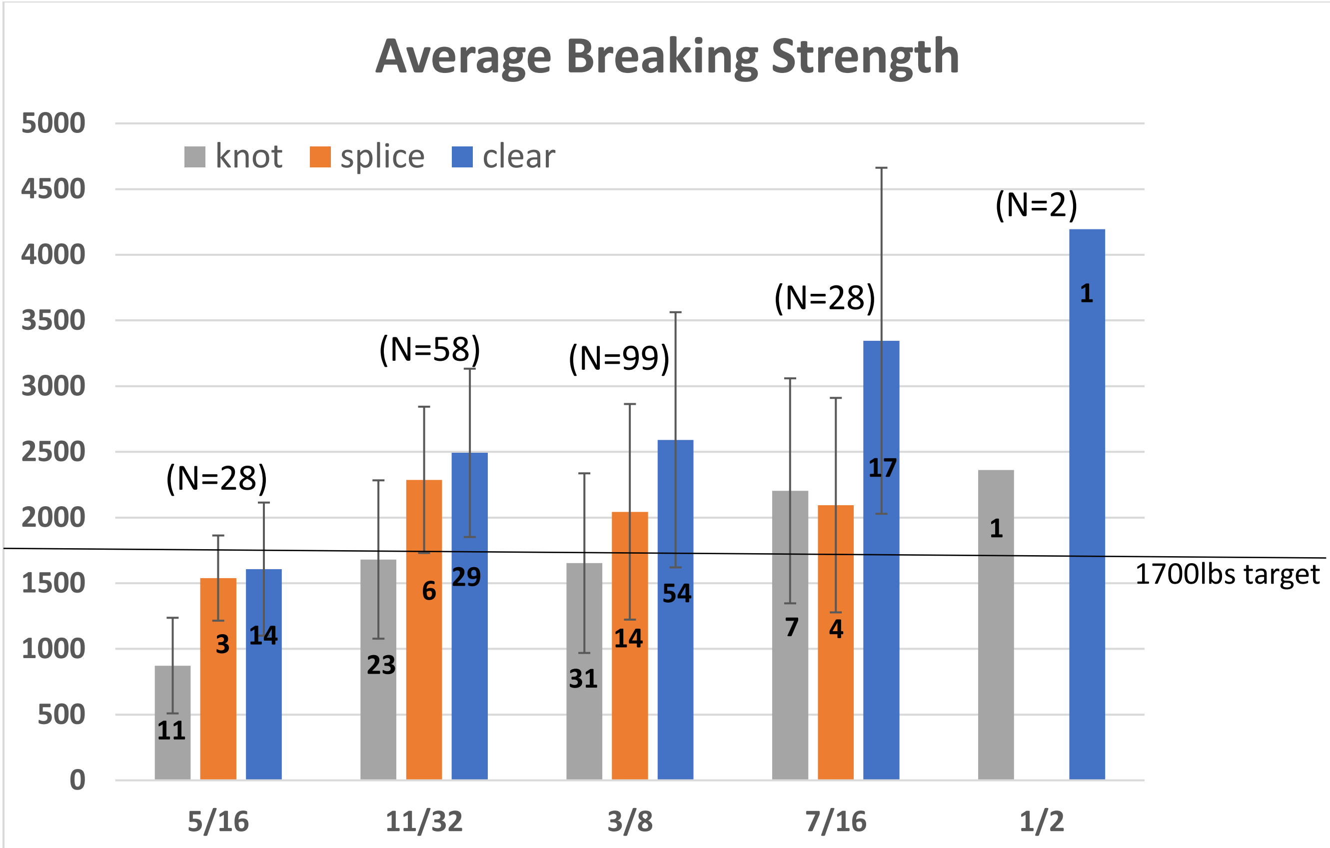

Figure 4. *The breaking strength in pounds for over 200 samples of vertical lines donated by lobstermen in the Northeast region for ropes 5/16" to ½". The varying sample sizes for each diameter and sample type are denoted in the figure. Sample breaks included the knots (grey) or splices (orange). Unaltered (no knots or splices) lengths of lines were also broken to show how much a knot or splice reduces the breaking strength. Those breaks are labeled as "clear" in blue.*

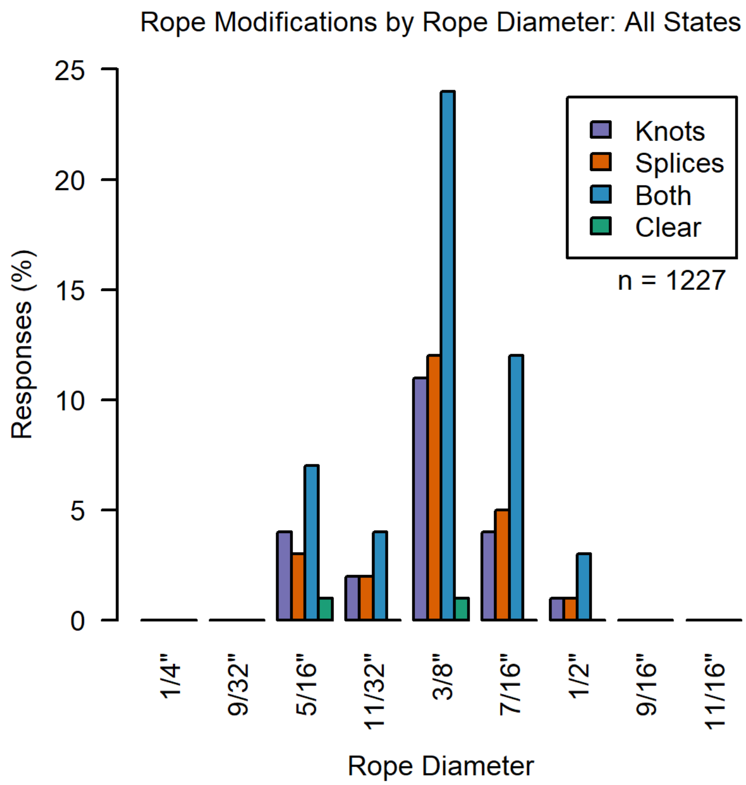

Figure 5. *The percentage of respondents to the gear survey that utilize knots, splices, or both knots and splices by rope diameters. Less than 5% of respondents do not modify vertical lines ("clear").*

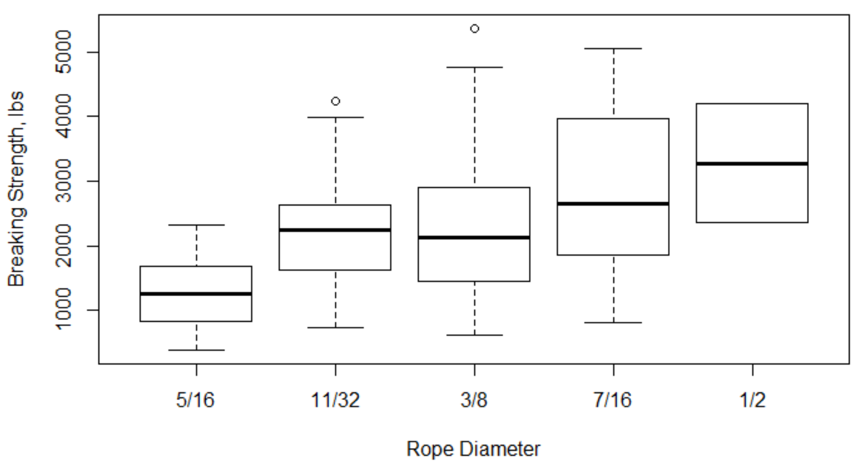

Figure 6. One-way ANOVA suggests a significant linear relationship between the rope diameter and the breaking strength of the line (F=11.512; Pr(>F) = 1.811e-08 ***)

Initial Weak Point Workshop

ME DMR held an initial industry workshop to test various configurations of vertical line attachment points that might meet the requirements of an approved weak point. Several fishermen were in attendance and came with ideas they wanted to test for weak points. Table 2 summarizes the more than twenty options that were initially tested. Of those options, a subset that showed promise of breaking below 1700lbs were chosen for further testing. Ten samples of each of those options were rigged up by fishermen and sent back to ME DMR for breaking strength testing. The results of those samples are summarized in Table 3 and are the basis for what has been discussed with the industry to-date. Potential options that will move on to the field-testing phase include lengths of 5/16" line knotted or spliced into the vertical line, 3/8" rope connected with a loop and double tuck ("lazy splice"), and manufactured products like dog bones (Figure 7).

Some of the options tested during the workshop included a couple of different brands of dog bones, as well as some modified dog bones (Figure 7). Dog bones were included because some fishermen in attendance were interested in investigating a manufactured weak point option that integrated easily into the line and was already being used in the fishery. The benefit of a manufactured point, as opposed to utilizing certain knots or splices in the line, is that the point will not degrade in strength over time. A rope made to break 1700lbs over its entire length or of a small diameter, like 5/16", will decrease in strength with the use of knots or splices and will lose strength over time. While strength over the age of the rope varies based on diameter, rope material, storage, and UV exposure, there is a significant decline in strength versus the number of seasons fished for a vertical line (Figure 8).

Table 2. *Ideas brought forward by fishermen and initially tested for breaking strength. Highlighted ideas were carried through to have additional samples tested or will be field tested with fishermen in the future. This list is not meant to be exhaustive but it what has been tested so far.*

Break	Diameter	Rope Modification	Breaking Strength (lbs)
1	3/8 danline	lazy man splice one pleat	no break, stretched until 1950
2	3/8 manline	sqaure "splice"	2435
3	3/8 manline	sqaure "splice"	2300
4	**3/8 manline**	**lazy man splice two tuck**	**1650**
5	**11/32 sink to 3/8 float**	**lazy man splice two tuck**	**1396**
6	3/8 float 11/32 sink	short splice	2326
7	11/32 sink 7/16 float	lazy man splice two tuck	2050 slipped off wheel
8	**5/16 sink 3/8 float**	**lazy man splice two tuck**	**1257**
9	11/32 sink 7/16 float	lazy man splice one tuck each side taped	slide out of tape at 700
10	5/16 sink 3/8 float	white dog bone and knot	2300
11	5/16 sink 7/16 float	lazy man splice 2 tuck	1378 no break pulled through
12	**3/8 loat 7/16 float**	**black dog bone**	**1550**
13	**5/16 sink 3/8 float**	**short splice**	**1800**
14	5/16 sink	clear	
15	**3/8**	**notched dog bone**	**1468**
16	11/32 sink 3/8 float	short splice	2454

17	**3/8**	**modified white dog bone, drilled on the top**	**1656**
18	11/32 sink 7/16 float	short splice	2202
19	**3/8**	**lazy man splice two tucks**	**1209**
20		steel swivel	2500+

Table 3. *Trials of options from the initial weak point workshop. *denotes trials where the tuck slipped out instead of breaking the line. Some dog bones were testing higher than 1700lbs and, therefore, were modified with drilled holes to reduce the strength prior to completion of the tests.*

Description	trial 1	trial 2	trial 3	trial 4	trial 5	trial 6	trial 7	trial 8	trial 9	trial 10	average
7/16 white dog bone to 3/8	1470	1748	1892	1674	1835	1722	1870	1854			1758.13
3/8 white dof bone to 3/8	1121	1922	1442	1415	1742	1776	2016	1869	1798	1826	1692.70
7/16 lazy splice to 3/8	2123	2215	2101	2199	2204	2119	1715	2168	2103	2067	2101.40
3/8 lazy splice to 3/8	483*	1845	728*	1301	1365	1761	1159	1246	1654		1475.86
3/8 blackdog bone to 3/8 no hole	2423	2313	2476								2404.00
3/8 black dog bone to 3/8 3.5mm hole	1866	1876	2328								2023.33
7/16 black dog bone to 3/8 3.5mm hole	2153	1814	2105	2312	2414	1919	2497	2023	1938	2014	2118.90

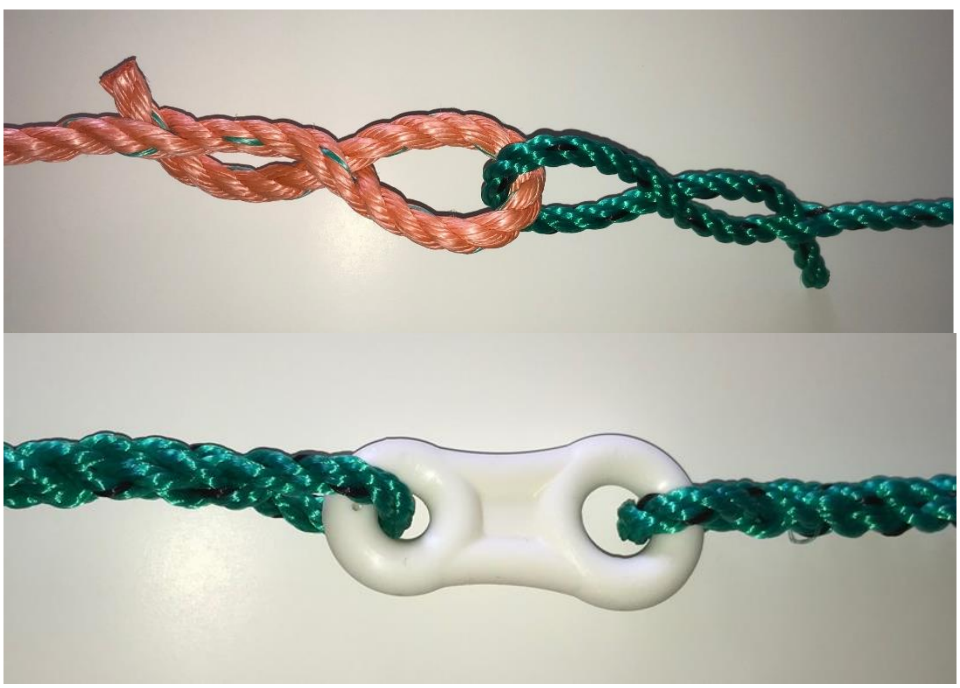

Figure 7. *Examples of options testing for weak points. The top option is a photo of the loop and double tuck (7/16" into 3/8") or "lazy splice". The bottom is an example of a dog bone. Several different types of dog bones were broken and/or modified and broken during the tests.*

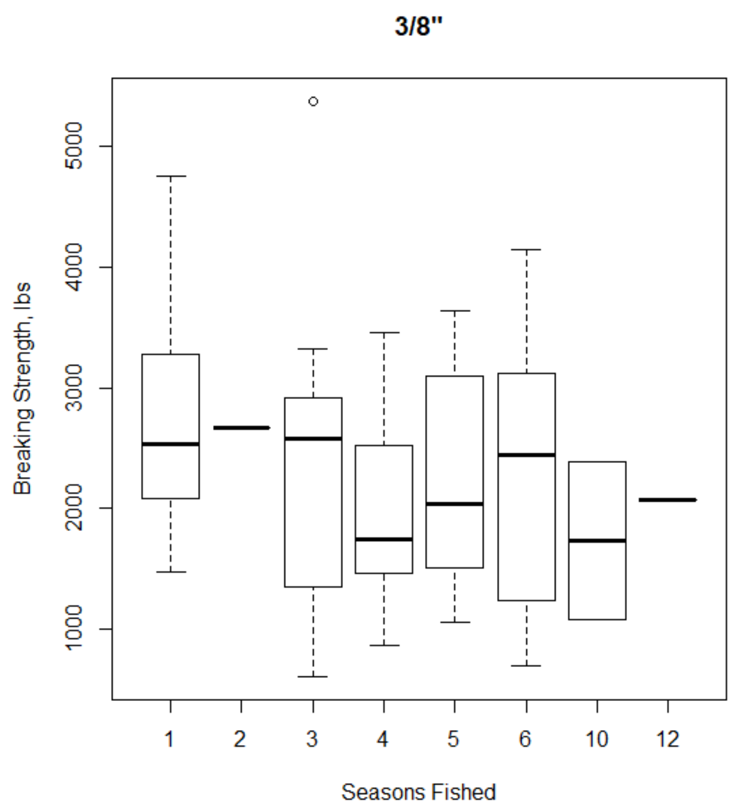

Figure 8. *Using 3/8" rope only (the most common rope diameter), this plot shows the relationship between rope breaking strength and seasons fished or age. All different types of rope and manufacturers are included in this analysis and accounts for some of the variability in the results.*

Future Work

ME DMR is continuing to work with the fishing industry and other stakeholders in the ALWTRT process to find options for weak points in vertical lines. The next steps in this work will include field testing some of these ideas with fishermen and conducting load cell testing integrated into their vertical lines. ME DMR has already begun soliciting ideas from fishermen for ways to rig weak points into their existing gear and will work with them to test those ideas on the Tinius Olsen Tensil testing machine in Boothbay Harbor. ME DMR is also pursuing funding to work with the manufacturers of products liked dog bones and engineers to create new manufactured weak points (similar to existing weak links) that will run through the hauler when integrated into the vertical line. ME DMR is committed to working with NMFS throughout this process to develop options that will work for all stakeholders.