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Weak modifications testing

Report Identifier: 13780-RP-001-REV01

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Revision	Date	Author	Review	Approved
REV01	16JUL2022	SAW	RHA	RHA

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1 Background

The Canadian Department of Fisheries and Oceans (DFO) is implementing a whale safe gear initiative to mitigate the impact on local whale populations. Part of this whale safe gear initiative is introducing a 1700lb weak section into the buoy line of stationary traps (DFO, 2022). To verify available weak modifications, Fundy North Fishermen's Association conducted third party tensile test. This report summaries the conducted tensile tests. The report is broken into two testing sections; testing will be conducted on pre-season and post-season weak links. The tensile test values will then be compared between the as-new pre-season weak links and the as-used post-season weak links. The 1700lb break strength is the value recommended by NOAA (NOAA, 2022) and verified by the New England Aquarium (DeCew, 2017) as the maximum a whale would be able to release if entrapped.

From a fisherman's perspective, an ideal weak modification would break at exactly 1700lb in order to comply with the DFO requirement, but also to minimize lost gear due to unnecessarily weak sections in a haul. Also, the variance between each modification that they've purchased should be very small. Understanding the limits of the gear is critical to safe fishing. These tensile tests aim to determine those features. It is additionally critical that no single sample should break above 1700lb as that would indicate a product that does not comply with the maximum break strength as defined by DFO.

2 Materials

Tensile testing was conducted using the ADMET model: 1220FHH-10K-B, the GR-50T bollard grips were used to mount the test samples into the machine.

A total of 6 rope modifications were evaluated during this tensile test. These samples are listed below. All samples have a reported break strength at or below 1700 lb.

- 5/16" Creeline rope spliced with regular 3/8" rope
- 5/16" Polyethylene rope spliced with regular 3/8" rope
- 3/8" weak Tuff Ropes product spliced with regular 3/8" rope
- 3/8" weak Candy Cane product spliced with regular 3/8" rope
- Coastline braided weak section spliced to regular 3/8" rope
- Seaside in-line link spliced with regular 3/8" rope

All modifications were tested with 5 samples. These samples are designed to be spliced into the length of regular buoy line. The 3/8" rope represents the buoy line and would make up the remainder of the trap trawl setup.

3 Test Procedure

Tensile tests were conducted using a ADMET model: 1220FHH-10K-B test machine, The calibration and certification sheet can be seen in Appendix A. Each sample was placed into the bollard grips such that the required testing section was positioned between the grips with a gauge length of approximately 12 in. This test setup can be seen in Figure 1, shown below. The tensile test was focused on the area where the weak modification is spliced or attached to the normal buoy line. The test was focused on this area because stress concentrations are introduced into the rope system whenever it is spliced or tied. These stress concentrations will decrease the load carrying capacity of the rope. This means that if two ropes are spliced together it will always fail at the splice (DMR, 2018). The test sample was then pulled at a constant rate of 20 in/min until failure. This was repeated five times for each of the six total modifications. The test results were logged to CSV file and then imported into Excel for charting and characterization. Those charts and summary data for each test is presented in the results sections below.

FIGURE 1: TEST BOLLARD GRIP SETUP

4 Results

4.1 Modification 1: 3/8 Candy Cane Pre-season

In order to understand all the charts in the following sections, a description of this first chart (Figure 2) is required. The X-axis displays the displacement and the Y-axis shows the load. The Admet machine automatically resets the displacement to 0 in just as the load exceeds 1 lb to ensure that the data, and therefore the charted output of all specimens are aligned. The charted output of every sample tested has an initial curve where the rope tightens around the bollards and it is only during the linear section of that all the displacement is being absorbed in the stretch of the modification (or its splice to the adjoining section of rope). This linear section continues until the modification fails and there is a rapid drop in load. A vertical drop means an instantaneous break. A sloping drop means the failure occurs over some additional displacement. Spikes in the drop likely indicate whipping or contact with the frame of the test machine..

In this case specifically (Figure 2) Candy Cane sample #3 undergoes a sharp drop in Load after 7.5in of travel. This indicates a point where a wrap of rope on the fixtures was initially crossed and then dropped into place. The expectation therefore is that sample #3 appears to stretch more than it actually did, and this is evident as at-break it was around 1in further stretched than the next nearest sample (#4).

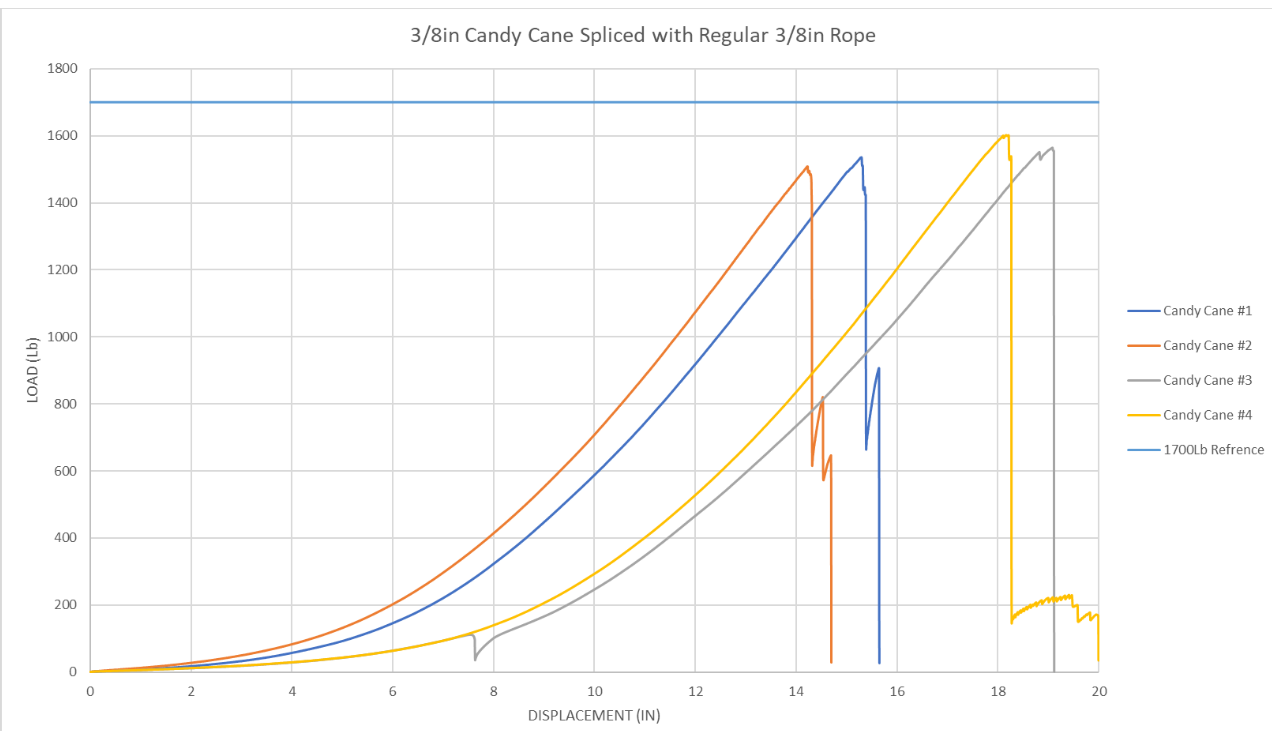

FIGURE 2: 3/8 CANDY CANE TENSILE TEST PLOT

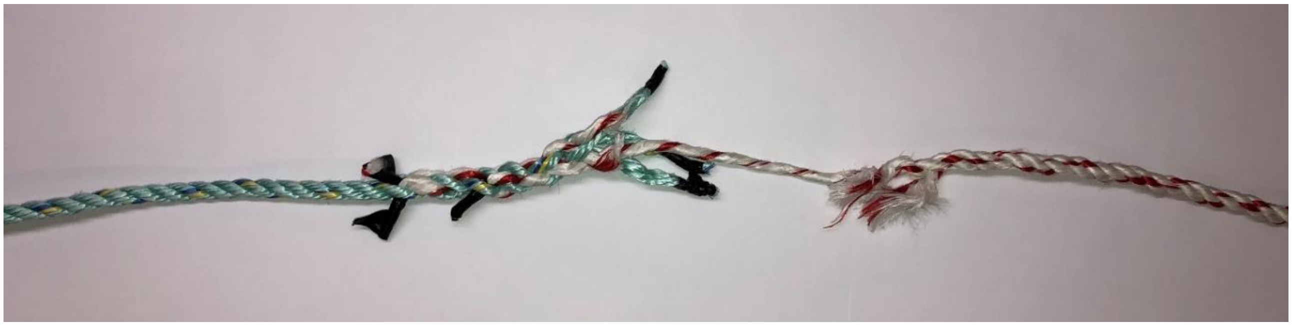

FIGURE 3: 3/8″ CANDY CANE SAMPLE #1

	Max Break Point (lb)						
Sample	1	2	3	4	5	Average	Standard Deviation
3/8 Candy Cane	1536.1	1508.6	1212.0	1381.5		1409.6	128.1

TABLE 1: 3/8" CANDY CANE TEST DATA

The 3/8″ candy cane sample failure shown in Figure 3 shows that two of the three twisted braids broke within the splice to the regular 3/8″ rope. This sample had a stretch of about 15″ at the point of break. The average break point for this product was 1409.6lb with a standard deviation of 128.1lb. This average is quite some distance from 1700lb target, but the high standard deviation shows means that there was a high variance between the tested samples. Although, even with this low average and high variation, no sample broke above the 1700lb threshold.

4.2 Modification 1: 3/8 Candy Cane Post-season

4.3 Modification 2: Seaside Link Pre-season

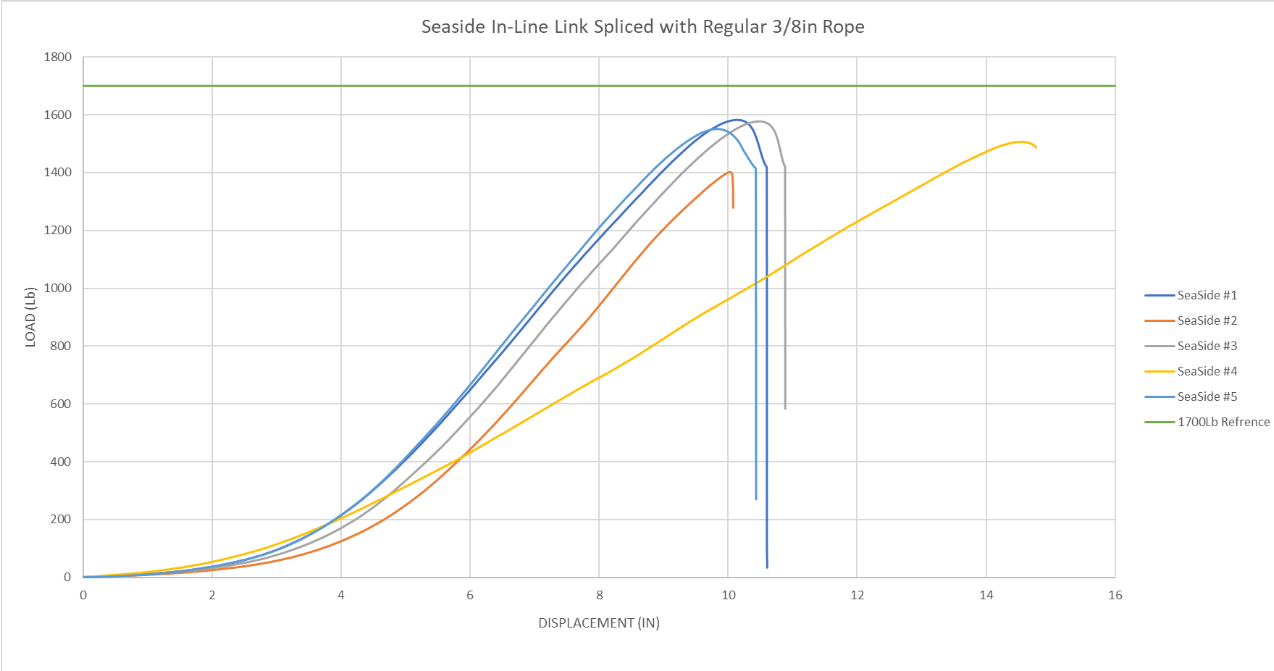

FIGURE 4: SEASIDE LINK TENSILE TEST PLOT

FIGURE 5: SEASIDE IN-LINE LINK SAMPLE #1

	Max Break Point (lb)						
Sample	1	2	3	4	5	Average	Standard Deviation
Seaside Link	1582.5	1402.0	1577.4	1506.6	1551.3	1524.0	74.5

TABLE 2: 3/8" CANDY CANE TEST DATA

The Seaside In-Line Link sample shown in Figure 5, it is seen that this sample breaks at the plastic link between the two splices. This sample had a stretch of about 10" at the point of break. The average break point for this product was 1524.9lb with a standard deviation of 74.5lb. This standard deviation was on the lower end compared to the other samples. All samples broke below the 1700lb threshold. The failure of the link goes through a plastic deformation prior to failure. This is shown in the gradual decrease in load before failure. This plastic deformation is the link stretching and necking at the failure point. This stretch within the sample can be seen in Figure 5 as the deformation on the failure side. This plastic deformation could decrease the load capacity of the sample if the sample experienced cyclic loading into the plastic region.

4.4 Modification 2: Seaside Link Post-season

4.5 Modification 3: 5/16 Polyethylene Pre-season

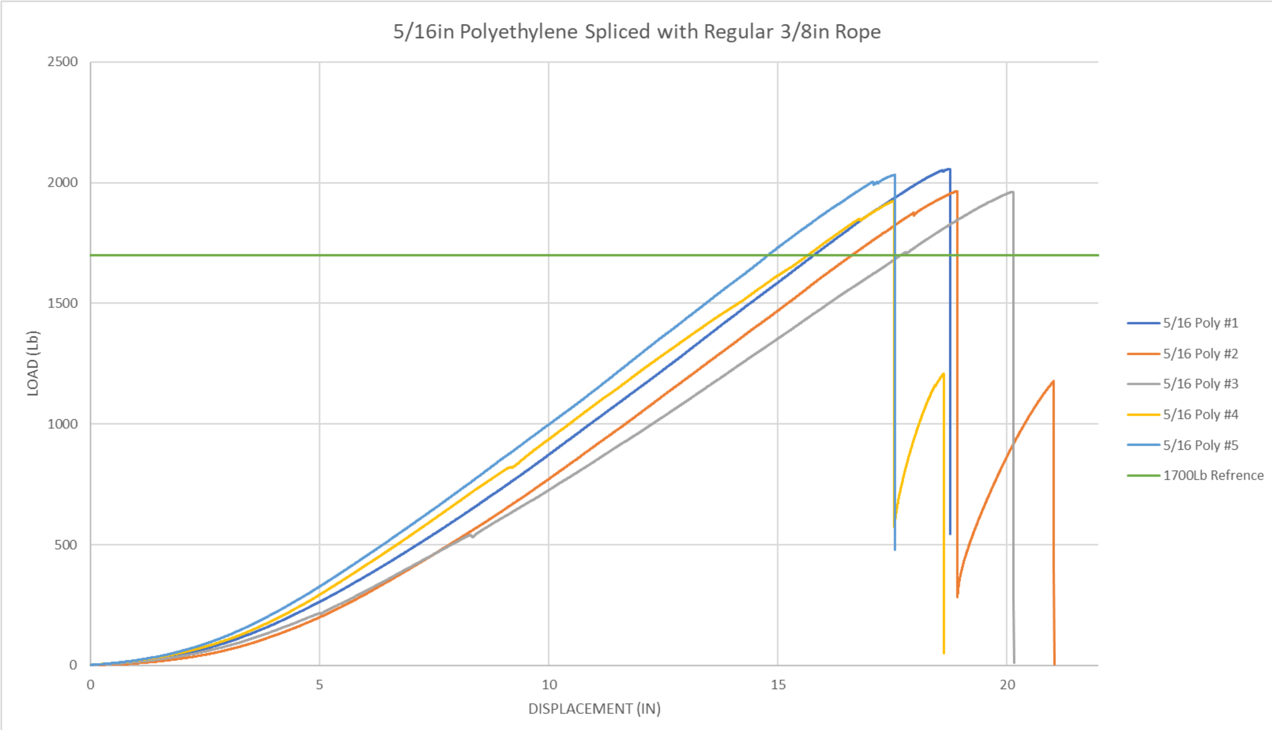

FIGURE 6: 5/16 POLYETHYLENE TENSILE TEST PLOT

FIGURE 7: 5/16" POLYETHYLENE SAMPLE #1

	Max Break Point (lb)						
Sample	1	2	3	4	5	Average	Standard Deviation
5/16 Polyethylene	1857.0	1739.0	1601.3	1857.5	1984.8	1807.9	144.6

TABLE 3: 5/16" POLYETHYLENE TEST DATA

The 5/16" Polyethylene sample shown in Figure 7: 5/16" Polyethylene Sample #1, it is seen that the sample breaks within the splice between the two ropes. This sample had a stretch of about 18" at the point of break. The average break point for this product was 1807.9lb with a standard deviation of 144.6lb. This standard deviation was the highest of the samples tested. This high variation compounds with the average for the samples being larger than the 1700lb threshold.

4.6 Modification 3: 5/16 Polyethylene Post-season

4.7 Modification 4: 5/16 Creeline Pre-season

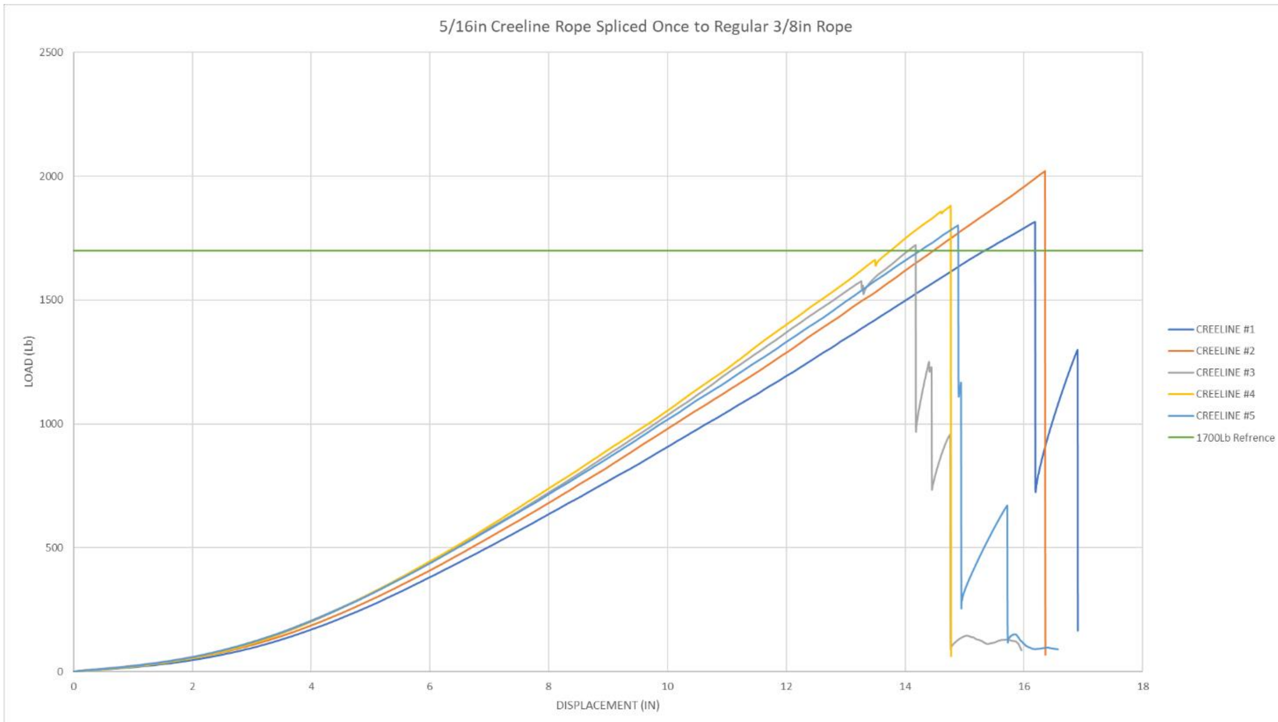

FIGURE 8: 5/16 CREELINE TENSILE TEST PLOT

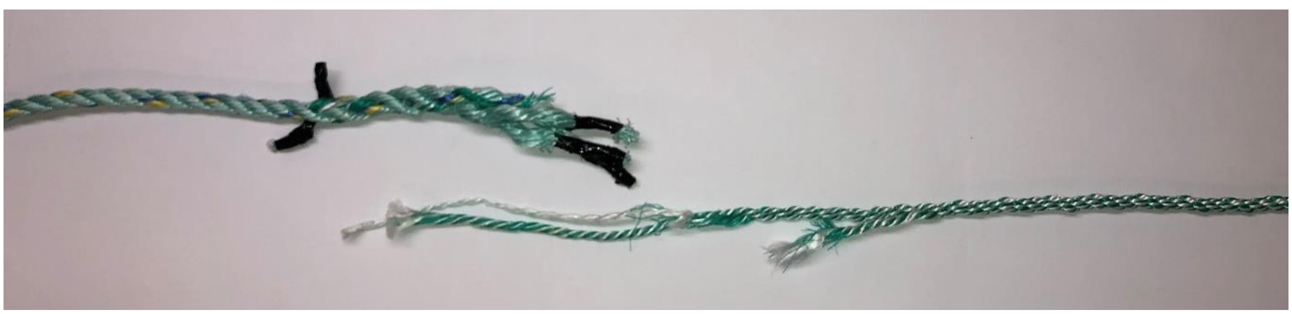

FIGURE 9: 5/16" CREELINE SAMPLE #1

	Max Break Point (lb)						
Sample	1	2	3	4	5	Average	Standard Deviation
5/16 Creeline	1816.1	2020.9	1722.3	1881.3	1802.3	1848.6	111.7

TABLE 4: 5/16" CREELINE TEST DATA

The 5/16" Creeline sample shown in Figure 9: 5/16" Creeline Sample #1, it is seen that the sample breaks partially within the splice between the two ropes. This sample had a stretch of about 16" at the point of break. The average break point for this product was 1848.6lb with a standard deviation of 111.7lb. This standard deviation was one of the highest of the samples tested. This high variation compounds with the average for the samples being larger than the 1700lb threshold. This sample would fail partially within the splice while the other strands of rope would pull out of the splice. This multistage failure would cause spikes in the load displacement curve. These spikes can be seen in Figure 9 after 14" of displacement,

4.8 Modification 4: 5/16 Creeline Post-season

4.9 Modification 5: 3/8 Tuff Ropes Pre-season

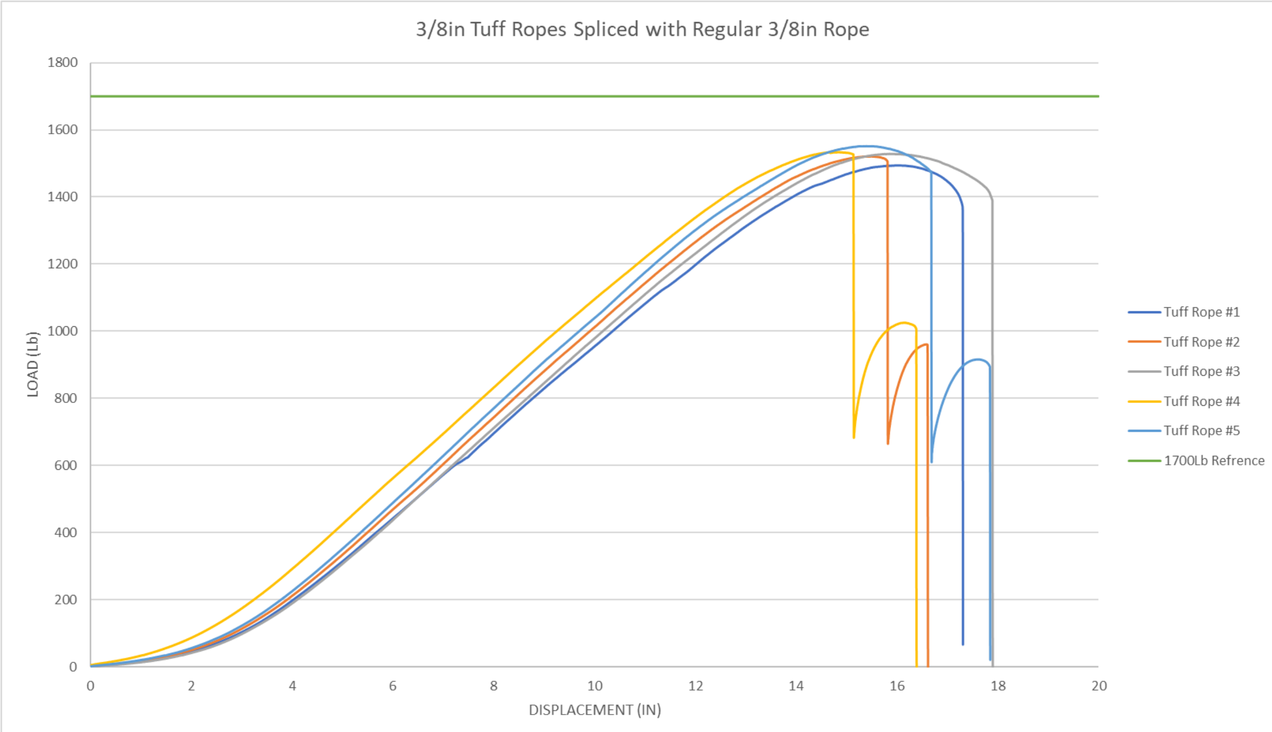

FIGURE 10: 3/8 TUFF ROPES TENSILE TEST PLOT

FIGURE 11: 3/8" TUFF ROPES SAMPLE #1

	Max Break Point (lb)						
Sample	1	2	3	4	5	Average	Standard Deviation
3/8 Tuff Ropes	1494.2	1520.9	1528.6	1533.7	1551.4	1525.8	20.9

TABLE 5: 3/8" TUFF ROPES TEST DATA

The 3/8" Tuff Ropes sample shown in Figure 11: 3/8" Tuff ropes Sample #1, it is seen that the sample breaks within the splice between the two ropes. This sample had a stretch of about 17" at the point of break. The average break point for this product was 1525.8lb with a standard deviation of 20.9lb. This standard deviation was lowest of the samples tested. This low variation in values shows how consistent the spice and rope can be. No sample exceeded a break above the 1700lb threshold , but the highest break force was 1551lb. The Tuff

Ropes sample consists of a leaded core within the 3 strands. Upon failure of the sample the lead core would be ejected from the splice. It appeared the strand that contained the lead would stretch less then the strands without the lead. This would cause the strands to fail at different points. As seen in Figure 11, the strands without the lead broke within the splice while the strand with the lead pulled out of the splice.

4.10 Modification 5: 3/8 Tuff Ropes Post-season

4.11 Modification 5: Coastline Pre-season

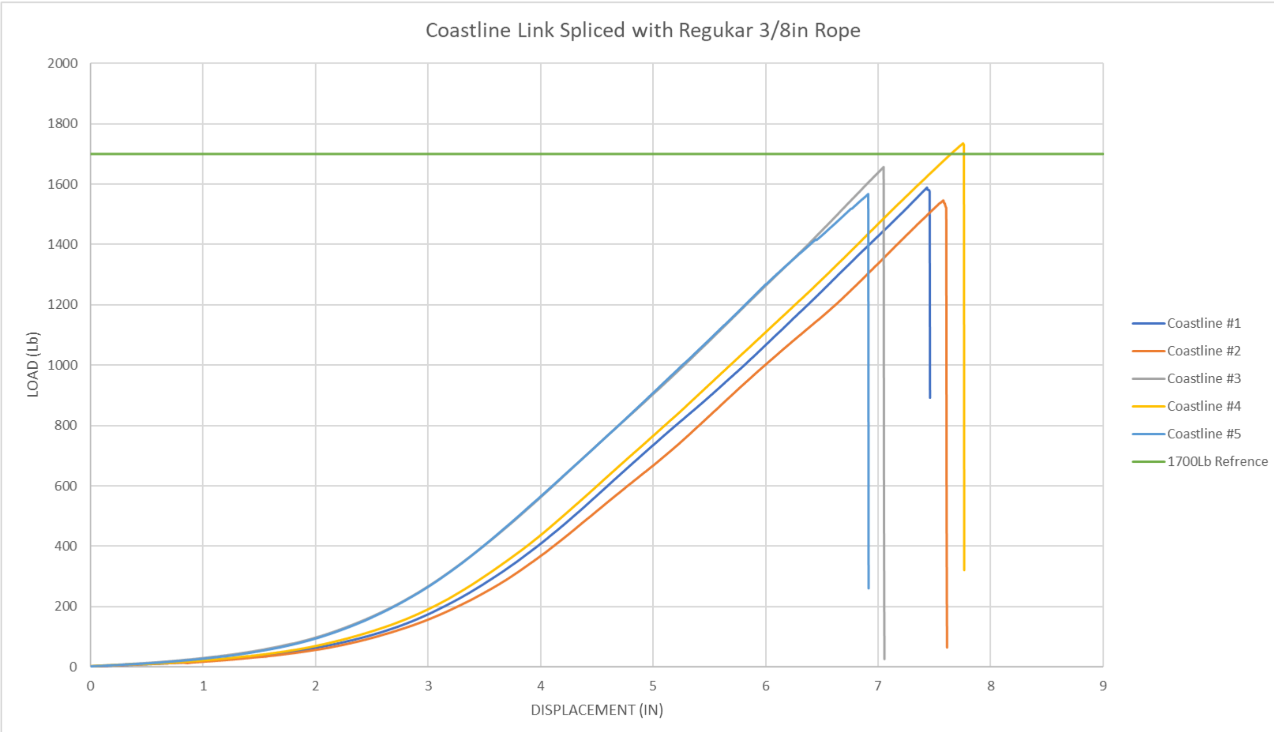

FIGURE 12: COASTLINE LINK TENSILE TEST PLOT

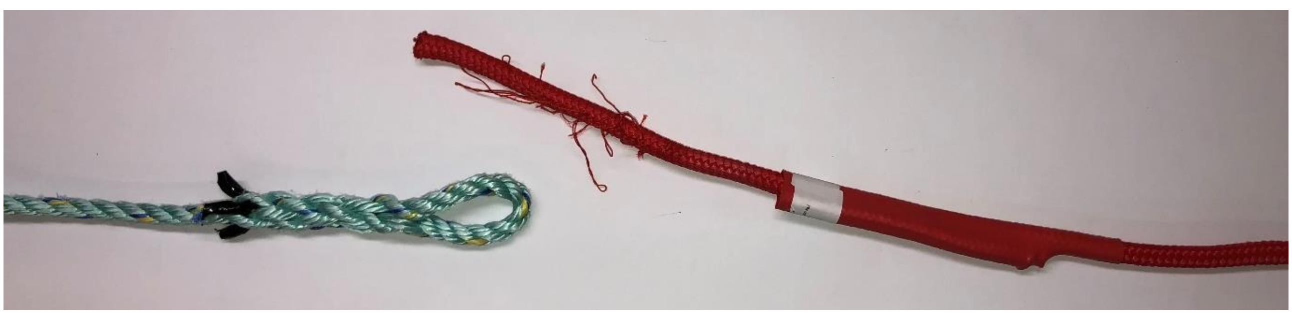

FIGURE 13: COASTLINE SAMPLE #1

	Max Break Point (lb)						
Sample	1	2	3	4	5	Average	Standard Deviation
Coastline Link	1588.5	1546.2	1656.7	1735.4	1567.1	1618.8	77.3

TABLE 6: COASTLINE TEST DATA

The Coastline Link sample shown in Figure 13, it is seen that the sample breaks at the stitched section of the splice. This sample had a stretch of about 6" at the point of break. The average break point for this product was 1618.8lb with a standard deviation of 77.3lb. This standard deviation was the lowest compared to the other modification tested. This modification required a low total stretch to break and averaged a maximum break below the 1700lb break threshold. One single test exceeded 1700lb, by 35lb. This modification would fail completely and suddenly once it reaches the failure point. This complete failure combined with the low standard deviation makes this a predictable sample.

4.12 Modification 5: Coastline Post-season

5 Discussion

The data from the tensile tests is presented in each section above. Each sample was tested with as many samples that were provided. The maximum break point is tabulated for each pull. The average and standard deviation of these maximum break points was calculated and presented. A summary of all test results is shown in Table 7.

	Max Break Point (lb)						
Sample	1	2	3	4	5	Average (lb)	Standard Deviation (lb)
3/8 Candy Cane	1536.1	1508.6	1212.0	1381.5		1409.6	128.1
Seaside Link	1582.5	1402.0	1577.4	1506.6	1551.3	1524.0	74.5
5/16 Polyethylene	1857.0	1739.0	1601.3	1857.5	1984.8	1807.9	144.6
5/16 Creeline	1816.1	2020.9	1722.3	1881.3	1802.3	1848.6	111.7
3/8 Tuff Ropes	1494.2	1520.9	1528.6	1533.7	1551.4	1525.8	20.9
Coastline Link	1588.5	1546.2	1656.7	1735.4	1567.1	1618.8	77.3

TABLE 7: SUMMARY TEST RESULTS

The graph below (Figure 14), represent the Load Vs. Displacement of each 1st sample tested. This graph directly compares the displacement required at the break points of each modification. The stretch of the modification is a combination of the quality of the splice and the material of the modification. The displacement at failure is an indication of the stiffness of the system. A modification that has a low stretch will have a more sudden inelastic failure. This type of sudden failure will happen quickly with little indication that the sample is about to fail which may be undesirable from a fishers perspective.

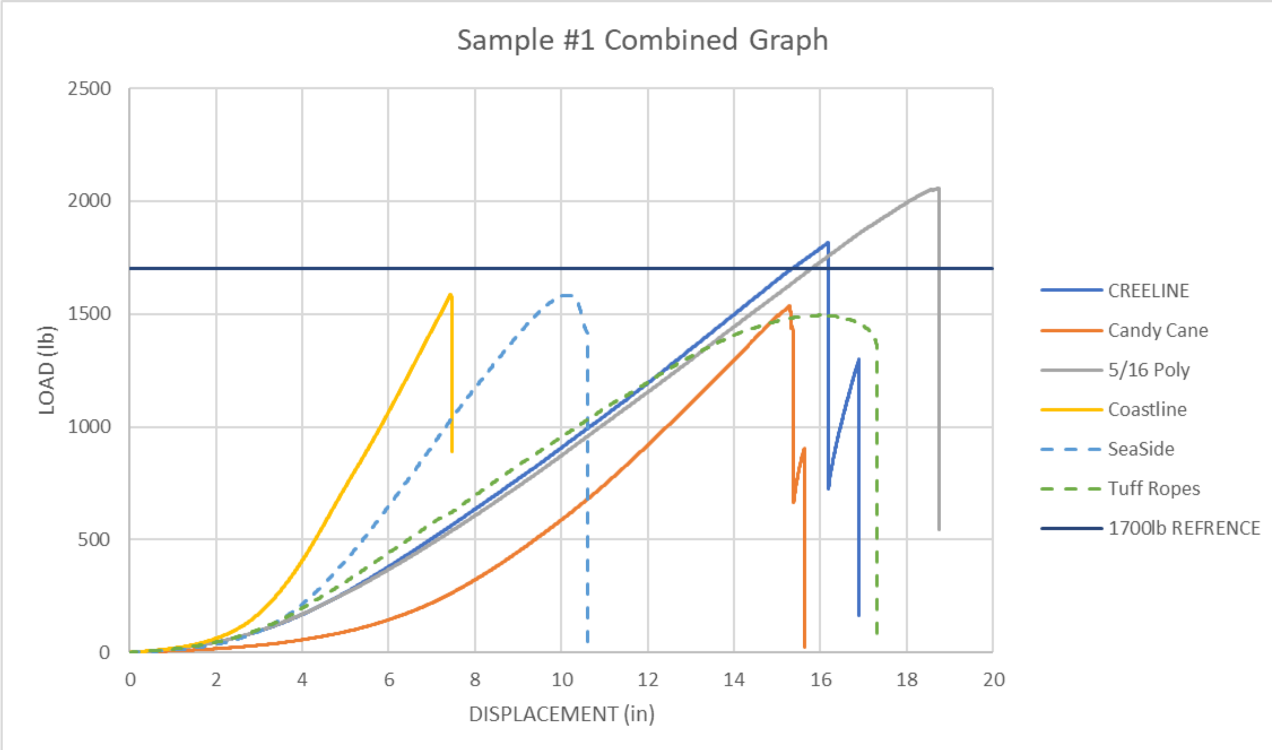

FIGURE 14: SAMPLE #1 COMBINED GRAPH

DFO regulations currently state that the weak modification must fail at 1700lb, this means that the samples that averaged a break strength above 1700 lb do not meet this requirement. This rules out the 5/16 Polyethylene and 5/16 Creeline modifications.

The end users of these weak modifications will be looking for a modification that will not accidentally release under unwanted circumstances. This would mean that the break strength is closest to the mandated 1700 lb and the standard deviation is low. This would mean the modification has repeatable and consistent performance from sample to sample. Thus a product such as the Coastline Link with an average break strength of 1618 lb and a standard deviation of 77 lb may have the most appropriate performance from a fishers perspective. This tensile testing does not take into account any consideration of the economic or business impacts of weak modifications.

6 References

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7 Appendix A

LOAD CELL CALIBRATION CERTIFICATION

ADMET

Interface, Inc. FEB 07 2022 QC-9805

CONDITION: FINAL
MODEL: 1210FHH-10K-B

PROCEDURE: C-1257
SERIAL: 1204267   BRIDGE: A   CAPACITY: 10 Klbf

INPUT RESISTANCE: 351.6 Ohm   OUTPUT RESISTANCE: 351.4 Ohm
ZERO BALANCE: 0.068 %RO

TEST CONDITIONS

TEMPERATURE: 71 °F   HUMIDITY: 31%   EXCITATION: 10 VDC

TRACEABILITY

FORCE STANDARD:	STD-42	NIST #:	STD-42D1621	DUE: 28-APR-2023
STANDARD INDICATOR:	BRD106	NIST #:	EVL729796	
TEST INDICATOR:	BRD300	NIST #:	EVL729796	

SHUNT CALIBRATION

	Shunt (+/- .01%)	Output	Straight Line Conversion	Connections*
TENSION	30.0 KOhm	2.90735 mV/V	7.0591 Klbf	-Out to -Exc
COMPRESSION	30.0 KOhm	-2.91000 mV/V	7.0620 Klbf	-Out to +Exc

*For models wired with +Sense, - Sense or -SCal leads, resistor connections are actually to these leads in place of +Exc, -Exc or -Out respectively.

PERFORMANCE

	Rated Output	SEB Output	Nonlinearity	Hysteresis	SEB
TENSION	4.11763 mV/V	4.11857 mV/V	0.007 %FS	0.027 %FS	±0.023 %FS
COMPRESSION	-4.12133 mV/V	-4.12064 mV/V	-0.024 %FS	0.022 %FS	±0.017 %FS

STATIC ERROR BAND (SEB) The band of maximum deviations of the ascending and descending calibration points from a best fit straight line through zero OUTPUT. It includes the effects of NONLINEARITY, HYSTERESIS, and nonreturn to MINIMUM LOAD.

TEST LOAD APPLIED (Klbf)	RECORDED READINGS (mV/V) Tension	Compression
0	.00000	.00000
2	.82363	- .82358
4	1.64726	-1.64756
6	2.47087	-2.47189
8	3.29440	-3.29645
10	4.11763	-4.12133
4	1.64837	-1.64848
0	- .00005	.00006

Calibration measurements are traceable to NIST.

TECHNICIAN : CRATTY, RICHARD C.   CALIBRATION DATE : 20-OCT-2021

APPROVED : Brad Hanson - Calib. Tech.

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