Development and Evaluation of Whale Release Ropes

Final Results

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New England Aquarium

In partnership with:
South Shore Lobster Fishermen’s Association
Mass Lobstermen’s Association
What have we learned from the ropes that entangle large whales

Published in April 2016

Open access
Right whales from calf to 2 year olds were in significantly lower rope strength than adult right whales.

- Data indicates that ropes of 1,700 lb strength could reduce lethal entanglements of large whales – “Whale release” rope.
Rope strength has increased substantially since the mid 1990's with improvements in rope manufacturing.
Some history....

Weak Rope Trials: 2006-2008

Three separate batches

Rope types: 5/16” and 3/8” diameter; 600 and 1200lb breaking strength

Rope was fished as endline and usually spliced with float rope on lower third
2006-2008: Weak rope trials

“Fishable” in many parts of Maine

In rocky habitats and where strong tides and currents occurred, lobster fishermen reported concerns about an increased likelihood that ropes would break at a greater rate than what they typically use.

Bycatch Consortium, unpublished results
PROJECT:

DEVELOPMENT AND EVALUATION OF WHALE RELEASE ROPES TO REDUCE LARGE WHALE ENTANGLEMENT SEVERITY

PI: NEAq
Co-PIs: SSLFA, MassLA

Funding provided by the MA Office of Energy and Environmental Affairs
Objectives

1) Produce prototype ropes that meet a target virgin breaking strength of 1700lb, including the SSLFA’s braided sleeve rope
2) Evaluate performance under a range of actual fishing conditions (# traps, depths, habitats, fishermen)
3) Record breaking strengths and other relevant performance information (qualitative and quantitative) during and after trials
4) Carry out lab observations of rope degradation
5) Create and refine computer models that can:
   a. Reliably calculate loads on pot gear
   b. Evaluate loads under whale entanglement scenarios
   c. Improve understanding of how whale-release ropes facilitate early escape from entanglements
6) Report results and provide recommendations on fishing conditions under which the ropes should be adequate
Getting 1,700 lbf Ropes Manufactured

Objective was to test multiple 1,700 lbf rope prototypes

Visited two major rope manufacturers in U.S. and Canada; reached out to over 20 rope manufacturers worldwide with rope specifications for 1,700 lbf rope

Rope manufacturers initially demonstrated limited interest in investing in R&D through this project but interest is growing

Taian Cord Rope in China did provide a ~1600 lbf prototype

A rope manufacturer in India has provided the Canadians a 1,700 lbf prototype

Not yet tested at sea but will do so in 2019
Design Testing of Other Options: manipulate regular rope to reduce breaking strength

1.) Novabraid Sleeve
- A 3/8” rope inserted and secured into a hollow 6’ Novabraid sleeve

2.) Embedded Strand
- A 7/64” Samson-Amsteel strand spliced into a cut 3/8” rope and wrapped with tape for structure.

3.) Spliced ¼” Polysteel
- A 1/4” piece of Polysteel rope spliced into a 3/8” rope.
Design Testing of Other Options: manipulate regular rope to reduce breaking strength

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A 3/8” rope inserted and secured into a hollow 6’ Novabraid sleeve

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A 7/64” Samson-Amsteel strand spliced into a cut 3/8” rope and wrapped with tape for structure.

3.) Spliced ¼” Polysteel

A 1/4” piece of Polysteel rope spliced into a 3/8” rope.
Knots also tested at request of TRT subgroup

This resulted in an originally manufactured \( \frac{3}{8} \) inch Everson Pro rope with an average virgin breaking strength of 3,975 lbf to be reduced to 2,108 lbf and 2,094 lbf when adding a single and double overhand knot, respectively.

However, the knots remained in the rope which is a concern as it will not pull through the baleen and be shed.
At-sea field testing: used NovaBraid sleeves integrated every 40 feet into endlines and fished near control rope (no sleeves) trawls
- Provided instructions for integrating sleeves into ropes
- Provided new ropes and sleeves to all participants
- Requested fishermen fill out log sheet each time sleeved or control endline hauled or if it parted
### NovaBraid Sleeves: Initial Tensile Strength Results

<table>
<thead>
<tr>
<th>Rope Brand</th>
<th>Test load (lbs.)</th>
<th>Max displacement (inches)</th>
<th>Hold Time (Minutes)</th>
<th>Max load (lbs.)</th>
<th>Average: Control / Sleeve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Everson Pro</td>
<td>3540</td>
<td>23.101</td>
<td>0.02</td>
<td>3975</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>16.273</td>
<td>0.02</td>
<td>3988</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>14.940</td>
<td>0.02</td>
<td>3925</td>
<td></td>
</tr>
<tr>
<td>3 Ex. Sleeve</td>
<td>1700</td>
<td>7.216</td>
<td>0.00</td>
<td>1316</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.034</td>
<td>0.00</td>
<td>1398</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>13.781</td>
<td>0.00</td>
<td>1411</td>
<td></td>
</tr>
<tr>
<td>Manline</td>
<td>3100</td>
<td>18.363</td>
<td>0.24</td>
<td>3811</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>16.143</td>
<td>0.24</td>
<td>3647</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>13.928</td>
<td>0.24</td>
<td>3786</td>
<td></td>
</tr>
<tr>
<td>3 Ex. Sleeve</td>
<td>1700</td>
<td>15.106</td>
<td>0.24</td>
<td>1423</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>13.905</td>
<td>0.24</td>
<td>1341</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>12.501</td>
<td>0.24</td>
<td>1202</td>
<td></td>
</tr>
</tbody>
</table>

**Average: Control / Sleeve**

- **Everson Pro**: 3962 lbs. / 1375 lbs.
- **Manline**: 3748 lbs. / 1322 lbs.
At-sea field testing

<table>
<thead>
<tr>
<th></th>
<th>Lobster</th>
<th>Whelk</th>
<th>Black Sea Bass</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Endlines used:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>59</td>
<td>7</td>
<td>2</td>
<td>68</td>
</tr>
<tr>
<td>Control</td>
<td>46</td>
<td>0</td>
<td>1</td>
<td>47</td>
</tr>
<tr>
<td><strong>Number of traps on a trawl</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Weight of a single trap (lbs)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30-118</td>
<td>40</td>
<td></td>
<td></td>
<td>40</td>
</tr>
<tr>
<td><strong>Maximum Depth (ft)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>310</td>
<td>55</td>
<td></td>
<td></td>
<td>42</td>
</tr>
<tr>
<td><strong>Dominant Substrate</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand-Rock Mix</td>
<td>Sand</td>
<td>Sand-Rock Mix</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Rope parting results

8 of 68 (11.8%) experimental endlines parted
  • 1 of 8 parted while hauling; the rest parted while soaking
  • The gear on the 1 that parted had apparently been damaged in a series of storms
  • All 8 parted at one of the sleeves

4 of 47 (8.5%) control endlines parted
  • All parted when gear had been soaking
  • 2 of 4 parted near the top of the endline; in one case the entire trawl had moved
  • For the remaining 2, no information was provided but it was 2 endlines of same trawl

Negligible difference between sleeved and control rope breakage
Post fishing sleeve breaking strength

<table>
<thead>
<tr>
<th></th>
<th>Maximum Load (lbf)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Min</td>
<td>Max</td>
<td>Average</td>
</tr>
<tr>
<td>All Sleeves</td>
<td>72</td>
<td>467</td>
<td>1,702</td>
<td>1,213.11</td>
</tr>
<tr>
<td>Level of Hauling:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High (14+)</td>
<td>18</td>
<td>872</td>
<td>1,436</td>
<td>1,202.9</td>
</tr>
<tr>
<td>Medium (7-14)</td>
<td>33</td>
<td>467</td>
<td>1,702</td>
<td>1,224.6</td>
</tr>
<tr>
<td>Low (0-6)</td>
<td>21</td>
<td>860</td>
<td>1,449</td>
<td>1,203.8</td>
</tr>
<tr>
<td>Sleeve position on Endline:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top</td>
<td>20</td>
<td>701</td>
<td>1,430</td>
<td>1,185.8</td>
</tr>
<tr>
<td>Middle</td>
<td>28</td>
<td>467</td>
<td>1,449</td>
<td>1,223.3</td>
</tr>
<tr>
<td>Bottom</td>
<td>24</td>
<td>746</td>
<td>1,702</td>
<td>1,224.0</td>
</tr>
<tr>
<td>Max Depth:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-100 ft</td>
<td>18</td>
<td>872</td>
<td>1,436</td>
<td>1,222.7</td>
</tr>
<tr>
<td>101-200 ft</td>
<td>39</td>
<td>467</td>
<td>1,449</td>
<td>1,210.0</td>
</tr>
<tr>
<td>201-300 ft</td>
<td>15</td>
<td>1,050</td>
<td>1,702</td>
<td>1,209.8</td>
</tr>
</tbody>
</table>

No patterns in breaking strength detected when evaluating hauling frequency, sleeve position and water depth
A Season of Use: Pre and Post fishing comparison

**Control / Sleeve**

(Everson)

Before being fished: 3,962 lbs. / 1,327 lbs.

After being fished: 3,694 lbs. / 1,213 lbs.
Load cell testing and modeling

- Two days of at-sea testing
- At sea testing used to inform OrcaFlex modeling approach
- OrcaFlex used by the oil and gas industry to understand tensions placed on ropes and cables
TOWING A SINGLE POT AT VARIOUS SPEEDS

Figure B1: The single lobster pot system line tensions as measured by NEAq personnel
OrcaFlex
- Consulted with engineer Dr. Jud DeCew
- OrcaFlex software – used in oil and gas industry to understand strains placed on ropes
- Can plug in a variety of changeable parameters to build a model
- Can evaluate different water depths and gear configurations
- At sea testing can be used to groundtruth the model

<table>
<thead>
<tr>
<th>Component</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line</td>
<td>Diameter</td>
<td>0.375”</td>
</tr>
<tr>
<td></td>
<td>Material</td>
<td>Polypropylene</td>
</tr>
<tr>
<td></td>
<td>Mass (dry)</td>
<td>0.028 lb/ft</td>
</tr>
<tr>
<td></td>
<td>Mass (wet)</td>
<td>-0.004 lb/ft</td>
</tr>
<tr>
<td></td>
<td>M.B.L.</td>
<td>2161 lbf</td>
</tr>
<tr>
<td>Lobster Pot</td>
<td>Dimensions</td>
<td>48” x 22.5” x 15”</td>
</tr>
<tr>
<td></td>
<td>Mass (dry)</td>
<td>65 lb</td>
</tr>
<tr>
<td></td>
<td>Mass (wet)</td>
<td>57 lb</td>
</tr>
<tr>
<td></td>
<td>Drag coefficient</td>
<td>1.395</td>
</tr>
</tbody>
</table>
Trap drag coefficient and # of traps on the water column had the most sensitivity as water velocity increases.
Evaluation of dynamic parameters

Different wave periods

Hauling initiated at 50 sec mark

Hauling speed can dramatically influence rope strain especially as waves are closer together

Peak at slow hauling is ~ 600 lbs

Peak at fast hauling is ~1,000 lbs
If a whale reacts by increasing its velocity when entangled, the greater the # of pots attached, the more quickly the whale will reach the 1700 lb breaking strength.

Trawling up may be a benefit **AS LONG AS** the end line is of reduced breaking strength.

Reducing the # of pots in the water column at any one time will reduce the hauling strain.

With reduced breaking strength endlines, if sinking groundlines are stronger, may help with gear retrieval.
Hauling 5 pot trawl in 200 ft water depth

With ~90 ft of groundline between first and second pot

With ~210 ft of groundline between first and second pot – “groundline extension” = notable reduction in strain
Correction factor employed to account for pulley system above which load cell was deployed (illustration from https://www.ropebook.com/information/angular-vector-forces/)
Hauling 5 pot trawl in 200 ft water depth

With ~90 ft of groundline between first and second pot

– "groundline extension" = notable reduction in strain

AT SEA TESTING

After applying correction factor, these tensions ranged from 570 to 190 lbf

With ~210 ft of groundline between first and second pot
Comparison with Maine testing

Maine Load Cell Testing Update

- Trap 1
- Trap 2
- Trap 3
- Trap 4
- Trap 5
- Trap 6

- 75fa depth
- 17 fa
- 17 fa
- 17 fa
- 17 fa
- 16

...
Maine testing results

<table>
<thead>
<tr>
<th></th>
<th>90 degrees</th>
<th>45 degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Load</td>
<td>1.41</td>
<td>1.84</td>
</tr>
<tr>
<td>Max</td>
<td>1889.22</td>
<td>1339.87</td>
</tr>
<tr>
<td>Min</td>
<td>556.43</td>
<td>394.63</td>
</tr>
<tr>
<td>Mean</td>
<td>1122.44</td>
<td>796.06</td>
</tr>
<tr>
<td>STD</td>
<td>221.04</td>
<td>156.77</td>
</tr>
</tbody>
</table>

Max depth of testing 450 feet

Max occurred at a layover

Means in similar range to model
Virtual Whale Entanglement Simulator

Tool developed to better understand entanglement interactions and resulting forces on gear

Initial simulations indicate whale may reach the 1700 lb force more quickly than hauling operations do because of other types of forces (Howle et al. In press. Marine Mammal Science

More simulations are underway

Figure 1. An example of the graphics depicted during a whale entanglement using the VWES model, and demonstrating the rolling behavior. The red portion of the rope is the upper sink rope. In (a) the whale approaches the rope and will initiate rolling behavior upon contact; (b) the whale begins to roll away from the rope that is becoming lodged in the attachment point of the left flipper and main body; (c) the whale continues to roll with its dorsal side facing downward; (d) the whale resumes swimming in an upright position with the rope attached. (Images from Howle et al., in press).
What have we learned?

• There are multiple design options for producing whale-release (1700lbf) rope
• 1700 lb sleeved ropes are generally working operationally for fishermen where evaluated
• Loads measured by at-sea testing by NEAq and Maine are well below 1700 lbs in waters of 450 feet or less (except when there are layovers)
• A groundline extension can be used to reduce tension when hauling endline
• Preliminary comparison show OrcaFlex model results are similar to Maine load cell results
• Initial entanglement scenario results are consistent with results from the Knowlton et al. (2016) study
Acknowledgements

Fishing Community Collaborators
Lori Caron, Beth Casoni, Dave Casoni, Denny Colbert, Beau Gribbon, John Havilland, Mike Lane, Kurt Martin, Rob Martin, Steve Keane, Dan Pronk, Chris Adamitis

Engineers
John Flory, Hank McKenna, Laurens Howle

Scientists
Doug Nowacek, Monica Zani

Rope Manufacturers
Sean Burke, Donnie MacLean; Chuck Gilchrest, Neil Prescott

Donors
Commonwealth of Massachusetts Office of Energy and Environmental Affairs, Foundation grants to NEAq