Analysis of the Functionality and Behavior of a Weak Rope Contrivance Involved in a Humpback Whale Entanglement

by

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Background

In May 2021, DMF implemented a regulation requiring all trap/pot vertical lines in state waters be equipped with 1,700 lb breaking strength rope in the upper 75% of the line or be equipped with 1,700 lb breaking strength contrivances every 60 feet in the upper 75% of the line. The goal of this regulation is to reduce the risk of serious injury or mortality (SIM) to large whales if an entanglement occurs. The 1,700 lb breaking strength threshold is derived from a study conducted by Amy Knowlton of the New England Aquarium (Knowlton et al. 2016) which examined the rate of serious injury and mortality in large whale relative to the breaking strength of ropes recovered from entanglements. This study concluded that up to a 72% reduction in SIM to North Atlantic right whales could be achieved if 1,700 lb rope were used in pot/trap fisheries. The breaking strength of rope typically used in inshore pot/trap fisheries, like the MA lobster fishery, ranges from 2,800 lbs to 3,400 lbs.

Case Study

On August 8, 2021, a humpback calf (calf of Jabiru) became entangled in a vertical line from the MA lobster fishery, approximately 4 miles off Rockport, MA in federal waters. The entanglement was observed by a local whale watch vessel. While the disentanglement team was underway to the location, the whale dove under the whale watch vessel, snagging the gear on the bottom of the vessel and releasing the whale. The whale watch vessel collected the remaining buoy line that was floating at the surface and remanded it to the National Marine Fisheries Service for analysis. The gear recovered from the entanglement was compliant with all MA gear marking and weak rope regulations, including being equipped with a 1,700 lb breaking strength weak rope contrivance.

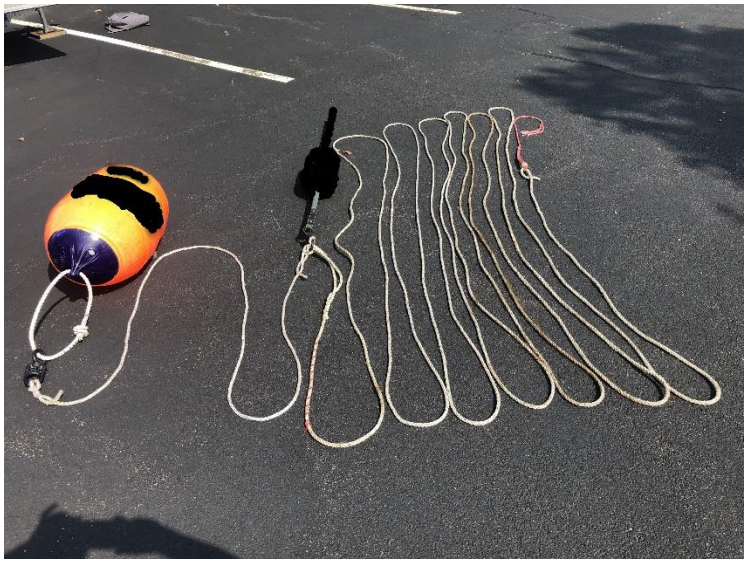

Figure 1. Gear recovered from August 8, 2021 entanglement

The contrivance used by the fishermen in this case was one that was previously tested and currently approved for use by NMFS. This is the first documented entanglement in a vertical line equipped with weak contrivances and presented a unique opportunity to confirm the functionality of this weak contrivance and to compare its breaking strength and behavior under strain to a similar configuration

using traditional rope. To that end, we partnered with the National Marine Fisheries Service to conduct an evaluation of the approved contrivance involved in this entanglement – an eye splice to a loop with 3 tucks (Figure 2).

Figure 2. 3 tuck loop of red weak rope into traditional rope eye splice

We partnered with Rob Martin, a NMFS gear specialist and commercial fishermen, to re-test 10 samples of the 3 tuck weak rope contrivance on NMFS break testing machine in Woods Hole (Figure 3). In addition, we asked Rob to test 10 samples of that same contrivance configuration but with only traditional breaking strength rope; no weak rope involved. The goal of this trial was to collect information about the performance and behavior of this contrivance that may be unique to the properties of the weak rope. For example, whether the two treatments (weak contrivance and traditional contrivance) would come apart in the same configuration.

Figure 3. Breaking testing machine from Test Resources used in trials (Sept 2021)

The weak contrivance we tested were constructed using 1,700-lb breaking strength 3/8" diameter weak rope from Rocky Mount Cordage Company and traditional strength 3/8" Esterpro by Polysteel Atlantic (Figure 4). This is the same weak rope and contrivance used in the gear encountered by the humpback whale calf. In January 2021 when the 3 tuck contrivance was initially tested on a machine in Maine, it broke at an average of 1,658 lbs, slight under the recommended 1,700 lbs.

Figure 4. 3 tuck weak contrivance tested in September 2021

After breaking 10 samples of the 3 tuck weak contrivance, the average breaking strength was 1,401 lbs (Table 1), a reduction of around 18% of the original 1,700 lb breaking strength of the weak rope. The average was also roughly 250 lbs lower than average breaking strength when this contrivance was previously tested in Maine in January 2021. This difference is likely due to the use of a different rope breaking machine in the initial testing and the fact that the sample were prepared by a different person. In 8 out of 10 samples of the weak contrivance tested in Sept 2021, the line parted within the 3 tucks of the weak rope and the weak rope fell out of the traditional (i.e. strong) rope eye splice after that. During testing, as the rope stretches the tension is placed most on the third tuck and the part of the line below it. This results in the weak contrivance breaking into two pieces (Fig. 5). The tag ends of the weak contrivance after breaking were stretched and frayed.

Figure 5. Broken weak contrivance after testing (Sept 2021)

The second portion of this case study involved testing the same contrivance configuration but with traditional breaking strength (i.e. strong) rope making up the entirety of the sample. The goal was to examine the breaking strength and contrivance behavior of the 3 tuck configuration without weak rope as an influencing factor and to determine if the 3 tucks represent a de facto weak 1,700 lb contrivance on their own.

10 samples of the "strong" contrivance were constructed with 3/8" Everson, which has a breaking strength of around 3,620 lbs (Figure 6). After breaking 10 samples of the 3 tuck "strong" contrivance, the average breaking strength was 3,176 lbs (Table 2), a reduction of around 12% of the original 3,620 lb breaking strength of the traditional "strong" rope. This is similar to the 18% loss in breaking strength caused by the contrivance in the weak rope. The behavior of the strong contrivance was also similar to the behavior of the weak contrivance when it parted – the tension was mostly observed on the third tuck and the line just below it. However, the major difference between the two sets of samples was that the strong contrivance broke at more than double the breaking strength of the weak contrivance. Based on this, we conclude that the method of attachment alone (3 tucks) was not the primary factor leading to the contrivance breaking at < 1,700 lbs.

Figure 6. 3 tuck “strong” contrivance tested in September 2021

In both treatments, the line parted at the same weak point, but the tension required for that break was determine by the breaking strength of the line used as the contrivance. The 3 tucks alone cannot serve as a weak contrivance, since the breaking strength of that contrivance will be a function of the breaking strength of the line used.

This trial confirms that the 3 tuck contrivance is an acceptable weak contrivance when constructed with 1,700 lb weak rope. The weakest point in the contrivance appears to be the 3 tucks, where the line parted most frequently. The same behavior was observed in the strong contrivance samples with the line parting at the 3 tucks.

It should be noted that the controlled conditions during break testing on the machine cannot fully simulate the conditions the buoy line and contrivances would be subjected to during an active entanglement, where the dynamic behavior of the whale will likely result in uneven force being exerted on the rope. However, in the case of the humpback whale entanglement, the contrivance exhibited characteristics similar to other contrivance samples tested by NMFS Gear Team (Figure 7). One end of the contrivance remained intact while the other parted during the entanglement. While the rope breaking machine is not large enough to test a full contrivance with traditional strength rope on both ends, the NMFS Gear Specialist has tested full length contrivances outside with a pick-up truck and found that one end of the contrivance always parts first. This is likely the result of slight variations in force, rope chemistry, and construction of the contrivance.

a. **b.**

Figure 7. Weak contrivance -3 tuck loop with Rocky Mount 1,700 lb rope; a. contrivance recovered from humpback whale entanglement on August 8, 2021; b. contrivance tested on NMFS rope breaking machine.

Table 1. Breaking strength of 3 tuck weak contrivance

Trial Number	Weak Rope	Strong Rope	Breaking Strength (lbs)
1	3/8" Red Rocky Mount	3/8" Esterpro	1446.8
2	3/8" Red Rocky Mount	3/8" Esterpro	1448
3	3/8" Red Rocky Mount	3/8" Esterpro	1423
4	3/8" Red Rocky Mount	3/8" Esterpro	1383.9
5	3/8" Red Rocky Mount	3/8" Esterpro	1451.9
6	3/8" Red Rocky Mount	3/8" Esterpro	1225
7	3/8" Red Rocky Mount	3/8" Esterpro	1353.2
8	3/8" Red Rocky Mount	3/8" Esterpro	1410.6
9	3/8" Red Rocky Mount	3/8" Esterpro	1434.6
10	3/8" Red Rocky Mount	3/8" Esterpro	1435
Average	3/8" Red Rocky Mount	3/8" Esterpro	1401.18

Table 2. Breaking strength of 3 tuck strong contrivance

Trial Number	Weak Rope	Strong Rope	Breaking Strength (lbs)
1	3/8 Everson	3/8 Everson	3251
2	3/8 Everson	3/8 Everson	3206.2
3	3/8 Everson	3/8 Everson	3062.5
4	3/8 Everson	3/8 Everson	3108.7
5	3/8 Everson	3/8 Everson	3201.8
6	3/8 Everson	3/8 Everson	3015
7	3/8 Everson	3/8 Everson	3317.7
8	3/8 Everson	3/8 Everson	3279.2
9	3/8 Everson	3/8 Everson	3279.1
10	3/8 Everson	3/8 Everson	3042.3
Average	3/8 Everson	3/8 Everson	3176.35

Conclusions

The weak contrivance inserted in the buoy line that was involved in the humpback whale calf entangled on August 8, 2021 worked as it was intended to. The buoy line parted at the weak contrivance allowing the whale to become disentangled and shed the gear. Subsequent laboratory testing confirmed that the characteristics of the weak contrivance involved in the entanglement were consistent with the characteristics of weak contrivances tested in the laboratory. The weak contrivances (3 tuck loop using Rocky Mount weak rope) tested on the NMFS rope breaking machine consistently (8/10) broke within the 3 tuck loop and broke at < 1,700 lbs in all cases. Our testing also confirmed that the breaking strength of the material used to make the weak contrivance is critical. 3 tuck loops constructed of standard rope used in commercial lobster fishing consistently broke > 3,000 lbs. While this entanglement case only provides us with 1 in situ observation on the effectiveness of weak contrivances, we are cautiously optimistic of their potential effectiveness.