LESSONS LEARNED FROM EAST COAST AND RECENT PACIFIC NORTHWEST ENTANGLEMENTS FROM FORENSIC REVIEWS
Images taken by the Center for Coastal Studies in Provincetown (unless otherwise credited)

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Large Whale Entanglement Response Network in the Pacific Northwest

Network Overseen by NOAA Fisheries:

~Twenty responders and equipment from six main organizations:

Source: NMFS NW Stranding Program
Reported Entanglement by Year 1994-2018 in WA & OR

- Humpback whale
- Gray whale
- Fin whale
Data and other information recorded from entanglements include:

- Sightings Data during responses
  - especially important for Permit Report to record number of takes
    (Jenn will talk more about this)
- Data collected during entanglement responses
  - Data about the response
  - responders
  - entangling gear and configuration on whale
  - wounds
  - whale health
  - behavior
  - samples
- Documentation of gear removed from entangled whales
- Chain of custody for gear removed from entangled whales
Second IWC Workshop – Welfare Issues Associated with the Entanglement of Large Whales with a Focus on Entanglement Response

- Provincetown, MA October, 2011
- 23 participants from 10 countries
- Topics Included
  - New tools and techniques
  - Documentation of entanglements and responses
  - Communication and Outreach
  - Principles and Guidelines for Entanglement Response

https://iwc.int/document_2636.download
Multiple forms could be filled out for a particular case with one for each response.
Entanglement Response Form

Basic Information about Response recorded in a systematic way:

- Team Roles
- Timeline
- Outcome of the Event
- Anchored / Free Swimming
- Gear Type
## Entanglement Response Form

<table>
<thead>
<tr>
<th>INDIVIDUAL ID:</th>
<th>OUTCOME</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DX</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GEAR AND WOUND DETAILS</th>
<th>MOUTH</th>
<th>HEAD</th>
<th>BODY</th>
<th>LEFT FLIPPER</th>
<th>RIGHT FLIPPER</th>
<th>PEDUNCLE</th>
<th>TAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gear Wrapping (Yes / No / Unk)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rope color/size</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gear Constricting (Yes / No / Unk)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tissue Penetration (Epidermis only, Blubber, Muscle, Bone, Other for flippers and tail record % penetration)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wound profile</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flat, Depressed, Raised,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wound color</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1=white, yellow</td>
<td>2 = red/pink</td>
<td>3=green/blue/black</td>
<td>4=unk</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Gear Configuration and Wounds Associated with Each Body Part
## Entanglement Response Form

<table>
<thead>
<tr>
<th>WHALE ACTIVITY TIMELINE</th>
<th>ENERGY</th>
<th>BEHAVIOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>Average</td>
</tr>
<tr>
<td>Pre-approach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At First Approach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>During Disentanglement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At Release</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post Release</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Entanglement Response Form

<table>
<thead>
<tr>
<th>Whale Movement</th>
<th>Stationary</th>
<th>Circling</th>
<th>Travel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whale Posture</td>
<td>Normal</td>
<td>Hunched</td>
<td>Head Raised</td>
</tr>
<tr>
<td>Role (if applicable)</td>
<td>none</td>
<td>mother</td>
<td>other: ____________________</td>
</tr>
<tr>
<td>Body Condition</td>
<td>normal</td>
<td>thin</td>
<td>emaciated</td>
</tr>
<tr>
<td>Estimated Whale Length</td>
<td>ft</td>
<td>m</td>
<td>Class</td>
</tr>
<tr>
<td>Odor Detected (Description if Yes)</td>
<td>Breath</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Skin Condition (for species)</td>
<td>Normal</td>
<td>Pale</td>
<td>Sloughing</td>
</tr>
<tr>
<td>Cyamid Proliferation</td>
<td>Normal</td>
<td>At Wounds</td>
<td>At Blowholes</td>
</tr>
<tr>
<td>Other Condition Details</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Whale Movement, Posture, Body Condition, Odors, Skin and Cyamid Load
Entanglement Response Form

<table>
<thead>
<tr>
<th>BIO SAMPLES ATTAINED</th>
<th>None</th>
<th>Biopsy</th>
<th>Sloughed Skin</th>
<th>Skin From Gear</th>
<th>Scat</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>OTHER DATA COLLECTED</td>
<td>Photos</td>
<td>Video</td>
<td>Ventilation Rates</td>
<td>Detailed Ethology</td>
<td>Veterinary Procedures</td>
<td>Rescue Boat Behaviour</td>
</tr>
</tbody>
</table>

Samples and Other Data Collected
Entanglement Response Form is useful for:

- Identifying characteristics of entangled whales such as:
  - Preliminary analysis shows energy post release is linked to survival

- Responder advancement by recording participation and roles for each response

- Characterizing gear involved in entanglements

- Configuration of gear on the whale and wounds on each body part

- Recording samples collected during responses

- Comparing characteristics of energy, behavior, entanglement configuration, etc among multiple responses
Documentation of gear collected from entangled whales

**knots, splices, seizings, etc**

<table>
<thead>
<tr>
<th>Gear Documentation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CASE NUMBER:</strong></td>
</tr>
<tr>
<td><strong>SPECIES / INDIVIDUAL:</strong></td>
</tr>
<tr>
<td><strong>DATE COLLECTED:</strong></td>
</tr>
<tr>
<td><strong>LOCATION COLLECTED:</strong></td>
</tr>
<tr>
<td><strong>DATE ANALYSED:</strong></td>
</tr>
<tr>
<td><strong>PERSONNEL INVOLVED:</strong></td>
</tr>
<tr>
<td><strong>DESCRIPTION:</strong></td>
</tr>
</tbody>
</table>

**Photos (use an SLR):**

- [ ] All gear collected in one frame
- [ ] Gear laid out as found on shelf (if applicable)
- [ ] Buoy (color, number, vessel number)
- [ ] Tags (color, number, vessel number)
- [ ] Weak links

**Gear Marking Scheme (if applicable):**

- [ ] S3 Flags
- [ ] S3 Cues
Documentation also includes:

Cuts, knots and grapple placement marks made by response team – labelled during analysis

Each line type, buoy, trap, buoy numbers and other gear present

Bitter ends
Gear collected from entangled gray whale – April 13, 2018

knots caught in baleen?
Direct line between first entanglement report and location of gear set – based on interview with fisherman.
On the east coast each gear set removed from an entangled whale is documented by responders and passed along to NOAA Fisheries for analysis and long-term storage to provide for later analysis.
Annual Report by NMFS

- Information from population biologists
- data collected by responders
- data from gear analysis
- interviews with fishermen

www.greateratlantic.fisheries.noaa.gov/protected/whaletrp/
Spinnaker
Entanglement

2015 Atlantic Large Whale Entanglement Report

Prepared by:
David Norin, Glenn Sylvestor, John Higgins, and Mark Motos
National Marine Fisheries Service
Office ofアイアラノミソロジー
Pinniped Resource Division
65 Great Republic Drive
Glocestn, MA 01930-2539

NMFS No.
E04-15

Initial Status
Alive

Subsequent Status
Deceased
(as of the date the NMFS report
was completed)

Date First Observed Entangled
5/14/2015

Species
Humpback

Individual ID
Spinnaker

Location First Observed Entangled
77.2 NM east of Portsmouth, NH

Latitude/Longitude First Observed Entangled
43° 01.50'N 68° 57.50'W

Event Description
5/14/2015
- NEFSC aerial survey located the animal and stood by until the
  CCS team could arrive. The whale was essentially immobile
  and had a very complex entanglement with a heavy amount of
gear suspended below. The CCS team managed to remove
most of the gear but some gear remained in the mouth.
6/11/2015
- Whale found deceased. Gear, from the 2014 case, was
  severely embedded in the mouth. No gear from the 2015 case
  was found on the animal.

Description of Gear on Whale as Reported
A. During Initial Sighting

B. Subsequent Descriptions

C. Diagram of Entangling Gear on Whale

Description of Wounds/Condition
A. During Initial Sighting

B. Subsequent Descriptions

Sighting prior to entanglement
Yes, consult CCS

Re-sightings Post-entanglement
None

Life History Information
Adult female

NMFS Serious Injury/Mortality Determination
Human-induced injury (2015 case)
# FISHERY INTERACTION GEAR ANALYSIS

<table>
<thead>
<tr>
<th>NMFS No.</th>
<th>ED4-15</th>
<th>Date First Observed</th>
<th>5/14/2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field No.</td>
<td>PR 51415 Mtn</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location First Observed</td>
<td>77.2 NM east of Portsmouth, NH 43°01.5' N, 68°57.6' W</td>
<td>Type of Event - Observation, Disentanglement, Stranding. Other (describe)</td>
<td>Disentanglement</td>
</tr>
<tr>
<td>Species</td>
<td>Humpback</td>
<td>Gear Recovered (y/n)</td>
<td>Yes</td>
</tr>
<tr>
<td>Individual ID</td>
<td>Spinnaker</td>
<td>Gear Analysis Conducted (y/n)</td>
<td>Yes</td>
</tr>
</tbody>
</table>

## GEAR DESCRIPTION / ANALYSIS

<table>
<thead>
<tr>
<th>Date Gear Retrieved</th>
<th>5/14/2015</th>
<th>Gear Retrieved By</th>
<th>CCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date Gear Received</td>
<td>May 2015</td>
<td>Received From</td>
<td>CCS</td>
</tr>
<tr>
<td>Sources:</td>
<td></td>
<td>Date Lost</td>
<td>Unknown</td>
</tr>
<tr>
<td>USCG</td>
<td>Photographs and recovered gear</td>
<td>Location</td>
<td>Unknown</td>
</tr>
<tr>
<td>CCS</td>
<td>Date Lost</td>
<td>Location</td>
<td>Unknown</td>
</tr>
<tr>
<td>Fisherman</td>
<td></td>
<td>Address</td>
<td>Unknown</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>Bottom Type</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

**Gear Type:** Lobster gear, gillnet gear and unknown line

**Target Species:** Lobster

**Gear Description:** 3 lobster traps recovered from a 10 pot trawl. Gillnet gear of unknown fishery and origin.

**Comments:** After viewing photographs of recovered gear, owner stated he had not fished the recovered traps in well over a year. Multiple lines of unknown fisheries and origin were also present. Recovered approximately 280' of 3/8" line and 20' of 1/4" line.

**Conclusions:** Whale was entangled in 3 traps of what was originally set as a 10 pot trawl. Animal had 3/8" sinking ground line in the mouth. A small portion of gillnet from the 2014 case was also documented in the mouth. Associated unknown lines were also involved in various portions of the entanglement.

**Report By:** Glenn Salvador | Date: 2/4/2017 | Current Location of Gear | NOAA Narragansett, RI
Surface Buoy Marking

SURFACE BUOYS ARE TO BE MARKED WITH:

Markings to help identify the associated vessel or fishery by including one of the following:
- The owner's boat registration number and/or US vessel documentation number;
- Federal commercial fishing permit number; or
- Whatever positive identification is required by the vessel's home-port state.

When marking is not already required by state or federal regulations, the letters and numbers must meet the following requirements:
- At least 1-inch (2.5cm) in height;
- Block letters or Arabic numbers; and
- In a color that contrasts with the color of the buoy.

Buoy Line Marking:

BUOY LINES ARE TO BE MARKED WITH:

THREE 12 inch (30.48 cm) colored marks:
- One at the top of the buoy line;
- One midway along the buoy line, and
- One at the bottom of the buoy line.

If the mark consists of two colors, EACH COLOR mark may be 6-inches for a TOTAL MARK of 12-inches.

Each color code must be permanently affixed on or along the line and each color code must be clearly visible when the gear is hauled or removed from the water.

Additional information on gear marking techniques can be found in Supplement C. Gear Marking.
### Trap/Pot Gear Marking - All Regions (Continued)

<table>
<thead>
<tr>
<th>Gear Marking Color</th>
<th>Applicable Trap/Pot Management Area</th>
</tr>
</thead>
</table>
| **RED**            | - Massachusetts Restricted Area  
                      - Northern Nearshore Trap/Pot Waters  
                      - Northern Inshore State Trap/Pot Waters  
                      - Stellwagen Bank Jeffreys Ledge Restricted Area  
                      - Great South Channel Restricted Area overlapping Lobster Management Area (LMA) 2 and/or the Outer Cape (OC) LMA. |
| **ORANGE**         | - Southern Nearshore Trap/Pot Waters. |
| **BLACK**          | - Offshore Trap/Pot Waters; Great South Channel Restricted Area overlapping with the LMA 2/3 Overlap and/or LMA 3 |
| **BLUE & ORANGE**  | - Southeast Restricted Area North-state waters |
| **GREEN & ORANGE** | - Southeast Restricted Area North-Federal waters |
| **RED & BLUE**     | - Min. trap per trawl exempt RI state waters (singles) |
| **RED & WHITE**    | - Min. trap per trawl exempt MA state waters in LMA 1 (singles) |
| **RED & BLACK**    | - Min. trap per trawl exempt MA state waters in LMA 2 (singles) |
| **RED & YELLOW**   | - Min. trap per trawl exempt MA waters in Outer Cape (singles) |
| **RED & PURPLE**   | - Jordan Basin (Trap/Pot) overlapping LMA 1 |
| **BLACK & PURPLE** | - Jordan Basin (Trap/Pot) overlapping Offshore Trap/Pot Waters |
| **RED & ORANGE**   | - Isle of Shoals group, Maine |
| **RED & GREEN**    | - Jeffreys Ledge (Trap/Pot) |
Two recent papers that utilize gear collected from entangled whales
Drag from fishing gear entangling North Atlantic right whales

Julie M. van der Hoop, Peter Corkeron, John Kenney, Scott Landry, David Morin and Jamison Smith
Abstract

Lethal and sublethal fishing gear entanglement is pervasive in North Atlantic right whales (*Eubalaena glacialis*). Entanglement can lead to direct injury and is likely to incur substantial energetic costs. This study (1) evaluates drag characteristics of entangled right whales, (2) contextualizes gear drag measurements for individual whales, and (3) quantifies the benefits of partial disentanglement. A load cell measured drag forces on 15 sets of fishing gear removed from entangled right whales, a tagged satellite telemetry buoy, and 200 m of polypropylene line as it was towed behind a vessel at 0.77, 1.3, and 2.1 m/s (~1.5, 2.5, and 4 knots) and ~0.3, and 6 m depth. Mean drag ranges from 8.5 N to 315 N, and can be predicted from the dry weight or length of the gear. Combining gear drag measurements with theoretical estimates of drag on whales’ bodies suggests that on average, entanglement increases drag and propulsive power by 1.47 fold. Reducing trailing line length by 75% can reduce parasitic gear drag by 85%, reinforcing current disentanglement response practices. These drag measurements can be incorporated into disentanglement response, serious injury determination, and evaluation of sublethal effects on population dynamics.

Key words: whale, fisheries, rope, thrust, line, drag coefficient, energetics.

- study estimated the normal drag characteristics of right whales
- a load cell measured drag from
  - 15 gear sets removed during disentanglements
  - line and standard telemetry buoy as they were towed behind a vessel at various speeds
SUMMARY

• Drag forces ranged over two orders of magnitudes

• Drag coefficients ranged over four orders of magnitude

• Small entanglements can still impart significant drag

• Gear configurations with multiple floats and buoys have especially high drag

• Reinforces the practice of adding telemetry buoy at one body length behind whale

• Recovering gear from entangled whales, documenting and storing for future analysis can have significant benefit
Effects of fishing rope strength on the severity of large whale entanglements

Amy R. Knowlton,* † Jooke Robbins,† Scott Landry,† Henry A. McKenna,‡ Scott D. Kraus,* and Timothy B. Werner* §

*New England Aquarium, Central Wharf, Boston, MA 02110, U.S.A.
†Center for Coastal Studies, 5 Holway Avenue, Provincetown, MA 02657, U.S.A.
‡55 Hubbard Road, Westport, MA 02790, U.S.A.
§Department of Biology, Boston University, 5 Cambridge Mall, Boston, MA 02215, U.S.A.

Abstract: Entanglement in fixed fishing gear affects whales worldwide. In the United States, deaths of North Atlantic right (Eubalaena glacialis) and humpback whales (Megaptera novaeangliae) have exceeded management limits for decades. We examined live and dead whales entangled in fishing gear along the U.S. East Coast and the Canadian Maritimes from 1991 to 2010. We recorded whale species, age, and injury severity and determined rope polymer type, breaking strength, and diameter of the fishing gear. For the 132 retrieved ropes from 70 cases, tested breaking strength range was 0.89–39.63 kN (8.9–400 lbs) and the mean was 11.54 kN (SD 8.29), which is 26% lower than strength at manufacture (range 2.89–53.38 kN; mean = 15.70 kN [9.80]). Median rope diameter was 9.5 mm. Right and humpback whales were found in ropes with significantly stronger breaking strengths at time of manufacture than hake whales (Balanoglossus aculeatus) (19.50, 17.13, and 10.47 mean kN, respectively). Adult right whales were found in stronger ropes (mean 34.00 kN) than juvenile right whales (mean 15.53 kN) and than all humpback whale age classes (mean 17.37 kN). For right whales, severity of injuries increased since the mid 1990s, possibly due to changes in rope manufacturing in the mid 1990s that resulted in production of stronger ropes at the same diameter. Our results suggest that broad adoption of ropes with breaking strengths of ≥7.56 kN (≥1.709 lbf) could reduce the number of life-threatening entanglements for large whales by at least 72%, and yet could provide sufficient strength to withstand the routine forces involved in many fishing operations. A reduction of this magnitude would achieve nearly all the mitigation legally required for U.S. stocks of North Atlantic right and humpback whales. Ropes with reduced breaking strength should be developed and tested to determine the feasibility of their use in a variety of fisheries.

Keywords: bycatch, humpback whales, injury severity, North Atlantic right whales, rope diameter, rope manufacturing
132 rope specimens from 70 entangled whales were archived by NMFS at a warehouse in Rhode Island.

Rope characteristics were analyzed and compared to characteristics of entanglement (species, injury severity, outcome)

Includes supplementary material including case study examples and rope analysis techniques
KEY RESULTS

- 71% had diameters of 5/16”, 3/8”, or 7/16”
- Majority of ropes were in good to very good shape (70%)
- Ropes in poor shape were polypropylene or polypro blend.
- Ropes that entangled right and humpback whales had higher breaking strengths than ropes that entangled minke whales
- Utilizing ropes with breaking strength less than 7.5 kN (1700 lbs-force) in fixed gear fisheries could reduce the probability of mortality and suffering by at least 72%.
Summary

• documentation is a key component entanglement response towards prevention of entanglements

• collection, documentation and analysis of gear leads to insights into where, when and how whales became entangled

• documentation of the individual whale is important towards understanding of:
  • the ultimate outcome for the individual
  • effect of entanglement on different populations
Thank you