On-Call Buoy
Bottom-Stowed Line Spool

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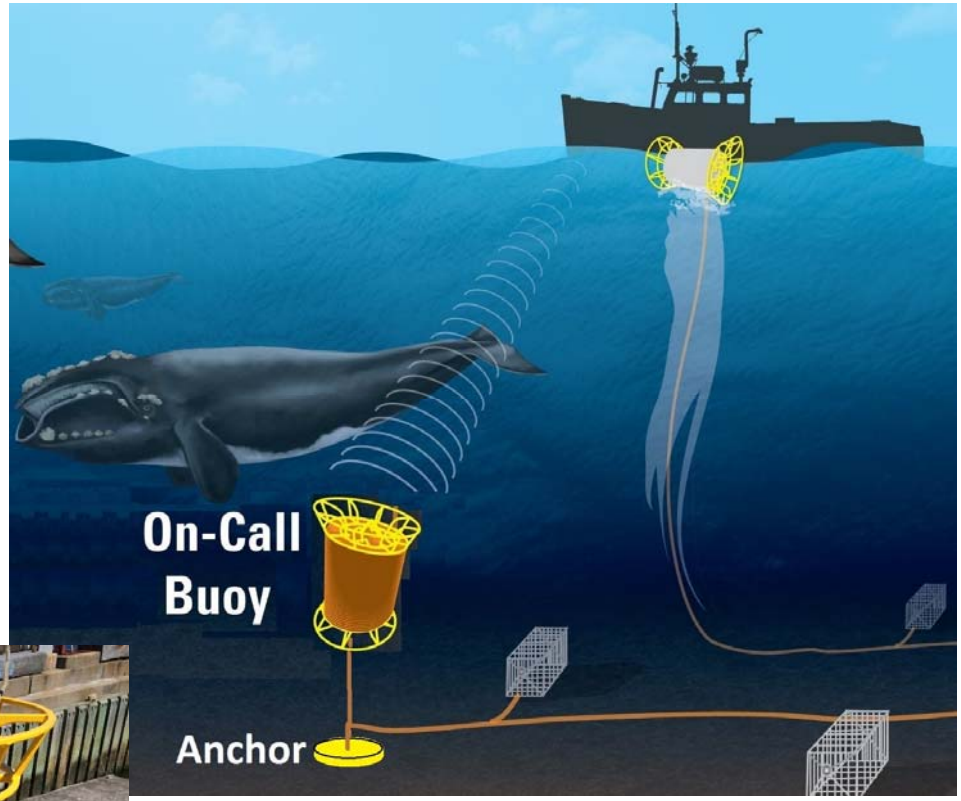
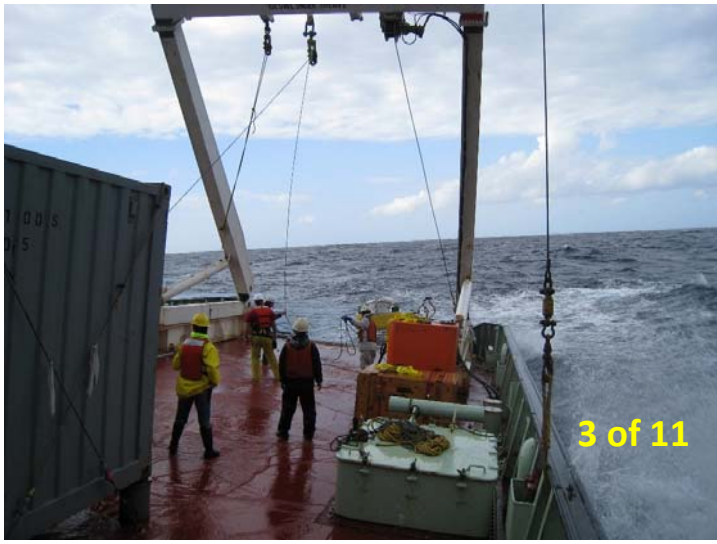
Outline of Presentation

- WHOI Acoustic Communication Group.
- Problem and Design Space.
- Bottom-Stowed Line Spool Design:
  - Flotation, acoustic commands, re-spooling.
- Testing Status.
- Conclusions and Next Steps.



WHOI Acoustic Communication Group

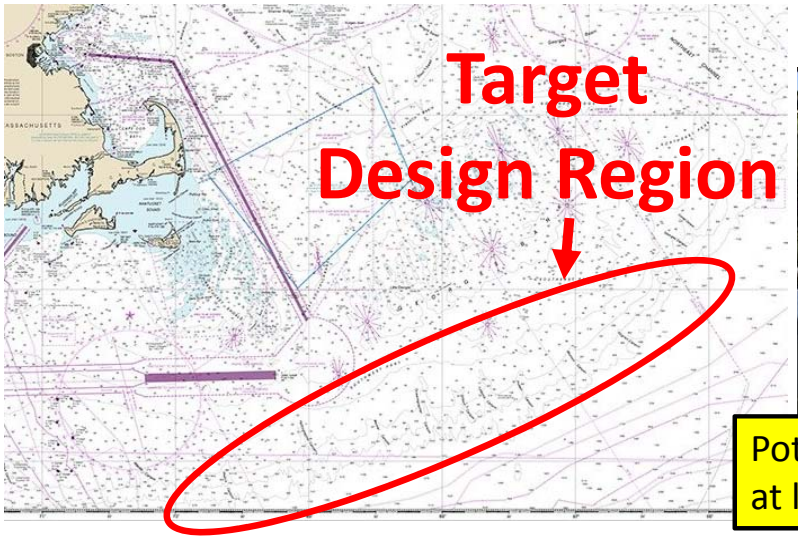
- Engineering expertise is ***underwater acoustic communication systems***.
- Extensive field deployments over 20 years, with hundreds of autonomous vehicles, buoys, and seafloor sensors.
- Manufactured several thousand underwater acoustic modems (WHOI Micromodem), for military, academic, and industrial customers.



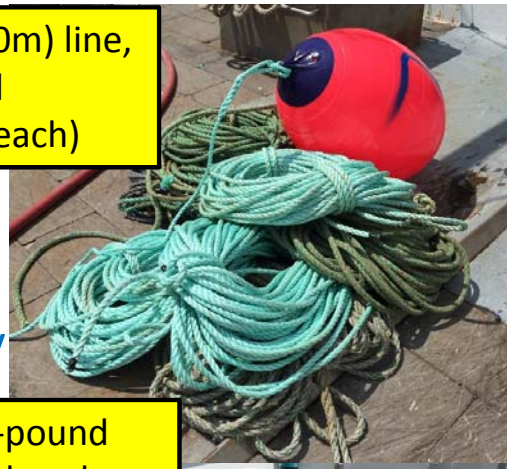
Problem and Design Space

- *Southern New England far offshore lobster fishery*
  - Near Gulf Stream – **strong currents** and surface layers.
  - Near canyons and shelf break – **deep** & rapidly changing bathymetry
  - Existing gear uses 150-180 lb flotation, scope up to 3x.
  - *Weak ropes & weak links not viable with heaviest offshore gear.*

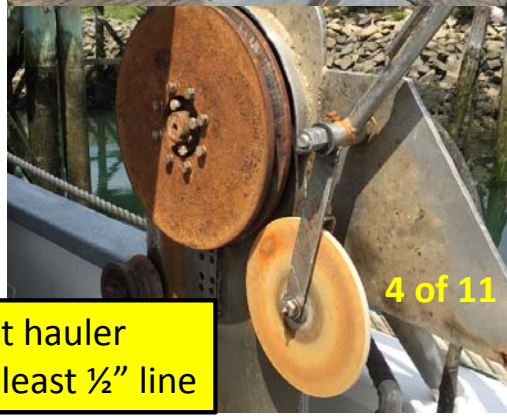
- *Try to Minimize Impact on Fishermen:*
  - Use existing ropes and haulers.
  - Similar sizes and weights to existing offshore gear:
    - 100-pound loaded traps, 180-pound anchors.
  - Quick turnaround on site.



300 fathoms (600m) line,
1 of 2 floats used
(90 lb buoyancy each)



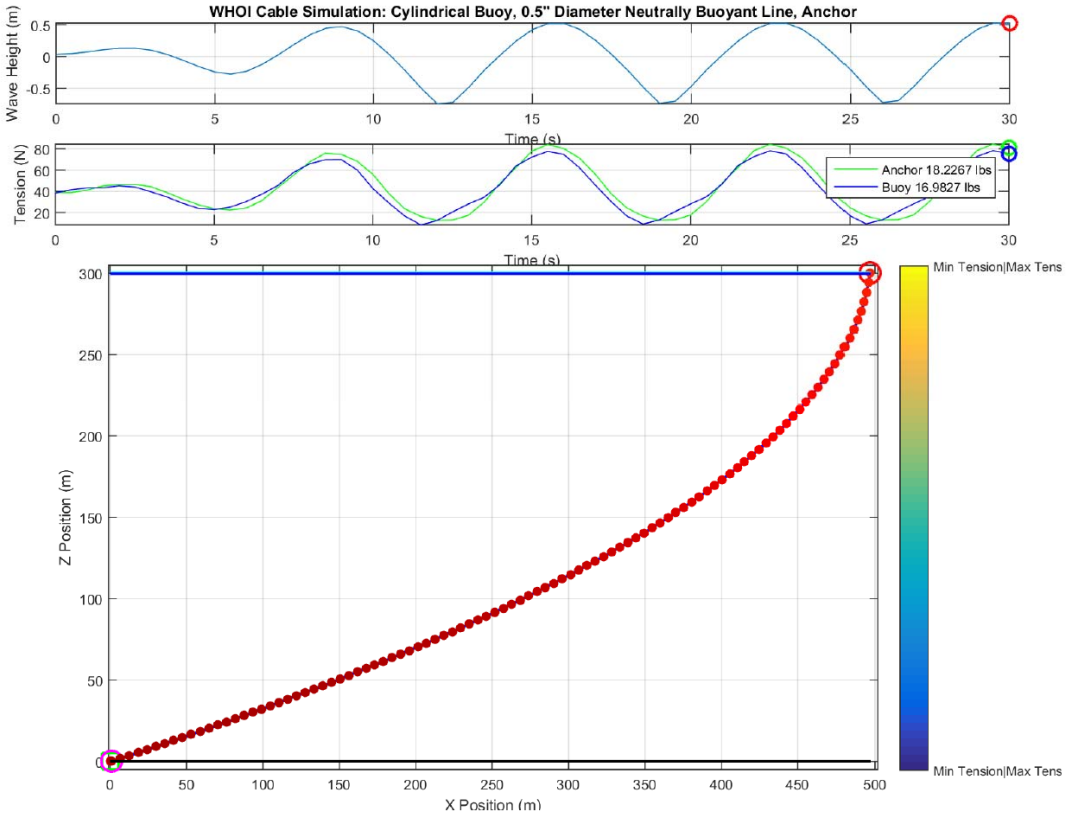
180-pound
trawl anchors



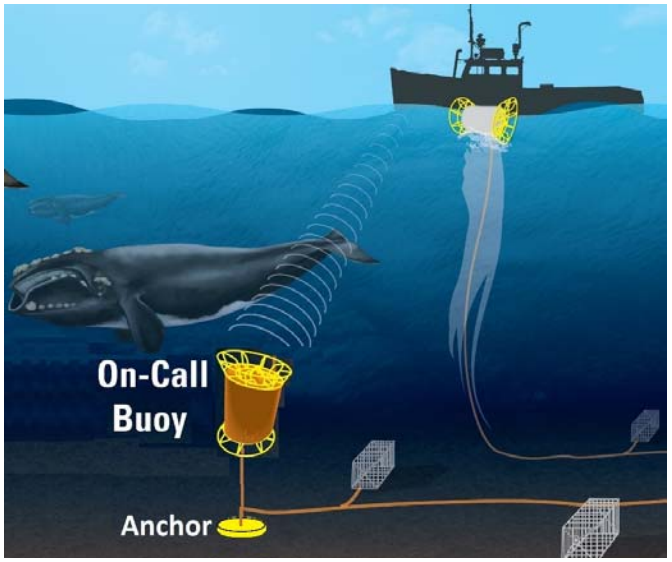
Pot hauler
at least ½" line

Design: Modeling of Mooring System

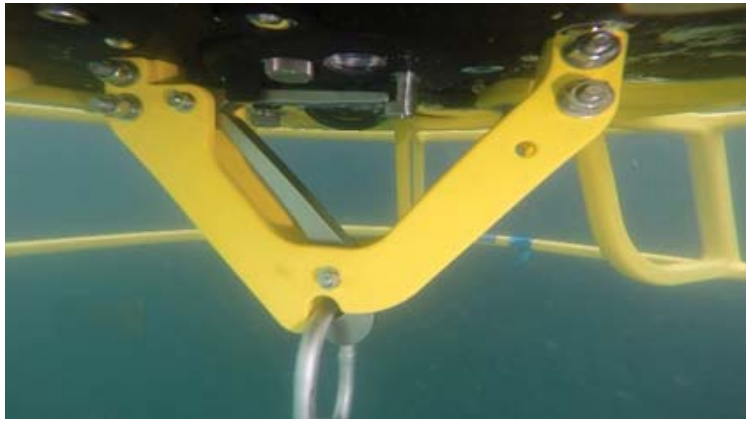
- WHOI CABLE: Used to model the mooring from known water currents, water depth, and line diameters to determine the appropriate amount of flotation required to remain on surface.
  - Correlated nicely with existing gear being utilized.
  - 2-3x water depths for line length
  - Line spool/cartridge since random-pack line bags more likely to foul with 500m-900m of line



Design: Acoustics and Release



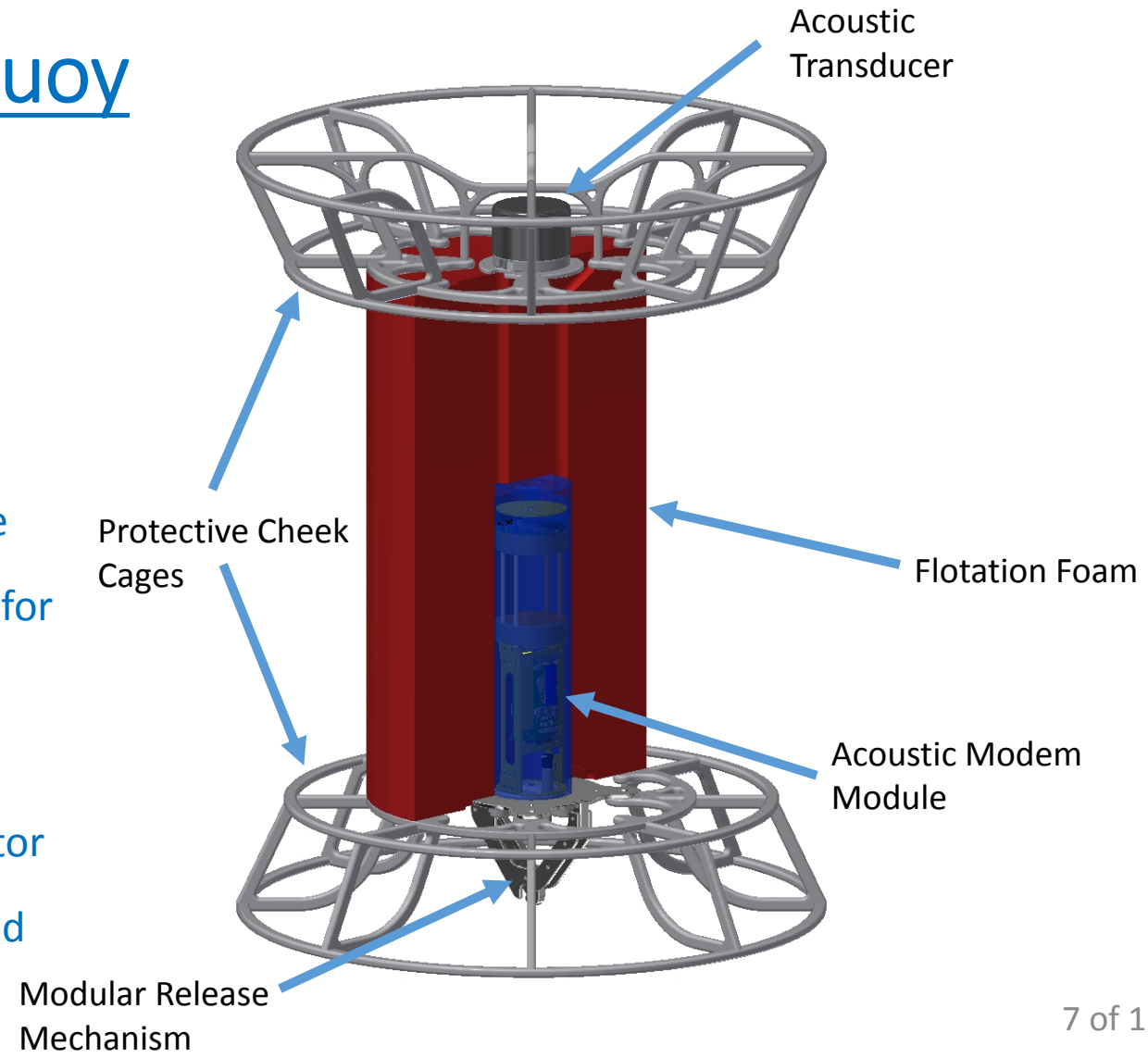
- **On-Call Acoustic Release:**
  - Secure, unique IDs *plus general data payloads*.
  - Multiple levels of access:
    - **Gear conflict** queries from any vessel:
      - Location, Orientation, Length of trawl – integrate with chart plotters
    - **License verification** queries by regulators.
    - **Authenticated release commands** only from owner.
    - Other status information for owners – eventually trap occupancy photos?
- **Electronics can actuate many types of releases:**
  - Lever-Arm Releases:
    - Motor-driven (our prototype)
    - Solenoids
    - Burn wires
  - Compressed-Gas Relays



Release Detail

Design: On-Call Buoy

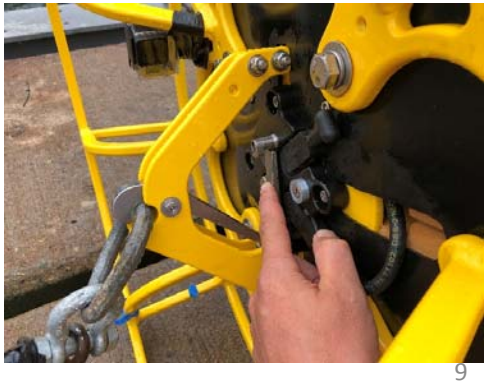
- Scalable Design
  - Packaging reduces in size with
    - shallower water depths
    - lesser currents
    - smaller line diameters
- Modular Design
  - Acoustic modem module can be transplanted
  - Foam core can be swapped out for different sizes
  - Release mechanism leverage reconfigured for different loads
- Rechargeable Batteries
  - Charge through endcap connector
  - Increased reliability via reduce number of time housing serviced



Design: Pre-Wound Line Cartidges

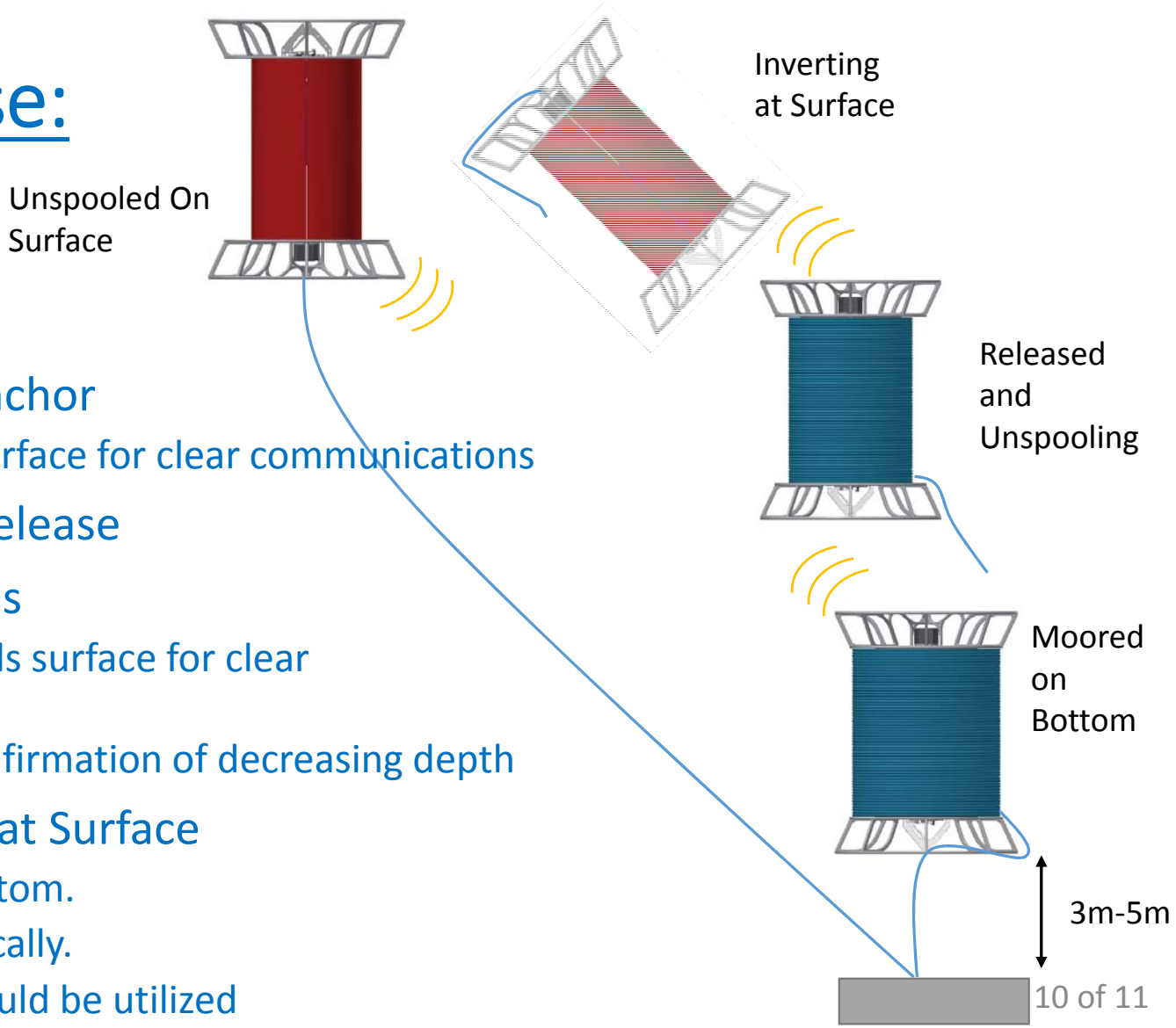
- Pre-wound self-supporting line cartridge to minimize time resetting at sea.
  - Line is held together with a mastic, no reel required
- **Linen service model** for providing reliable, inspected line cartridges
  - Crew places order for cartridges of lengths for deployment area
  - Service provider delivers fresh cartridges
  - Service provider takes away recovered line
  - Service provider inspects line and rebuilds cartridges
- Quick 15 min turn around at-sea.
- Recovered line from trawl stored as figure 8 in ship's hold or in 50 gallon plastic drums

Example Cartridge Reload and Release Reset

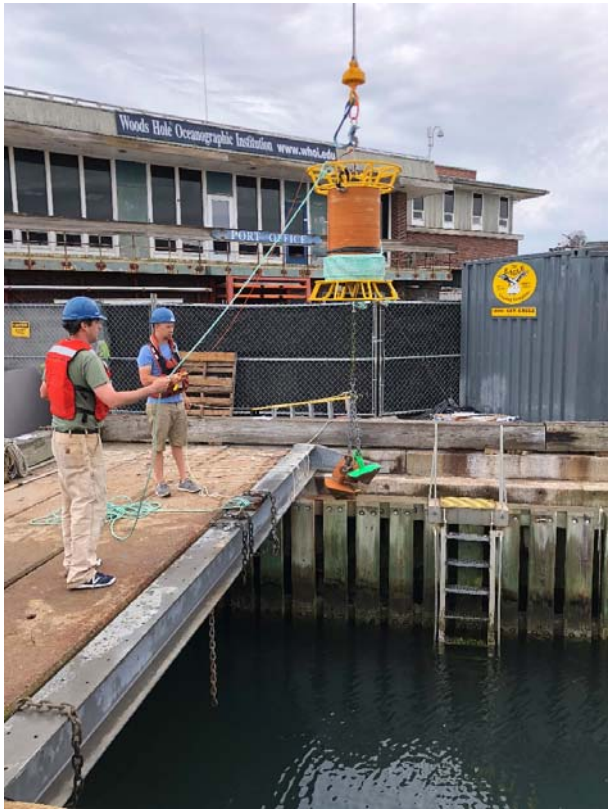


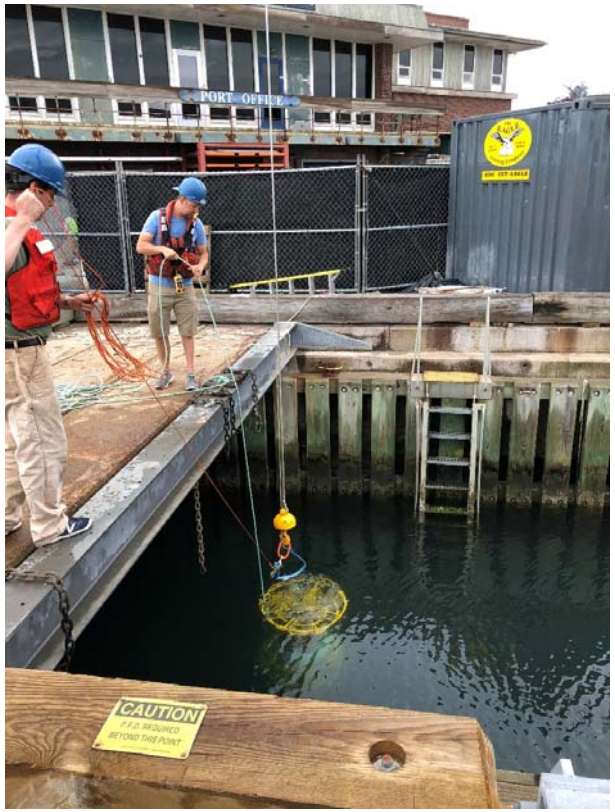
Stages of Release:

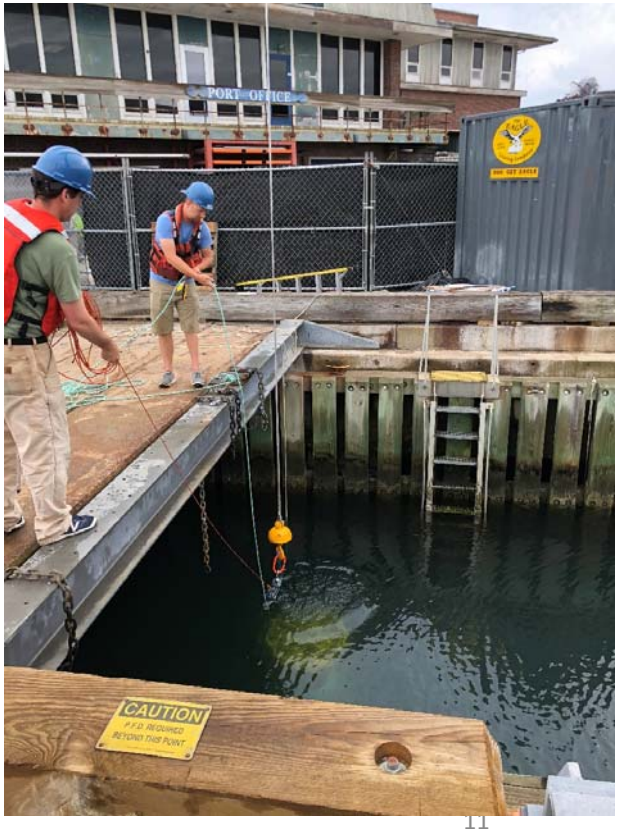
- On-Call Buoy Floats Above Anchor
  - Transducer pointed towards surface for clear communications
- Acoustic Signal Received to Release
- System Releases and Unspools
  - Transducer still pointed towards surface for clear communications.
  - Acoustic ranging allows for confirmation of decreasing depth
- System Unspools and Inverts at Surface
  - Transducer points towards bottom.
  - Surface ship can range acoustically.
  - RF beacons or Light Strobes could be utilized



Example Dock Test Deployment





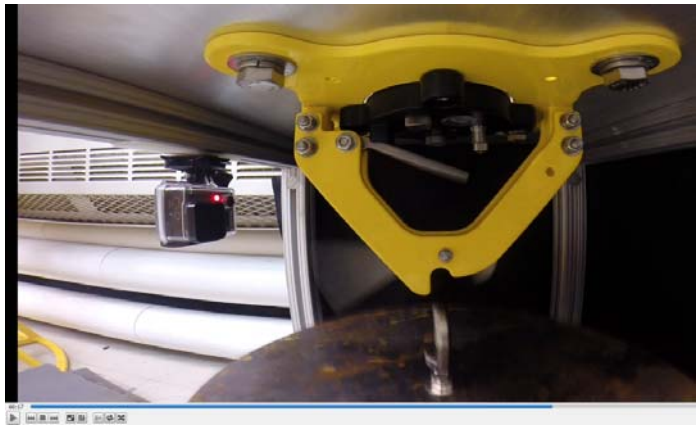


Example Dock Test Deployment

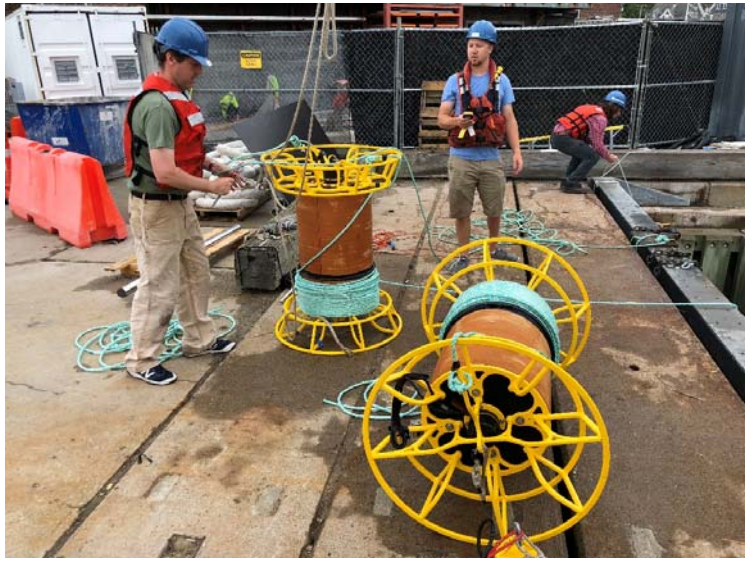
Testing Status

- 100’s of lab-based tests to optimize release mechanism and controller code.
- 30+ shallow water releases on the dock using prototype line cartridges.
- Future at-sea test in deeper water planned for 2019.

Benchtop Testing:



Dock Testing:



Conclusions and Next Steps

- *Robust acoustic communication*:
  - authenticate release commands, reduce gear conflict.
- *Line Spool Approach*:
  - robust line payout even with up to 500m-900m of line.
- *Pre-Spooled Line Cartridge*:
  - quick turn-around at sea while maintaining robustness.
- *Modular design*:
  - scales *much smaller* for *smaller line diameter*, shallower water, and lower currents.
- **Line diameter is critical** (drag/flotation, spool size, hauler compatibility, injuries to fishermen, entanglement lethality, abrasion tolerance, overall system cost).
- Planning for preliminary at-sea tests in late 2018.

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End of Presentation

Modular Core: Release Mechanism and Electronics

Modular core allows straightforward scaling to shallower water and lower currents.

Core contains:

- Electronics (acoustic modem and release actuation).
- Release Mechanism and Lever Arms.
- Rechargeable Battery (currently sized for ~4-6 months).
- Pictured housing is 18” x 4.5” diameter.

- Smaller batteries and higher acoustic carrier frequency would yield a smaller core pressure housing.

- Can be quickly adapted for other line storage and release methods:
  - Line spool, random-pack line canister/bag, lift bags.
  - Lever-Arm releases (motor, solenoid, burn-wire); compressed gas relay.

Line Cartridge Winding Fixture

Line cartridges need to be wound carefully to ensure robustness of release.

Winding fixture features:

- Fits standard oceanographic line-winding carts.
- Demonstrates manufacturability of pre-spooled line cartridges as potential shore-side industry.
- Feasibility of line-cartridge re-spooling machine on fishing vessel?

Line Cartridge Prototype

Sign for Line Spool Prototype

Far Offshore Design Prototype:

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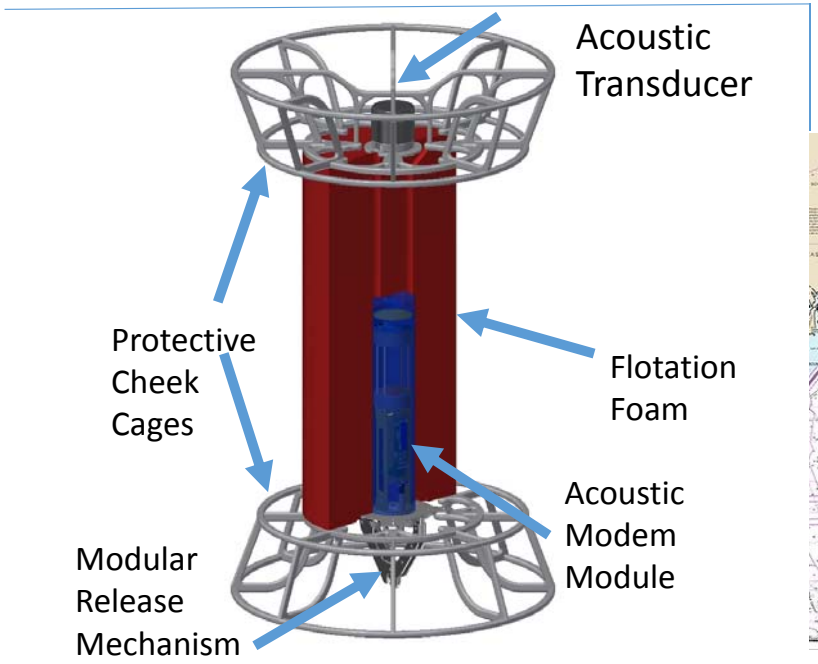
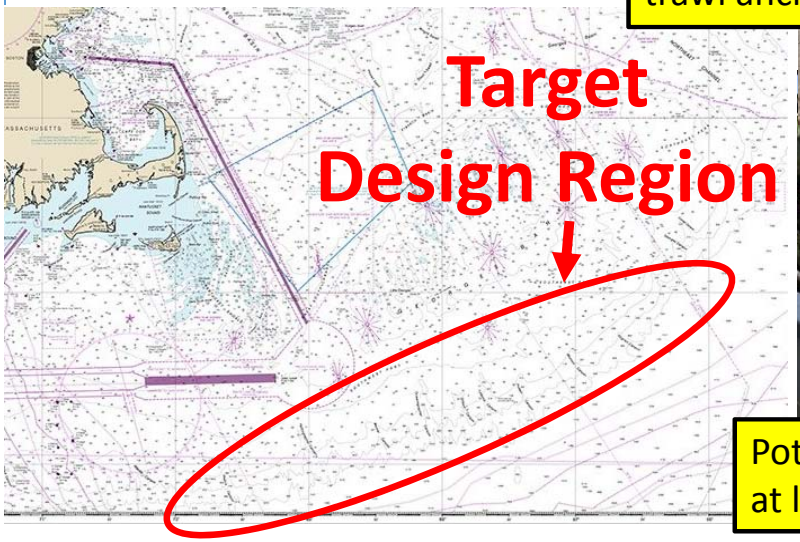
  - Existing gear uses 150-180 lb flotation, scope up to 3x.
  - Scales *much smaller* for *smaller line diameter*, water depth, currents





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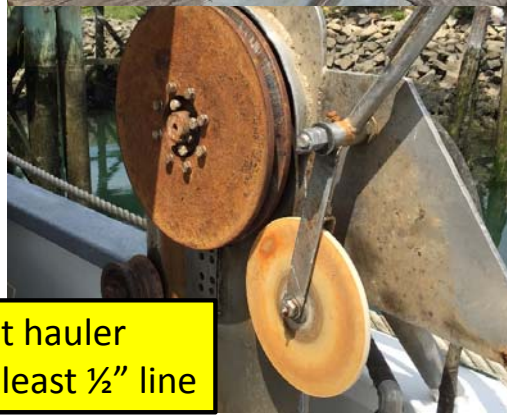

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