Estimates of sea scallop incidental mortality from AUV-based BACI surveys

Danielle Ferraro[1], Art Trembanis[1], David Rudders[2], Doug Miller[1]

[1]School of Marine Science and Policy, University of Delaware
[2]Virginia Institute of Marine Science

Working Group Data Meeting– 2018 Feb 8

UNIVERSITY OF DELAWARE

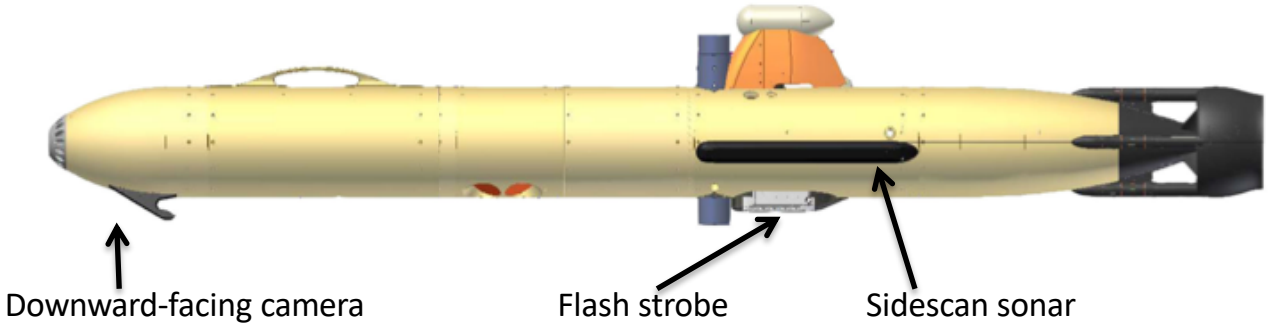
Overview

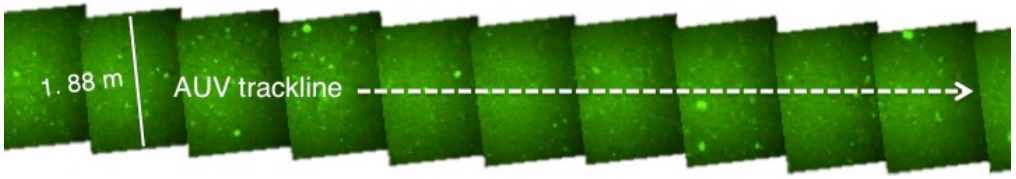
Study objective: to estimate incidental mortality (IM) of uncaptured scallops using an autonomous underwater vehicle

- Part 1 – RSA 2014-2015
  - Estimate IM and compare to values currently used
    Effect of substrate and tow intensity (1 vs. 5 tows)
- Part 2 – RSA 2017-2018
  - Size-selective IM rates

Gavia autonomous underwater vehicle

- ~3 hour battery life, 500 m depth rating
- Precise navigation enables replicate surveys
- Point Gray Grasshopper digital camera and Marine Sonic side-scan sonar

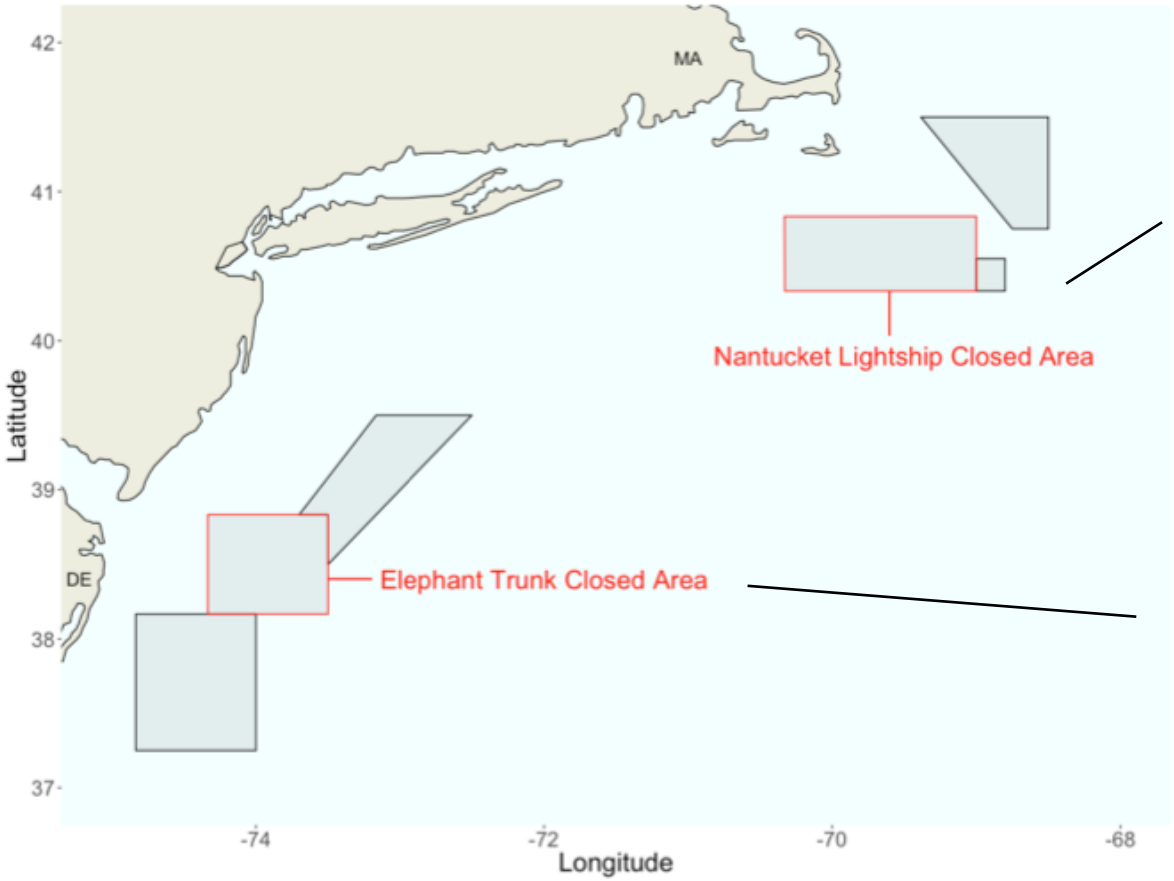




Gavia camera and sample photo filmstrip

Dredge scar in sidescan

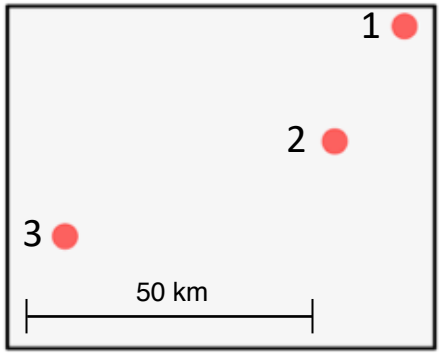
Study areas



July 8-14, 2015

50-60 m depth

July 8-16, 2014



70-80 m depth

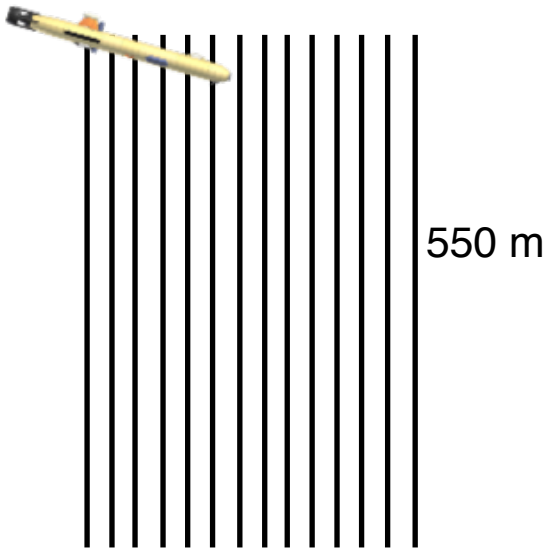
Before-after-control-impact experimental design

1. Before
2. Control or Impact
3. After

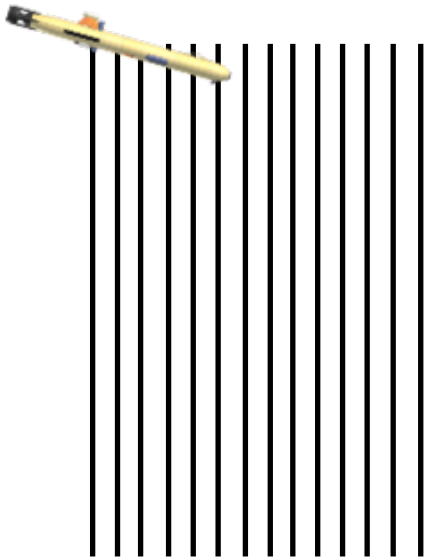
- Pre-tow AUV mission
- Digital images @ 2 fps
- 1800 kHz HF side-scan sonar

- 0, 1, or 5 tows
- 1 bushel sized

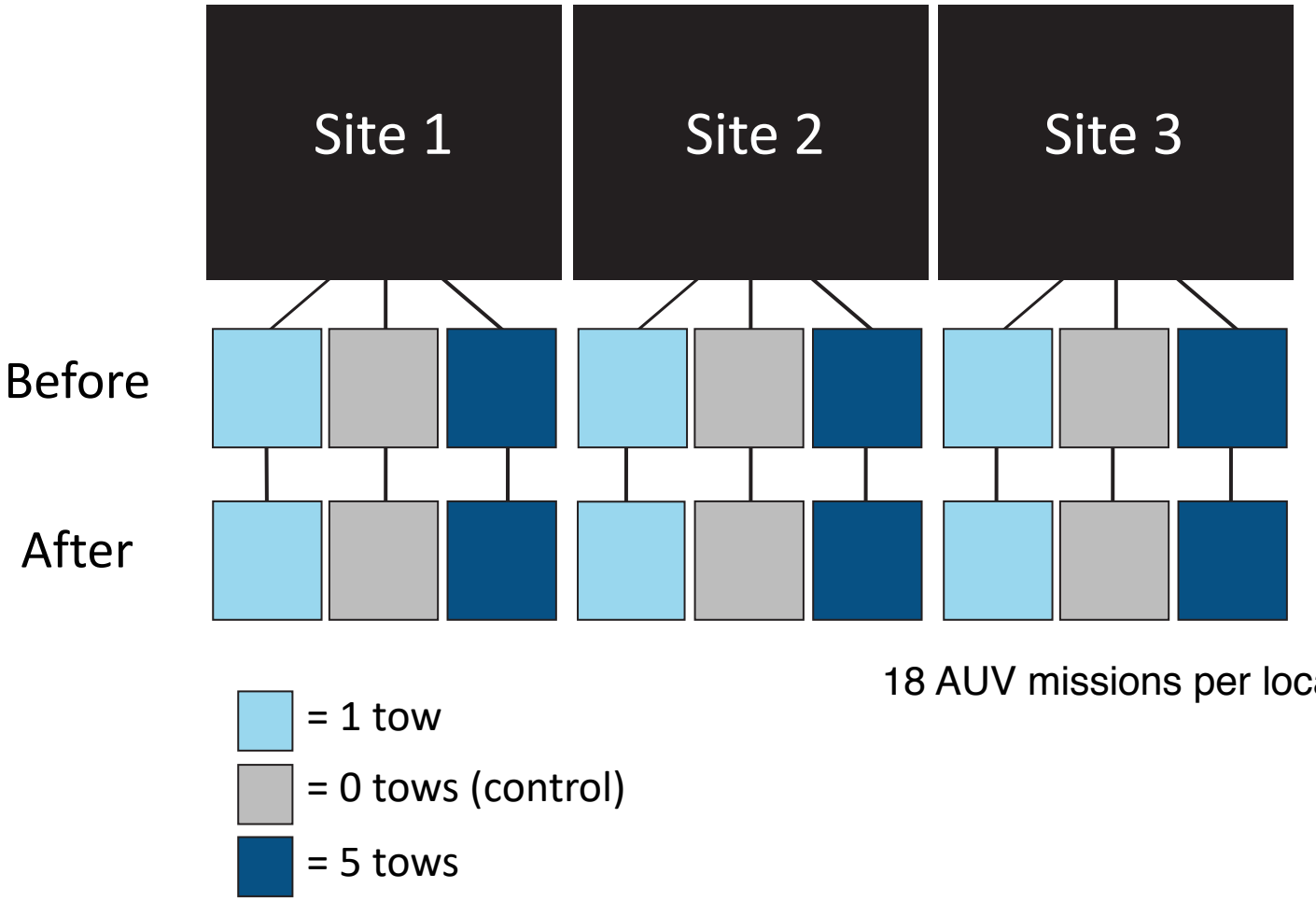
- Post-tow AUV mission
- ~7 hours after tows



F/V Christian and Alexa



Experimental design



18 AUV missions per location

Image annotation summary

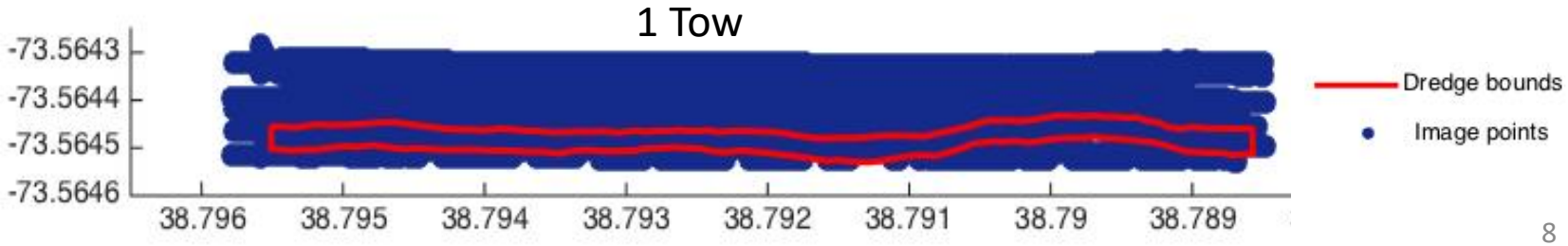
- Images annotated in custom online system and stored in MySQL database
- 36 AUV missions (18 ETCA, 18 NLCA)
  - ETCA: scallops counted
  - NLCA: scallops counted and sized
  - All scallops given a healthy or compromised rating
- ~172,000 total photos annotated
- 272,000 total scallops annotated (average of ~7000 per AUV mission)
- 40 trained student annotators over the past 3 years

Incidental mortality calculation

Dredge scars visible in side-scan image

$$c = \left(\frac{compromised_t}{total_t} - \frac{compromised_0}{total_0}\right) * 100$$

- IM calculated from images within the dredge path only
- Removed “untreated” images from the sample



Recognizing Mortality

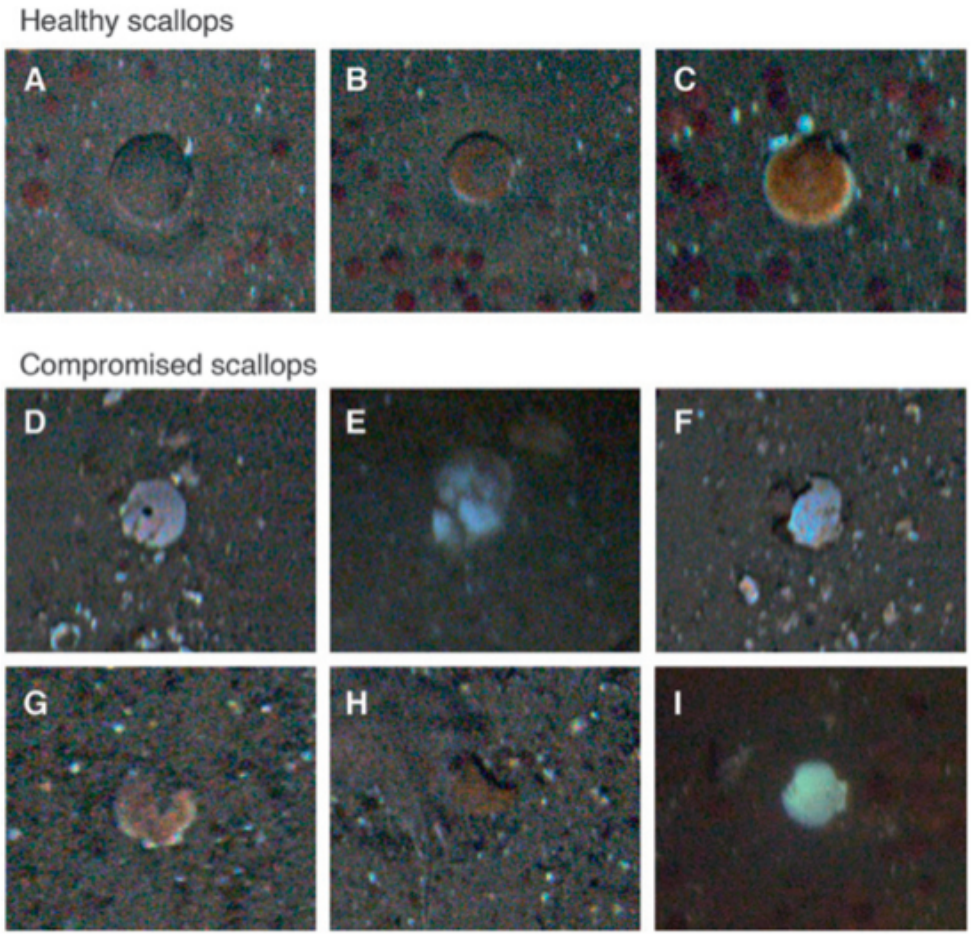
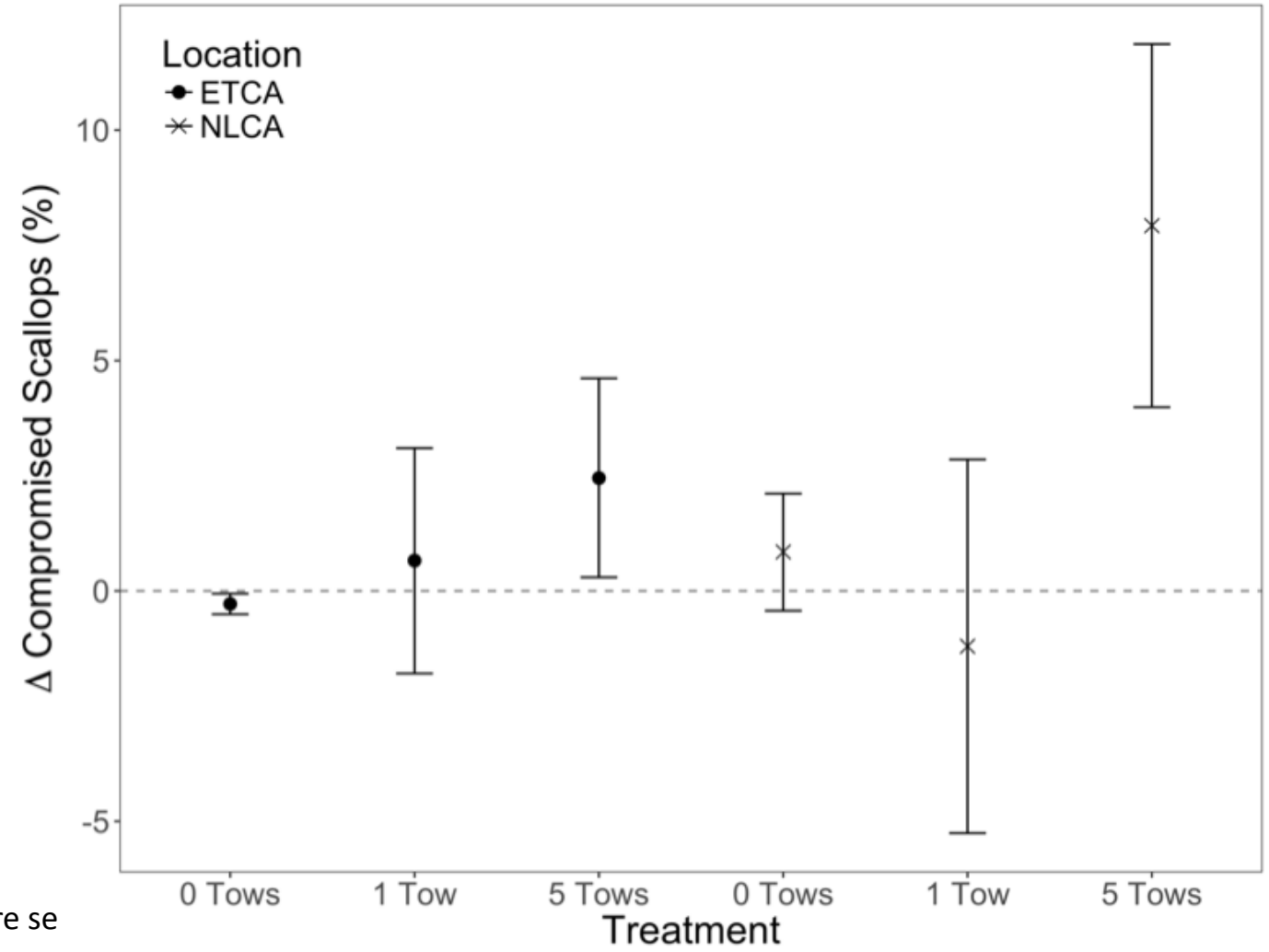


Figure 3. Examples of healthy, undamaged scallops (A–C), and damaged scallops from the project imagery database. Annotations of compromised scallops included individuals that were punctured (D), crushed (E), broken (F–H), or inverted (I).

- Training set of 100 scallops
- IM varied among annotators +/- 3%

Part 1: Incidental mortality



Errors are se

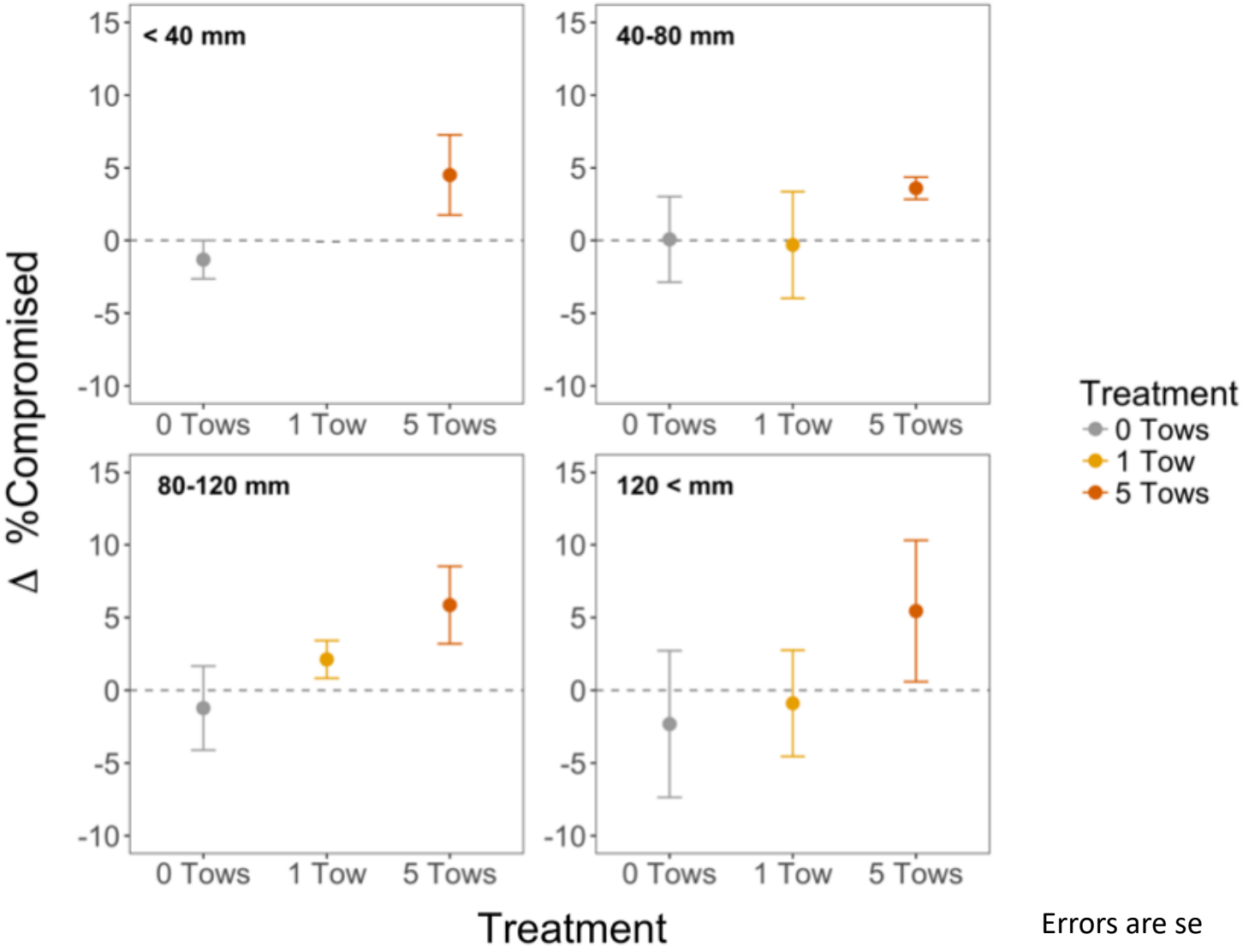
Comparison to existing mortality estimates

	Sandy	Hard bottom
Fishery model	10%	20%
Literature	< 5% (Murawski and Serchuk, 1989)	15-20% (Caddy, 1973)
Study mean	2.5 ± 2.2%	7.9 ± 3.9%

Part 2: Shell height measurement

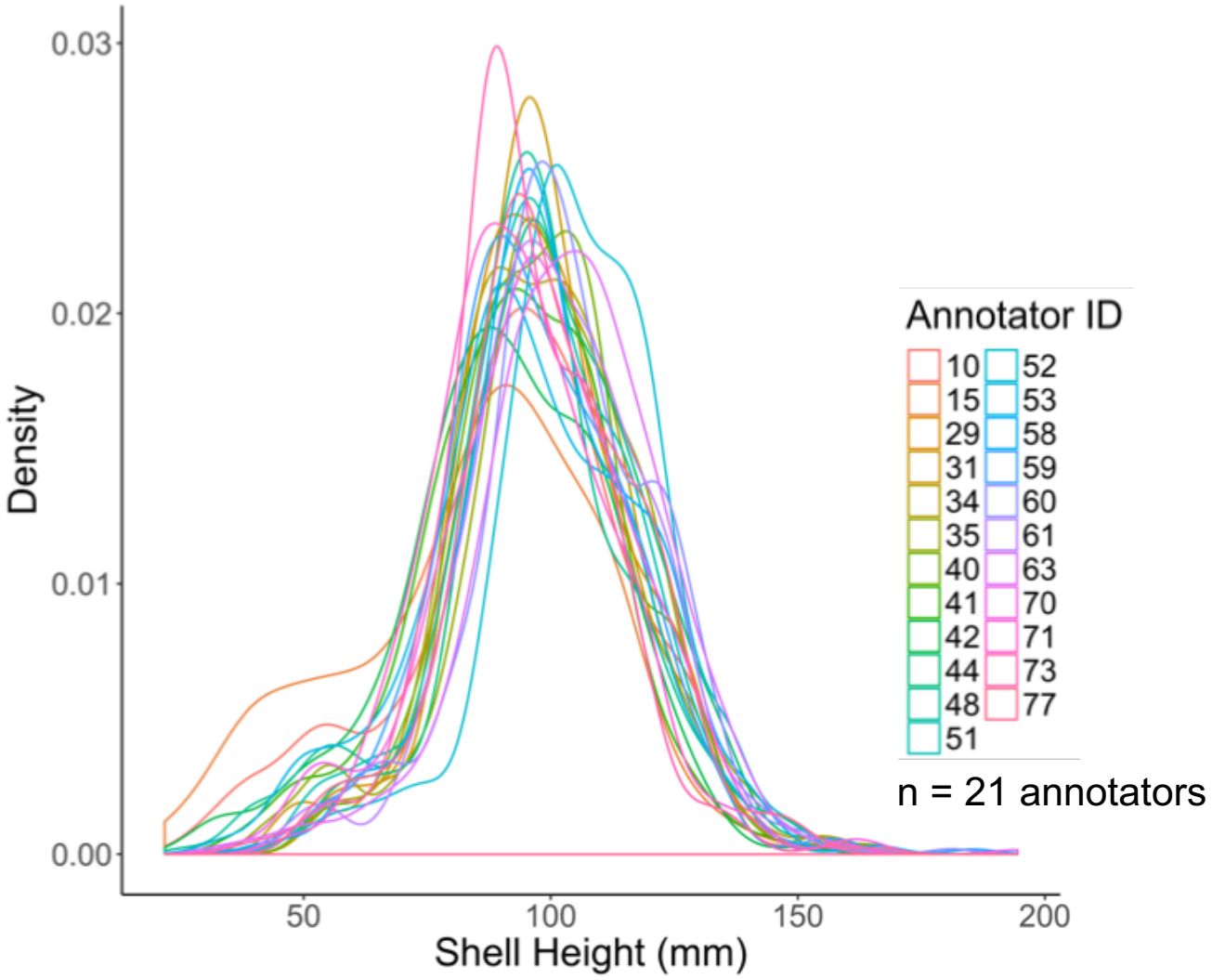
- Re-annotated images from the NLCA with respect to size
- Measured shell height using line tool
- Heights were adjusted per photo with respect to AUV altitude
  - Mean = 2.3 mm per pixel

Incidental mortality by size class



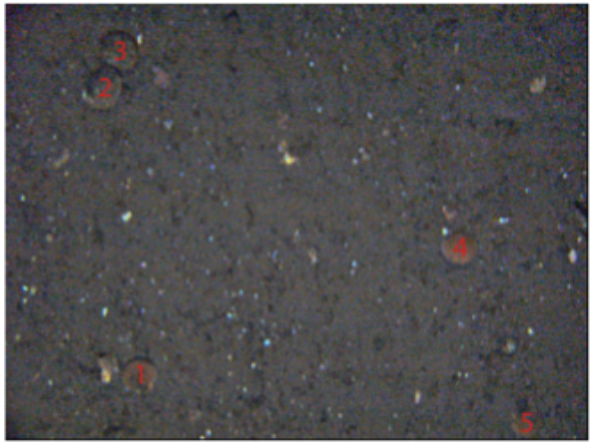
Errors are se

Annotator uncertainty

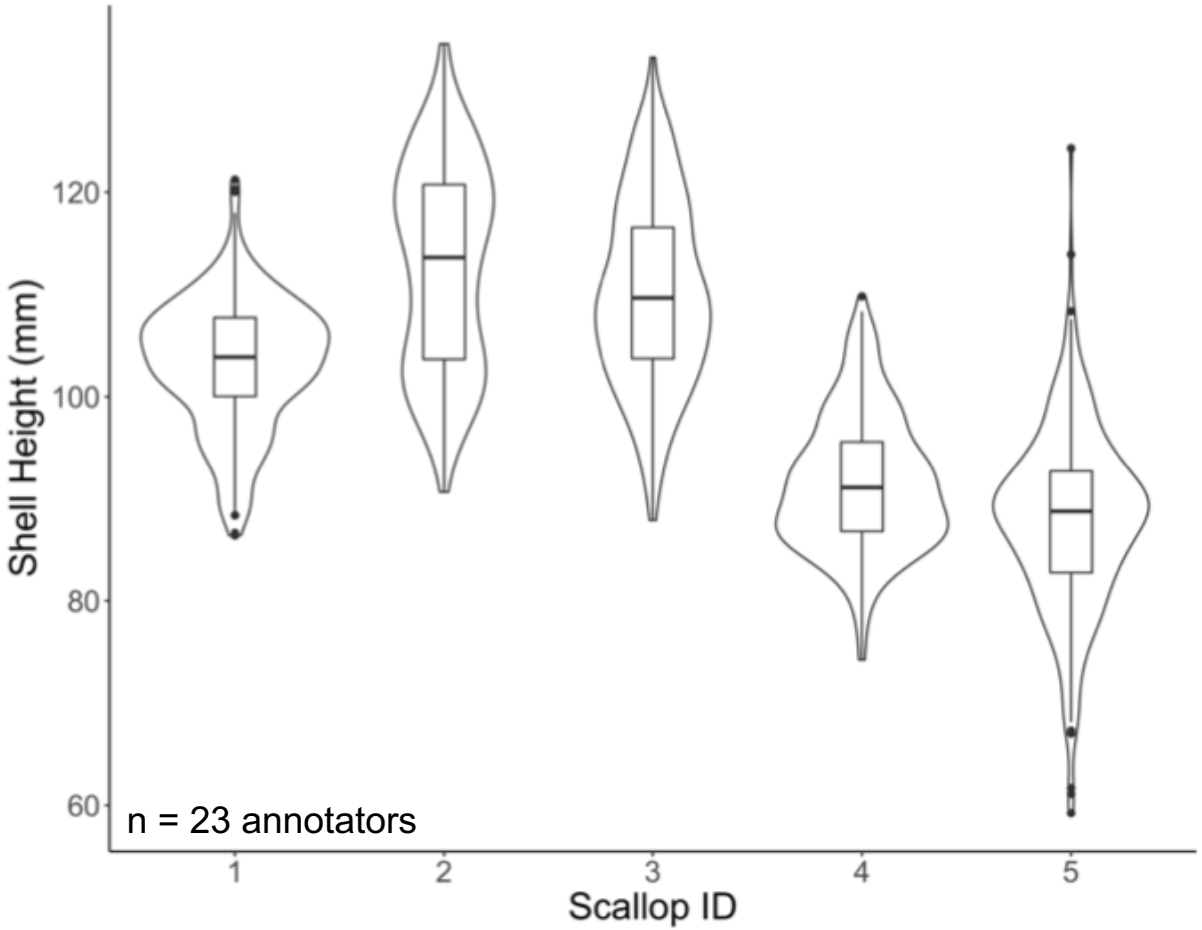


- All annotators (n=21) annotated a subset of 562 photos containing ~400 scallops
- Similar distributions among annotators
- Mean SH sd = 4.7 mm (<2 pixels)
- Smaller scallops more difficult to measure
- Total scallop counts varied +/- 10%

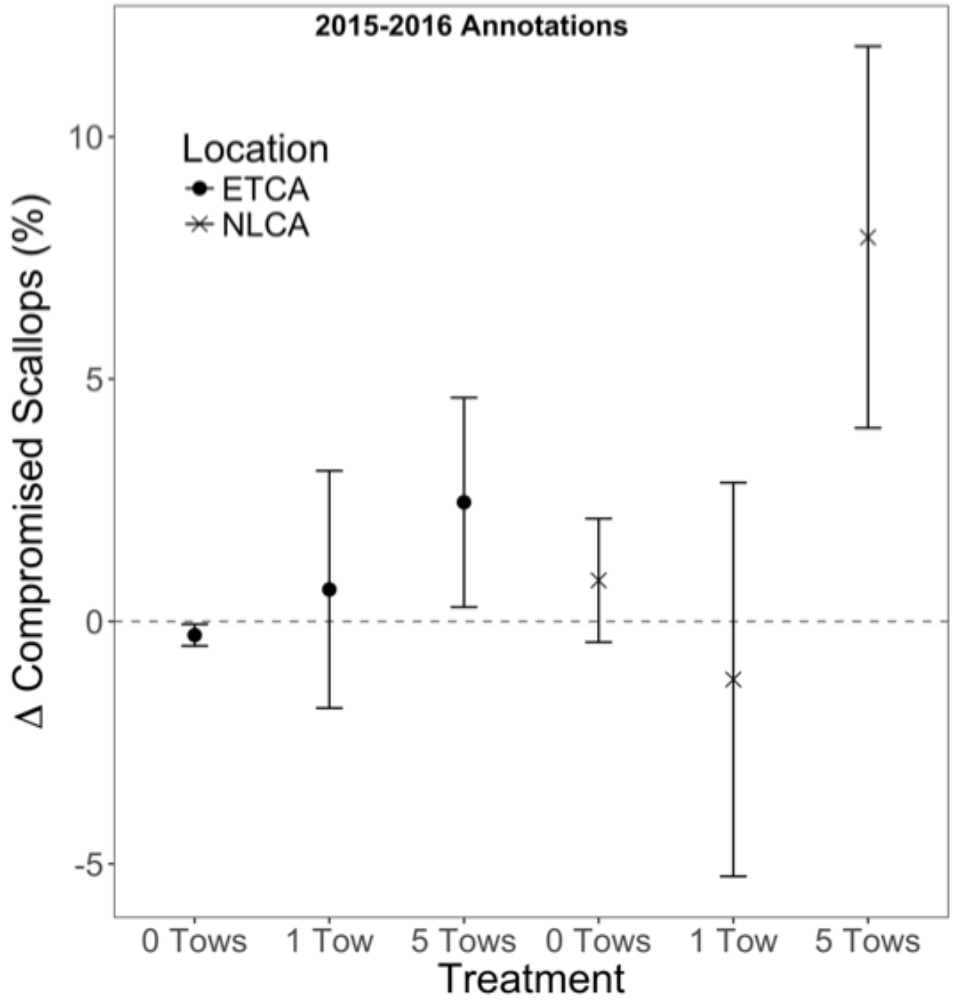
Annotator uncertainty

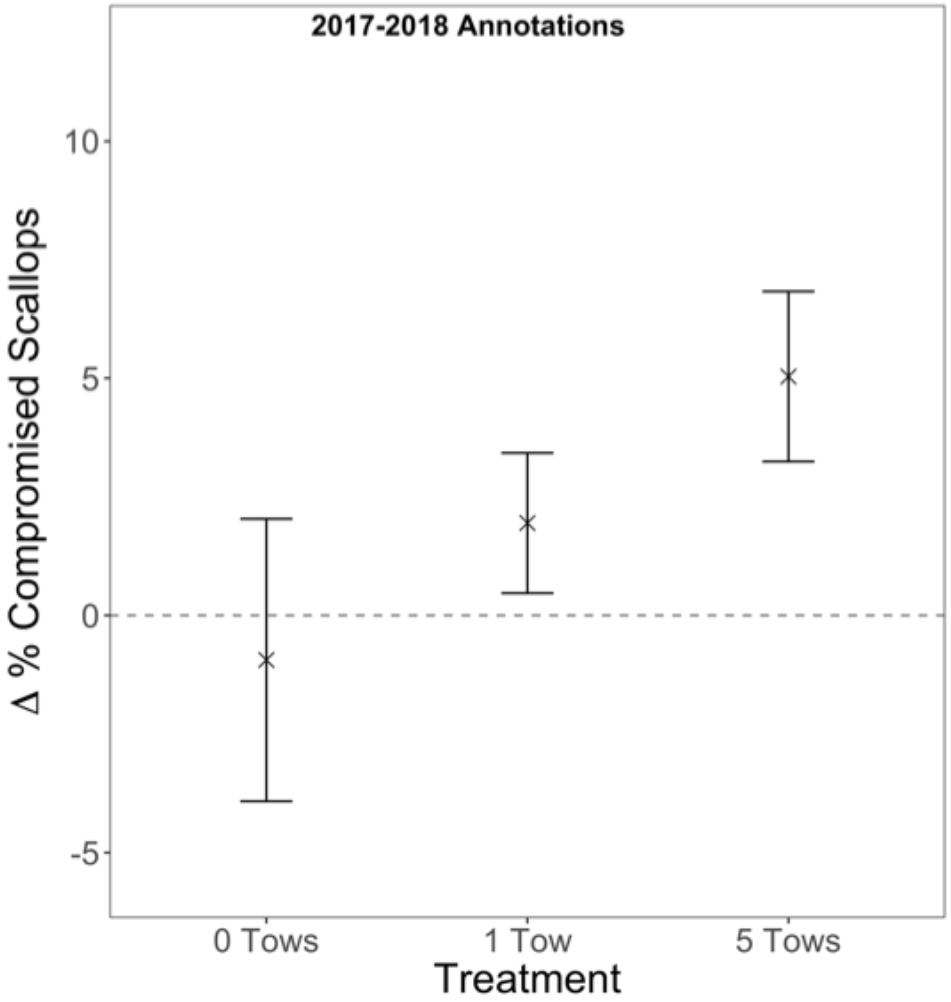


- All annotators (n=23) annotated the same 5 scallops 10x
- Mean sd per annotator = 4.4 mm (~2 pixels)
- Mean sd per scallop = 8.2 mm (<4 pixels)



Incidental mortality





Errors are se

Implications

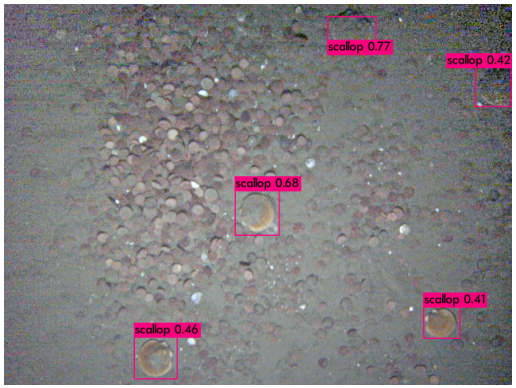
- IM estimates lower than those currently used
  - Support estimates used in fishery models
- IM consistently higher at hard-bottom sites
- Shell height does not appear to be a factor
- More information at:

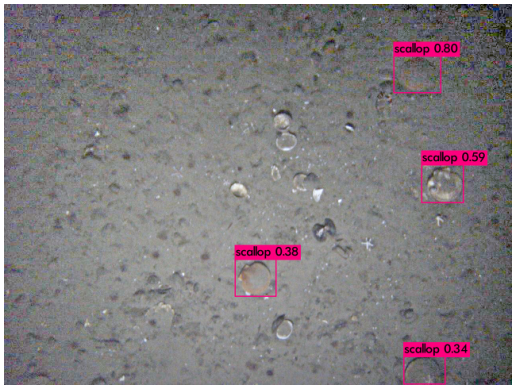
Estimates of Sea Scallop (*Placopecten magellanicus*) Incidental Mortality from Photographic Multiple Before—After-Control—Impact Surveys

Author(s): Danielle M. Ferraro, Arthur C. Trembanis, Douglas C. Miller and David B. Rudders
Source: Journal of Shellfish Research, 36(3):615-626.
Published By: National Shellfisheries Association
https://doi.org/10.2983/035.036.0310
URL: http://www.bioone.org/doi/full/10.2983/035.036.0310

Ongoing work

- 2017 field season:
  - Targeted hard substrate in Closed Area I
  - 3 sites; 18 AUV missions; ~14,000 images per mission
  - Deep learning with YOLO2 to augment human annotations



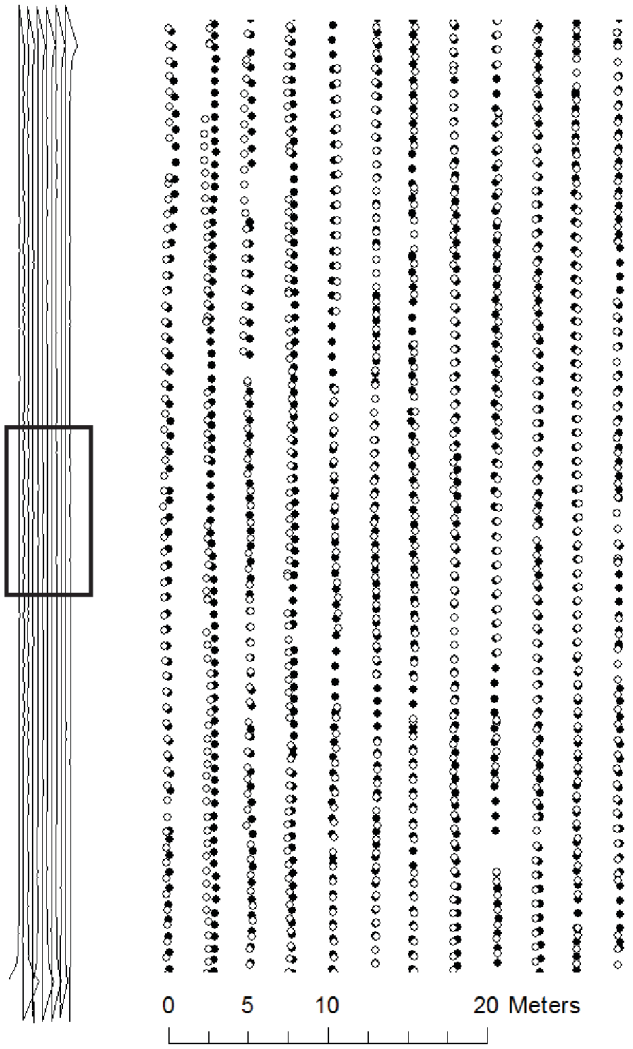


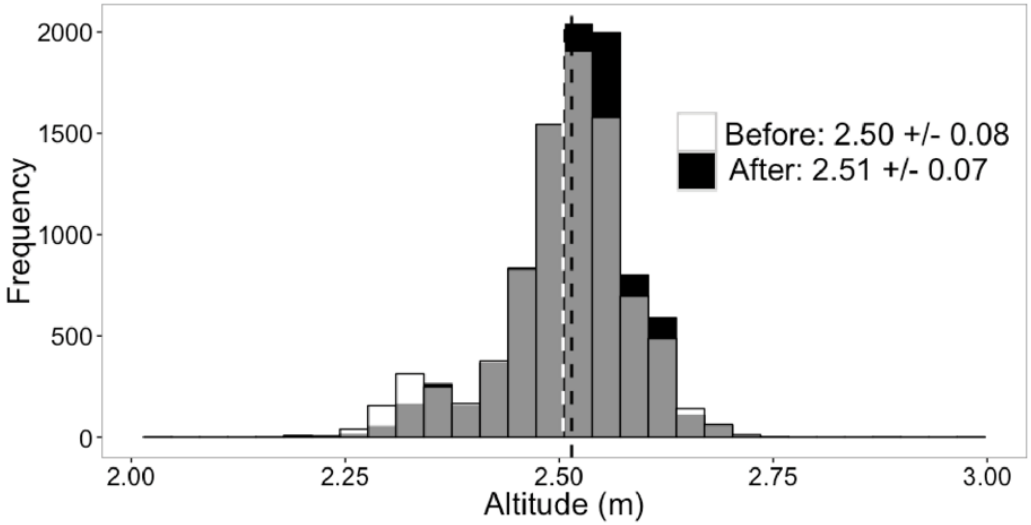
Acknowledgements

- Captains and crew of F/V Christian and Alexa
- University of Delaware Robotics Discovery Lab members
- U. Delaware and VIMS image annotation team
- NOAA NMFS Research Set-Aside Award NA14NMF4540073
- NOAA NMFS Research Set-Aside Award NA17NMF4540038

Scallop annotation system

AUV precision





Dredge Scars