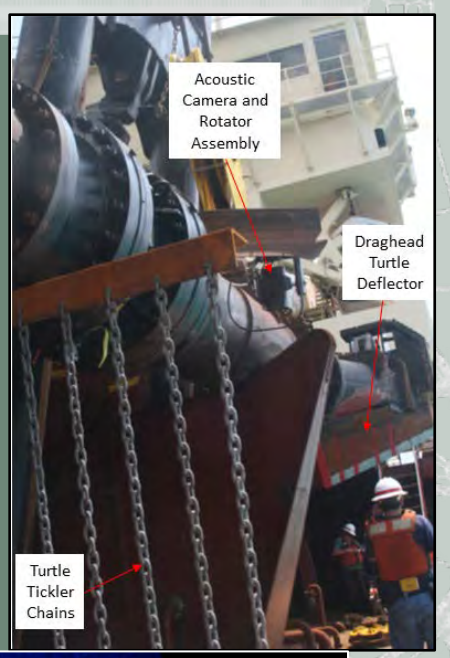
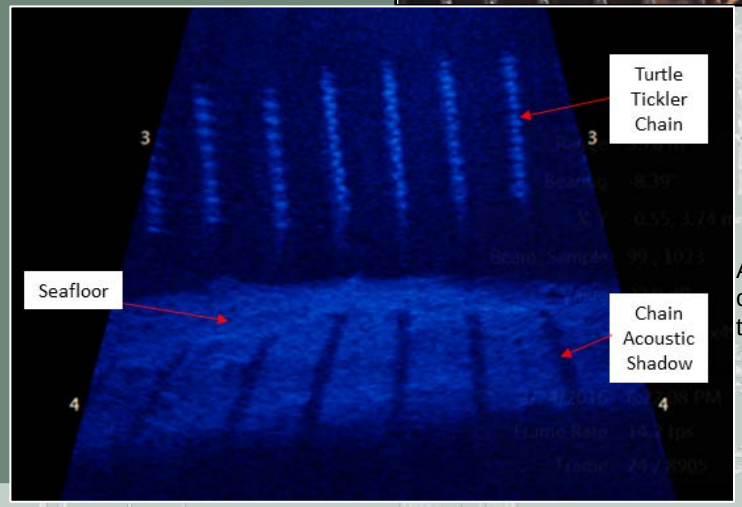
USE OF ACOUSTIC CAMERAS IN DREDGING RESEARCH



Acoustic camera mounted to drag-arm.



Acoustic camera viewing tickler chains.

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Brian C. McFall and Dena D. Dickerson
Coastal & Hydraulics Laboratory
US Army Engineer
Research & Development Center

28 June 2017

U.S.ARMY

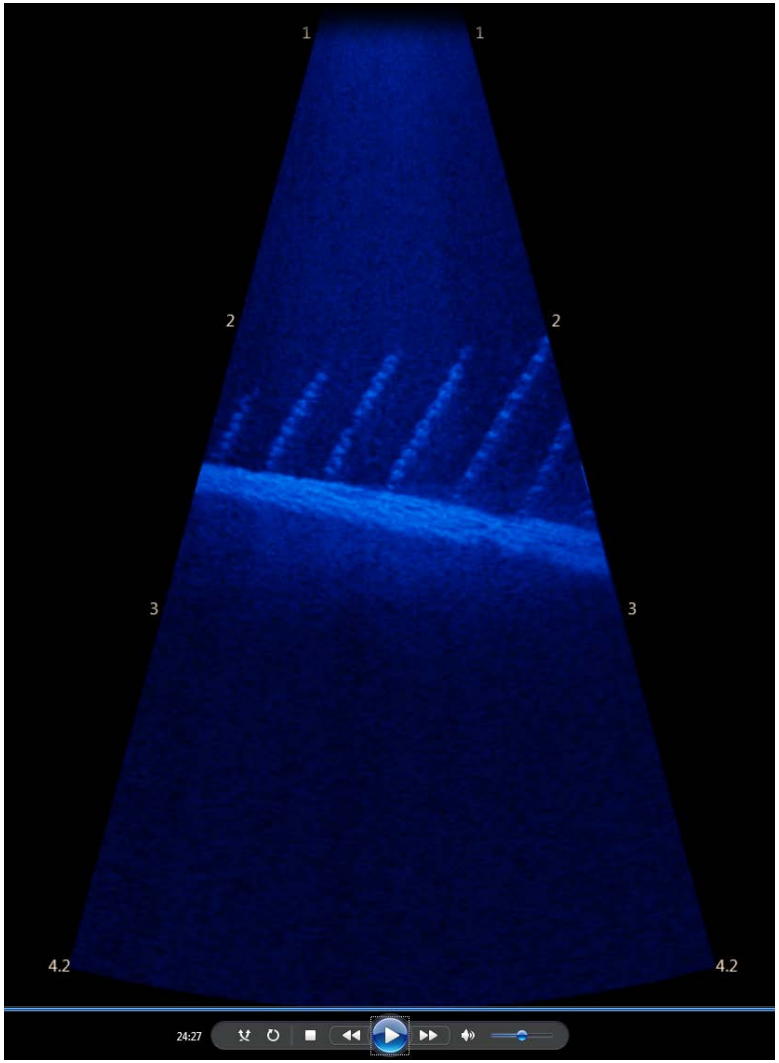
US Army Corps of Engineers ®

COASTAL & HYDRAULICS LABORATORY

WHAT IS AN ACOUSTIC CAMERA?

- Small multi-beam active sonar.
- 128 beams, 30° in-plane, 14° out-of-plane.
- Beamforming to determine direction.
- Returned intensity converted to pixel intensity.

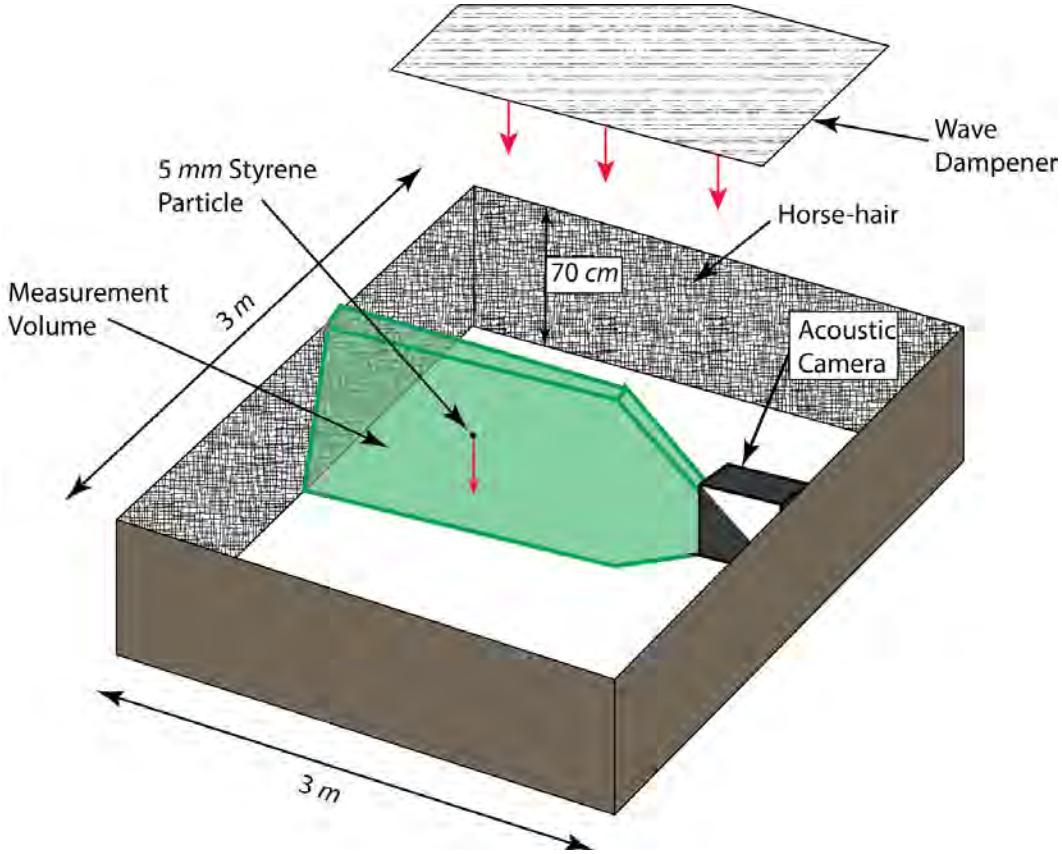
Soundmetrics
ARIS 3000



Raw acoustic camera image.

EXPERIMENT DESIGN

- Conducted in 3*m* x 3*m x 0.7m* tank.
- Acoustic camera equipped with 1^0 concentrator lens.
- Images at 15 fps.
- Sub-surface hand release of particles.

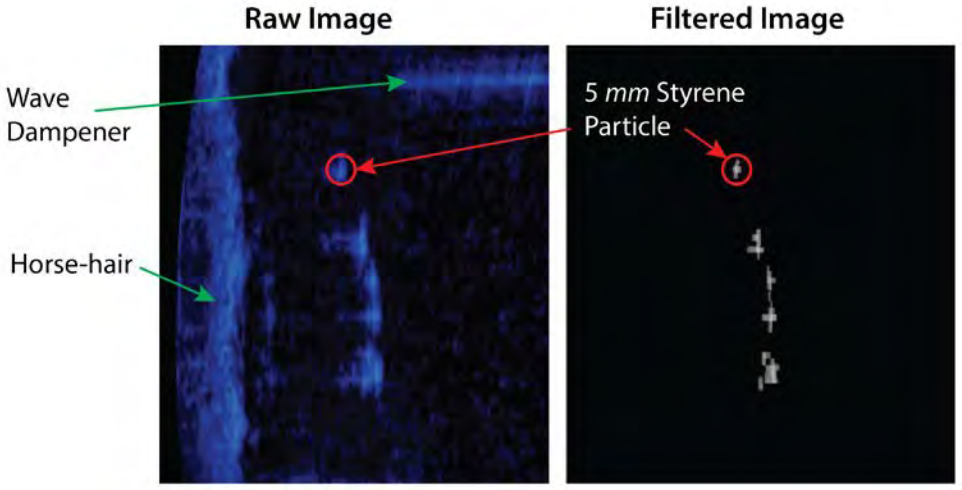


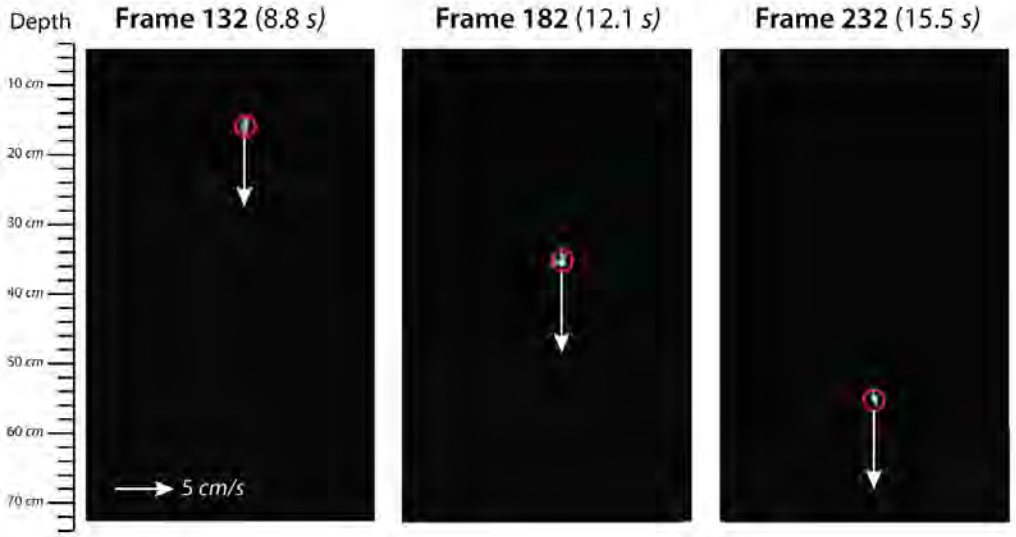
Soundmetrics ARIS 3000

Particle Type	d_s range (mm)	Assumed d_s (mm)	ρ_s range (kg/m^3)	Assumed ρ_s (kg/m^3)
0.5 mm PMMA	0.425 – 0.5	0.465	1186.5	1186.5
1 mm Cellulose Acetate	1	1	1280	1280
5 mm Styrene	5	5	1040 - 1060	1050

IMAGE PROCESSING AND PARTICLE TRACKING

- Convert raw polar-coordinate acoustic camera output to Cartesian.
- Image processing:
  - Subtract time-mean pixel intensity.
  - Set minimum pixel intensity threshold.
- Particles tracked using DLTdv5 (Hedrick 2008).
- Velocity estimated with first-order central differencing scheme.





Successive frames of tracked 5 *mm* Styrene particle.

SETTLING VELOCITY THEORY

- Final fall velocity reached when drag force on sphere balanced the negative buoyancy.

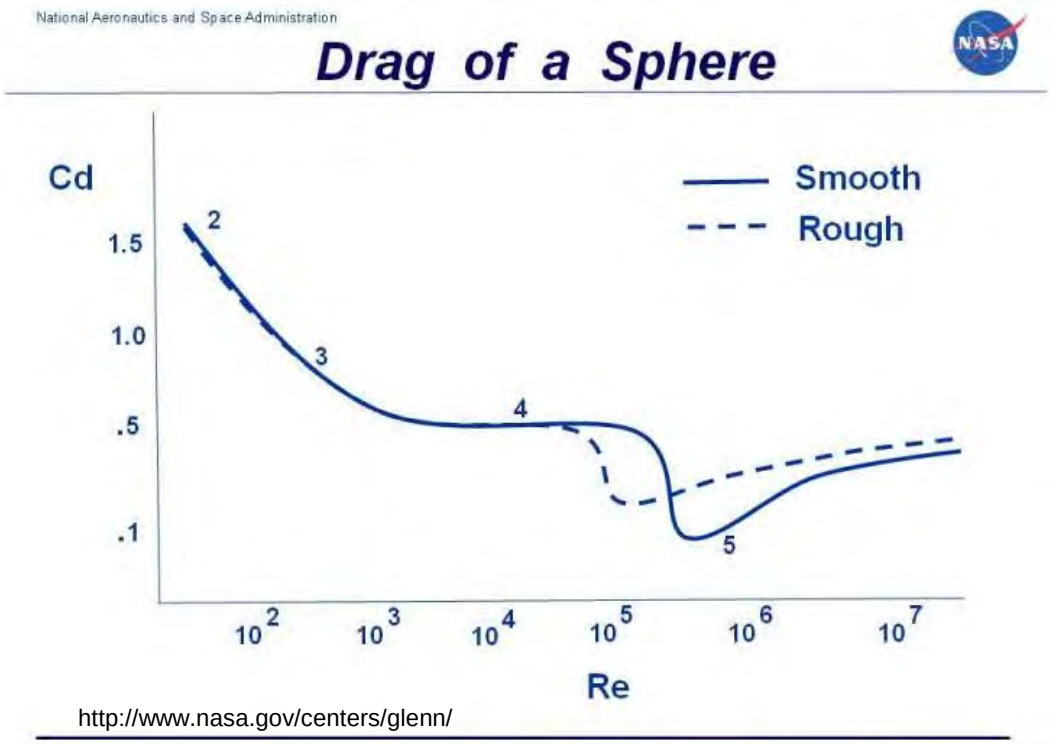
$$V = \sqrt{\frac{4gd_s}{3C_d}\left(\frac{\rho_s - \rho}{\rho}\right)}$$

- Drag coefficient is a function of sphere Reynolds number.

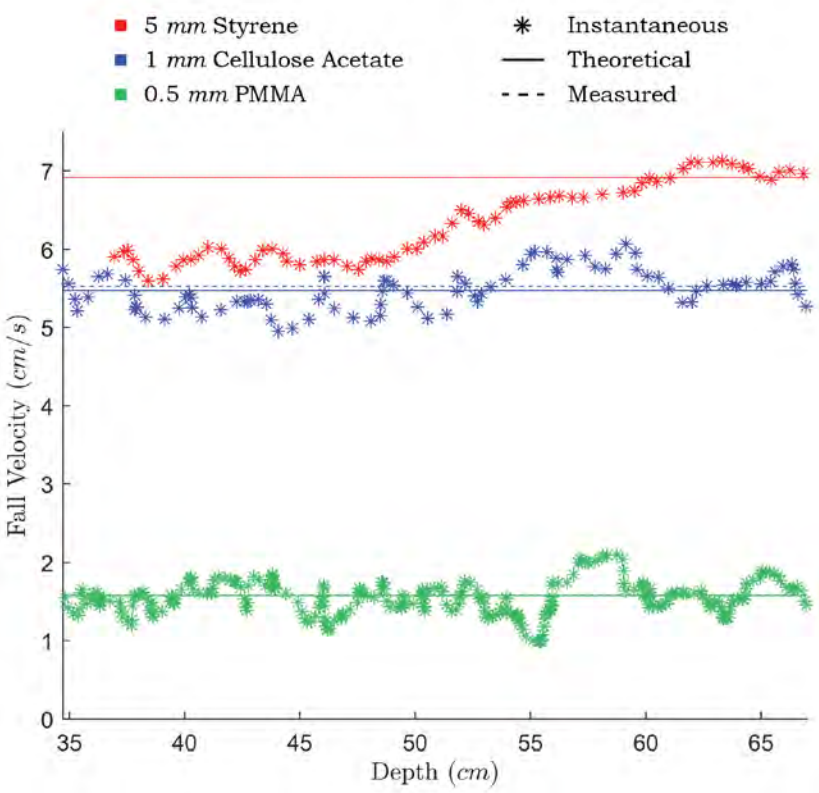
$$Re = \frac{Vd_s}{\nu}$$

- Rate at which sphere approaches final fall velocity is characterized by Stokes number.

$$Stk \cong \frac{d_s^2 V(\rho_s - \rho)}{18\mu h}$$



RESULTS - PART ONE



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1 mm Cellulose Acetate	1	1	1280	1280
5 mm Styrene	5	5	1040 - 1060	1050

- 5 *mm* Styrene has largest fall velocity.
  - Buoyancy term becomes more important with larger diameter…
- 5 *mm* Styrene takes longest to reach terminal velocity
  - Highest Stokes number…
- Terminal velocity reported is the mean of the deepest $1/3$ measurements.

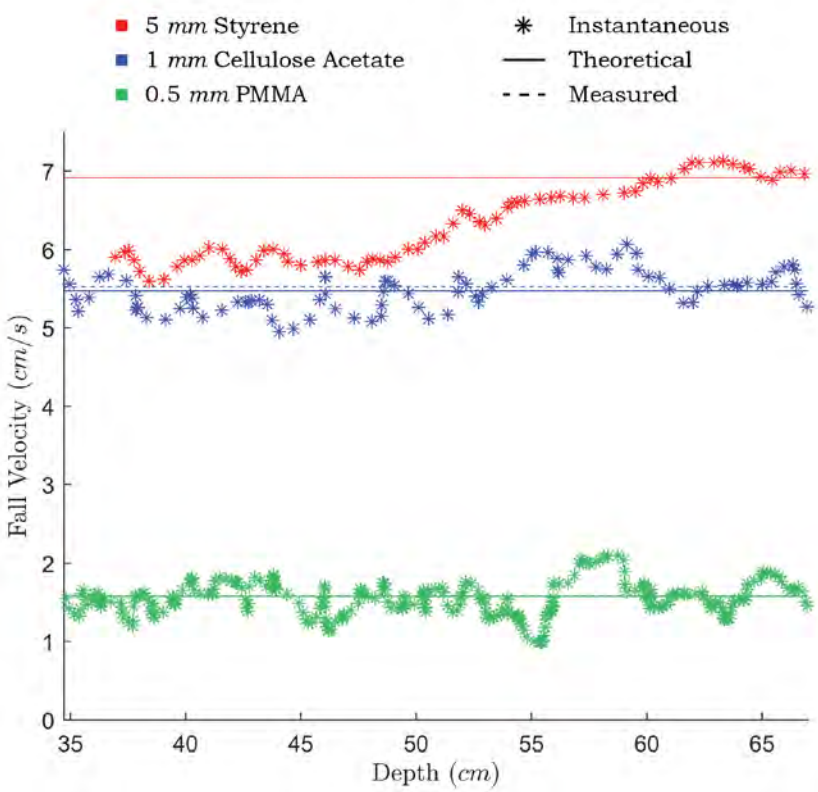
RESULTS – PART TWO

Particle Type	Measured Fall Velocity (cm/s)	Theoretical Fall Velocity (cm/s)	Error (mm/s)	% Error
0.5 mm PMMA	1.58	1.57	+ 0.06	+ 0.40
1 mm Cellulose Acetate	5.53	5.47	+ 0.55	+ 1.00
5 mm Styrene	6.91	6.91	- 0.01	- 0.02

Particle Type	Re	C_d	Stk
0.5 mm PMMA	6.9	4.60	49.3
1 mm Cellulose Acetate	52.5	1.23	1208
5 mm Styrene	328.5	0.70	6176

- Reynolds number computed with measured velocity.

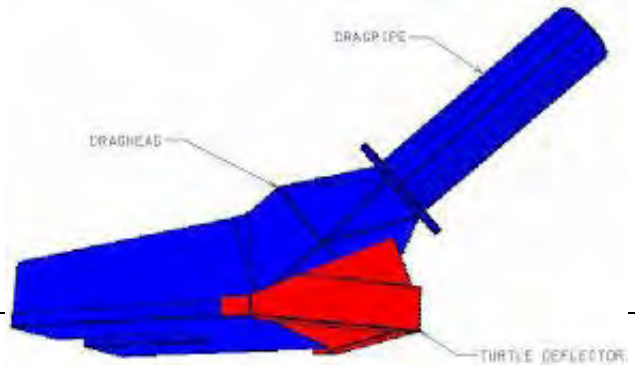
- Excellent agreement between measured and theoretical fall velocity.
- Results indicate Acoustic camera valuable for examining inertial particles.



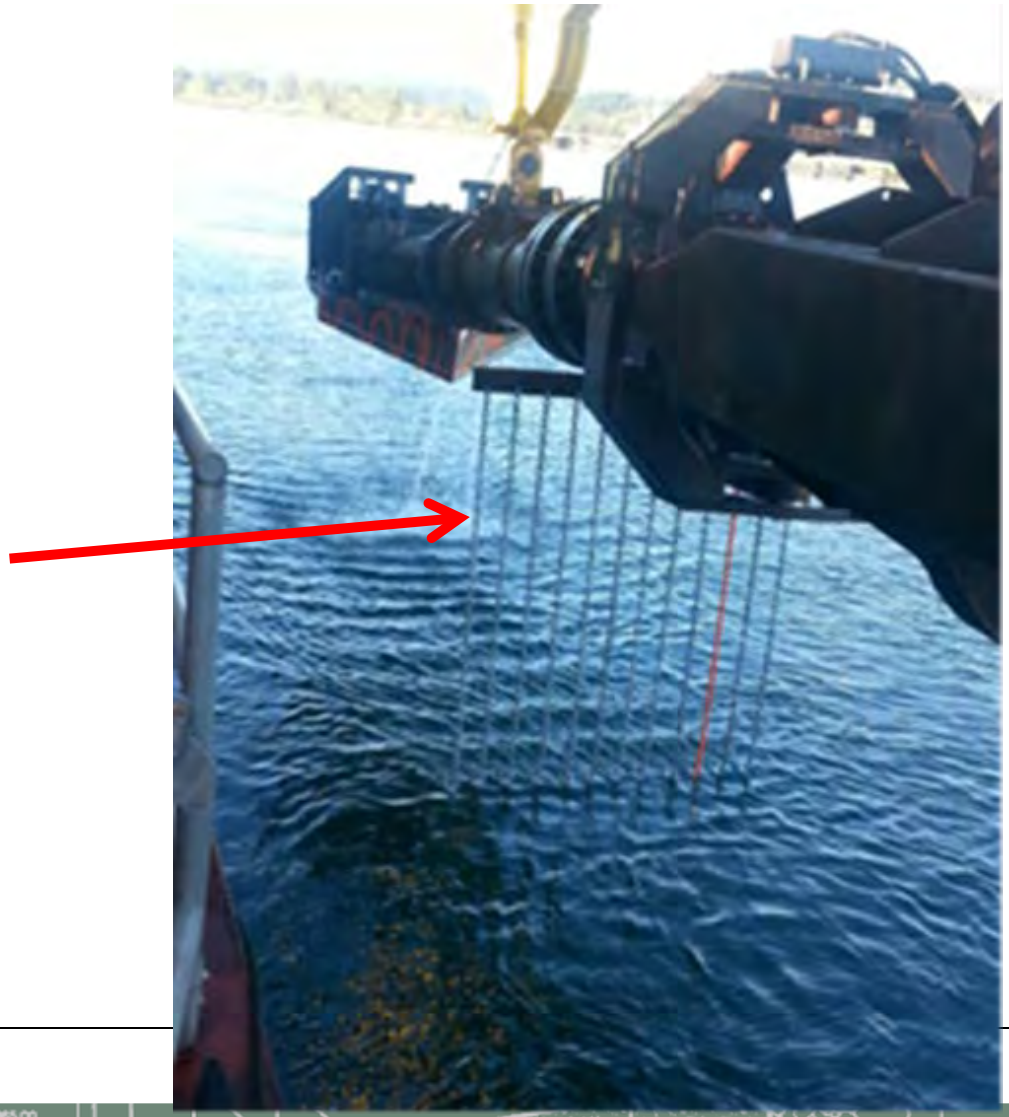
FIELD DEPLOYMENT OF ACOUSTIC CAMERAS

Reduction of Entrainment Risk of Sea Turtles by Hopper Dredges

EVOLUTION OF DRAGHEAD DEFLECTOR DESIGNS



Turtle Tickler Chains (TTC)



TTC Demonstration

US Army Corps of Engineers
San Francisco District

US Army Corps of Engineers ®
Portland District

GREAT LAKES DREDGE & DOCK COMPANY RIVER & HARBOR IMPROVEMENTS

U.S. ARMY ENGINEER RESEARCH AND DEVELOPMENT CENTER ERDC

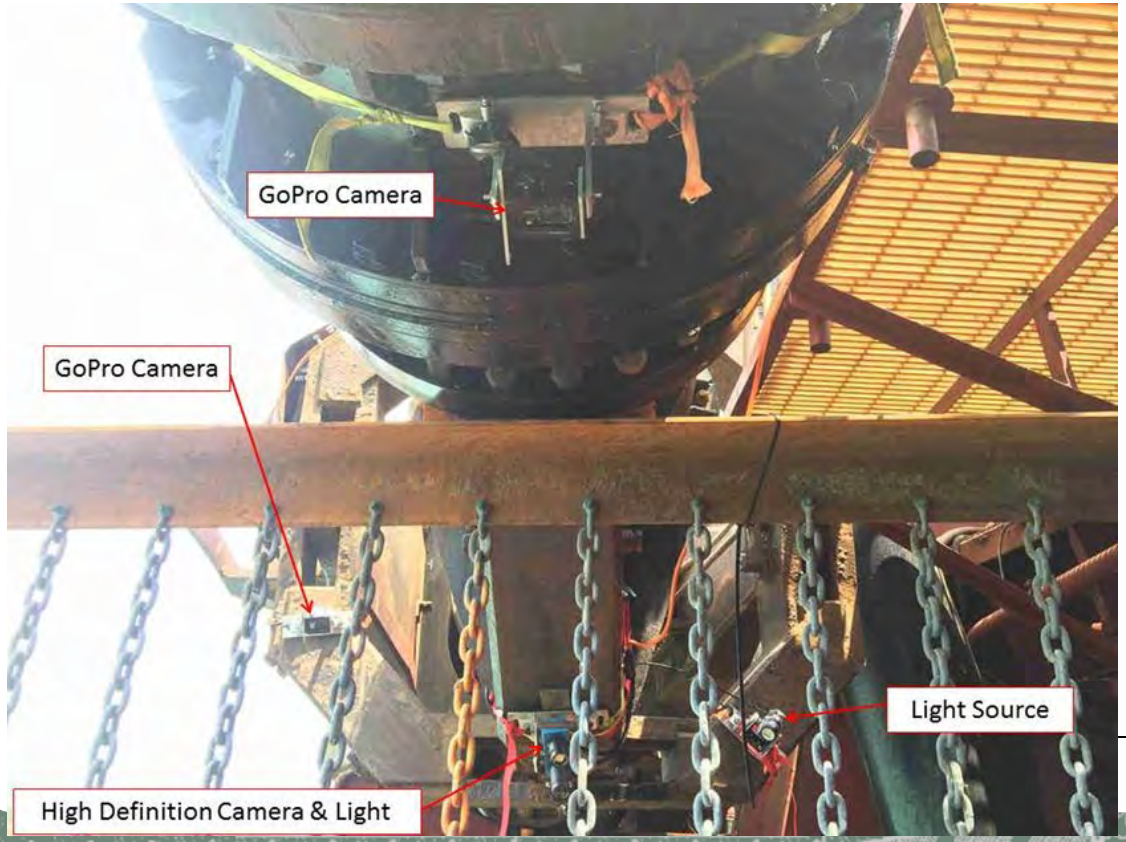
MANSON CONSTRUCTION CO.

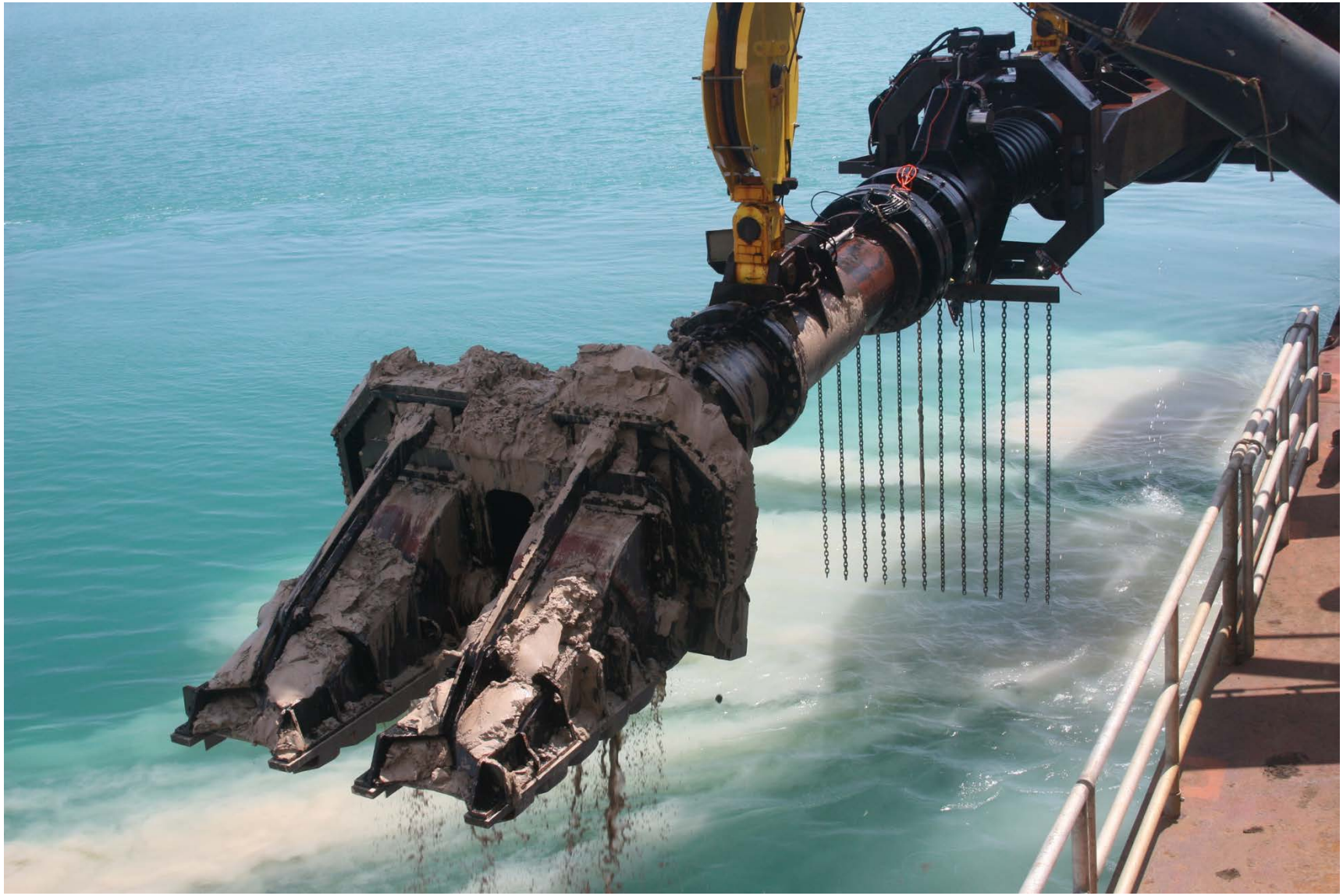
Strategic Objective:
Replace turtle deflectors with TTC

Courtesy of NMFS & Sound Metrics


GoPro Camera
GoPro Camera
Acoustic Camera
High Def Camera
w/ Lights


ARIS


GoPro Camera
GoPro Camera
Light Source
High Definition Camera & Light

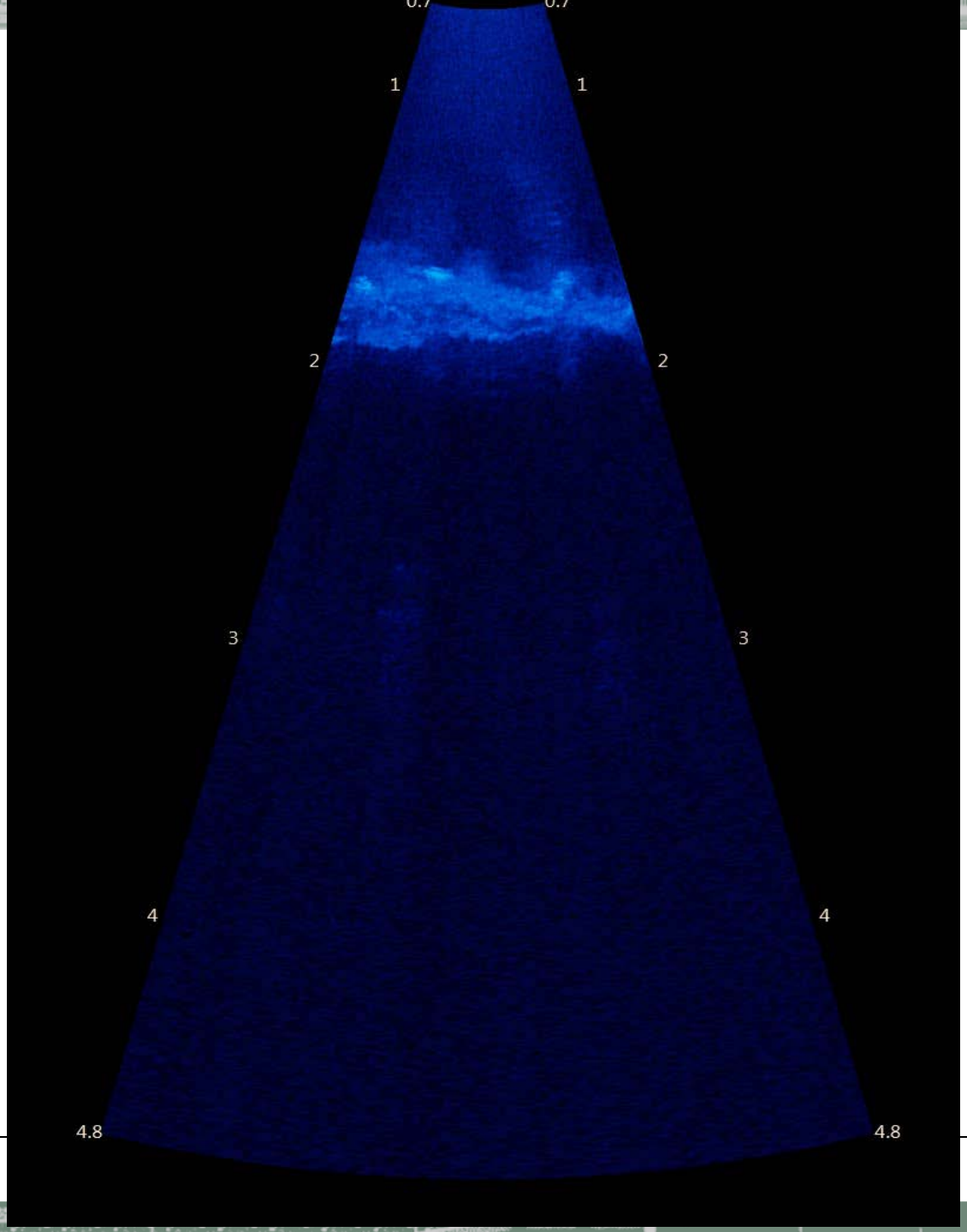


Kalaeloa Barbers Point, Oahu, Hawaii

ESSAYONS' turtle chains streaming in water column

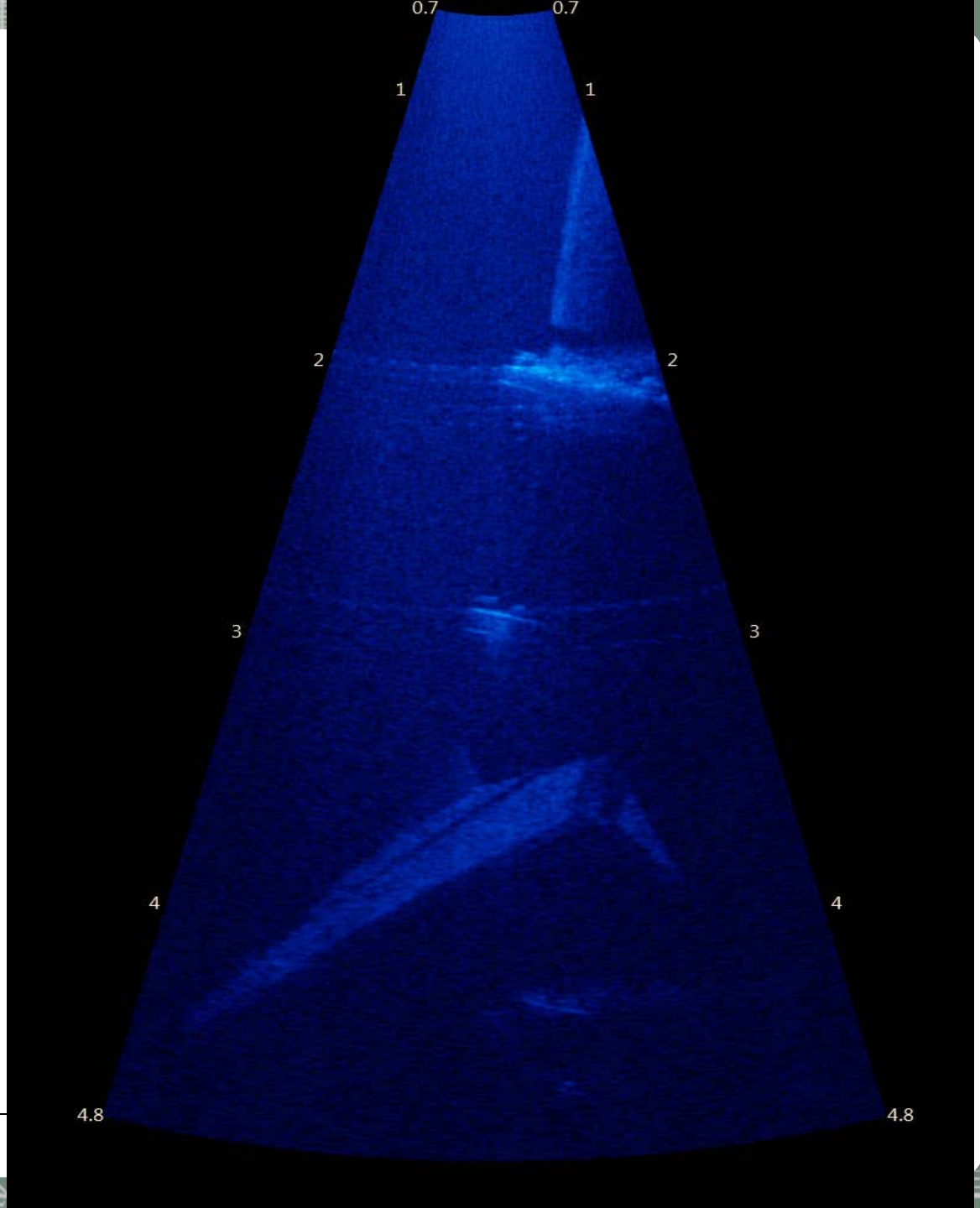
Kalaeloa Barbers Point, Oahu, Hawaii

ESSAYONS' turtle chains in the bottom material



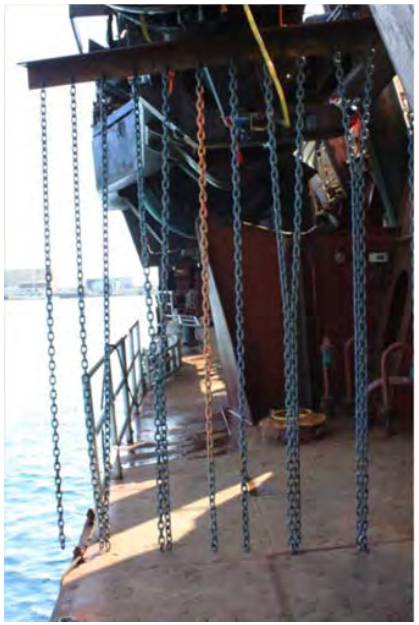
Kalaeloa
Barbers Point,
Oahu, Hawaii

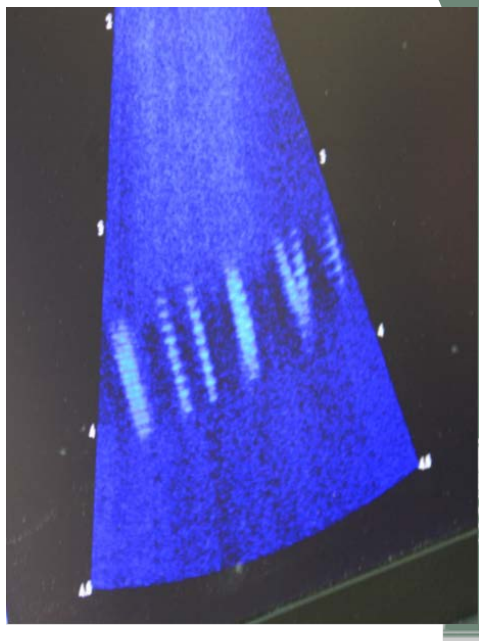
ESSAYONS'
draghead in the
fine-grained
bottom material.



Study Successfully Demonstrated:

- Feasibility of mounting cameras on dragarm for monitoring.
- Acoustic camera works in extremely limited visibility and on a dynamic dragarm for monitoring chain behavior.
- Feasibility of deploying tickler chains off the dragarm
- Tickler chains maintained contact on bottom and do not entangle.
- Draghead deflector deployed correctly and generated required sediment wave.





THANK YOU FOR YOUR ATTENTION

REFERENCES

Hedrick, T. (2008) “Software Techniques for Two- and Three-Dimensional Kinematic Measurements of Biological and Biomimetic Systems.” *Bioinspiration and Biomimetics*, 3.3, 34001.