

An aerial photograph of a coastal area. In the upper left, a road runs parallel to a shoreline with several buildings. The water is shallow and greenish-brown, with a prominent sandbar or shoal in the center. A long, narrow pier or breakwater extends from the shore into the water. The overall scene depicts a shallow lagoon or estuarine environment.

# BENTHIC GEOLOGIC HABITAT MAPPING IN SHALLOW LAGOON AND ESTUARINE ENVIRONMENTS

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## BOATING SAFETY: REVISITED

- Man missing after boating accident in Taunton River (WPRI12.com 9 August, 2010)
- Four men did in a southern Idaho reservoir (CNN.com, 10 August, 2010)

# GEOLOGISTS AND SOIL SCIENTISTS WORKING SIDE BY SIDE: NOT SO CRAZY AFTER ALL!

Low-energy basin  
organic silt?

Fluid silt loam?

J. Turrene



# **OUTLINE**

**What are benthic geologic habitats?**

**How do we map them**

- What is side-scan sonar?**
- Interpreting side-scan images**
- Collecting ground truth data**

**Interpreting and naming Benthic  
Geologic Habitats**

# BENTHIC GEOLOGIC HABITATS

- What is a habitat?
  - A spatially recognizable area with physical, chemical, and biological characteristics that are distinctly different from surrounding areas. (Valentine et al., 2005)
- Benthic Geologic Habitat
  - A spatially recognizable area with *geologic characteristics* that are distinctly different from surrounding areas.

# BENTHIC GEOLOGIC HABITATS

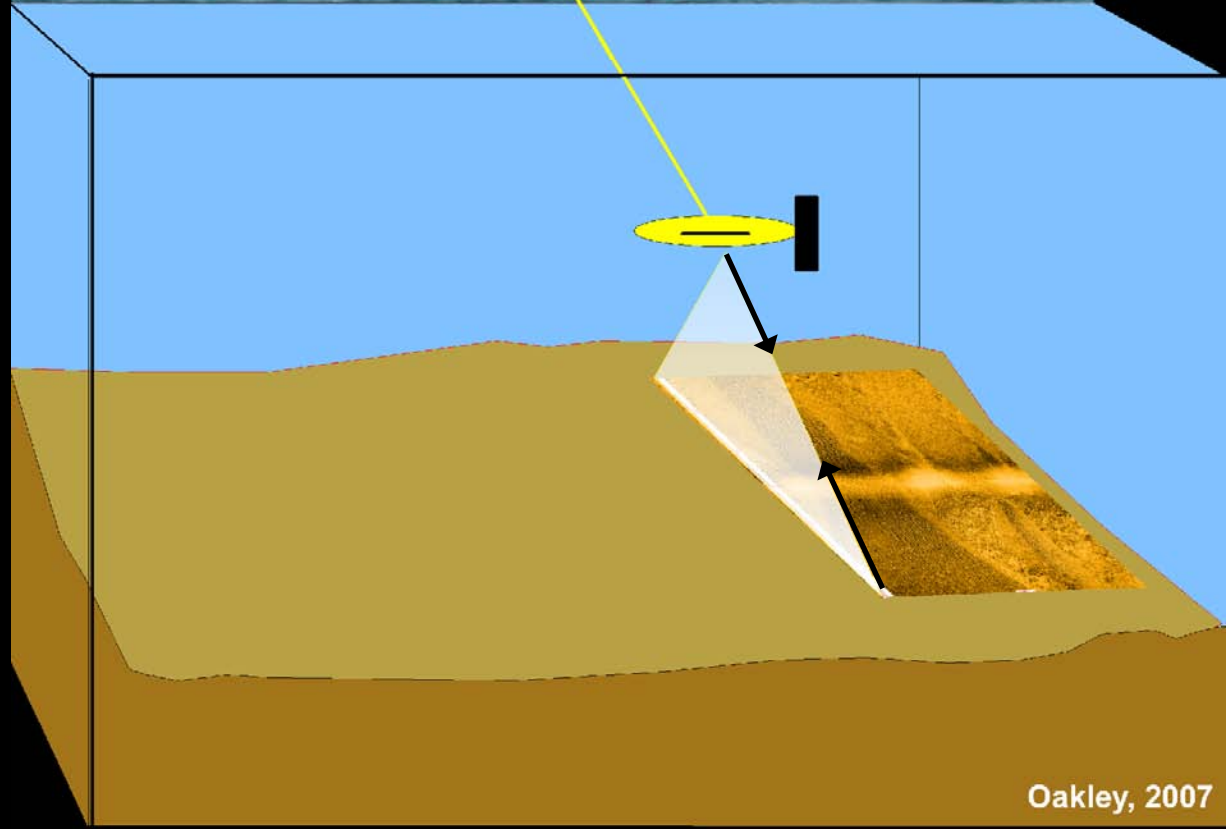
- Geologic Characteristics = Facies
  - Particle size, shape, sorting, color, composition and biologic content
- Extent determined with side scan sonar
- Physical Characteristics from sediment samples, underwater video, etc..
- Interpreted into Depositional Environments / Benthic Geologic Habitats

# SO WHAT IS SIDE-SCAN SONAR?

A towed system, that images the ocean floor using acoustic energy (sound)

Sound reflected from the bottom back to the towfish

Hard or rough bottoms reflect more energy





SOUTH BEACH MARINA  
Blue Water  
Boat & Tackle  
1000 BEACH ROAD  
WOLFORD, RI

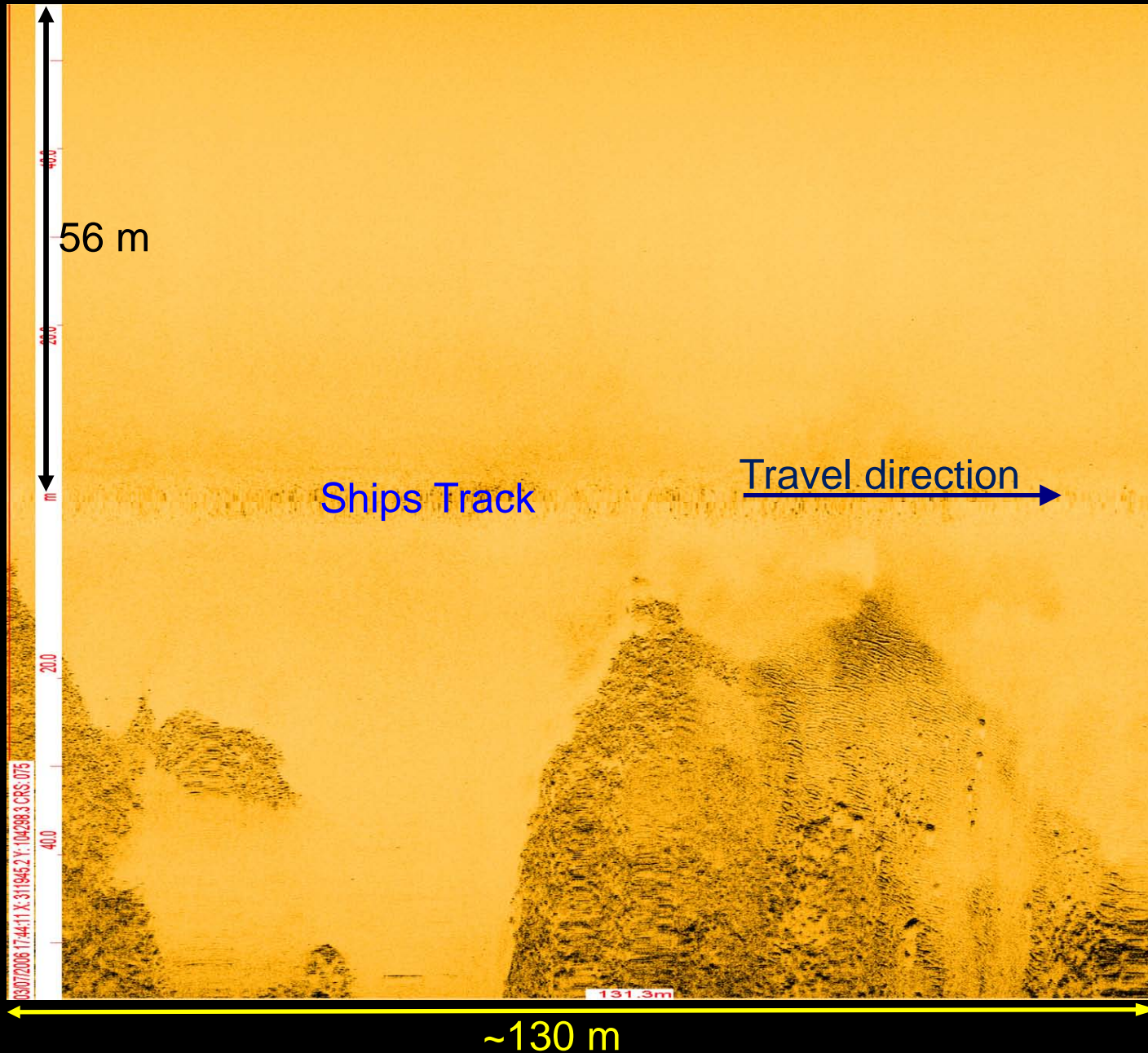
BIZZY BALL  
WOLFORD, RI

EdgeTech 272-TD





# Anatomy of a Side Scan Sonar Record



\*\* All side-scan data  
Collected and  
processed using  
Chesapeake  
Tech. Sonar Wiz  
and Sonar Web  
Software

# INTERPRETING SIDE-SCAN SONAR DATA

Interpreted based on the texture and intensity of the returning side-scan sonar signal

## – Intensity

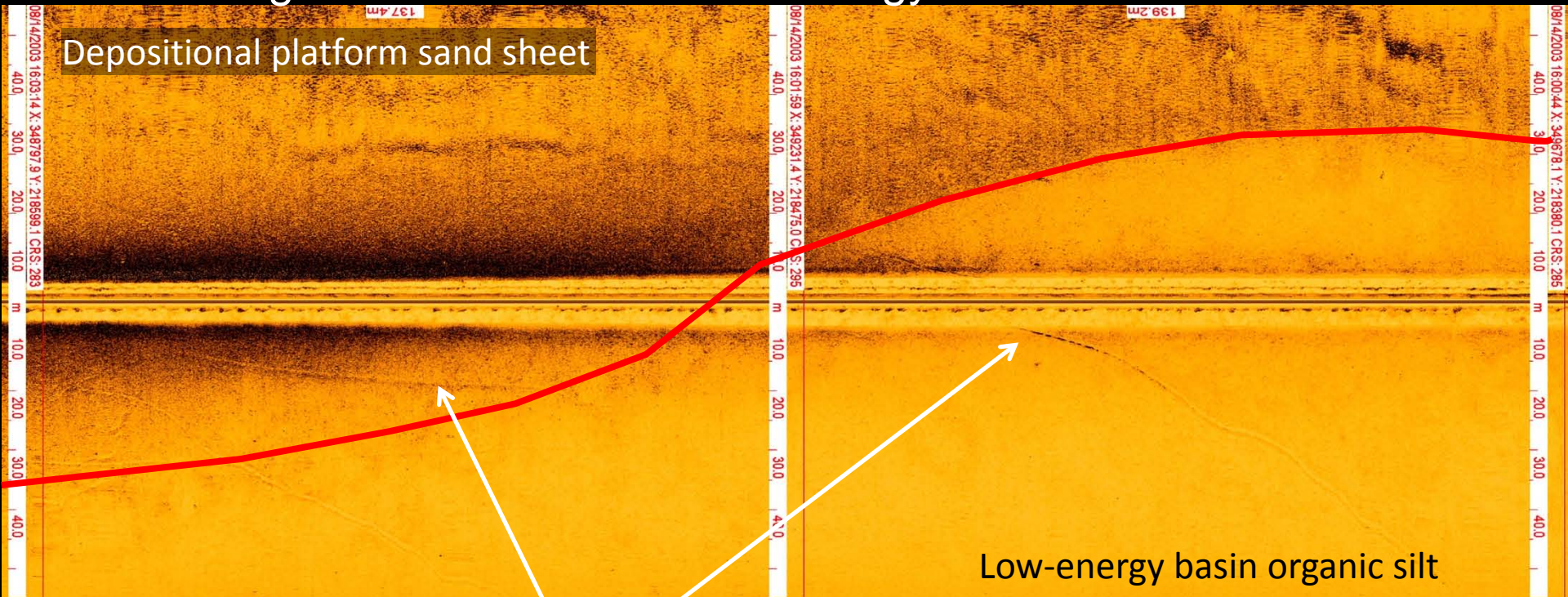
- How light/dark is the image
- Quasi relationship between grainsize and intensity

## – Texture

- What is the pattern of the image
- “Geology” (bedforms, boulders etc.)
- “Biology” (Microalgae, SAV)

# INTENSITY OF SIDE-SCAN SIGNAL

“Hard or rough bottoms reflect more energy...”



Depositional platform sand sheet

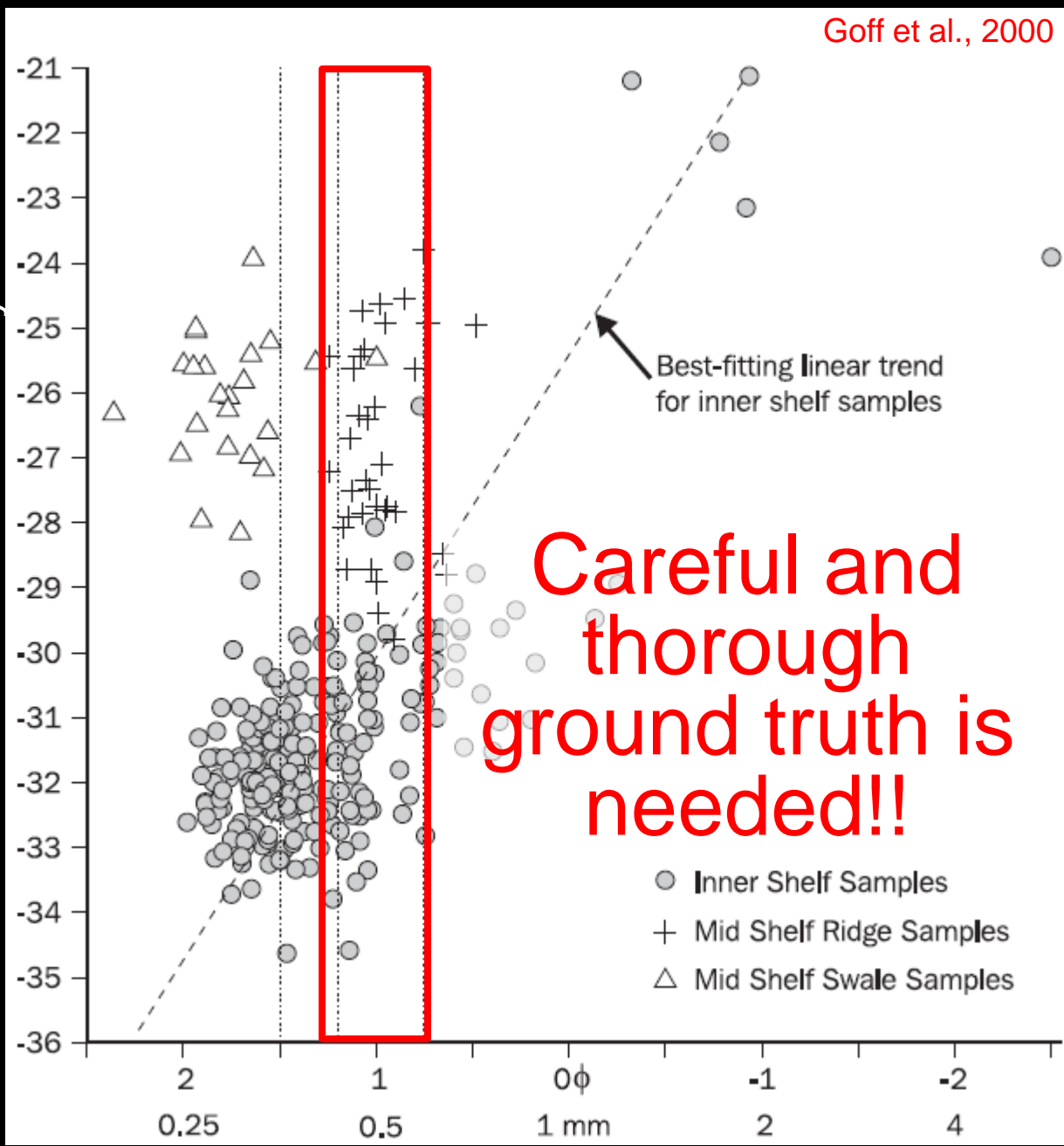
Low-energy basin organic silt

Trails from hydraulic dredge

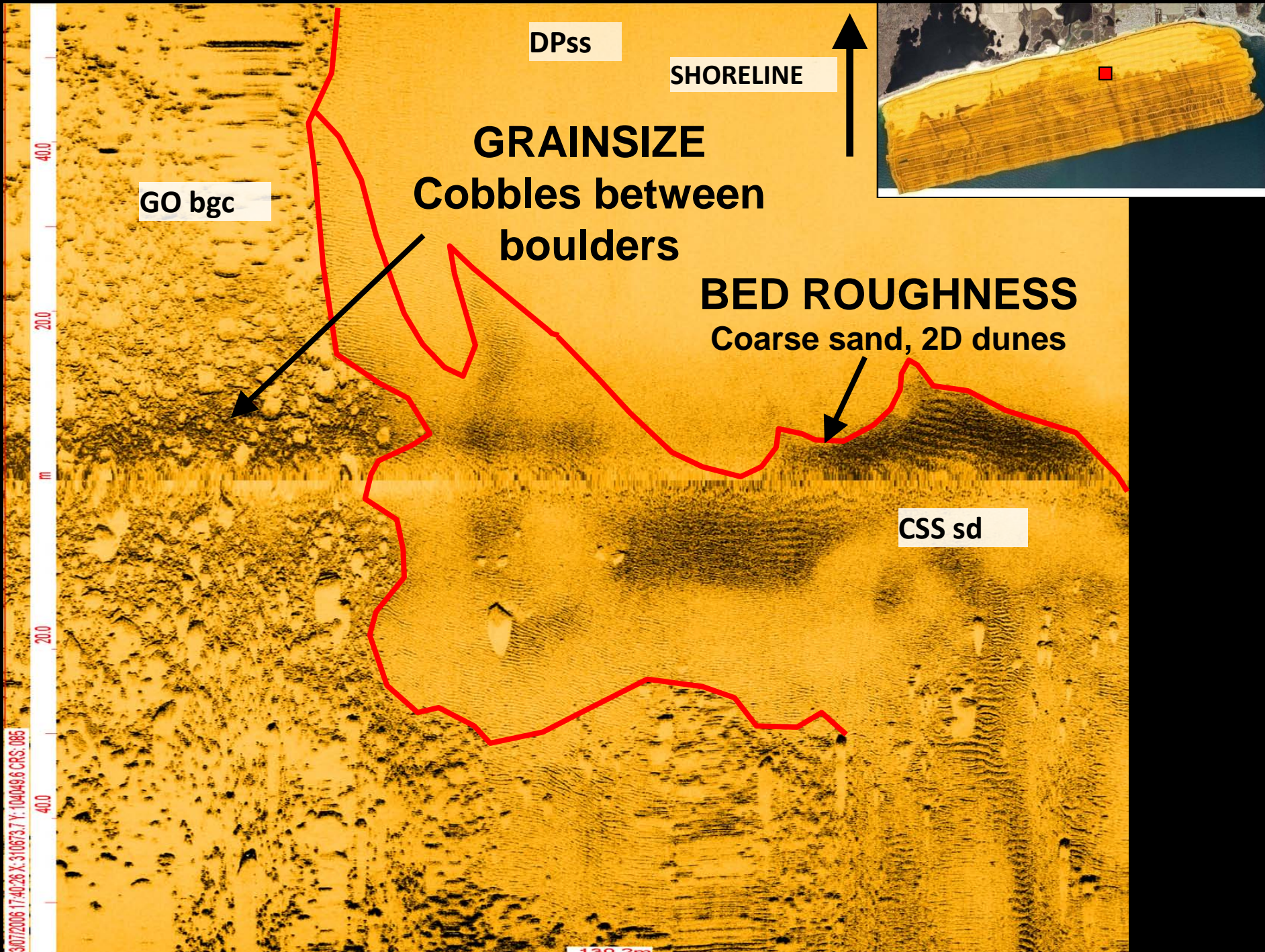
# BACKSCATTER VS. GRAINSIZE

“As close as it gets”

Backscatter intensity



Grainsize

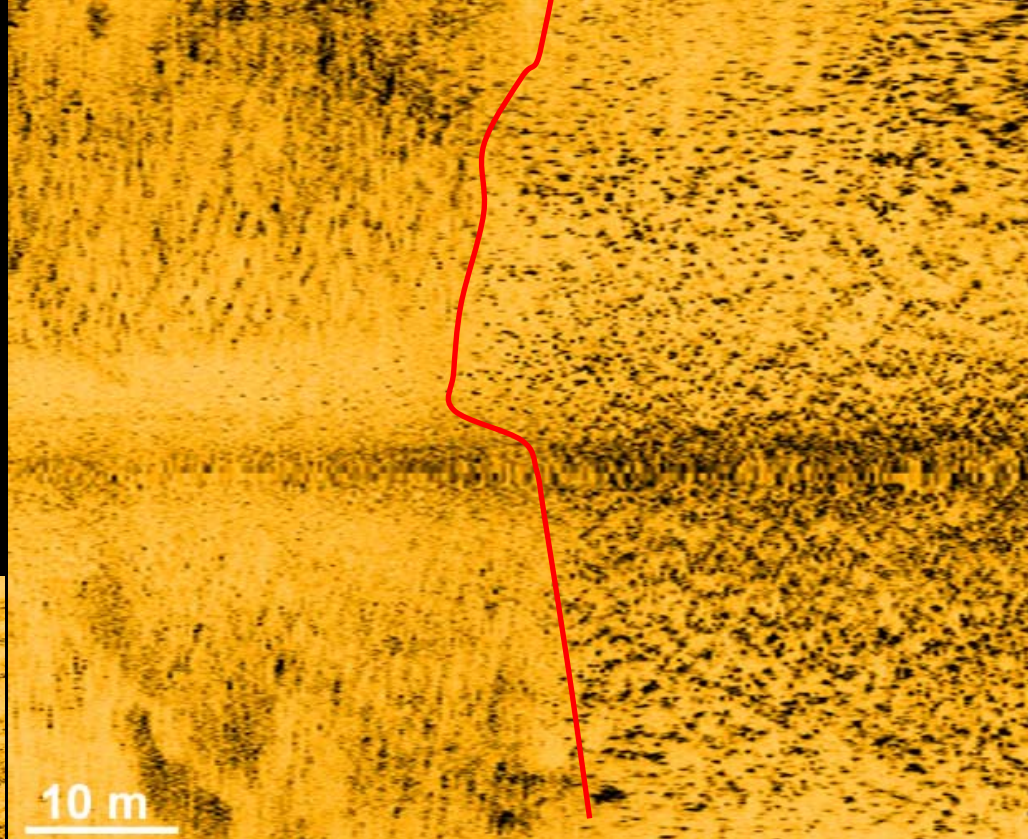
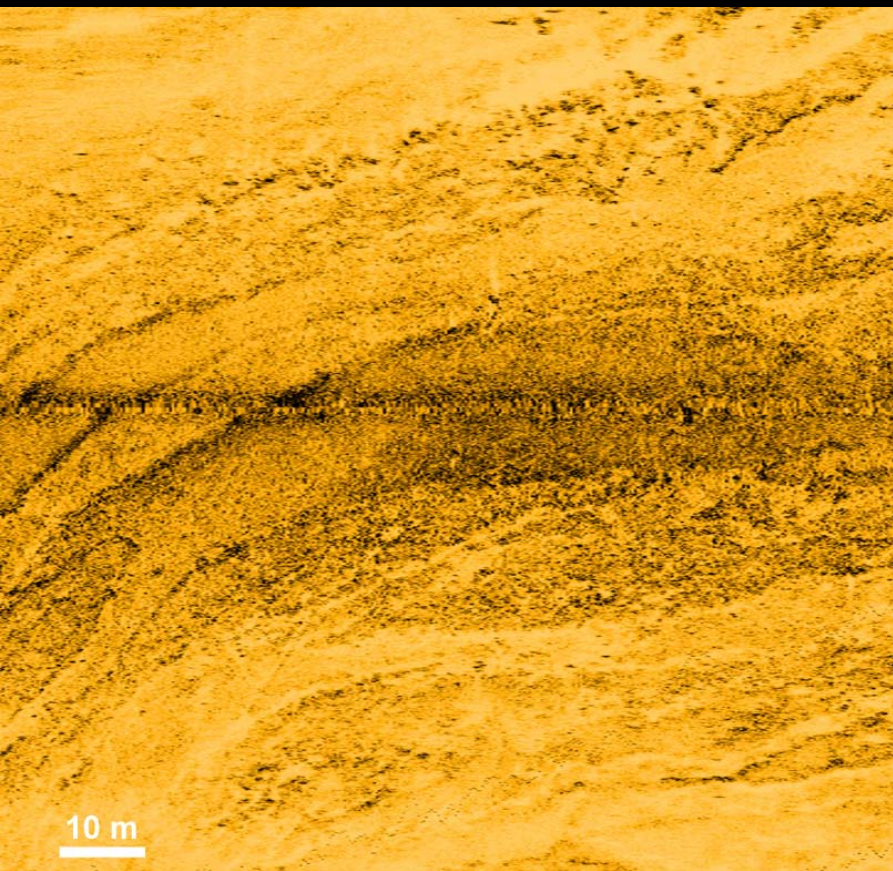


# SOME EXAMPLES OF BIOLOGIC AND ANTHROPOGENIC IMAGES: EELGRASS TRANSPLANT SITES



Different patterns reflect different years  
plantings

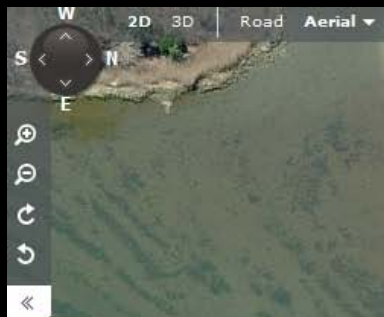
MACROALGAE  
VS.  
EELGRASS  
Wickford Harbor, RI



Eelgrass

Macroalgae (Ulva)





# MACROALGAE

## Wickford Harbor, RI



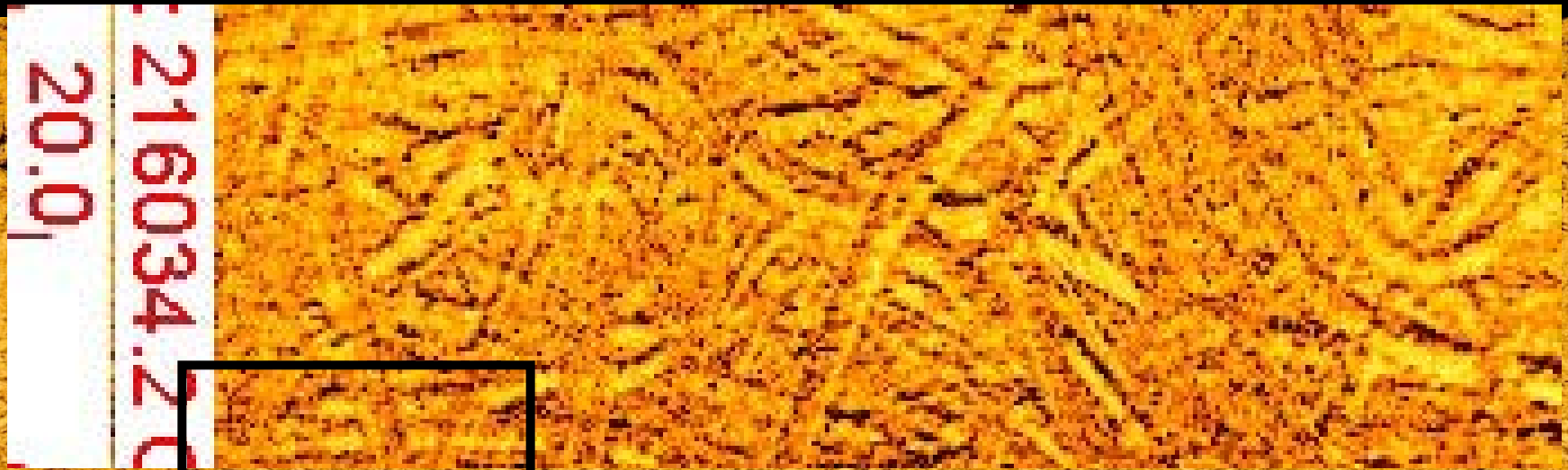
Hopedale Dr

Roger Williams Dr

Roger Williams Dr

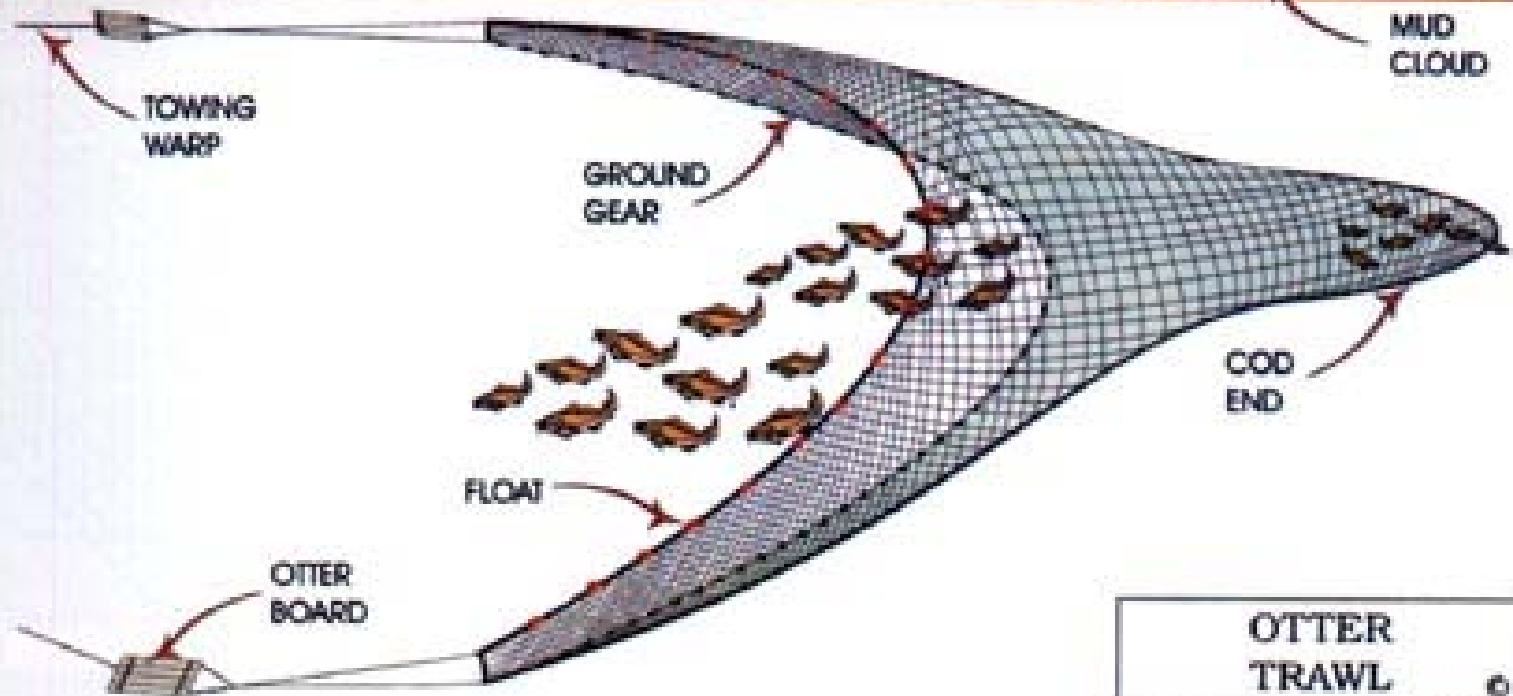
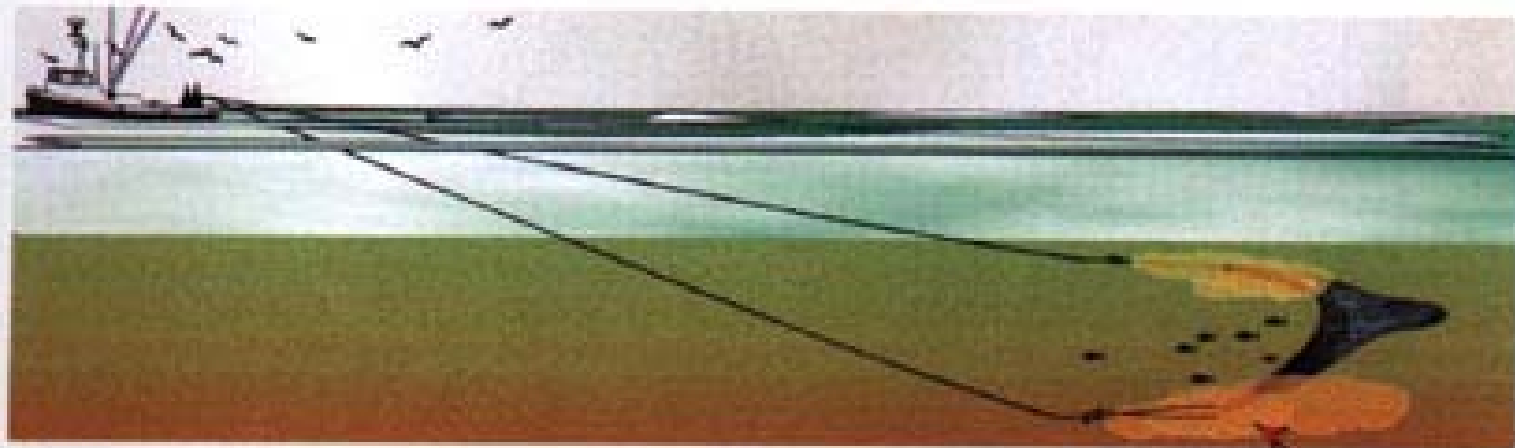
50 feet 20 m

© 2010 Microsoft Corporation © 2010 NAVTEQ © AND  
Pictometry Bird's Eye © 2010 Pictometry International Corp  
Pictometry Bird's Eye © 2010 MDA Geospatial Services Inc.



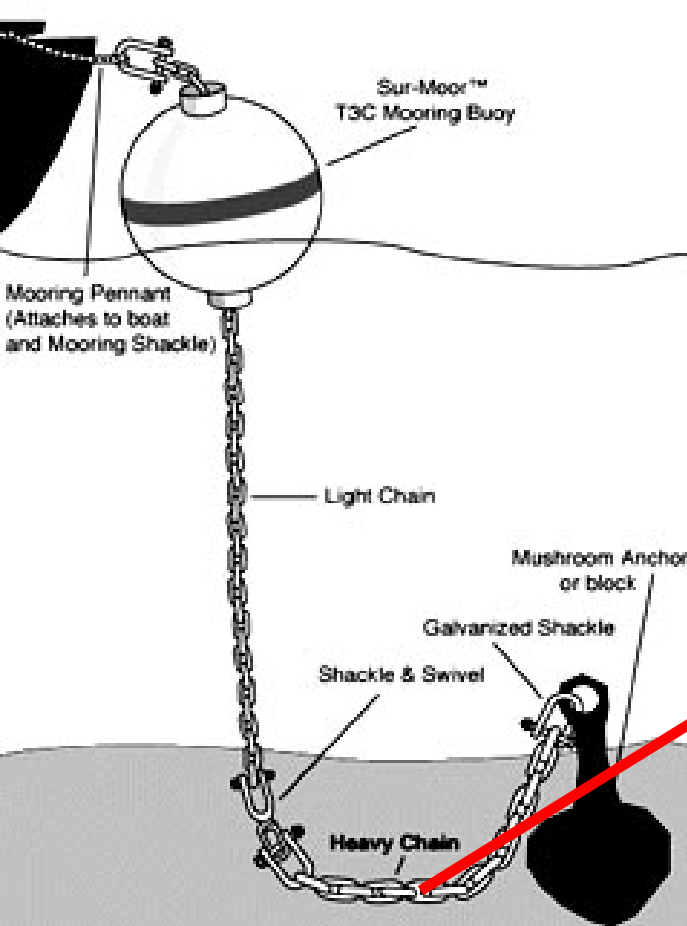
<http://www.bullraker.com/>

**SMOLOWITZ**  
**FIGURE 3**  
**(page 49)**  
A bottom trawl.  
Drawing  
by Robin  
Amaral.

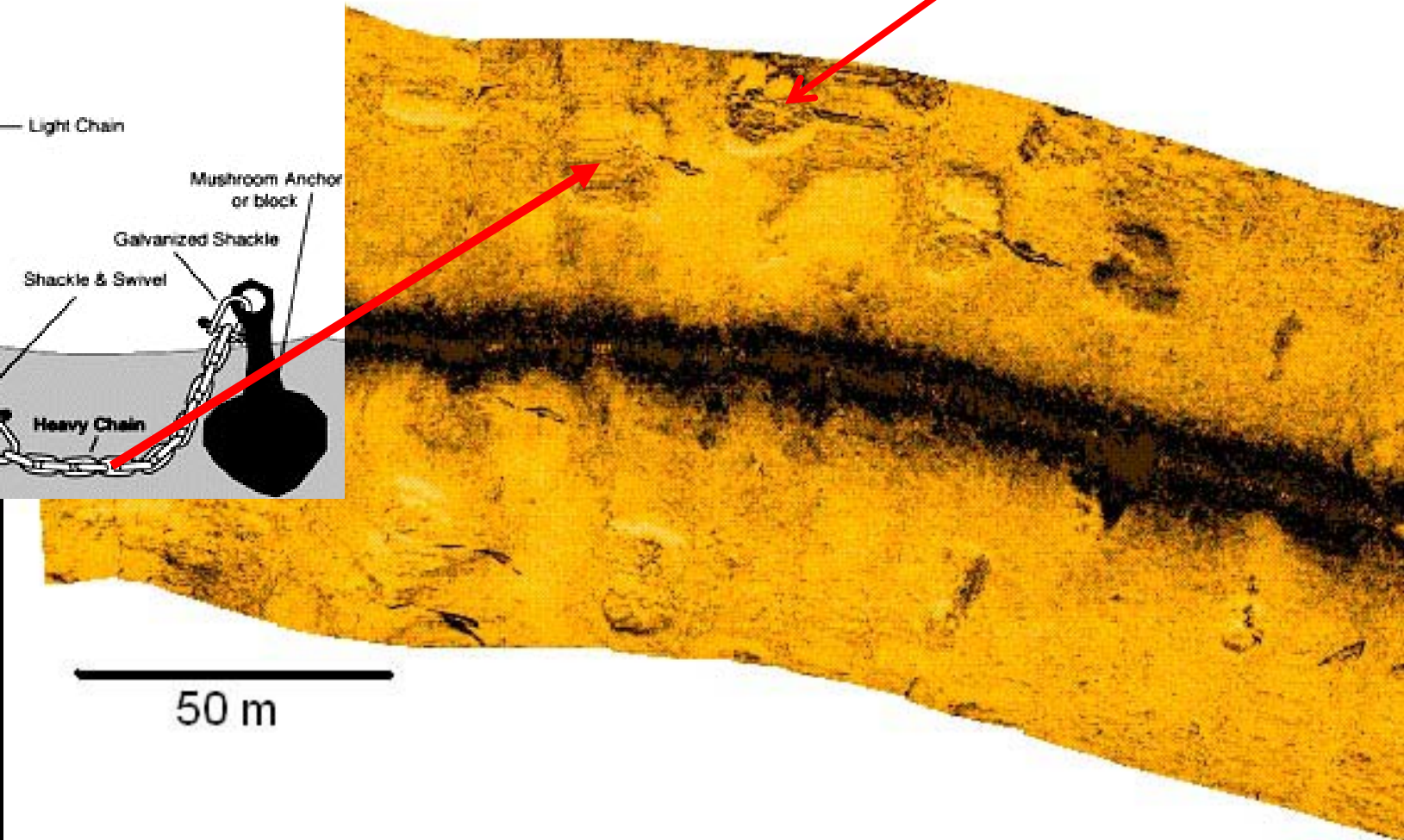


**OTTER  
TRAWL**  
©  
drawn by: Robin Amaral





# Mooring cables

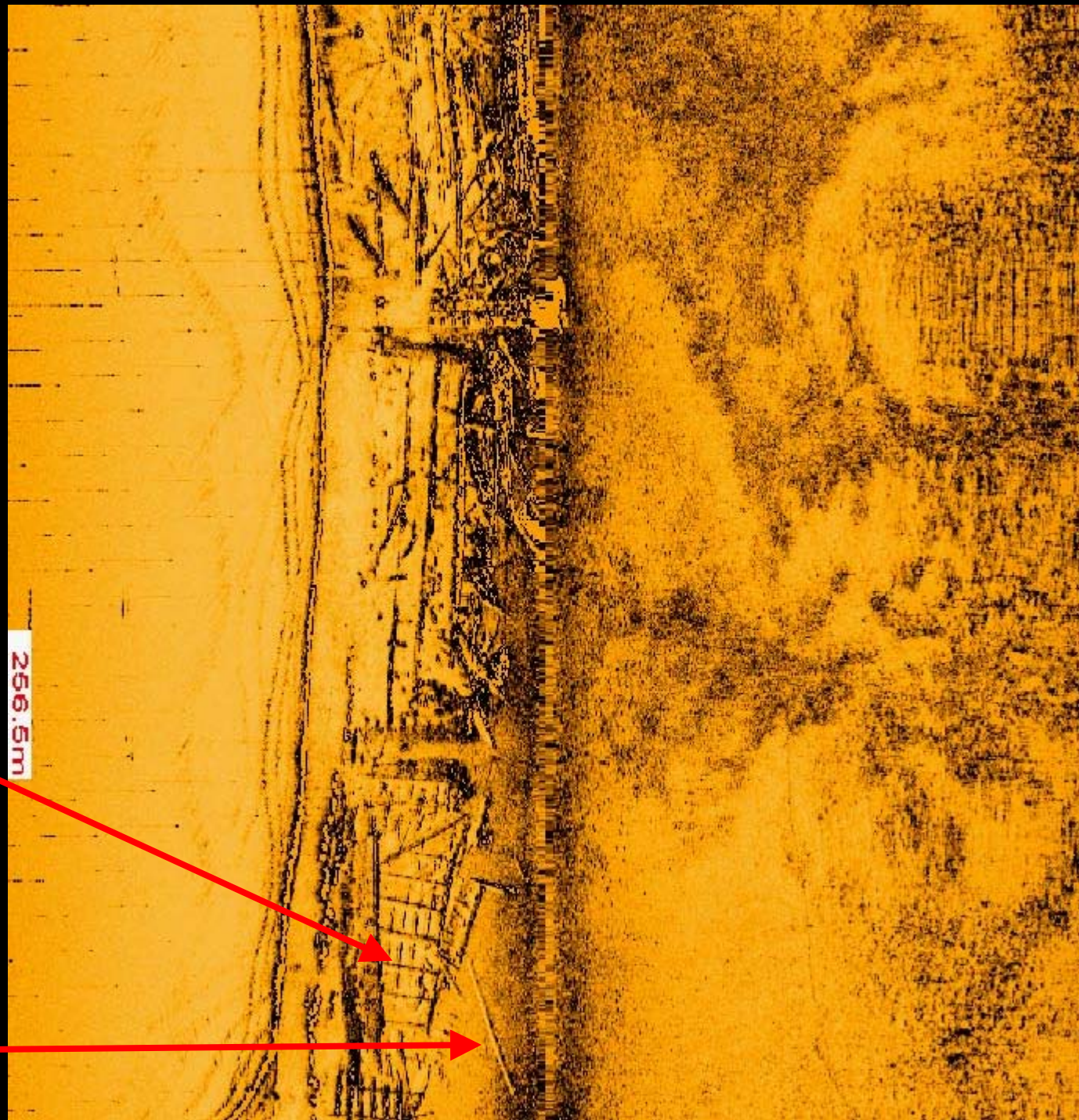


# Shoreline Protection Structures

Sunken wooden barge

256.5m

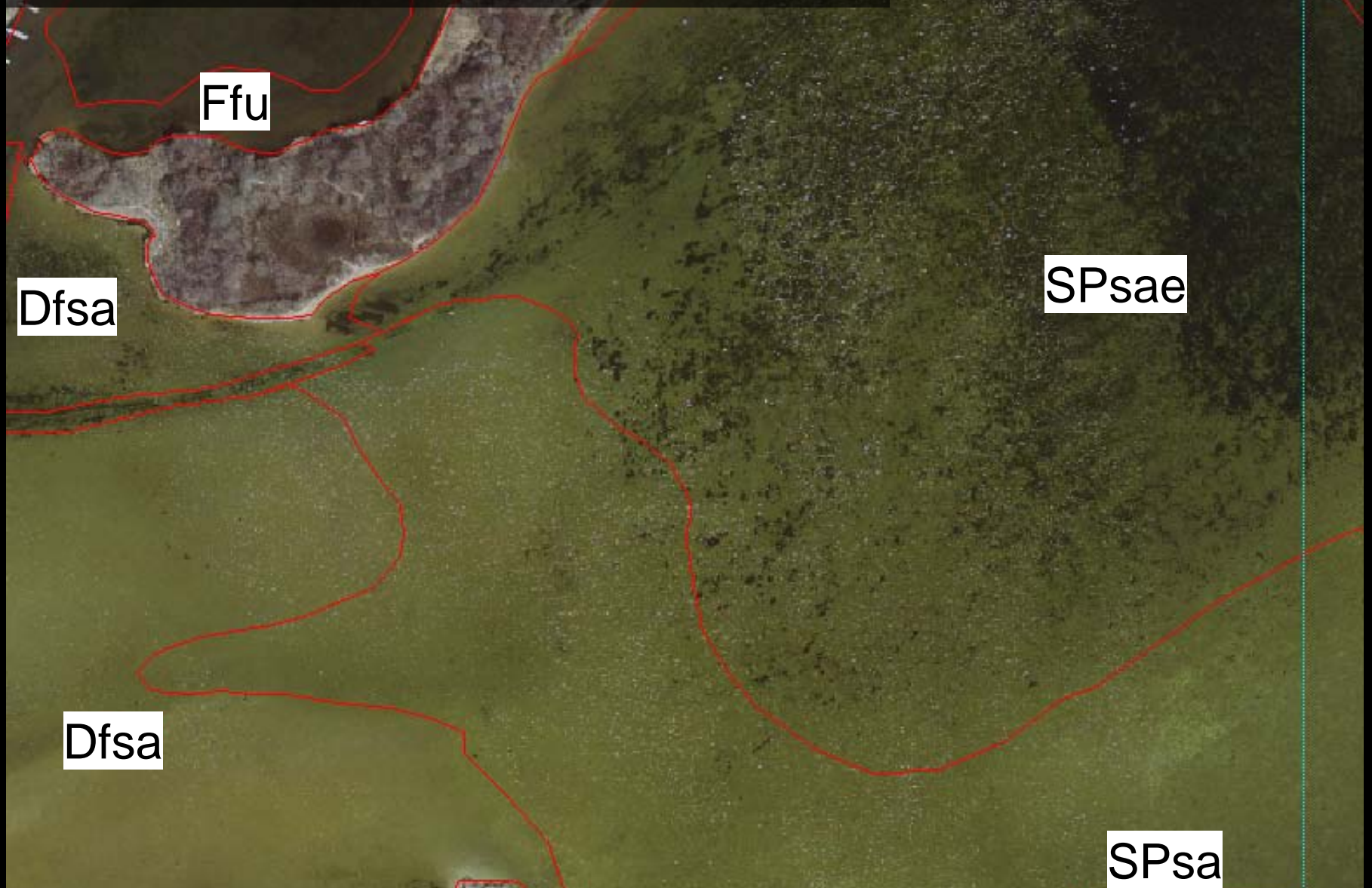
Piling



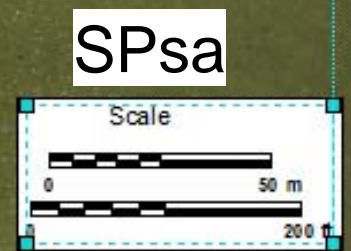
# OTHER SOURCES OF IMAGERY

- Aerial imagery serves two purposes:
  - Base map to display data
  - Additional data source for shallow dep. environments
- Digital orthophotographs
- Low-angle oblique photos
- Vertical aerial photos
  - \* Know the date of the photos, and low-tide is the best

# Digital orthophotography – Green Hill Pond

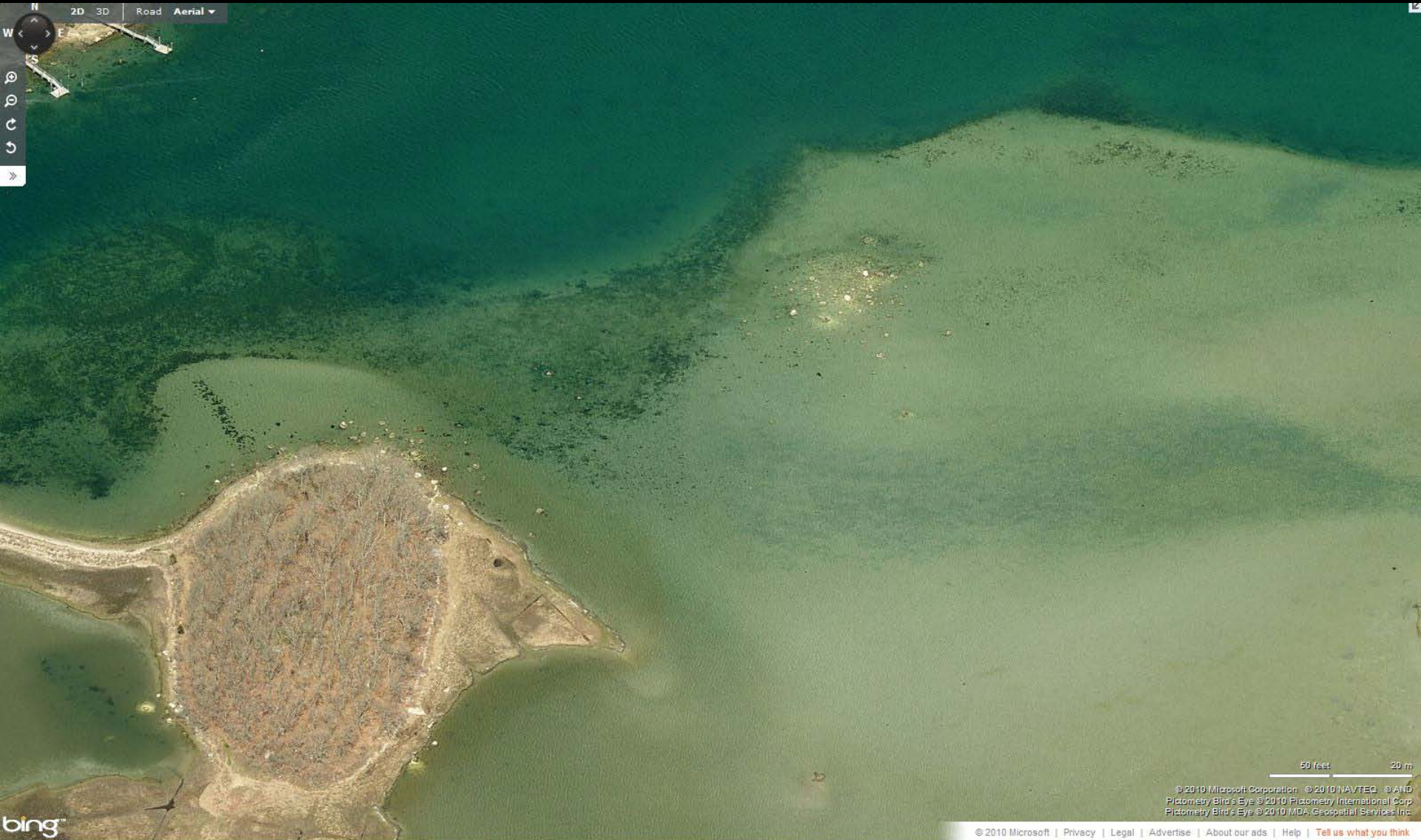


\*Not always a perfect match  
If the images are from previous years





# Low-angle oblique photos Bing.com “Birds eye images” – Quonnie Pond



# COLLECTING GROUND-TRUTH

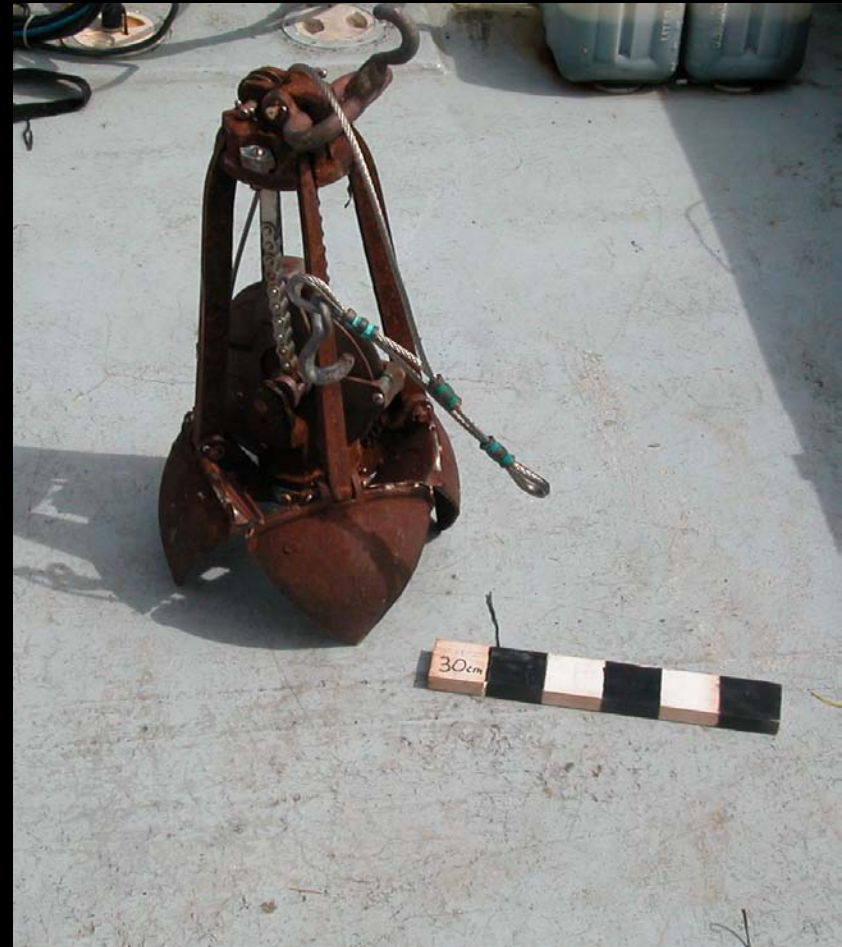
- A side-scan only mosaic is not a geologic map!
- Beware 'Automated interpretations'
- Sources of ground-truth data
  - *Surface sediment grab samples*
  - *Underwater video images*
  - Sediment cores
  - SPI Imagery
  - Direct (Diver) Observation

# SURFACE GRAB SAMPLERS

“PETITE” PONAR GRAB:  
(Mud and Sand)



Orange Peel Grab:  
(Sand and Gravel)



SURFACE GRAB SAMPLE  
MISQUAMICUT, RI

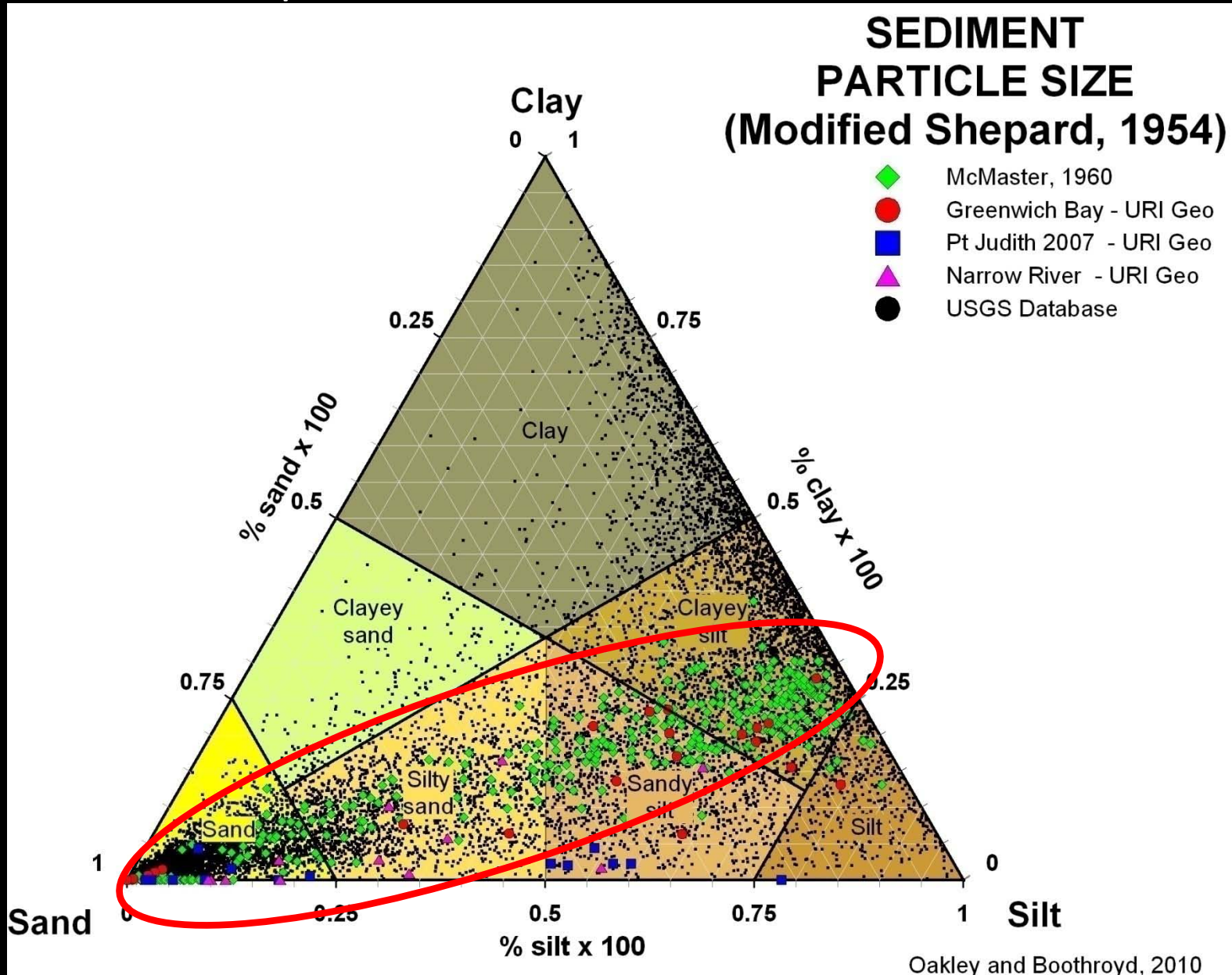
Misquamicut 15  
26-Aug-08

Collected by:  
URI Geosciences and  
RI Geological Survey

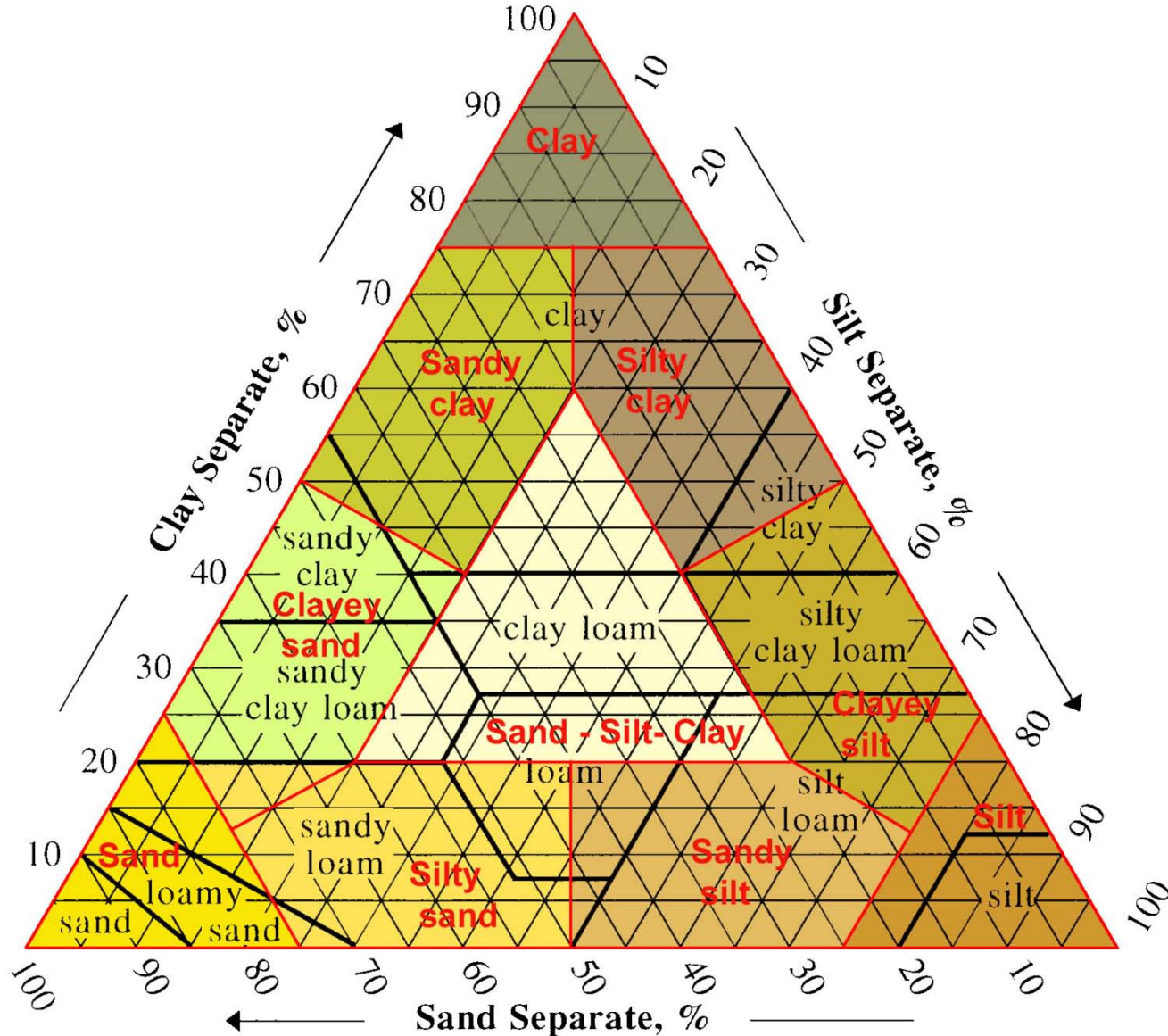
Dakley Sutherland and Troskosky

30cm

# CLASSIFYING PARTICLE SIZE: Modified Shepard, 1954



# CLASSIFYING PARTICLE SIZE: Shepard, 1954 vs. USDA "Agree to disagree"



# UNDERWATER VIDEO IMAGERY



LED Lights

Underwater Laser Pointers

**SeaViewer**  
Underwater Video Systems

J. Turenne, Photos

N 41 24. 71383  
W071 30. 25328

157 deg  
0 mph

12:52:36

5 cm

10-08-08

Low-energy basin silt  
w/ burrows

Low-energy basin silt w/ shells  
Slipper shells, (*Credula fornicata*)

N 41 24. 71443  
W071 30. 21785

353 deg  
0 mph

13:14:24

2 cm

10-08-08



N 41 23.67027  
W071 30.89462

168 deg  
0 mph

13:28:52

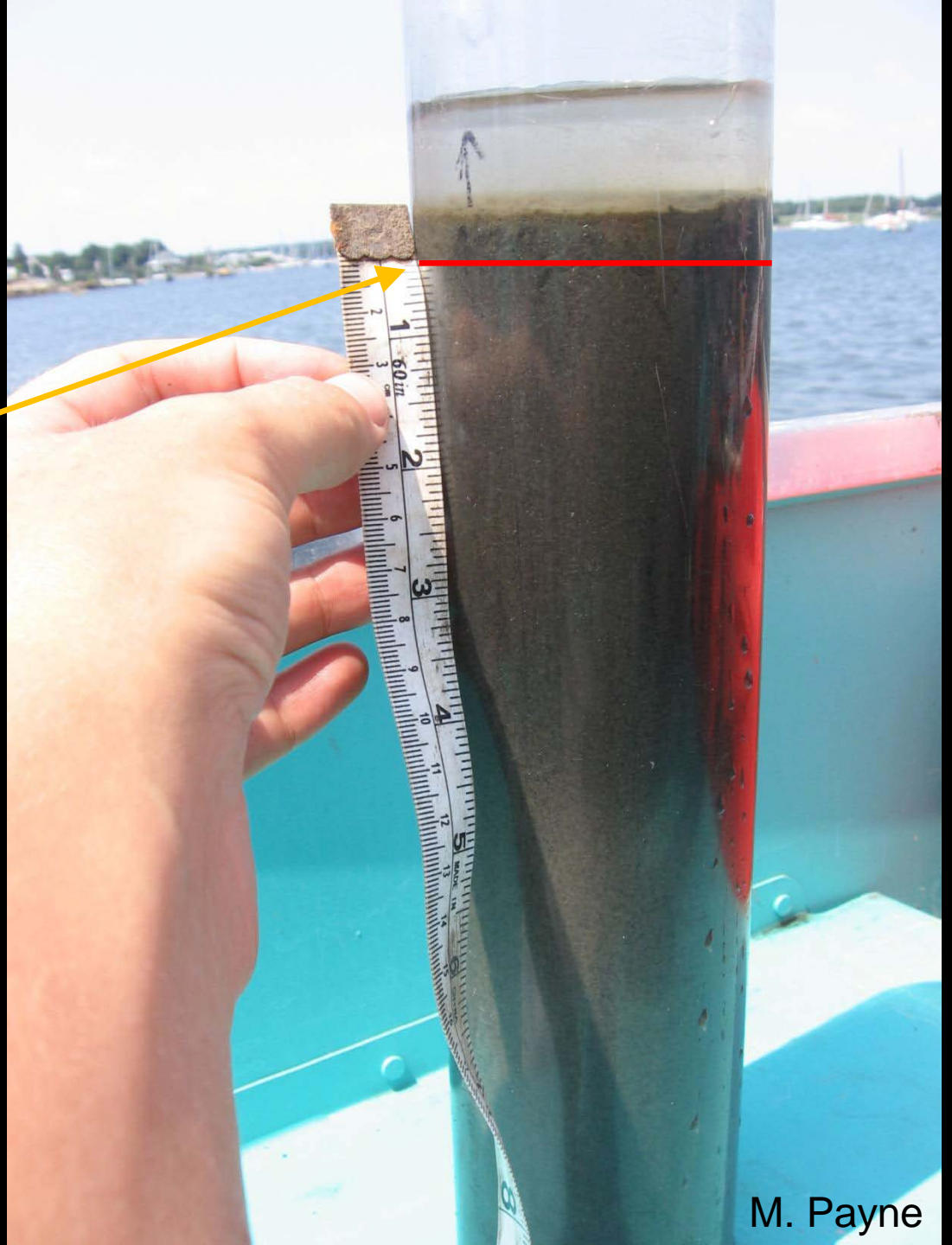
08-09-07

**Eelgrass (*Zostera marina*) on a  
Flood tidal delta, Pt. Judith Pond**

# CORE DATA

Use top layer to  
ground-truth side-scan  
facies

Penetration limit of  
500 kHz side-scan



# SEDIMENT PROFILE IMAGERY (SPI)



# BENTHIC GEOLOGIC HABITATS

- Place where the geologic processes (Water, wind, ice, humans) work to transport and deposit the sediment
- Based on a combination of geologic characteristics, wave action and tidal currents, bathymetry and biologic/anthropogenic activities



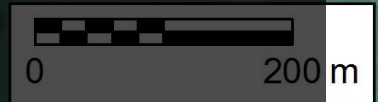
# BENTHIC GEOLOGIC HABITATS

Some examples in estuaries and lagoons

- Low-energy basins
- Channels
- Tidal deltas
- Tidal flats
- Etc. etc. etc.

*“Benthic Geologic Habitats of Greenwich Bay and Wickford Harbor, Narragansett Bay”*

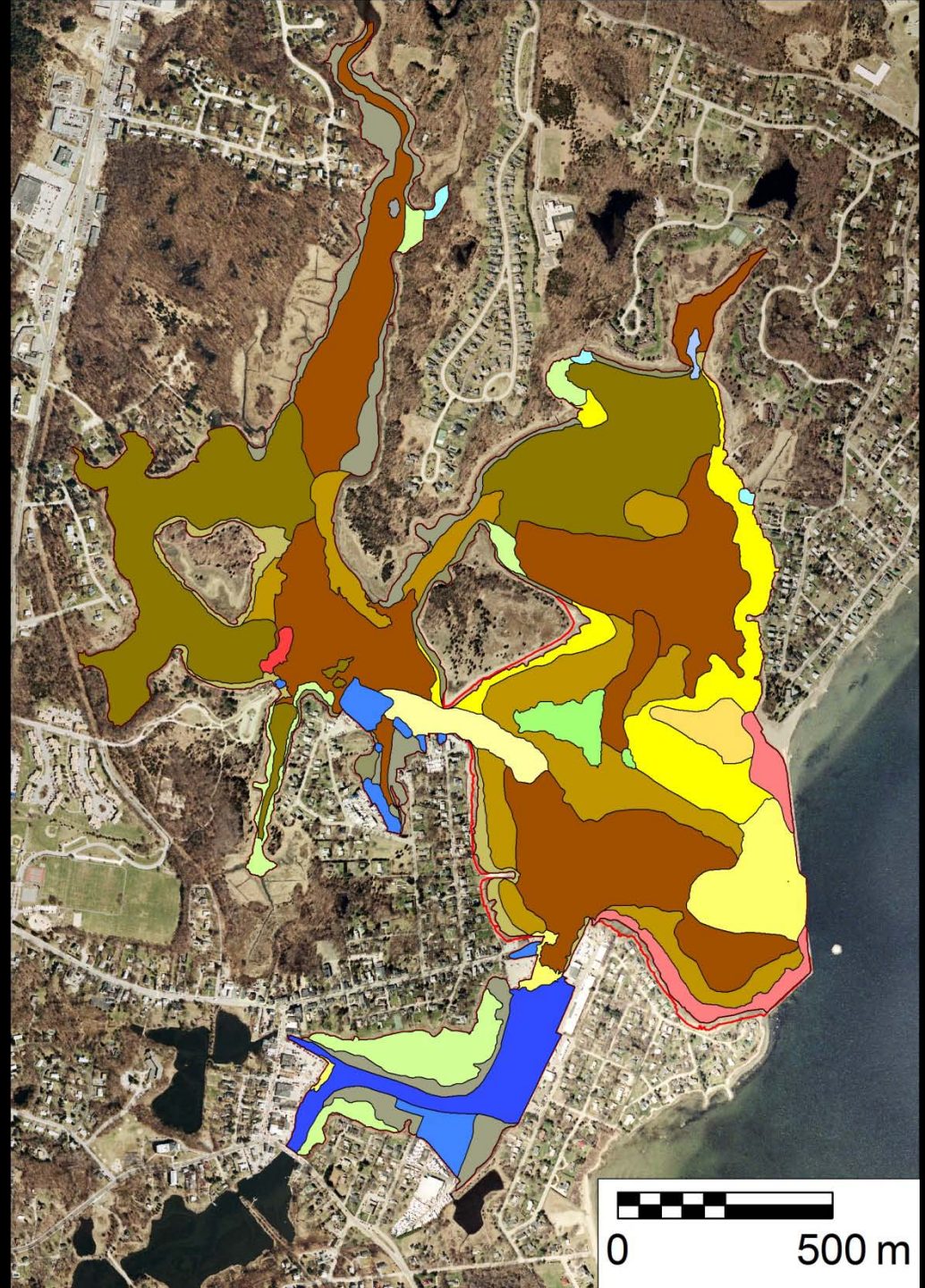
*(Oakley, Alvarez and Boothroyd, 2010 in Prep)*



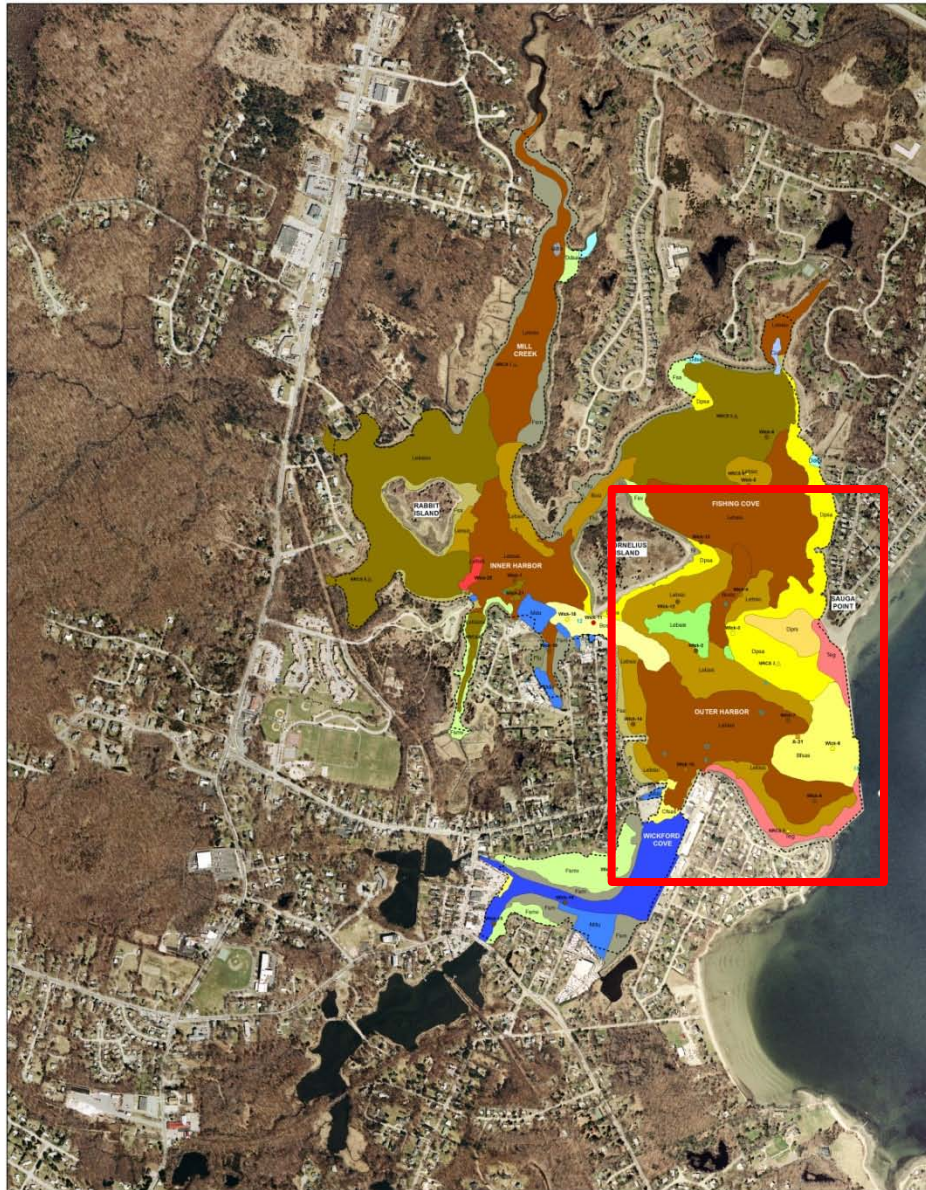
# WICKFORD HARBOR

## A Benthic Geologic Habitat Example

1. Collect and process  
Side-scan sonar data
2. Delineate side-scan facies
3. Collect ground – truth data
  - Surface sediment grabs
  - Cores
  - Underwater video
4. Interpret Benthic Geologic Habitats
  - Pinks: Gravel
  - Yellows: Sand
  - Blues: Channels
  - Greens: Macroalgae or SAV
  - Browns: Silt



# WICKFORD HARBOR



Map was either flying in July and August, 2006.  
 by R. Chelley, J. Alvarez, M. Sabatowski and W. Payne.

The 2003/04 digital bathymetry data were provided by the Rhode Island Department of Transportation via the Rhode Island Geographic Information System.

## BENTHIC GEOLOGIC HABITATS OF WICKFORD HARBOR, NARRAGANSETT BAY, RHODE ISLAND

by  
 Bryan Oakley, Jon D. Alvarez and Jon C. Boothroyd

2008

DRAFT: 18 APRIL 2008



### EXPLANATION

**ESTUARINE BAY FLOOR**

- Blow** Bayflower sand sheet: This habitat was mapped at the entrance to the outer harbor, where there is enough water and still energy to permit deposition of fine grained organic rich sediments. There is a low energy zone in the outer harbor from the outer harbor to the inner harbor. This habitat is composed of blowflower sand sheet, which is composed of fine grained organic rich sediments. This habitat is composed of blowflower sand sheet, which is composed of fine grained organic rich sediments. This habitat is composed of blowflower sand sheet, which is composed of fine grained organic rich sediments.
- Leaves** Low-energy basin coarse silt: This habitat occurs along the shoreline edges of the Outer Harbor low-energy basin. Surface sediment samples from the habitat plot are very sandy to silty and are composed of coarse to medium grained sand. The substrate represents the historical depositional style of the adjacent sand sheet.
- Leaves** Low-energy basin organic silt: This habitat, identified by a light, featureless silt on the side view record, is composed of fine grained organic rich sediments. Surface sediment samples collected over 90% silt and clay.
- Leaves** Low-energy basin silt with seaweeds: This habitat was mapped at the entrance to the outer harbor, where there is enough water and still energy to permit deposition of fine grained organic rich sediments. This habitat is composed of silt with seaweeds, which is composed of fine grained organic rich sediments. This habitat is composed of silt with seaweeds, which is composed of fine grained organic rich sediments.

**Fishing Cove low-energy basin**

**Subtidal habitats**

- Leaves** Low-energy basin coarse silt: This habitat was mapped at the entrance to the Fishing Cove, where there is enough water and still energy to permit deposition of fine grained organic rich sediments. This habitat is composed of coarse silt, which is composed of fine grained organic rich sediments. This habitat is composed of coarse silt, which is composed of fine grained organic rich sediments.
- Leaves** Low-energy basin organic silt: This habitat is identified by a light, featureless silt on the side view record, and is composed of fine grained organic rich sediments. Surface sediment samples collected over 90% silt and clay.
- Leaves** Low-energy basin vegetated organic silt: This habitat is the same as the low-energy basin organic silt, however, it is characterized by the presence of seaweeds. This habitat is composed of vegetated organic silt, which is composed of fine grained organic rich sediments. This habitat is composed of vegetated organic silt, which is composed of fine grained organic rich sediments.

**Inner Harbor low-energy basin**

**Subtidal habitats**

- Leaves** Low-energy basin coarse silt: This habitat was mapped at the entrance to the Inner Harbor, where there is enough water and still energy to permit deposition of fine grained organic rich sediments. This habitat is composed of coarse silt, which is composed of fine grained organic rich sediments. This habitat is composed of coarse silt, which is composed of fine grained organic rich sediments.
- Leaves** Low-energy basin organic silt: This habitat is identified by a light, featureless silt on the side view record, and is composed of fine grained organic rich sediments. Surface sediment samples collected over 90% silt and clay.
- Leaves** Low-energy basin vegetated organic silt: This habitat is the same as the low-energy basin organic silt, however, it is characterized by the presence of seaweeds. This habitat is composed of vegetated organic silt, which is composed of fine grained organic rich sediments. This habitat is composed of vegetated organic silt, which is composed of fine grained organic rich sediments.

**ESTUARINE CHANNEL**

- Blow** Blow channel sand sheet: This habitat was mapped in the channel connecting the inner and outer harbors of the harbor. Grain size in this habitat ranges from sand to silt, with occasional shells and shell fragments. This represents an area of relatively high flow current flow, which inhibits deposition of the adjacent sand sheet. Analysis of historic NOAA charts indicates that portions of the channel were dredged prior to 1967.
- Blow** Blow channel coarse silt: Mapped in the small channel on the northern edge of Narragansett Bay, connecting Fishing Cove and the inner harbor. This habitat is composed of coarse silt, which is composed of fine grained organic rich sediments. This habitat is composed of coarse silt, which is composed of fine grained organic rich sediments.
- Blow** Blow channel organic silt: This habitat occurs in the shallow deeper channel bed connecting Fishing Cove and the outer harbor of the harbor. No sediment samples were collected within the habitat, but the habitat is composed of organic silt, which is composed of fine grained organic rich sediments. This habitat is composed of organic silt, which is composed of fine grained organic rich sediments.

**ESTUARINE COVE**

**Subtidal habitats**

- Blow** Blowflower sand sheet: This habitat occurs at the entrance to the Fishing Cove, where there is enough water and still energy to permit deposition of fine grained organic rich sediments. This habitat is composed of blowflower sand sheet, which is composed of fine grained organic rich sediments. This habitat is composed of blowflower sand sheet, which is composed of fine grained organic rich sediments.
- Leaves** Low-energy basin organic silt: This habitat was mapped in both the Inner Harbor and the Outer Harbor. This habitat is identified by a light, featureless silt on the side view record, and is composed of fine grained organic rich sediments. Surface sediment samples collected over 90% silt and clay.
- Leaves** Low-energy basin vegetated organic silt: This habitat is the same as the low-energy basin organic silt, however, it is characterized by the presence of seaweeds. This habitat is composed of vegetated organic silt, which is composed of fine grained organic rich sediments. This habitat is composed of vegetated organic silt, which is composed of fine grained organic rich sediments.
- Clay** Dredged channel organic silt: Occupying most of Narragansett Bay is a dredged channel. Historic NOAA charts indicate Narragansett Bay has been dredged since the early 1920s. Sediment samples collected from the harbor indicate coarse organic silt, silt, or silt with seaweeds in various areas.
- Clay** Inlet channel (unvegetated): This habitat was mapped in the small channel that is the S&M connection between Fishing Cove and the outer harbor. This habitat is composed of coarse silt, which is composed of fine grained organic rich sediments. This habitat is composed of coarse silt, which is composed of fine grained organic rich sediments.
- Clay** Dredged marina (unvegetated): This habitat is confined with in various marinas throughout the cove. Coarse silt was not observed, but is usually under the adjacent habitat.

**ESTUARINE MARGINAL ENVIRONMENTS**

**Sub/Subtidal habitats**

- Clay** Great elevated terraces: This habitat is found on intertidal and upper subtidal portions of eroding terraces composed of elevated level and sand. It is formed from green sand dunes as the fine grained material is transported along in channels, and leaves behind sand and gravel. Intertidal boundaries are visible throughout the harbor.
- Clay** Depositional pattern ridge silt (sand): This habitat represents a former depositional silt that extended south from the entrance of Narragansett Bay. This habitat is composed of silt, which is composed of fine grained organic rich sediments. This habitat is composed of silt, which is composed of fine grained organic rich sediments.
- Clay** Depositional pattern sand sheet: Formed by deposition of sand eroded from the shoreline as it eroded and is composed of coarse sand and silt. This habitat is composed of sand sheet, which is composed of fine grained organic rich sediments. This habitat is composed of sand sheet, which is composed of fine grained organic rich sediments.
- Silt** Low-energy beach (sand): Beaches composed of sand bars formed along the interior of adjacent terraces and are composed of coarse sand and silt. This habitat is composed of beach, which is composed of fine grained organic rich sediments. This habitat is composed of beach, which is composed of fine grained organic rich sediments.
- Clay** Discrete dune (sand): Clay dune or dune-like features are composed of coarse sand and silt. This habitat is composed of dune, which is composed of fine grained organic rich sediments. This habitat is composed of dune, which is composed of fine grained organic rich sediments.
- Sand** Sand flat: Flat composed of mixed fine sand and coarse silt. Some portions are exposed at low tide.
- Flora** Mudflat: Flat composed of mixed fine sand and coarse silt. Other flats are composed of mudflat, which is composed of fine grained organic rich sediments. This habitat is composed of mudflat, which is composed of fine grained organic rich sediments.
- Flora** Vegetated mud flat: Occurring in low sand areas along the depositional basin of Fishing Cove. The composition of mud flat is composed of mixed fine sand and coarse silt, and is composed of mudflat, which is composed of fine grained organic rich sediments. This habitat is composed of vegetated mud flat, which is composed of fine grained organic rich sediments.
- Flora** Floating bed (unvegetated): This habitat represents some of the shoreline of Fishing Cove and the channel connecting the cove and the inner harbor. The grain size of this habitat ranges from silt to sand and silt, and is composed of floating bed, which is composed of fine grained organic rich sediments. This habitat is composed of floating bed, which is composed of fine grained organic rich sediments.

**OTHER MAP SYMBOLS**

- SAUGA POINT**
- W&A-1** Surface sediment grab sample: Collected by the University of Rhode Island Department of Oceanography during August 2006. Sample area indicated on a 1:5000 scale surface sediment grab sample. Location is shown in the legend below.
- W&A-2** Vibracore location: Collected by the National Resources Conservation Service during the summer of 2006. The 1:5000 scale map shows the location of the vibracore location. Location is shown in the legend below.
- A-21** Surface sediment grab sample: Collected by the National Resources Conservation Service during the summer of 2006. Sample area indicated on a 1:5000 scale map. Location is shown in the legend below.

**Legend:**

- Dredged, 1980s sediment class:**
  - Coarsely sediment
  - Sand silt
- Limit of subtidal cover boundary:**
  - Coarsely sediment
  - Sand silt
- Bathymetry:** Feet below MLLW. Data was collected in 2006 by the National Resources Conservation Service.
- Block:** Outcrop exposure of bedrock (Continental Rhode Island Formation). Limited to a small island exposure in the southern portion of M&C Cove.



# WICKFORD HARBOR

Some examples...

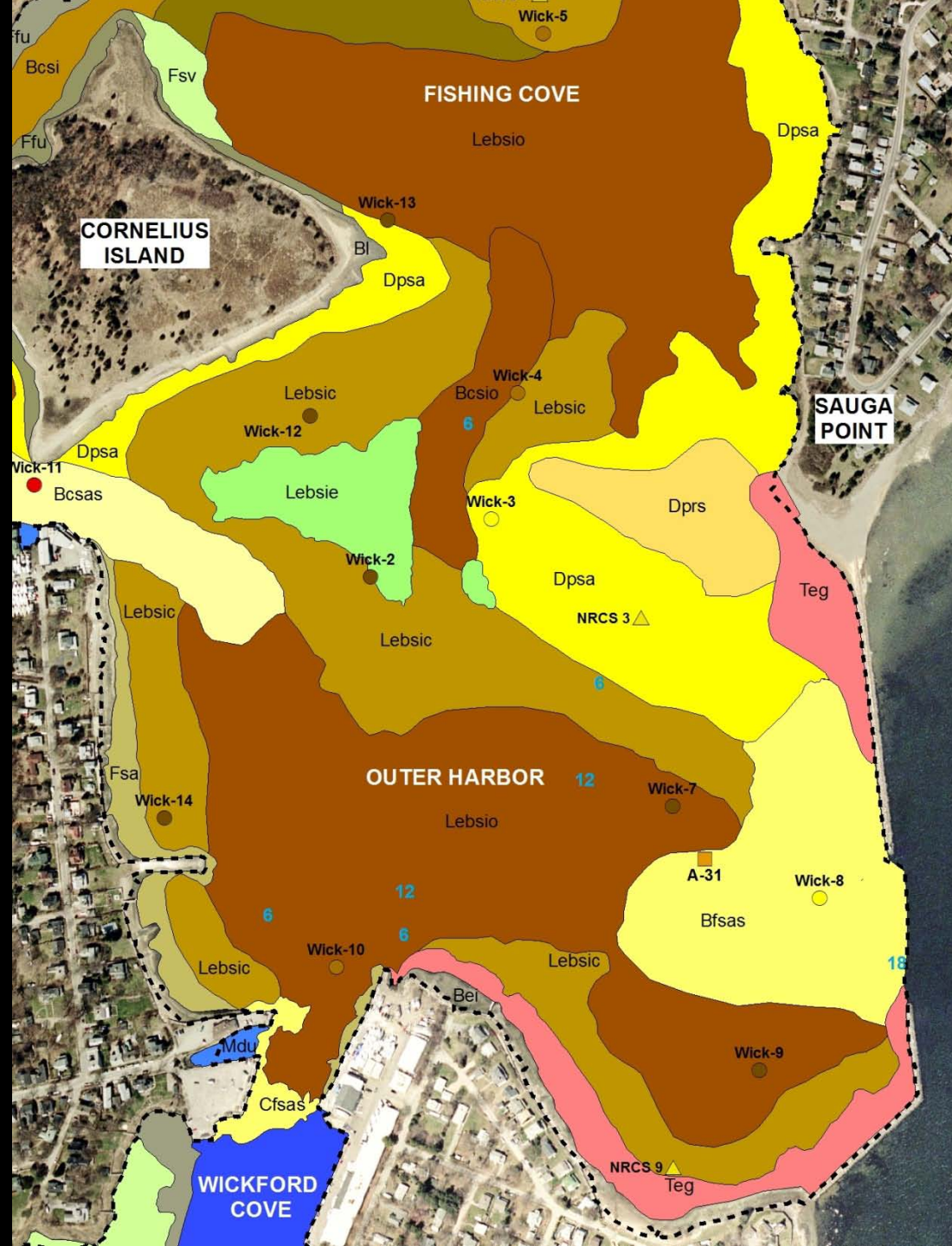
Lebsie – Low-energy basin  
silt w/ eelgrass

Dpsa – Depositional platform  
sand sheet

Lebsio – Low-energy basin  
organic silt

Fsa – Sand Flat

Teg – Gravel erosional  
terrace





# BENTHIC GEOLOGIC HABITATS AND SAS

- Mapping is based on different data sets
- BGH's
  - Side-scan, video, grab samples
- SAS
  - Bathymetry, Soil Descriptions
- Map units are typically similar in extent and distribution

# BENTHIC GEOLOGIC HABITATS: WICKFORD, RI



# SUBAQUEOUS SOILS: WICKFORD, RI



# BENTHIC GEOLOGIC HABITATS AND SAS

- Benefits to SAS mapping
  - Resolution of the data interpreted from side-scan sonar is much higher than SAS data
  - Provides a check on the bathymetry driven interpretations
  - Video and grab samples provide some check/additional data on SAS interpretations and presence absence of SAV

# BENTHIC GEOLOGIC HABITATS and SAS QUONNIE EXAMPLE:

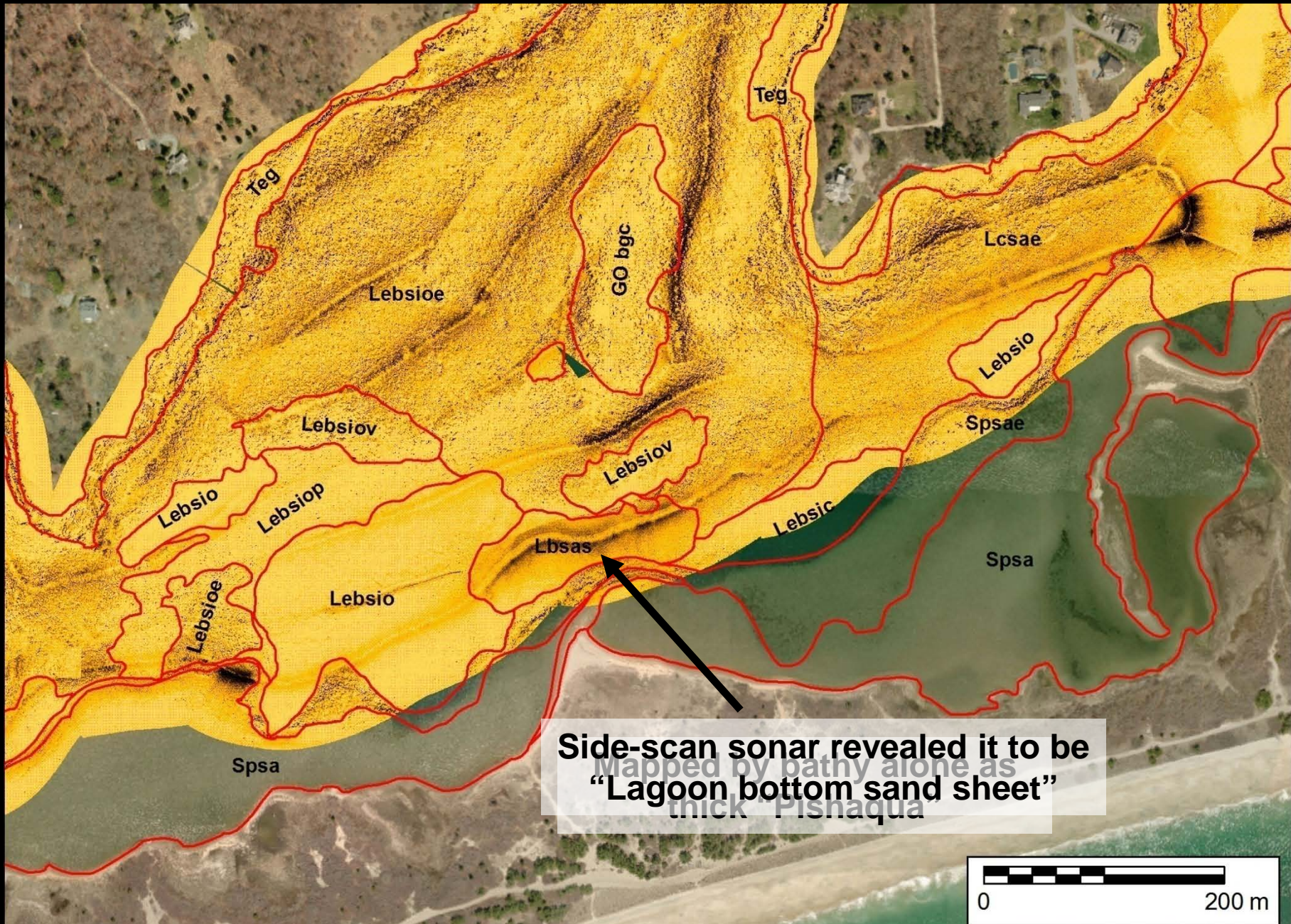
- SAS mapping alone based on bathymetric data points and soil descriptions
  - In Quonnie: 70 sampled locations
  - Bathymetric data line spacing  $>50$  m
- Resolution of side-scan sonar
  - 30 cm pixel size, near continuous coverage
  - Minimum polygon size  $< 100$  m

# Single-Beam Bathymetry and SAS



Mapped by bathy alone as thick "Pishaqua"

# Side-Scan Sonar and SAS: Resolution, Resolution, Resolution!



Side-scan sonar revealed it to be  
"Lagoon bottom sand sheet"



# QUESTIONS?

