Mapping Subaqueous Soils in Rhode Island: Integration of Pedologic and Acoustic Approaches

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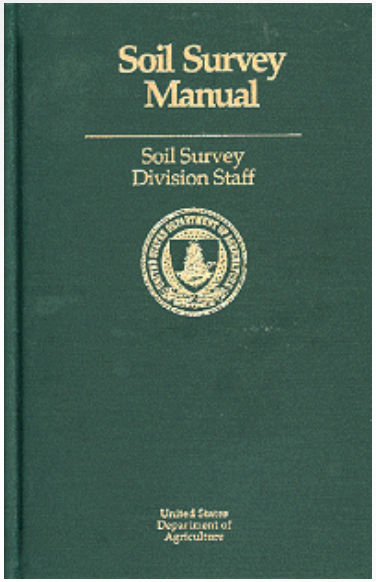
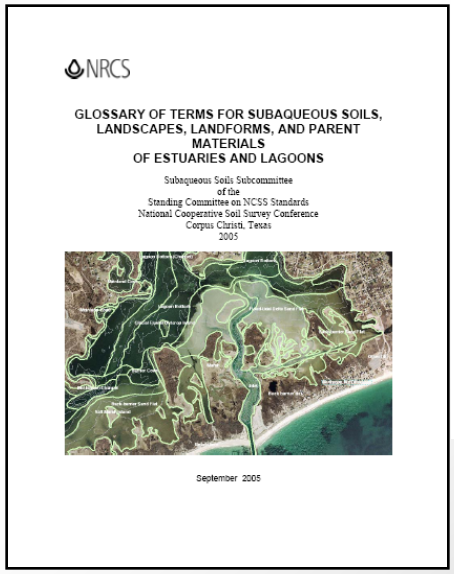
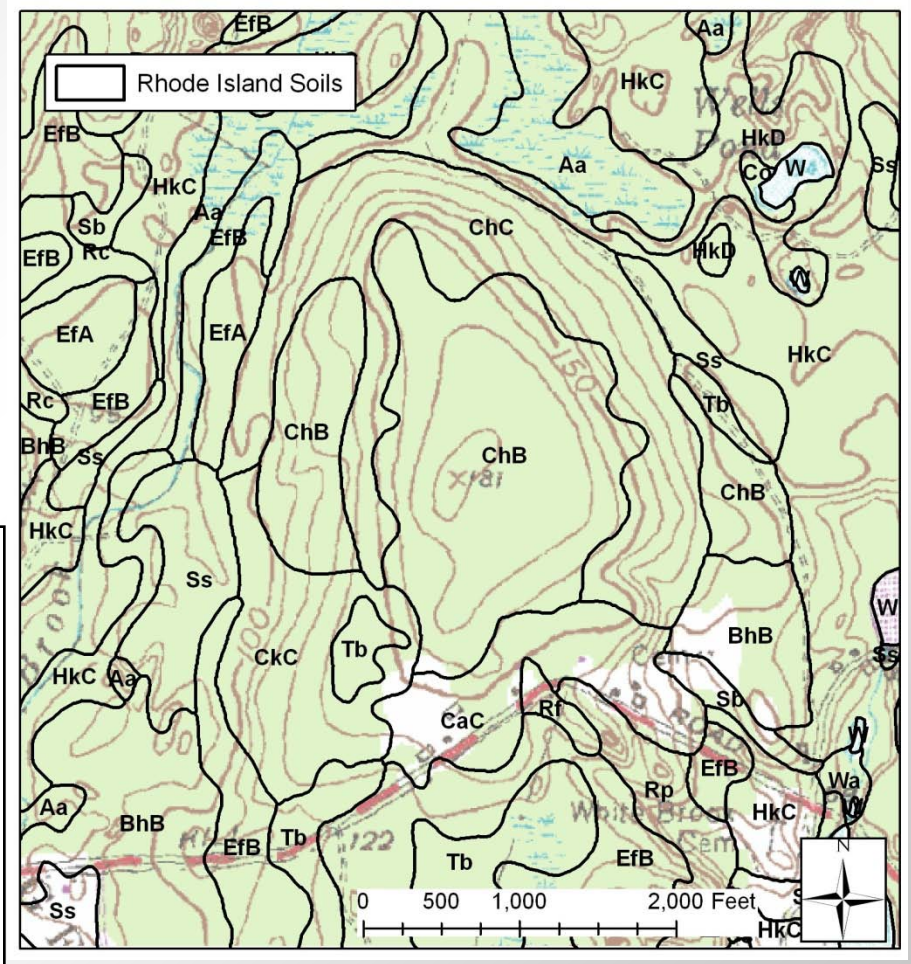
Photo: Giancarlo Cicchetti USEPA

Pedologic (soil) Mapping Techniques

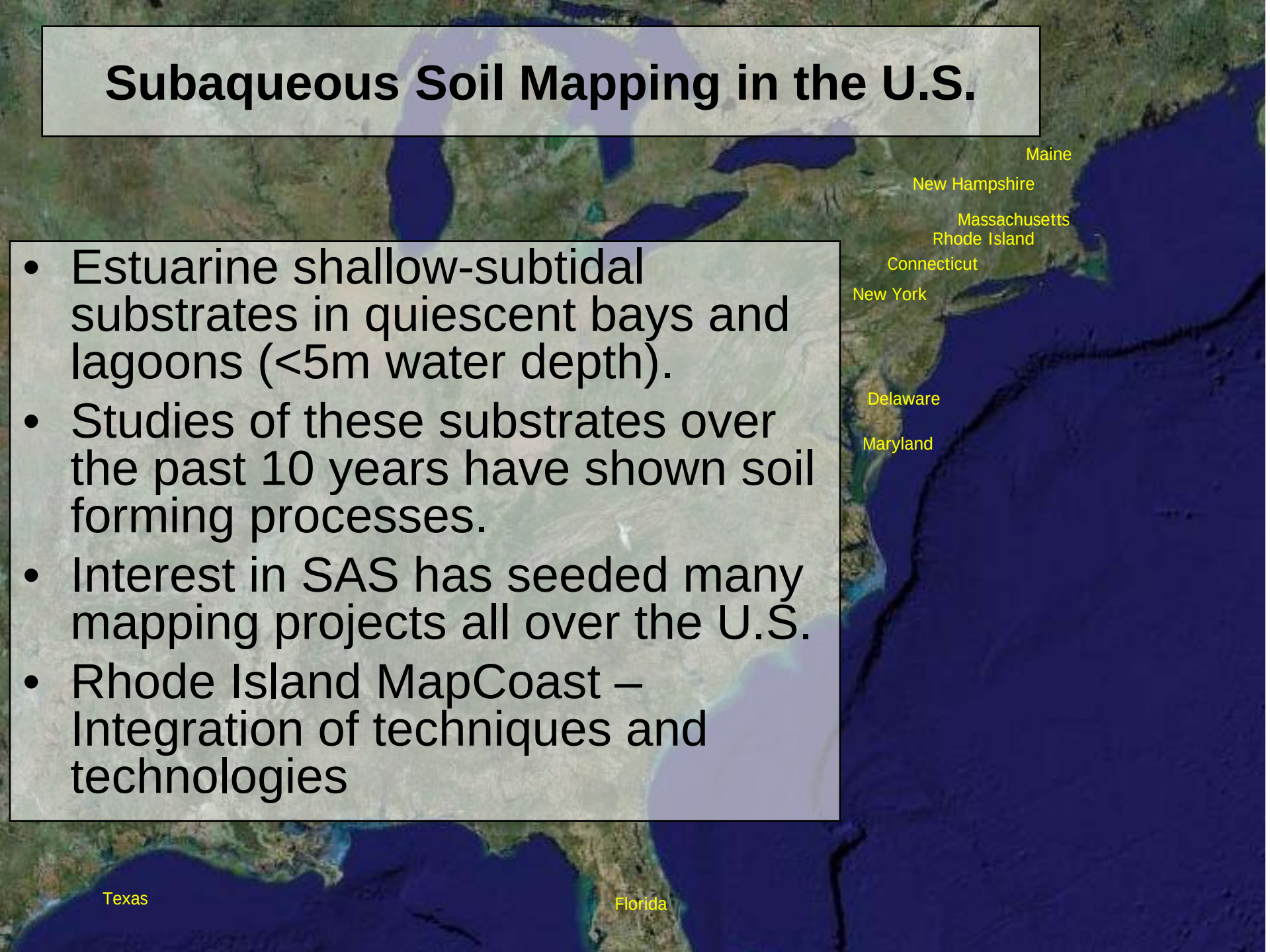


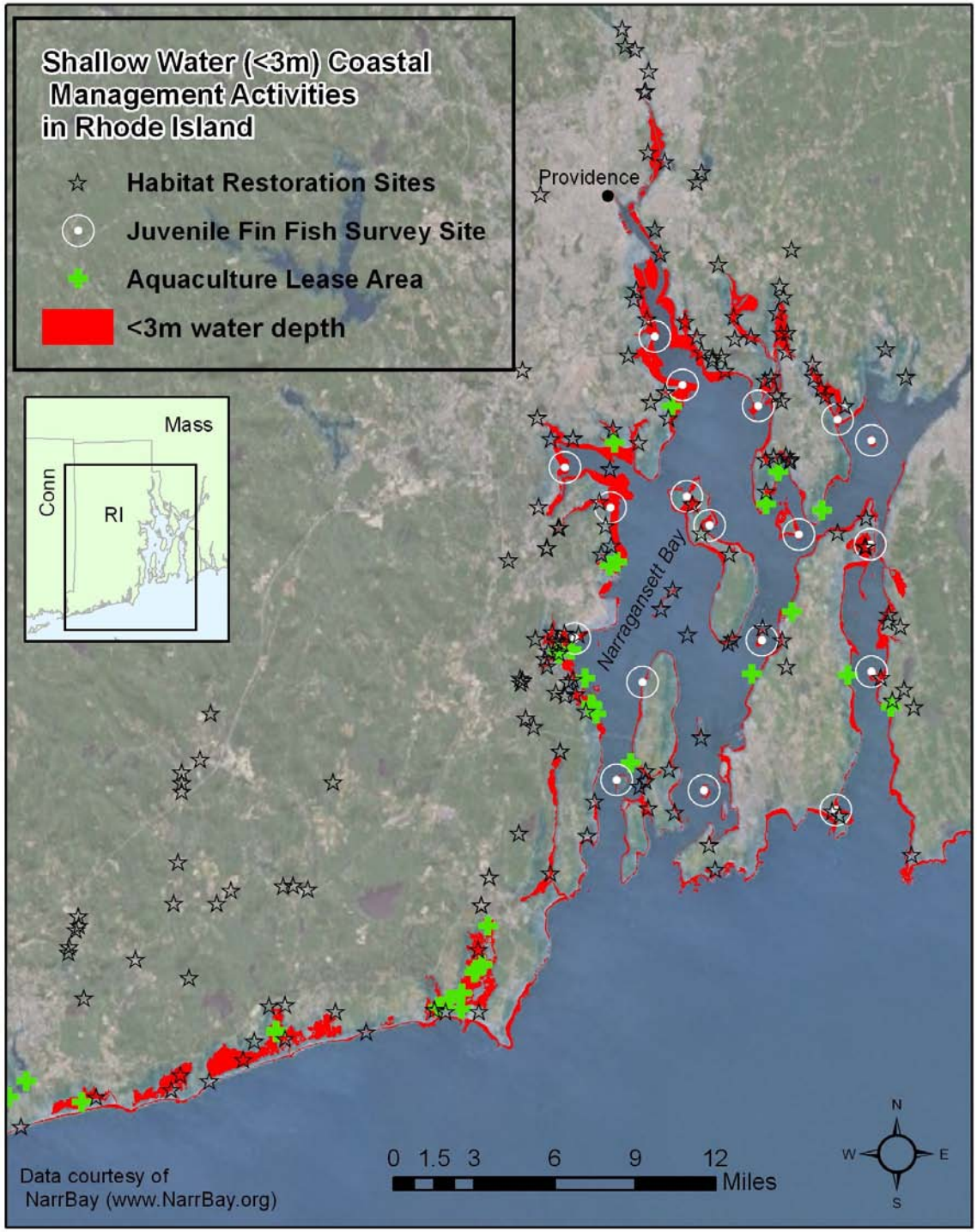


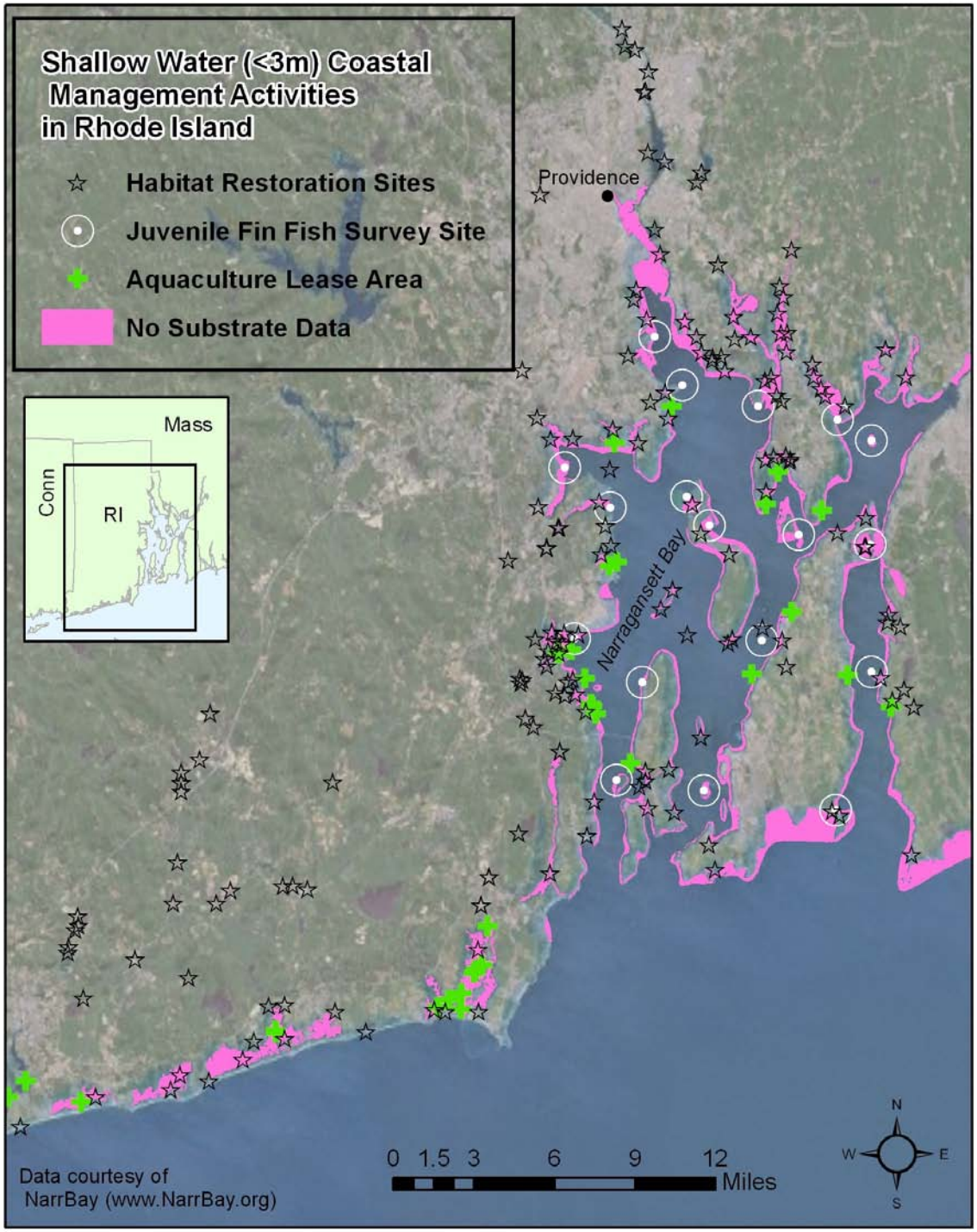


Subaqueous Soil Mapping in the U.S.

- Estuarine shallow-subtidal substrates in quiescent bays and lagoons (<5m water depth).
- Studies of these substrates over the past 10 years have shown soil forming processes.
- Interest in SAS has seeded many mapping projects all over the U.S.
- Rhode Island MapCoast – Integration of techniques and technologies

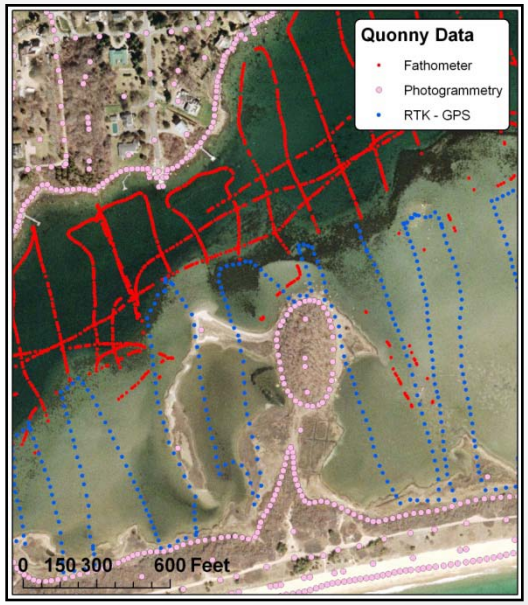



Shallow Water (<3m) Coastal Management Activities in Rhode Island
Habitat Restoration Sites
Juvenile Fin Fish Survey Site
Aquaculture Lease Area
<3m water depth
Providence
Narragansett Bay
Mass
Conn
RI
0 1.5 3 6 9 12
Miles
N
W
E
S
Data courtesy of NarrBay (www.NarrBay.org)


Shallow Water (<3m) Coastal Management Activities in Rhode Island
Habitat Restoration Sites
Juvenile Fin Fish Survey Site
Aquaculture Lease Area
No Substrate Data
Providence
Narragansett Bay
Mass
Conn
RI
0 1.5 3 6 9 12
Miles
N
W
E
S
Data courtesy of NarrBay (www.NarrBay.org)

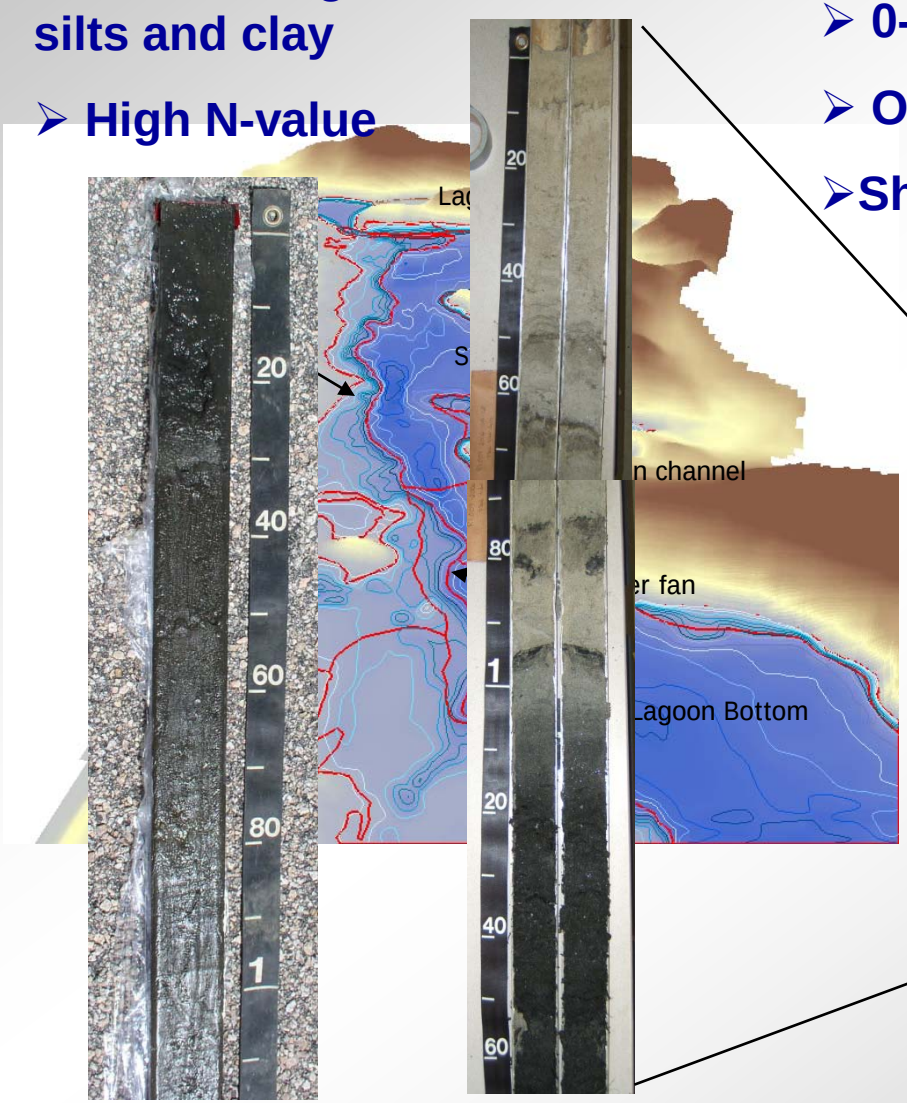
Methods and Process

1. Collect bathymetry (single beam and RTK)
2. Identify subaqueous landforms and landscapes
3. Sample soils (McCauley, augers, vibracore, hammer cores)

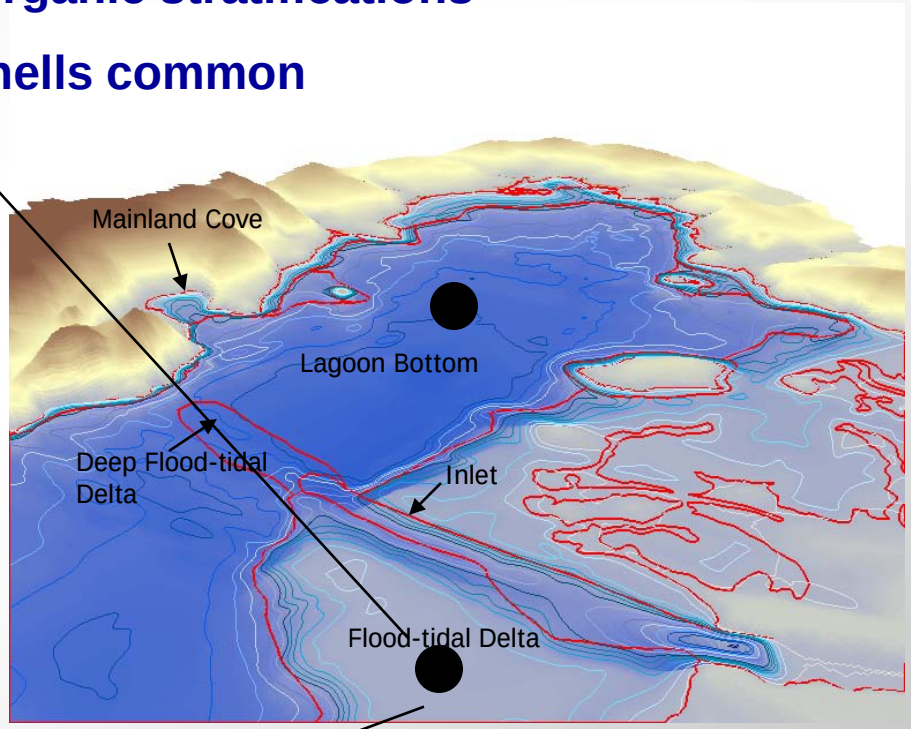


Shallow-subtidal Landscape Units (Oblique view)

- 0-2m of organic silts and clay
- High N-value



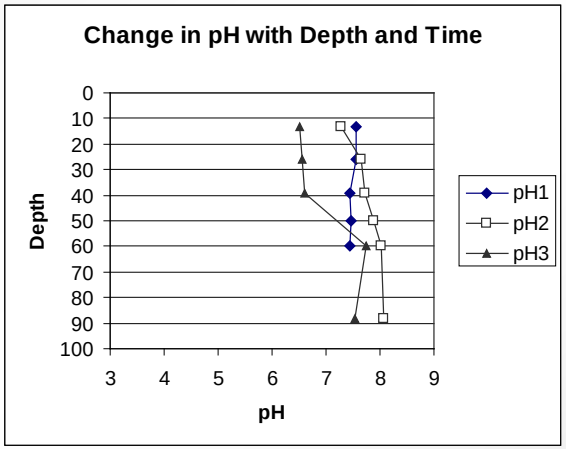
- 0-2m of grey sands
- Organic stratifications
- Shells common

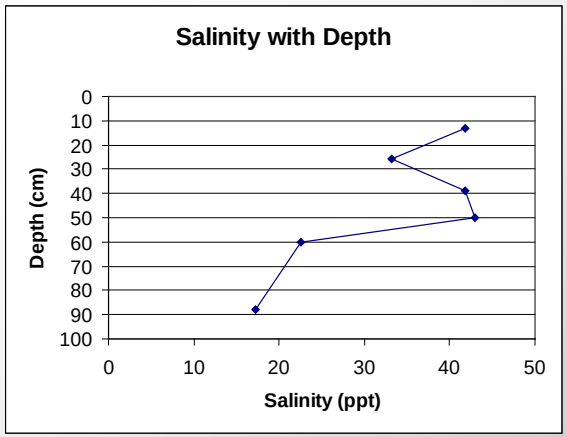


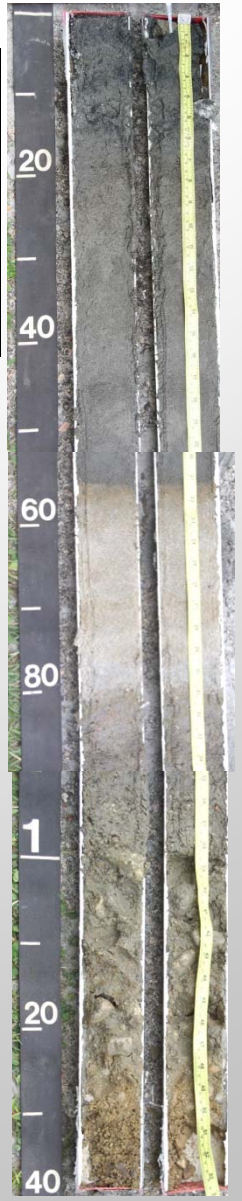
Lab Data for Soil Map Unit Shallow Lagoon Bottom (Ls)

Horizon	Depth (cm)	% Coarse Frags	% Shell Frags	% VCO (1-2 mm)	% CO (1-0.5 mm)	% M (0.5-0.25 mm)	% F (0.25-0.1 mm)	% VF (0.1-0.05 mm)	% Total Sand	% Silt	% Clay	USDA Texture Class
A1	13	0	0	0.2	0.4	0.3	0	34	34.9	52.7	12.4	sil
AC	26	0	0	0	0.1	0	7	39.5	46.6	42.7	10.7	l
C1	39	0	0	0.2	0.5	0.4	0.4	17.5	19	59.1	21.9	sil
C2	50	13.64	0.36	2	6	3.6	4.6	38.5	54.7	30.7	14.6	sil
C3	60	1.84	4.18	7.9	17.3	16	13	30	84.2	14.2	1.6	ls
2C1	88	75.5	0	10.2	32.3	15.4	18	6.5	82.4	16.1	1.5	egrlcos

Horizon	Depth (cm)	Total Nitrogen (%)	AVS (ug/g)	CRS (ug/g)	CaCO3 (%)	Organic Carbon (%)
A1	13	0.180	148.0	50.0	0.816	2.120
AC	26	0.149	16.7	53.0	0.757	1.646
C1	39	0.293	26.5	20.5	1.353	3.520
C2	50	0.198	NA	NA	1.308	2.769

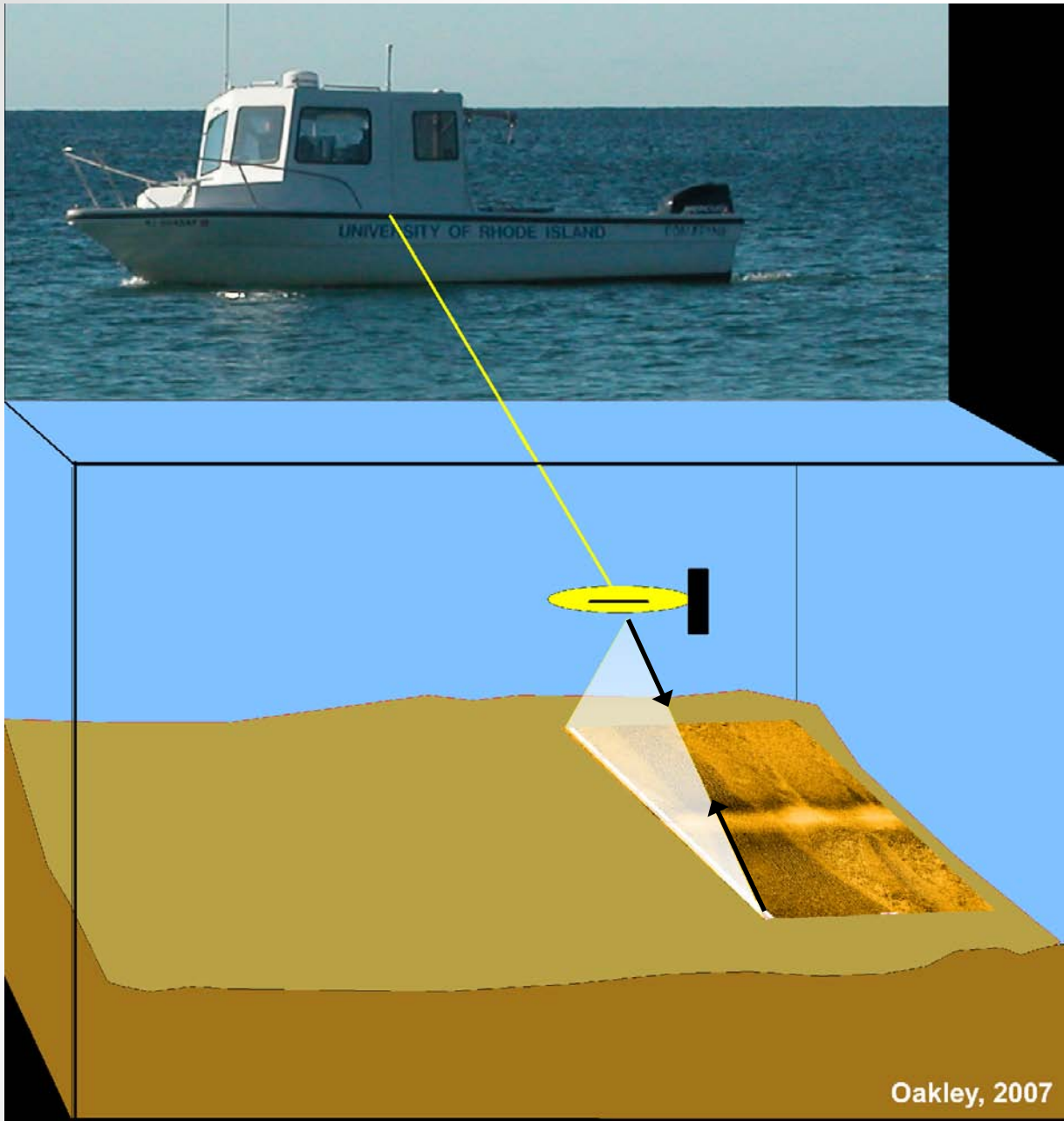


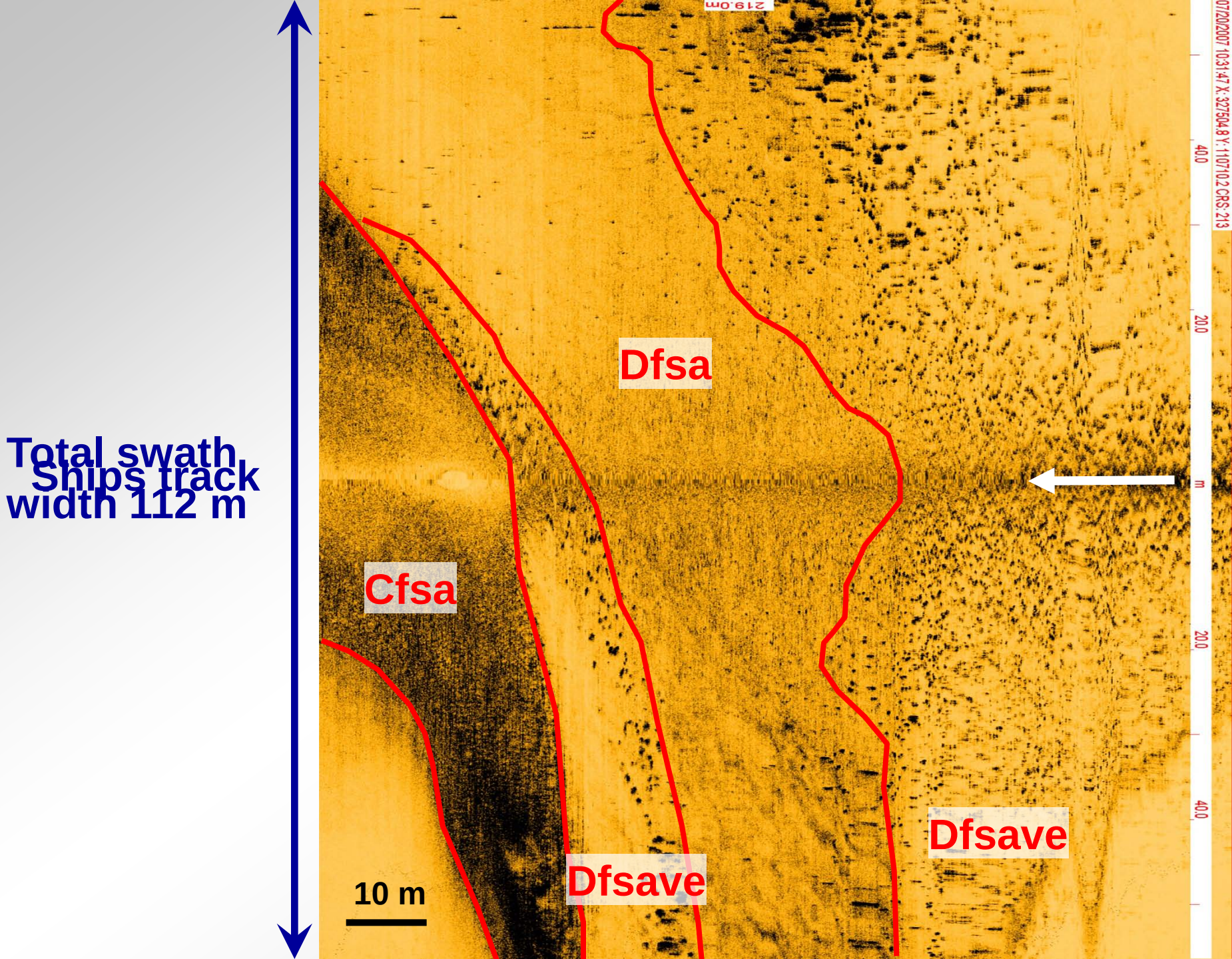




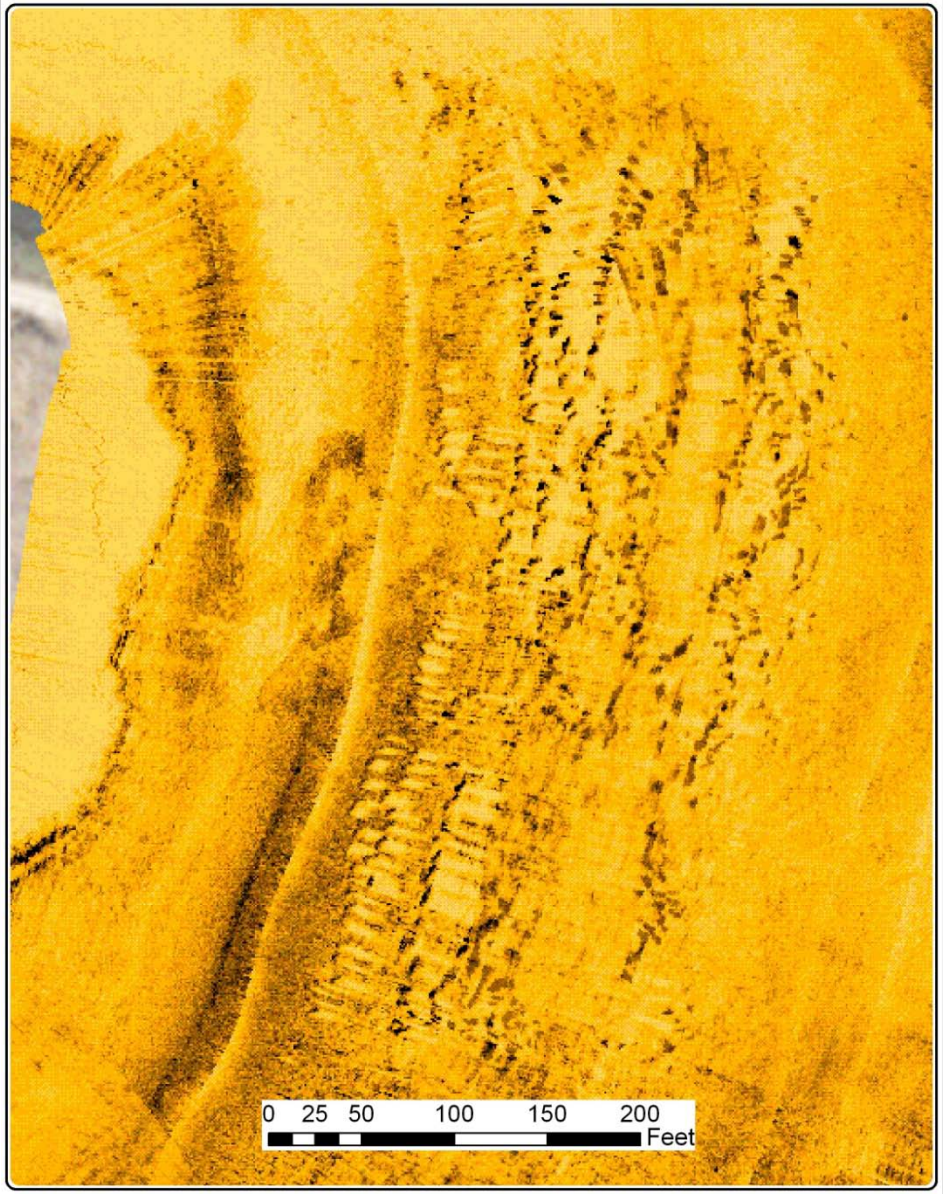
Side-Scan Sonar

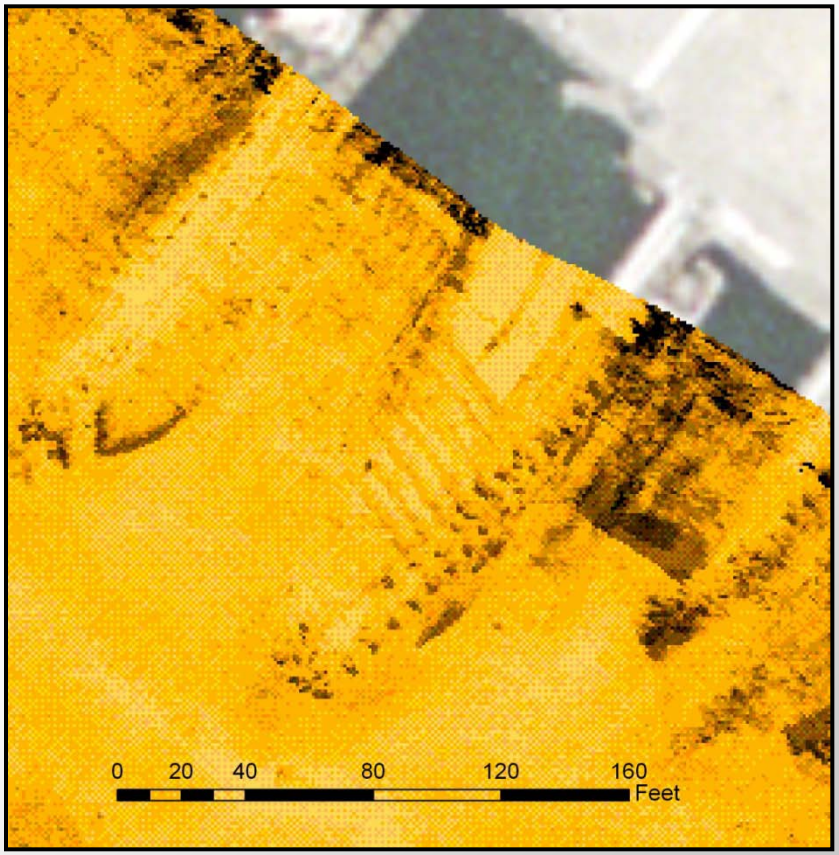
- A towed system, images the ocean floor using acoustic energy (sound)
- Sound reflected from the bottom back to the towfish
- Hard or rough bottoms reflect more energy




Total swath
width 112 m
Ships track
Dfsa
Cfsa
Dfsave
Dfsave
10 m
219.0m
40.0
20.0
m
20.0
40.0
07/20/2007 10:31:47 X: 327504.8 Y: 1107102 CRS: 213

Anthropogenic Features





Geologic Interpretations

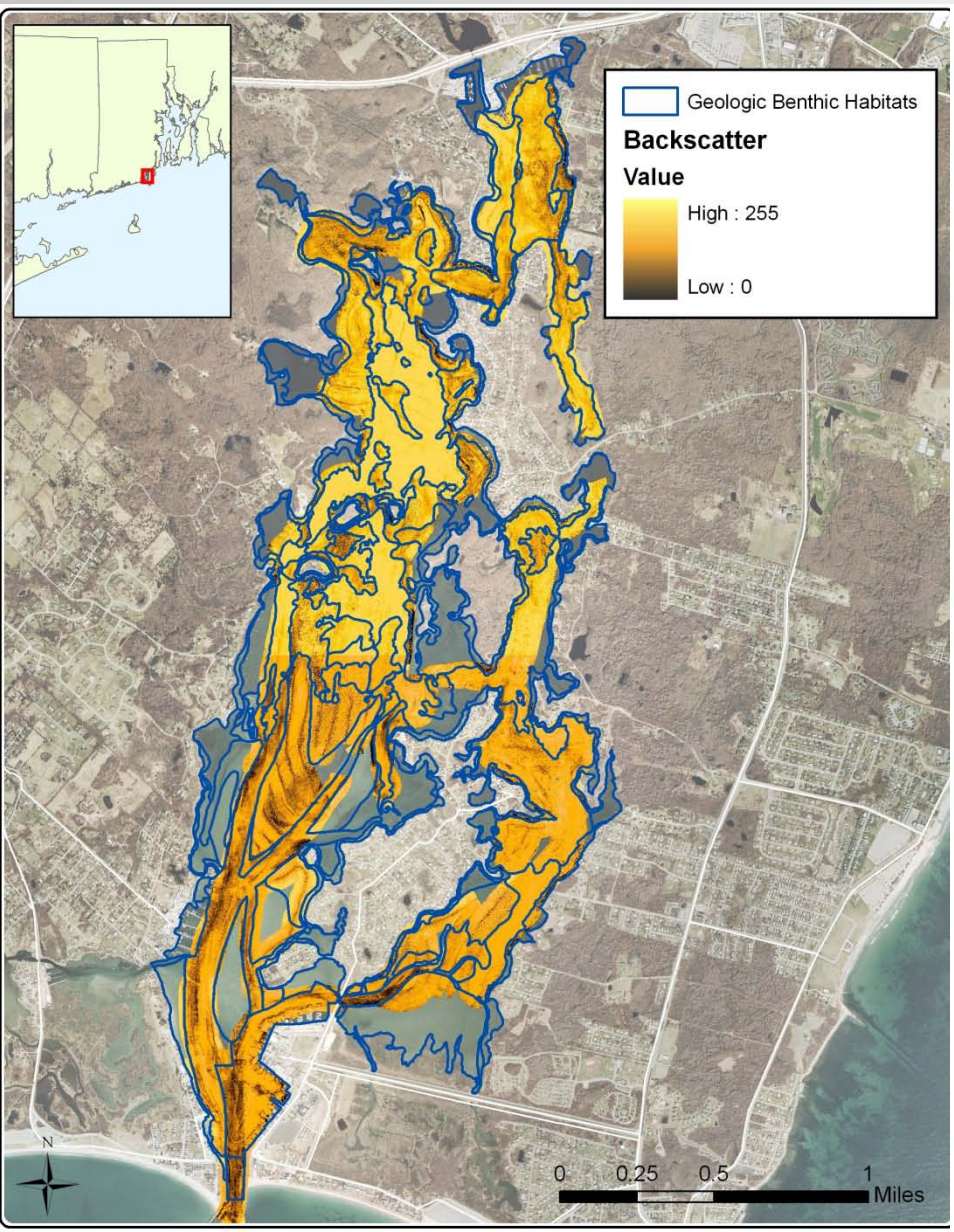
Side-scan sonar facies

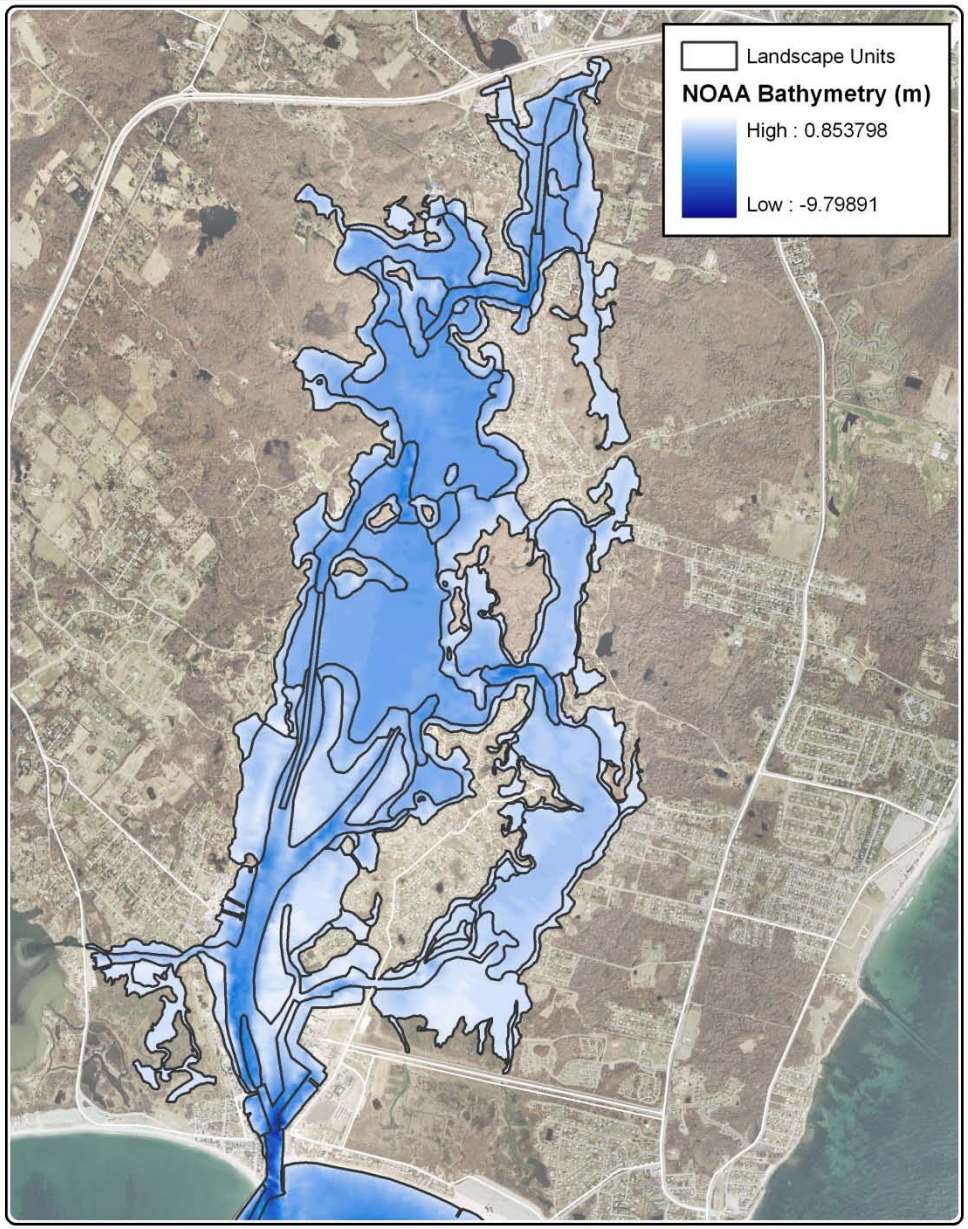
Geologic facies in which information about particle size, shape, sorting, structure and biologic content are determined by backscatter patterns

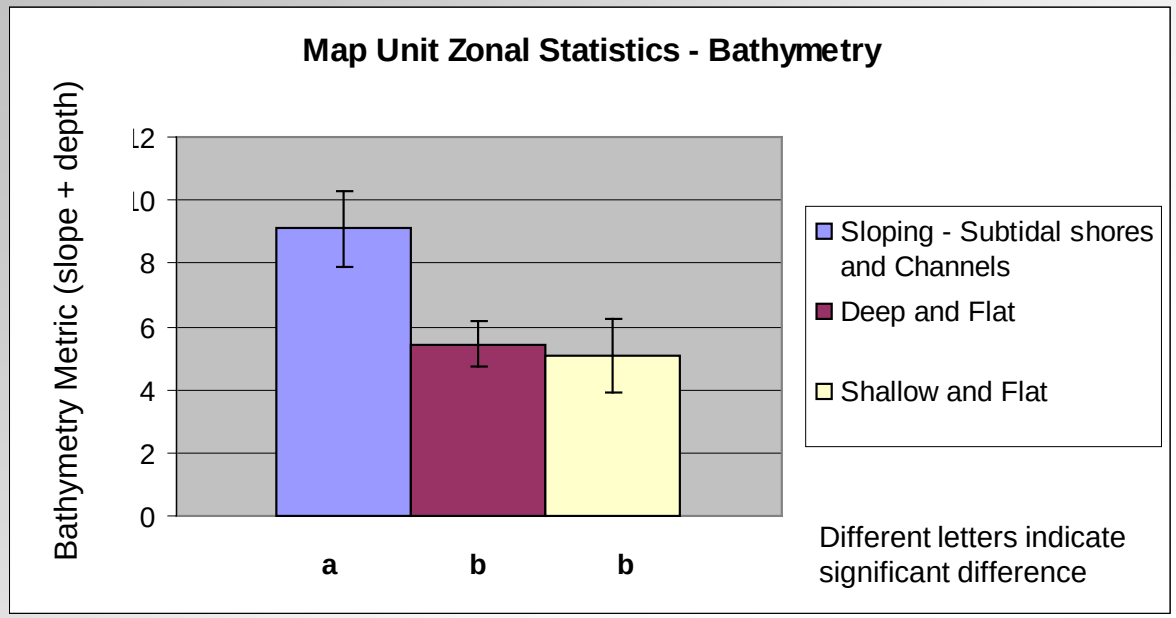
Benthic geologic habitats

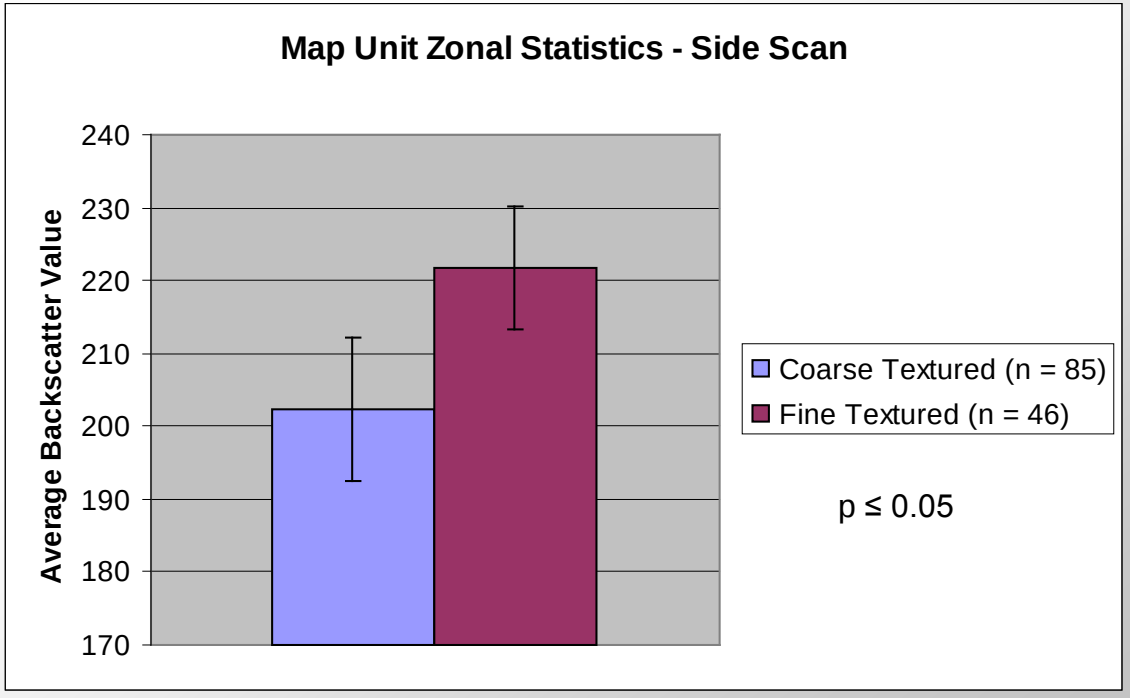
- Where the facies were deposited
- Identified using side-scan records, sediment samples and underwater videos
- THESE ARE DEPOSITIONAL ENVIRONMENTS FOR THE NON-GEOLOGIST

MASS
CONN
RI
Point Judith Pond
Potters Pond
Green Hill Pond
Ninigret Pond
Quonochontaug Pond
Winnapaug Pond
BLOCK ISLAND SOUND
N
0
1.25
2.5
5
7.5
10
Kilometers


Geologic Benthic Habitats
Backscatter
Value
High : 255
Low : 0
N
0
0.25
0.5
1
Miles


Landscape Units
NOAA Bathymetry (m)
High : 0.853798
Low : -9.79891

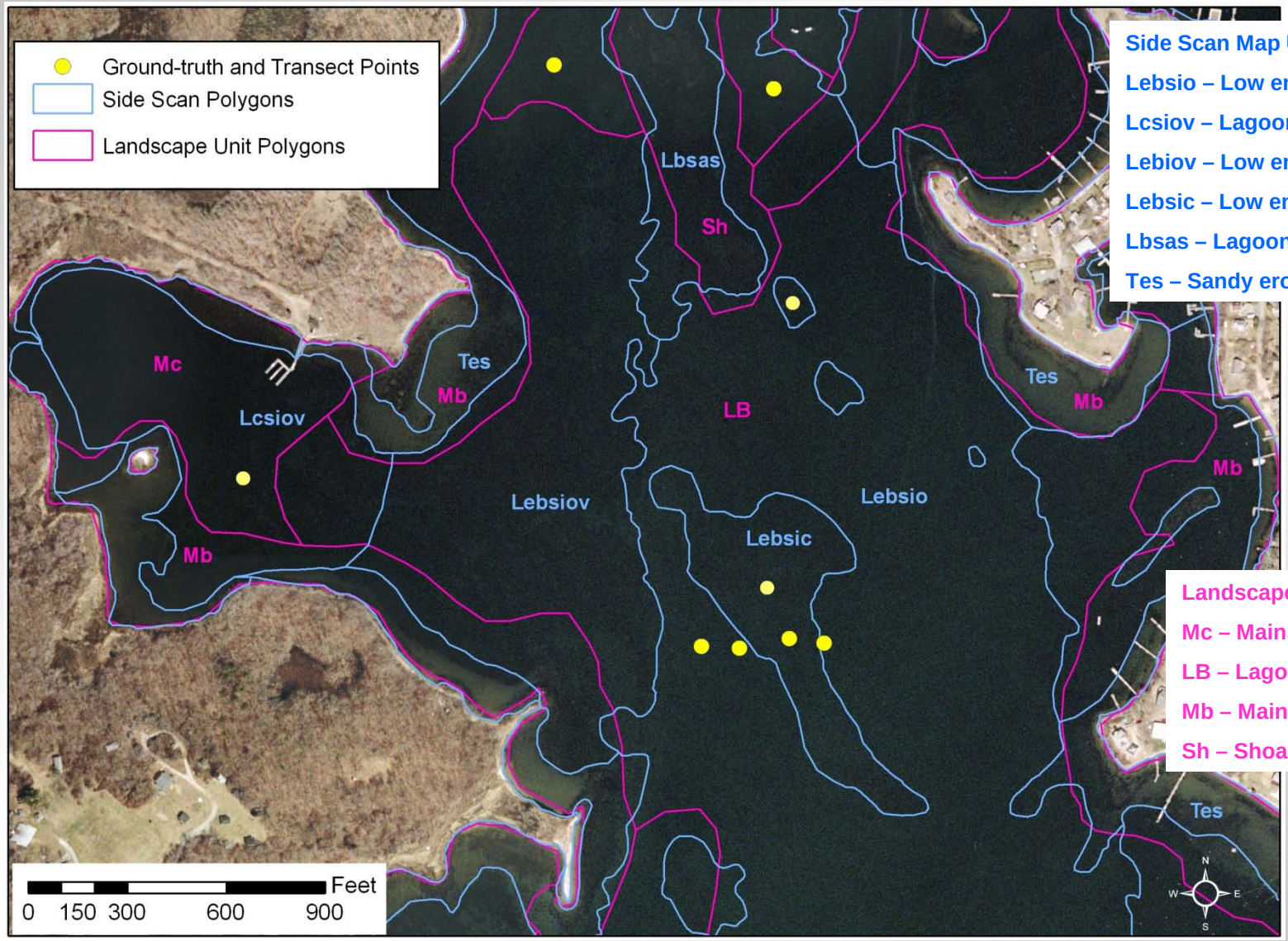

Map Unit Zonal Statistics - Bathymetry
Bathymetry Metric (slope + depth)
12
10
8
6
4
2
0
a
b
b
Sloping - Subtidal shores and Channels
Deep and Flat
Shallow and Flat
Different letters indicate significant difference


Map Unit Zonal Statistics - Side Scan
Average Backscatter Value
240
230
220
210
200
190
180
170
Coarse Textured (n = 85)
Fine Textured (n = 46)
p ≤ 0.05

Integration - Steps

- Using GIS, both data sets were intersected and inspected for areas of differing interpretations
- Ground-truth of conflict areas
- Transects of map units and boundaries using cores and video

Integration – Map Units



Side Scan Map Units

Lebsio – Low energy organic silt

Lcsiov – Lagoon cove organic silt

Lebiov – Low energy basin organic silt

Lebsic – Low energy basin silt (coarse)

Lbsas – Lagoon bottom sand

Tes – Sandy erosional terrace

Landscape Units

Mc – Mainland Cove

LB – Lagoon Bottom

Mb – Mainland Submerged Beach

Sh – Shoal

Low-energy basin organic silt

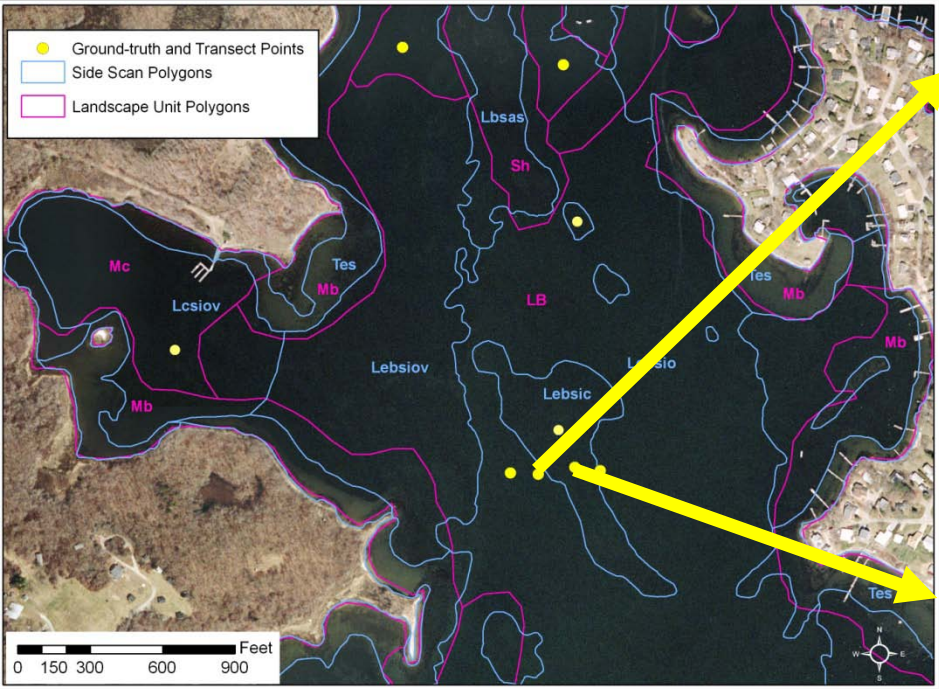


Photo: Bryan Oakley

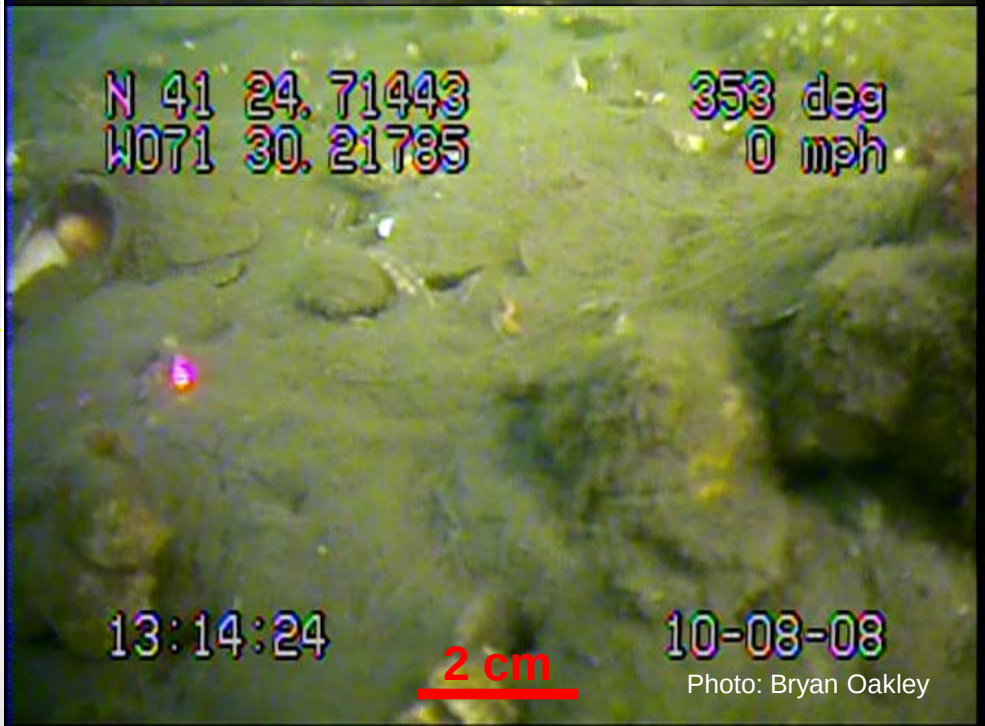


Photo: Bryan Oakley

Low-energy basin (coarse)

With shells *(Crepidula fornicata)*

Integration - Results

MAPPING METRIC (HABITAT)

DATA	Depth	Slope	Surface composition and characteristics	Subsurface composition and characteristics	Geographic location	Subtidal landscape shape	Subtidal geologic landform
Orthophotography (1,2)	X		X		X		X
Depth Isolines (contours) (1)	X	X				X	
Single Beam Bathymetry w/RTK (DEM) (1)	X	X					
Side Scan Backscatter (2)			X				X
Cores or Grab Samples (1,2)			X	X			

1. Data used for subaqueous soil mapping.
2. Data used for geologic benthic habitat maps.

Summary

- Both mapping models and methods produce usable, accurate maps.
- Acoustic backscatter images can have gaps in coverage (areas with water depths of <1m and slivers)
- Pedological methods rely on extrapolation of point data (soil cores and single beam bathymetry) and therefore do not provide complete coverage of an area.
- When all possible data sources and models are integrated, many data gaps can be filled to produce a more accurate and complete benthic habitat map.
- Manual interpretation of data is still required.

QUESTIONS?