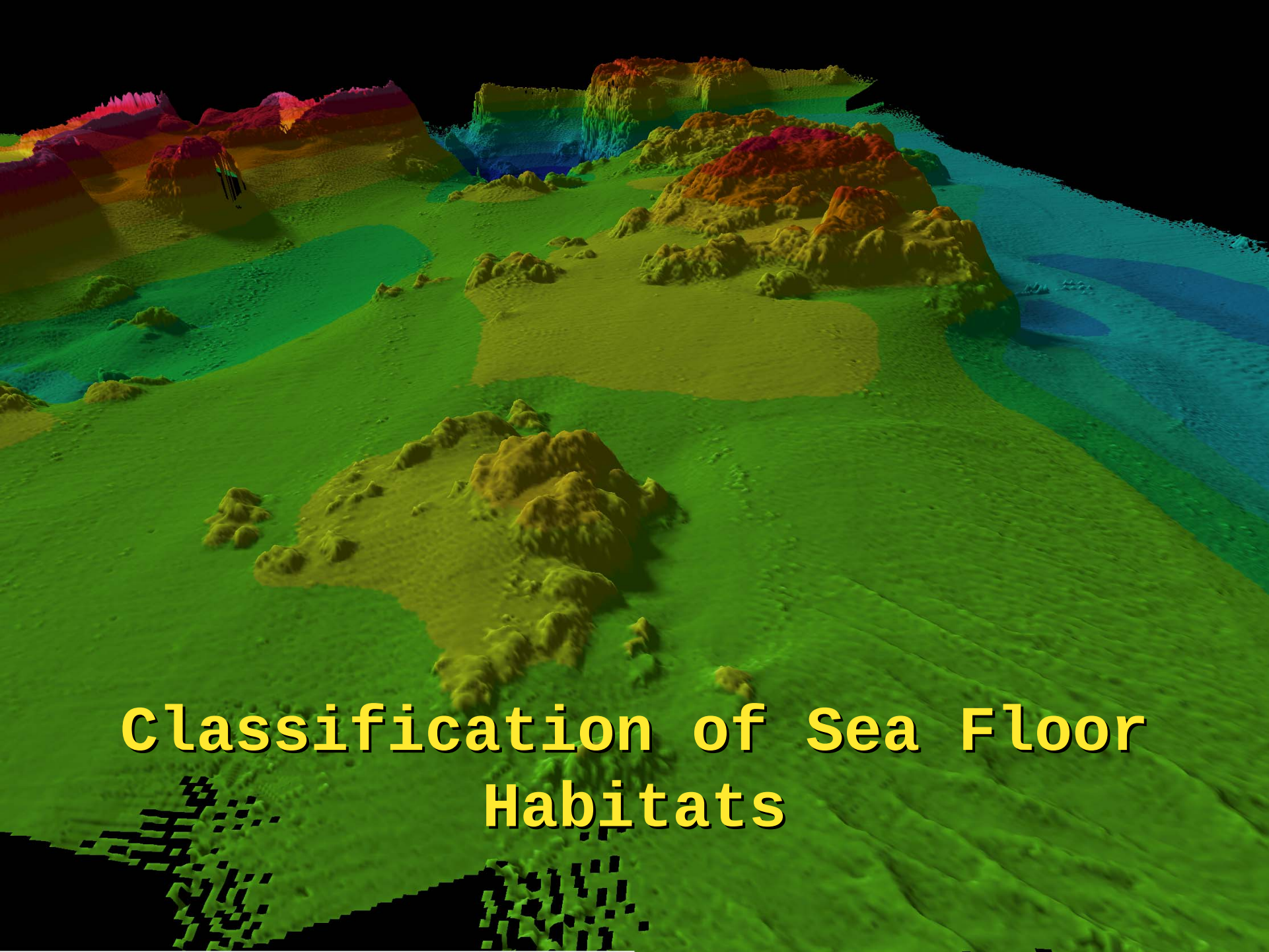
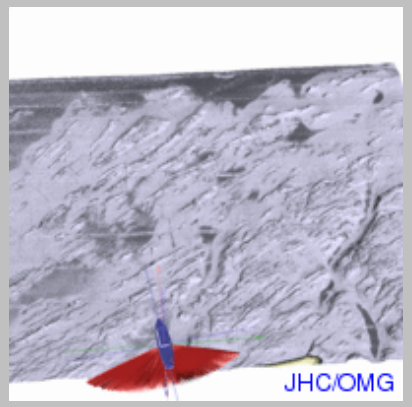
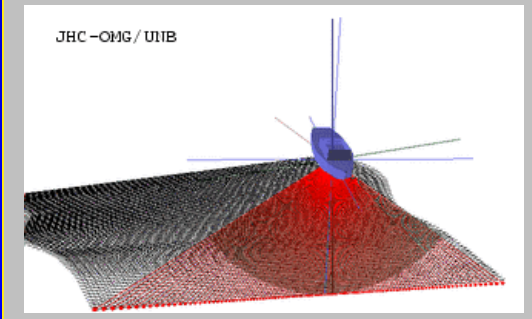
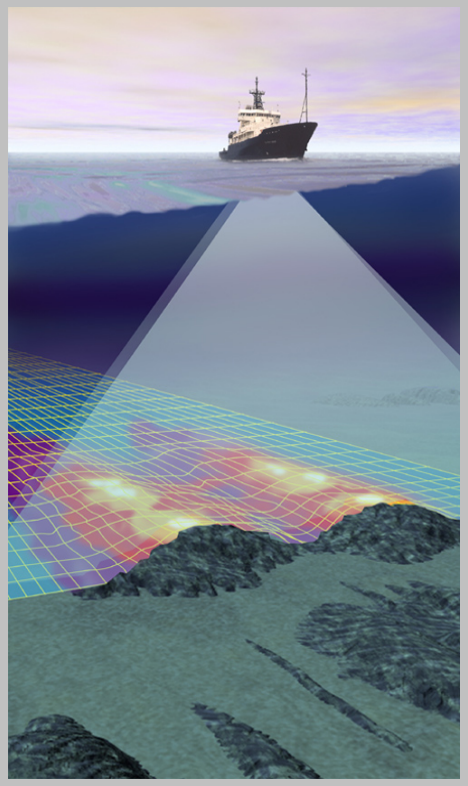


Classification of Sea Floor Habitats

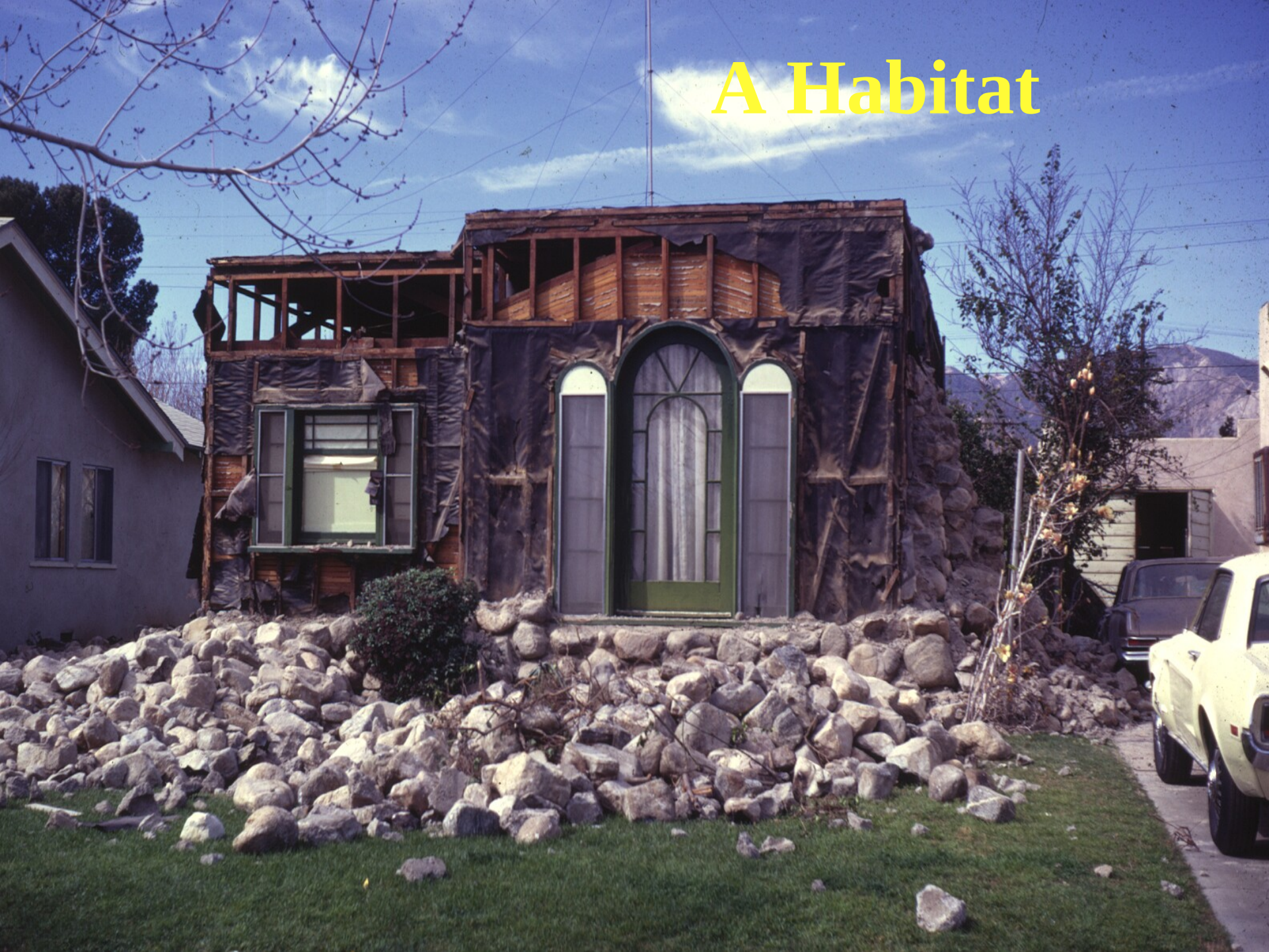
The advantages of MBES data





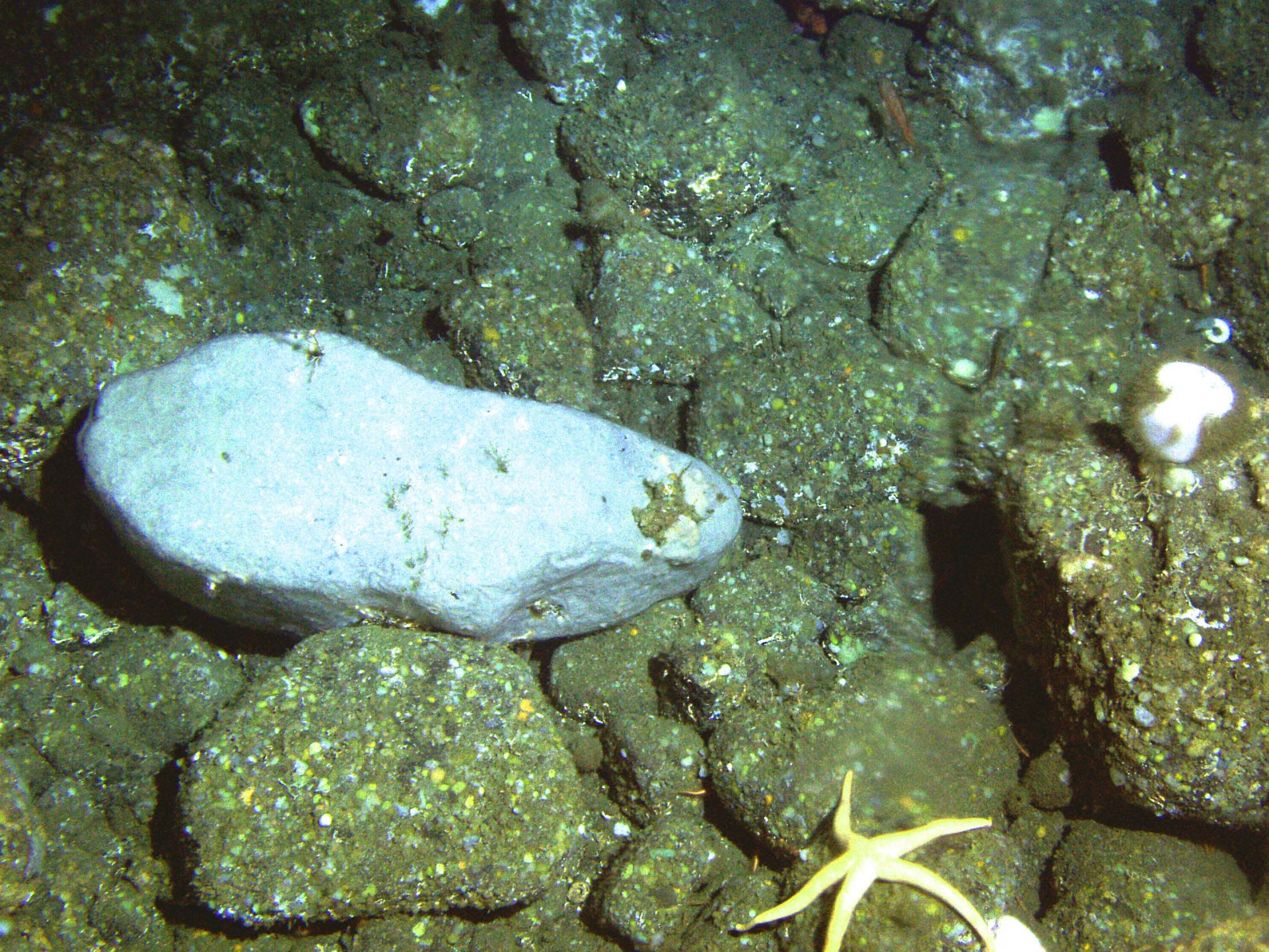


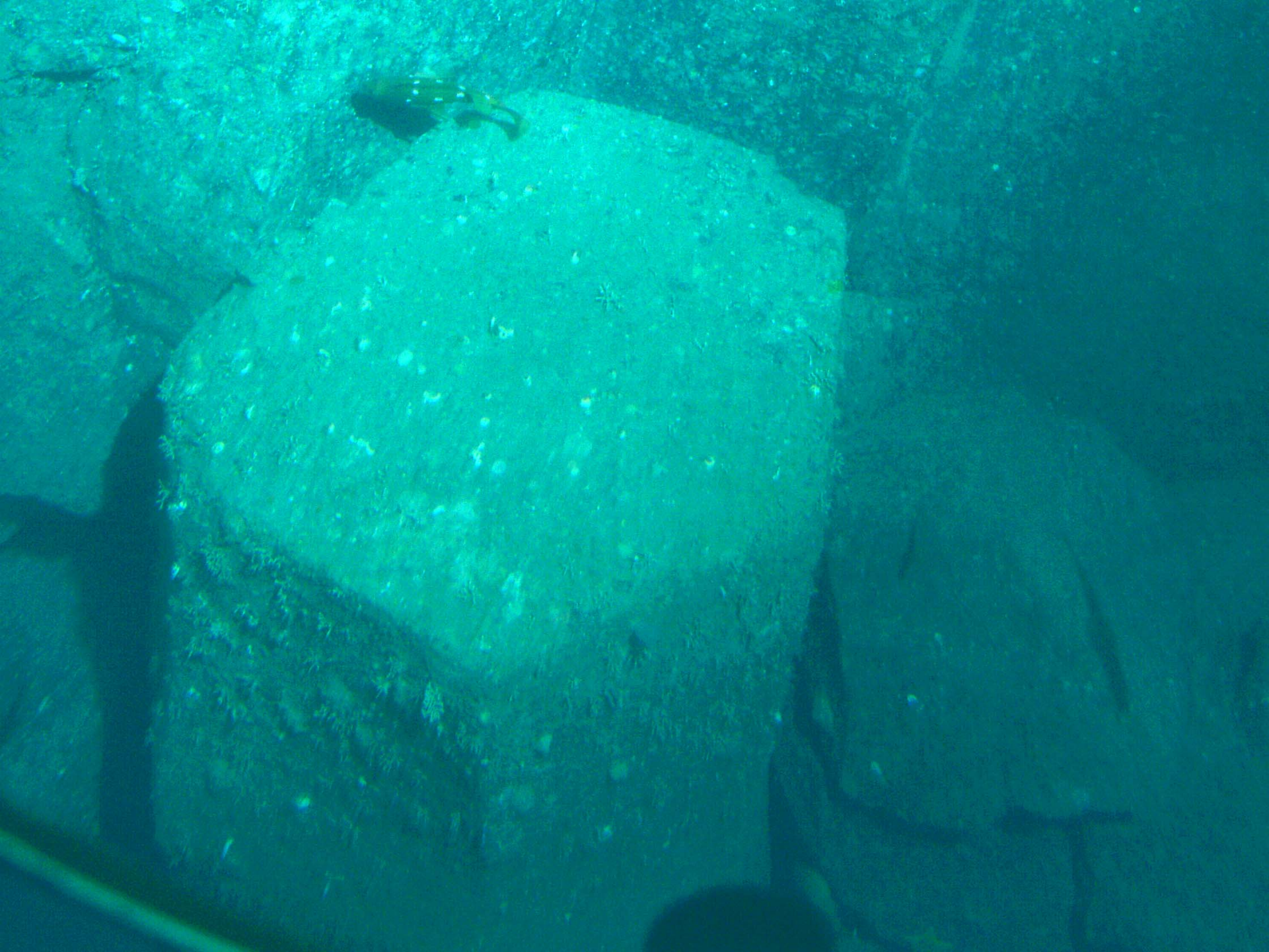
Acoustic surveys


A Habitat

A Biologist

A Geologist





Top-Down
(Biology)

versus

Bottom-Up
(Geology)

Either/Or?

Habitat Classification Schemes

- Many schemes exist
- Few, if any, compatible
- Very few actually applied to mapping
- Push underway to set a standard

Evaluation of Habitat Schemes

- Recently Lund and Wilbur reviewed 12 habitat classifications schemes and arrived at four that appear good for mapping
- The four are: Greene et al. (1999, 2007)

  Kutcher et al. (2005) - Estuarine

  Madden et al. (2004) - CMECS

  Valentine et al. (2005) - East Coast US
- CMECS is integrating the above schemes as well as others

Interpretive Process

- Location - depth and physiography
- Substrate types
- Scale - most data interpreted at a scale that produces the highest resolution

SCALE

SCALE

SCALE

Scale

In Time & Space

System

- Subsystem
  - Class (based on seafloor morphology)
    - Subclass (based on substratum textures)
    - Subclass (based on slope)

- Modifiers
  - For seafloor morphology
  - For seafloor deposition
  - For seafloor texture
  - For physical processes
  - For chemical processes
  - For biological processes

Habitat Classification Scheme

(modified after Greene *et al.* 1999)

Megahabitats (depth-related) - 10s+ of kilometers to kilometers

e.g.: F = Flanks - continental slope, island/basin flanks (200 - 2500 m)

Seafloor Induration (hardness)

e.g.: m = mixed hard and soft substrates

Meso/Macrohabitats (scale-related) – 1 kilometer to 10 meters

e.g.: c = submarine canyon

Seafloor morphology (textural relationship)

e.g.: h = hummocky

Megahabitat

A = Aprons, continental rise, deep fans and bajadas (3000-5000 m)

B = Basin floors, Borderland types (floors at 1000-2500 m)

F = Flanks, continental slope, basin/island-atoll flanks (200-3000 m)

I = Inland seas, fiords (0-200 m)

P = Plains, abyssal (>5000 m)

R = Ridges, banks and seamounts (crests at 200-2500 m)

S = Shelf, continental and island shelves (0-200 m)

Seafloor Induration

h = hard substrate, rock outcrop, relic beach rock or sediment pavement

m = mixed (hard & soft substrate)

s = soft substrate, sediment covered

Sediment types (for above indurations) - Use parentheses.

(b) = boulder

(c) = cobble

(g) = gravel

(h) = halimeda sediment, carbonate

(m) = mud, silt, clay

(p) = pebble

(s) = sand

Meso/Macrohabitat

a = atoll

b = beach, relic

c = canyon

d = deformed, tilted and folded bedrock

e = exposure, bedrock

f = flats

g = gully, channel

i = ice-formed feature or deposit, moraine, drop-stone depression

k = karst, solution pit, sink

l = landslide

m = mound, depression

n = enclosed waters, lagoon

Meso/Macrohabitat (cont.)

o = overbank deposit (levee)

p = pinnacle

r = rill

s = scarp, cliff, fault or slump

t = terrace

w = sediment waves

y = delta, fan

$z_{\#}$ = zooxanthellae hosting structure, carbonate reef

- 1= barrier reef
- 2 = fringing reef
- 3 = head, bommie
- 4 = patch reef

Modifier

$_a$ = anthropogenic (artificial reef/breakwall/shipwreck)

$_b$ = bimodal (conglomeratic, mixed [includes gravel, cobbles and pebbles])

$_c$ = consolidated sediment (includes claystone, mudstone, siltstone, sandstone, breccia, and conglomerate)

$_d$ = differentially eroded

$_f$ = fracture, joints-faulted

$_g$ = granite

$_h$ = hummocky, irregular relief

$_i$ = interface, lithologic contact

$_k$ = kelp

Modifier (cont.)

$_l$ = limestone or carbonate

$_m$ = massive

$_p$ = pavement

$_r$ = ripples

$_s$ = scour (current or ice, direction noted)

$_u$ = unconsolidated sediment

$_v$ = volcanic rock

Seafloor Slope

1 Flat (0-1º)
2 Sloping (1-30º)
3 Steeply Sloping (30-60º)
4 Vertical (60-90º)
5 Overhang (> 90º)

Seafloor Complexity

A	Very Low Complexity (-1 to 0)
B	Low Complexity (0 to 1)
C	Moderate Complexity (1 to 2)
D	High Complexity (2 to 3)
E	Very High Complexity (3+)

Attribute Code – Level of Detail

Simple:	Ss_u or Shc_c
Moderate:	$Sh(b)p_{d/v}$
Complex:	$Sh(b)p_{d/v}$*(b/c/p)[s/c/a]2B

Macro/Microhabitat from In Situ Observations and Sampling

Geologic attributes (note percent grain sizes when possible) *

(b) = boulder

(c) = cobble

(d) = deformed, faulted, or folded

(e) = exposure, bedrock (sedimentary, igneous, or metamorphic)

(f) = fans

(g) = gravel

(h) = halimeda sediment, carbonate slates or mounds

(i) = interface

(j) = joints, cracks, and crevices

Macro/Microhabitat (cont.)

(m) = mud, silt, or clay

(p) = pebble

(q) = coquina (shell hash)

(r) = rubble

(s) = sand

(t) = terrace-like seafloor including sedimentary pavements

(w) = wall, scarp, or cliff

Macro/Microhabitat (cont.)

<u>Biologic attributes</u>

[a] = algae

[b] = bryozoans

[c] = corals

[d] = detritus, drift algae

[g] = gorgonians

[n] = anemones

[o] = other sessile organisms

[s] = sponges

[t] = tracks, trails, or trace fossils

[u] = unusual organisms, or chemosythetic communities

[w] = worm tubes

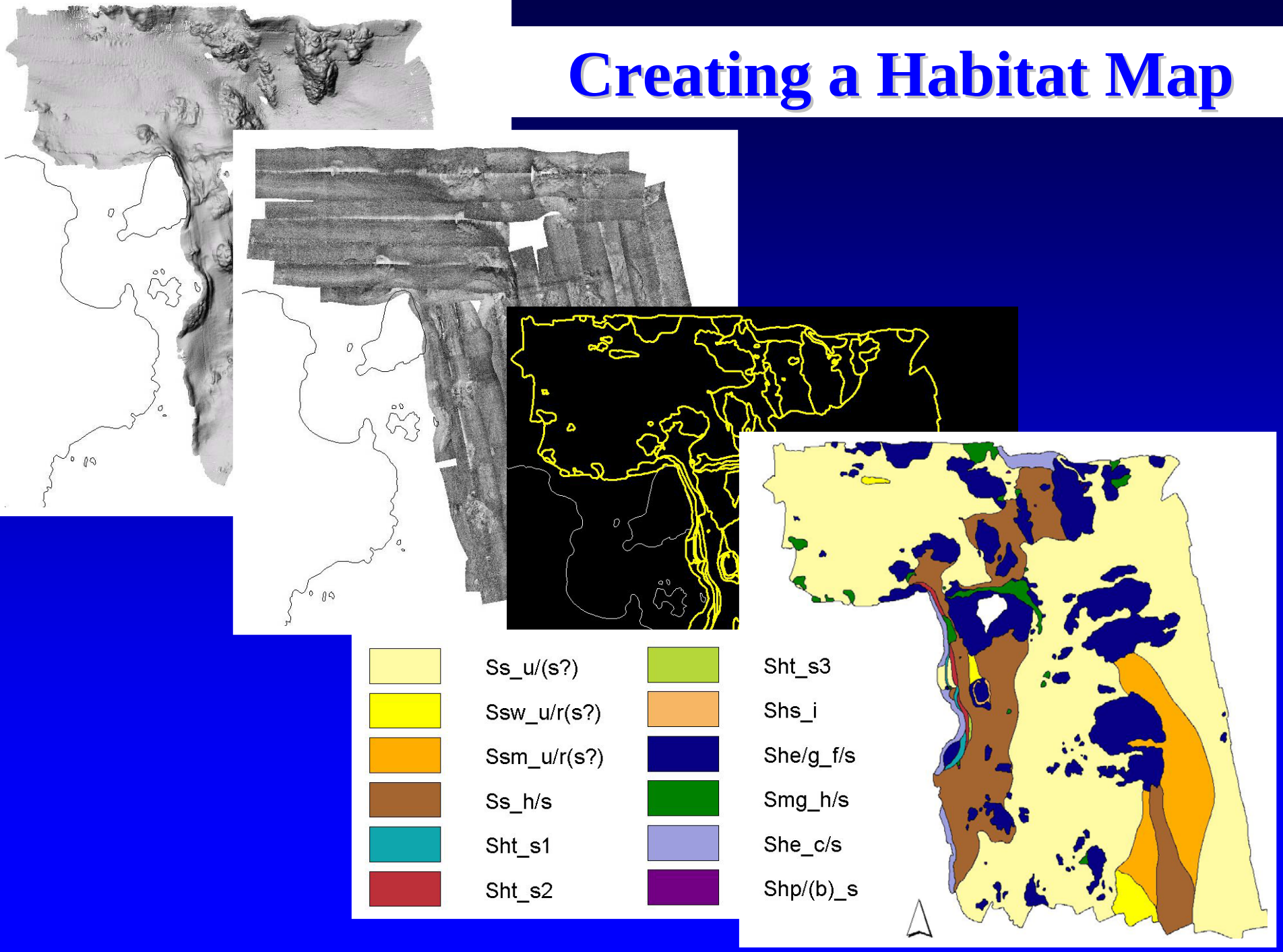
Examples:

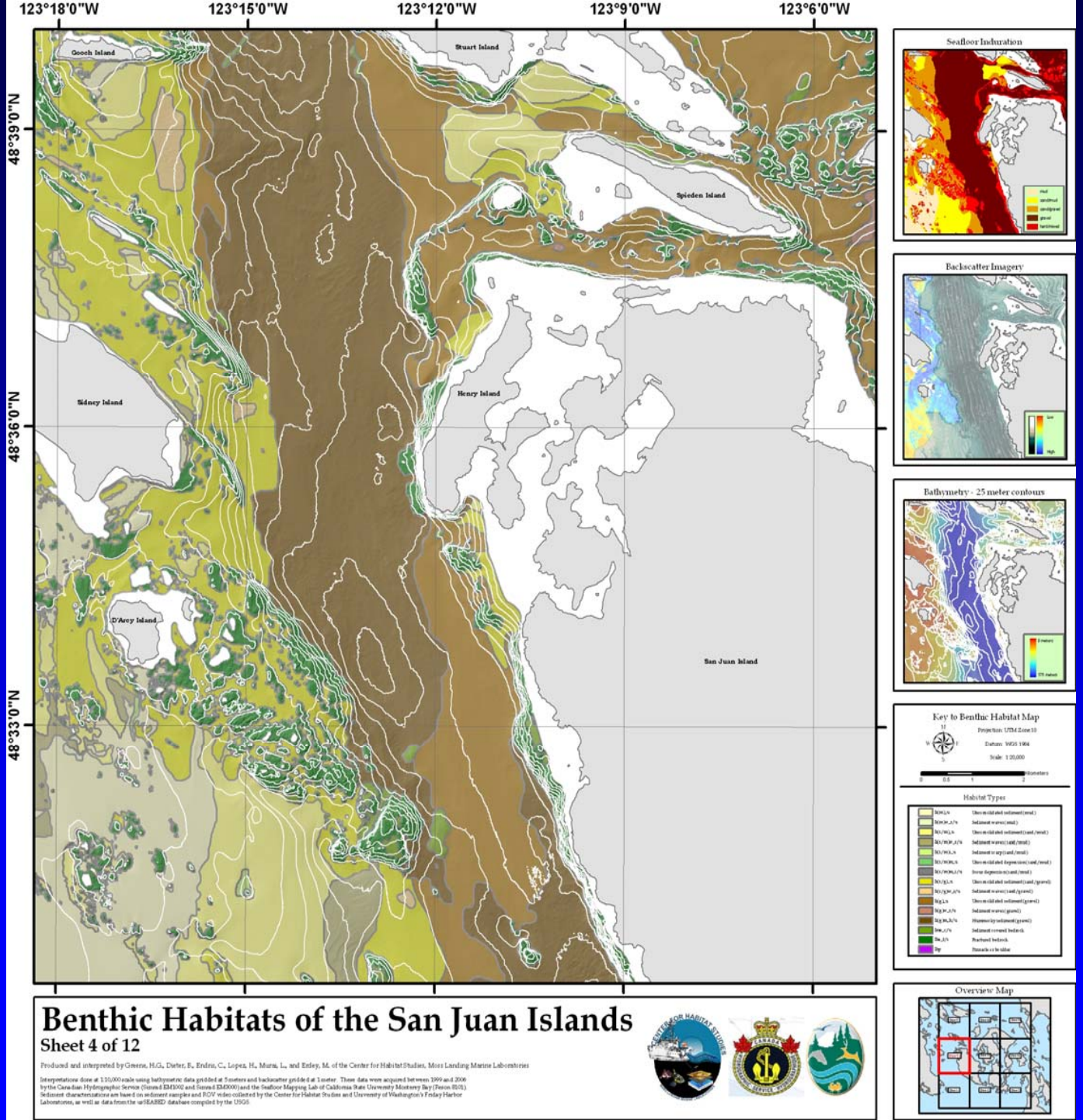
*(m)[w]1D - Flat or nearly flat mud (100%) bottom with worm tubes; high complexity.

*(s/c)1A - Sand bottom (>50%) with cobbles. Flat or nearly flat with very low complexity.

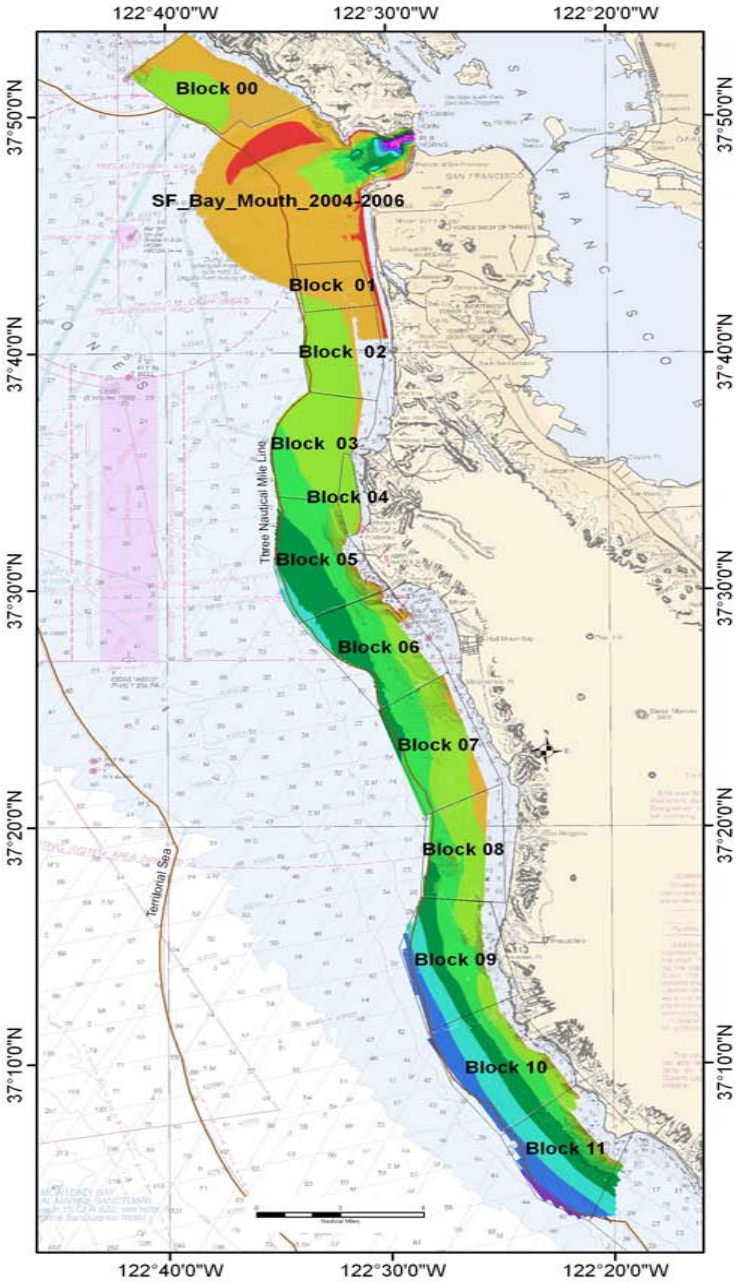
*(h)[c]1E - Coral reef on flat bottom with halimeda sediment. Very high complexity.

Creating a Habitat Map

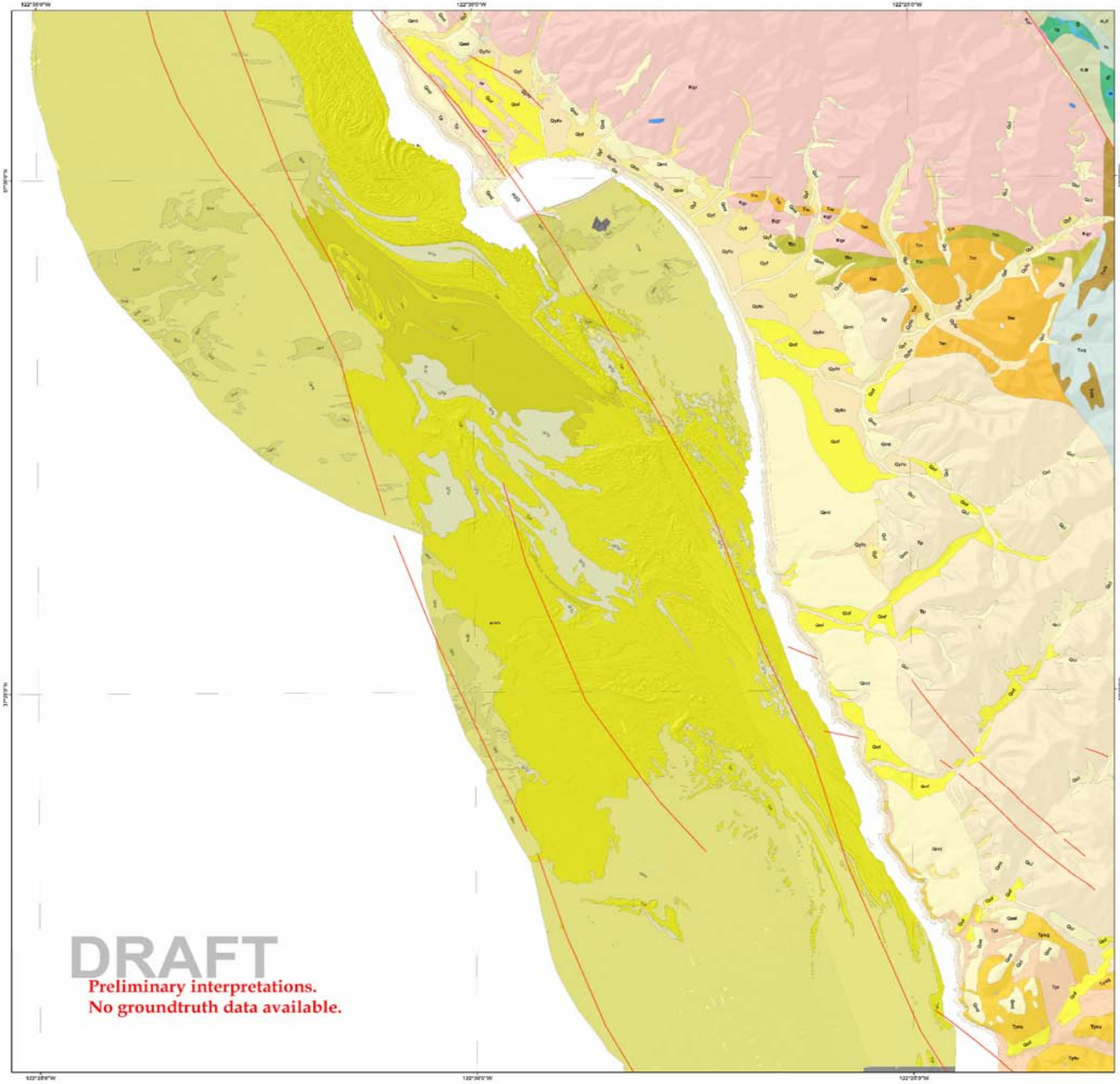



123°18'0"W
123°15'0"W
123°12'0"W
123°9'0"W
123°6'0"W
48°39'0"N
48°36'0"N
48°33'0"N
Gooch Island
Stuart Island
Spieden Island
Sidney Island
Henry Island
D'Arcy Island
San Juan Island
Seafloor Induration
Backscatter Imagery
Bathymetry - 25 meter contours
Key to Benthic Habitat Map
Projection: UTM Zone 10
Datum: WGS 1984
Scale: 1:20,000
Habitat Types
Overview Map
Benthic Habitats of the San Juan Islands
Sheet 4 of 12
Produced and interpreted by Greene, H.G., Dieter, B., Endris, C., Lopez, H., Murai, L., and Erdey, M. of the Center for Habitat Studies, Moss Landing Marine Laboratories
Interpretations done at 1:10,000 scale using bathymetric data gridded at 5 meters and backscatter gridded at 1 meter. These data were acquired between 1999 and 2006 by the Canadian Hydrographic Service (Simrad EM3000 and Simrad EM1000) and the Seafloor Mapping Lab of California State University Monterey Bay (Reson 8101). Sediment characterizations are based on sediment samples and ROV video collected by the Center for Habitat Studies and University of Washington's Friday Harbor Laboratories, as well as data from the usSEABED database compiled by the USGS

NCCMP Phase 1 - Offshore Survey Blocks (3nm - 15m)



Multibeam bathymetry data (2m resolution) shown in shaded relief colored by depth at 10 meter contour intervals. Background NOAA Chart 18680 (soundings in fathoms). Surveys conducted by Fugro Pelagos Incorporated (November 2006) and CSUMB Seafloor Mapping Lab (2004, 2005, 2006, 2007) as part of the North Central Coast Mapping Project and San Francisco Bay Mouth Mapping Project. Sponsors: California Coastal Conservancy, Ocean Protection Council, US Geological Survey, US Army Corps of Engineers. Inshore mapping (15m isobath - MHW) to be completed in 2007.



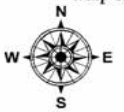
Central California Mapping Project

Half Moon Bay Sheet

DRAFT

September, 2007

Map Information



Map Scale - 1:24,000

Datum - WGS 1984
Projection - UTM Zone 10

Contour Interval - 10 meters

0 1 2 4 Kilometers

0 0.25 0.5 1 Nautical Miles

Coastal Conservancy

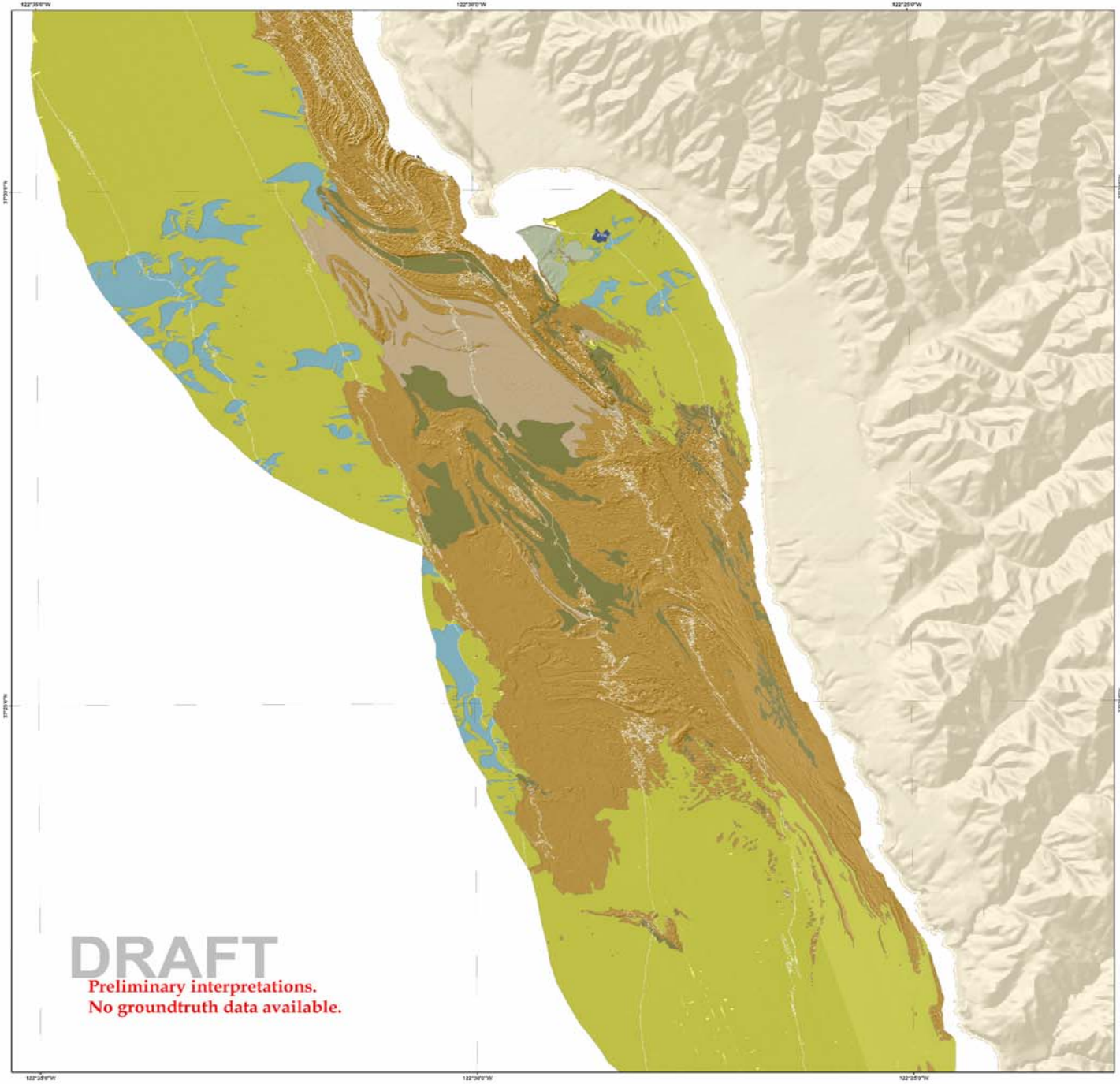
USGS science for a changing world

CENTER FOR HABITAT STUDIES

CALIFORNIA OCEAN PROTECTION COUNCIL

CGS CALIFORNIA GEOLOGICAL SURVEY

FUGRO



Central California Mapping Project

Half Moon Bay Sheet

DRAFT

September, 2007

Map Information

Map Scale - 1:24,000

Datum - WGS 1984
Projection - UTM Zone 10

Contour Interval - 10 meters

Kilometers
0 1 2 4

Nautical Miles
0 0.5 1 2

Key to Habitat Types

	Ss(s)_u	Unconsolidated sediment - Sand
	Ssw	Sediment waves
	Sm	Sediment covered bedrock
	Ss(s,g)m_r/u	Rippled scour depressions - Coarse Sand and Gravel
	Ss_a	Dredge spoils (anthropogenic)?
	She/f	Rock outcrop - flat/low rugosity
	She	Bedrock outcrop

Coastal Conservancy

USGS science for a changing world

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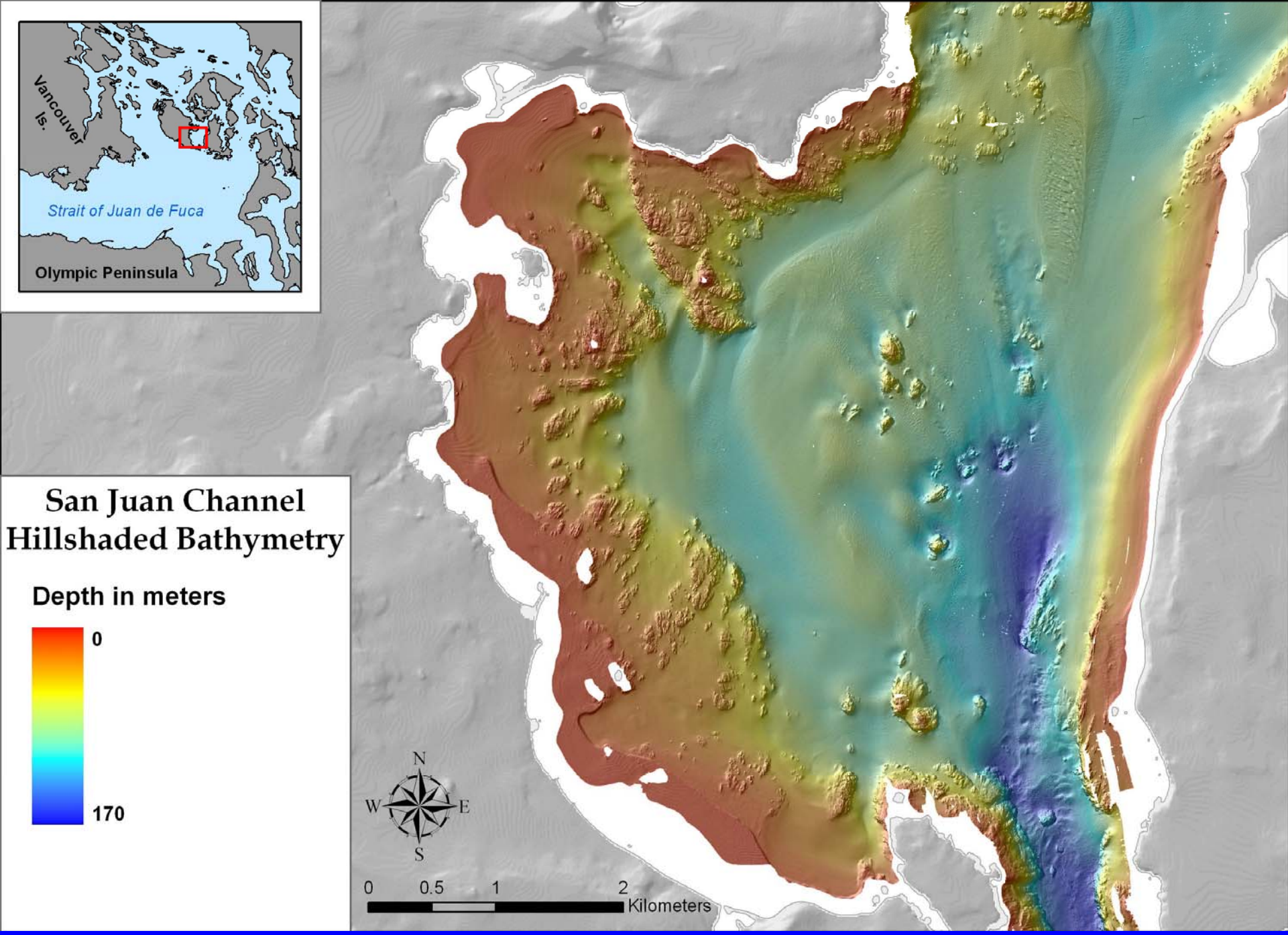
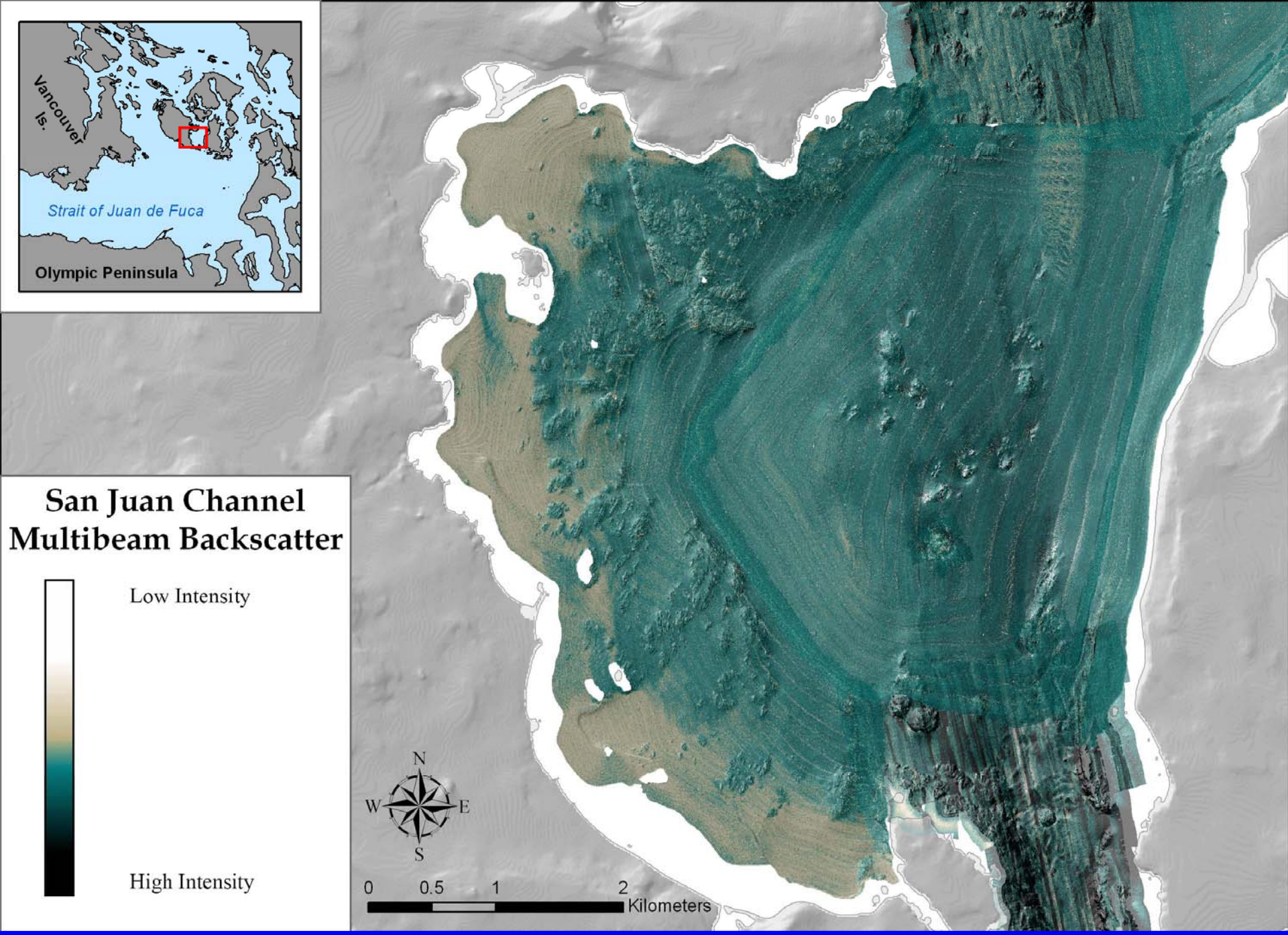
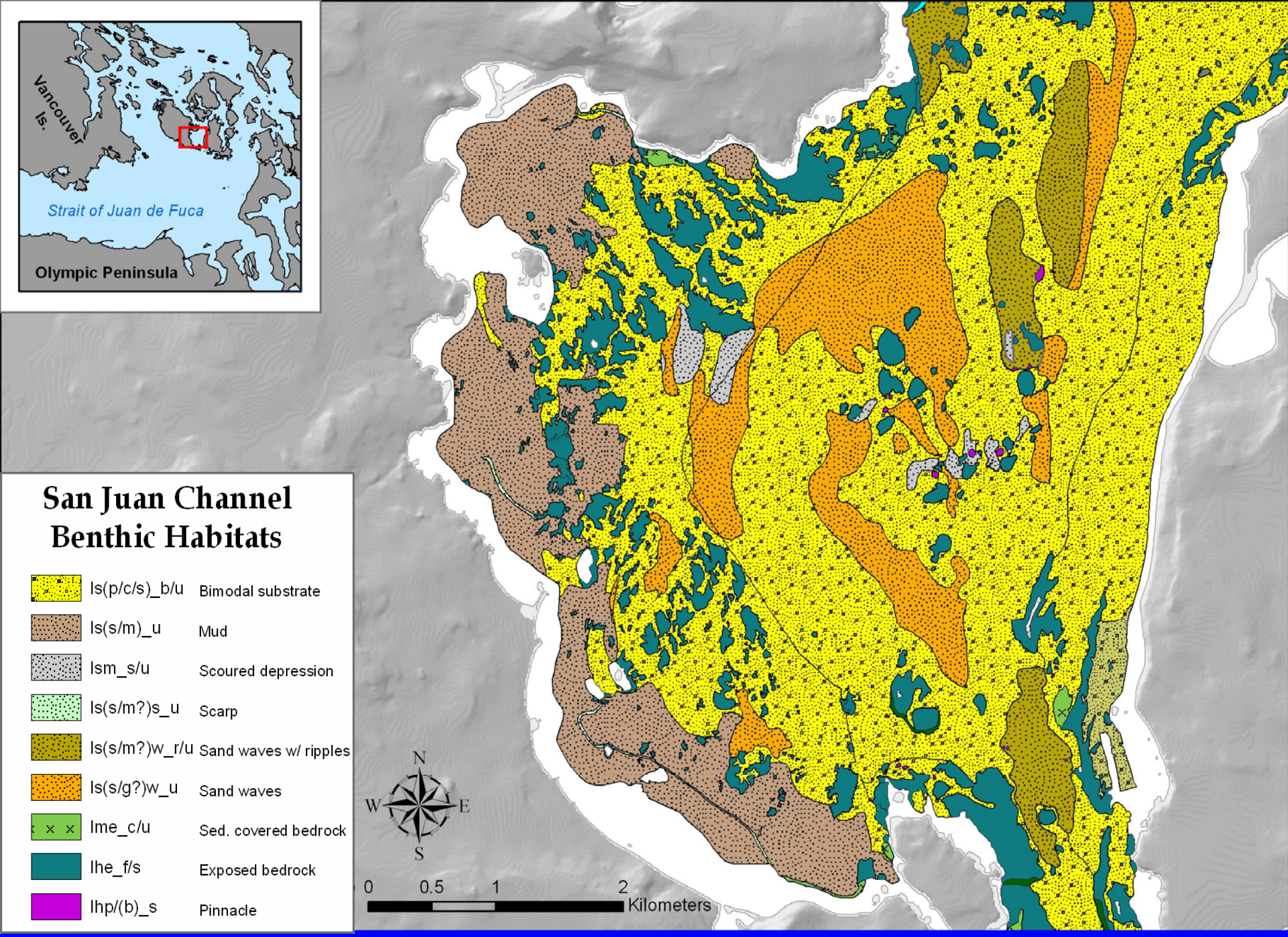
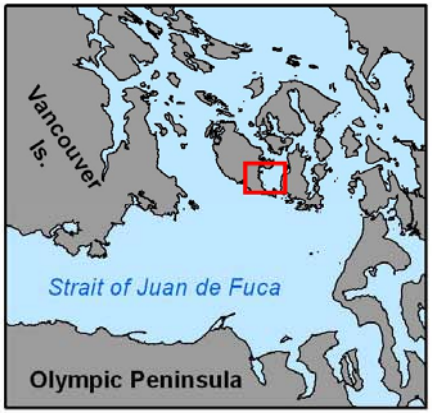
FUGRO


Vancouver Is.
Strait of Juan de Fuca
Olympic Peninsula
San Juan Channel
Hillshaded Bathymetry
Depth in meters
0
170
N
W
E
S
0
0.5
1
2
Kilometers


Vancouver Is.
Strait of Juan de Fuca
Olympic Peninsula
San Juan Channel
Multibeam Backscatter
Low Intensity
High Intensity
N
W
E
S
0
0.5
1
2
Kilometers


Vancouver Is.
Strait of Juan de Fuca
Olympic Peninsula
San Juan Channel
Benthic Habitats
ls(p/c/s)_b/u Bimodal substrate
ls(s/m)_u Mud
lsm_s/u Scoured depression
ls(s/m?)s_u Scarp
ls(s/m?)w_r/u Sand waves w/ ripples
ls(s/g?)w_u Sand waves
lme_c/u Sed. covered bedrock
lhe_f/s Exposed bedrock
lhp/(b)_s Pinnacle
N
W
E
S
0 0.5 1 2
Kilometers



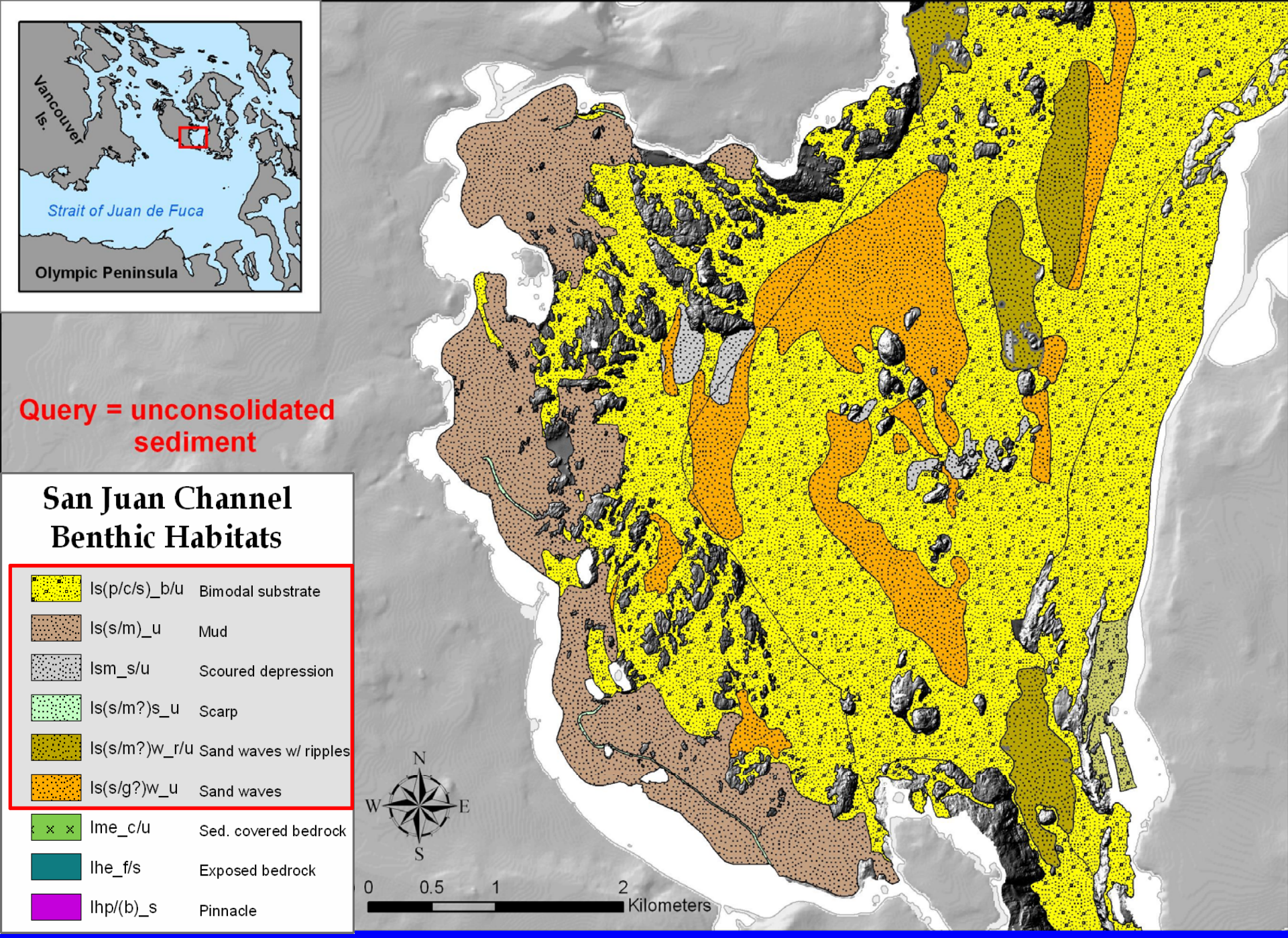
Query = hard substrate

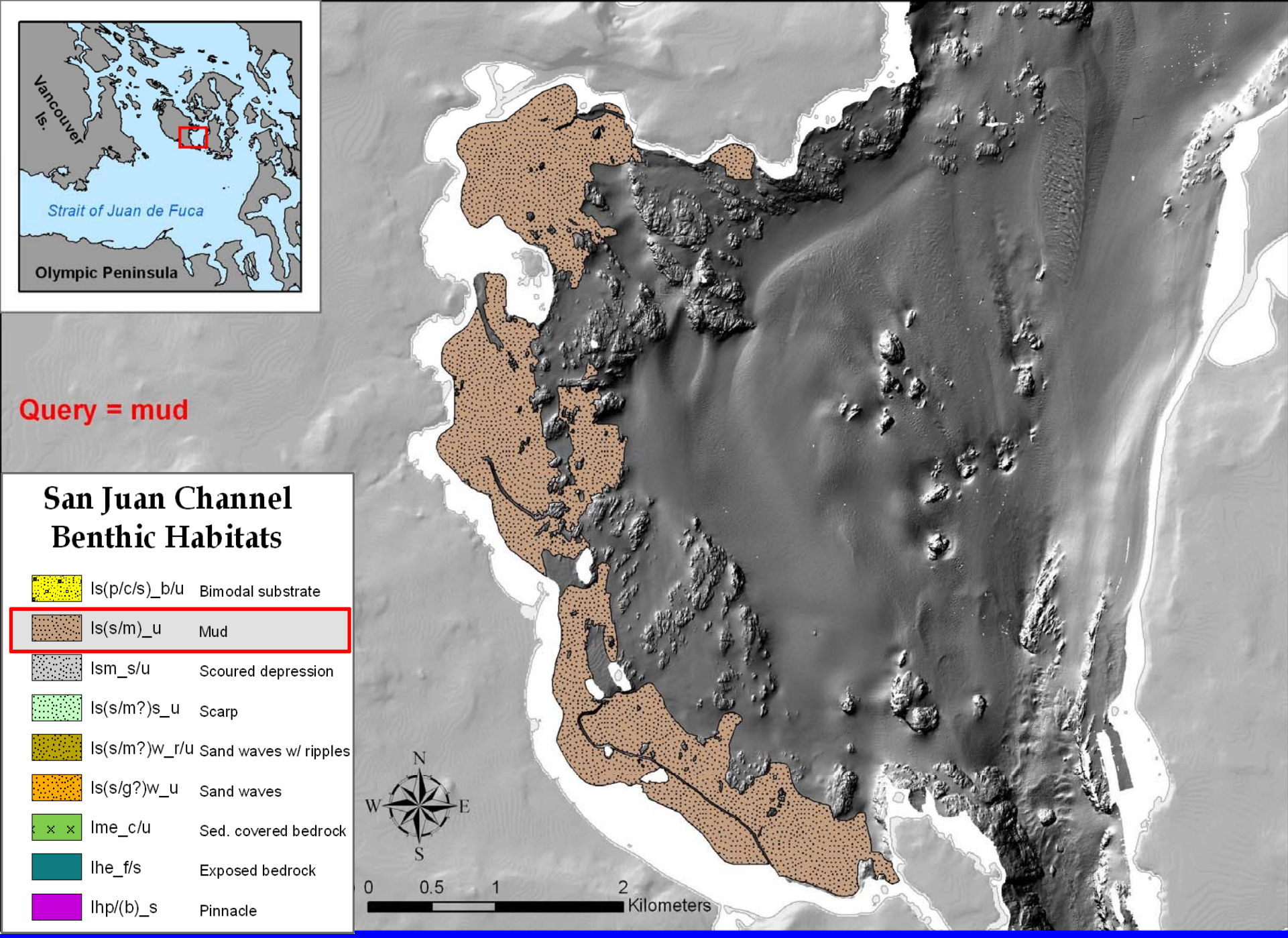
San Juan Channel Benthic Habitats

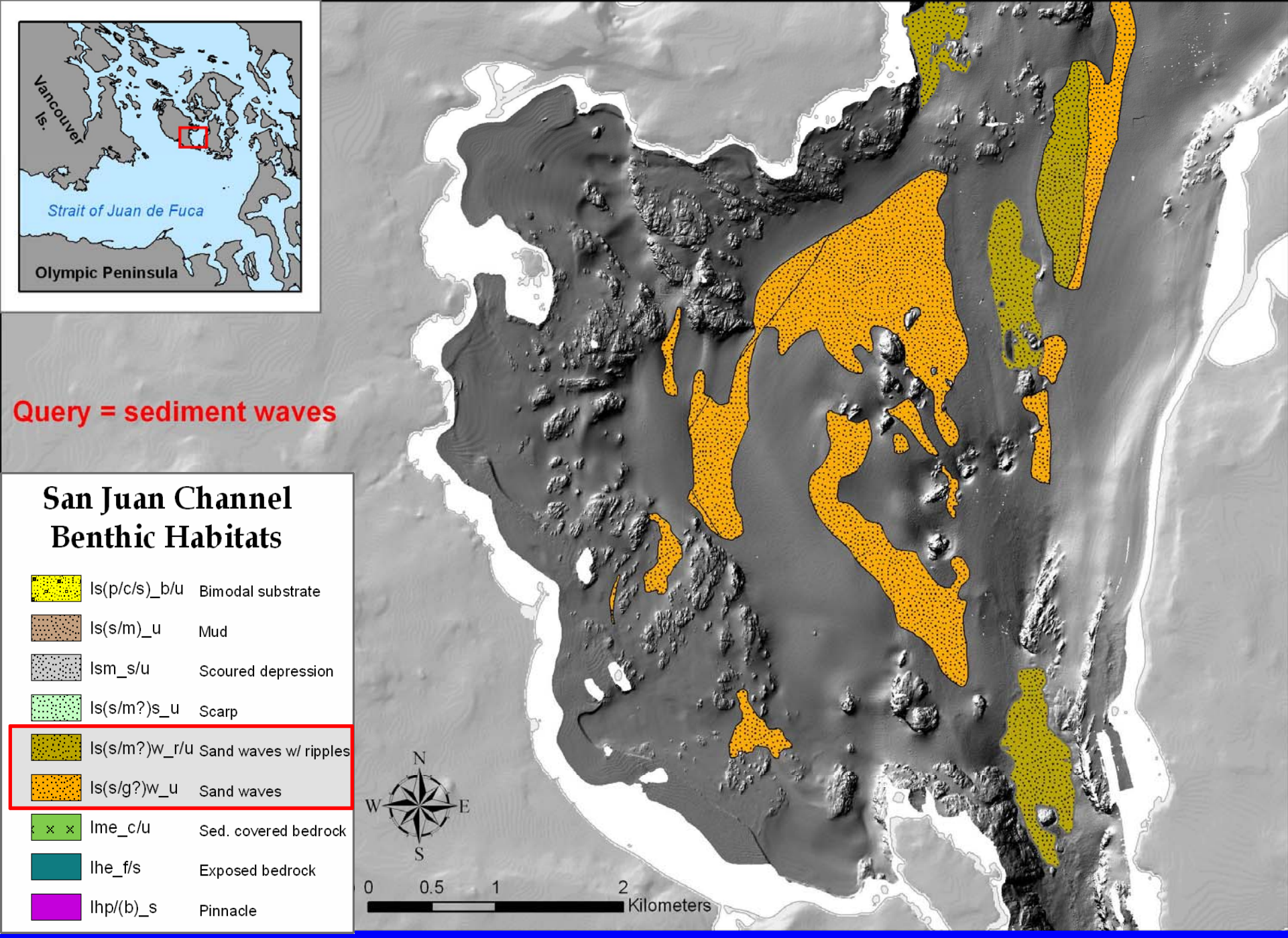
ls(p/c/s)_b/u	Bimodal substrate
ls(s/m)_u	Mud
lsm_s/u	Scoured depression
ls(s/m?)s_u	Scarp
ls(s/m?)w_r/u	Sand waves w/ ripples
ls(s/g?)w_u	Sand waves
lme_c/u	Sed. covered bedrock
lhe_f/s	Exposed bedrock
lhp/(b)_s	Pinnacle

N
W E
S

0 0.5 1 2 Kilometers


Vancouver Is.
Strait of Juan de Fuca
Olympic Peninsula
Query = unconsolidated sediment
San Juan Channel Benthic Habitats
ls(p/c/s)_b/u Bimodal substrate
ls(s/m)_u Mud
lsm_s/u Scoured depression
ls(s/m?)s_u Scarp
ls(s/m?)w_r/u Sand waves w/ ripples
ls(s/g?)w_u Sand waves
lme_c/u Sed. covered bedrock
lhe_f/s Exposed bedrock
lhp/(b)_s Pinnacle
N
W
E
S
0 0.5 1 2
Kilometers


Vancouver Is.
Strait of Juan de Fuca
Olympic Peninsula
Query = mud
San Juan Channel Benthic Habitats
ls(p/c/s)_b/u Bimodal substrate
ls(s/m)_u Mud
lsm_s/u Scoured depression
ls(s/m?)s_u Scarp
ls(s/m?)w_r/u Sand waves w/ ripples
ls(s/g?)w_u Sand waves
lme_c/u Sed. covered bedrock
lhe_f/s Exposed bedrock
lhp/(b)_s Pinnacle
N
W
E
S
0 0.5 1 2
Kilometers


Vancouver Is.
Strait of Juan de Fuca
Olympic Peninsula
Query = sediment waves
San Juan Channel Benthic Habitats
ls(p/c/s)_b/u Bimodal substrate
ls(s/m)_u Mud
lsm_s/u Scoured depression
ls(s/m?)s_u Scarp
ls(s/m?)w_r/u Sand waves w/ ripples
ls(s/g?)w_u Sand waves
lme_c/u Sed. covered bedrock
lhe_f/s Exposed bedrock
lhp/(b)_s Pinnacle
N
W
E
S
0 0.5 1 2
Kilometers

Aleutian Is. Site 17 Hillshaded Bathymetry

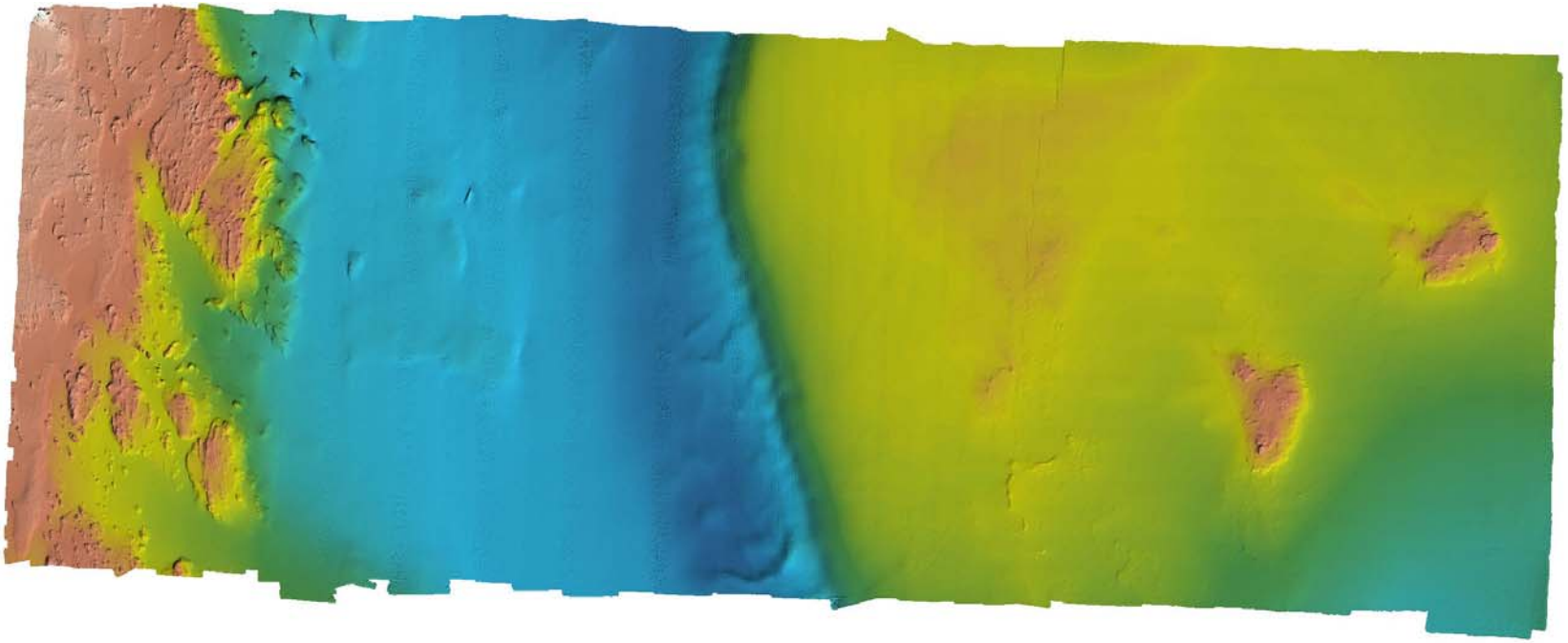
0 1 2 4 Kilometers

N

Depth in meters

30

90



Aleutian Is. Site 17 Backscatter Imagery

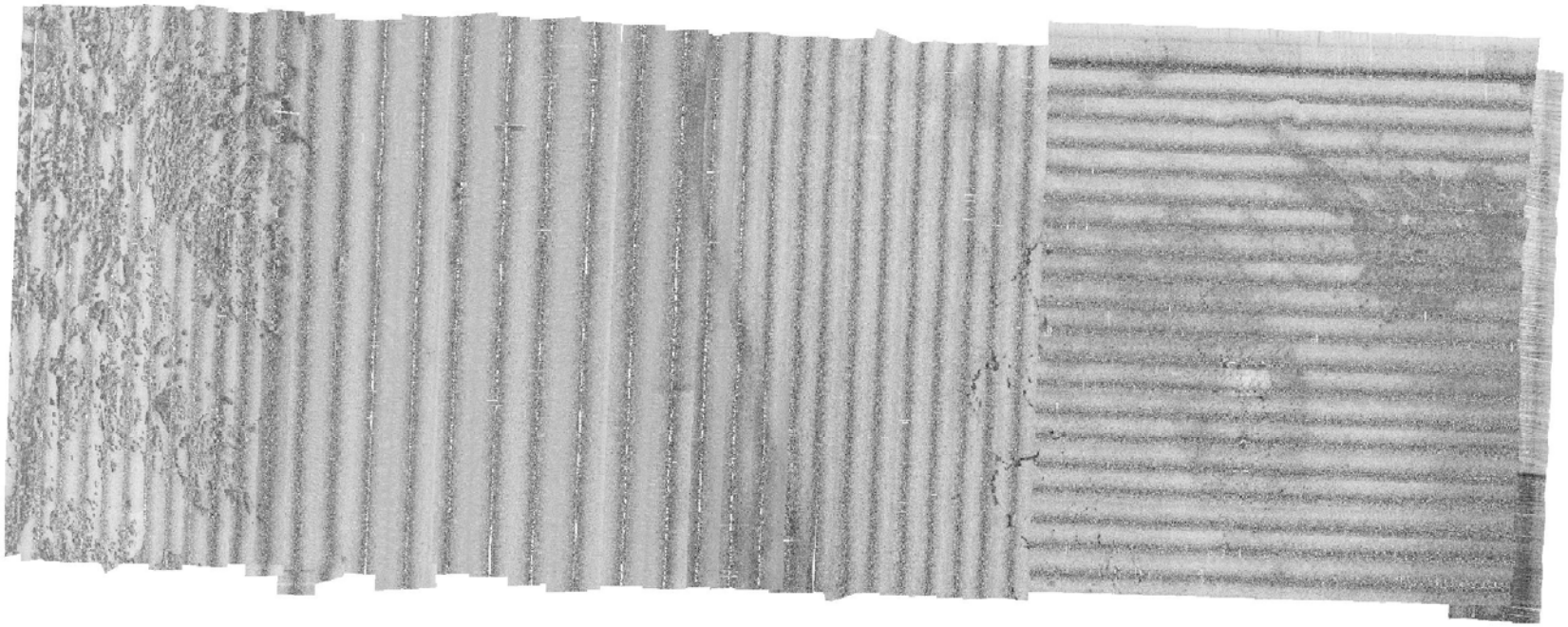
0 1 2 4 Kilometers

N

Backscatter Intensity

High

Low



Aleutian Is. Site 17 Benthic Habitats

0 1 2 4 Kilometers

N

Key to Habitat Types

Ss_u	Unconsolidated sediment
Ss(s)_u	Unconsolidated sand
Ss(g?)_u	Gravel apron
Sss_c/u	Fault scarp
Ssm_s/u	Current scour
Ss(g?)w?_u	Gravel stringers/bedforms
Ss(s)w_u	Sediment waves
Ssm_u	Mound
Sm(s)e_u/d	Sed. covered bedrock
She_d	Bedrock exposure
Sh_a	Shipwreck

Aleutian Is. Site 17 Benthic Habitats

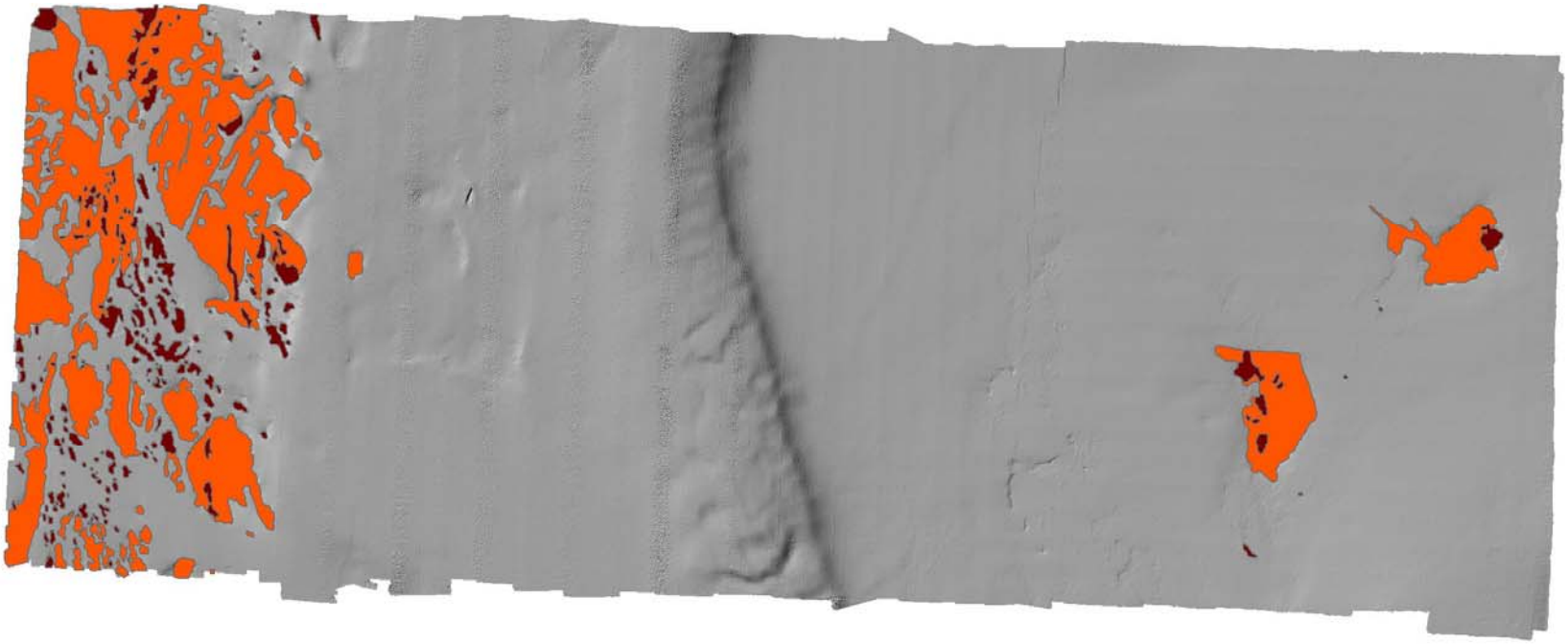
0 1 2 4 Kilometers

N

Key to Habitat Types

Ss_u	Unconsolidated sediment
Ss(s)_u	Unconsolidated sand
Ss(g?)_u	Gravel apron
Sss_c/u	Fault scarp
Ssm_s/u	Current scour
Ss(g?)w?_u	Gravel stringers/bedforms
Ss(s)w_u	Sediment waves
Ssm_u	Mound
Sm(s)e_u/d	Sed. covered bedrock
She_d	Bedrock exposure
Sh_a	Shipwreck

Query = Bedrock



Aleutian Is. Site 17 Benthic Habitats

0 1 2 4 Kilometers

N

Key to Habitat Types

Ss_u	Unconsolidated sediment
Ss(s)_u	Unconsolidated sand
Ss(g?)_u	Gravel apron
Sss_c/u	Fault scarp
Ssm_s/u	Current scour
Ss(g?)w?_u	Gravel stringers/bedforms
Ss(s)w_u	Sediment waves
Ssm_u	Mound
Sm(s)e_u/d	Sed. covered bedrock
She_d	Bedrock exposure
Sh_a	Shipwreck

Query = Unconsolidated Sediment

Aleutian Is. Site 17 Benthic Habitats

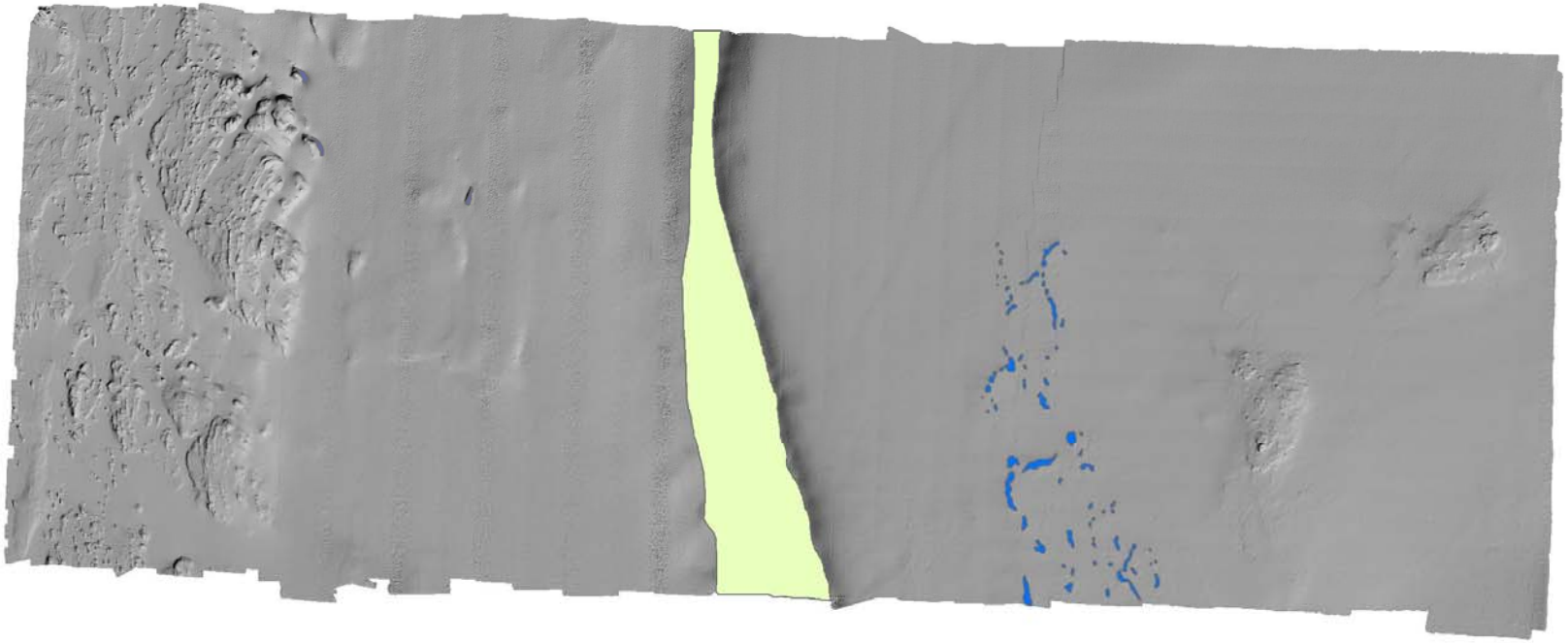
0 1 2 4 Kilometers

N

Key to Habitat Types

Ss_u	Unconsolidated sediment
Ss(s)_u	Unconsolidated sand
Ss(g?)_u	Gravel apron
Sss_c/u	Fault scarp
Ssm_s/u	Current scour
Ss(g?)w?_u	Gravel stringers/bedforms
Ss(s)w_u	Sediment waves
Ssm_u	Mound
Sm(s)e_u/d	Sed. covered bedrock
She_d	Bedrock exposure
Sh_a	Shipwreck

Query = Bedforms



Criteria for Recommended Habitat Classification Schemes (Lund and Valentine 2007)

- Geographic Focus
- Classification Coding System
- Data Sources and Scale
- Comments and Updates

Coastal Zone Management Considerations

- **What are the specific management questions CZM hopes to address with a classification approach?**
- **Does CZM want to adopt a system that has local, regional and/or national relevance?**
- **Does CZM want to include nearshore and even terrestrial habitats in coastal watersheds (coastal wetlands, tidal rivers, etc) in a classification approach?**

(Lund and Valentine, 2007)

Key Terms

(Valentine et al. 2005)

- **Habitat characterization** produces narrative and illustrative descriptions of habitats based on geological, biological, chemical and oceanographic observations and sampling.
- **Habitat classification** is the process of identifying habitat types based on a set of standard terms.
- **Habitat mapping** is the spatial representation of described and classified habitat units.

Scale (Resolution) Application to CMECS

Scale	Approximate Exte	Data Resolution	Application to CM
Megascale	Few km to 100s of km	30-50m pixels	system/subsystem
Mesoscale	10s of m to few km	10-20m pixels	class
Macroscale	1 to 10s of m	4 to 10m pixels	subclass/habitat/bi
Microscale	cm to m	submeter to 3m pixels	subclass/habitat/bi

Scale Considerations Need to Know

- Data collection objectives
- Scale of data acquisition
- Scale of processing
- Scale of interpretation
- Quality of data
- Evaluation of accuracy

Other Considerations

- Nested vs. Hierarchal vs. Agglomerated
- Need to map at highest resolution and fully interpret data to maximize use
- Relationship between thematic and spatial resolution not always positive
- Need to accommodate for rare and unique habitats

Other Other Considerations

- Science and technology is pushing towards higher resolution with possibility of management following suite as capability increases
- Scheme must be flexible to absorb future technological advancement such as temporal variability
- Variability modifiers for ephemeral conditions

Conclusions

- Application of GIS to mapping seafloor conditions is useful in illustrating potential marine benthic habitats and geology.

- In GIS habitat and geology (including geohazards) are easily converted between each other using the attribute code modified after Greene et al., (1999, 2007).

- The spatial analysis tool in GIS can be used for time series analyses.

Conclusions (cont.)

- Technology drives deep-water benthic habitat mapping (Bottom-Up)

- Advisable to have a classification scheme keyed to a retrievable GIS system so data can be easily simplified, combined, and added

- In cases where we know what attracts flora or fauna, or an assemblage of organisms, to a particular habitat, we can map "true habitat"

- Where we lack good biological information, we can only map "potential habitats"