



Mapping Benthic Habitats from Classified Video Data:

*Applying the Coastal and Marine Ecological Classification
Standard (CMECS) to ROV Video Data for Enhanced
Geospatial Analysis of Deep Sea Environments*

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NOAA's National Centers for Environmental Information

NROC Habitat Classification and Ocean Mapping Sub-Committee Workshop

March 12th – 13th, 2018

NOAA Satellite and Information Service | National Centers for Environmental Information



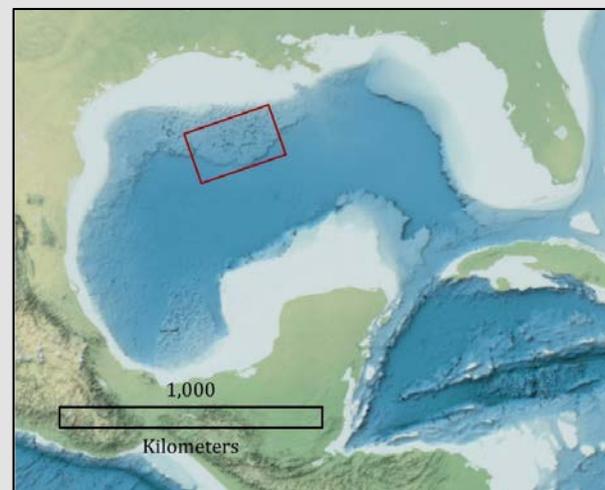
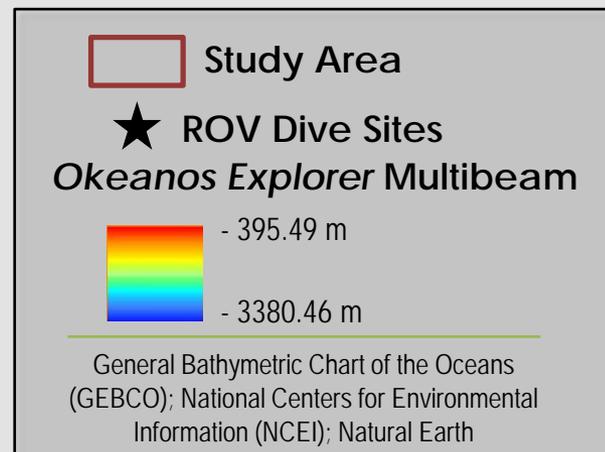
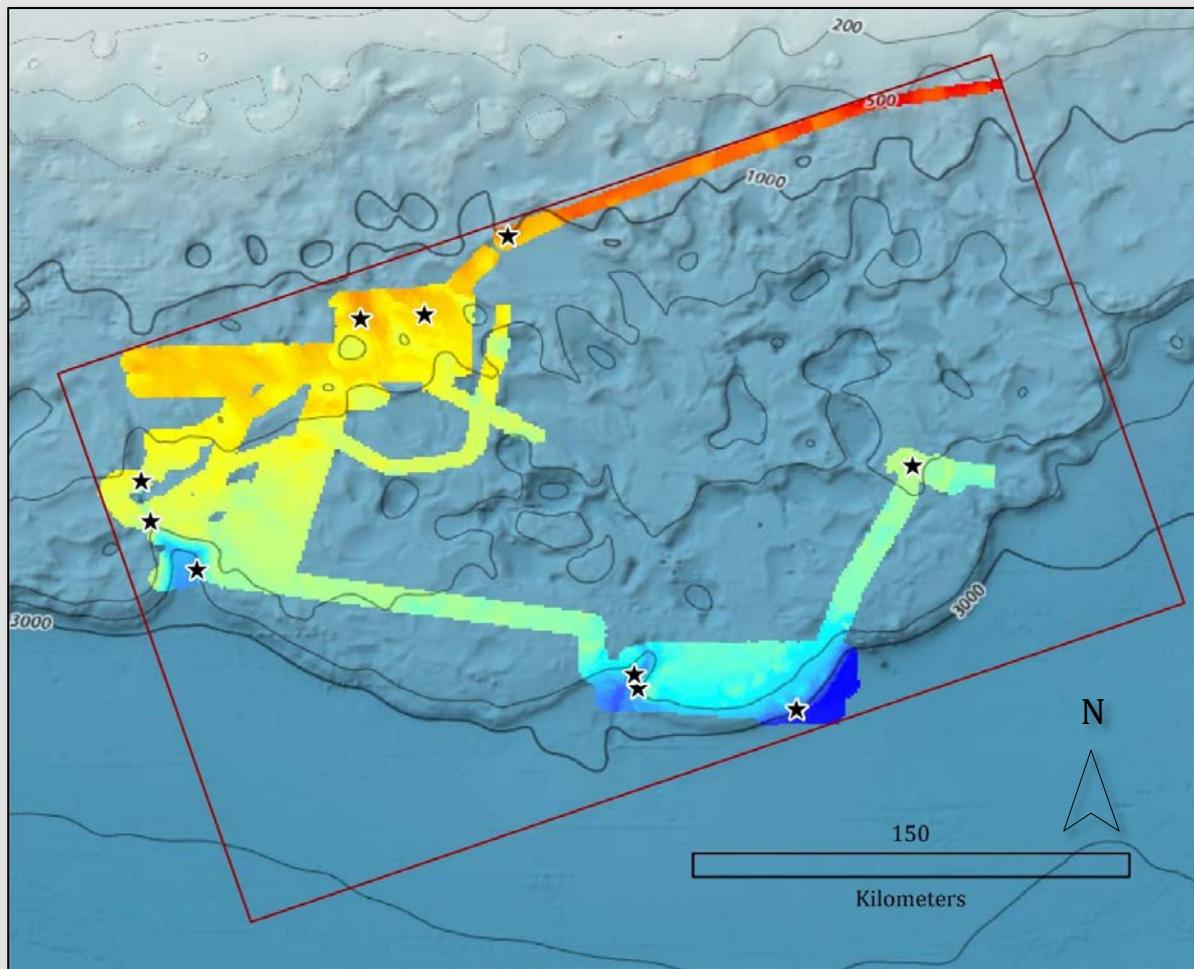
NOAA Ship *Okeanos Explorer* & ROV



- ROV *Deep Discoverer***
- Maximum Depth: 6,000m
 - Onboard CTD sensor
 - Records continuous ROV position/attitude information
 - 6 High definition video cameras



2014 Gulf of Mexico Expedition



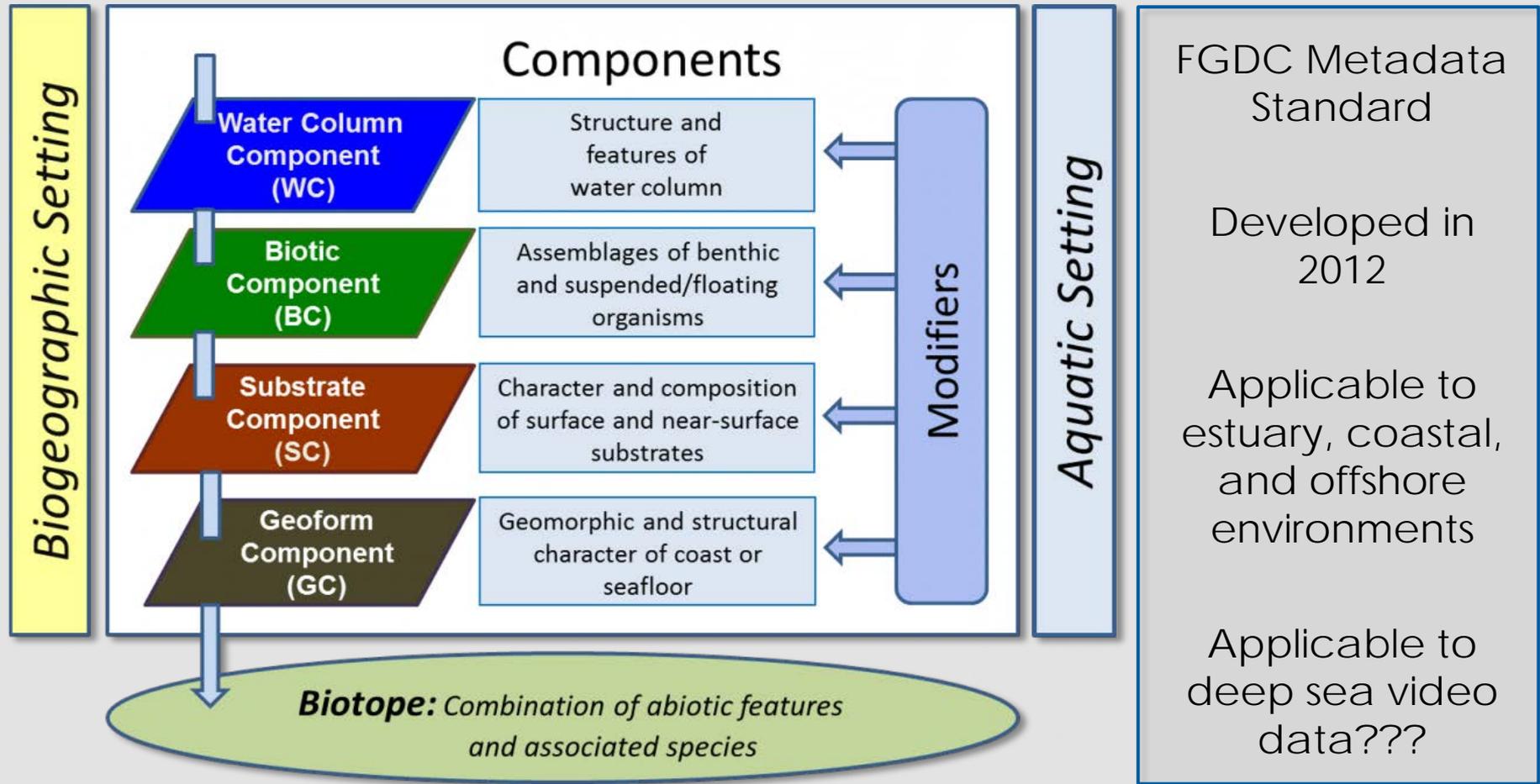
ROV Video Data Challenges



How do we organize video with reusability in mind?

- Data are voluminous and do not compress well
- No guidance for mapping benthic habitats from video observations
- No efficient way to spatially search or analyze video observations
- Annotations are not consistently applied by scientific community

Coastal & Marine Ecological Classification Standard (CMECS)



* Graphic courtesy of the CMECS Document





Research Objectives

- 1. Determine the extent to which CMECS can be applied to deep sea benthic habitats in the Northern Gulf of Mexico.**
- 2. Assess the feasibility of implementing CMECS to ROV video and ancillary data in near-real-time applications.**
- 3. Develop geospatial processing techniques necessary to analyze and generate maps of the observed video content for enhanced geospatial analysis within a GIS.**

Classifying Deep Sea Imagery



ROV Highlight Image from EX1402L3 Dive 9

Biogeographic Setting: Warm Temperate Northwest Atlantic – Northern Gulf of Mexico

Aquatic Setting: Marine Oceanic in the Subtidal Zone

Water Column Component: Very Cold, Euhaline Water on the Benthic Boundary Layer in the Marine Oceanic Bathypelagic Layer (Oxic)

Geoform Component: Ridge in a Submarine Canyon (Bryant Canyon)

Substrate Component: Coarse Unconsolidated Mineral Substrate with Co-occurring Shell Substrate

Biotic Component: Attached Anemones with the following Associated Taxa: Sessile Gastropods

Classifying Video with CMECS Annotations

The image displays three screenshots of the ROV Data Analyzer Software interface. The top-left screenshot shows a video player window titled 'EX1402L3_VID_20140416T160121Z_20140416T183126Z_STREAM-1.MOV - VLC media player' with a video of a fish on the seabed. The top-right screenshot shows a 'Utilities' menu with options like 'Text to find: cor', 'Go to Unix time:', and 'Enter a new event log entry:'. The bottom screenshot shows a 'Hot Keyboard of CMECS Keys' with a grid of buttons for various CMECS codes such as Chanl, Dpn, Dpr, Fan, Frac, Hole, Mnd, Mvol, Rips, Otrcp, Wall, Scar, Reef, Tfall, Wfall, Trash, Rs, coarseUMs, fineUMs, Cs, Ss, Ws, ANE, BARN, BRAC, BSTAR, BRY, CEPH, CHIT, CLAM, COR, CORreef, CRI, CRUS, DIVRS, ECH, GAS, GLAS, GLASreef, HOL, HYD, MUS, MUSreef, PEN, UCH, SPO, STFH, TUB, TUNIC, SEEP, WORMreef, INFRD, flmatMICR, susMAC, susMICR, UnknGeo, UnknSub, noBIO, NoBtm, and a 'Text annotation/remarks' field.

ROV Data Analyzer Software Still Under Development by Mashkoor Malik (OER)

*** Disclaimer ***
 Current operations use alternate software developed by Ocean Networks Canada

SeaScribe (real-time) SeaTube (post-dive)

Hot Keyboard of CMECS Keys

* Screenshots of ROV Data Analyzer Software





Geospatial Objectives

a. Environmental Maps of Water Column Information

- Temperature
- Salinity
- Dissolved Oxygen Concentration
- Total Depth (Local Bathymetry)

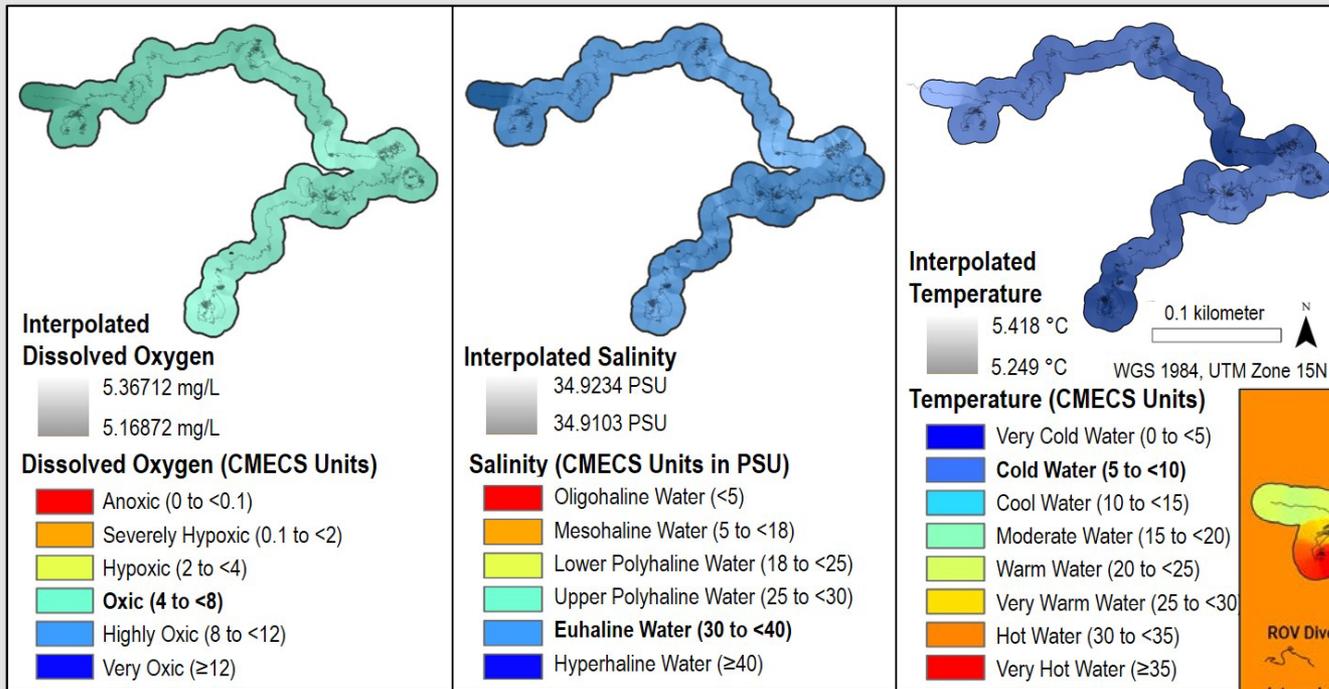
b. CMECS Compliant Habitat Maps

- Geoform (Seafloor Shape)
- Substrate (Seafloor Composition)
- Biotic (Benthic Biology)
- 2 Mapping Approaches (Buffered & Viewshed)

Mapping the Surrounding Environment

Dissolved Oxygen	Salinity	Temperature
------------------	----------	-------------

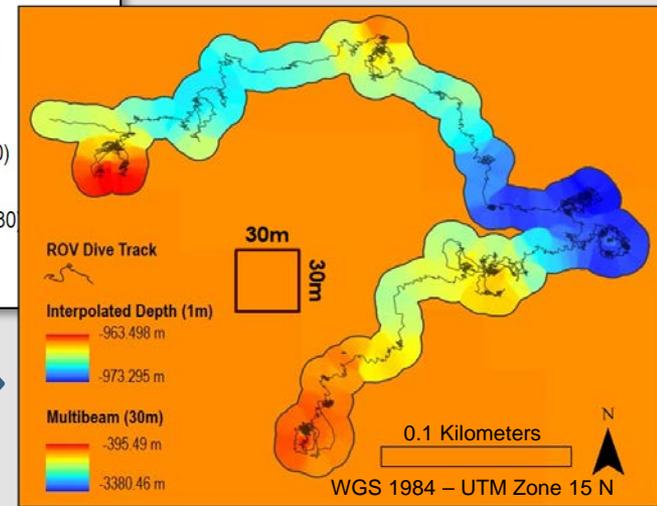
← Calculated from CTD



- 10m Buffer around Dive Track
- 0.5 m cell size
- Interpolated using Inverse Distance Weighted (IDW)

Calculated Seafloor Depth = ROV Depth + ROV Altitude →

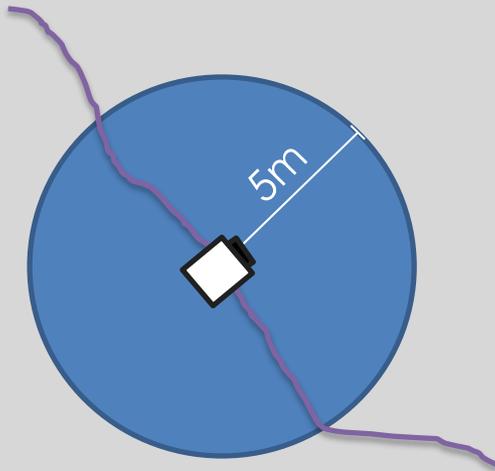
CMECS Layer Unit: Marine Oceanic Mesopelagic Layer



Mapping ROV Video

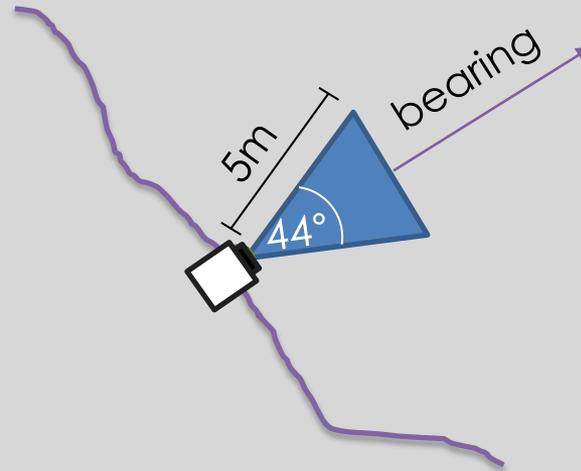
2 Mapping Approaches

Buffered



5 Meter Annular Buffer
Around
ROV Dive Track Line

Viewshed

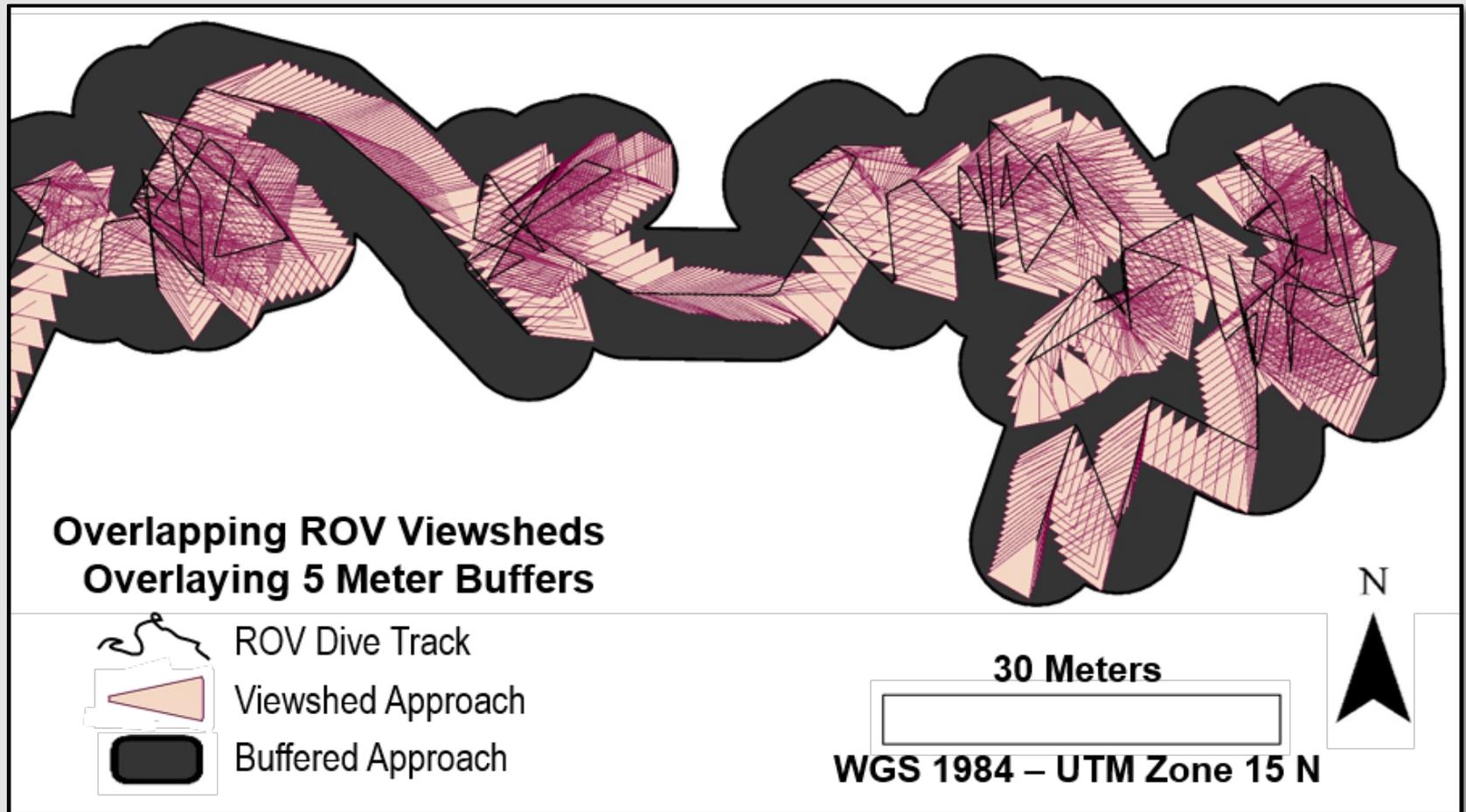


44° Wedge Polygon
Extending 5 Meters from
ROV Location

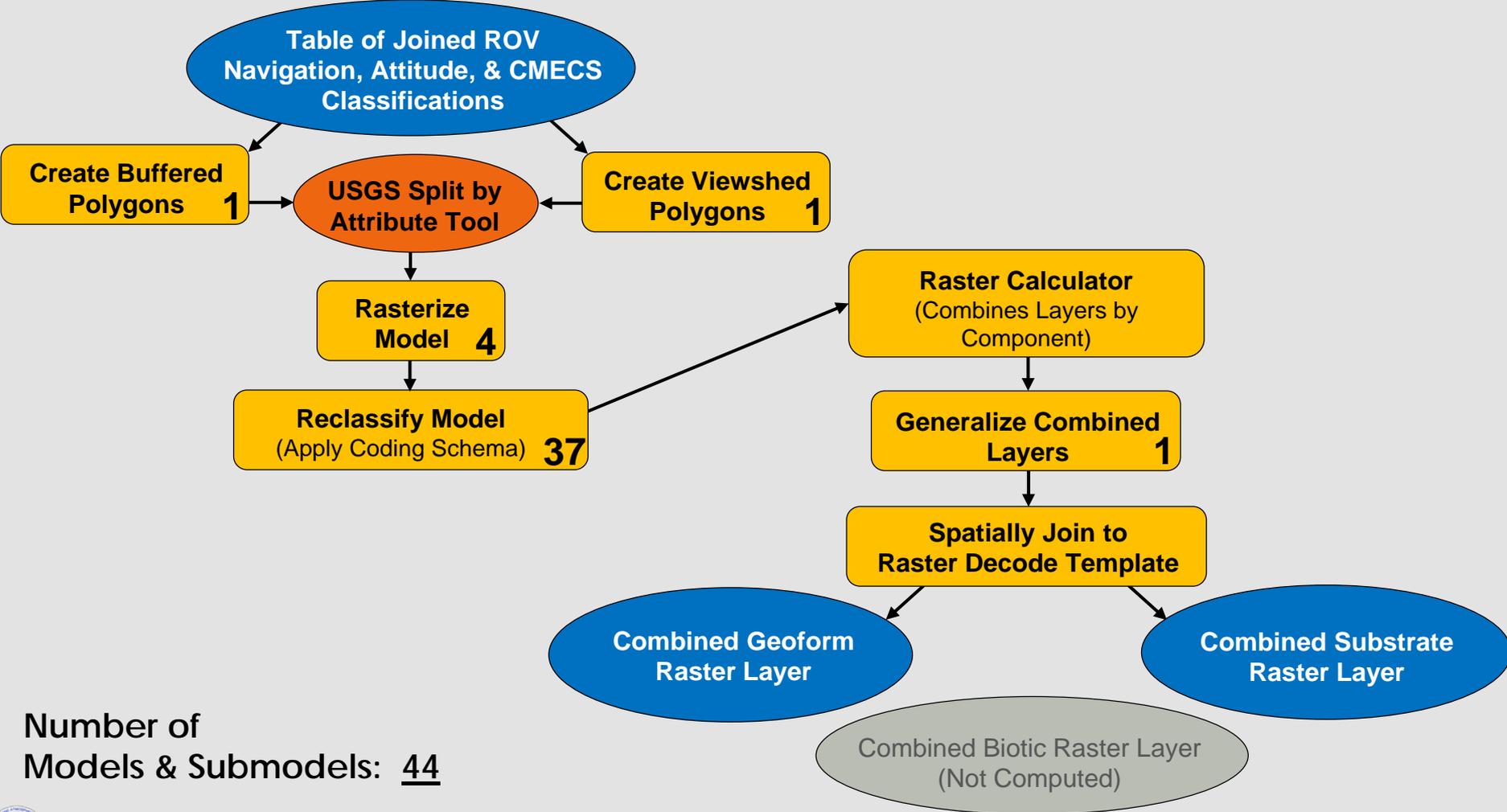
CMECS Compliant Habitat Maps

- **Geoform Component**
 - Individual layers
 - Combined layer
- **Substrate Component**
 - Individual layers
 - Combined layer
- **Biotic Component**
 - Individual layers
 - Too many classes to legibly combine

Comparison of Mapping Approaches



General Workflow for Habitat Mapping



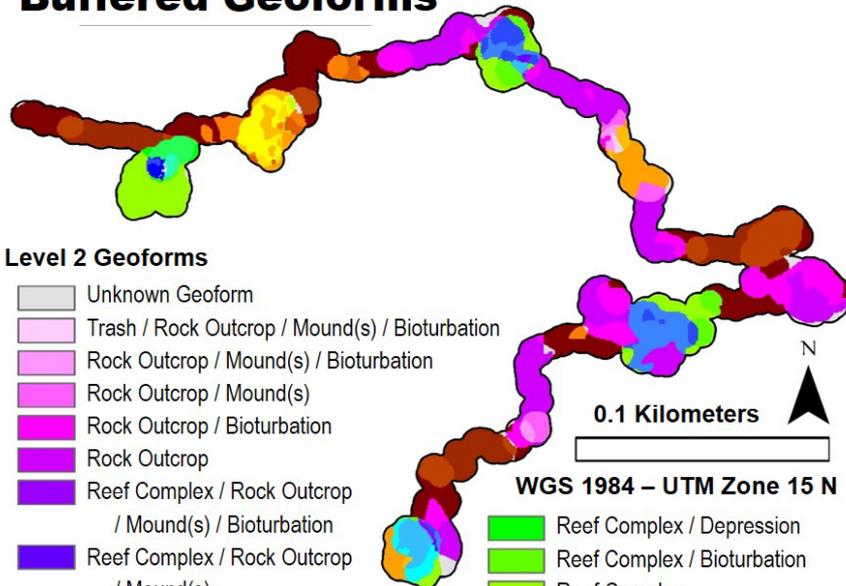
Number of Models & Submodels: 44



Mapping with CMECS

Eliminates 4 erroneous overlapping classes

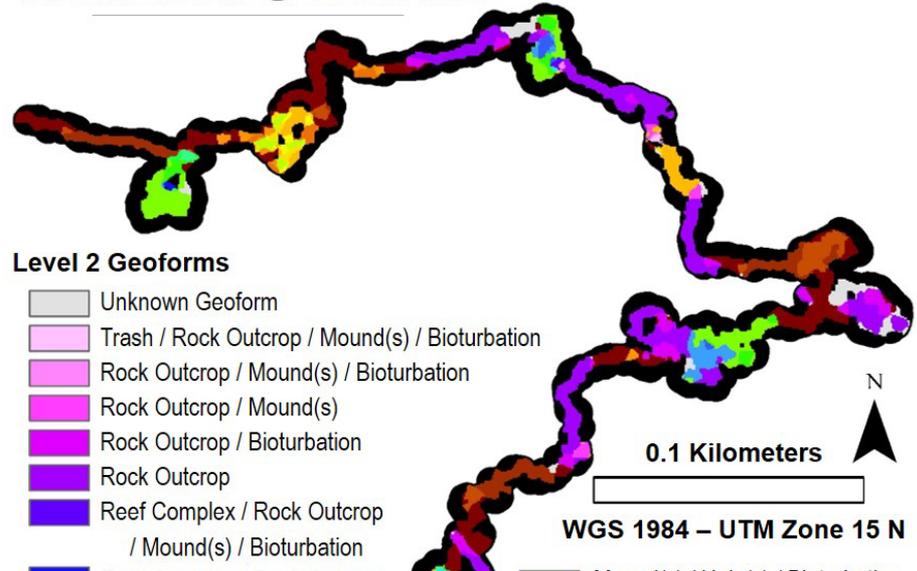
Dive 01: Buffered Geoforms



Level 2 Geoforms

- Unknown Geoform
 - Trash / Rock Outcrop / Mound(s) / Bioturbation
 - Rock Outcrop / Mound(s) / Bioturbation
 - Rock Outcrop / Mound(s)
 - Rock Outcrop / Bioturbation
 - Rock Outcrop
 - Reef Complex / Rock Outcrop / Mound(s) / Bioturbation
 - Reef Complex / Rock Outcrop / Mound(s)
 - Reef Complex / Rock Outcrop / Depression / Channel
 - Reef Complex / Rock Outcrop / Bioturbation
 - Reef Complex / Rock Outcrop
 - Reef Complex / Rock Outcrop / Mound(s) / Bioturbation
 - Reef Complex / Mound(s)
 - Reef Complex / Hole(s) / Depression / Channel
 - Reef Complex / Hole(s) / Bioturbation
 - Reef Complex / Depression / Channel
 - Reef Complex / Depression
 - Reef Complex / Bioturbation
 - Reef Complex
 - Reef Complex / Depression
 - Reef Complex / Bioturbation
 - Reef Complex
 - Mound(s) / Hole(s) / Depression / Channel
 - Mound(s) / Hole(s) / Channel
 - Mound(s) / Hole(s) / Bioturbation
 - Mound(s) / Hole(s)
 - Mound(s) / Bioturbation
 - Mound(s)
 - Hole(s) / Bioturbation
 - Hole(s)
 - Depression / Channel
 - Depression
 - Bioturbation
- WGS 1984 – UTM Zone 15 N

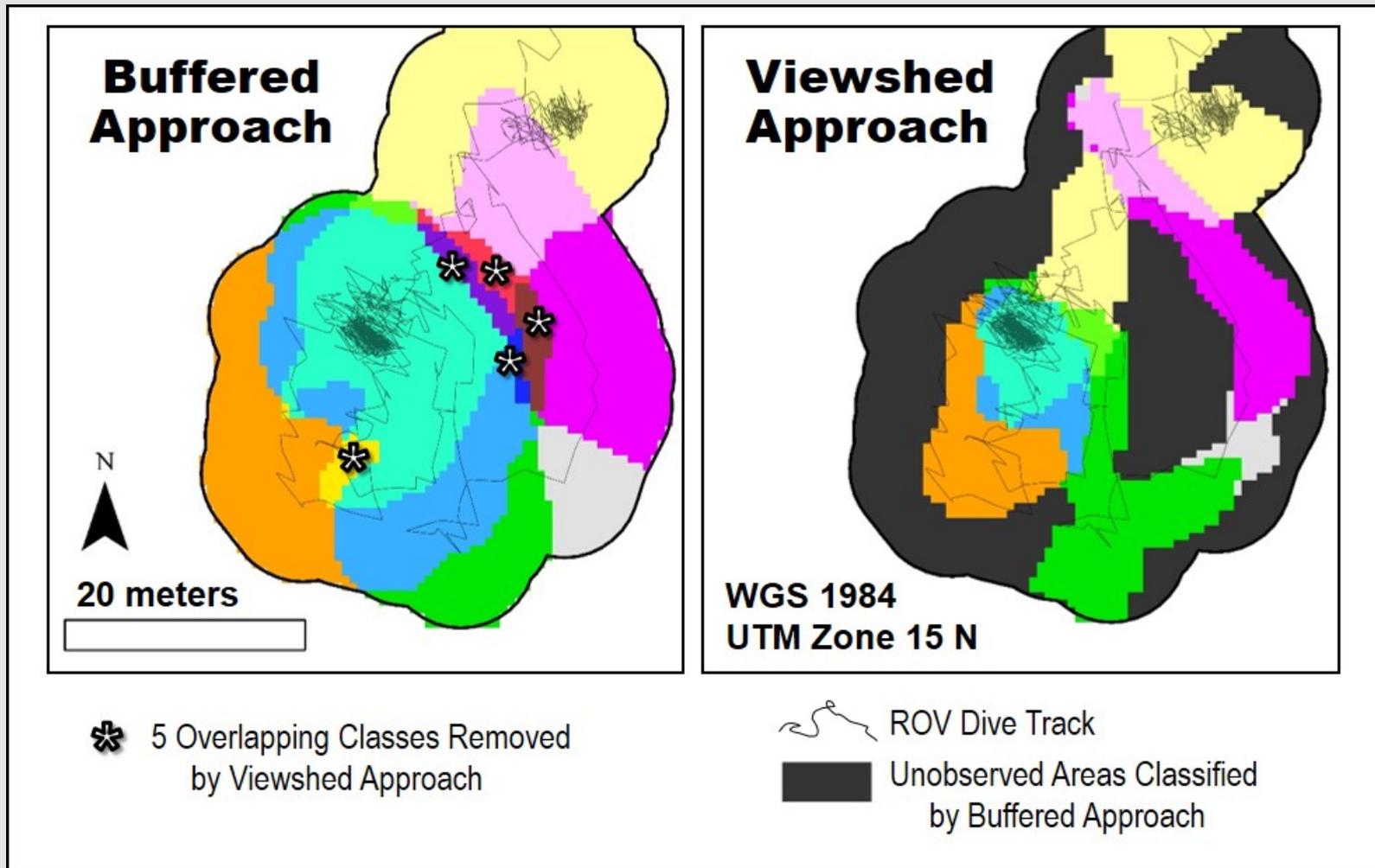
Dive 01: Viewshed Geoforms



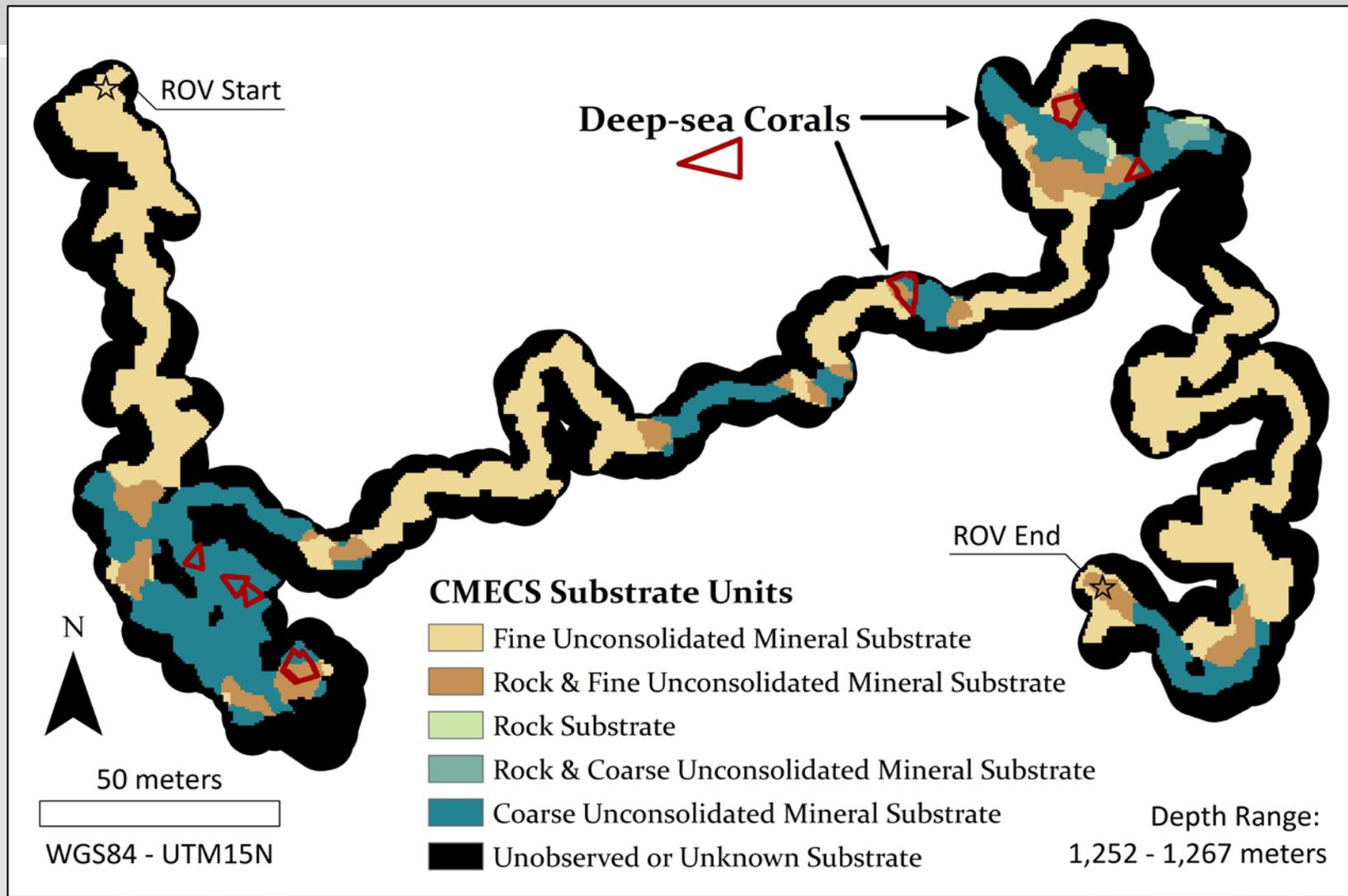
Level 2 Geoforms

- Unknown Geoform
 - Trash / Rock Outcrop / Mound(s) / Bioturbation
 - Rock Outcrop / Mound(s) / Bioturbation
 - Rock Outcrop / Mound(s)
 - Rock Outcrop / Bioturbation
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 - Reef Complex / Mound(s) / Bioturbation
 - Reef Complex / Mound(s)
 - Reef Complex / Depression / Channel
 - Reef Complex / Depression
 - Reef Complex / Bioturbation
 - Reef Complex
 - Mound(s) / Hole(s) / Bioturbation
 - Mound(s) / Hole(s)
 - Mound(s) / Bioturbation
 - Mound(s)
 - Hole(s) / Bioturbation
 - Hole(s)
 - Depression / Channel
 - Depression
 - Bioturbation
 - Unobserved Areas Classified by Buffered Approach
- WGS 1984 – UTM Zone 15 N

Comparison of Mapping Approaches



Enhanced Geospatial Analysis



Enhanced Geospatial Analysis

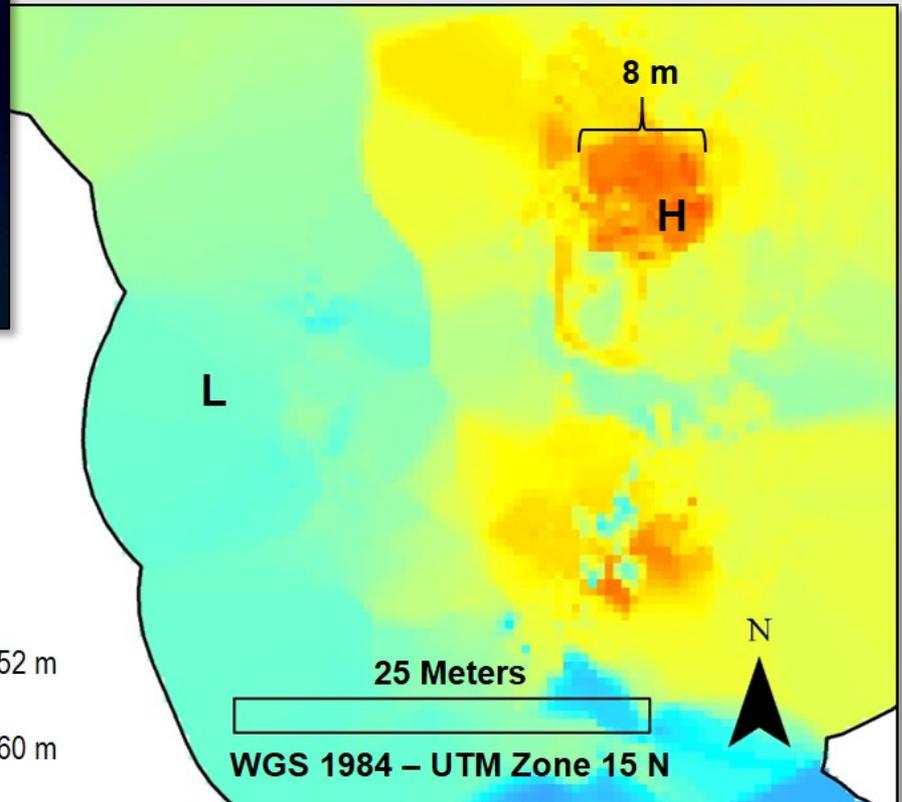
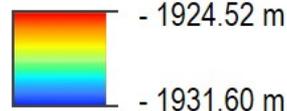


Depth interpolations
allow for feature size
estimates.

Topographic High (H) =
-1,926 meters

Topographic Low (L) =
-1,929 meters

Interpolated
Total Depth
of Dive Track
Bathymetry





Conclusions

1. CMECS **IS** applicable to deep sea benthic habitats in the Northern Gulf of Mexico.
 - Observed elements not addressed by CMECS: Brittle stars attached to biology (neither sediment or hard substrate), Brine, and Hydrate
2. CMECS **IS** applicable to ROV video and ancillary data but **IS NOT** practical for a single analyst to apply in near-real-time.
3. Geospatial outputs promote data discovery, accelerated data analysis and data visualization – especially within the context of a GIS.
 - Viewshed mapping approach DECREASES the number of overlapping classes at most dive sites.
 - Buffered mapping approach is most useful for vehicles lacking the appropriate bearing information.



Thank you!!

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Current EX Video Annotation Software

Resolution: Low Time: 25-Sep-2017 19:45:00 Latitude: 25.16045 Longitude: -161.64389 Depth: 1791.6 Heading: 206.6

Insite Pacific Zeus Plus Camera on ROV Deep Discoverer

OKEANOS EXPLORER 2017

Map Profile Detail

Map Satellite

Google Imagery ©2017 TerraMetrics Terms of Use

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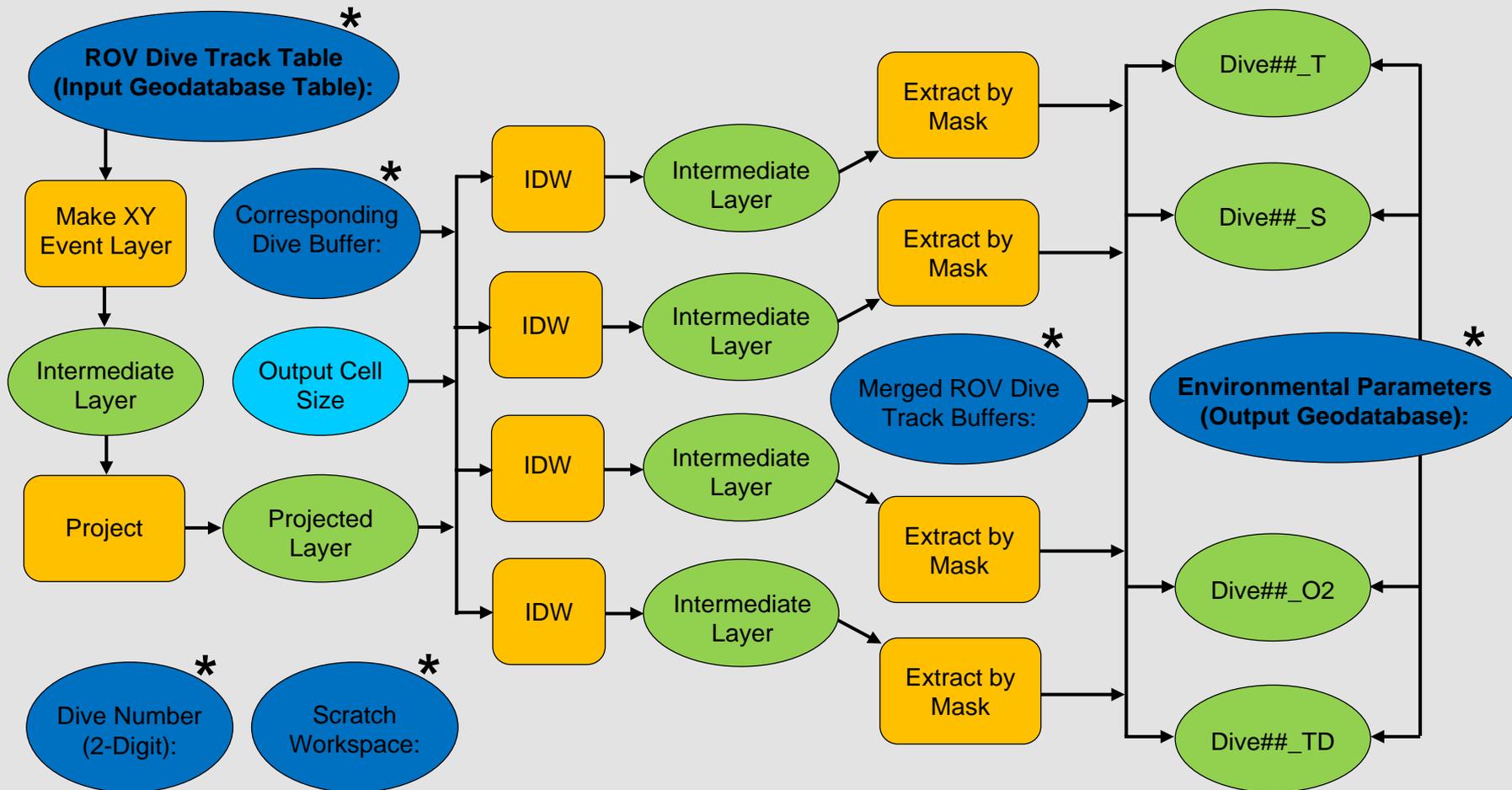
Start Date (UTC)	End Date (UTC)	Comment	Latitude	Longitude	Depth	Origin	Action
25-Sep-2017 19:41:52	25-Sep-2017 19:41:52	Echinodermata Crinoidea Articulata (Crinoid) on Cnidaria Anthozoa Octocorallia Alcyonacea Scleraxonia Coralliidae (Precious Coral)	25.16049	-161.64388	1792.2	SeaScribe	
25-Sep-2017 19:43:26	25-Sep-2017 19:43:26	Arthropoda Crustacea Malacostraca Decapoda (Decapod) shrimp in water	25.16043	-161.6438	1790.8	SeaScribe	
25-Sep-2017 19:44:01	25-Sep-2017 19:44:01	Cnidaria Anthozoa Hexacorallia Actinaria (Anemone)	25.16043	-161.64387	1791.4	SeaScribe	
25-Sep-2017 19:46:24	25-Sep-2017 19:46:24	Cnidaria Medusozoa (Jellyfish)	25.16039	-161.6439	1791.5	SeaScribe	
25-Sep-2017 19:52:43	25-Sep-2017 19:52:43	Cnidaria Medusozoa Hydrozoa (Hydroid)	25.16038	-161.64401	1794.6	SeaScribe	

ONC's annotation software SeaTube provides a user interface that enables video playback, position, and time-stamped annotations.

* Photo credit: NOAA OER & Ocean Networks Canada (ONC)



Environmental Parameters Model



Model for Viewshed Creation

