

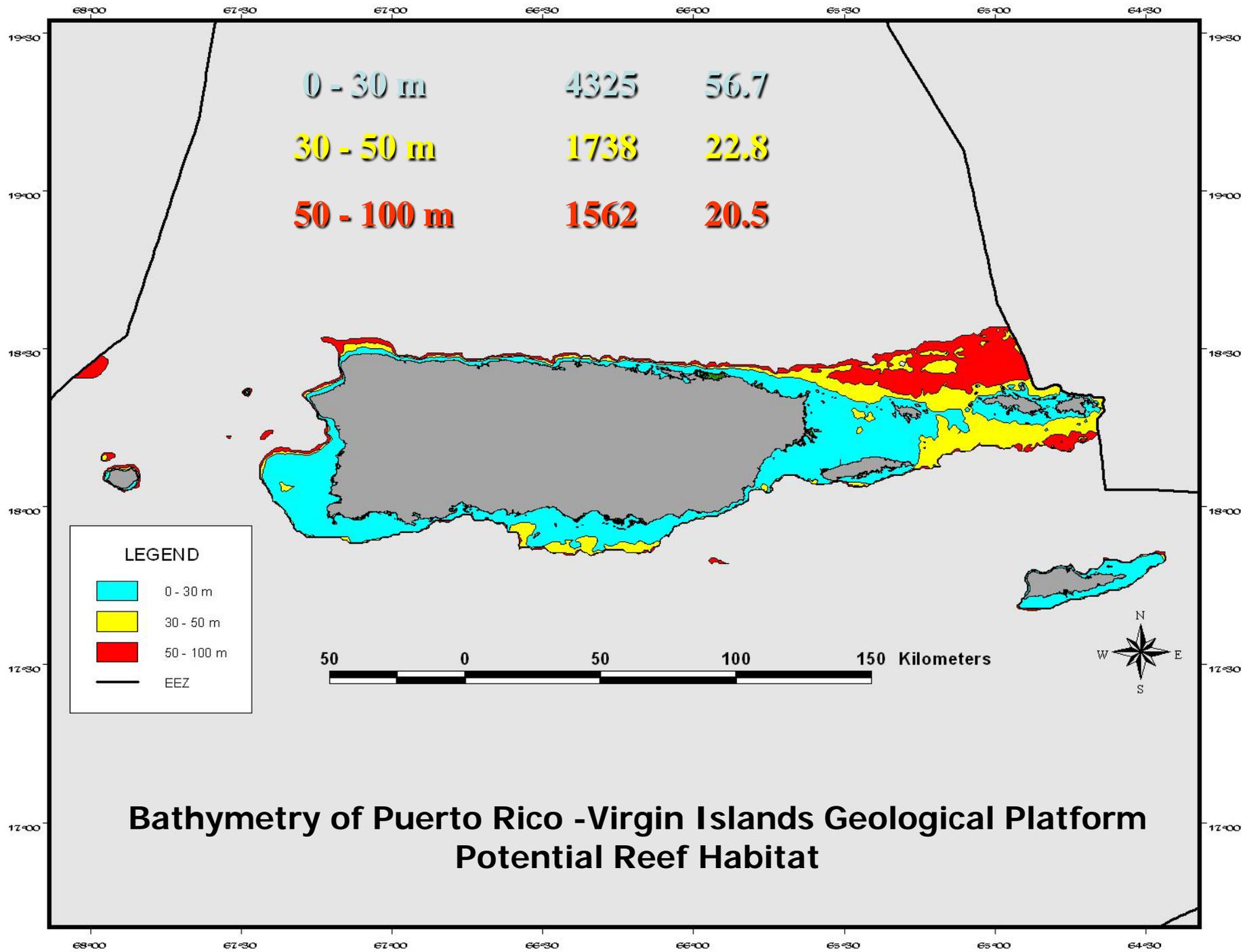
The use of autonomous underwater vehicles in studies of mesophotic and deep water coral reefs



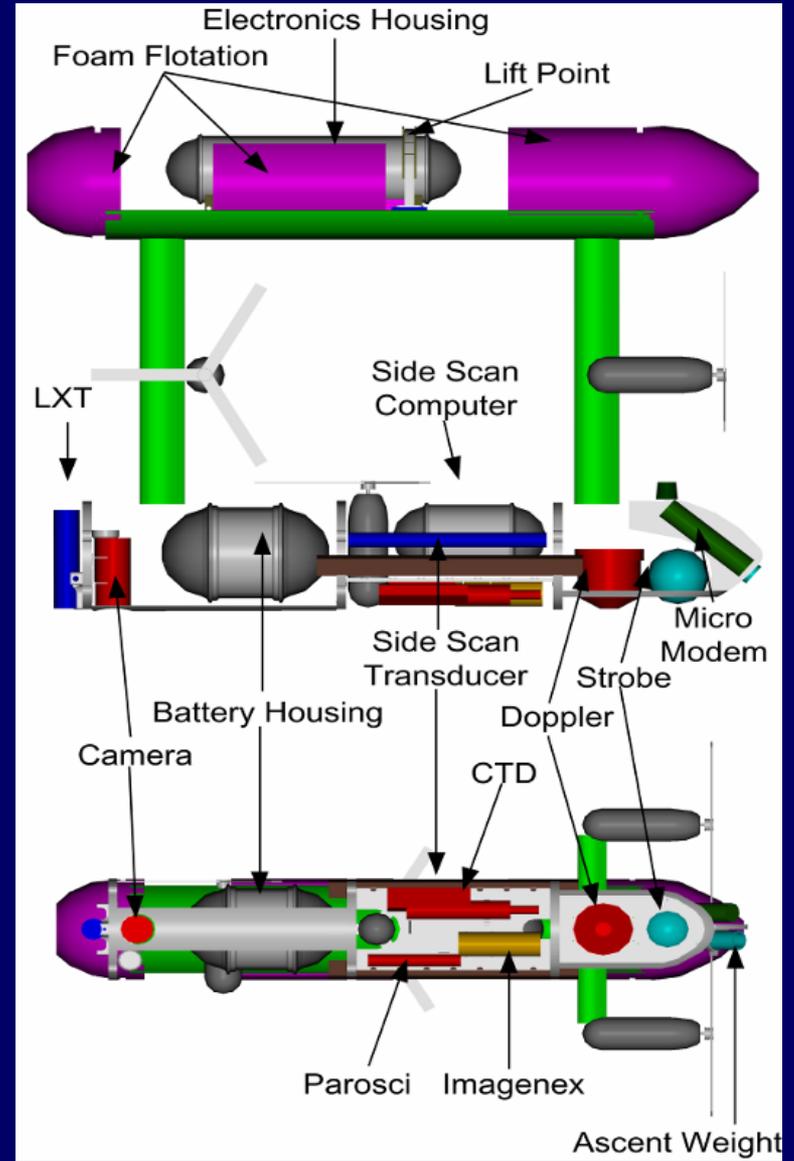
Roy A. Armstrong, Ph.D.
NOAA Center for Atmospheric Sciences
University of Puerto Rico at Mayaguez

NOAA Brown Bag Seminar
August 9, 2012

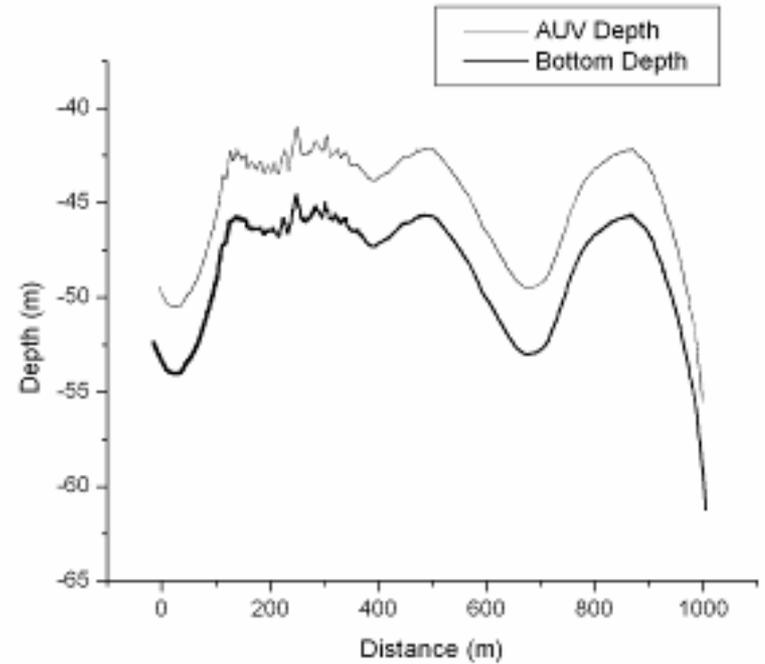
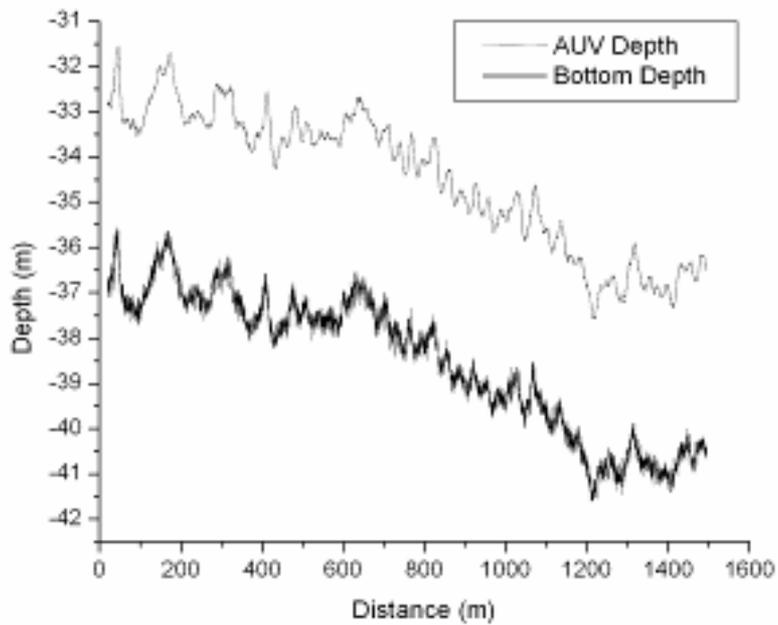




Seabed AUV Operations and Sensors



Seabed altitude



Seabed Optical Imaging



Two Prosilica GC-1380C CCD cameras with 1360 x 1024 resolution
12 bit dynamic range (0 - 4,095 grey levels)

From an altitude of 3 m, the images are 3.12 m wide by 2.3 m long,
covering an area of 7.17 m²

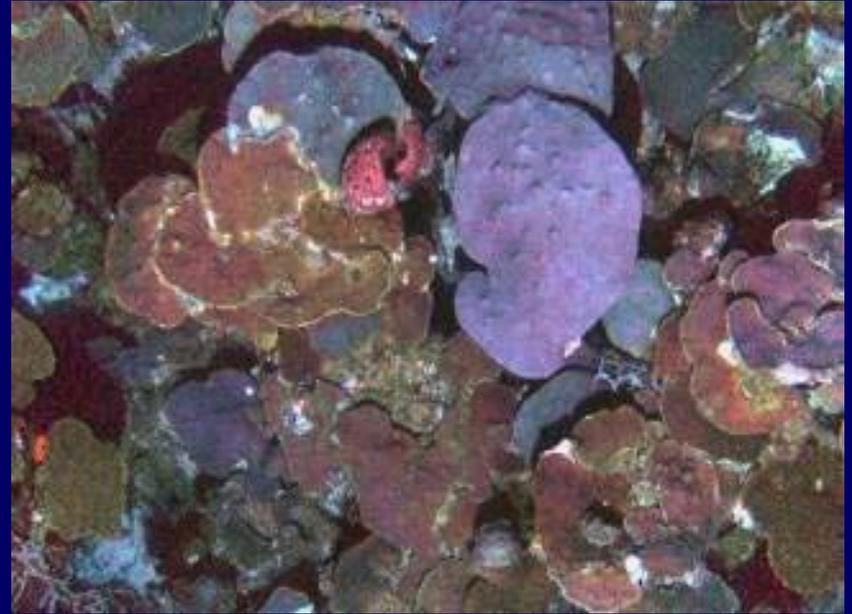
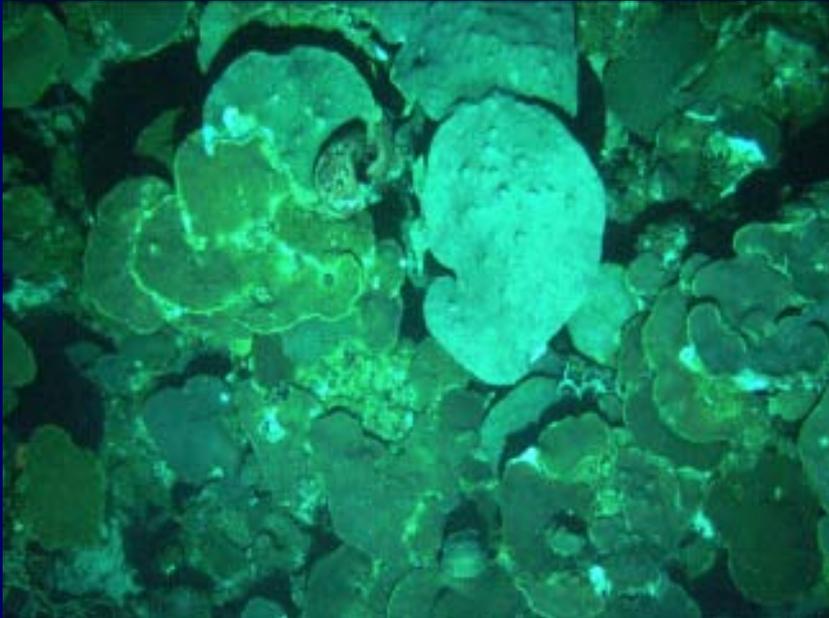
Spatial resolutions of 2.2 mm per pixel

A 150 Ws strobe provides the only source of illumination

Two cameras can be used, a downward looking camera and a forward
facing camera

Over 100,000 images of mesophotic reefs in the Puerto Rico Shelf

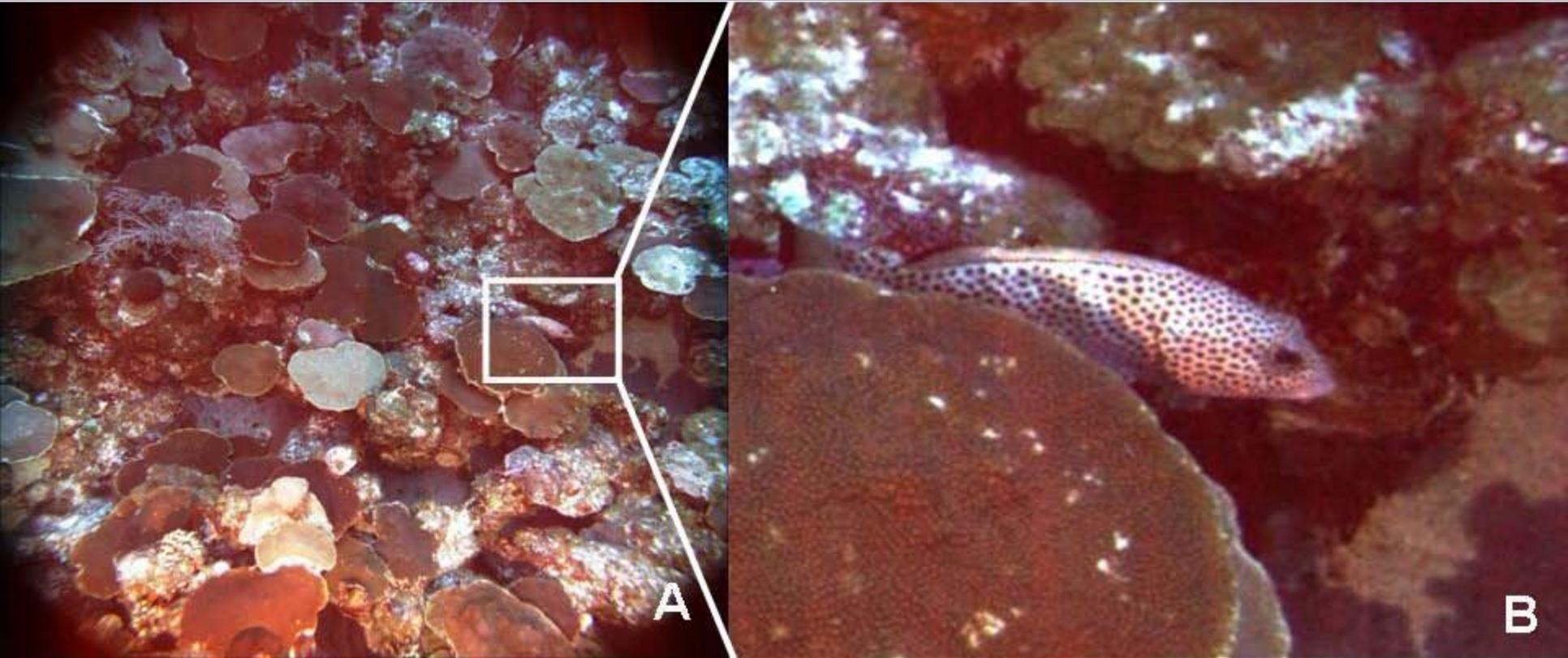
Color Compensation of Underwater Imagery



- U/W Imagery characterized by low contrast and low color fidelity
- Nonlinear attenuation of the visible spectrum in seawater
- U/W images tend to be saturated in the blue-green region



Forward-looking Camera



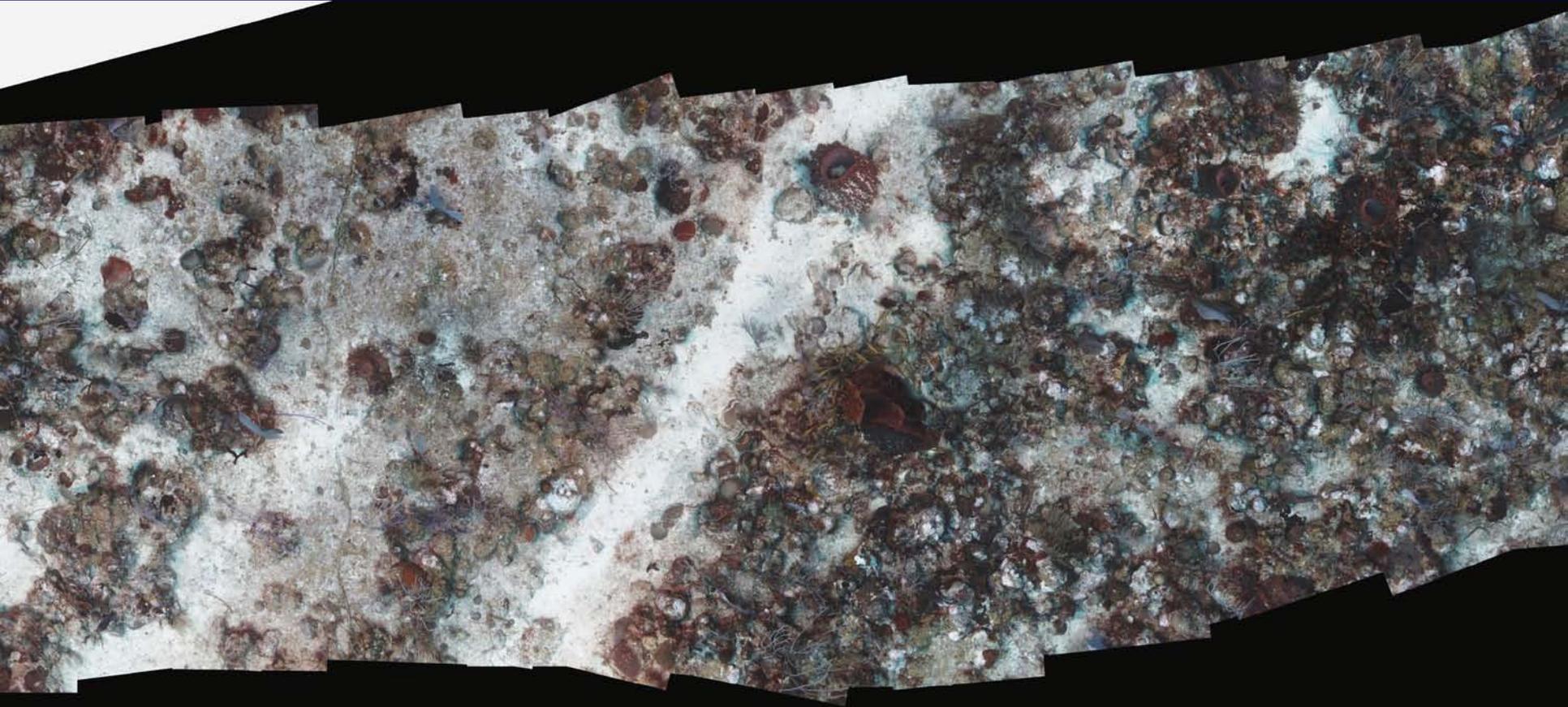
Forward-looking camera image showing a red hind grouper (*E. guttatus*) (A) and enlargement of the fish (B)

Photo Mosaicking

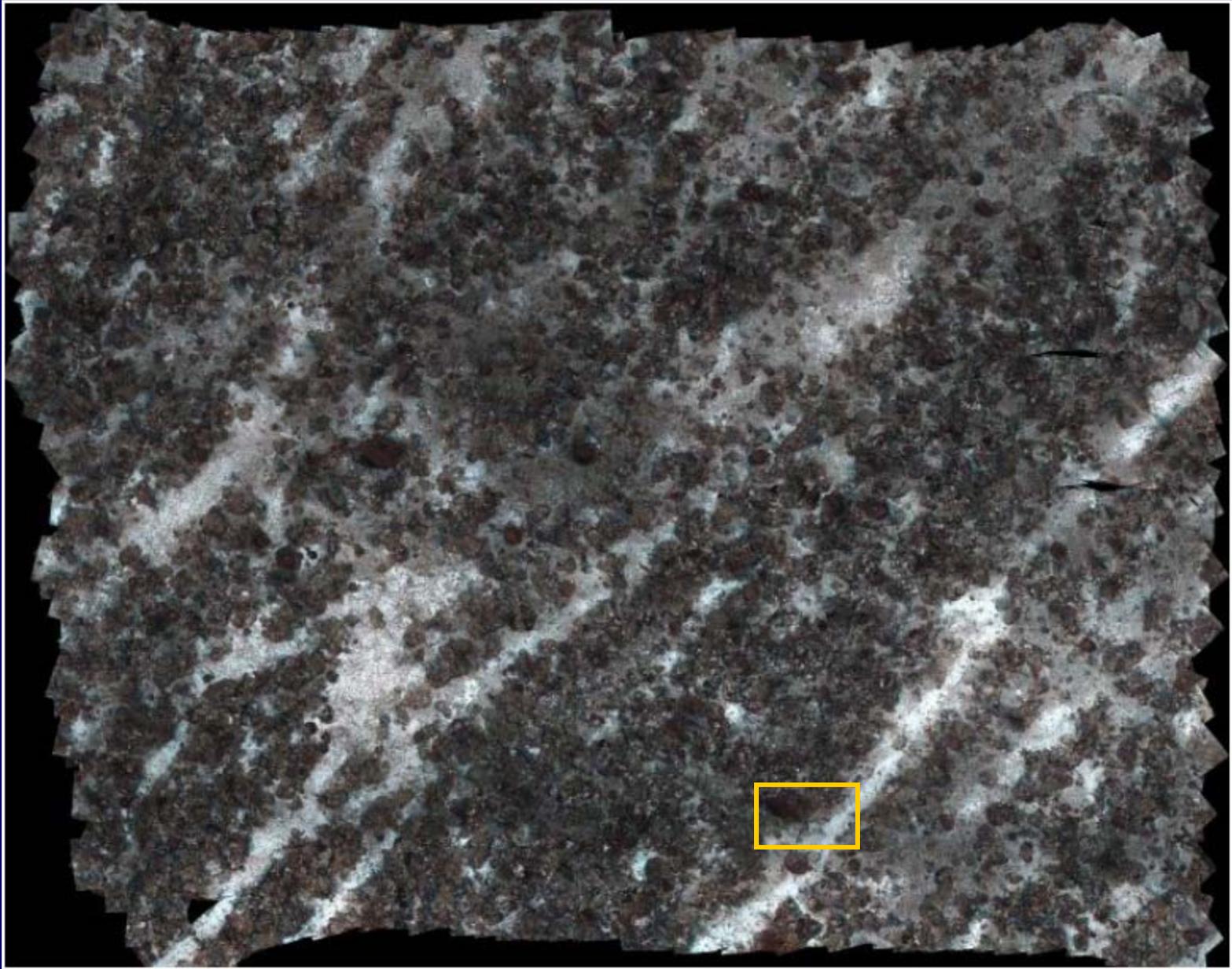


Seven images were used from a depth of 35 m measuring approximately 6.3 m long and covering an area of about 20 m²

Two-dimensional mosaic

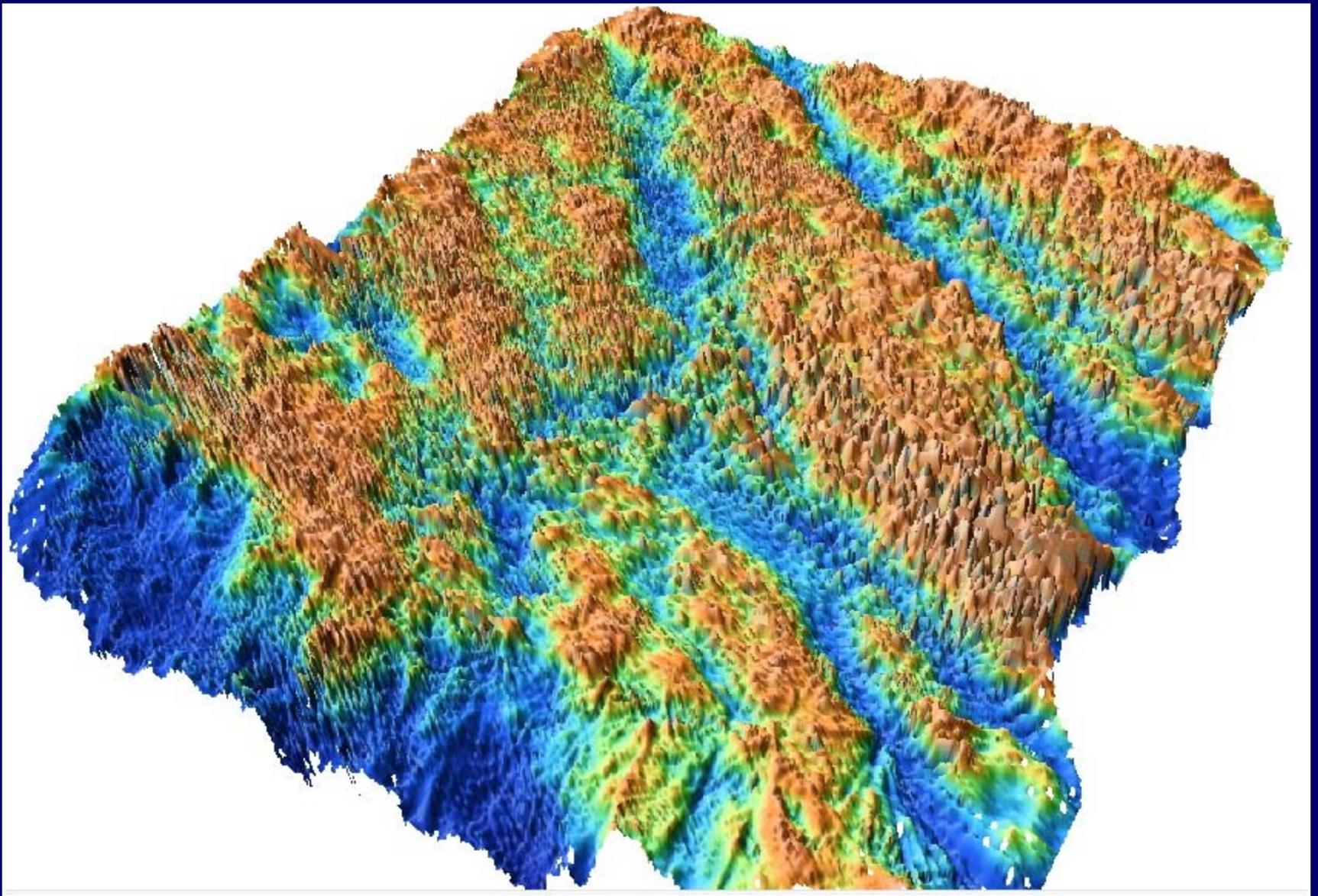


Approximately 80 images at 50% resolution were used to create this mosaic measuring about 4.5 m wide by 14 m long

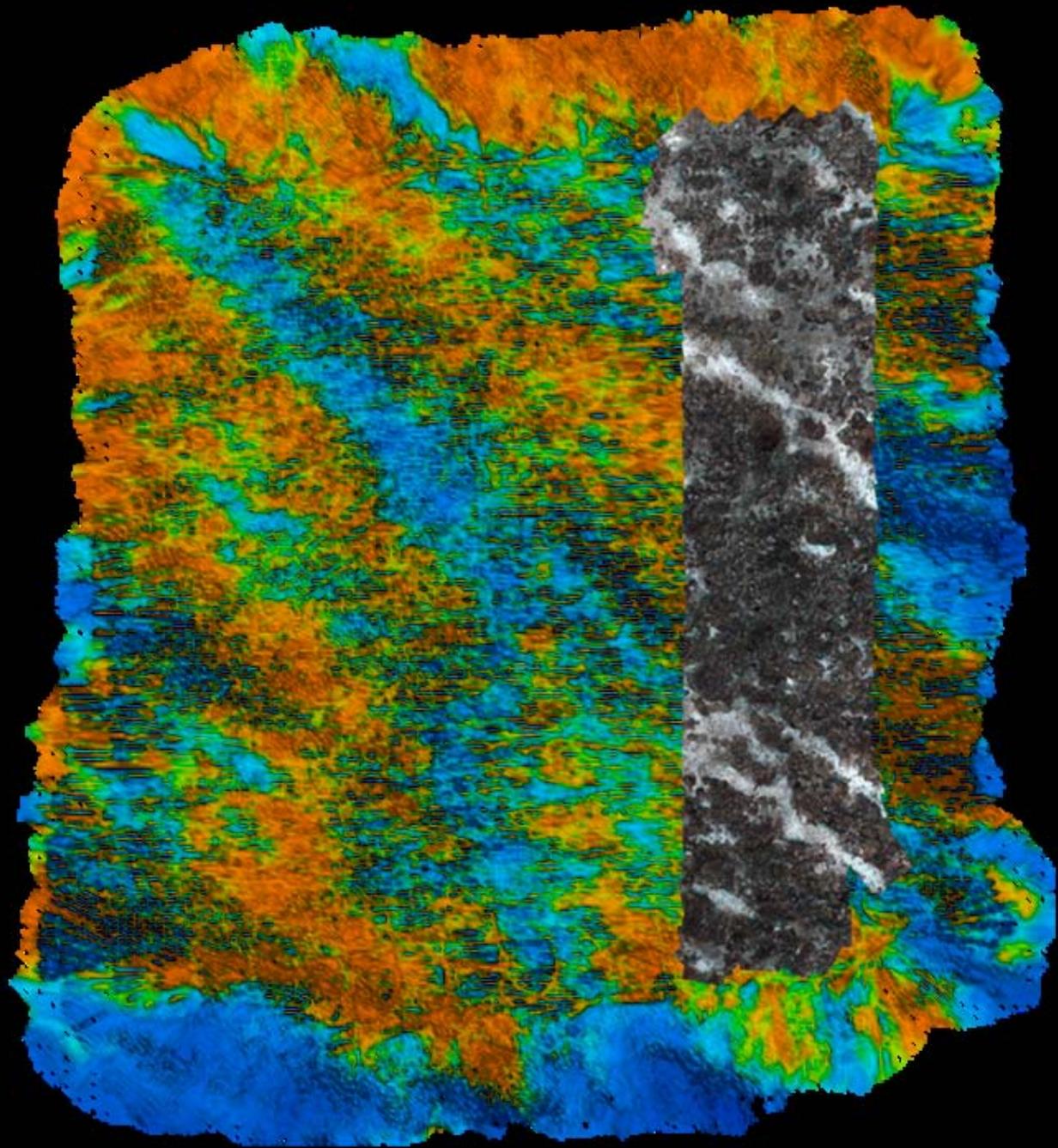




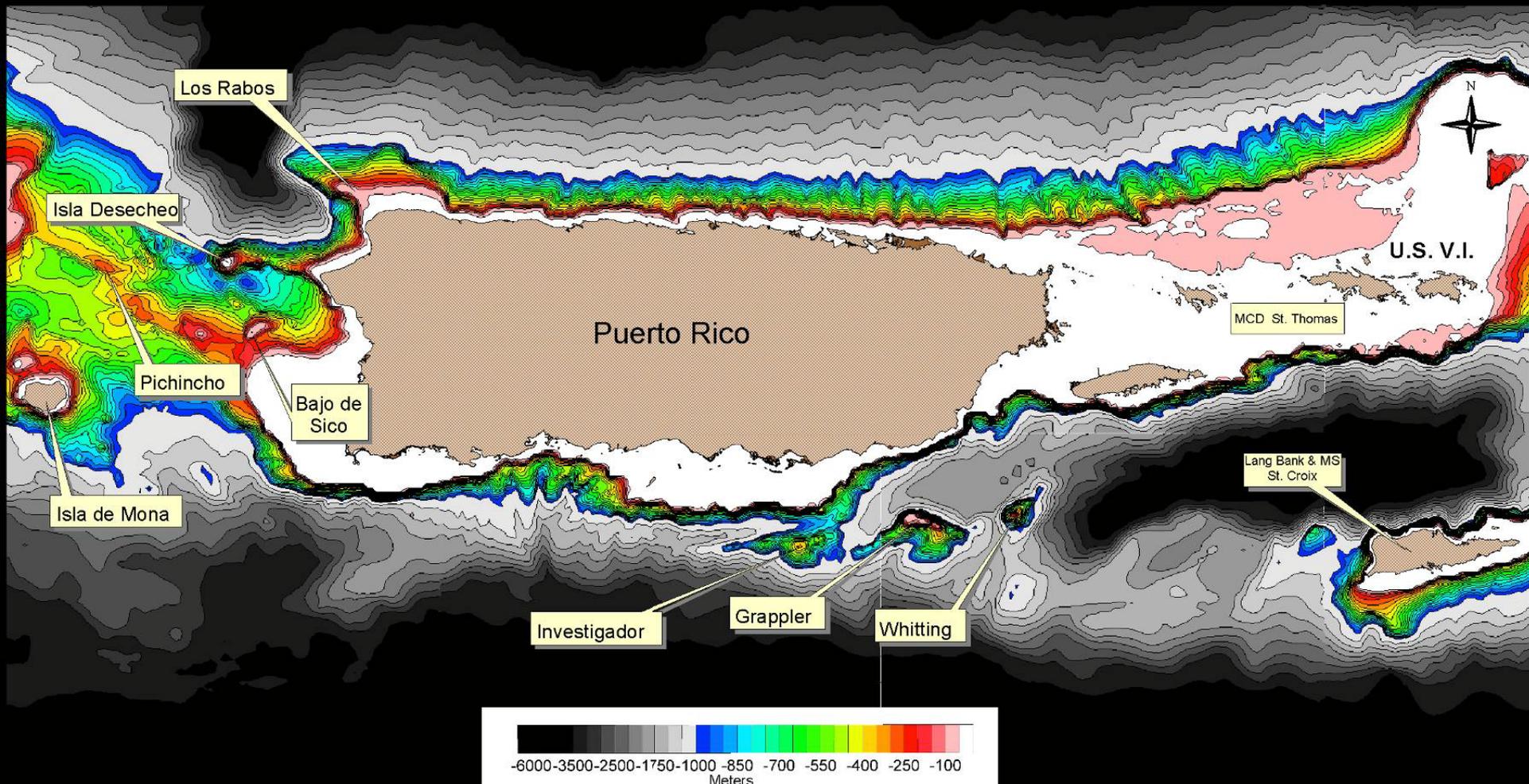




**Imagenex Delta-T 245 Khz Multi-beam image of Weinberg Site, SW Puerto Rico
30 track lines of 30 meters, with 1-meter spacing between track lines.**

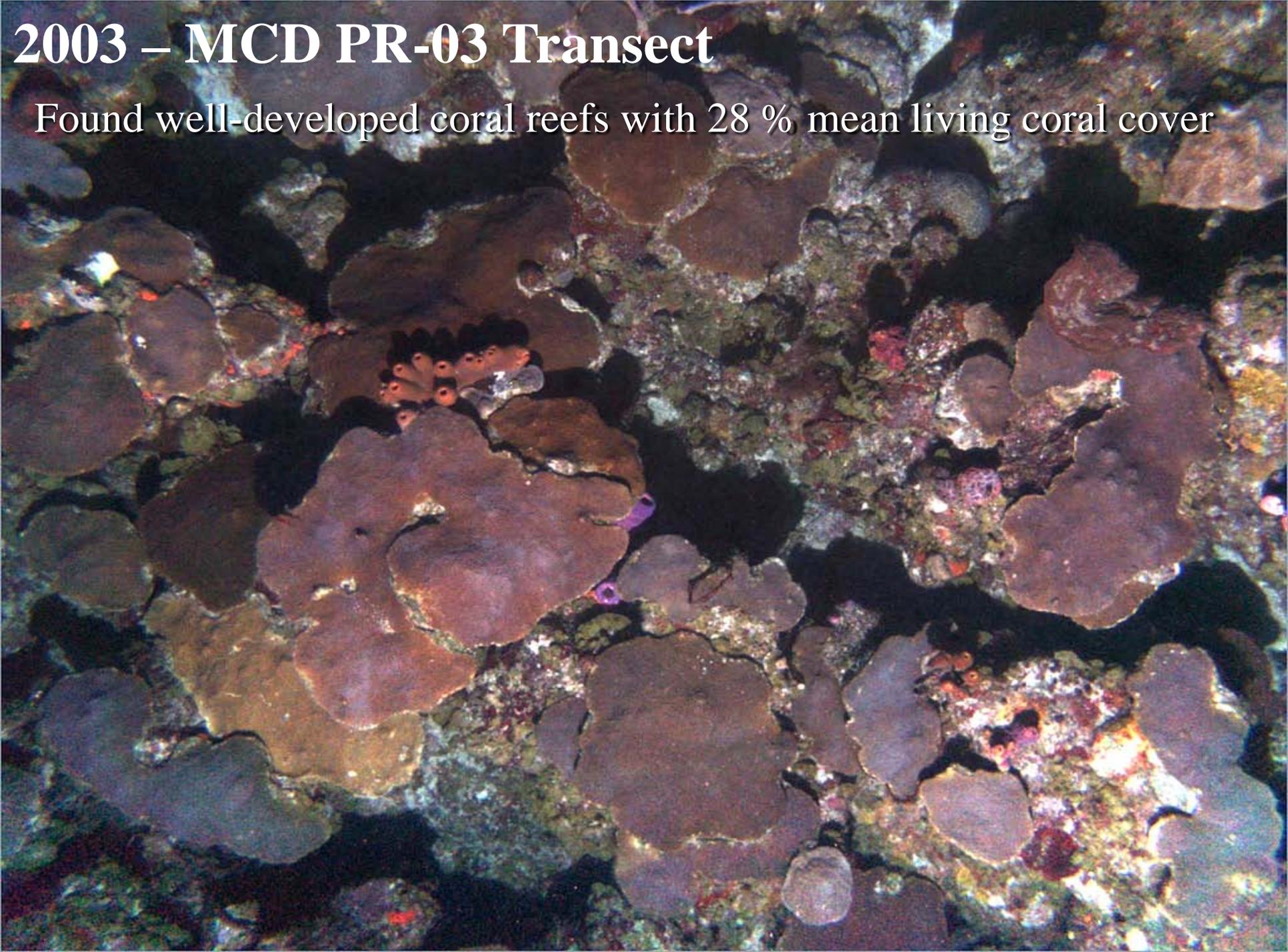


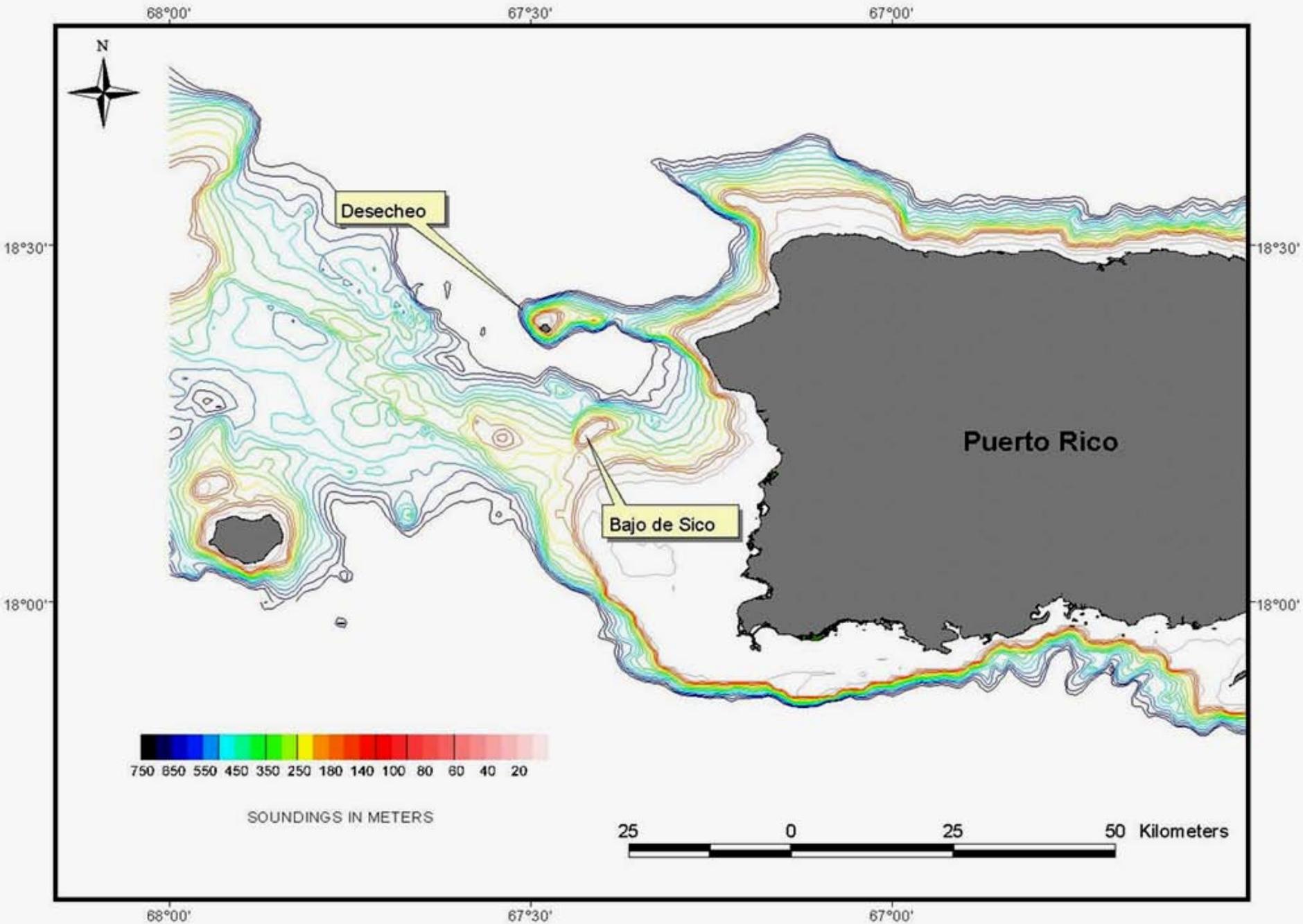
Deep insular shelf reefs of Puerto Rico and the USVI Seabed AUV Surveys

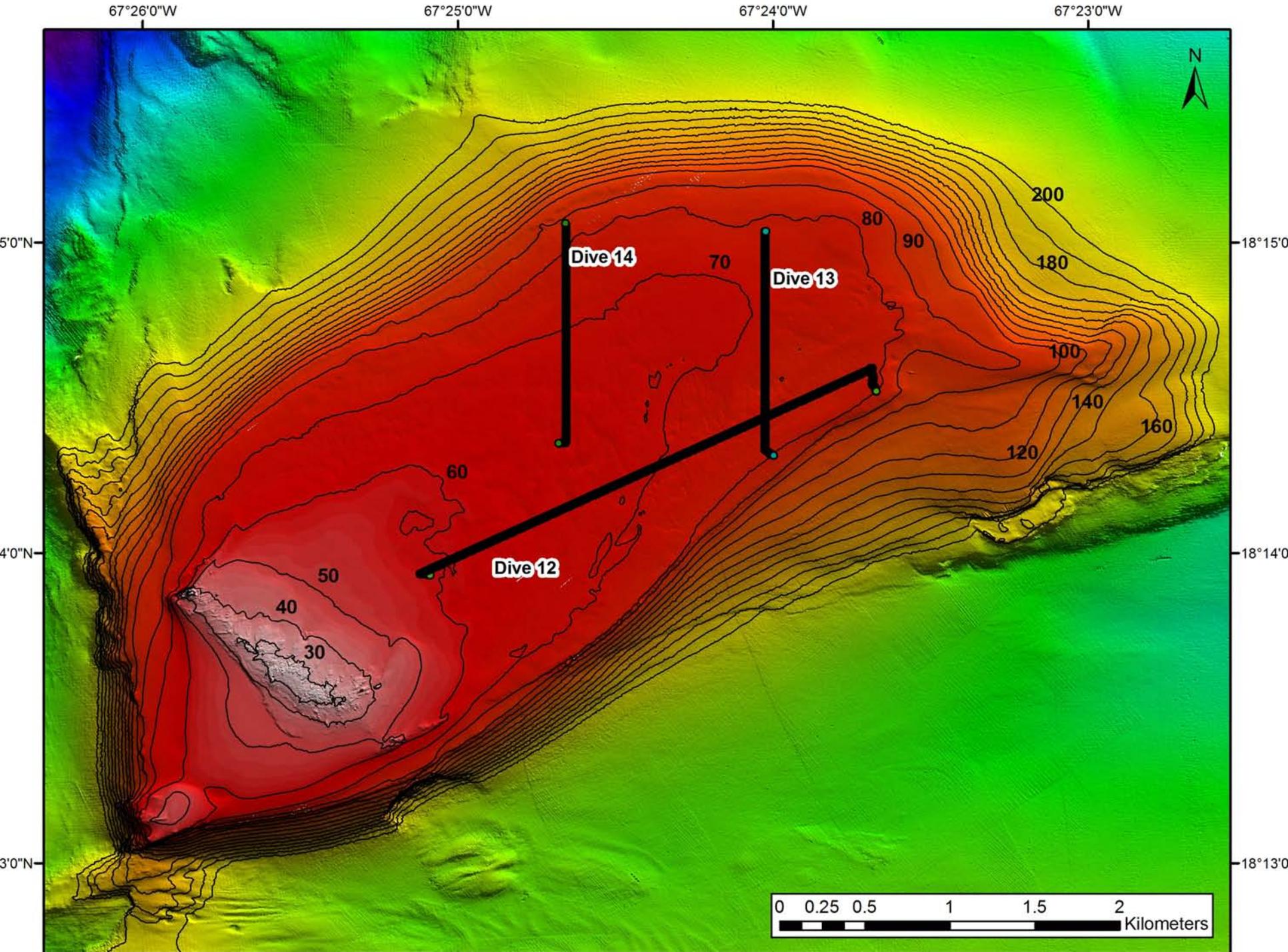


2003 – MCD PR-03 Transect

Found well-developed coral reefs with 28 % mean living coral cover

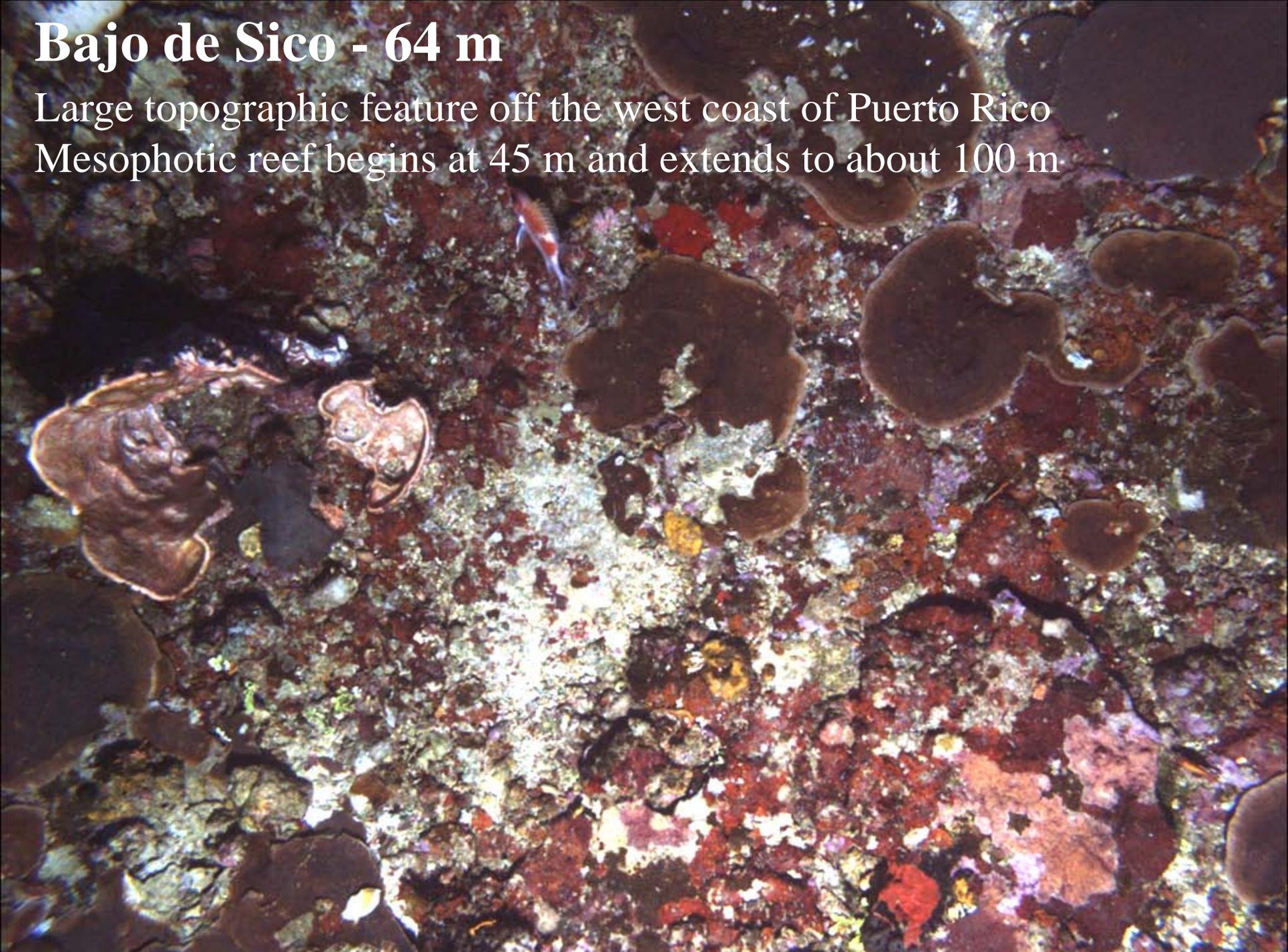






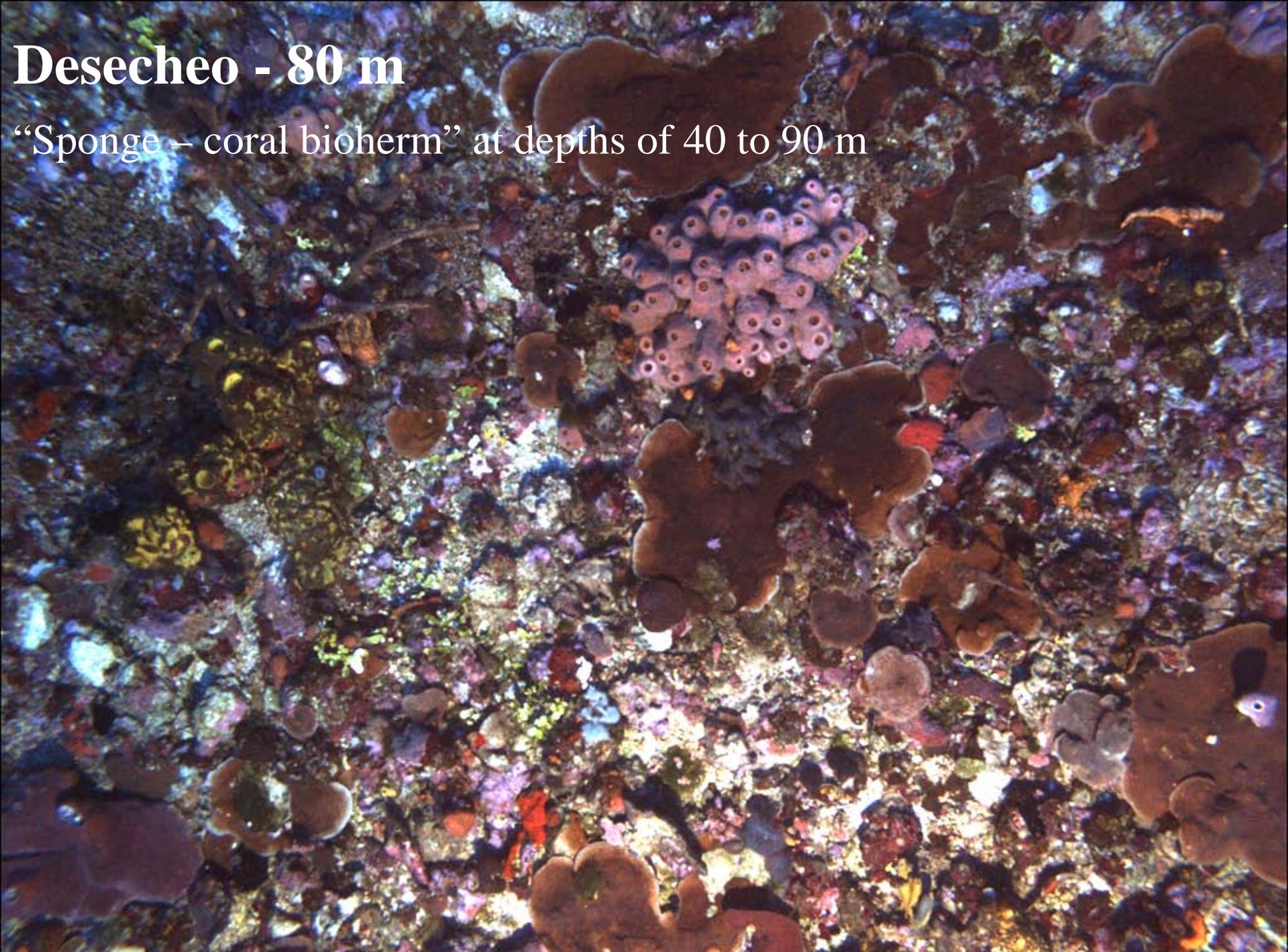
Bajo de Sico - 64 m

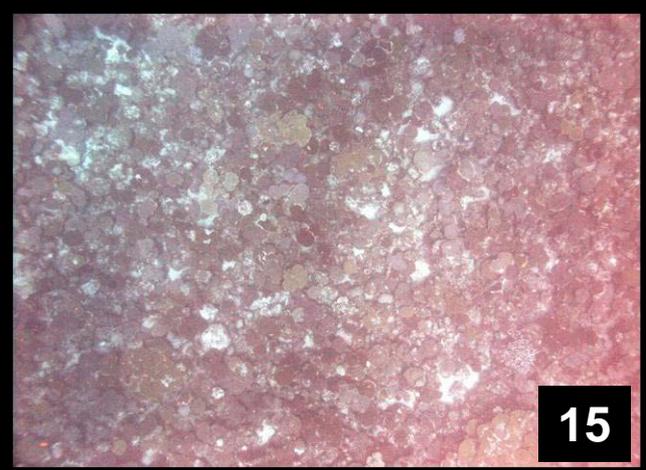
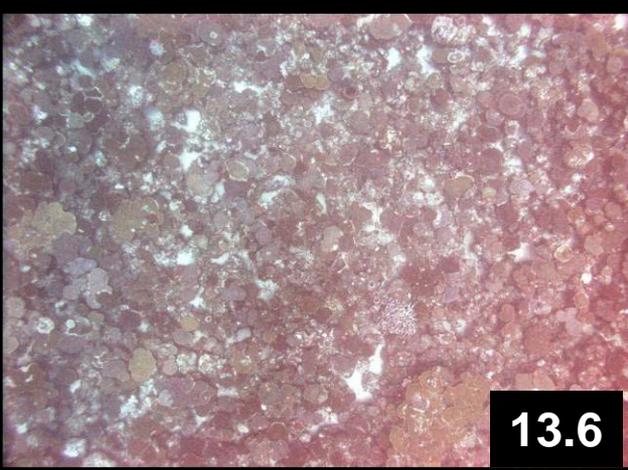
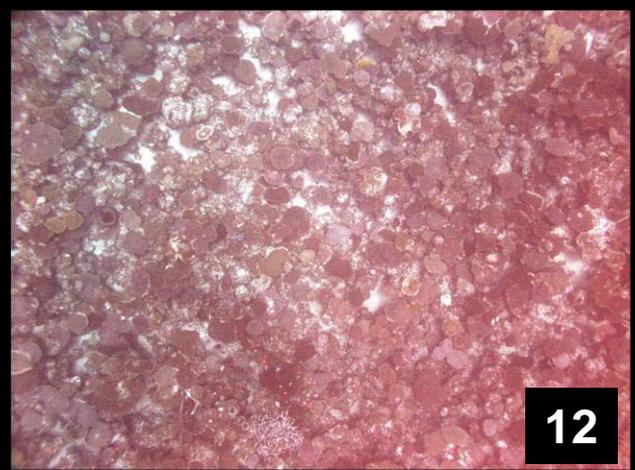
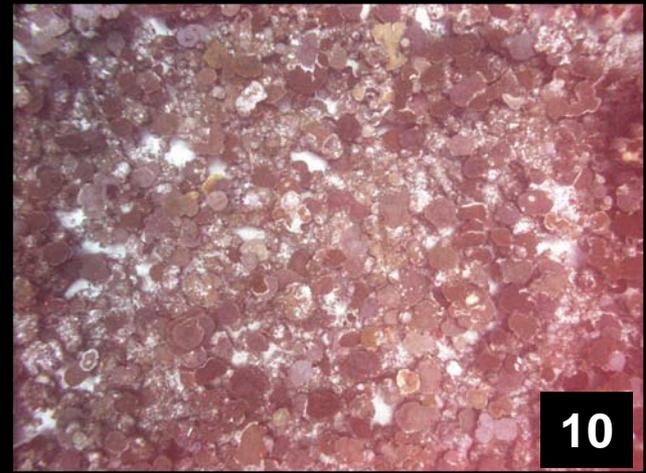
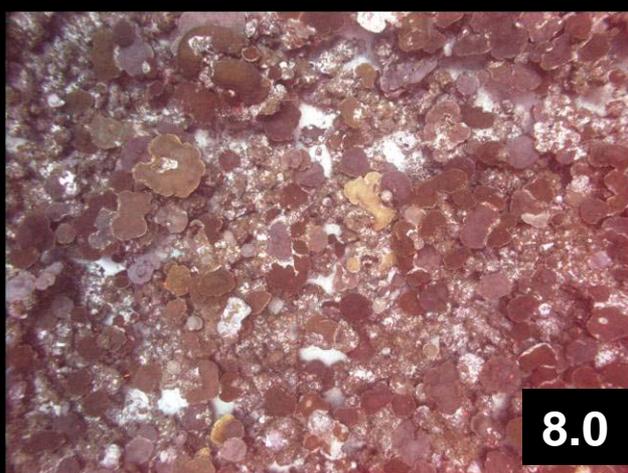
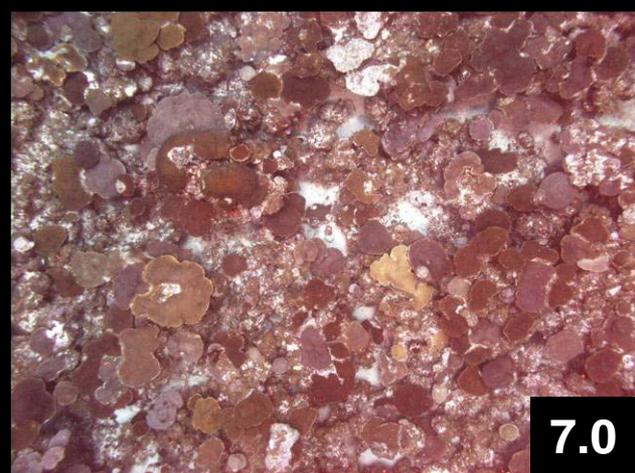
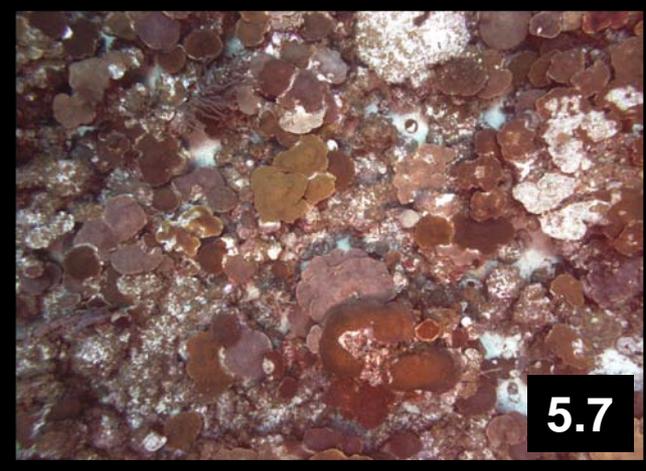
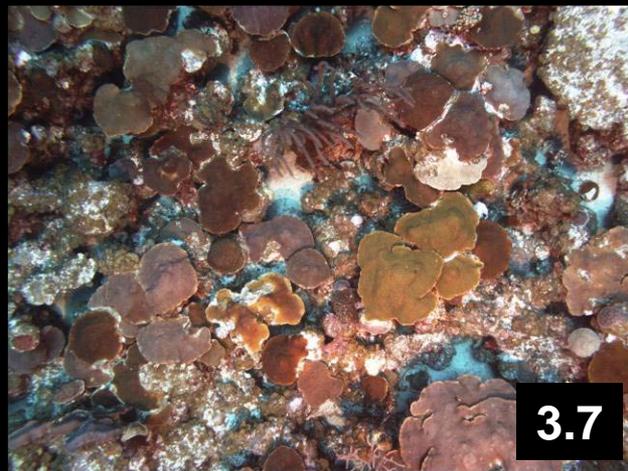
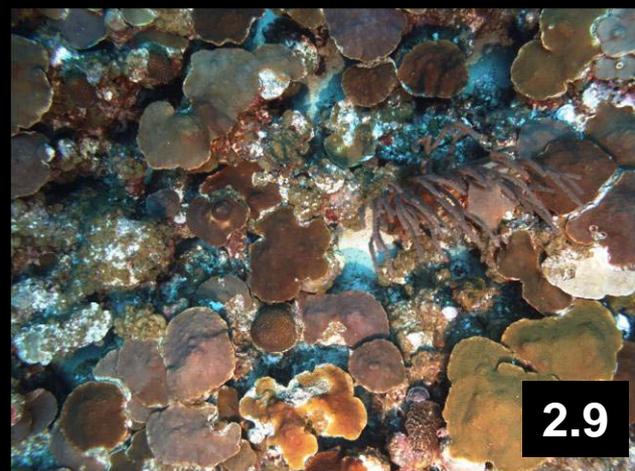
Large topographic feature off the west coast of Puerto Rico
Mesophotic reef begins at 45 m and extends to about 100 m



Desecheo - 80 m

“Sponge – coral bioherm” at depths of 40 to 90 m

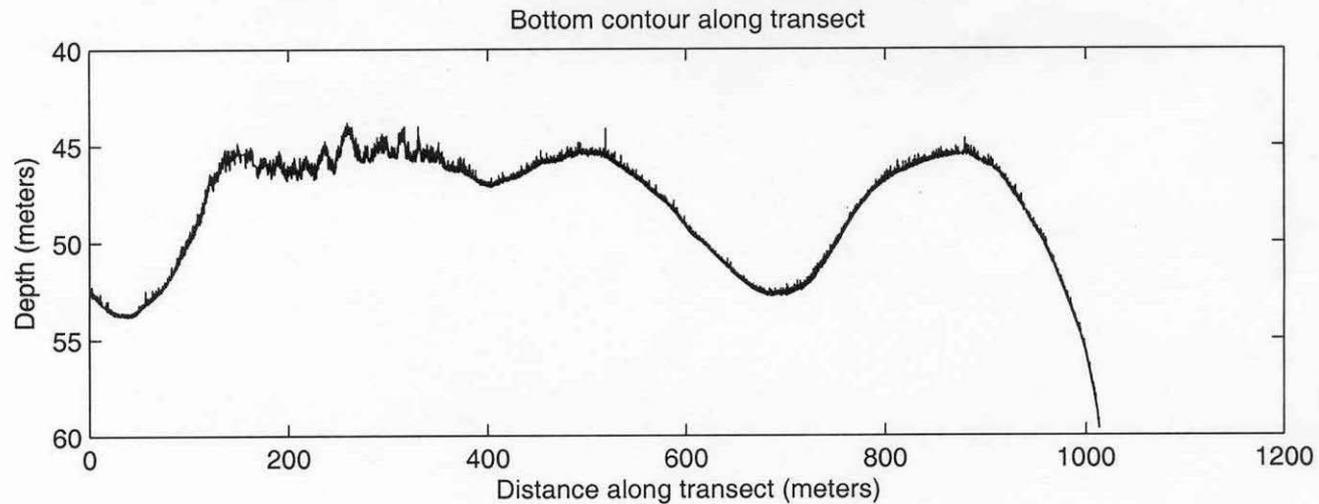
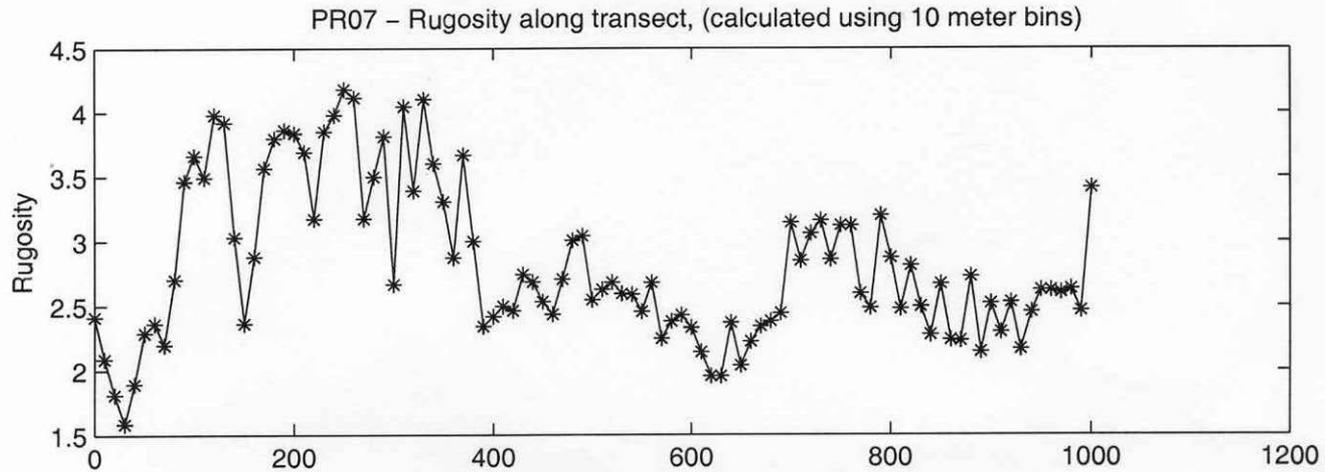




Area Covered vs. AUV Altitude

- From a 3 m altitude the area covered by a typical, 1 km AUV transect is approximately 3,120 m²
- At 15 m altitude the area covered by each image is 178 m²
- A one km transect at this altitude will cover an area of approximately 10,700 m² (assuming 40% overlap)
- Landscape-level analysis of coral bleaching and mortality can be obtained from altitudes of 5-10 m, depending on the level of detail required, while covering an area of 52 and 104 m², respectively, per image.

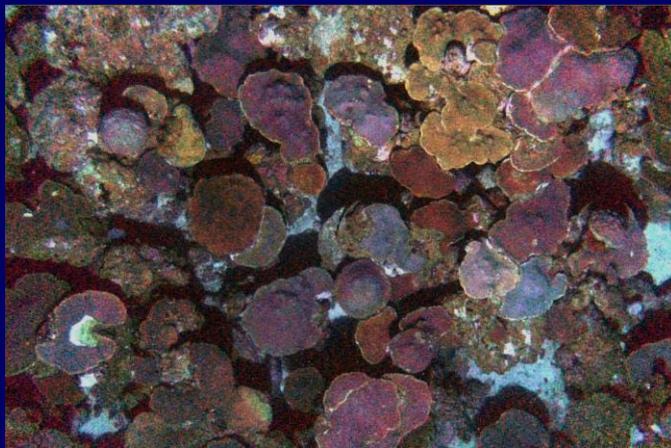
Coral reef rugosity from the pencil-beam sonar



AUV Digital Still Images vs. Diver Digital Video Transects

- 1000 m transects
- AUV flies 3-4 m above reef
- Still images captured every 3 sec
- Images about 7.74 m²
- 50 random dots on each image
- Substrate under each dot identified
% benthic composition
organisms identified to lowest taxonomic level

- 10 m random transects
- Camera held 40 cm above reef
- Video captured as 20-30 non-overlapping still images 0.31 m²
- 10 random dots on each image
- Substrate under each dot identified
% benthic composition
organisms identified to species level



2.48 m

3.12 m



Photo by R. Nemeth

Comparison of Results: AUV vs. SCUBA

- Corals - % cover nearly identical between methods
- Sponge - more variable with SCUBA transects
- Gorgonians - underestimated with SCUBA transects
- Algae (macro, turf and coralline) – better resolution using SCUBA transects and diver observation
- Other substrates – similar between methods
- Species Diversity – variable and dependant upon site, depth, transect length or number. SCUBA may have advantage for species that are difficult to identify in the larger AUV images.
- Disease – SCUBA detects more cryptic diseases.
- Bleaching – should be visible in AUV images but seasonal variability prevented comparison.

Forward – Looking Camera - 216 m Depth



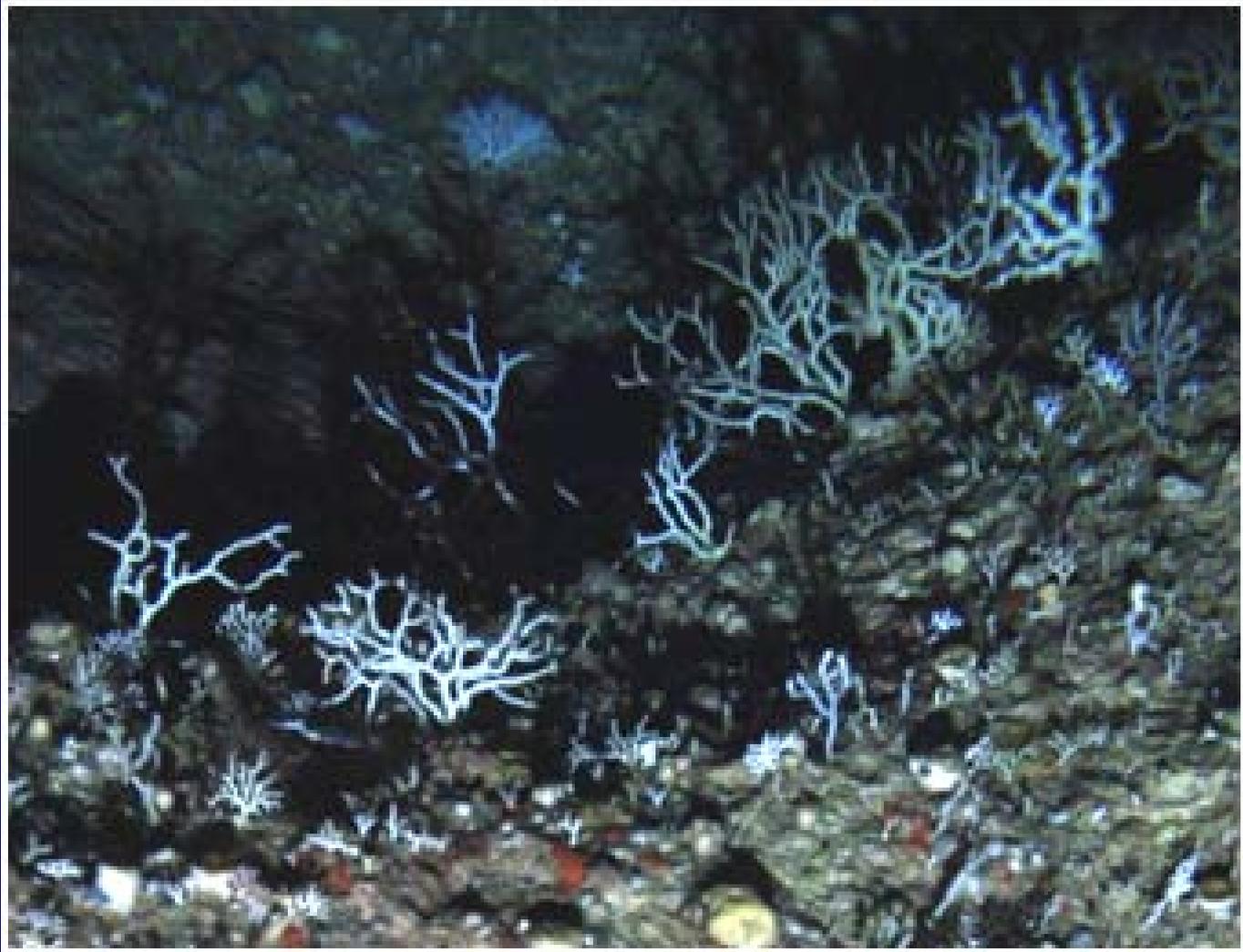
Silk snappers (*Lutjanus vivanus*) at a depth of 219 m.



Silk snappers (*Lutjanus vivanus*) at 21 m from the bottom (total depth 198 m)



Deep water sponges and corals off western Puerto Rico



Close up of small ahermatypic coral colonies, most likely *Madracis myriaster*

Acknowledgments

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