

THE UNIVERSITY OF
SYDNEY

Making sense of seafloor images collected by autonomous robots

Ariell Friedman, Stefan Williams, Oscar Pizarro

IVER 1

Australian Centre
for Field Robotics



IVER 2

Australian
Marine Ecology



SLOCUM GLIDER

Woods Hole
Oceanographic
Institute



Photo: Logan Mock Bunting



WAVE GLIDER

University of
Hawaii at Manoa

Photo: Logan Mock Bunting

PHOTO FLOAT

University of
Rhode Island

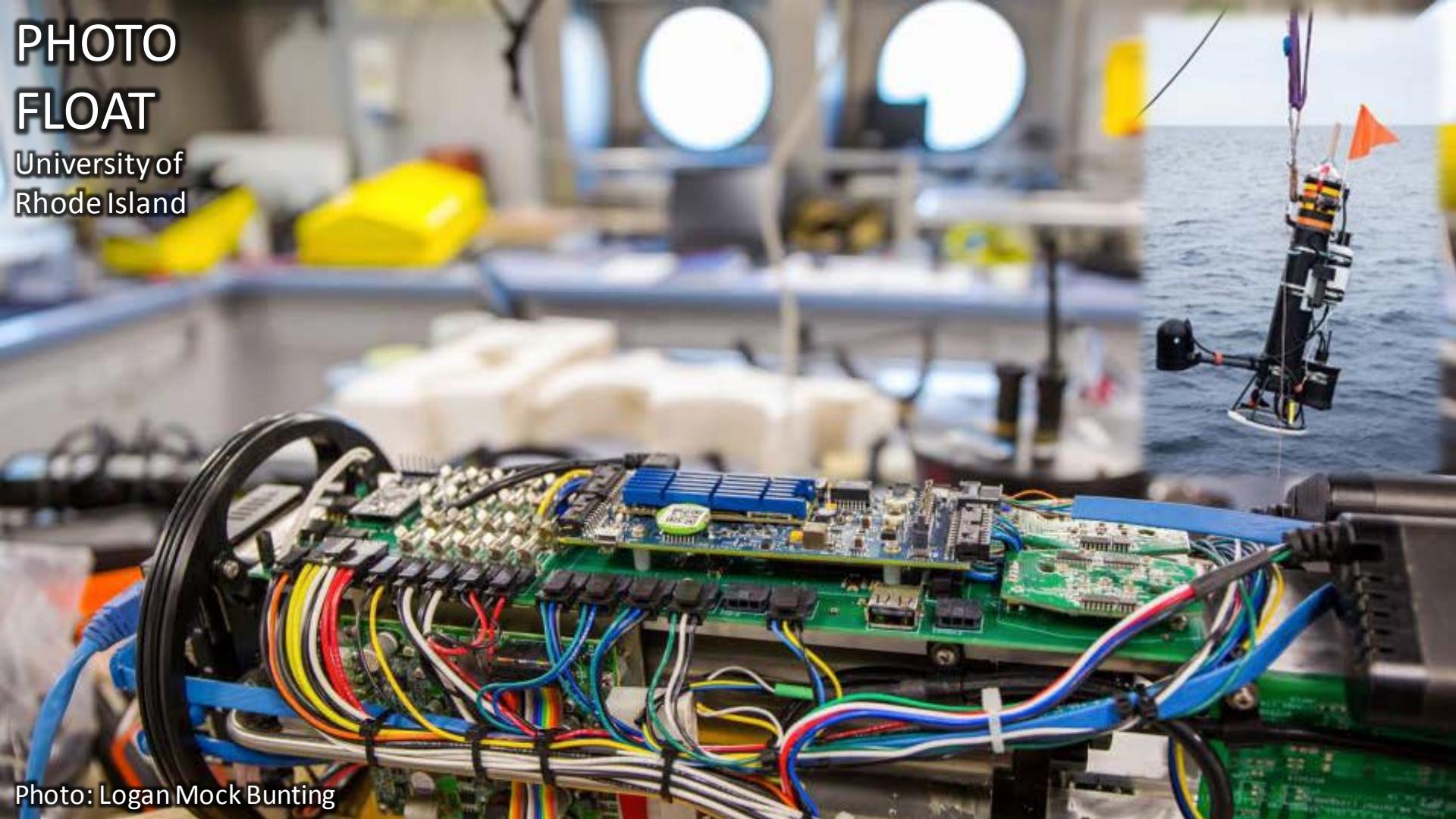
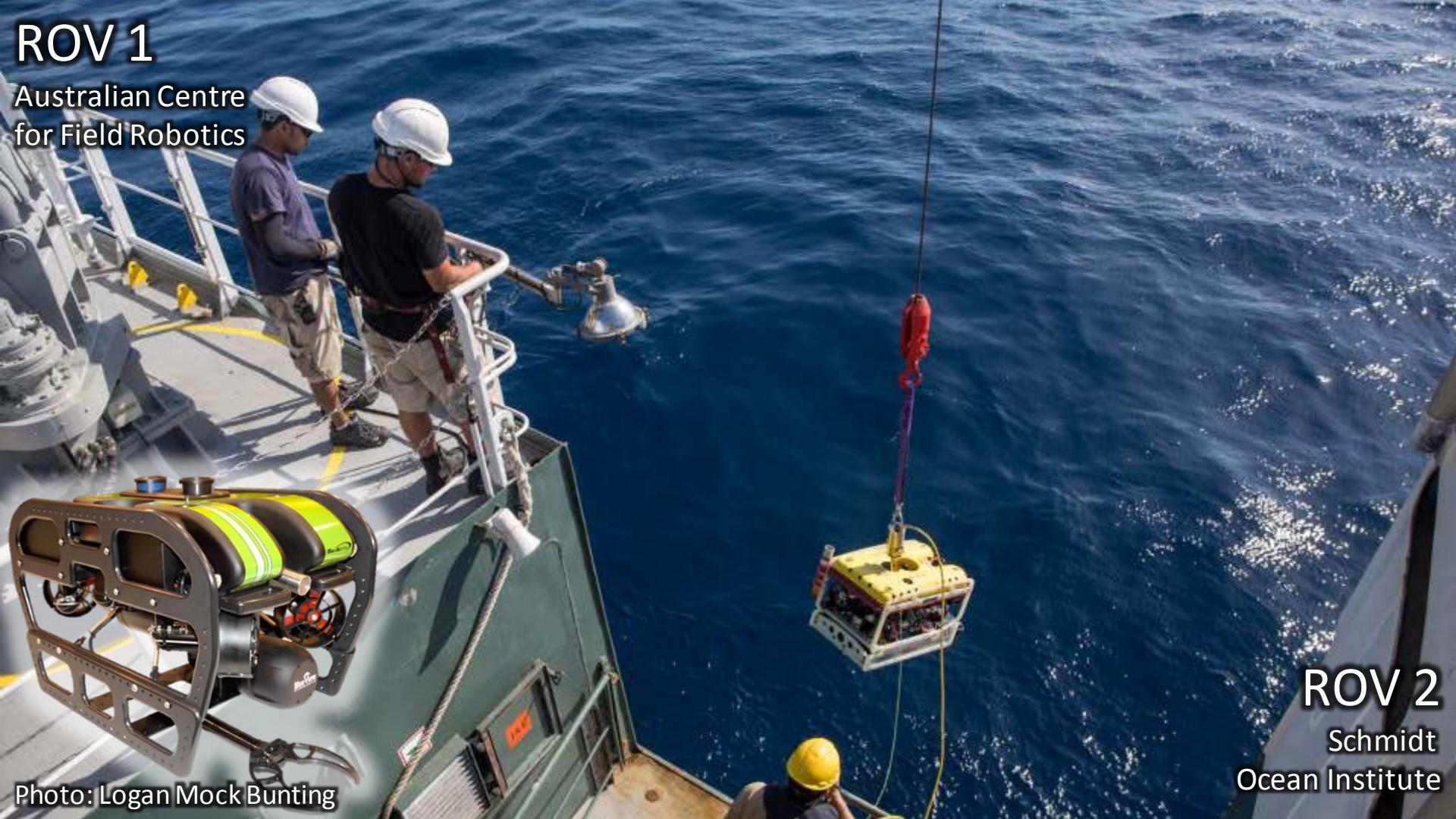


Photo: Logan Mock Bunting

ROV 1

Australian Centre
for Field Robotics



ROV 2

Schmidt
Ocean Institute

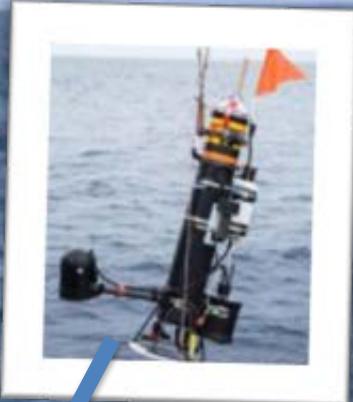
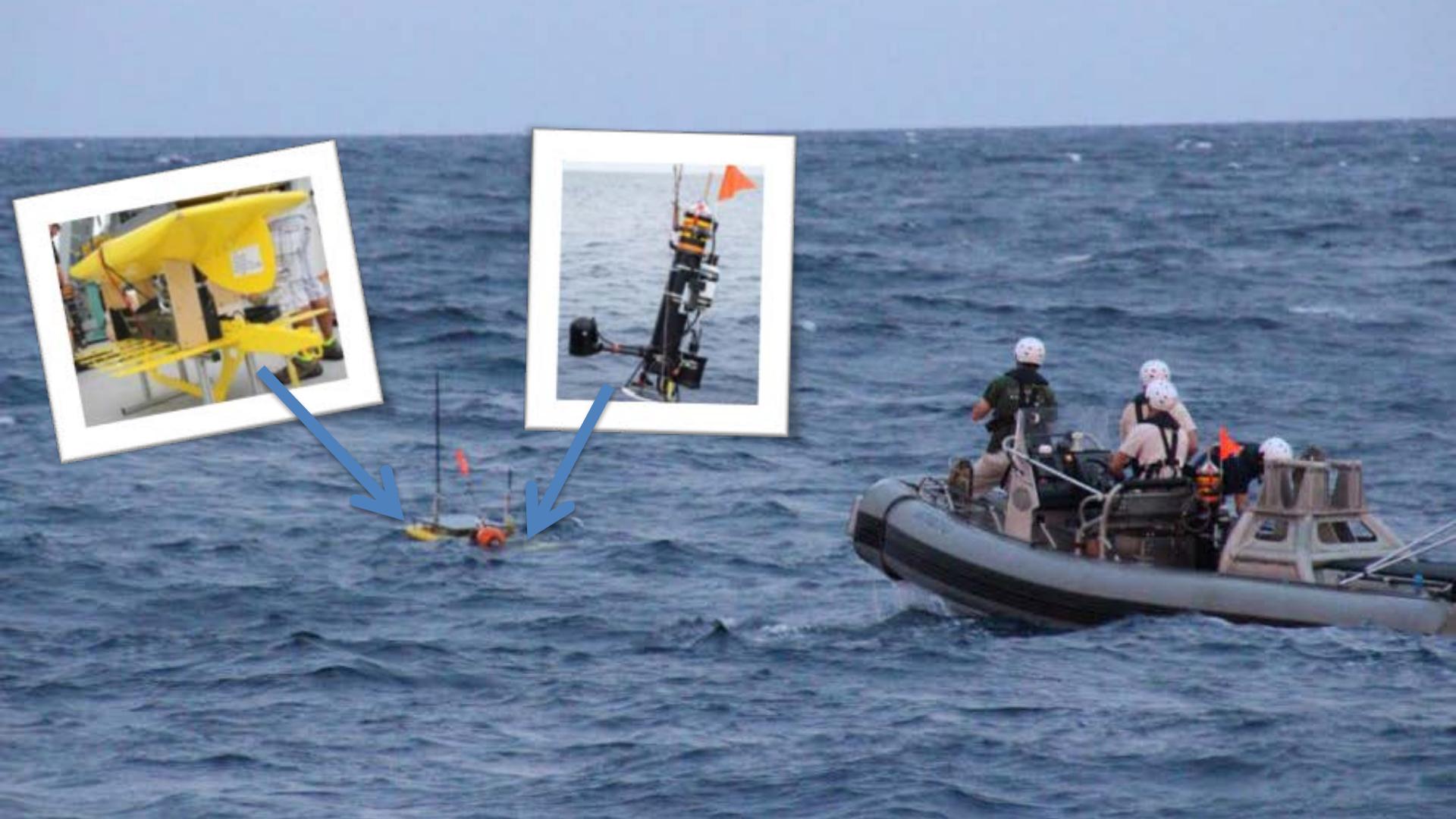
Photo: Logan Mock Bunting

FALKOR

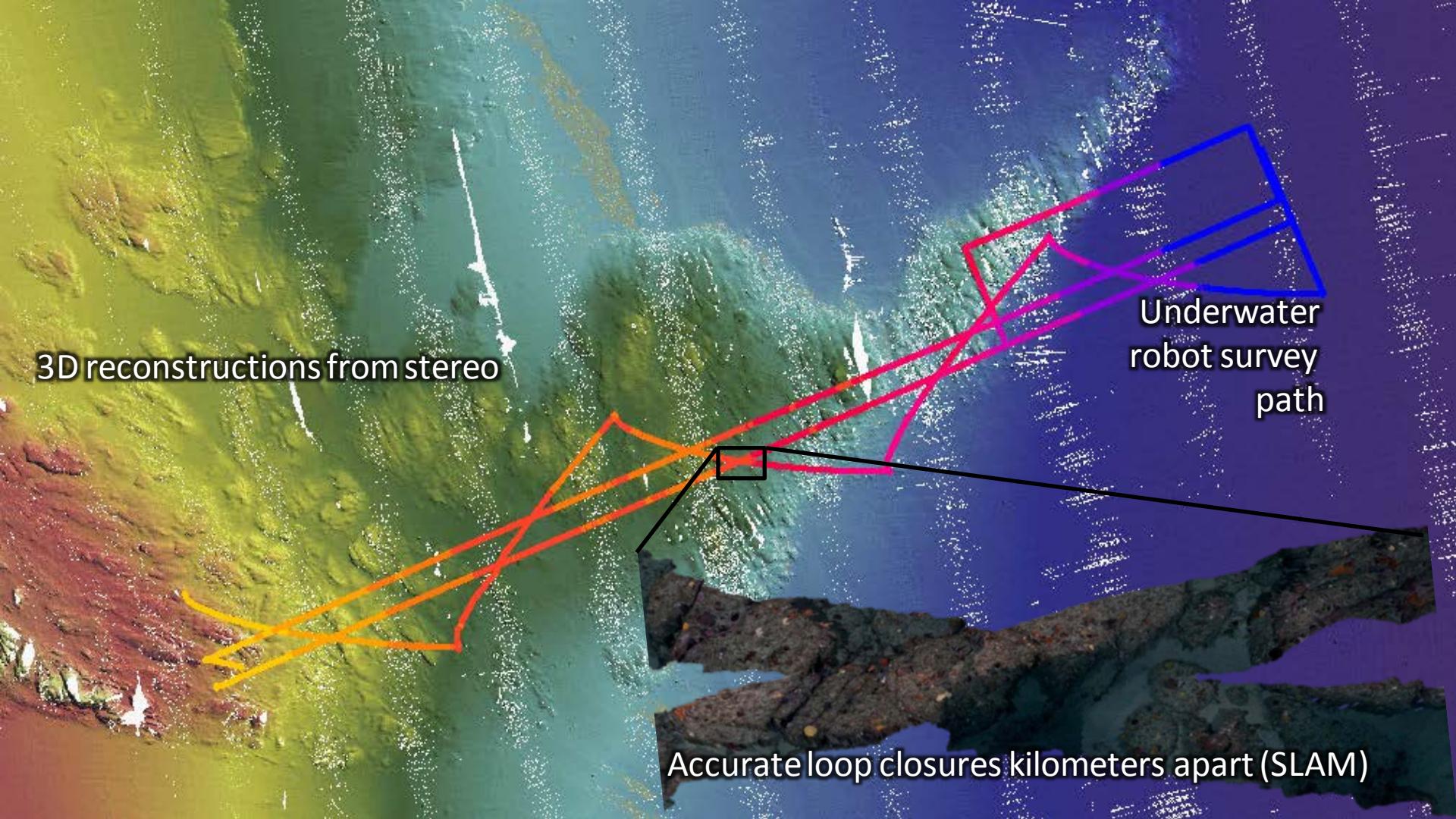
Schmidt Ocean
Institute

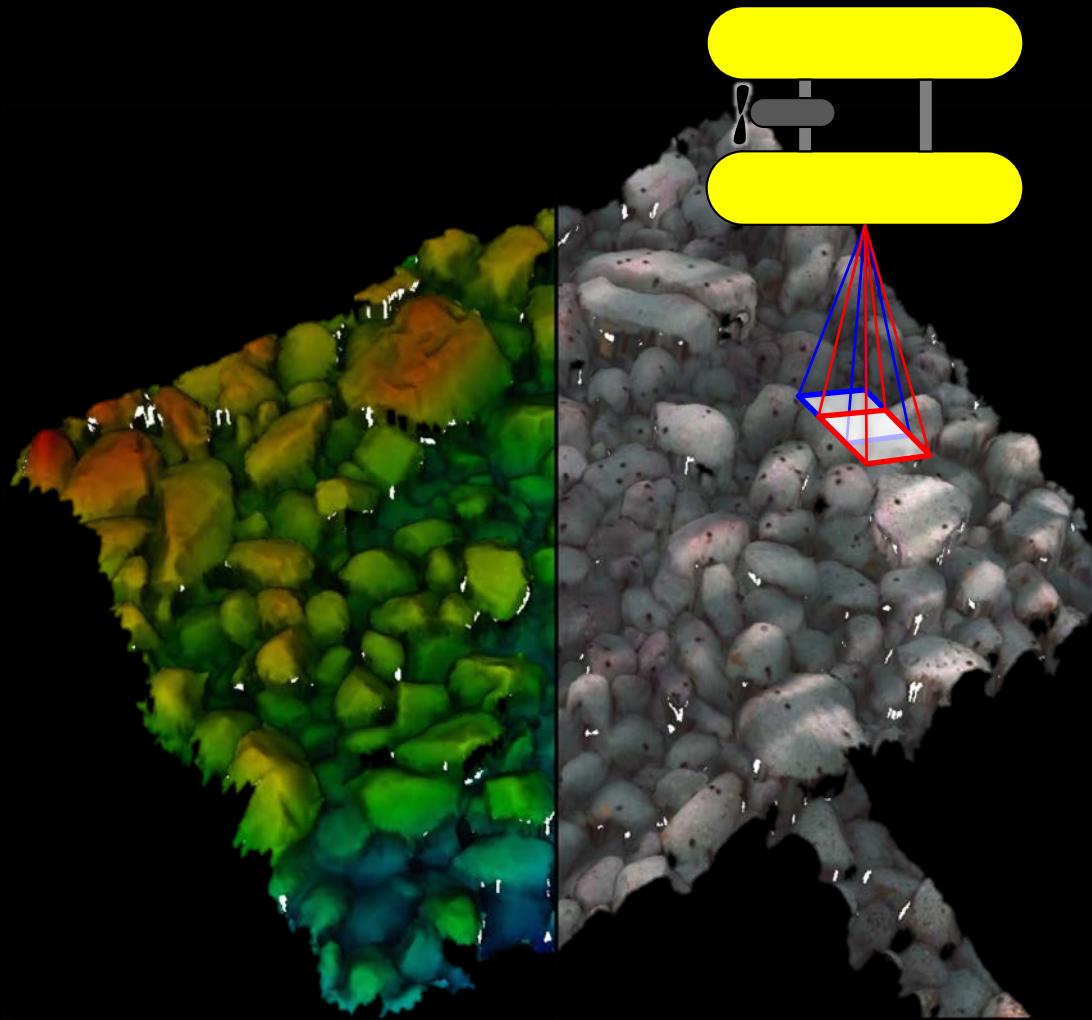


Photo: Logan Mock Bunting

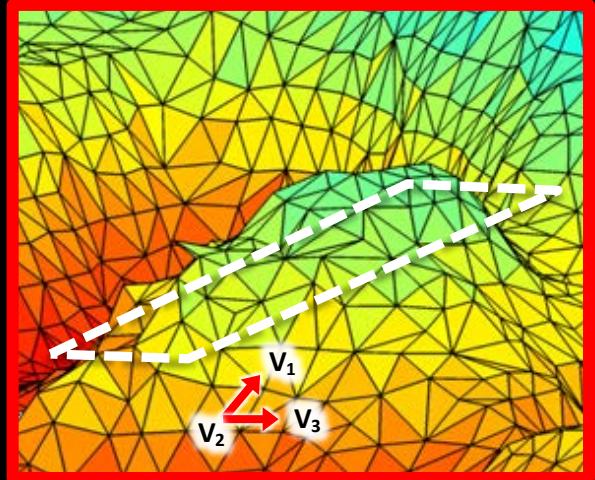




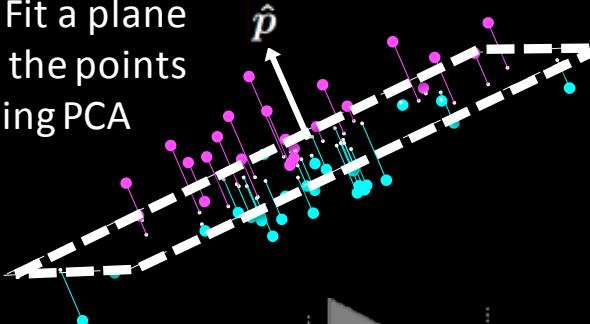




1. Slide a window over the terrain



3. Fit a plane to the points using PCA



4. Project points onto plane and compute projected areas

$$A' = \sum_{j=1}^J a_j (|\hat{p} \cdot \hat{n}_j|)$$

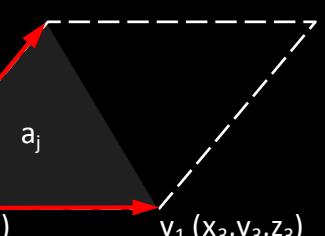
5. Compute rugosity, slope and aspect

$$r = \frac{A}{A'}$$

$$\theta = \cos^{-1}(\hat{p} \cdot \hat{k})$$

$$\psi = \tan^{-1} \left(\frac{p_x}{p_y} \right)$$

$v_3(x_2, y_2, z_2)$

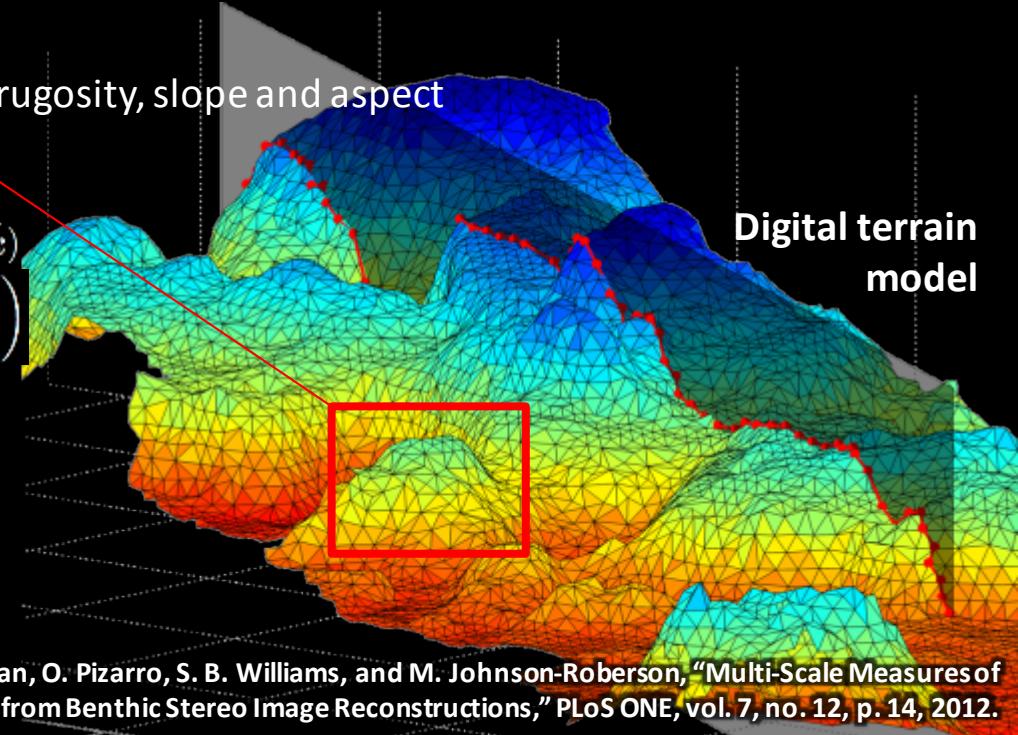


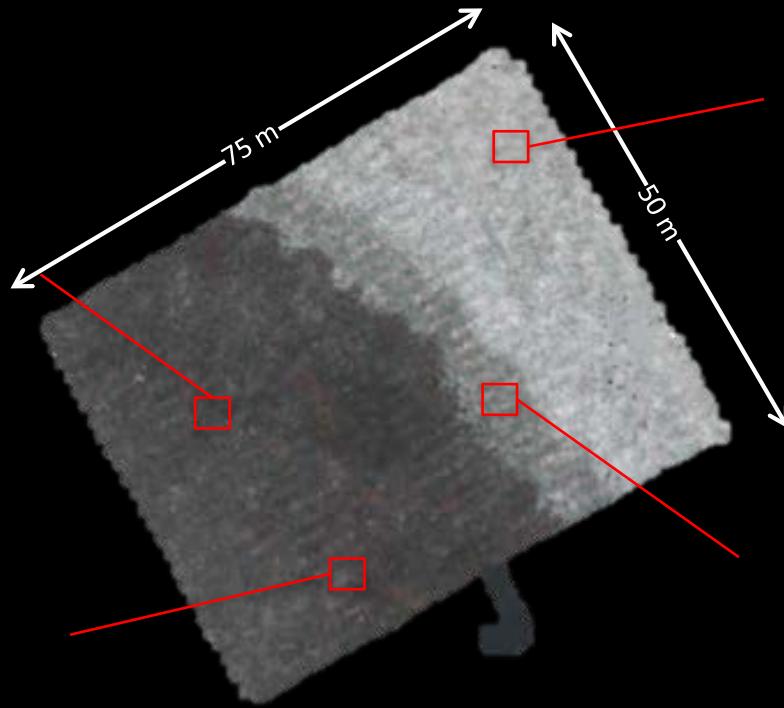
2. Compute surface area using triangles

$$A = \sum_{j=1}^J a_j$$

$$a_j = \frac{1}{2} \left\| \overrightarrow{x_2 x_1} \times \overrightarrow{x_2 x_3} \right\|$$

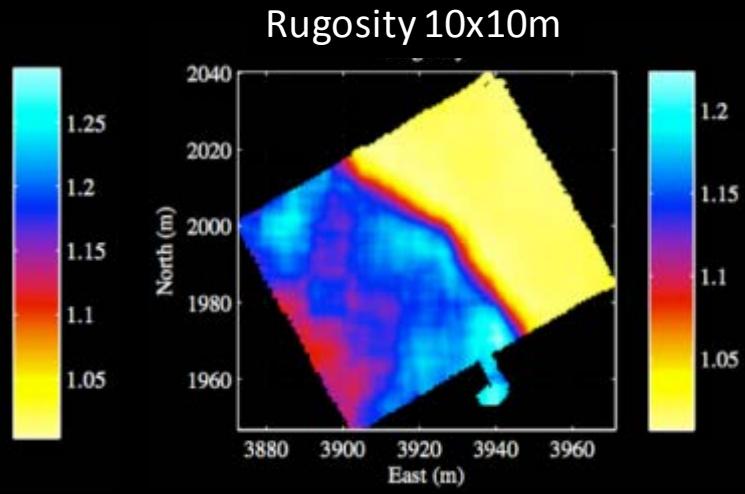
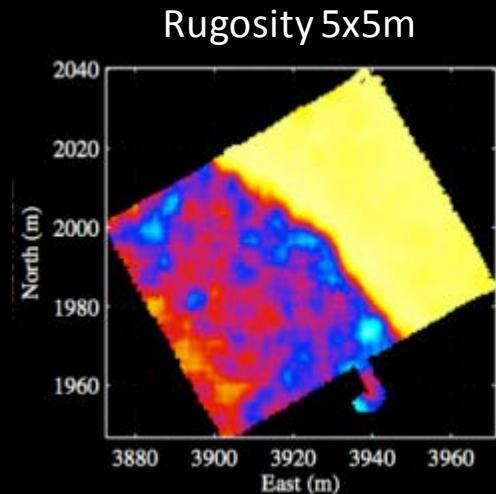
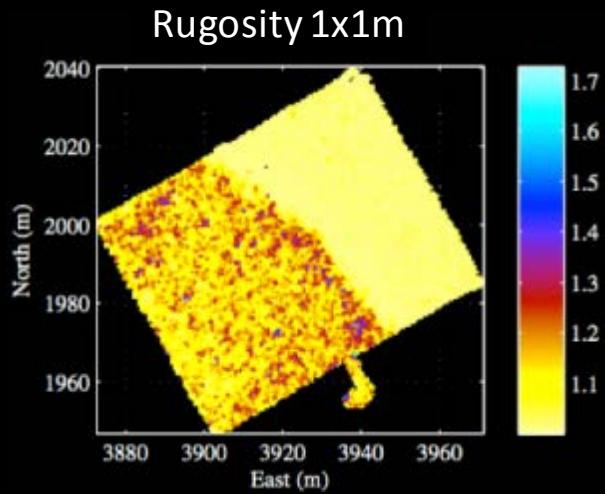
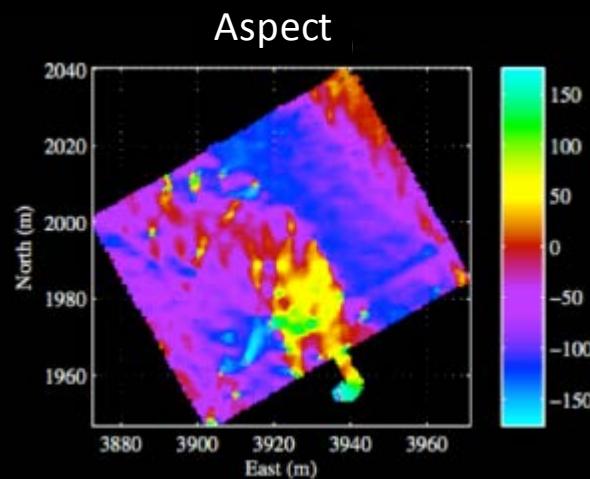
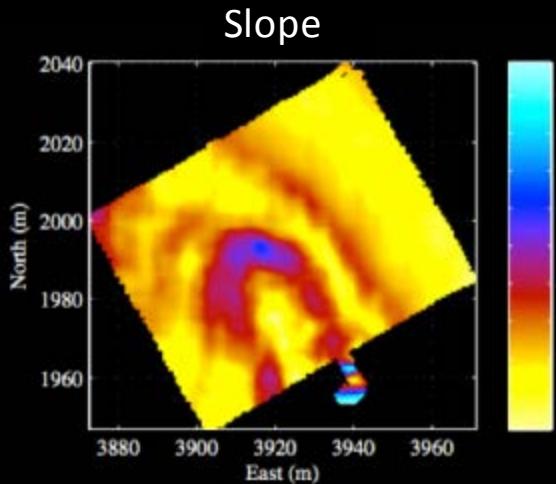
A. Friedman, O. Pizarro, S. B. Williams, and M. Johnson-Roberson, "Multi-Scale Measures of Rugosity, Slope and Aspect from Benthic Stereo Image Reconstructions," PLoS ONE, vol. 7, no. 12, p. 14, 2012.



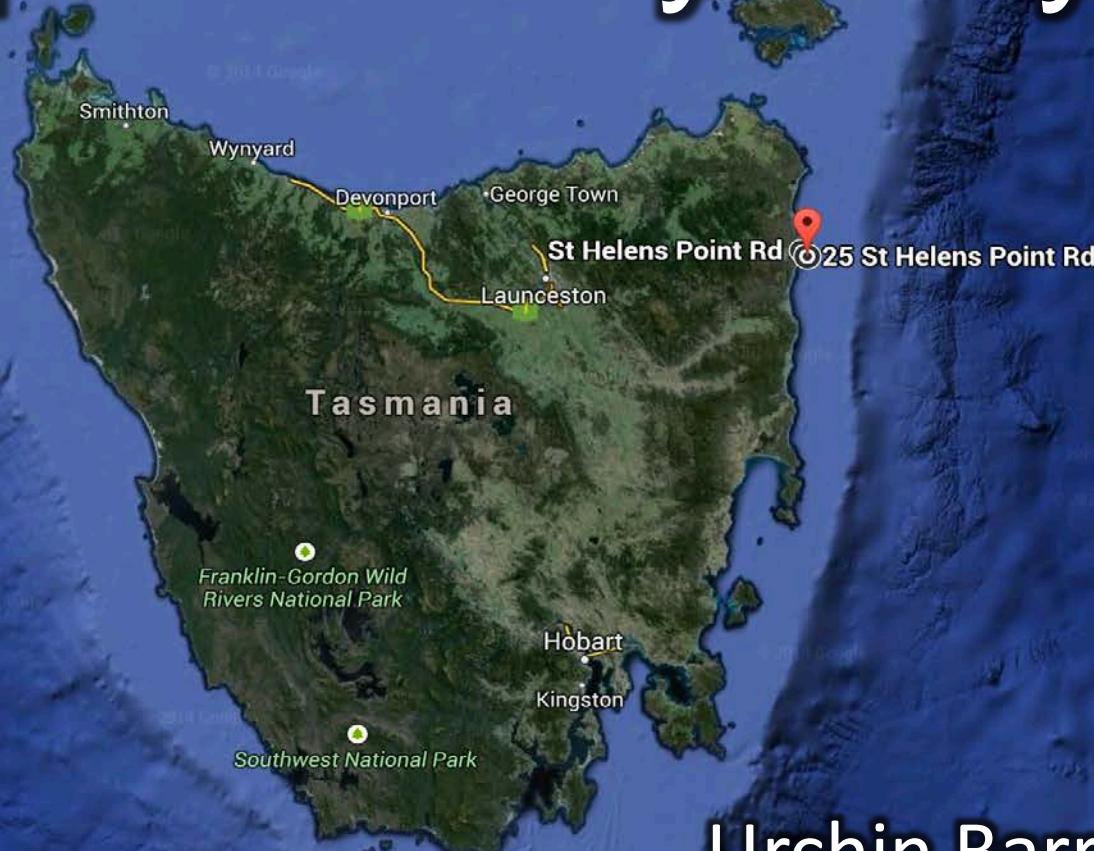


Measurement can be done at multiple spatial scales

RUGOSITY clearly shows different habitat types

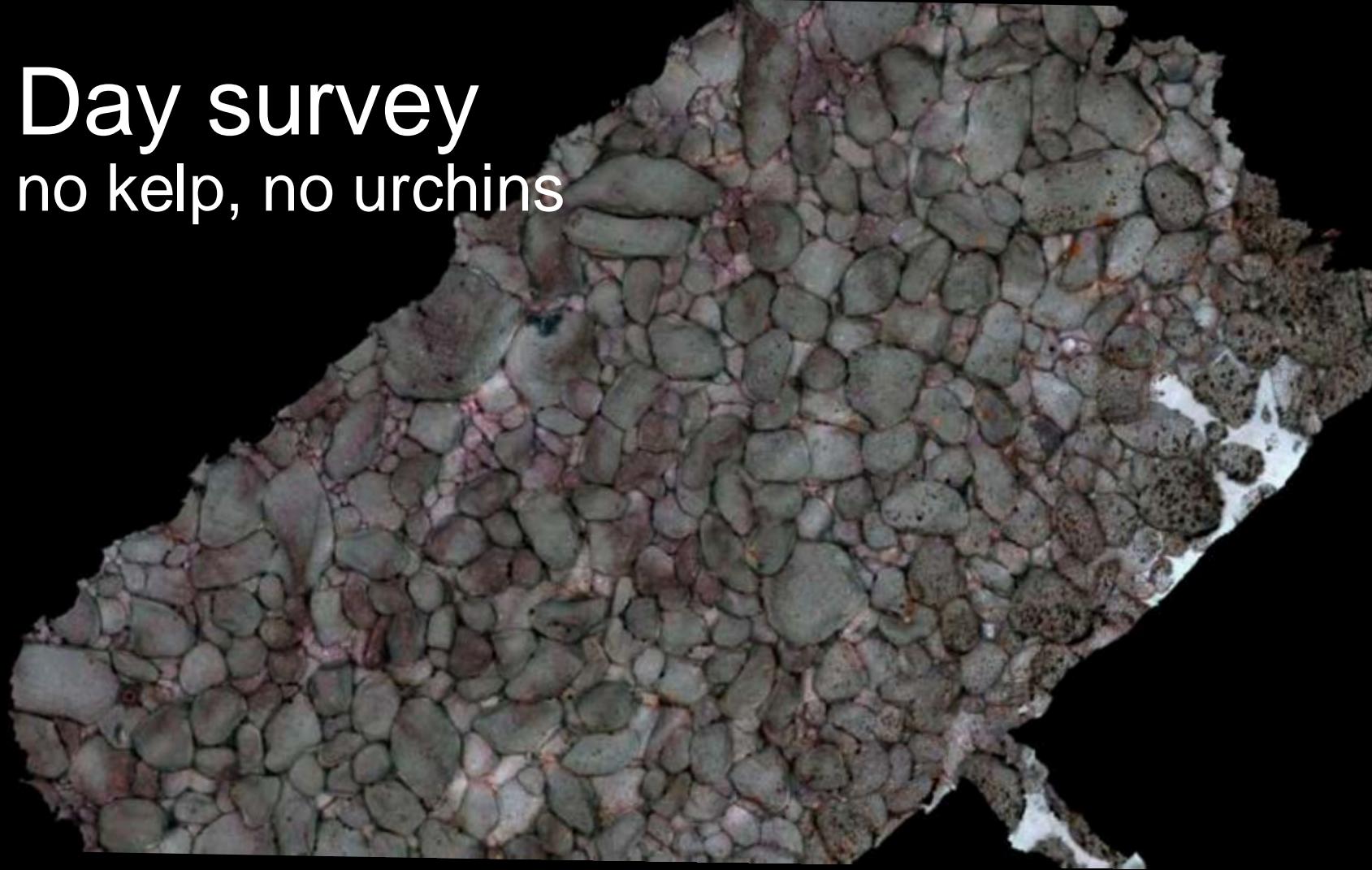


Repeat surveys: day & night

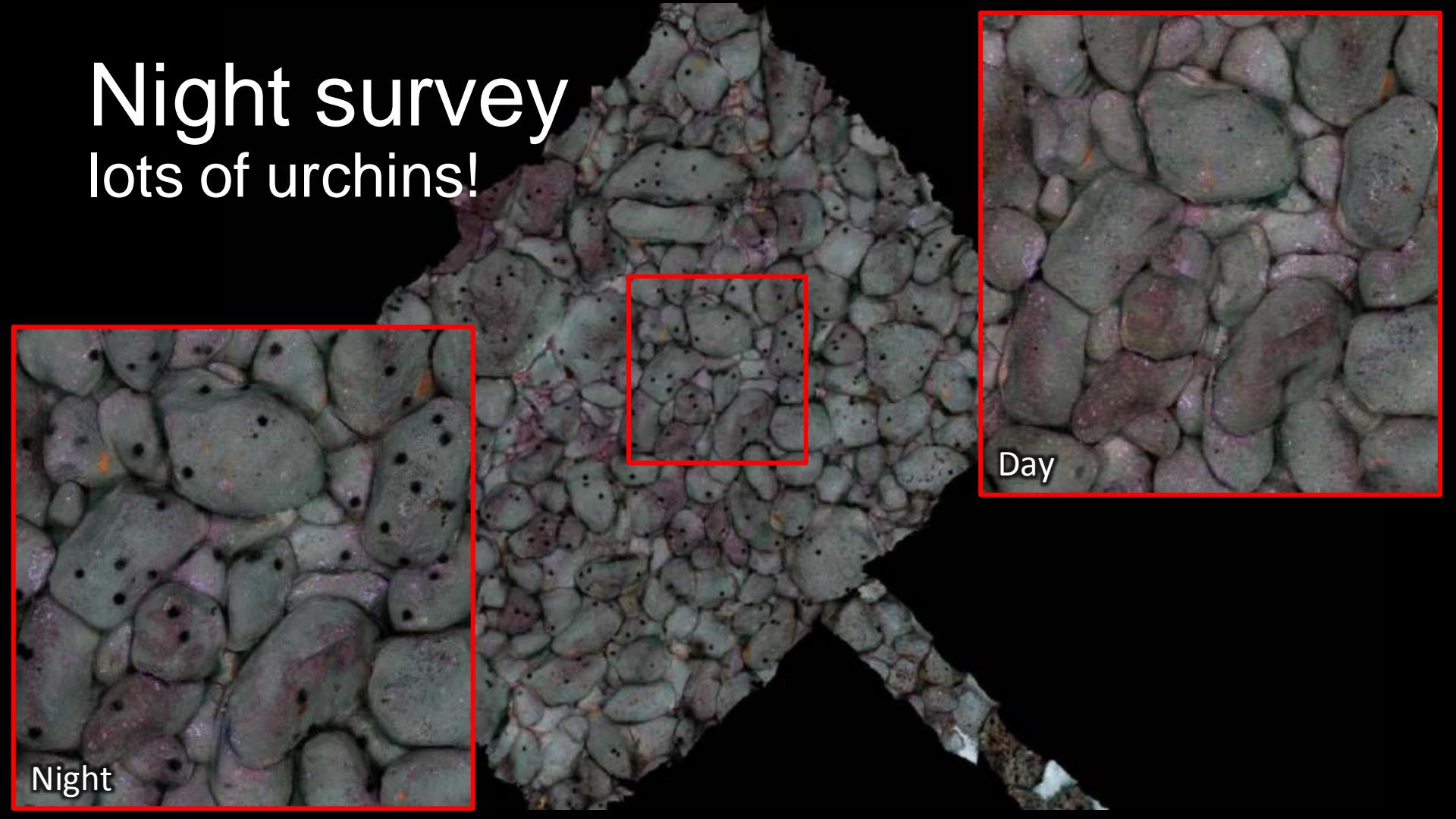


Urchin Barrens in Tasmania

Day survey
no kelp, no urchins



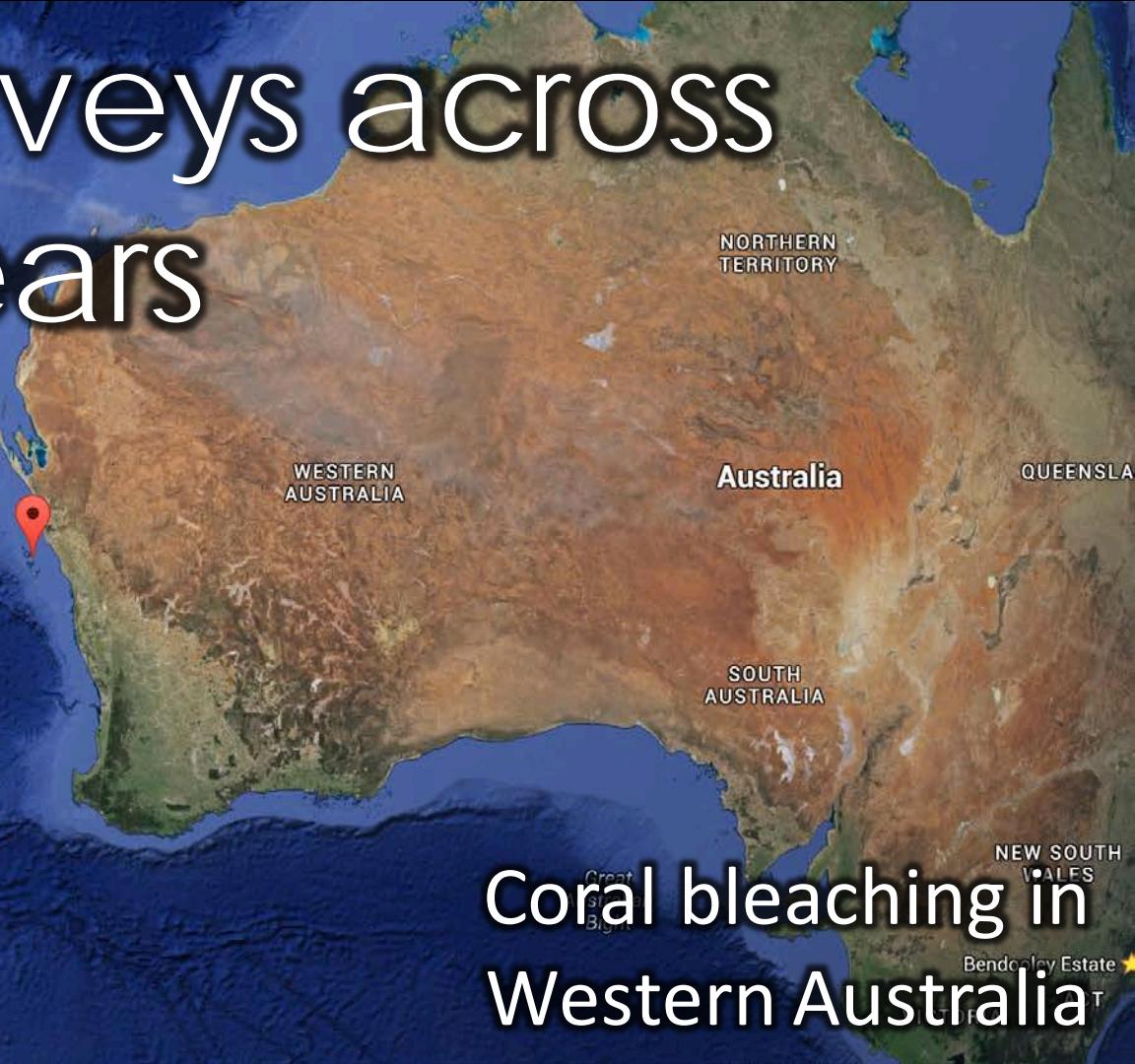
Night survey lots of urchins!



Night

Day

Repeat surveys across multiple years



Coral bleaching in
Western Australia^T

Healthy coral



April 2010

Bleached coral

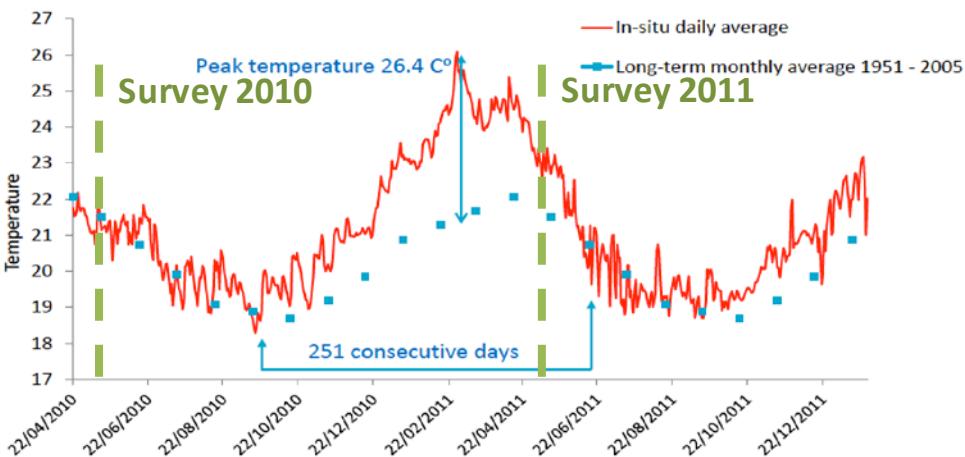


April 2011

Dead coral



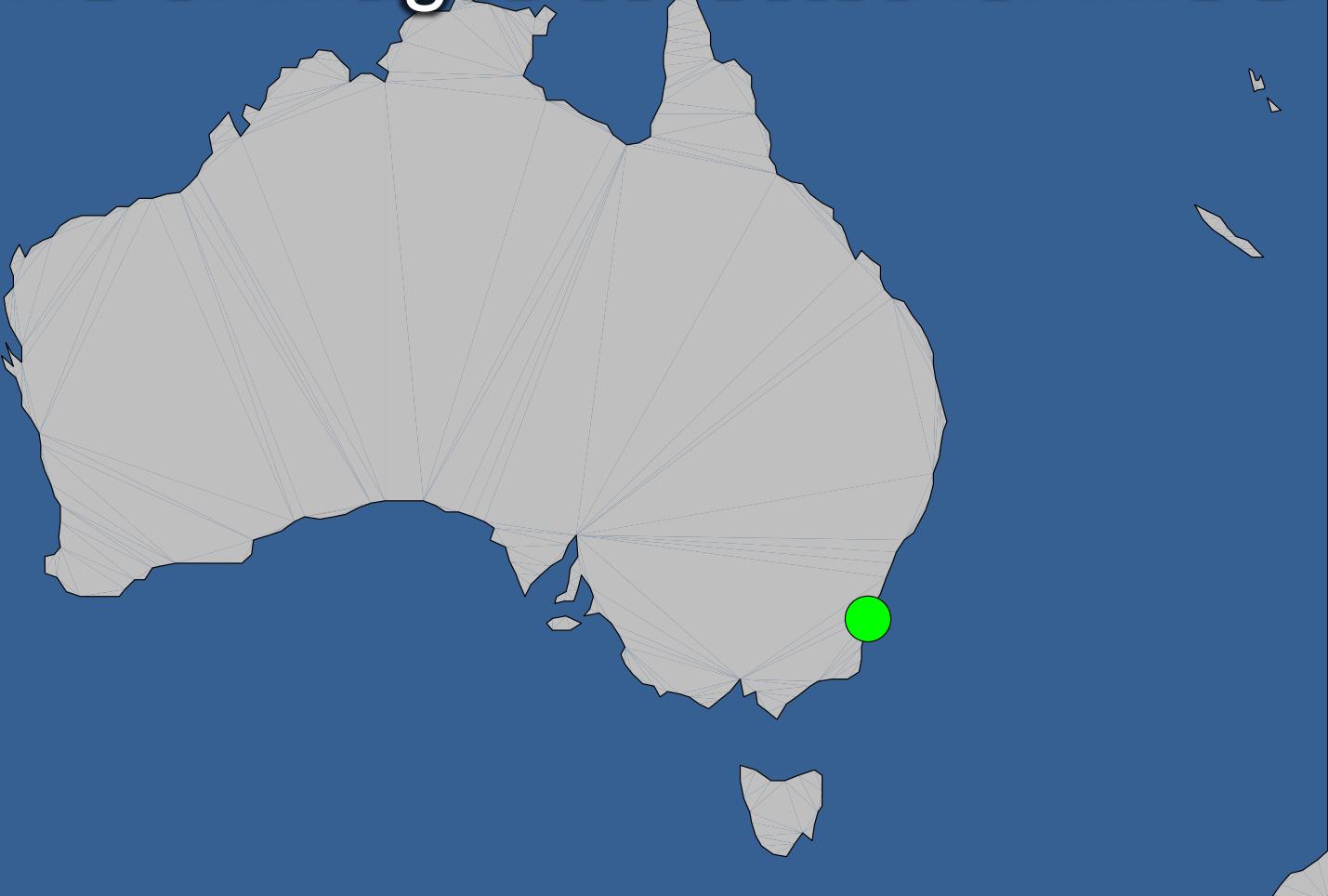
April 2



Growing corals



MILLIONS of images collected for IMOS



y reef

MILLIONS of images collected for IMOS



eg:

50 random pixels in
1% of collected images
=0.000035% of data analysed

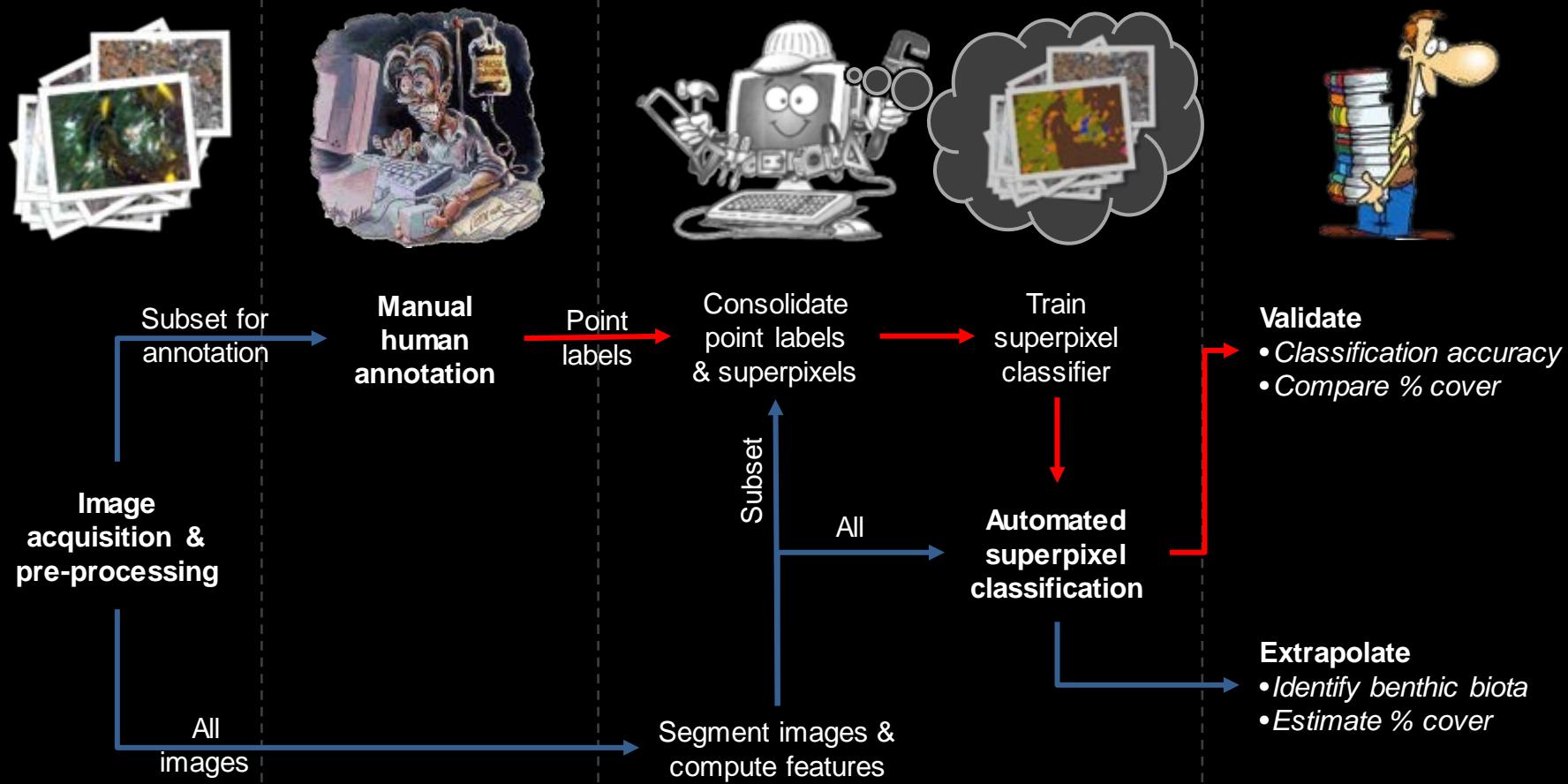


y reef



eg:

ALL pixels in
ALL collected images
=100% of data analysed



SVM| C-BM-E-M-MA-TMA-SP-SU



SVM| C-BM-E-M-MA-TMA-SP-SU

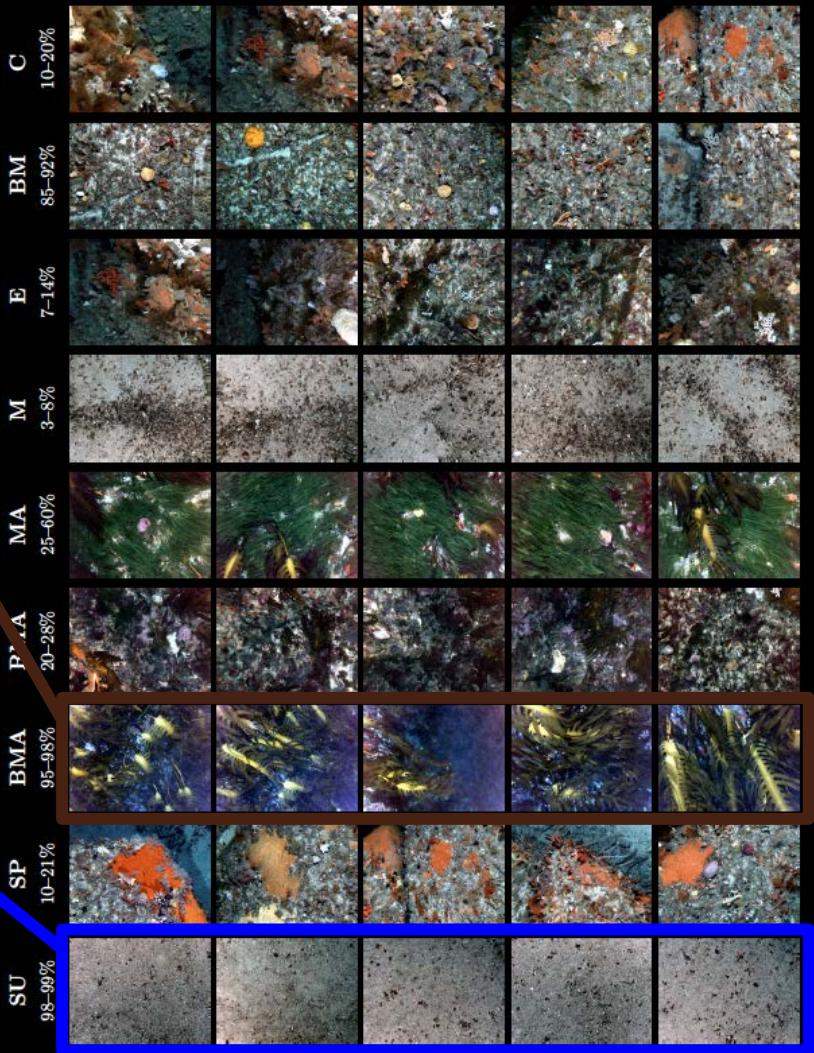
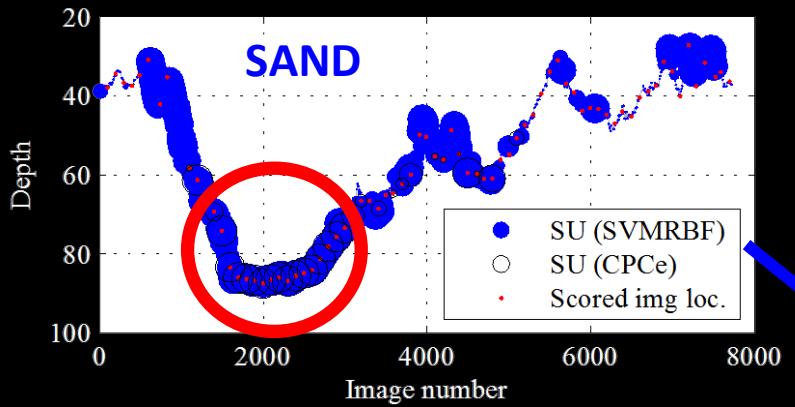
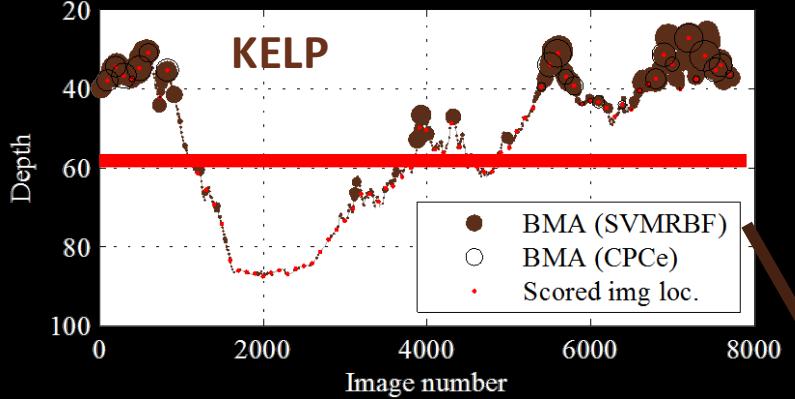


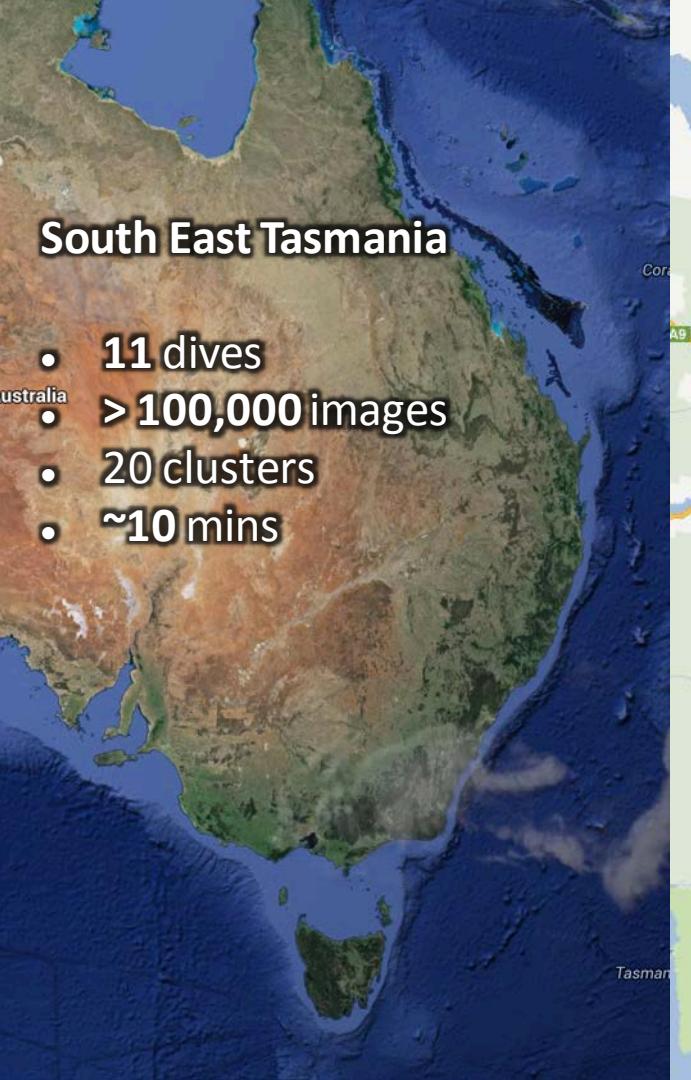
SVM| C-BM-E-M-MA-TMA-SP-SU



SVM| C-BM-E-M-MA-TMA-SP-SU

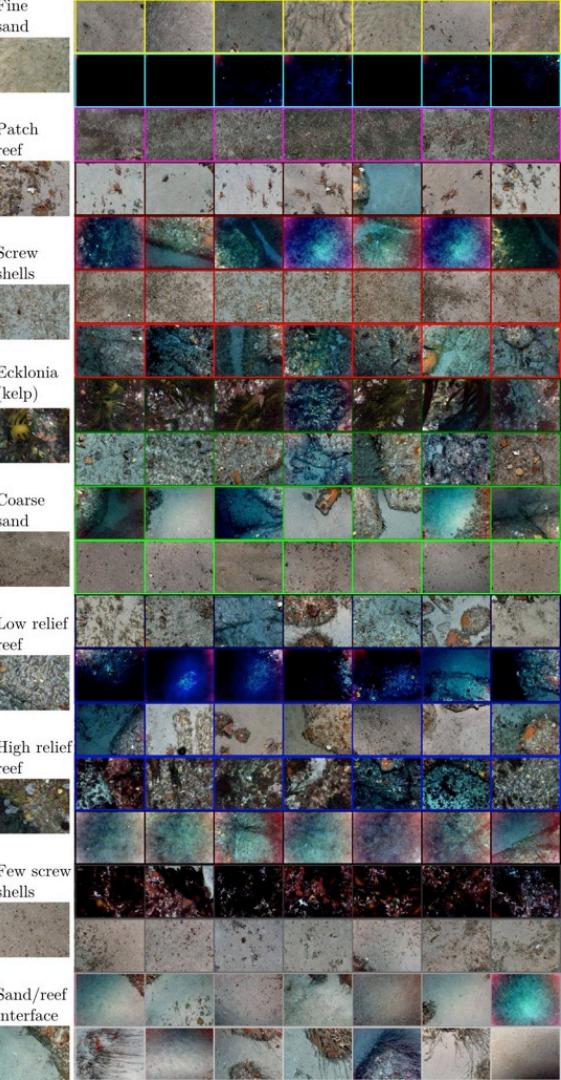
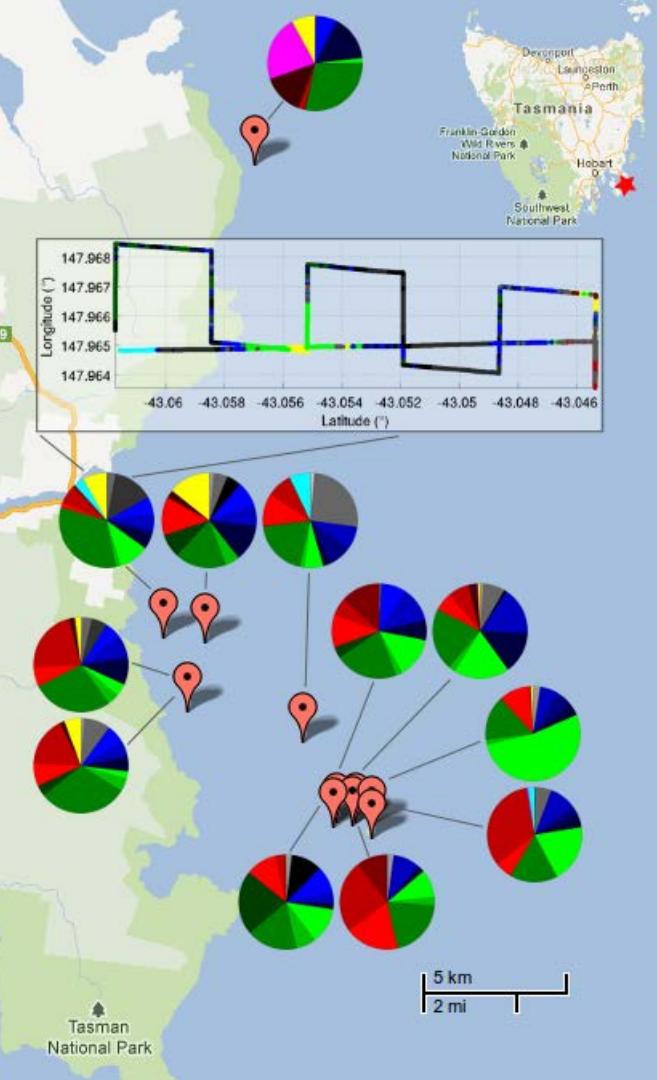


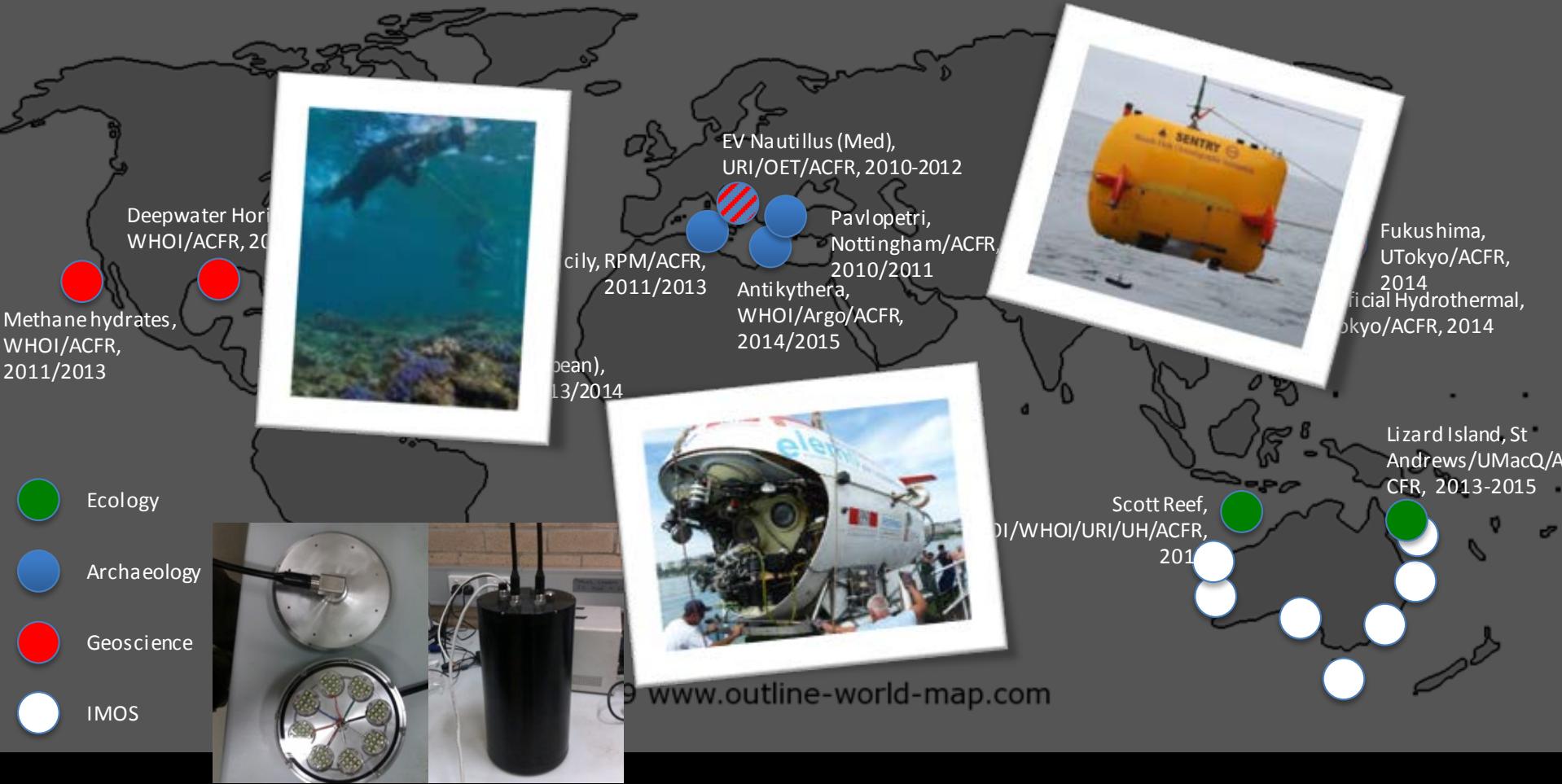




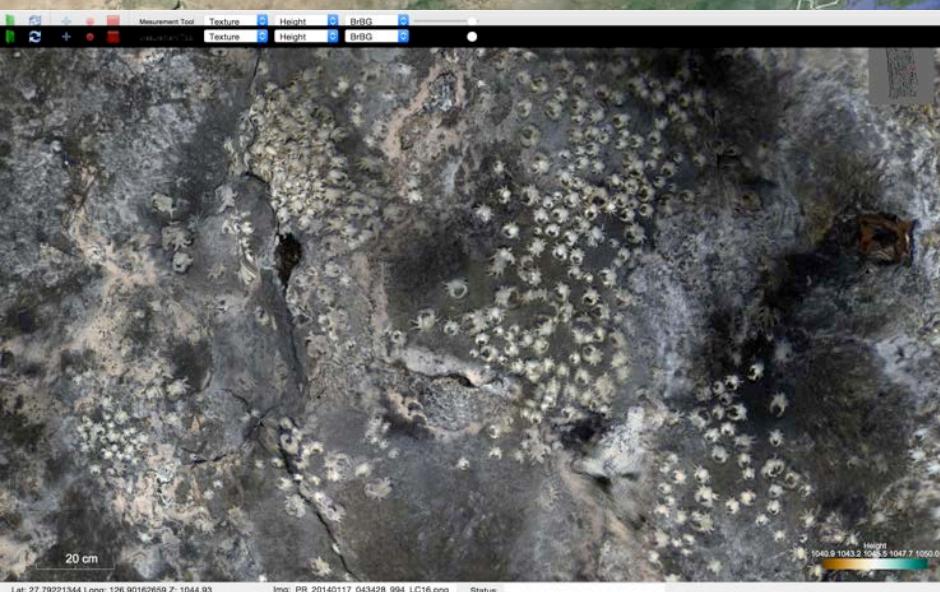
South East Tasmania

- 11 dives
- > 100,000 images
- 20 clusters
- ~10 mins





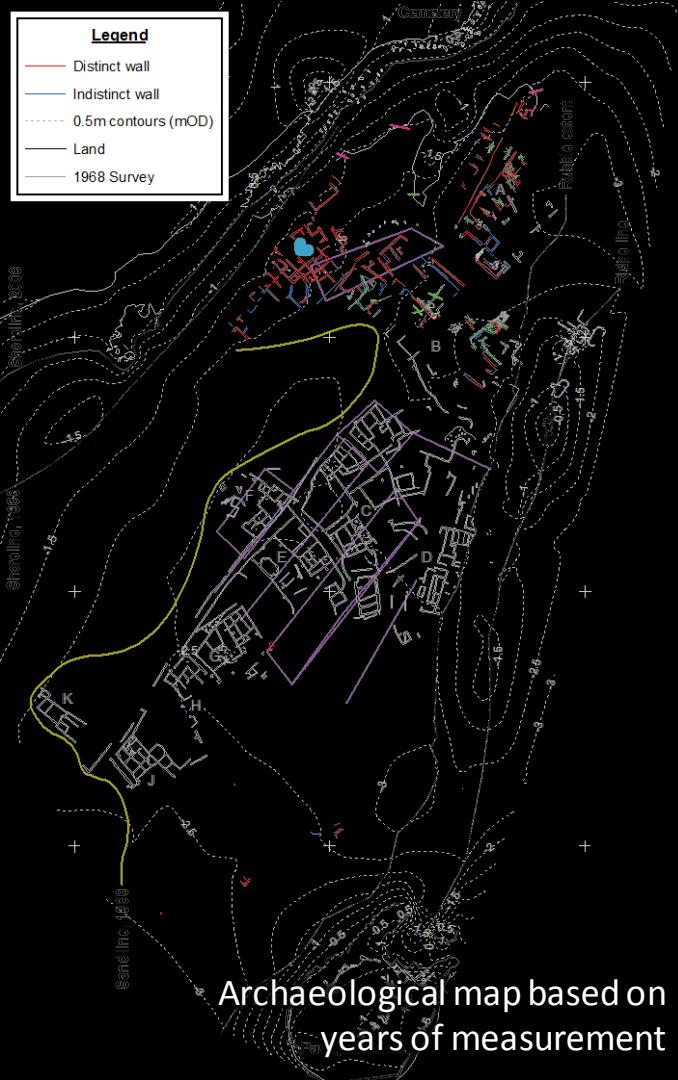
Artificial hydrothermal vents



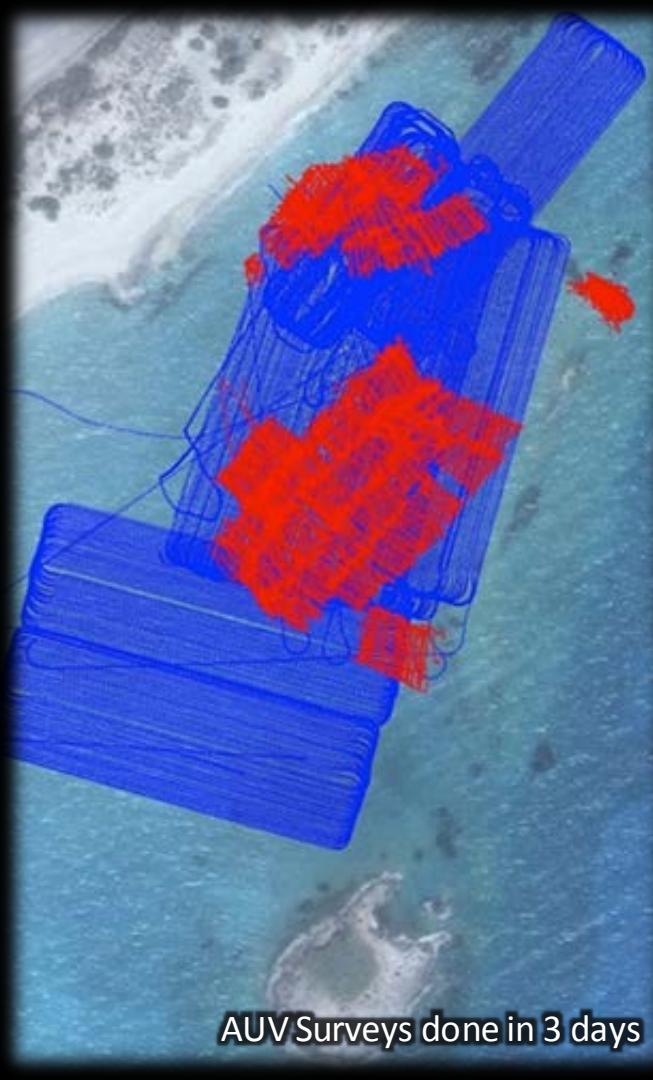
Japan 2014

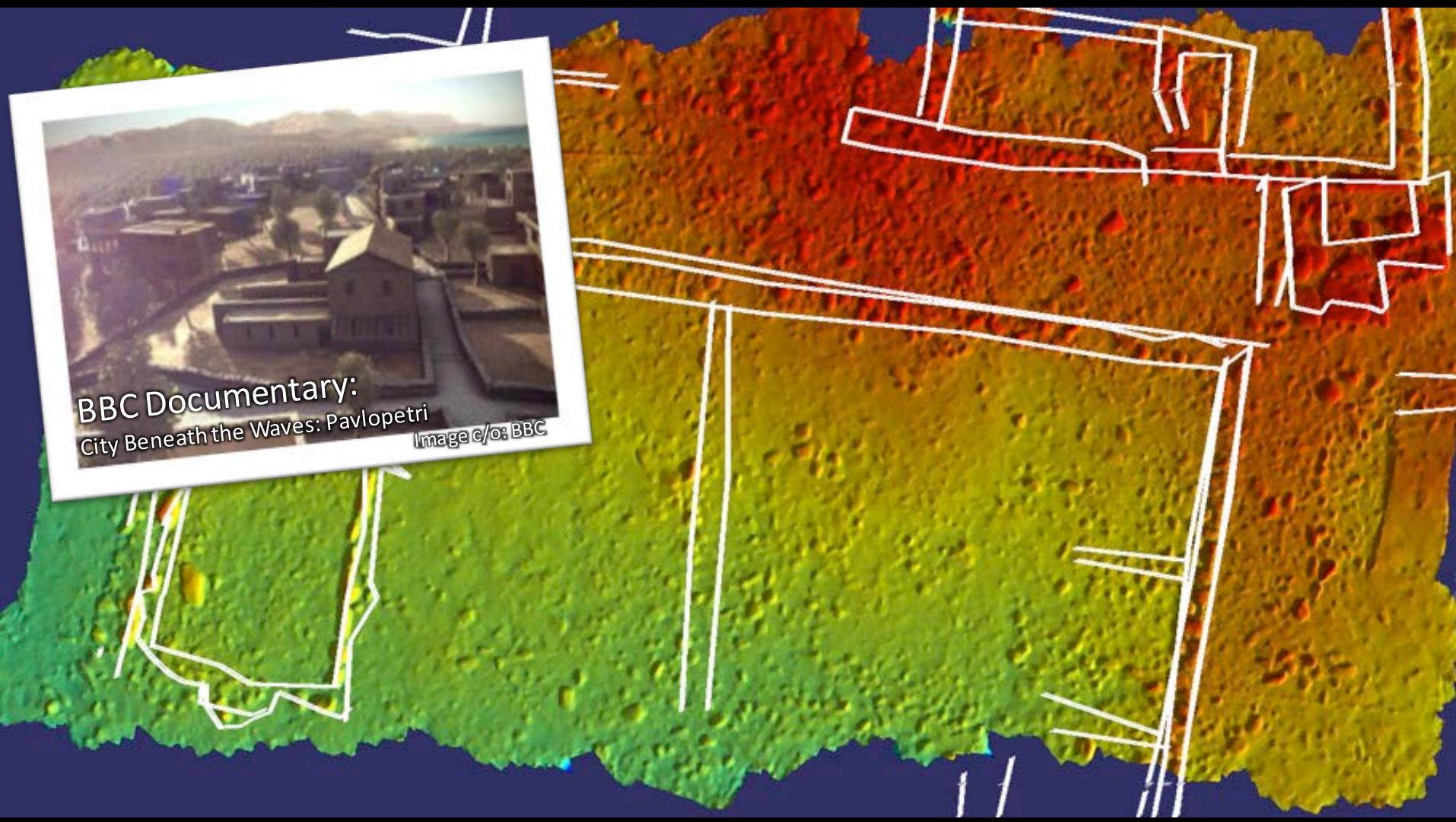
Submerged city of Pavlopetri, in Greece

Comparing stereo photogrammetry
to traditional
mapping methods



IVER AUV





BBC Documentary:

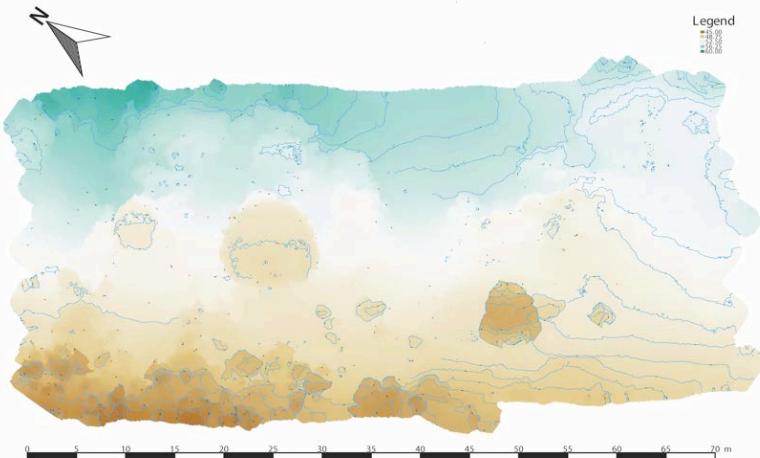
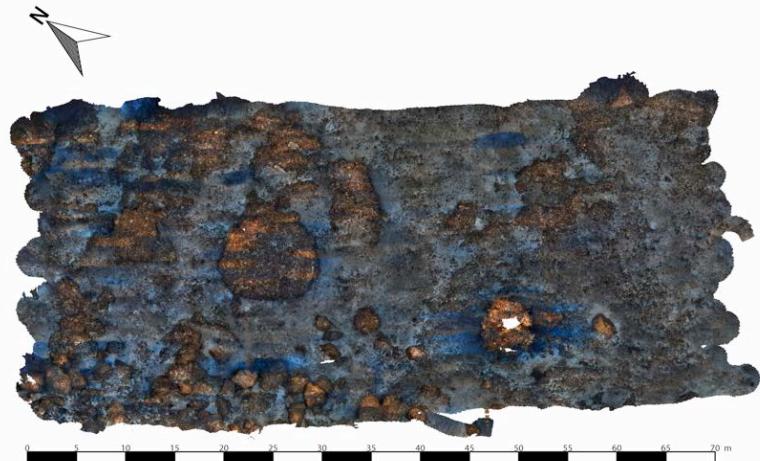
City Beneath the Waves: Pavlopetri

Image c/o: BBC

1st Century Shipwreck



2014 & 2015
Antikithera, Greece



Problem:

MANAGING DATA AND STANDARDIZING ANALYSIS

FEEL FREE TO ASK ME FOR A LIVE DEMO



squidle

explore • annotate • interpret • marine imagery

About the Project

What is this all about? Who is involved? Why should you care?

Click for more

How to...

Tutorials and videos that provide useful tips on how to use the system.

Click for more

Diving Deeper

Check out more details about the project and for more info about automated tools designed to make life easier.

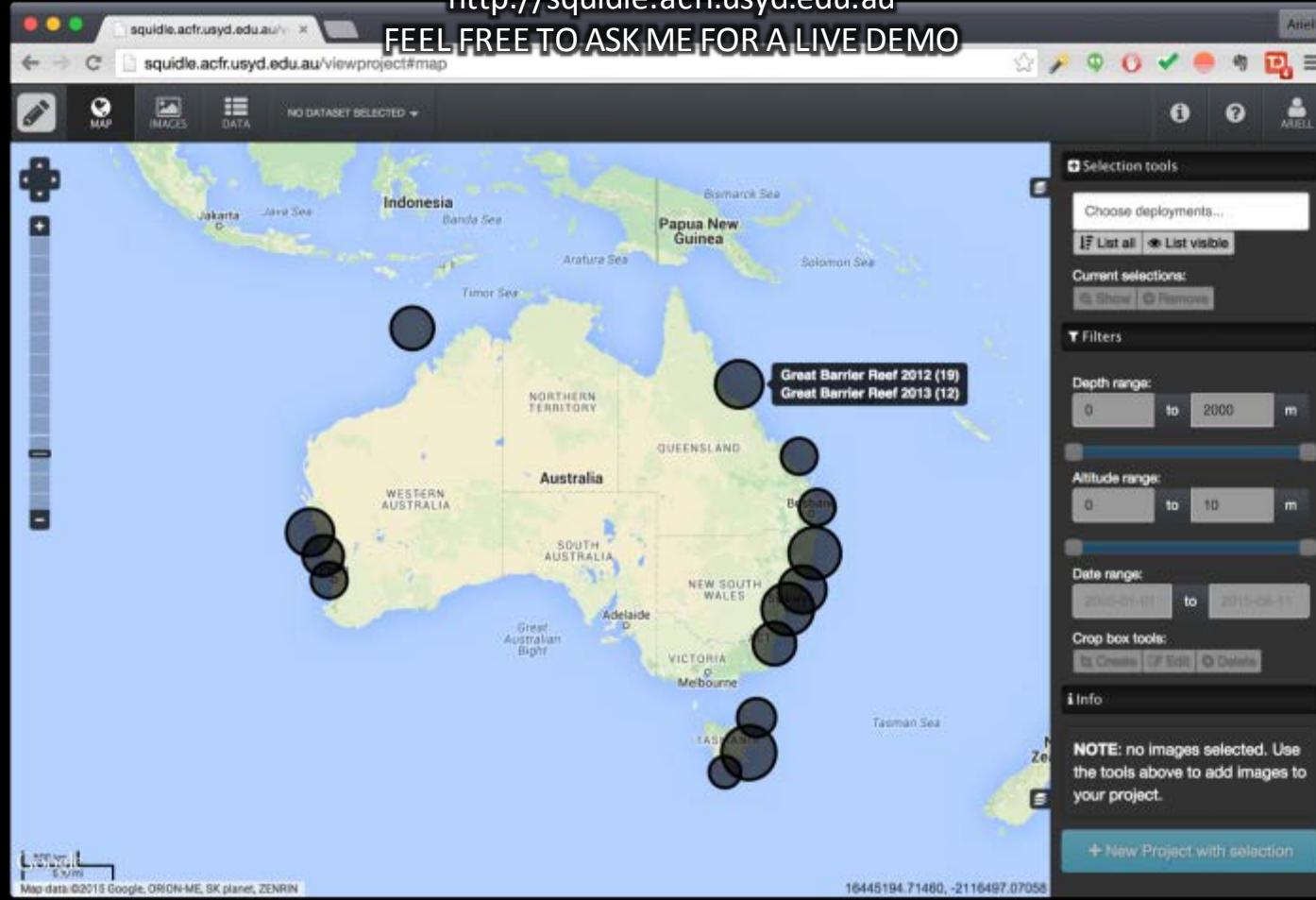
Click for more

Get started!

Click here to log in or sign up and jump straight into labeling seafloor images!

Click to start

FEEL FREE TO ASK ME FOR A LIVE DEMO



<http://squidle.acfr.usyd.edu.au>

FEEL FREE TO ASK ME FOR A LIVE DEMO

The screenshot shows the Squidle software interface running in a web browser. The main window displays a map with several black lines representing survey transects. A green polygon highlights a specific area of interest. In the bottom-left corner, a modal window provides details about a selected image:

Name: PR_20110816_145257_991_LC16.png
ID: 1056854
Depth: 45.62 m
LAT: -14.063304
LON: 121.925231
TS: 2011-08-17T00:52:57

Below this, there is a "Nearby images" section showing thumbnail previews of other images from the same survey.

The right side of the screen contains various toolbars and panels:

- Selection tools:** Shows a selected item: r20110816_143358_23_scott_dense_deep_auv1.
- Current selections:** Buttons for "List all" (unchecked) and "List visible" (checked).
- Filters:** Depth range (0 to 2000 m), Altitude range (0 to 10 m), Date range (2005-01-01 to 2015-08-11).
- Crop box tools:** Create, Edit, Delete.
- Info:** A button for "New Project with selection".

The status bar at the bottom shows the URL: squidle.acfr.usyd.edu.au/images/ScottReef201108/r20110816_143358_23_scott_dense_deep_auv1/images/PR_20110816_145257_991_LC16.png.

<http://squidle.acfr.usyd.edu.au>

FEEL FREE TO ASK ME FOR A LIVE DEMO

The screenshot shows the Squidle software interface running in a web browser. The main window displays a map of a reef system with various black lines representing survey transects. A blue line highlights a specific path. In the center, there is a 3D perspective view of a coral structure, colored green and purple, set against a light orange background. To the left of this 3D view, a small thumbnail image is visible. A tooltip provides detailed information about this image:

Name: PR_20110816_145257_991_LC16.png
ID: 1056854
Depth: 45.62 m
LAT: -14.063304
LON: 121.925231
TS: 2011-08-17T00:52:57

Below the map, a "Nearby images" section shows several small thumbnail images of the reef area.

The right side of the interface contains several panels:

- Selection tools:** Shows a list of selected datasets: r20110816_143358_23_scott_dense_deep_auv1. Buttons for "List all" and "List visible" are present.
- Current selections:** Buttons for "Show" and "Remove".
- Filters:** Options for "Crop filters" and "Altitude filter".
 - Depth range:** Set from 0 to 2000 m.
 - Altitude range:** Set from 1.6 to 2.4 m.
 - Date range:** Set from 2005-01-01 to 2015-08-11.
- Crop box tools:** Buttons for "Create", "Edit", and "Delete".
- Info:** A button labeled "+ New Project with selection".

FEEL FREE TO ASK ME FOR A LIVE DEMO

ARIELL

squidle.acfr.usyd.edu.au

viewproject?clid=455&wsid=1061&asid=1101&imid=538904#thm

MAP IMAGES DATA SOUTH SOL 06 | GILLS TEST | TEST

ARIELL

The screenshot shows a user interface for a biological survey tool. At the top, there's a browser header with the URL squidle.acfr.usyd.edu.au, a title bar with "FEEL FREE TO ASK ME FOR A LIVE DEMO", and a user profile "ARIELL". Below the header is a navigation bar with tabs for "MAP", "IMAGES", and "DATA", and a dropdown menu "SOUTH SOL 06 | GILLS TEST | TEST". The main area features a large image of a coral reef with various marine life. Overlaid on the image are numerous circular markers: white outlines with black dots, yellow outlines with black dots, and a single black box containing the text "Not labeled yet...". To the right of the image is a sidebar with annotation tools (eraser, pencil, selection), a search bar "Search all available labels", and a list of labels:

- Ascidiens
- Ascidiens: Stalked
- Ascidiens: Colonial
- Ascidiens: Stalked: Solitary

Below the labels is a "Tools" section with a color calibration strip and a magnifying glass icon.

A screenshot of a web browser showing a citizen science project titled "squidle". The main header features a large image of a clownfish swimming among anemone tentacles. Overlaid on the image is the text "22575 labels" with a fish tag icon, followed by a message encouraging users to help tag more. Below this, there are social sharing buttons for "Like" and "Share", with a note that "You and 46 others like this." To the right, the project ID "project#: citizenSOI201503" is displayed. The "squidle" logo, consisting of a pencil icon and the word "squidle" in a stylized font, is centered below the main image. Below the logo, the words "explore • annotate • interpret • marine imagery" are visible.

22575 labels

have been tagged so far thanks to citizen scientists like YOU! We still need many more. Click 'Get Started!' to help out...

Like Share You and 46 others like this.

project#: citizenSOI201503

squidle

explore • annotate • interpret • marine imagery

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What is this all about? Who is involved? Why should you care?

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Tutorials and videos that provide useful tips on how to use the system.

Click for more

Diving Deeper

Check out more details about the project and for more info about automated tools designed to make life easier.

Click for more

Get started!

Welcome back ariel!! Jump straight to working with the data using the annotation interface.

Click to start

Future directions for squidle

- Support for additional platforms, data types & data sources
- Video annotation interface
- Automated machine learning tools & active learning
- Incorporate novel & flexible annotation schemes

Thanks to:
Schmidt Ocean Institute
Integrated Marine Observing System
The ACFR AUV team
& everyone in the picture below

