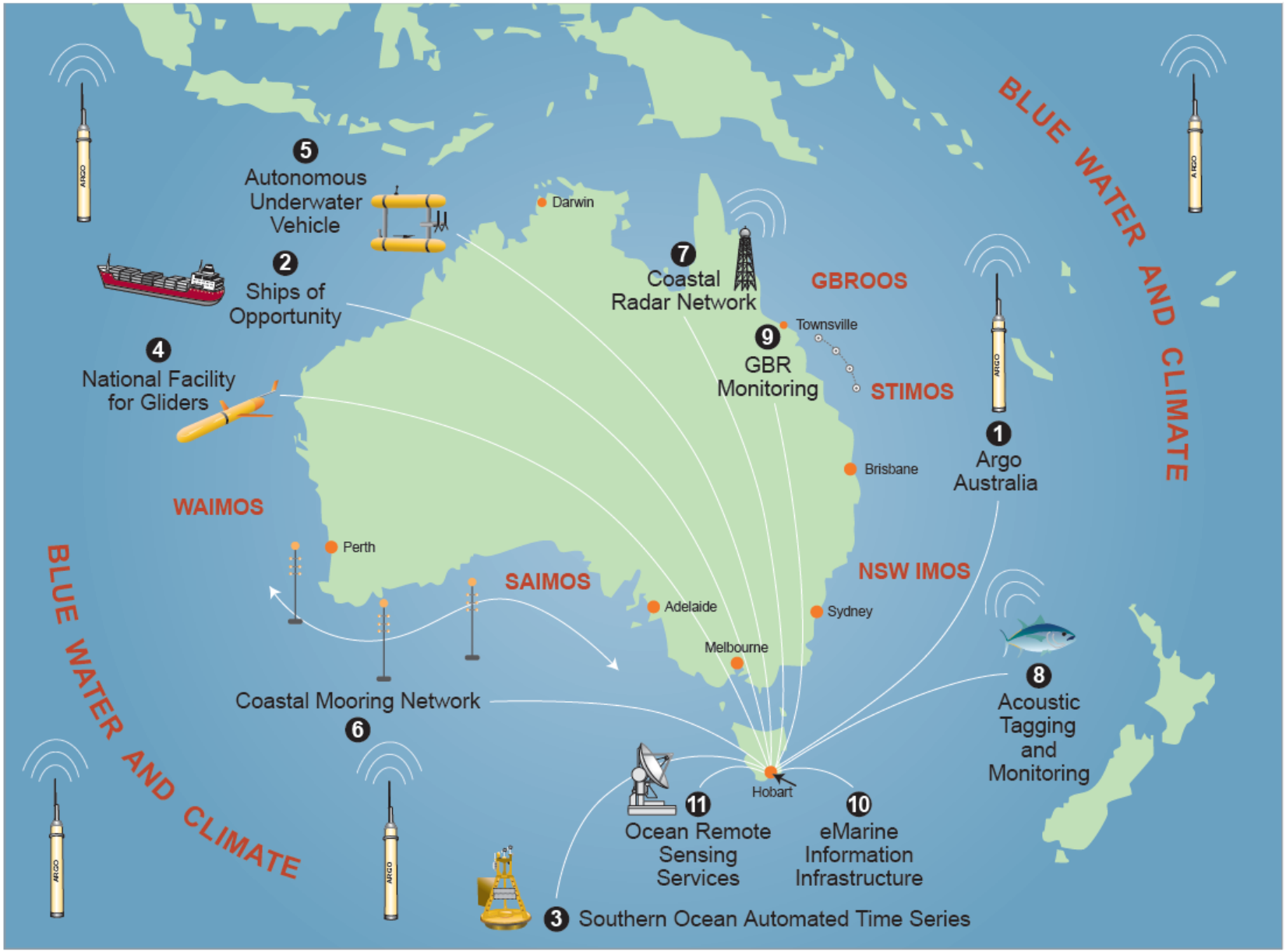
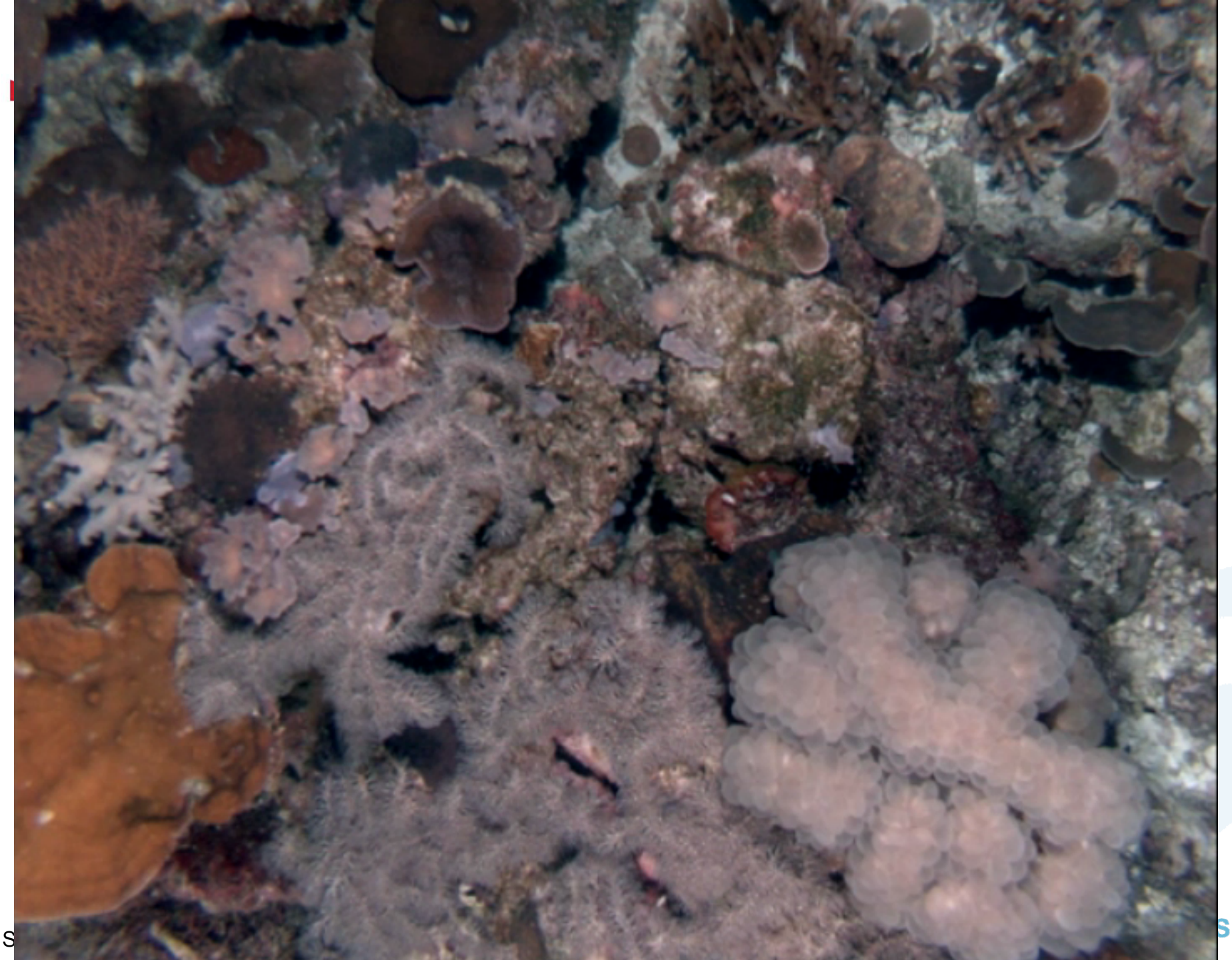
Autonomous Benthic Monitoring Downunder

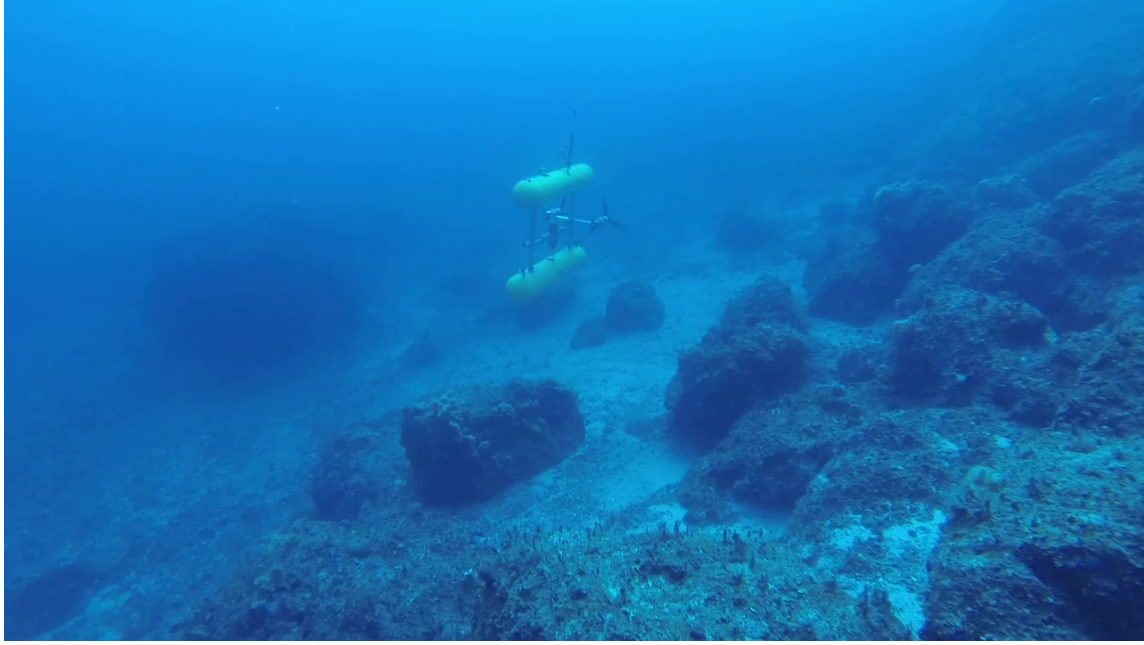
O. Pizarro, S.B. Williams, M. Bryson, A. Friedman

Integrated Marine Observing System

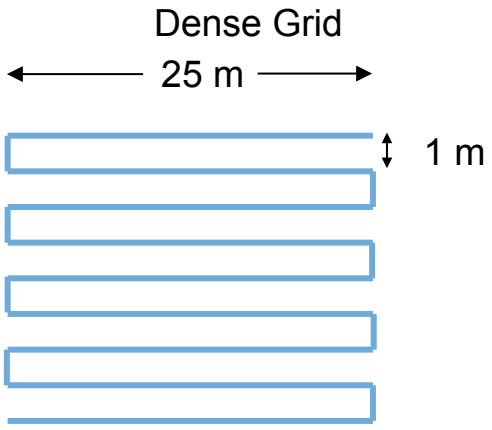


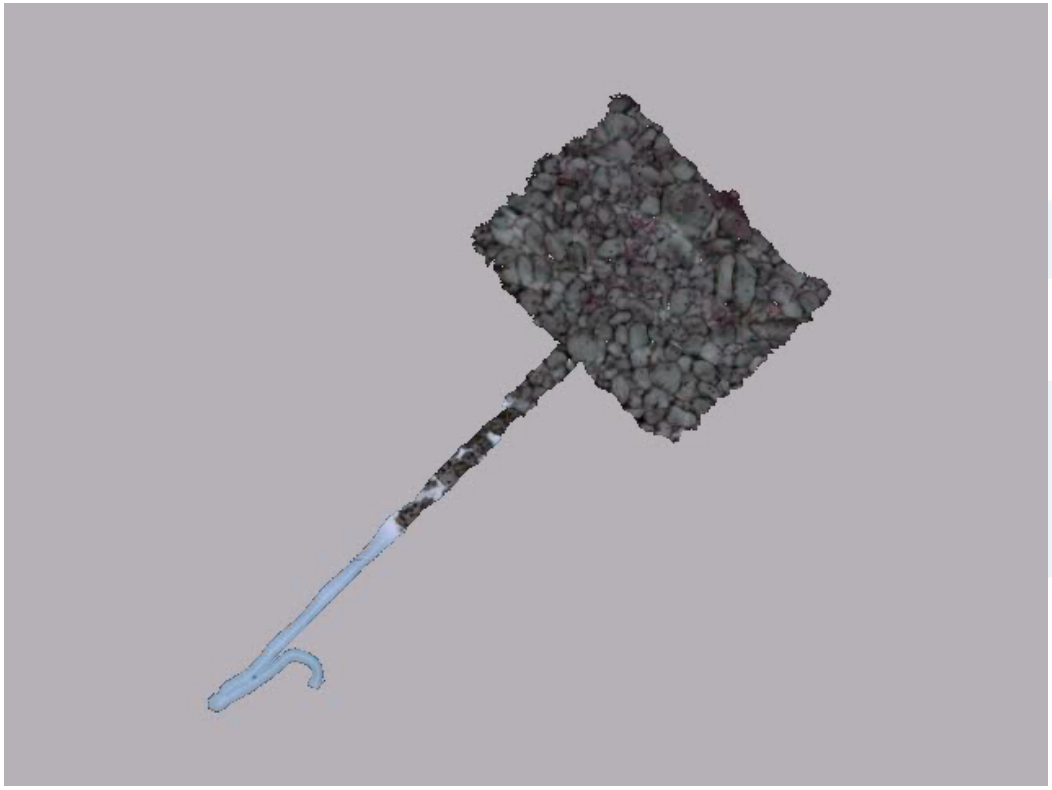


Sirius AUV

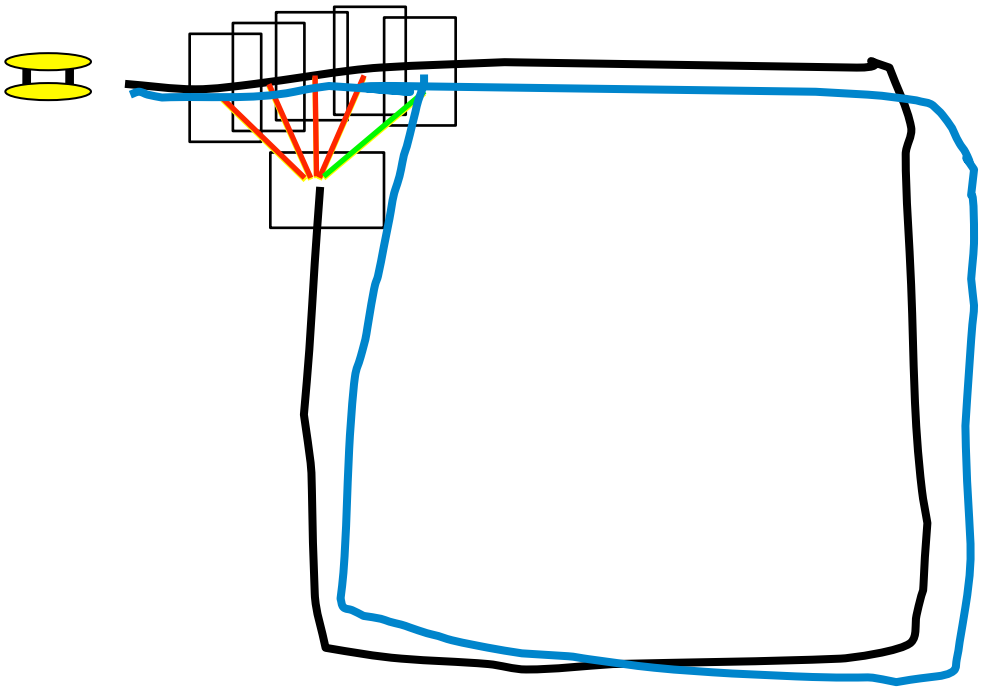


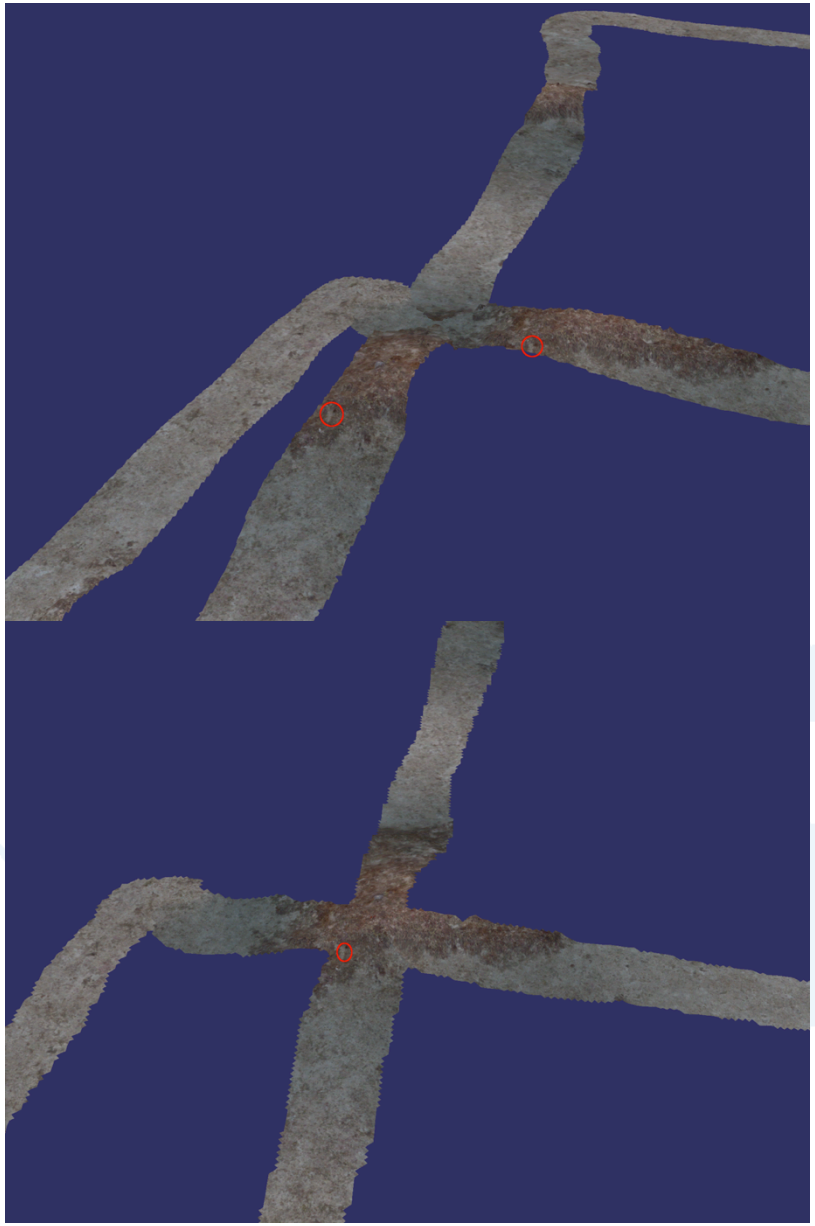
- Flexible, mobile, high resolution data collection
- Sensors include
  - **DVL**
  - **Attitude**
  - **Pressure depth**
  - **fwd obstacle avoidance**
  - **GPS (surface)**
  - **USBL**
  - ***Vision (stereo)***
  - Multibeam sonar
  - Water Column

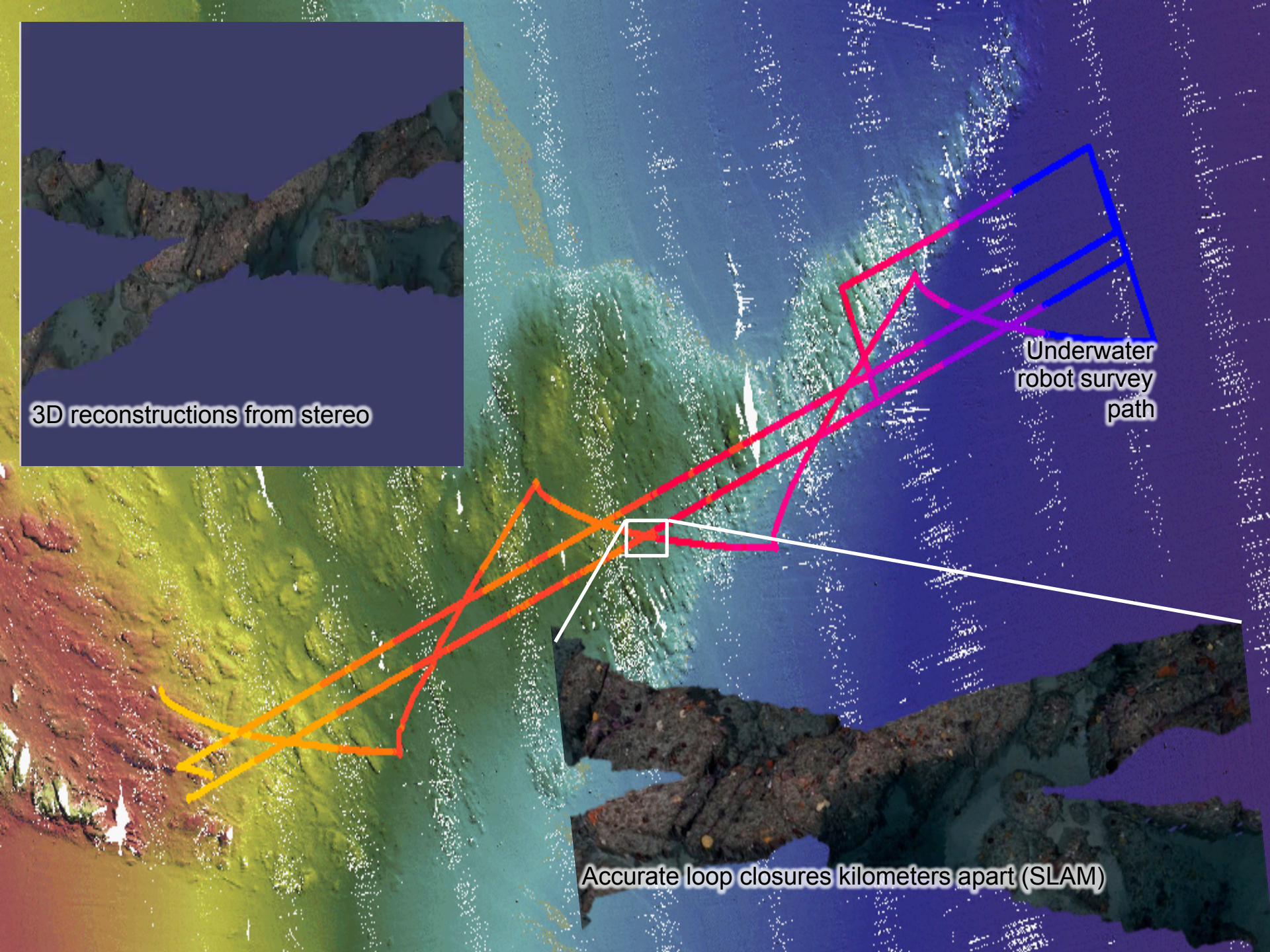




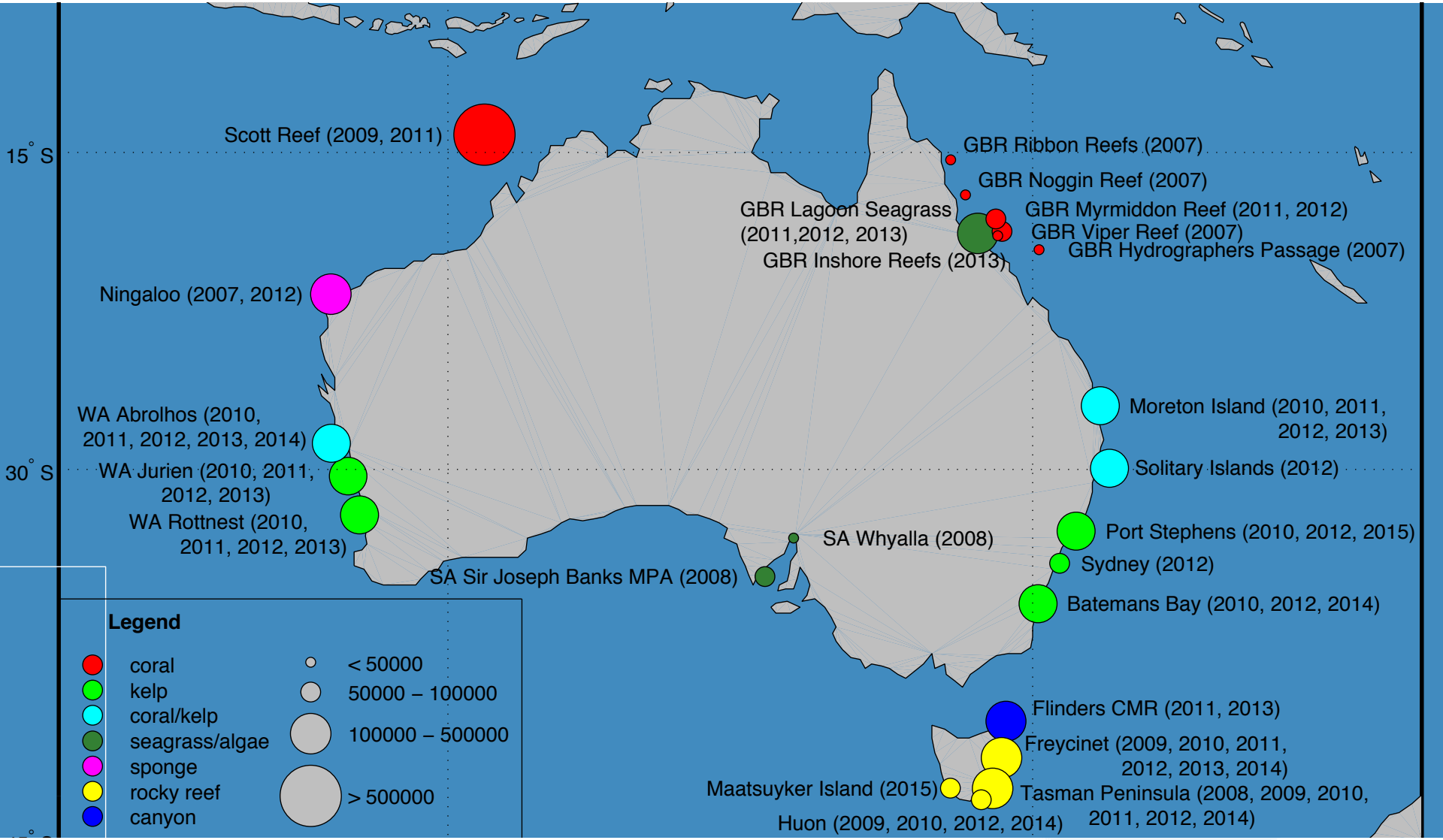
SLAM: Visually Augmented Navigation



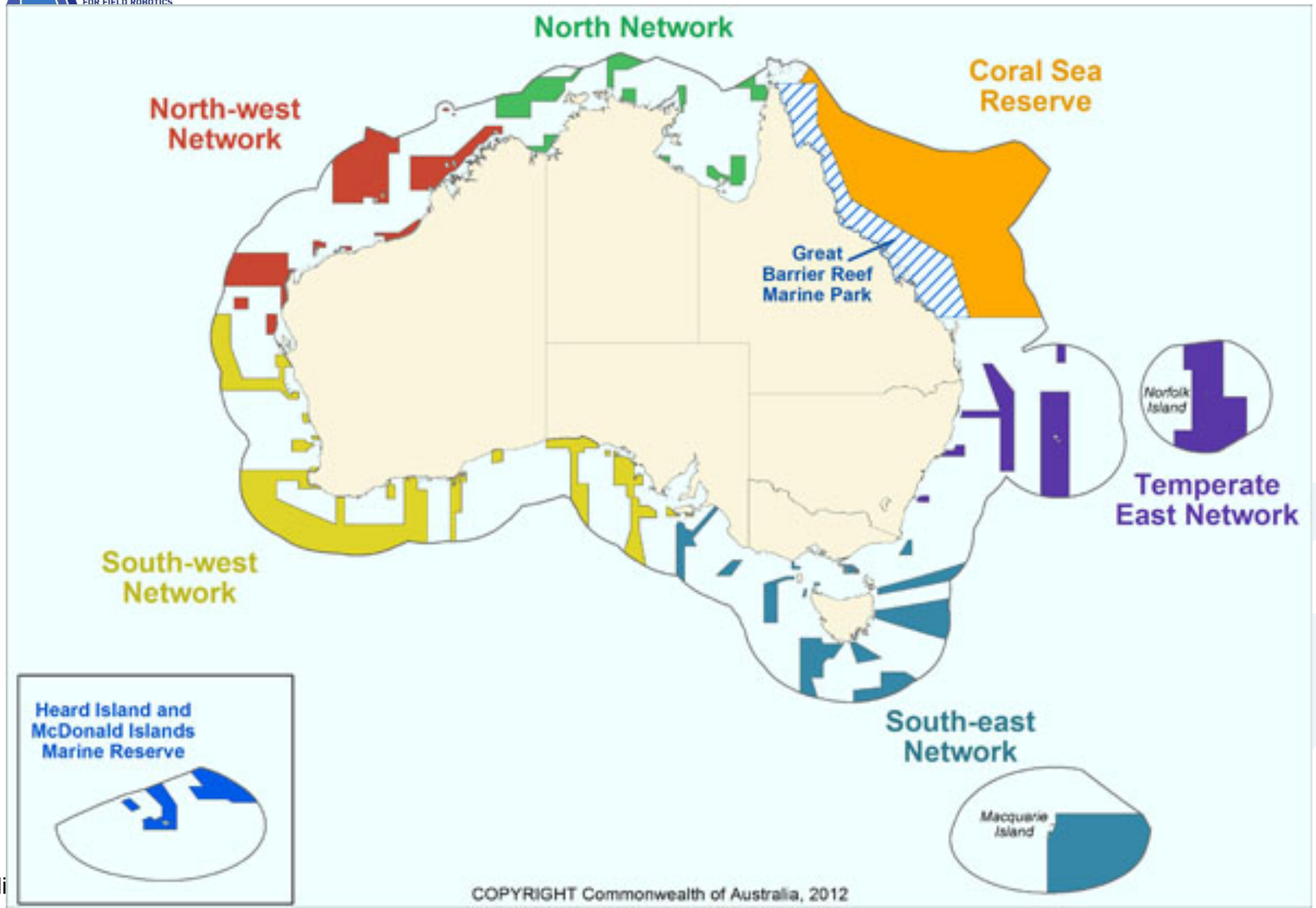


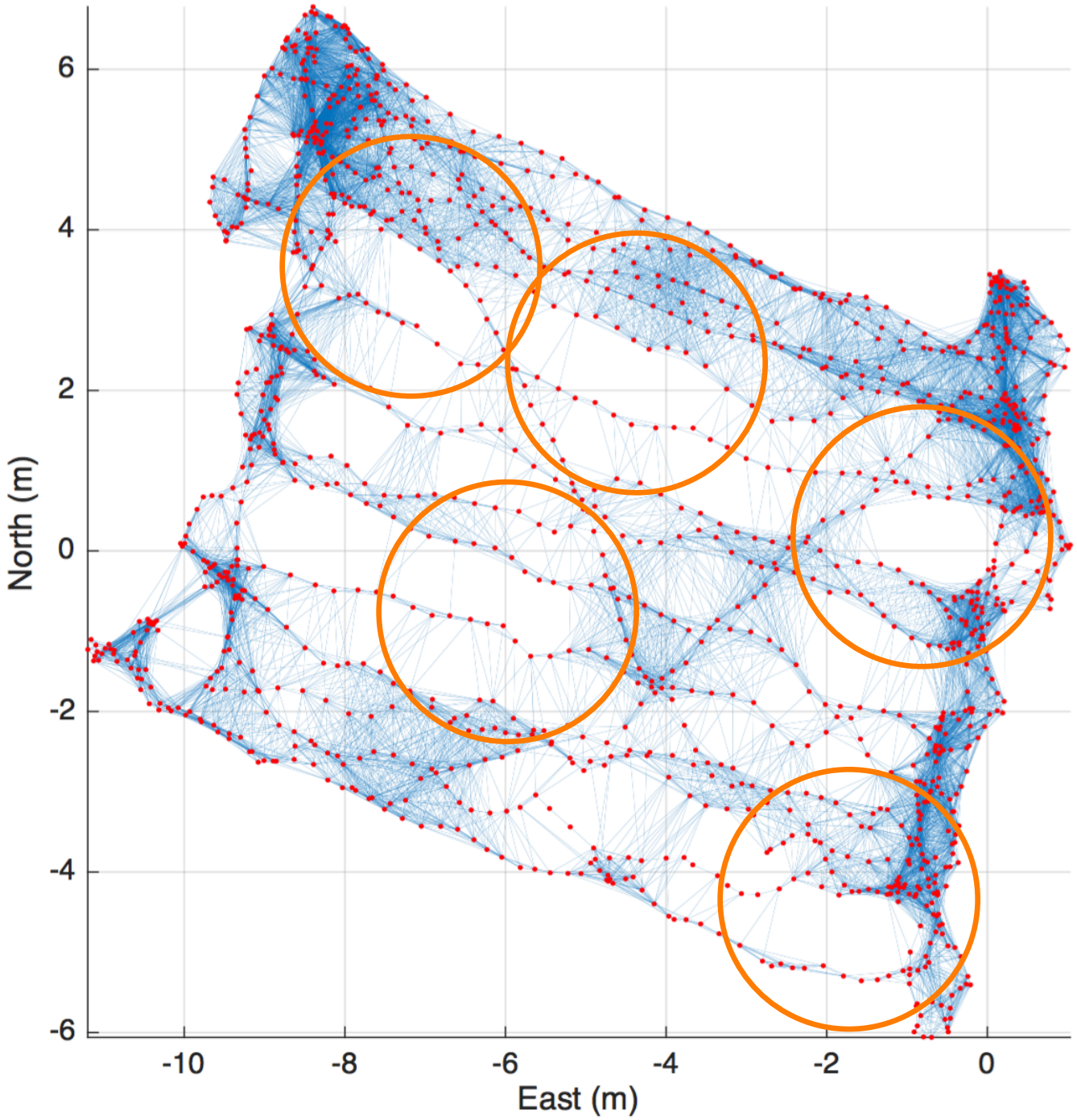

3D reconstructions from stereo
Underwater robot survey path
Accurate loop closures kilometers apart (SLAM)

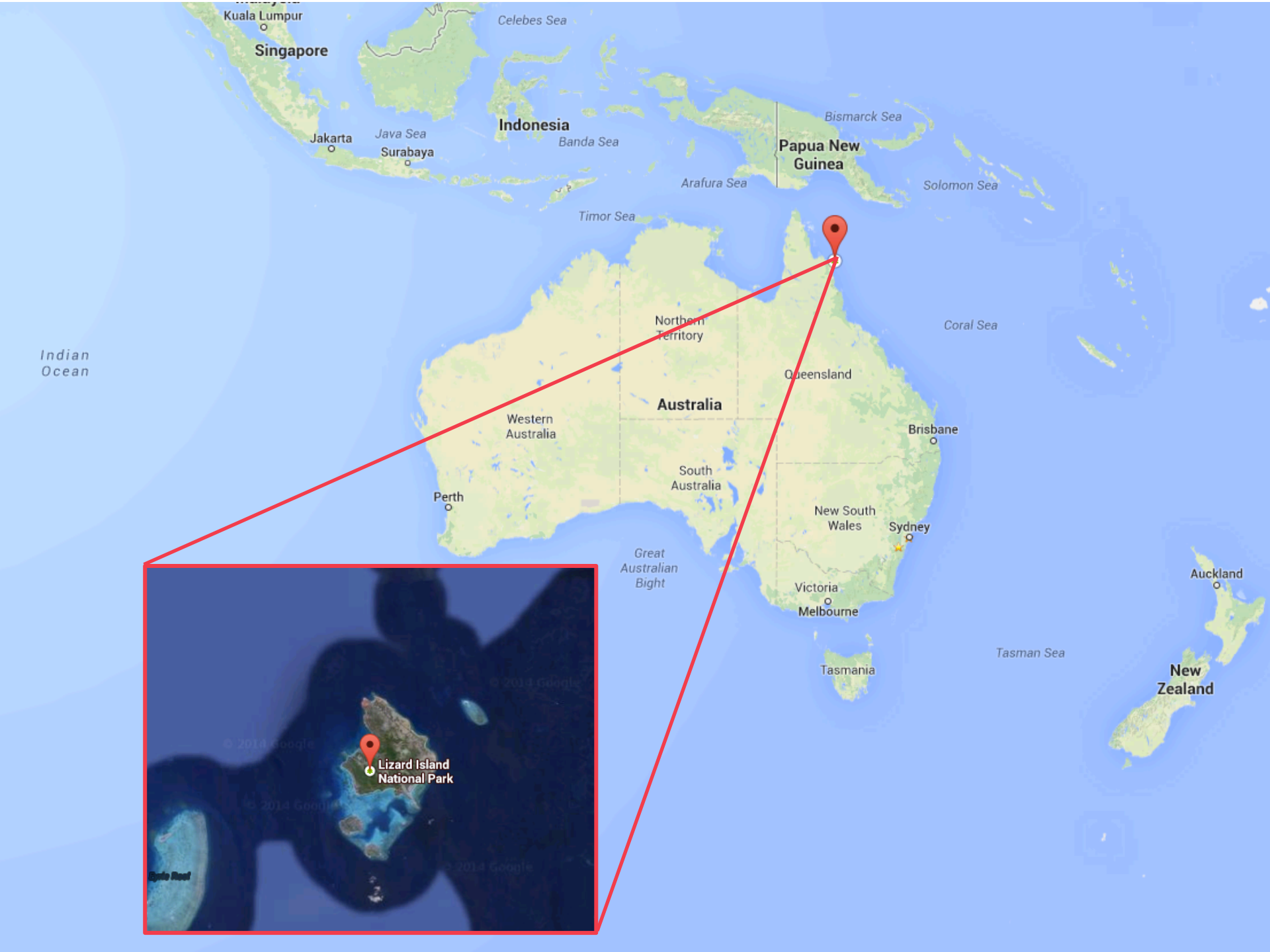
IMOS benthic monitoring program

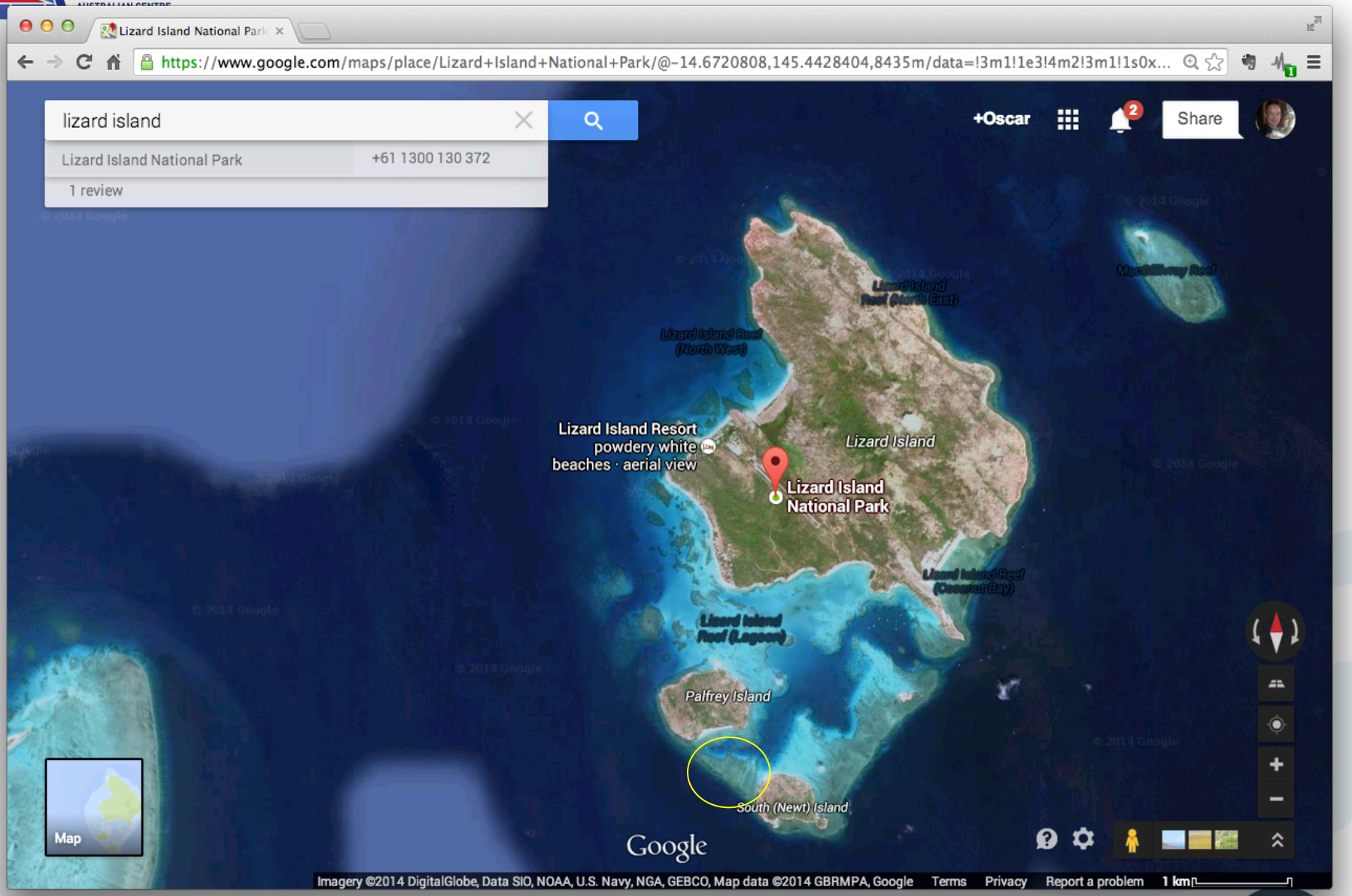


Australia's Network of Marine Protected Areas

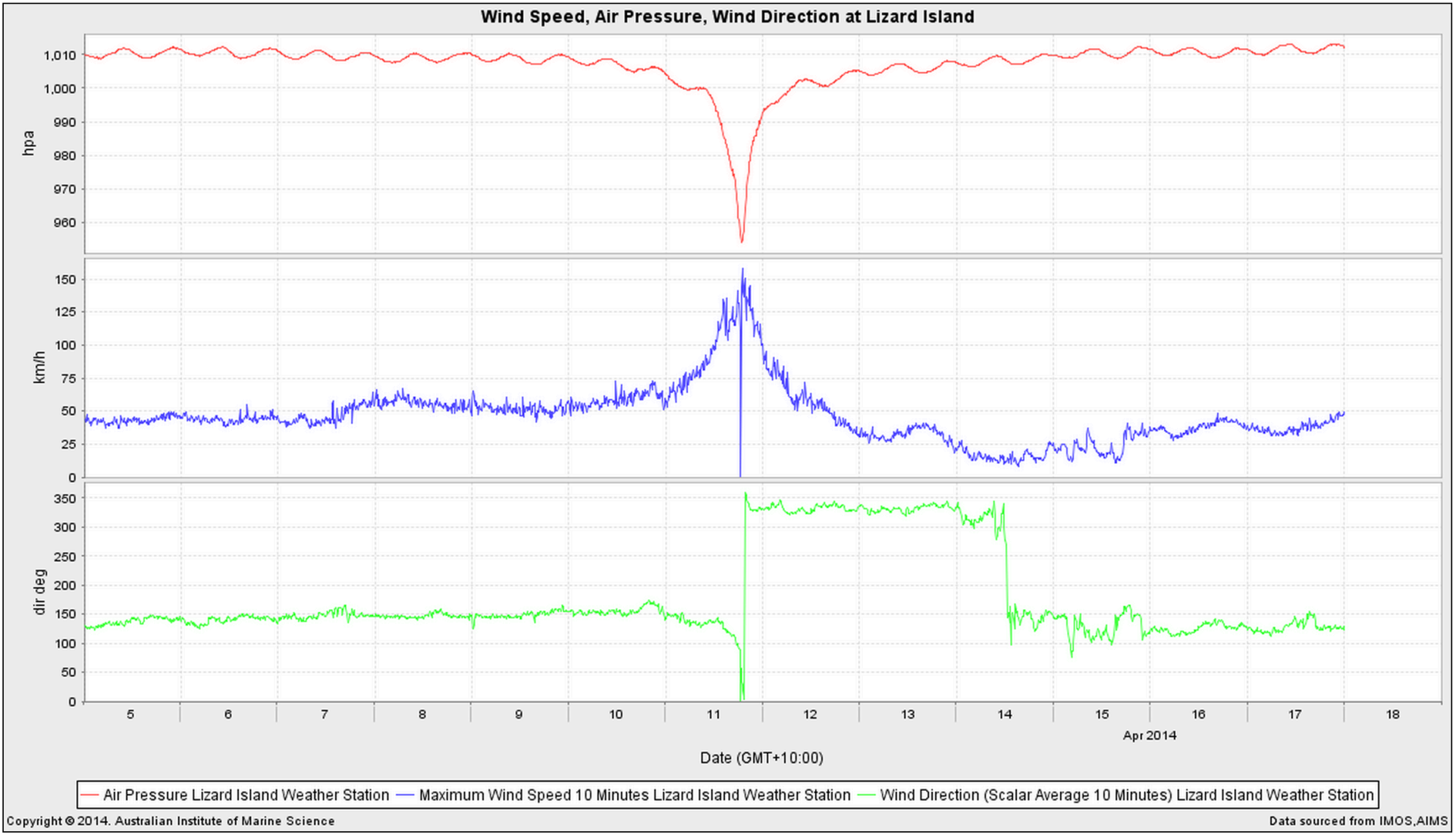



6
4
2
0
-2
-4
-6
North (m)
-10
-8
-6
-4
-2
0
East (m)


Kuala Lumpur
Singapore
Celebes Sea
Indonesia
Jakarta
Java Sea
Surabaya
Banda Sea
Bismarck Sea
Papua New Guinea
Arafura Sea
Solomon Sea
Timor Sea
Coral Sea
Indian Ocean
Northern Territory
Queensland
Australia
Western Australia
Brisbane
South Australia
Perth
New South Wales
Sydney
Great Australian Bight
Victoria
Melbourne
Auckland
Tasman Sea
Tasmania
New Zealand
Lizard Island National Park


Lizard Island National Park
https://www.google.com/maps/place/Lizard+Island+National+Park/@-14.6720808,145.4428404,8435m/data=!3m1!1e3!4m2!3m1!1s0x...
lizard island
Lizard Island National Park
+61 1300 130 372
1 review
+Oscar
Share
Lizard Island Resort
powdery white beaches · aerial view
Lizard Island
Lizard Island National Park
Palfrey Island
South (Newt) Island
Map
Google
Imagery ©2014 DigitalGlobe, Data SIO, NOAA, U.S. Navy, NGA, GEBCO, Map data ©2014 GBRMPA, Google
Terms
Privacy
Report a problem
1 km

Cyclone Ita path



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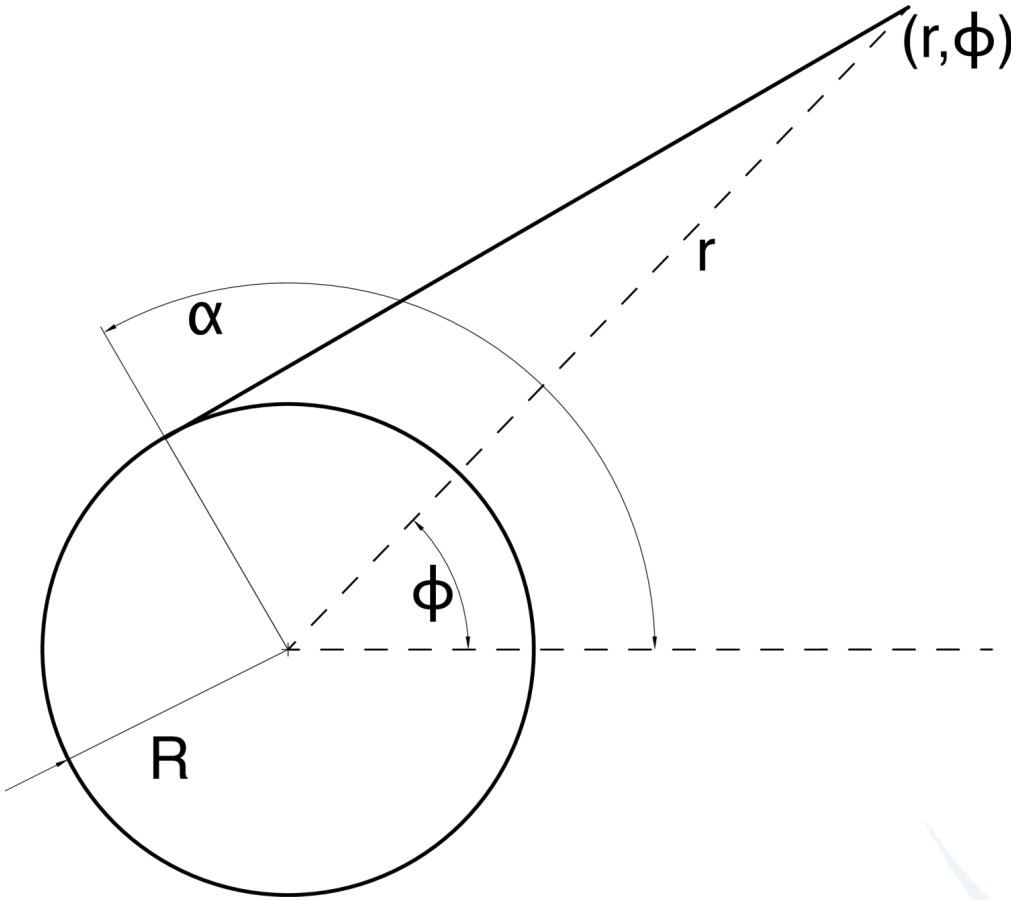
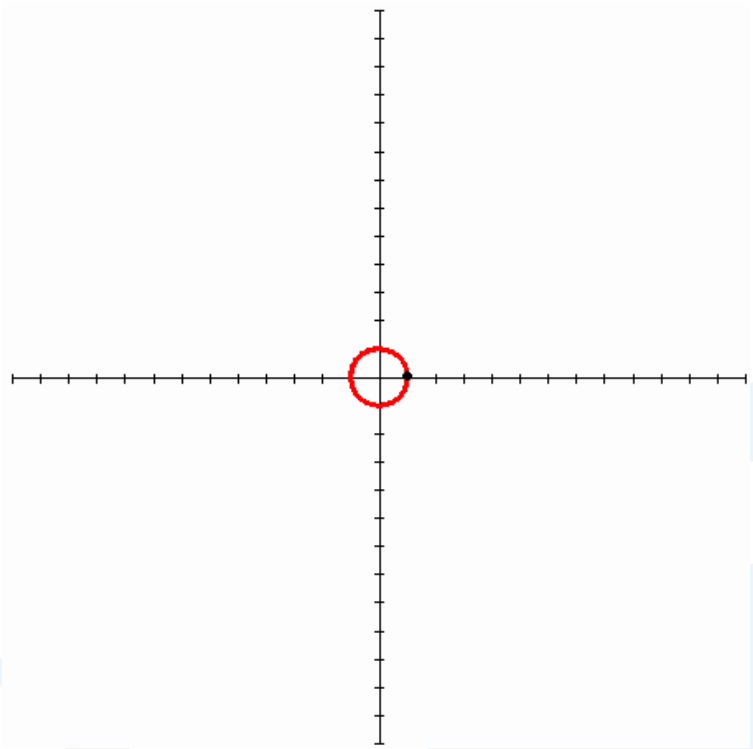
AUSTRALIAN CENTRE
FOR FIELD ROBOTICS

S

Involute of a circle



$$L = \frac{R}{2} \cdot \alpha^2$$



$$r = R \cdot \sqrt{1 + \alpha^2}$$

$$\phi = \alpha - \arctan \alpha$$

By Van helsing - Own work, CC BY 2.5, https://commons.wikimedia.org/w/index.php?curid=2533730

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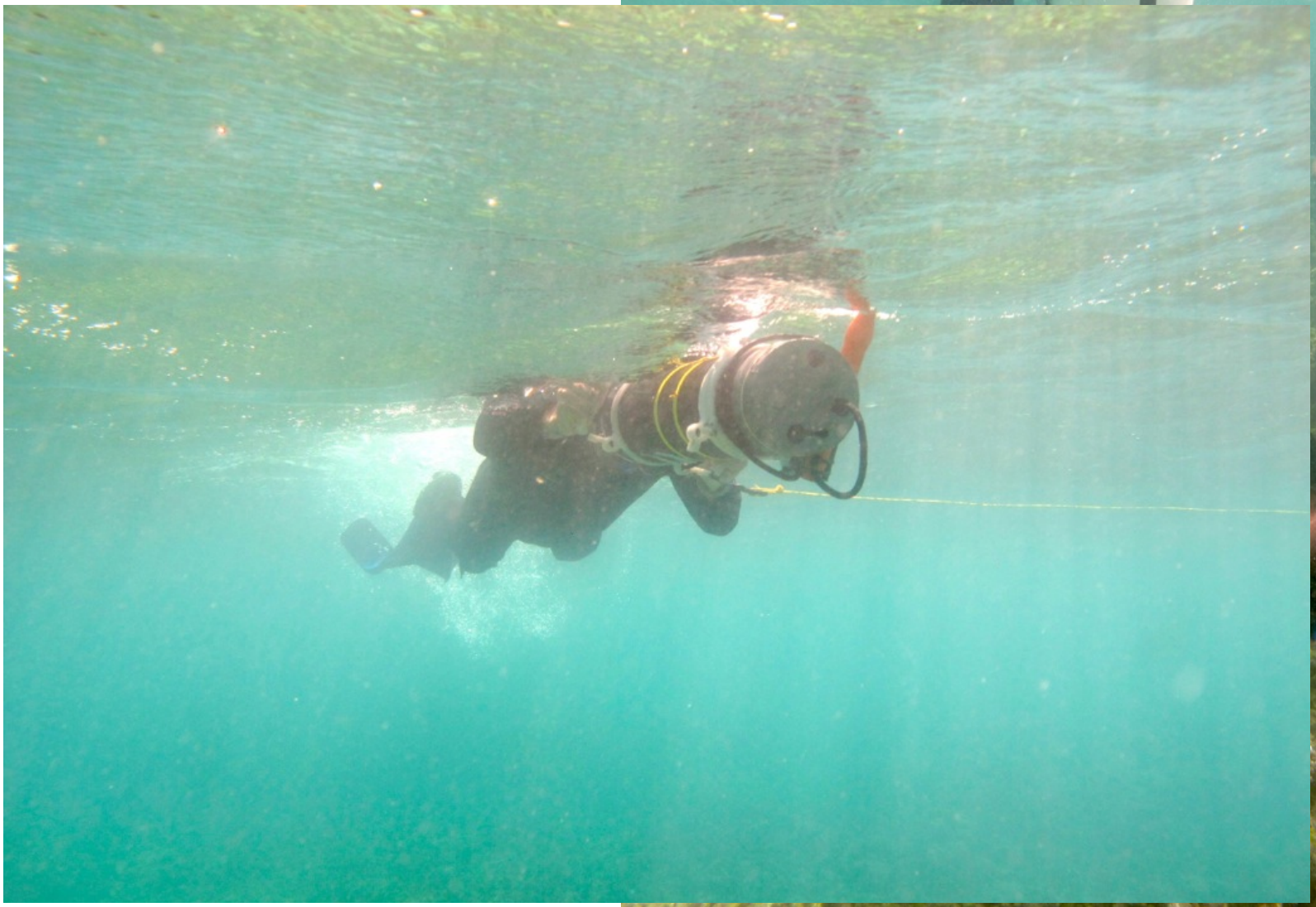
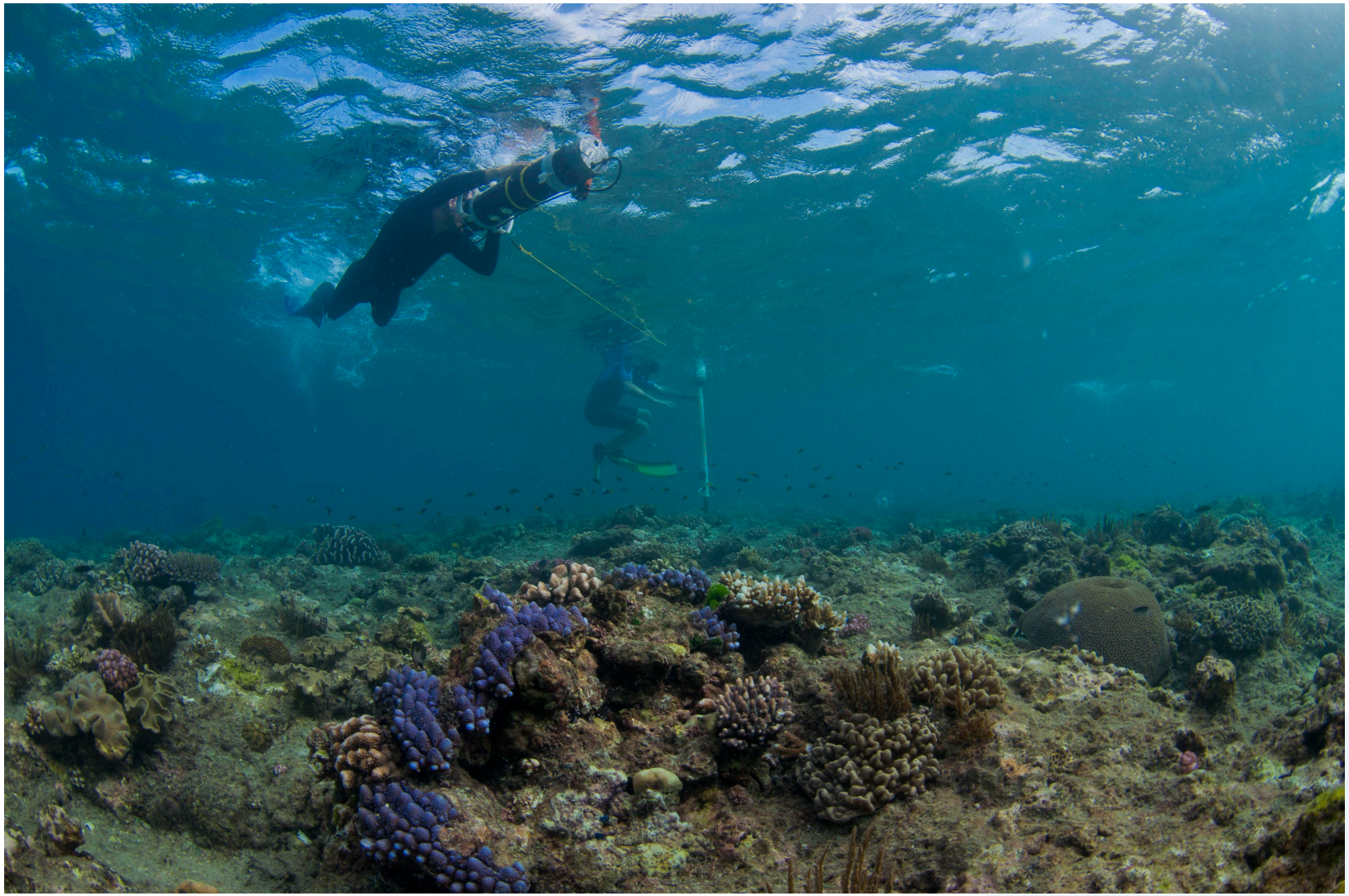
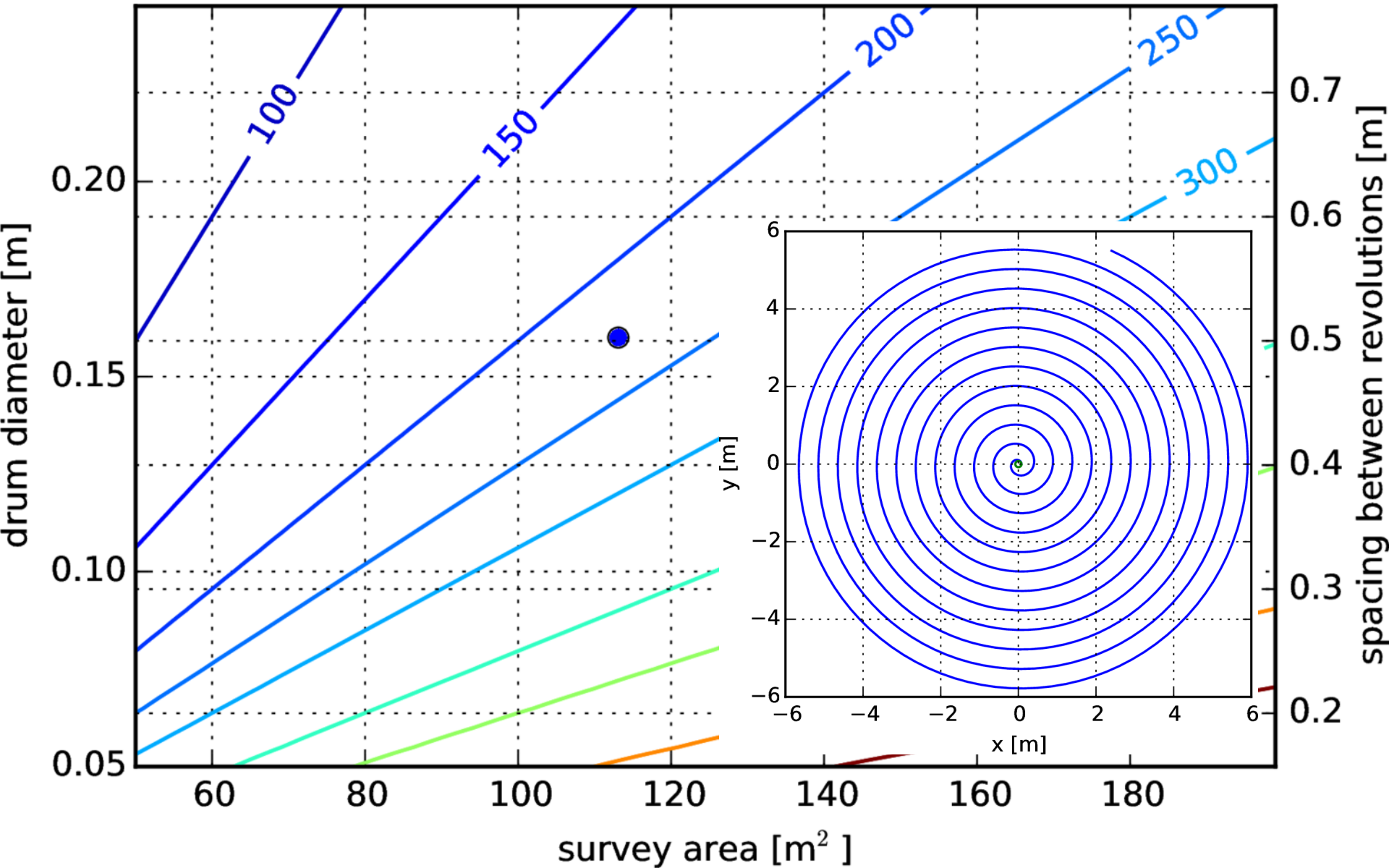
D2

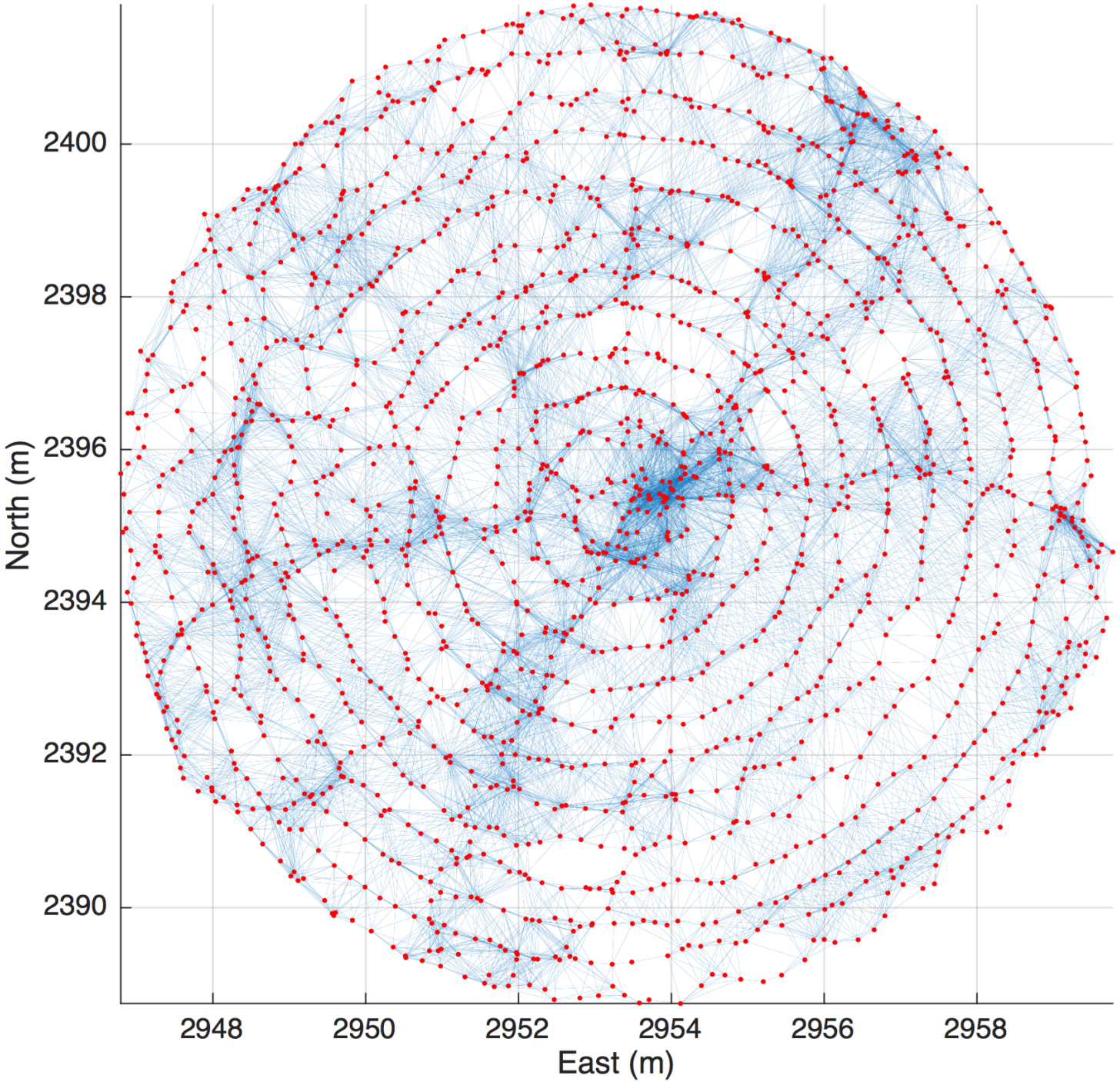


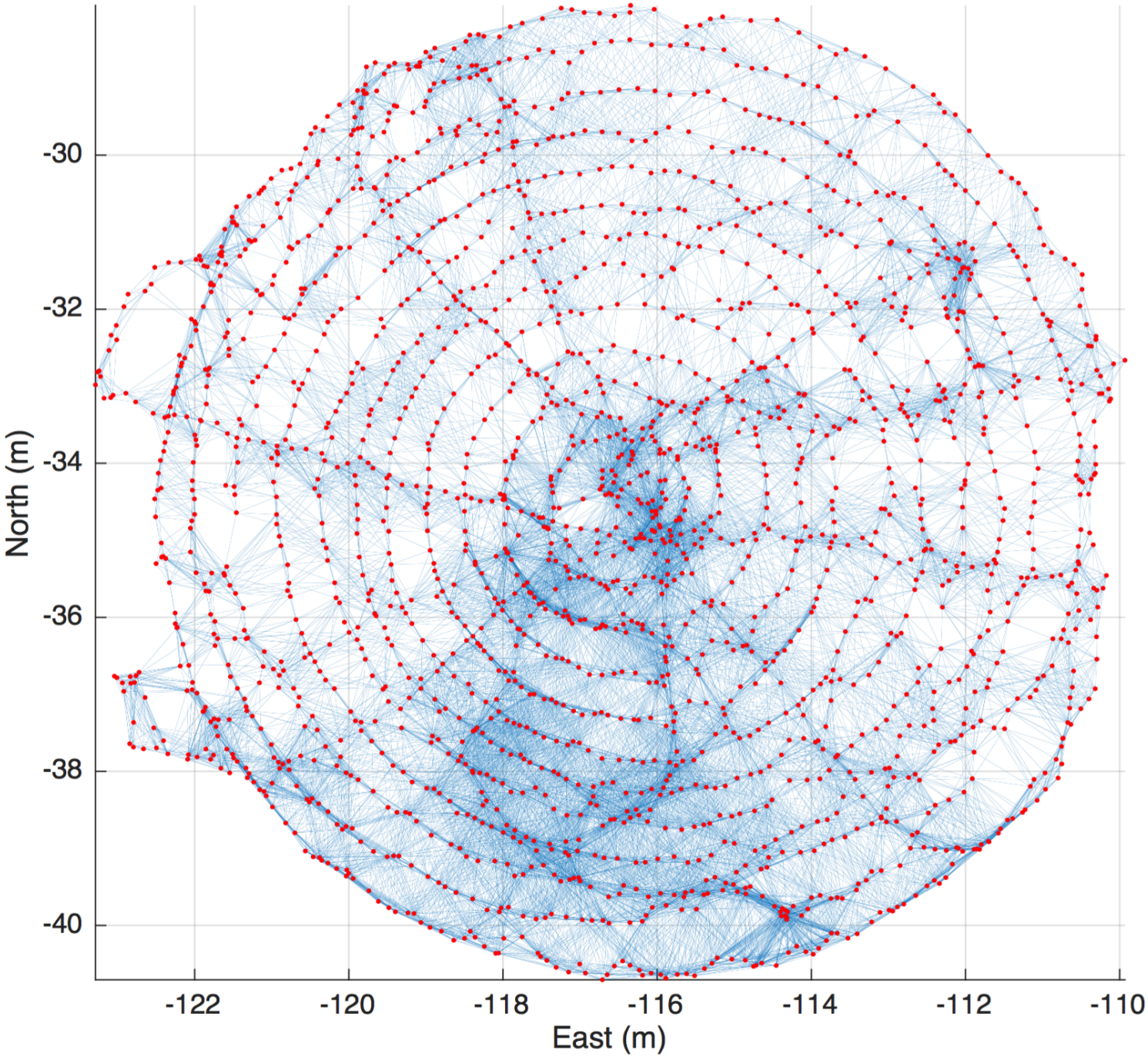
Lizard Island post cyclone surveys

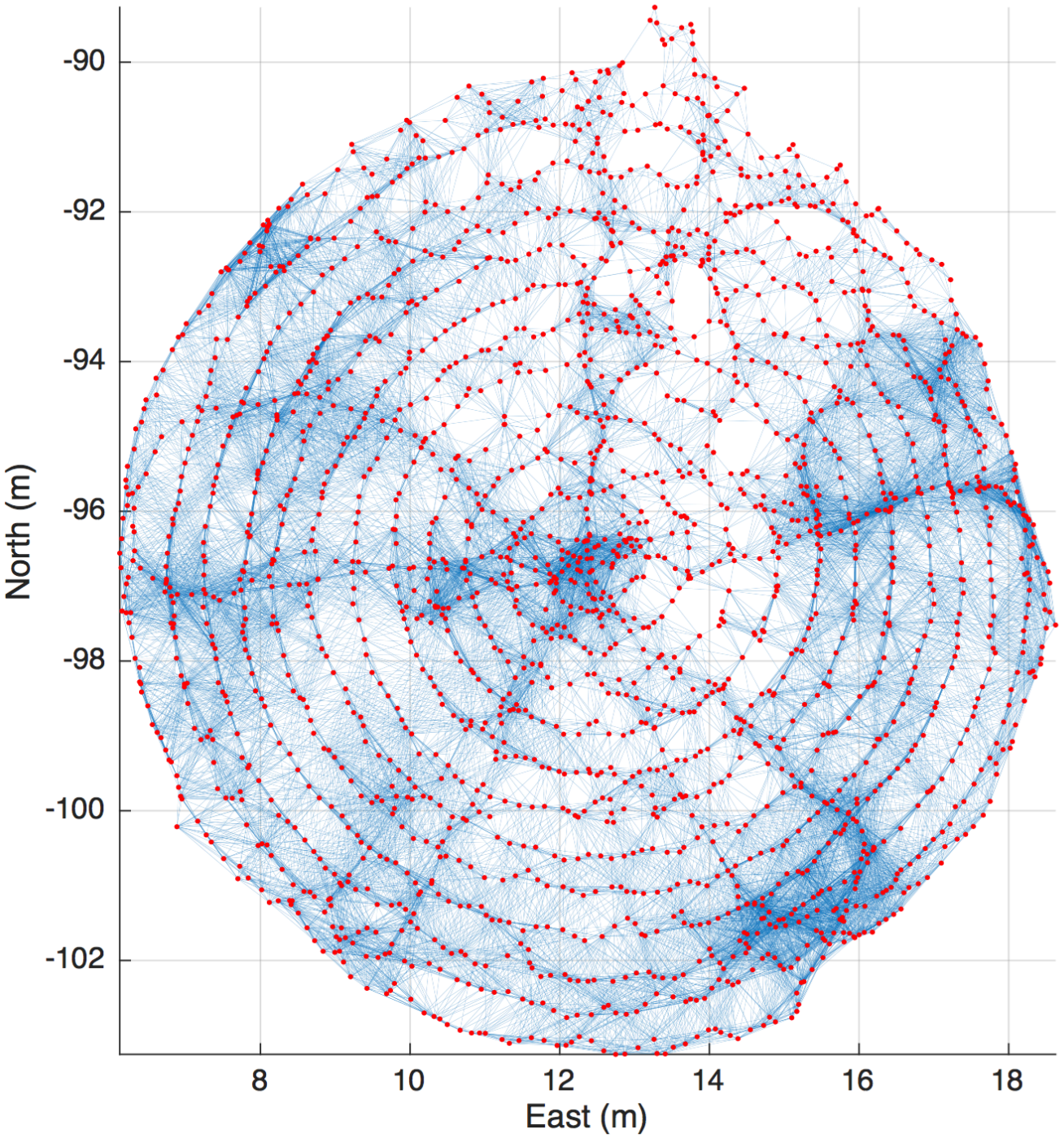


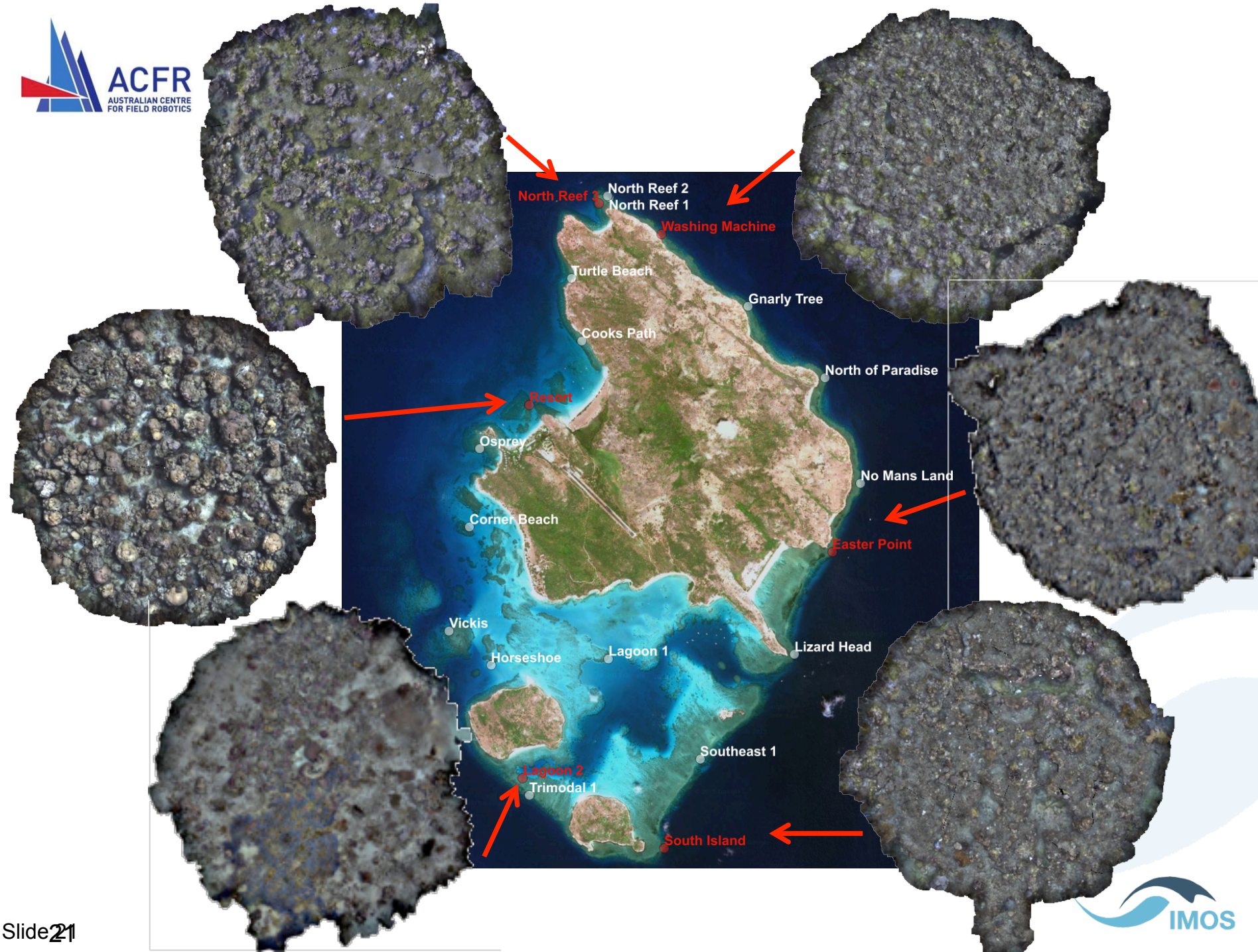
Path Length, area and spacing design curve




2400
2398
2396
2394
2392
2390
North (m)
2948
2950
2952
2954
2956
2958
East (m)


-30
-32
-34
-36
-38
-40
North (m)
-122
-120
-118
-116
-114
-112
-110
East (m)


-90
-92
-94
-96
-98
-100
-102
North (m)
8
10
12
14
16
18
East (m)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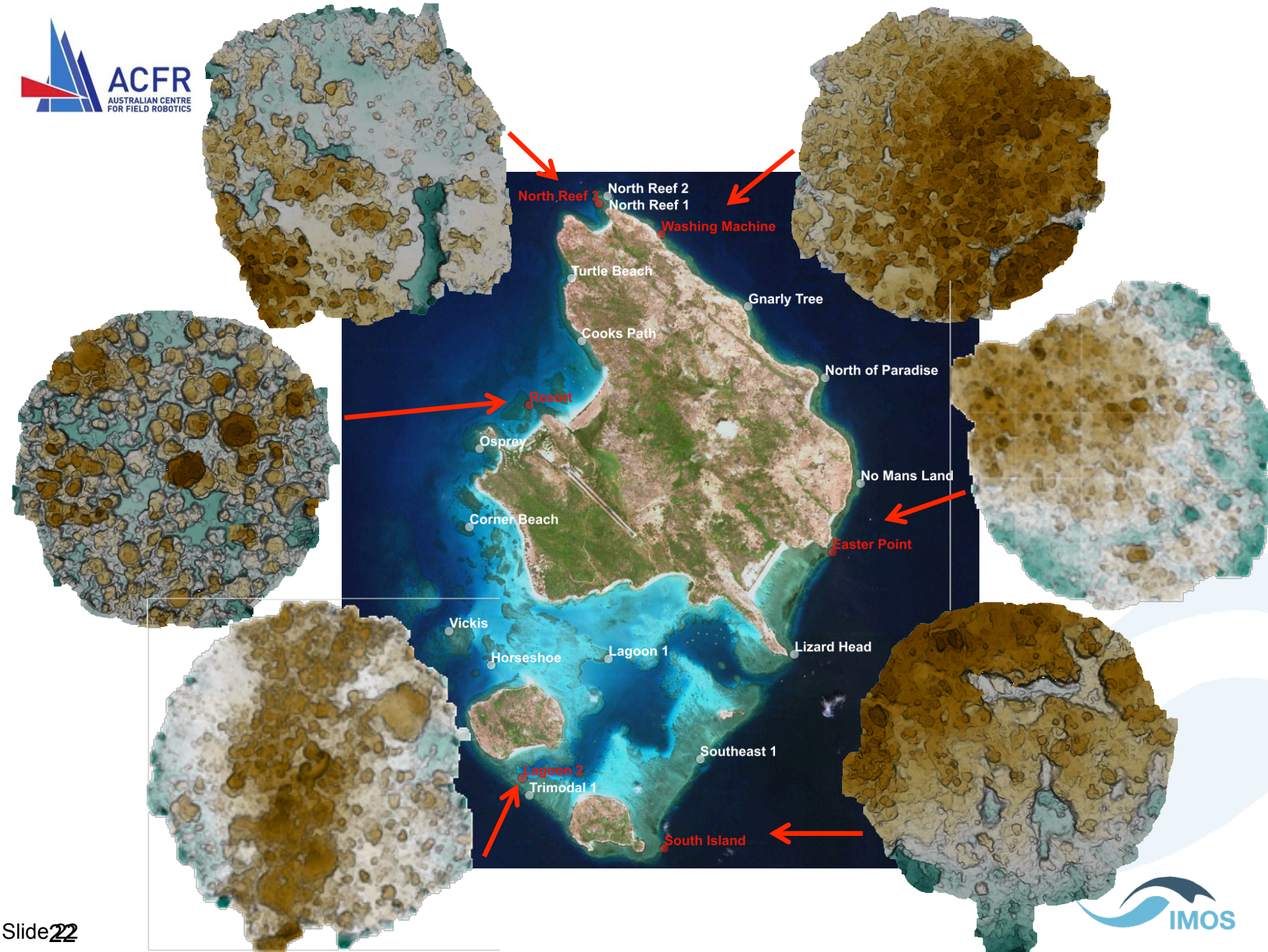
North Reef 3
North Reef 2
North Reef 1
Washing Machine
Turtle Beach
Gnarly Tree
Cooks Path
North of Paradise
Resort
Osprey
No Mans Land
Corner Beach
Easter Point
Vickis
Horseshoe
Lagoon 1
Lizard Head
Southeast 1
Lagoon 2
Trimodal 1
South Island
IMOS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North Reef 3
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South Island
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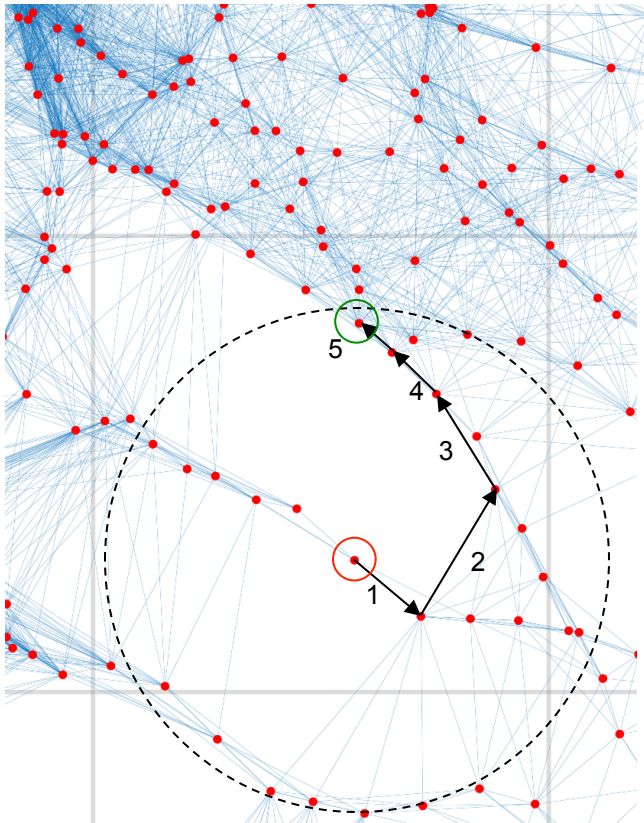
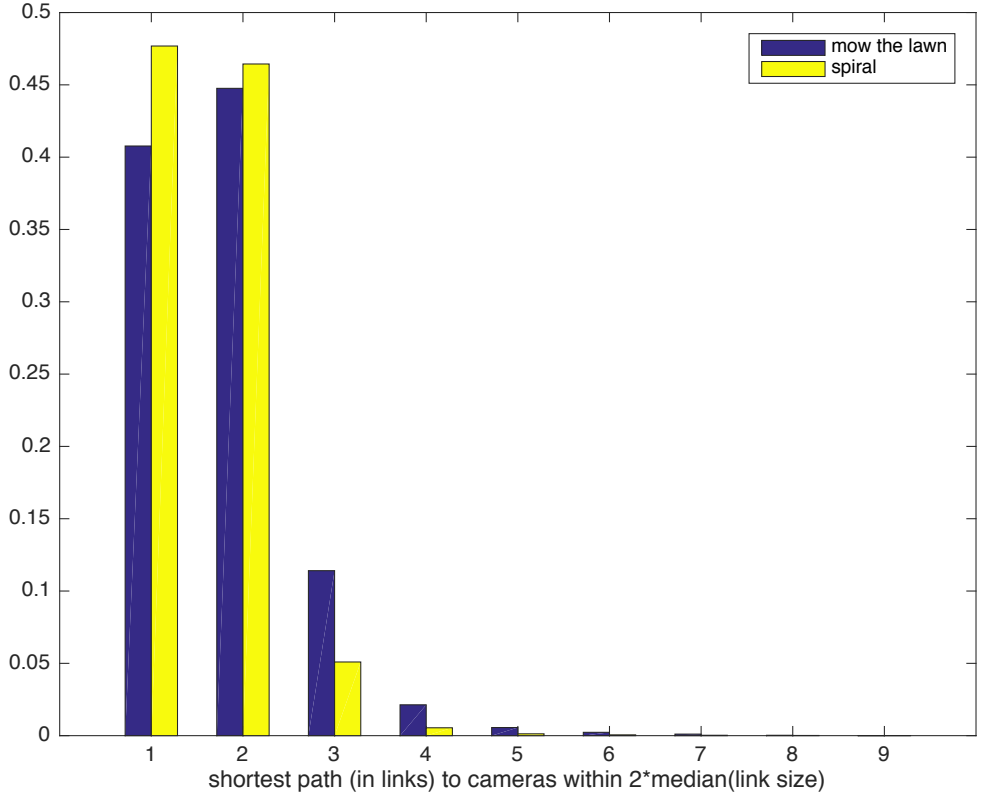

5
4
3
2
1


mow the lawn
spiral
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1
2
3
4
5
6
7
8
9
shortest path (in links) to cameras within 2*median(link size)

‘Reef Records’

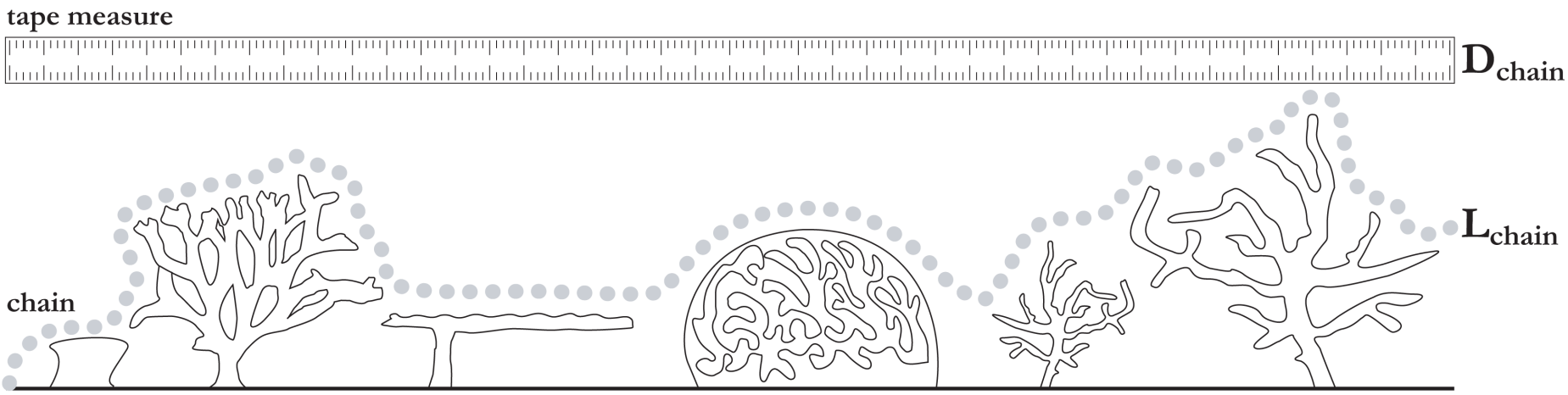
- High overlap by design
- Robust to swell and current
- Easy line handling underwater
- Monitoring through revisiting sites
- Visible range, 6m radius
- ~110m^2 area

	Avg.	Std. Dev.	Max.	Min.
Duration	15:26	01:43	18:47	12:58
Stereo pairs	1853	205.3	2255	1557
Image matches	19286.3	7098.1	33168	6194

Lizard Island – post cyclones ITA (and Nathan)

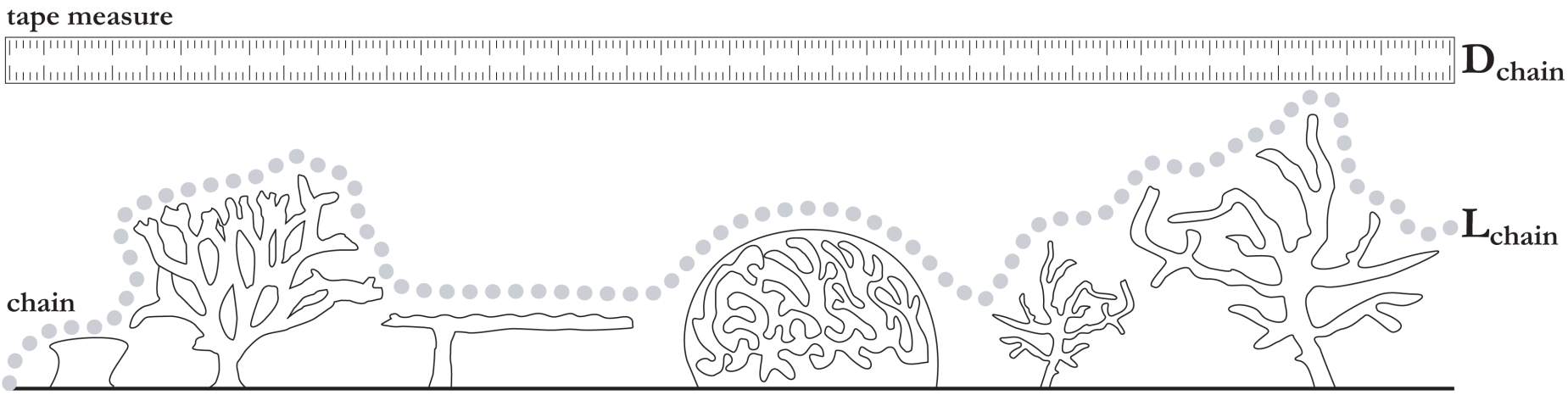
- APR 2014: 7 days, 23 sites
- OCT 2014:
  7 days, 23 sites
- APR 2015:
  5 days, 21+ sites
- NOV 2015, 21+ sites
- Data processed and delivered in field
- NOV 2016, 21+ sites

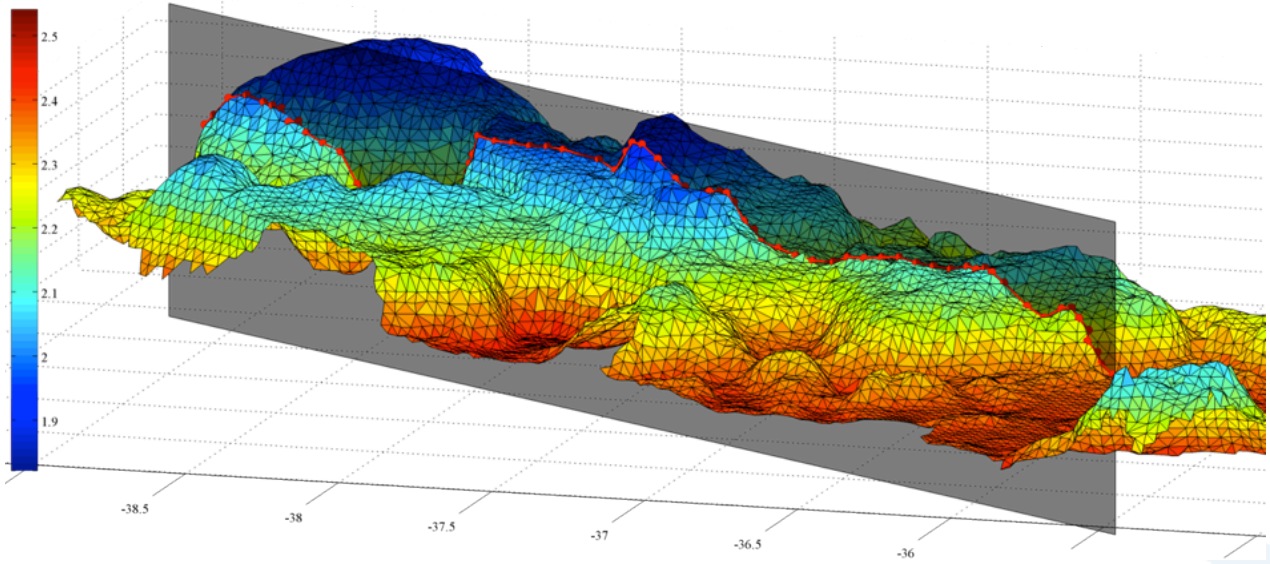
Structural Complexity Measurement: Rugosity



Friedman et. al. 2013, Multi-scale measures of rugosity, slope and aspect from benthic stereo image reconstructions

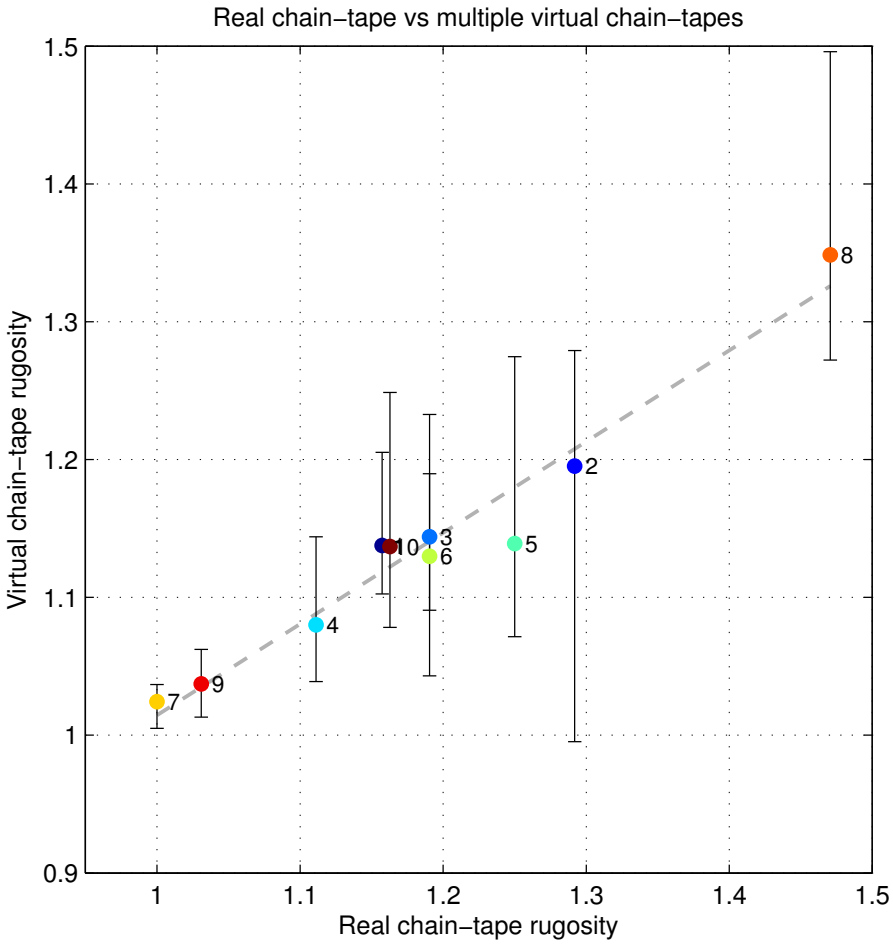
Structural Complexity Measurement: Rugosity

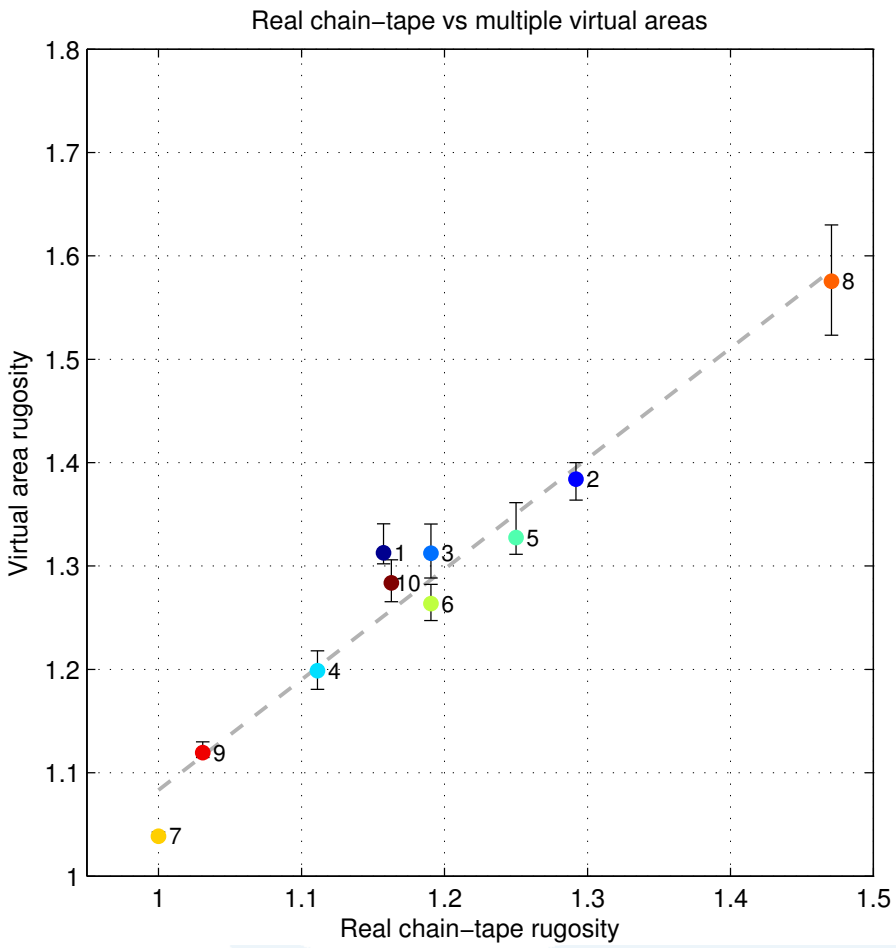




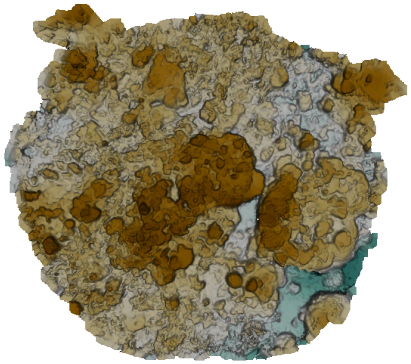
Friedman et. al. 2013, Multi-scale measures of rugosity, slope and aspect from benthic stereo image reconstructions

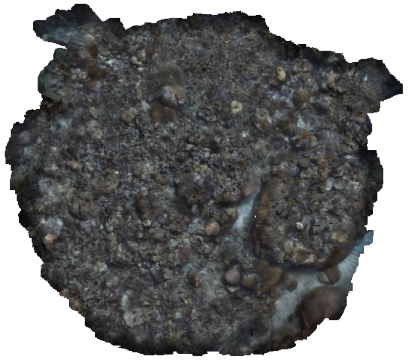
Real Chain to Virtual chain



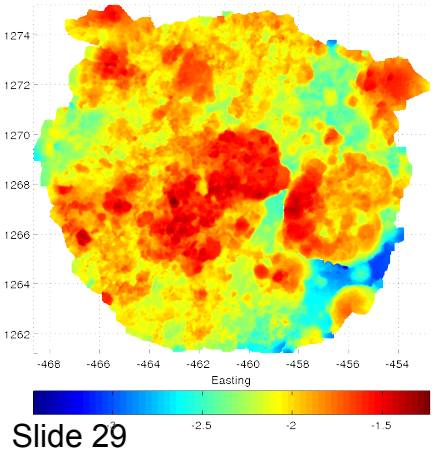


Mosaic





Depth

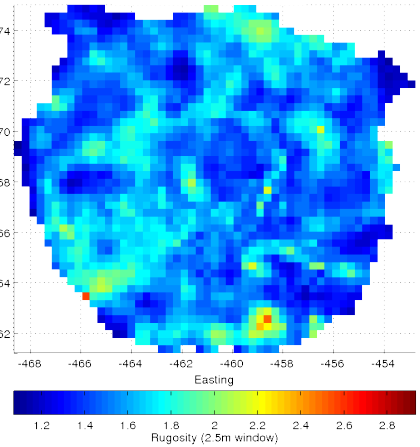


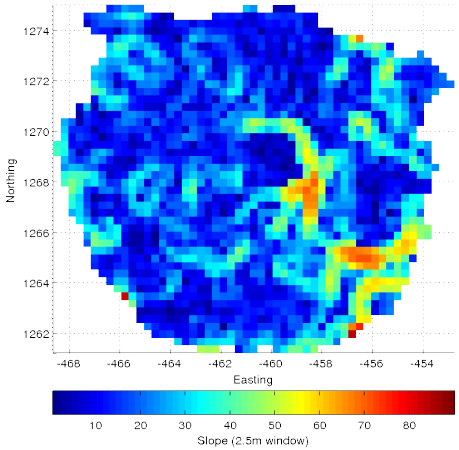
Rugosity

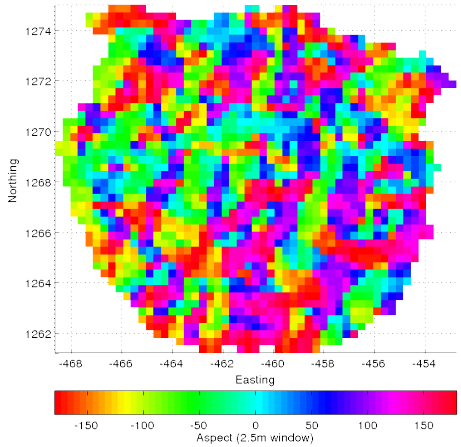
Slope

Aspect

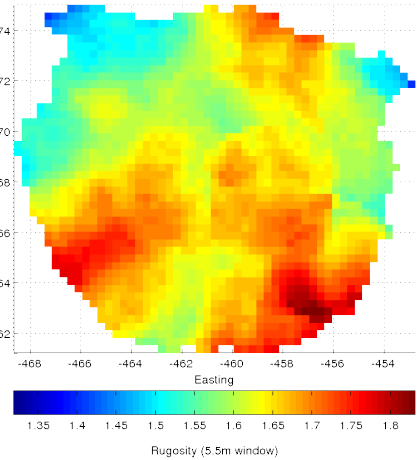
0.5m

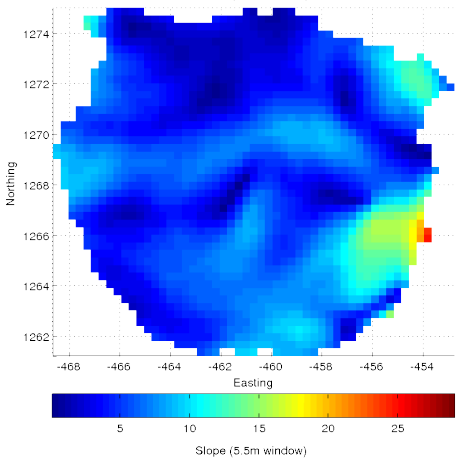


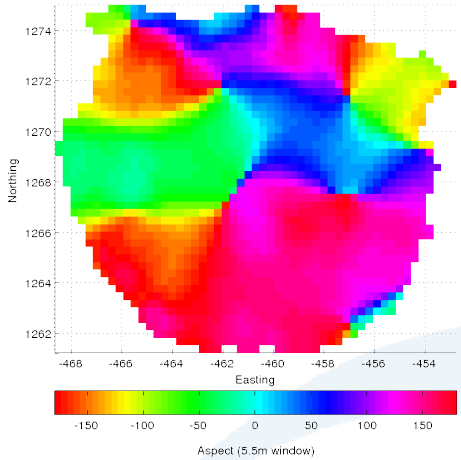




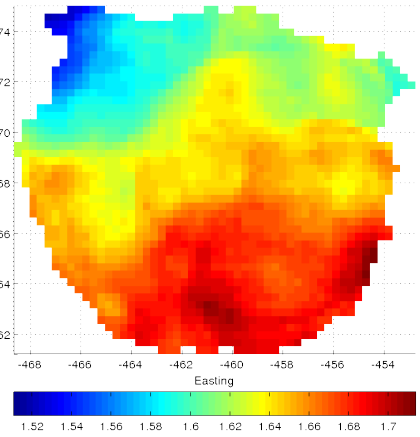
2.5m

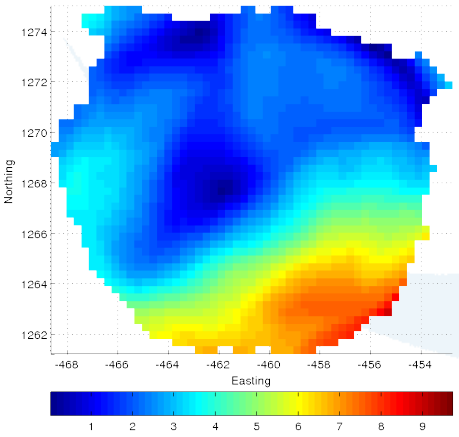


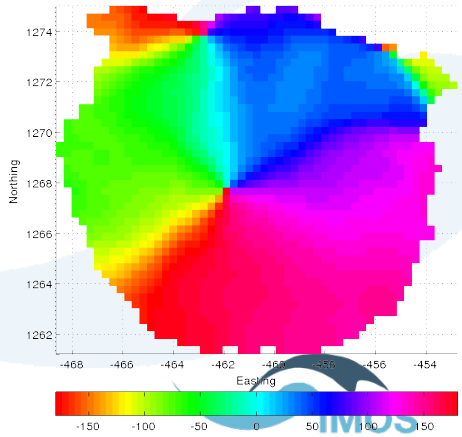




5.5m







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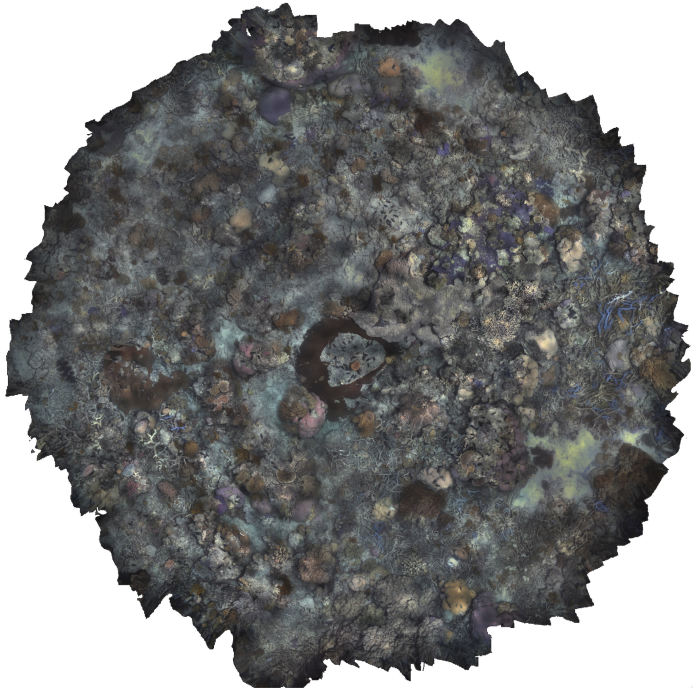
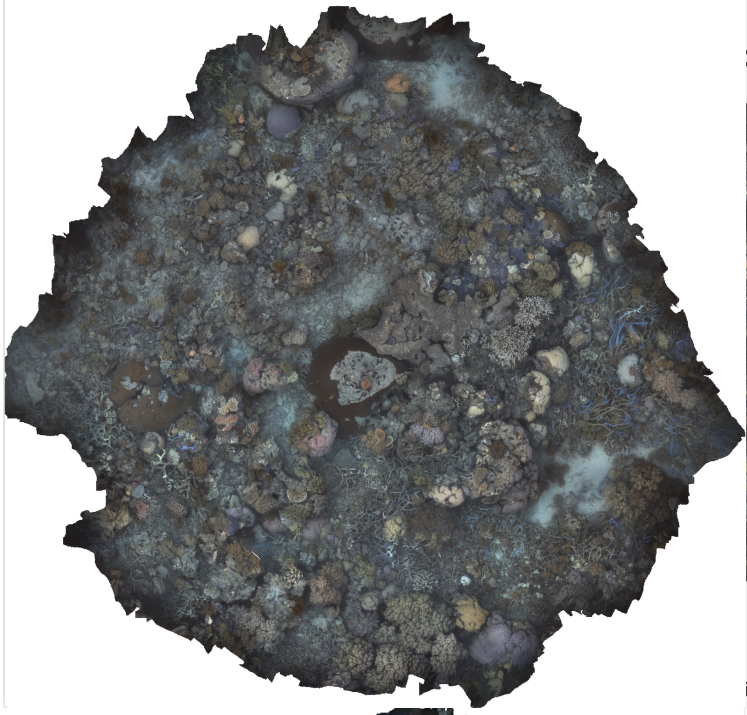
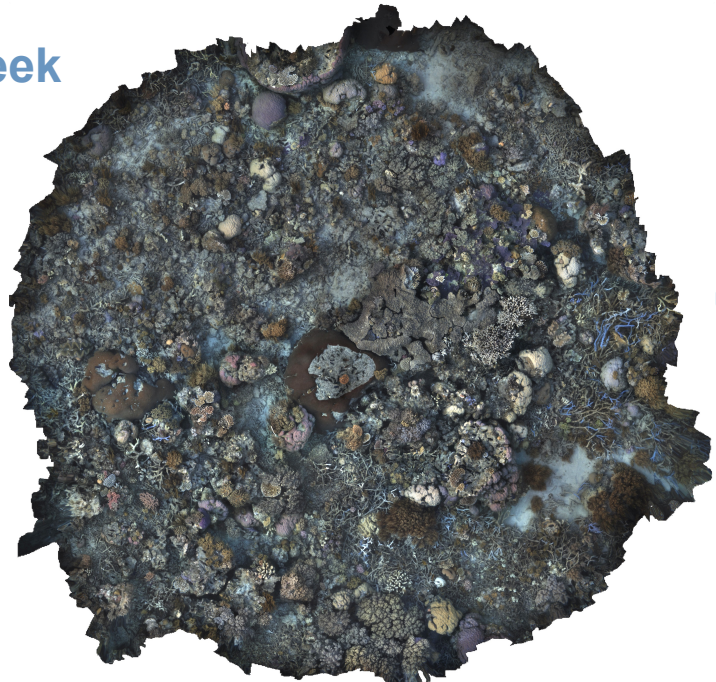
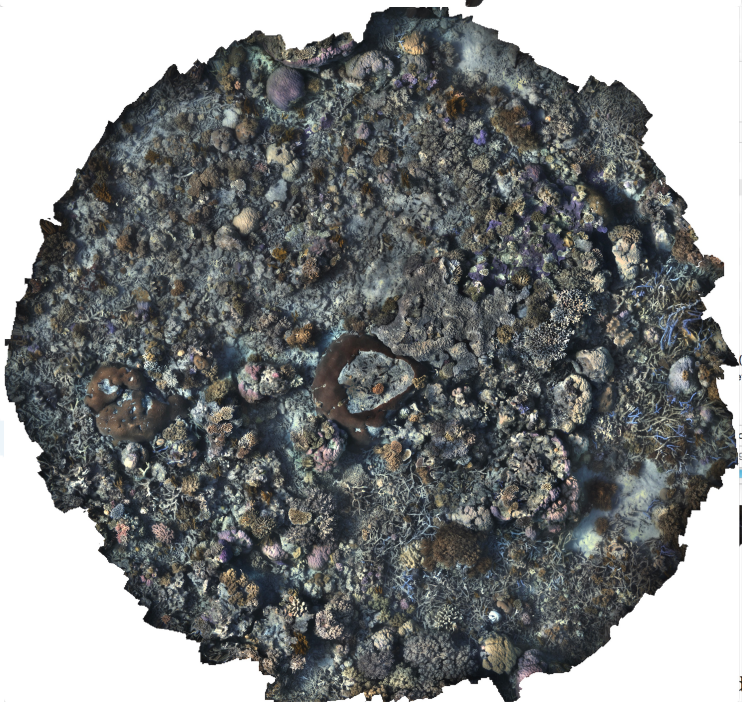
Horseshoe reefrecord Repeated OCT 2014 x4 over one week

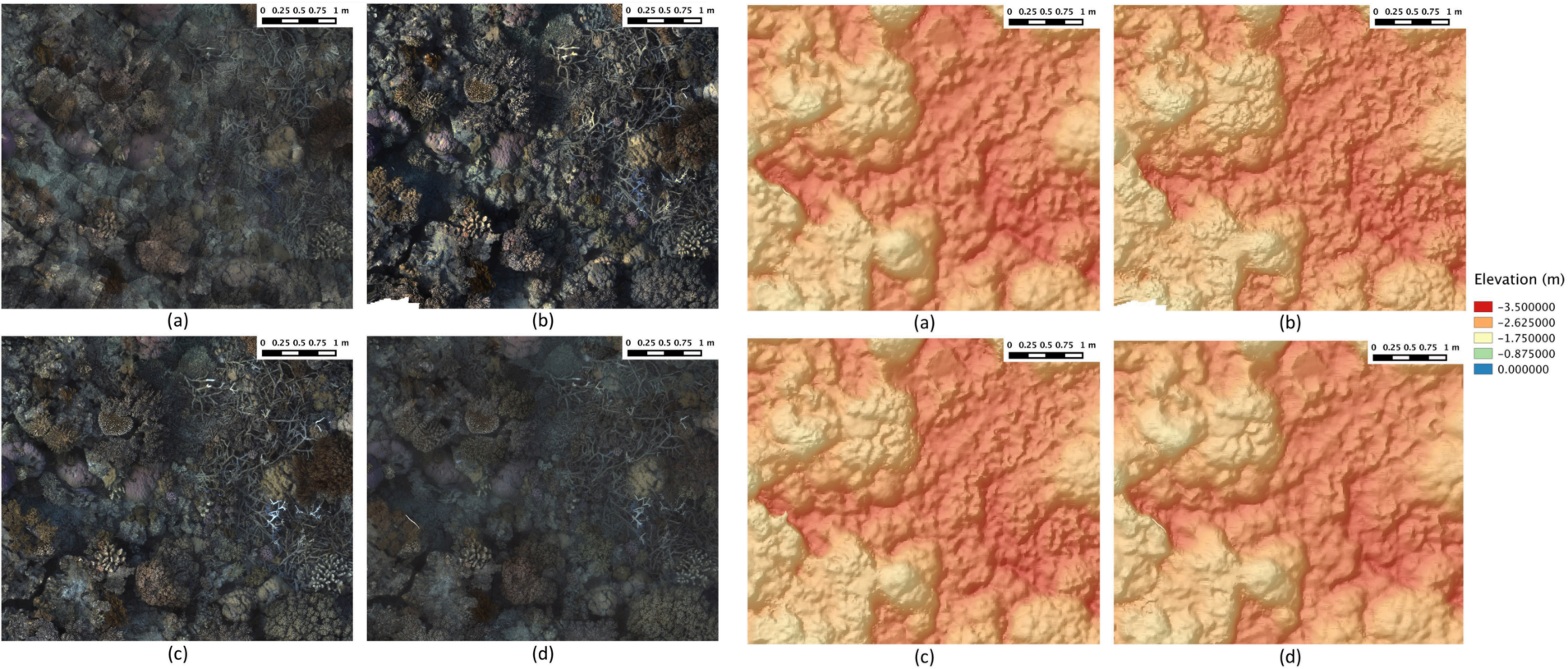




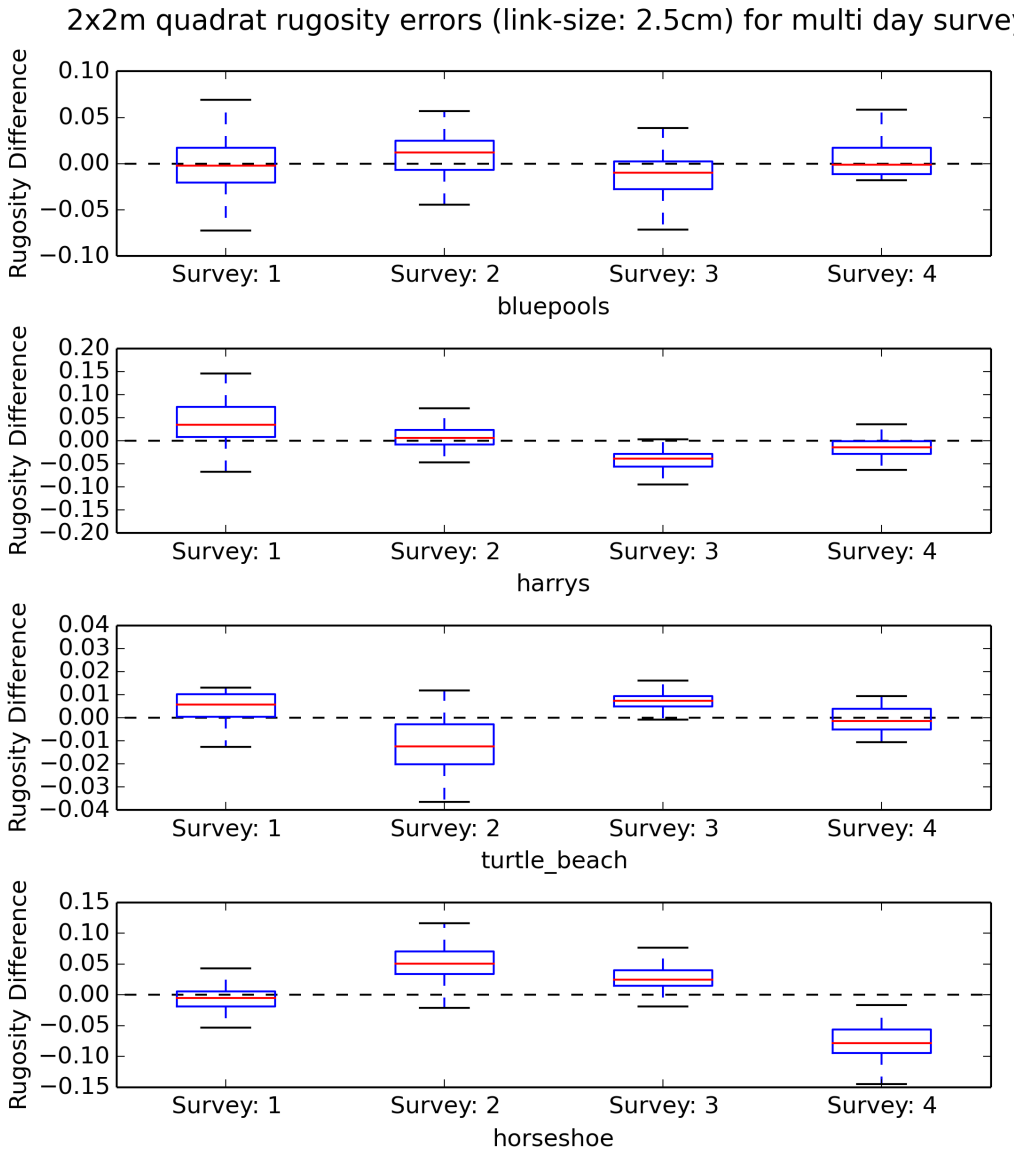




Horseshoe reefrecord repeats

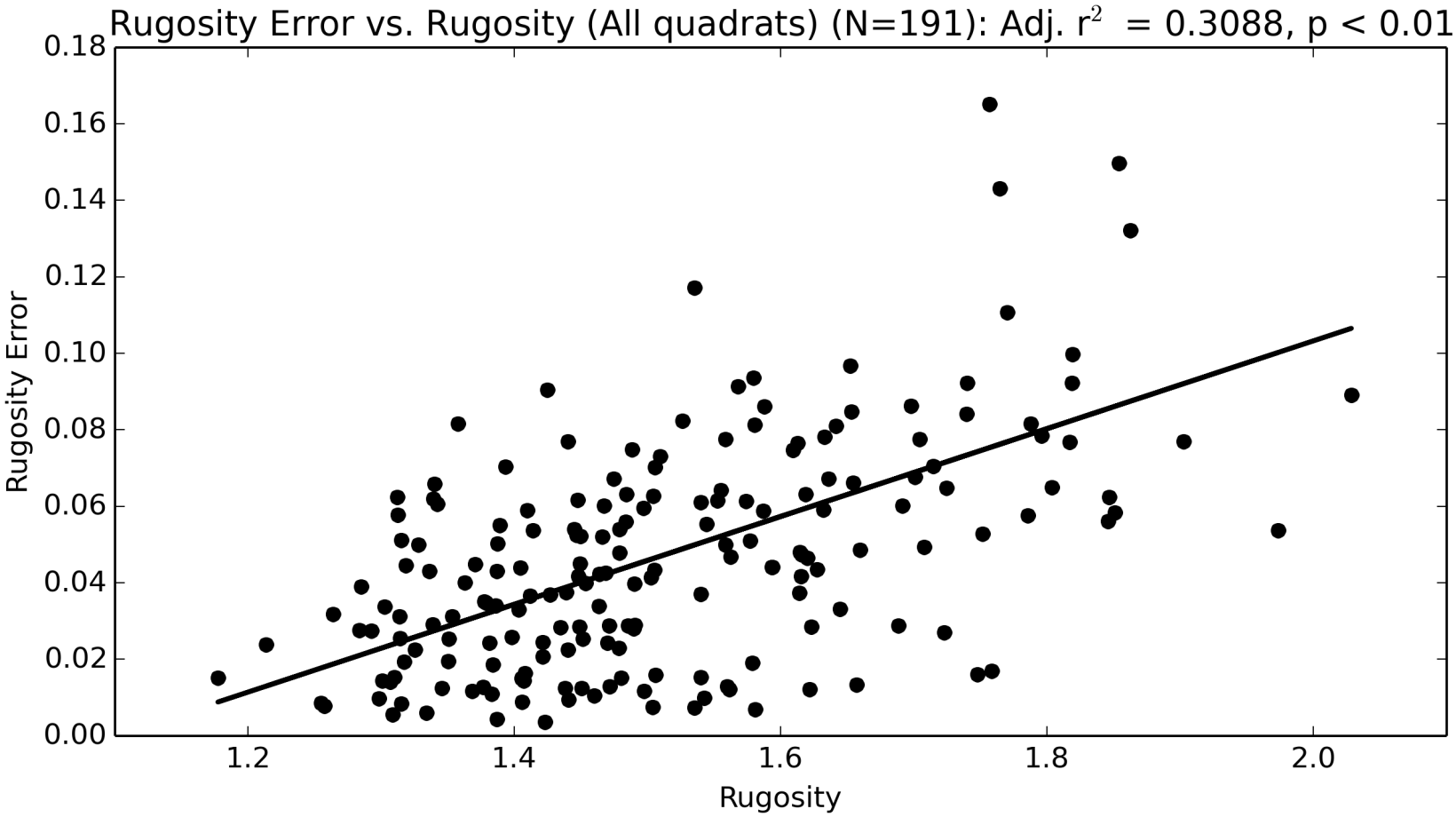


Results: distribution of rugosity errors for each specific survey time

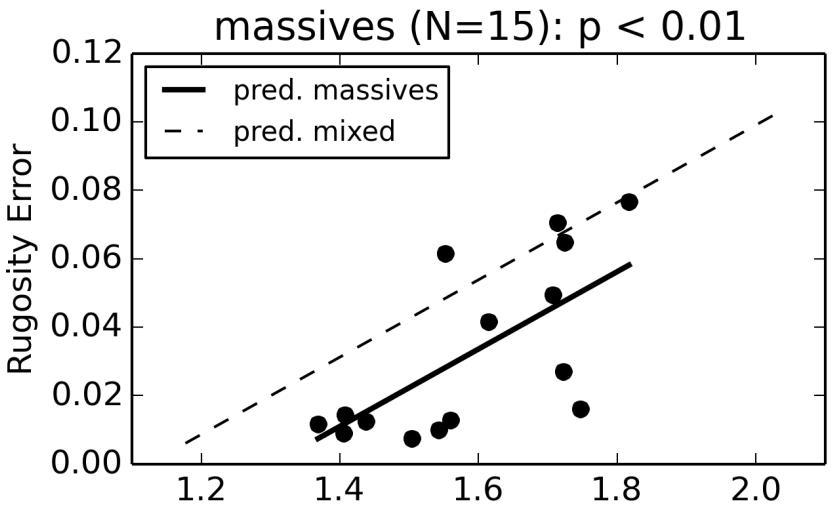


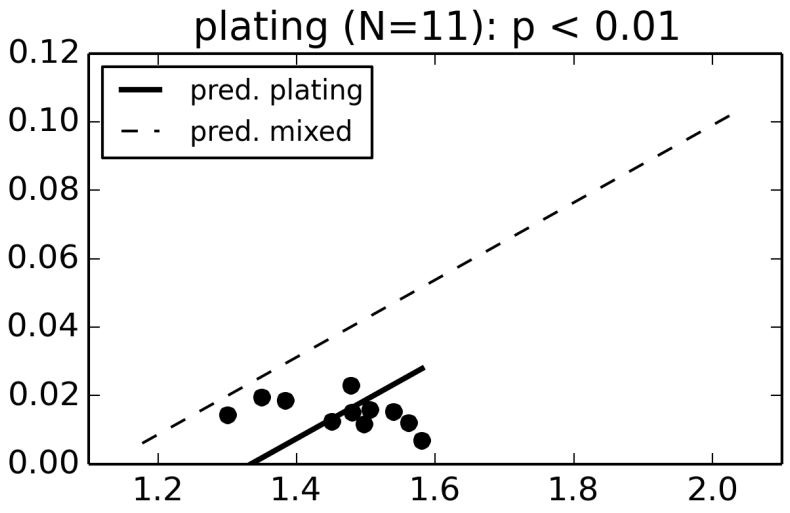
- For both single day and multiple day surveys, some sites exhibited significant per-survey biases (up to 7.5% of rugosity range)
- Highlights the importance in changes in survey conditions and survey trajectory parameters having a large influence on the actual measurements being made

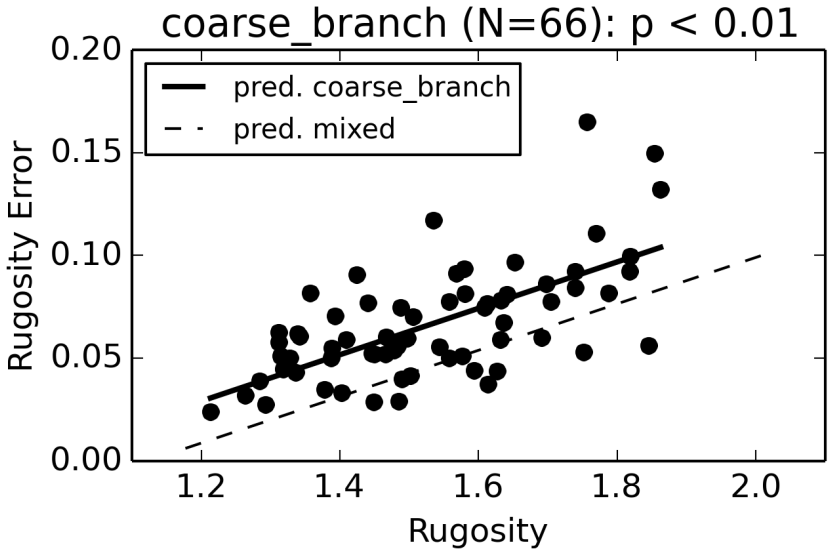
SC measurement errors vs. mean rugosity

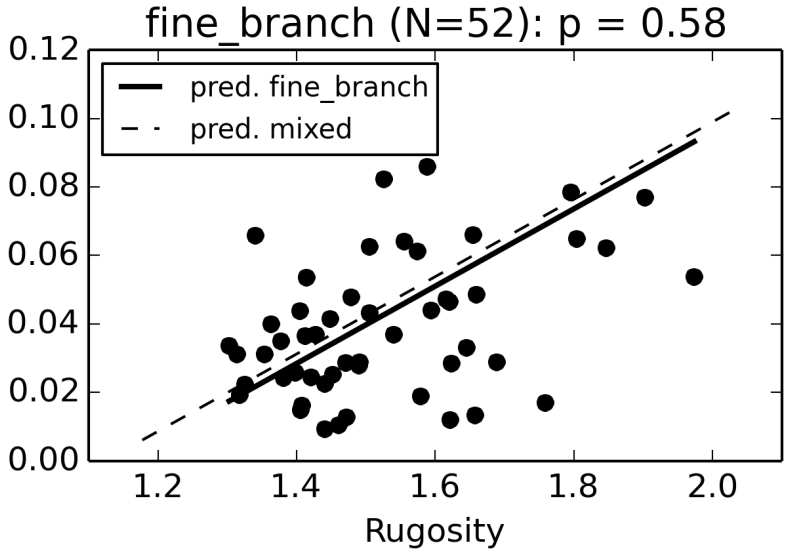


SC measurement errors vs. mean rugosity and coral morphotype

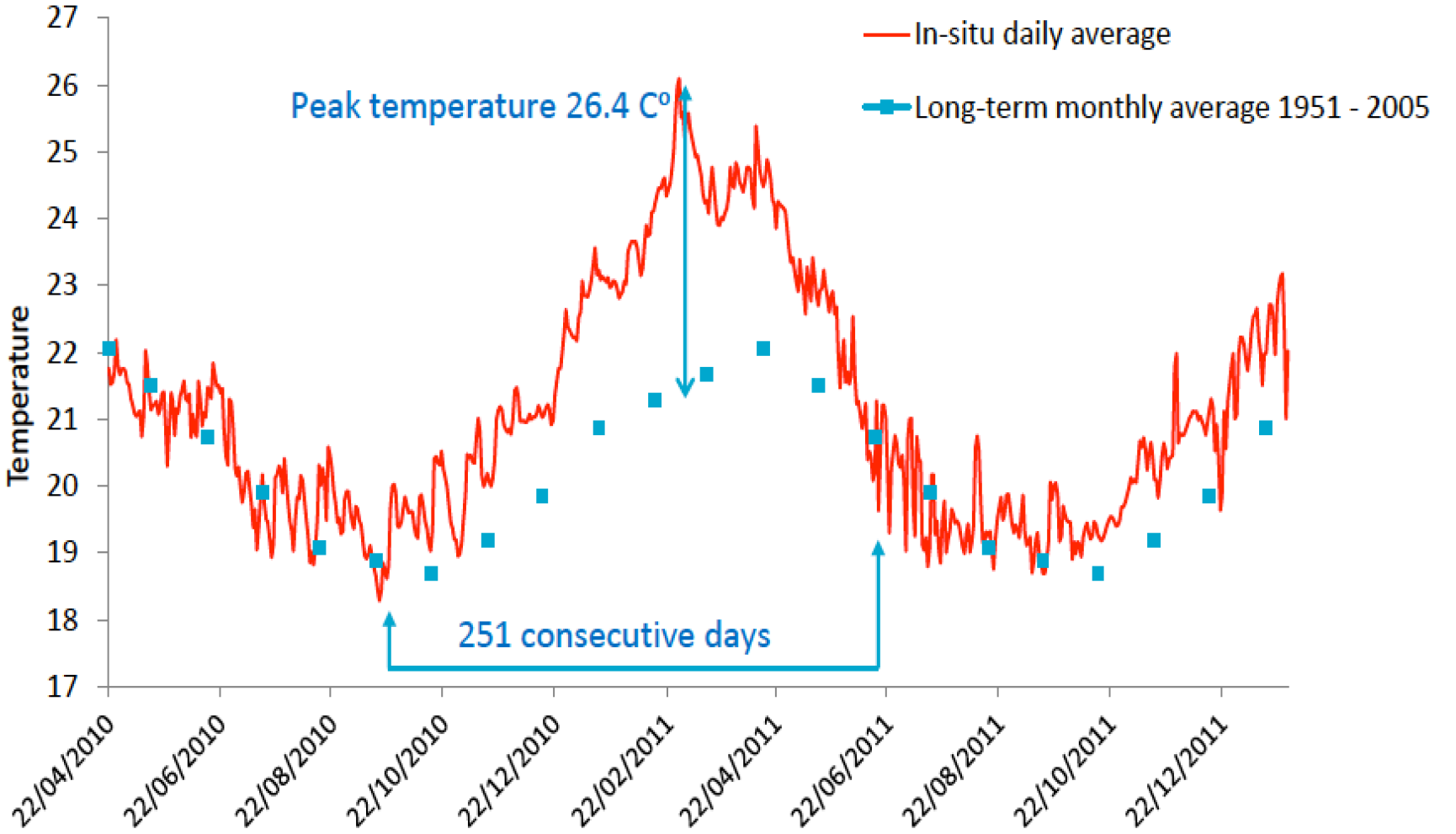




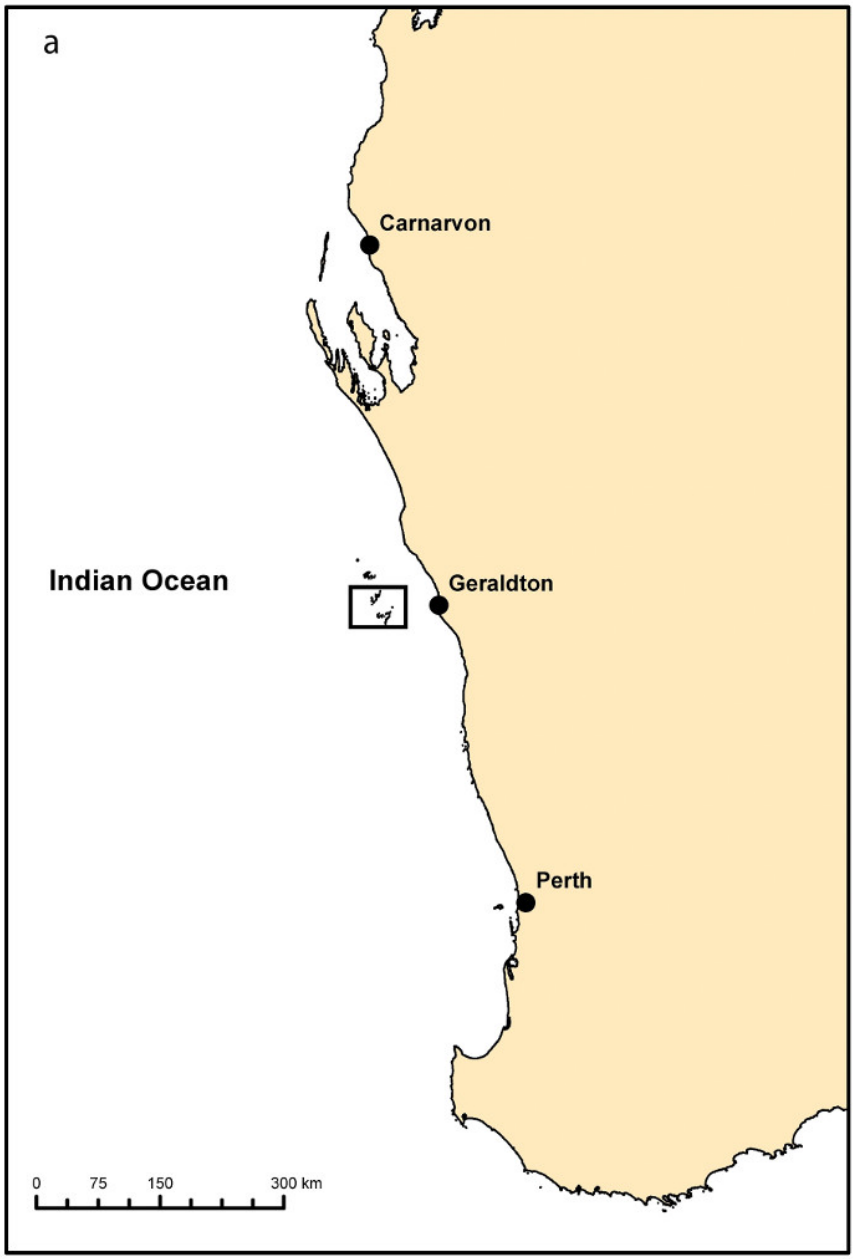


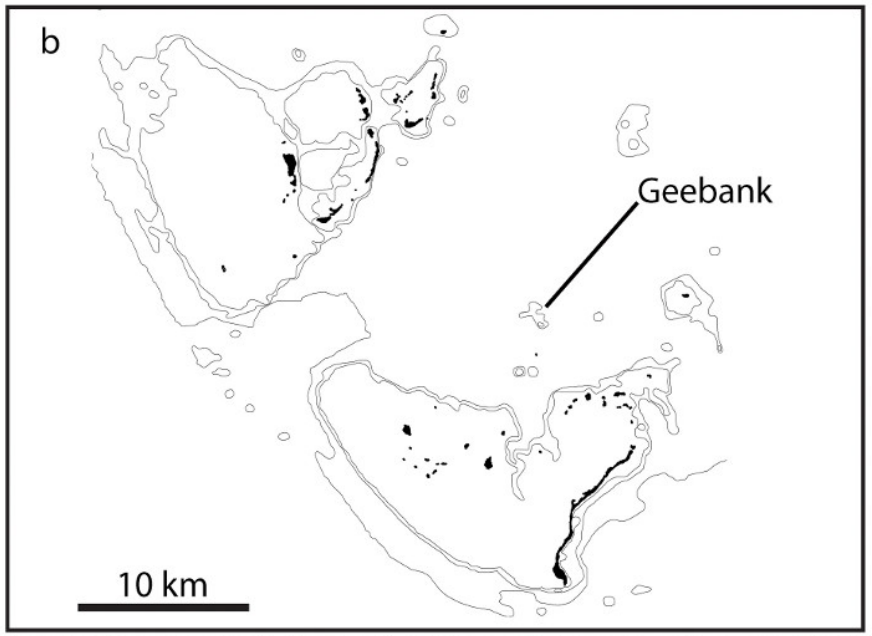


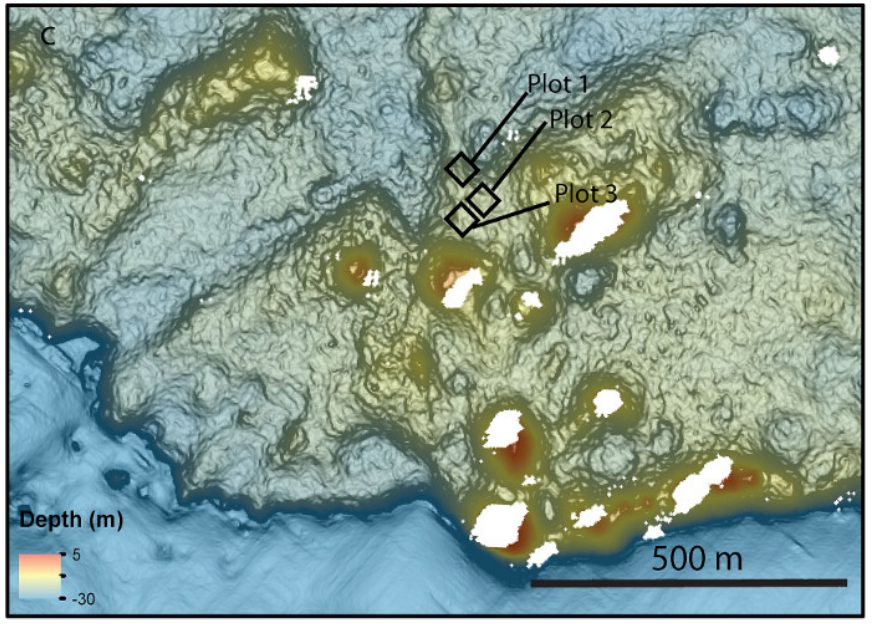
Western Australian 2011 marine heat-wave



Western Australian 2011 marine heat-wave

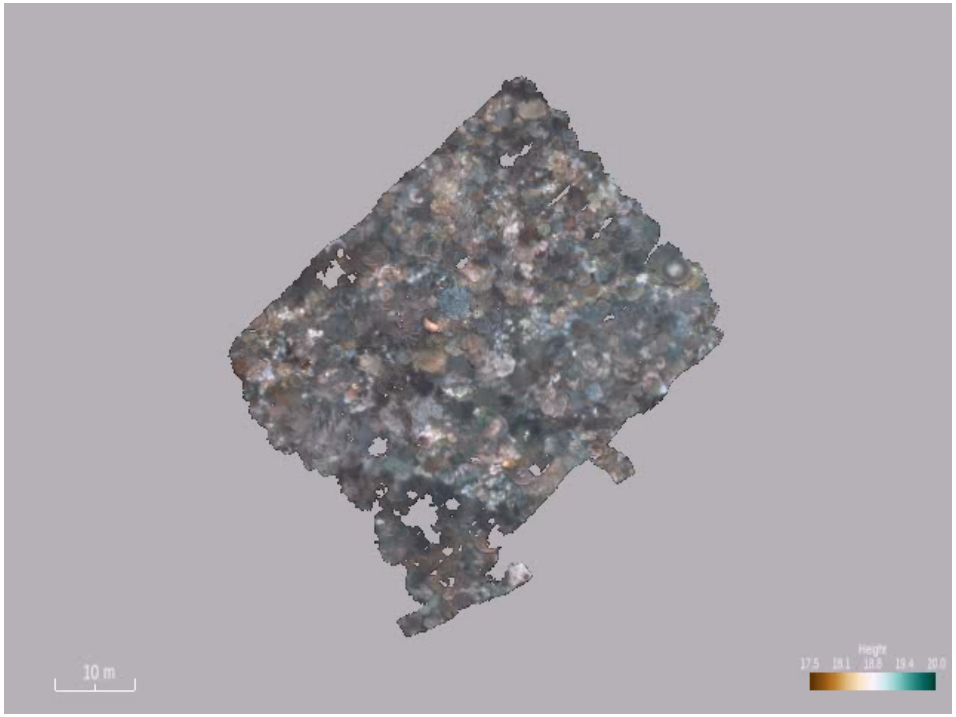




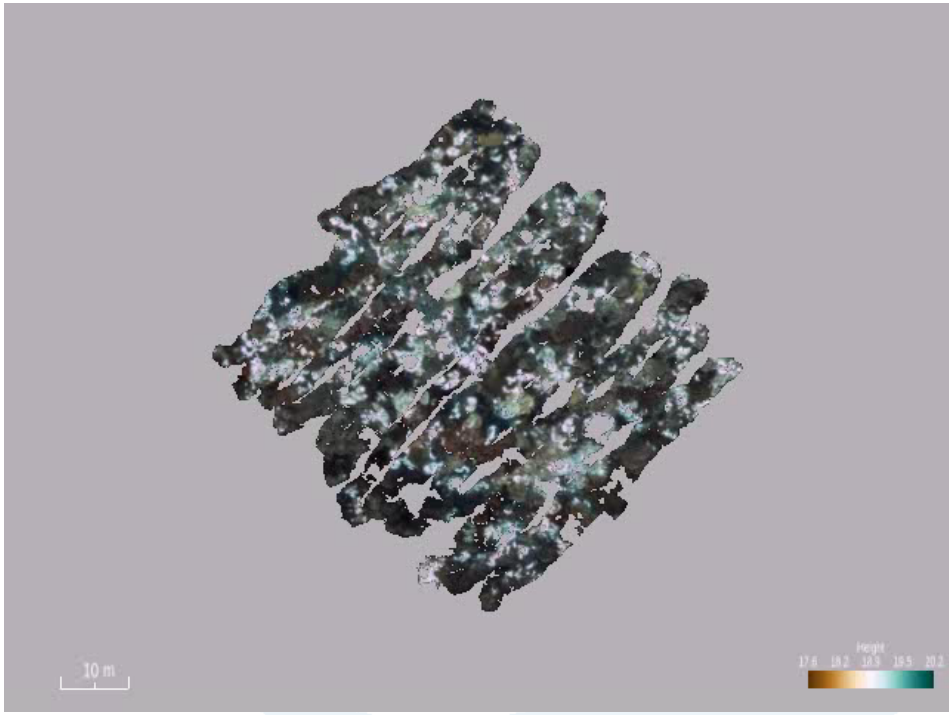


Western Australian 2011 marine heat-wave

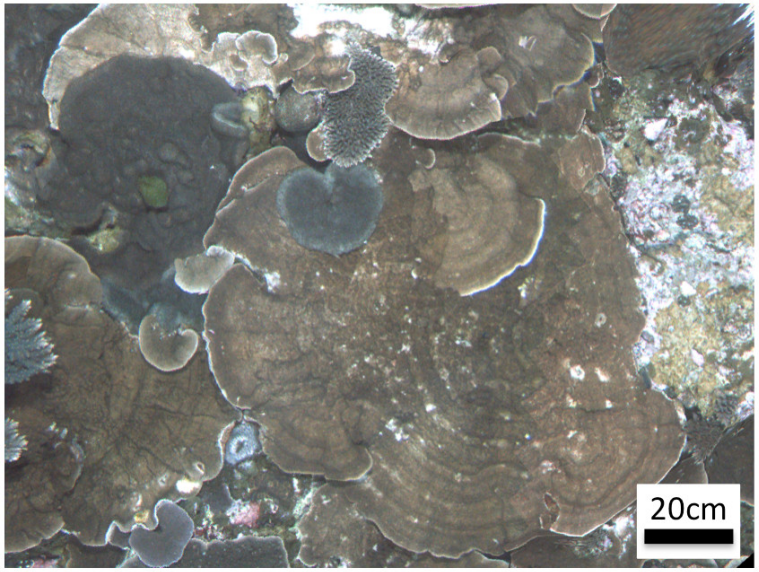
April 2010



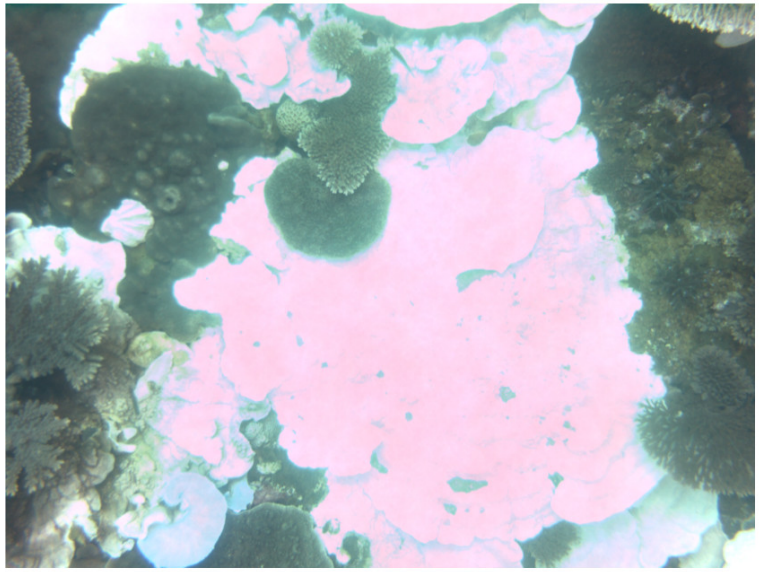
April 2011



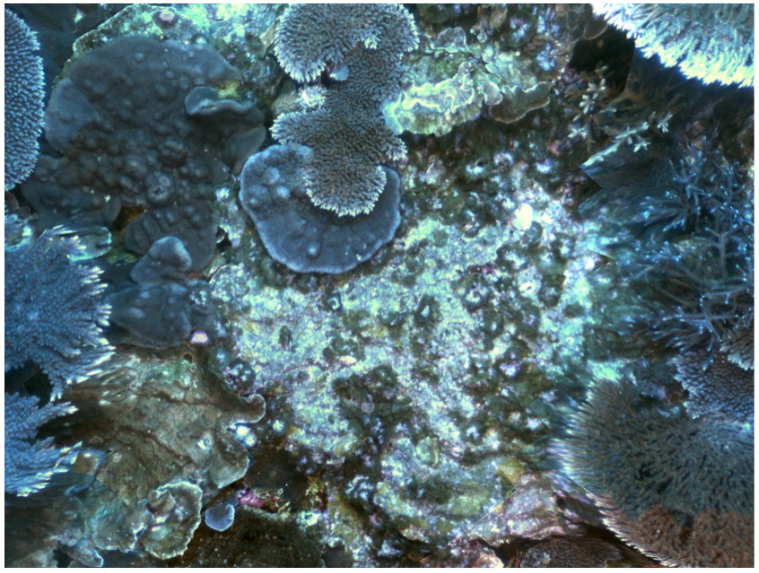
Western Australian 2011 marine heat-wave



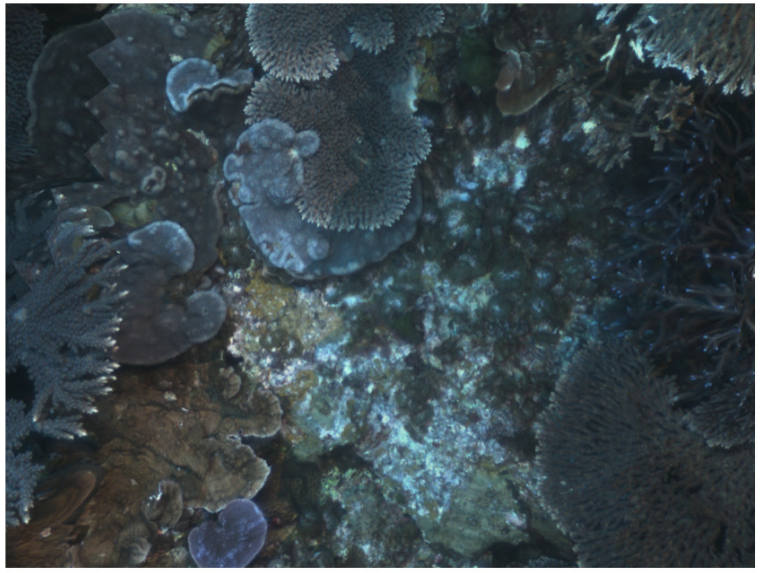
(a) April 2010



(b) April 2011

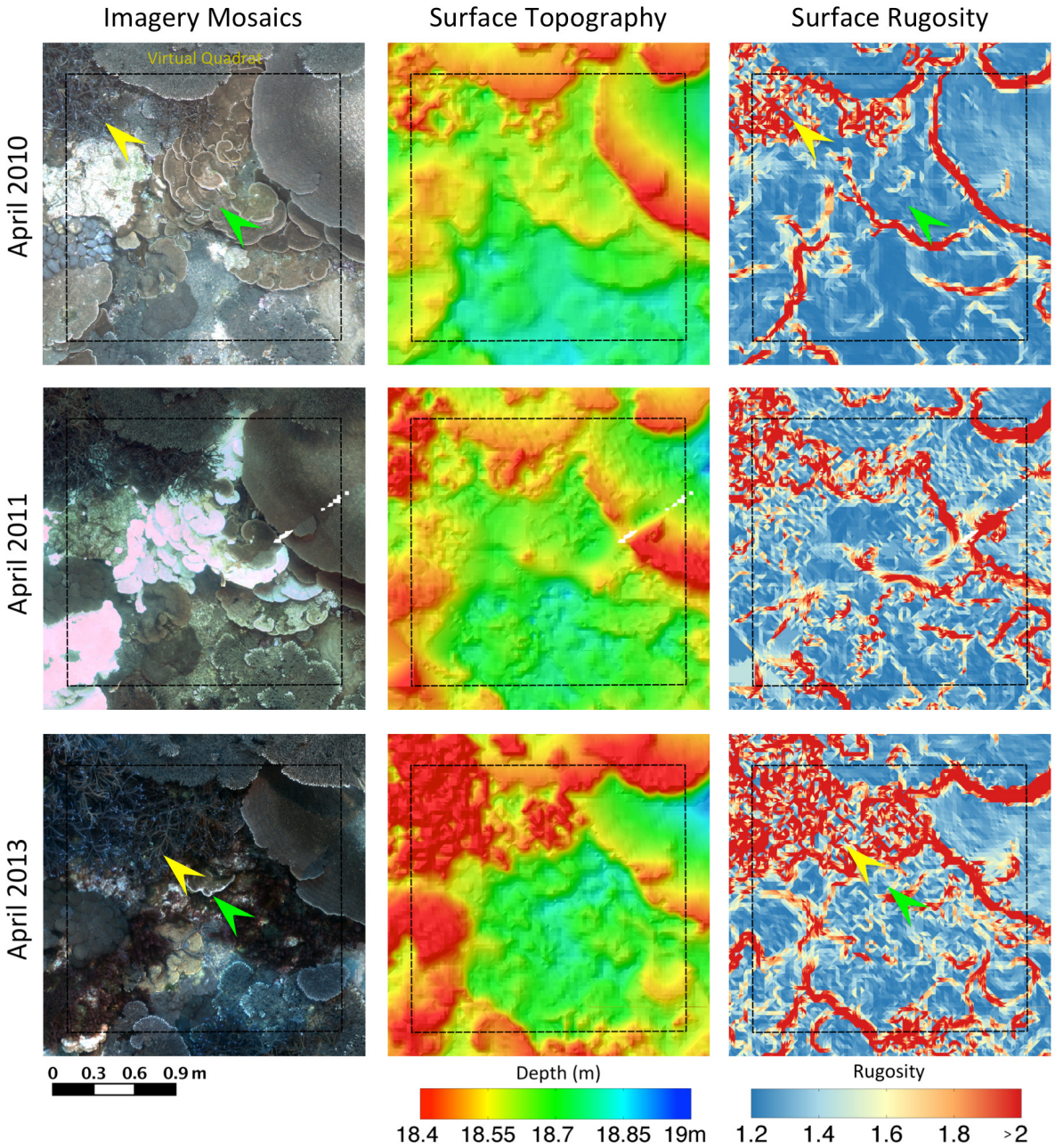


(c) April 2012

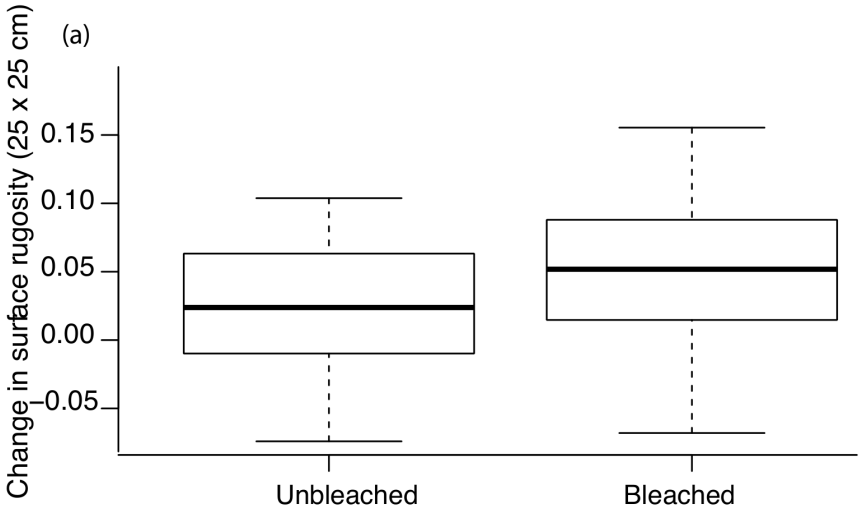


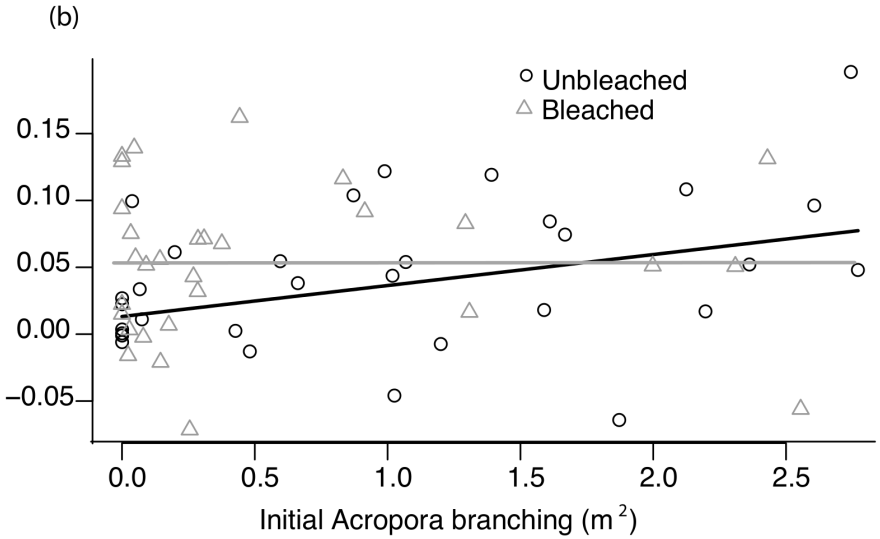
(d) April 2013

Changes in habitat structural complexity

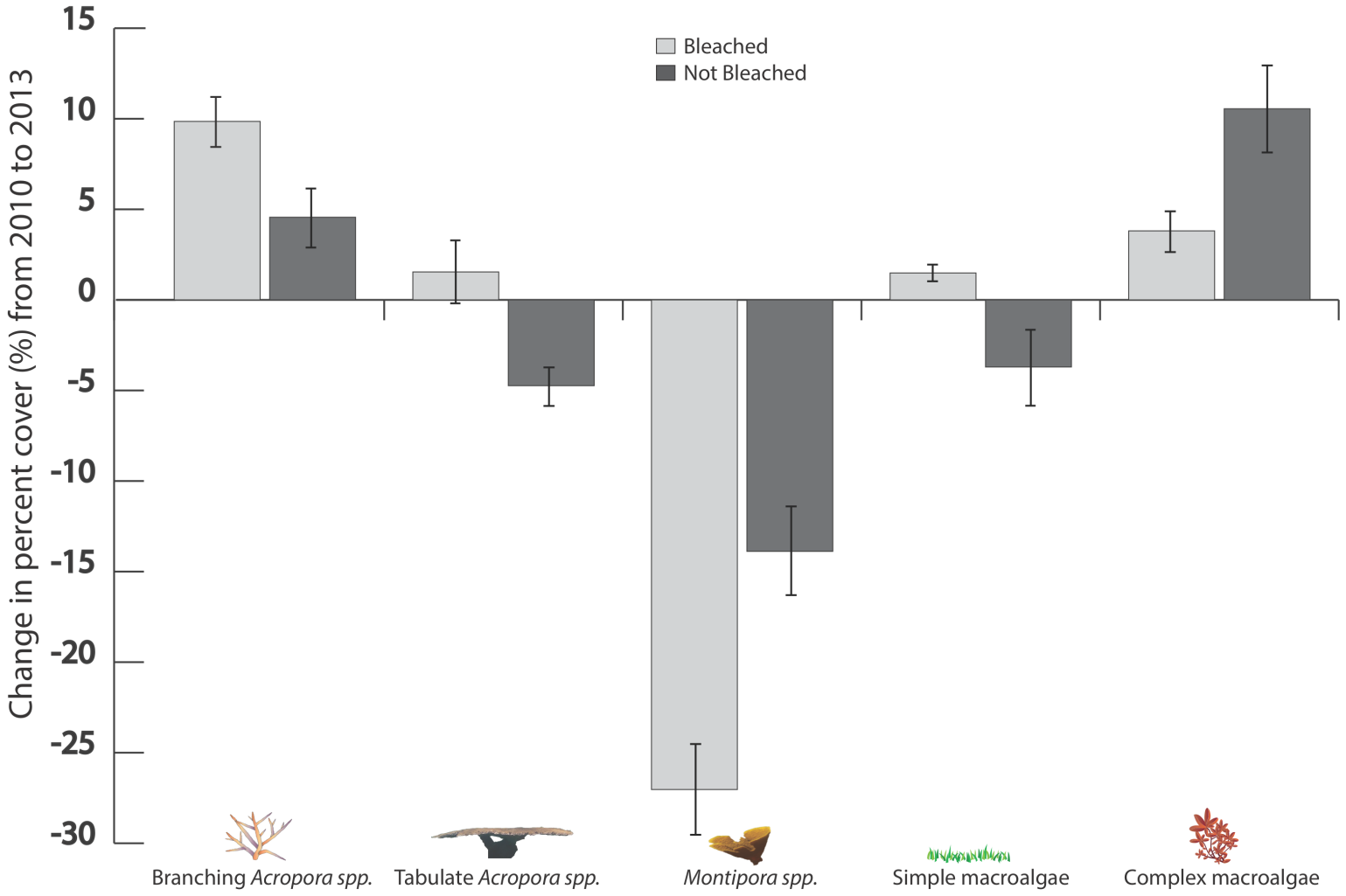


Changes in habitat structural complexity

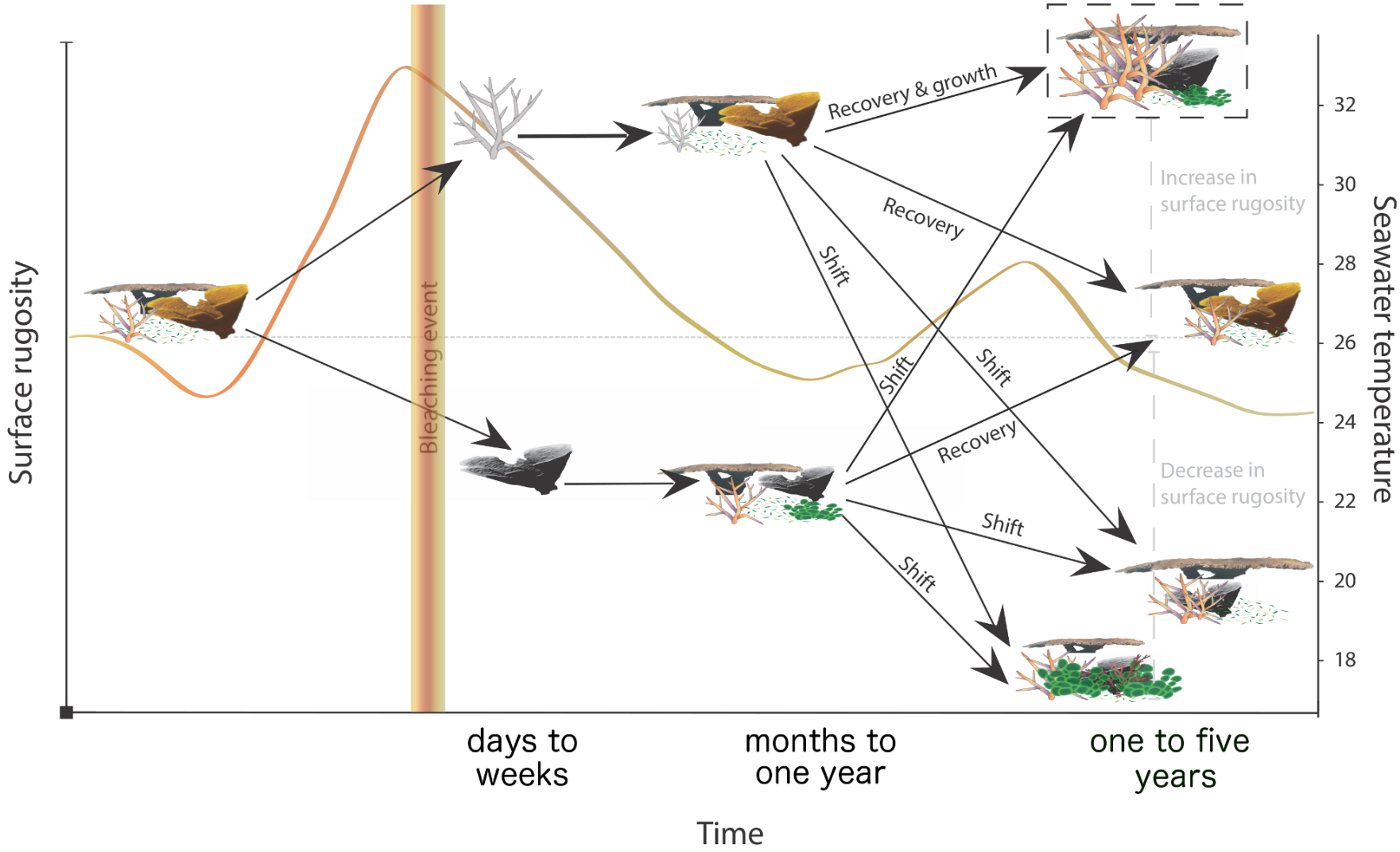




Changes in habitat structural complexity



Changes in habitat structural complexity



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