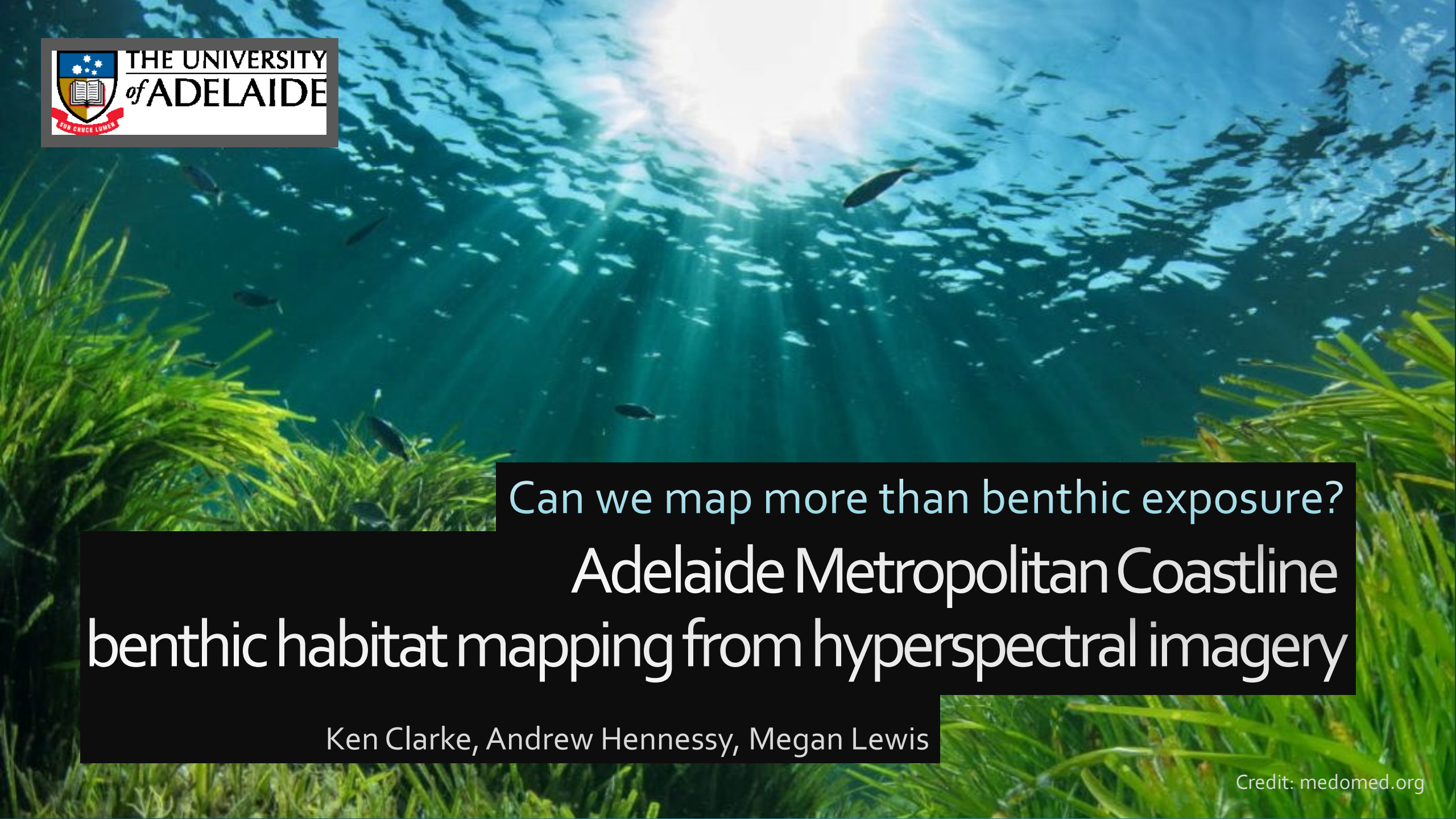

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SUB CRUCE LUMEN

Can we map more than benthic exposure?

Adelaide Metropolitan Coastline benthic habitat mapping from hyperspectral imagery

Ken Clarke, Andrew Hennessy, Megan Lewis

Credit: medomed.org

Project partners

THE UNIVERSITY of ADELAIDE

Government of South Australia

SA Water

EPA South Australia

Government of South Australia
Department for Environment and Water

Current benthos monitoring

Background

- Previous mapping with multispectral imagery (4 bands: red, green, blue, NIR)
  - Limited spectral information
  - Covered vs' exposed benthos
  - Valuable for understanding overall gain / losses of benthic cover
  - BUT, no insight into genus level effects
- Desire to examine potential of hyperspectral imagery (62 bands)
  - More accurate covered vs. exposed benthos mapping?
  - Possible to map more detail (*Amphibolis* spp., *Posidonia* spp., macroalgae, and bare sediment)?

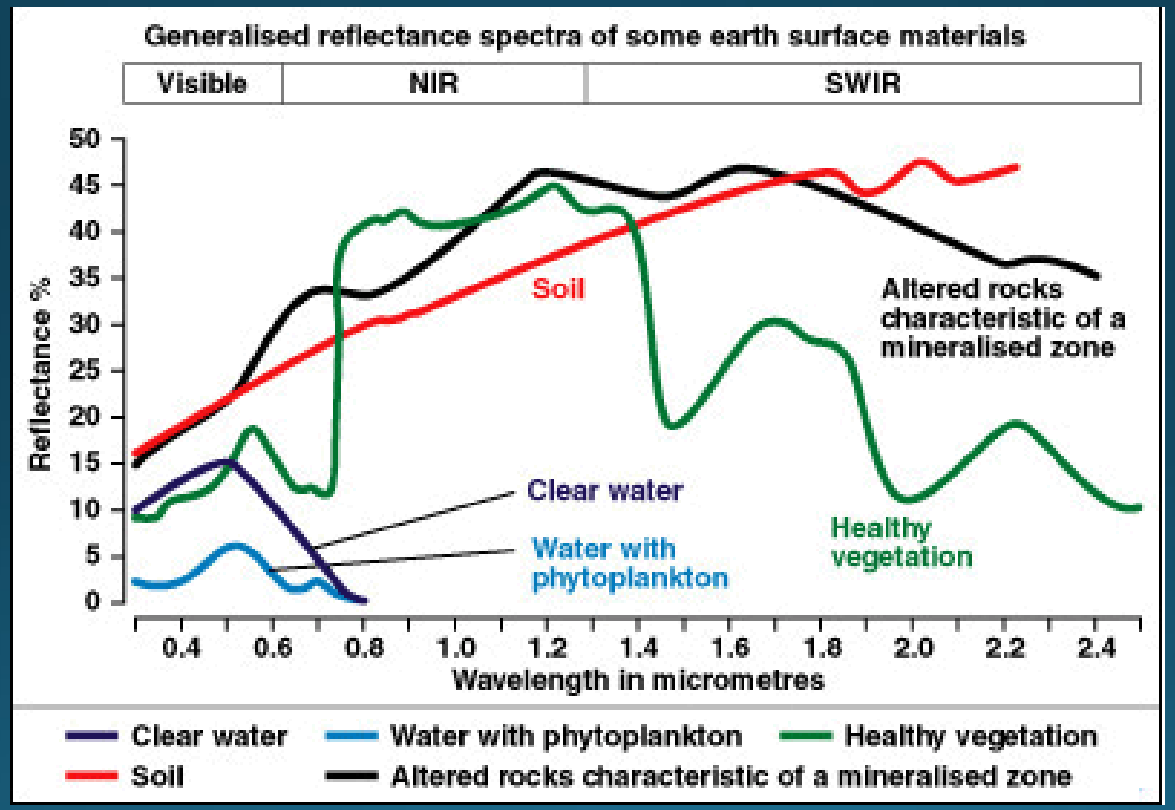
Talk overview

- Remote sensing overview
- Methods – field data
- Methods – imagery
  - Challenges of marine benthos remote sensing (and how to overcome them)
- Results
  - Benthic exposure mapping
    - And change in benthic exposure 2013 - 2018
  - Genus level benthic cover mapping
- Accuracy assessment
- Conclusions / recommendations

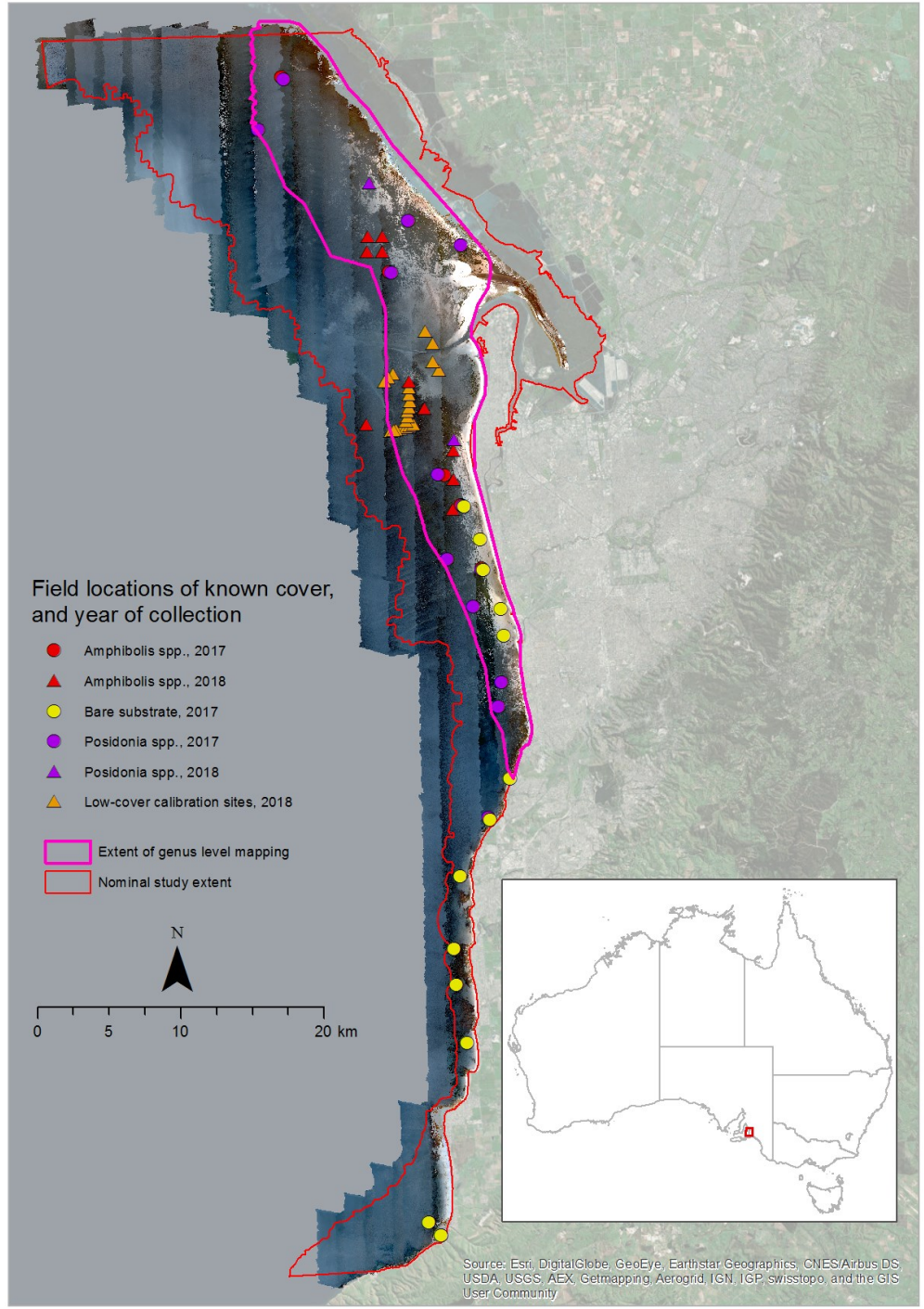
Credit: medwet.org

Credit: collections.museumvictoria.com.au

Remote sensing: spectral signatures



Methods: Study area



Methods - field

- EPA 2017/18 field data
  - Benthos camera drags ~ 50 m
  - 19 sites in study area
    - 10 transects per site
  - Need training and withheld sites (for accuracy assessment)
    - Withheld: need transects with areas (~ 26 m) of homogenous cover (*Amphibolis* spp., *Posidonia* spp., or sand)
    - SA Water collected some extra sites
    - Tota: 10 sand, 15 Found *Amphibolis* spp., and 15 *Posidonia* spp. sites

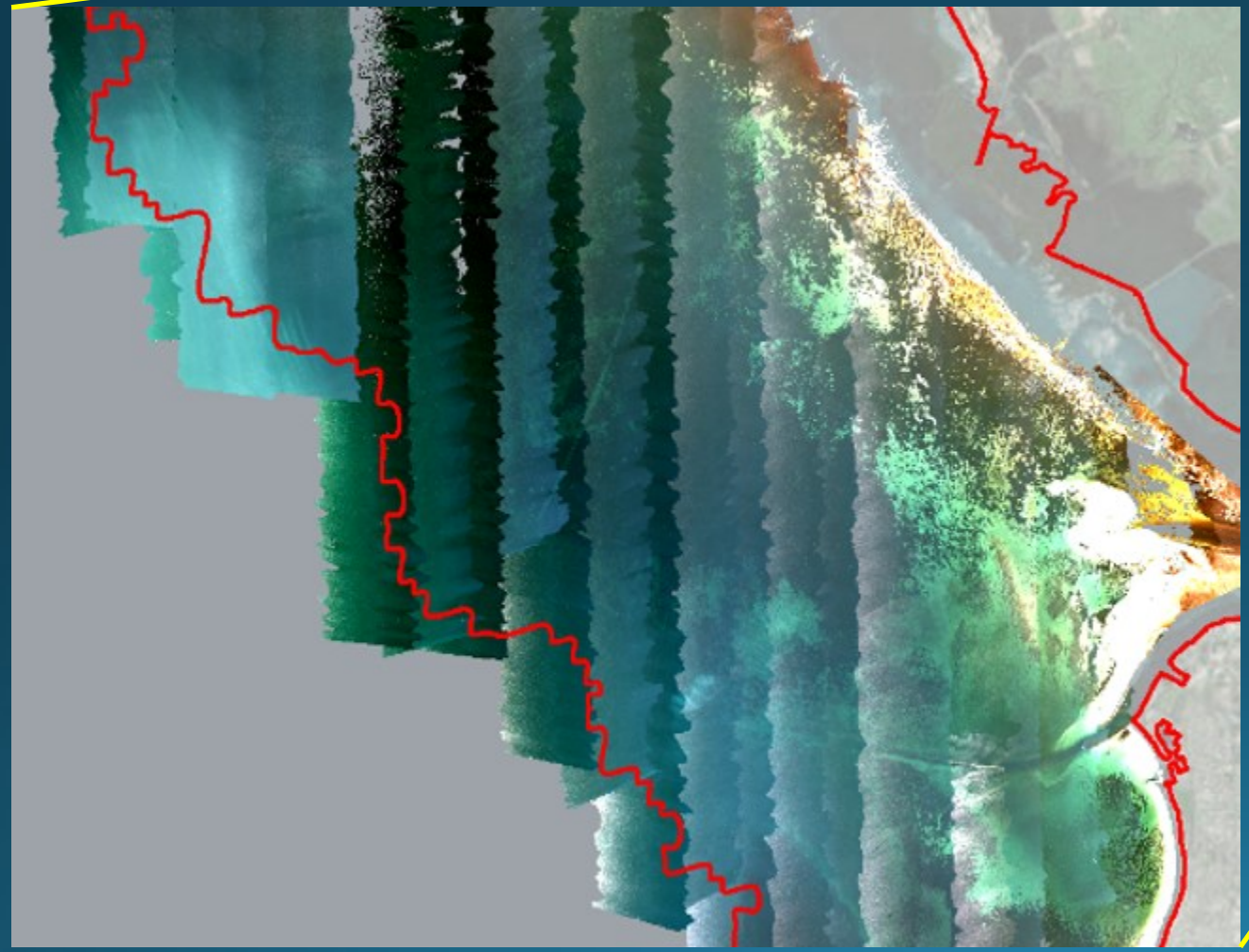
Methods: remote sensing

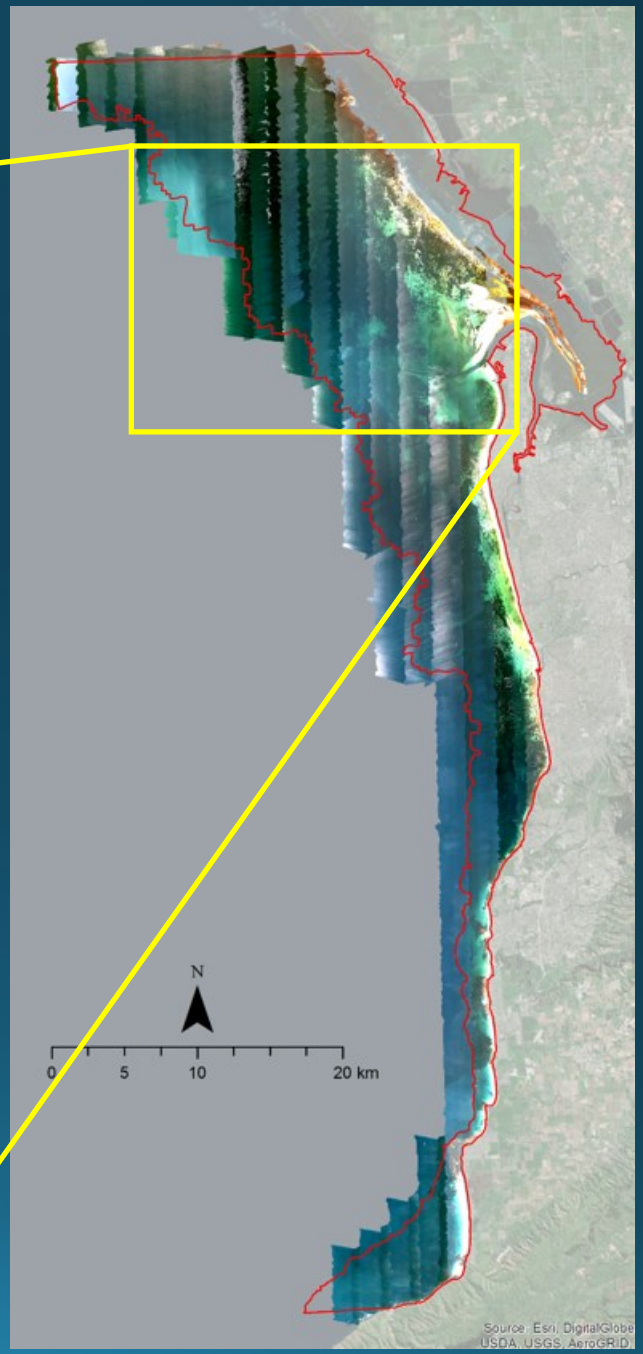
- Challenges (and how we overcame them)
- Classification methods

Marine benthos remote sensing challenges

- Received signal is a combination reflectance from:
  - Atmosphere and any cloud/mist
  - Water surface (sun-glint)
  - Water column (suspended matter and water scattering)
  - Benthos
- Water also strongly absorbs light
  - Red light more strongly
  - Effect increases with depth

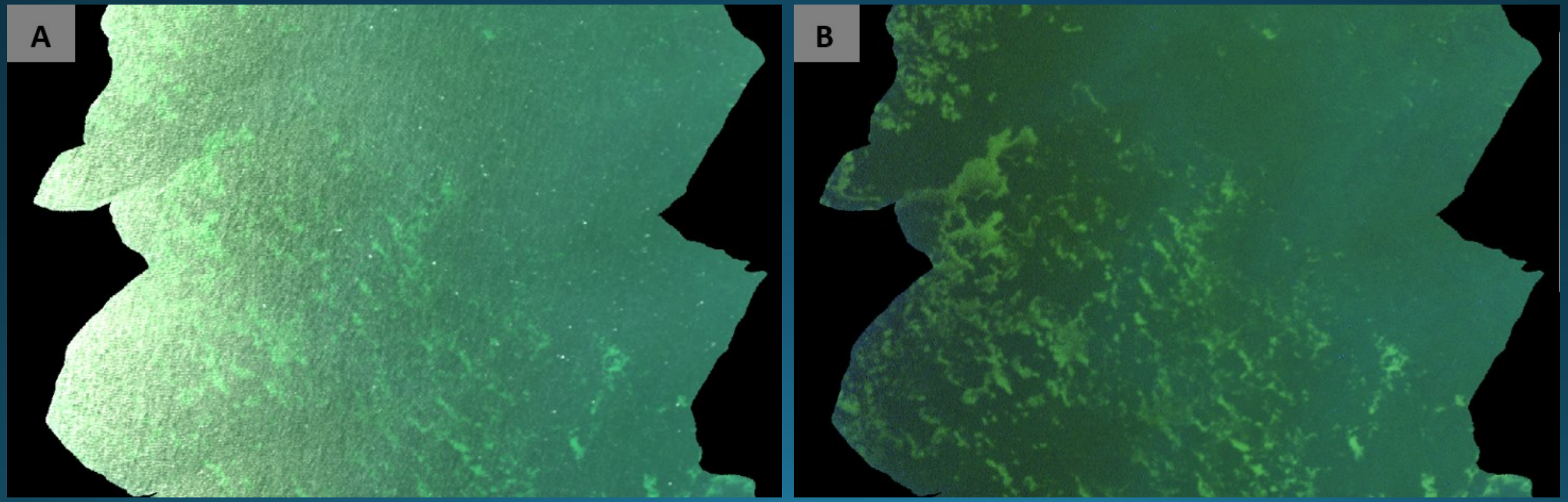
Hyperspectral mosaic





Sun-glint removal

(A) Before and (B) after sun-glint removal



Depth illumination difference normalisation

(A) Before and (B) after illumination normalisation

Posidonia spp. appears dark orange-brown, and *Amphibolis* spp. is very dark grey

Classifications

- Two goals
  - Benthic exposure (sand / seagrass)
    - And change detection (2013 – 2018)
  - Genus level (*Amphibolis* spp., *Posidonia* spp., and sand)
    - Change detection (where possible)
    - Spectral separability

Classifications

- 62 original reflectance bands, from blue to near-infrared (NIR)
  - Subset to 15 bands
    - Bands 7 (middle-blue, at 463.0 nm) through to 21 (orange, at 593.6 nm), and a single band in the NIR (band 62, at 990.6 nm)
    - Removing bands with little information reduces classification confusion later
- Select training areas within each flight line
  - 80 training areas for each cover type
  - Based on visual interpretation and the EPA benthic habitat data
  - Supervised classification
    - Benthic exposure: Mahalanobis classifier
    - Genus level: Support vector machine (SVM)

Post-processing

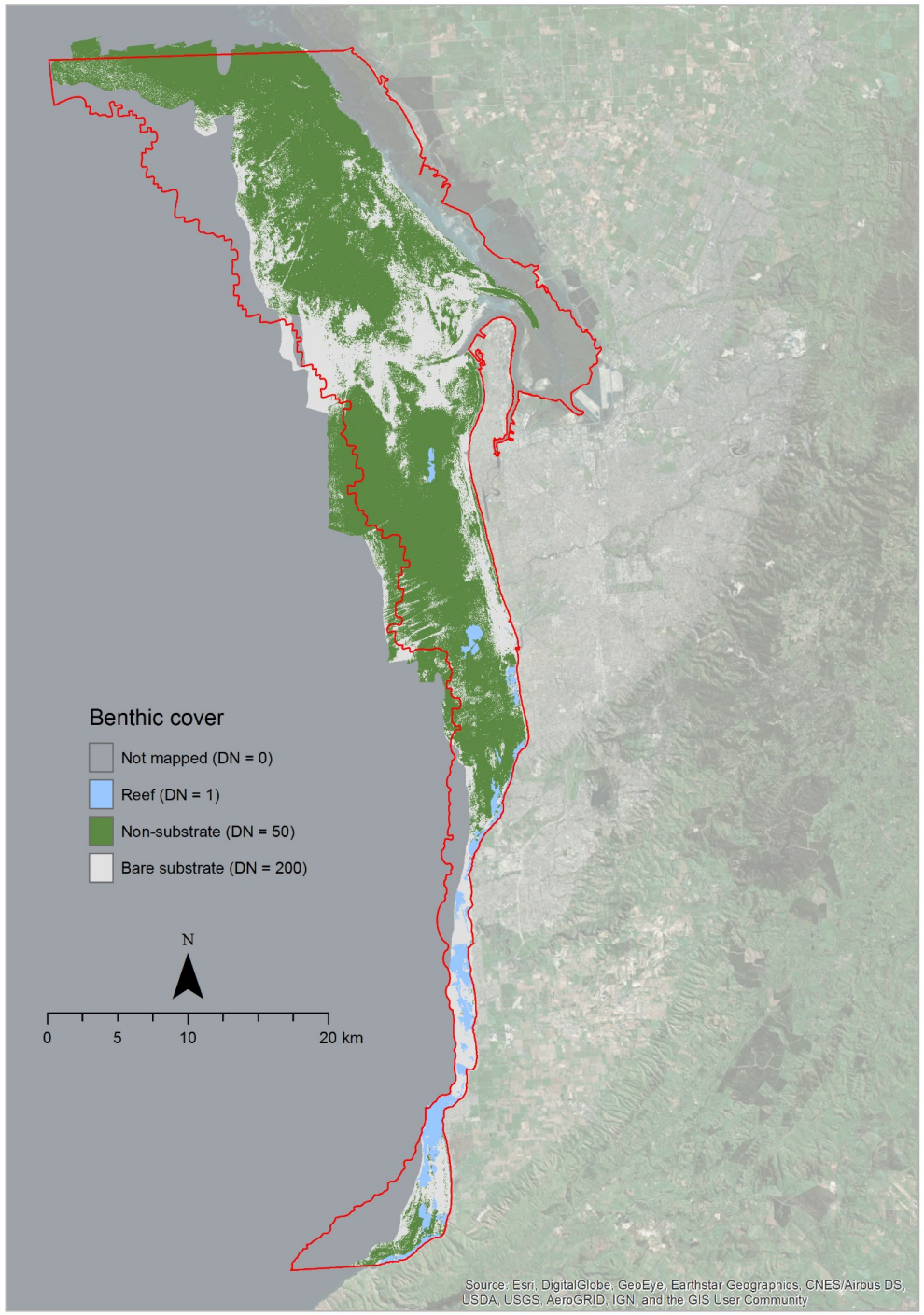
- Classified flight lines mosaicked together to create one image map
  - priority given to higher quality flight lines
- Majority filtering (5 x 5 pixels, or 10 x 10 m) used to reduce visual noise
  - occasional ‘sand’ pixles in otherwise ‘seagrass’ areas, or vice versa

Accuracy assessment

- Mapping is worthless without accuracy assessment
- Calculated
  - Producer's accuracy (map accuracy; proportion of real features on the ground that are mapped correctly)
  - User's accuracy (proportion of each map class that will be correct on the ground)
  - Cohen's kappa coefficient (is the mapping better than expected due to chance)

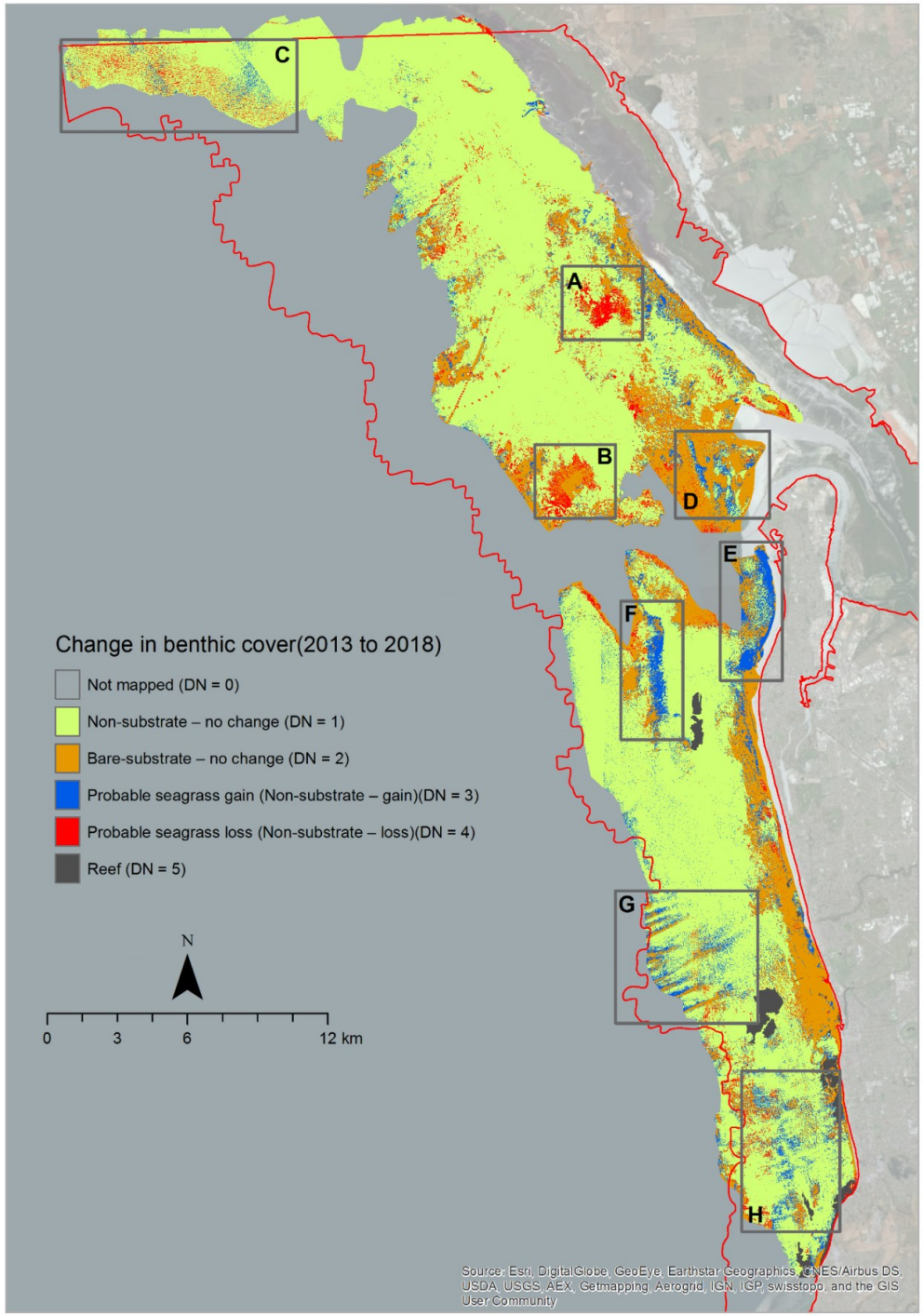
Benthic cover extent in 2018

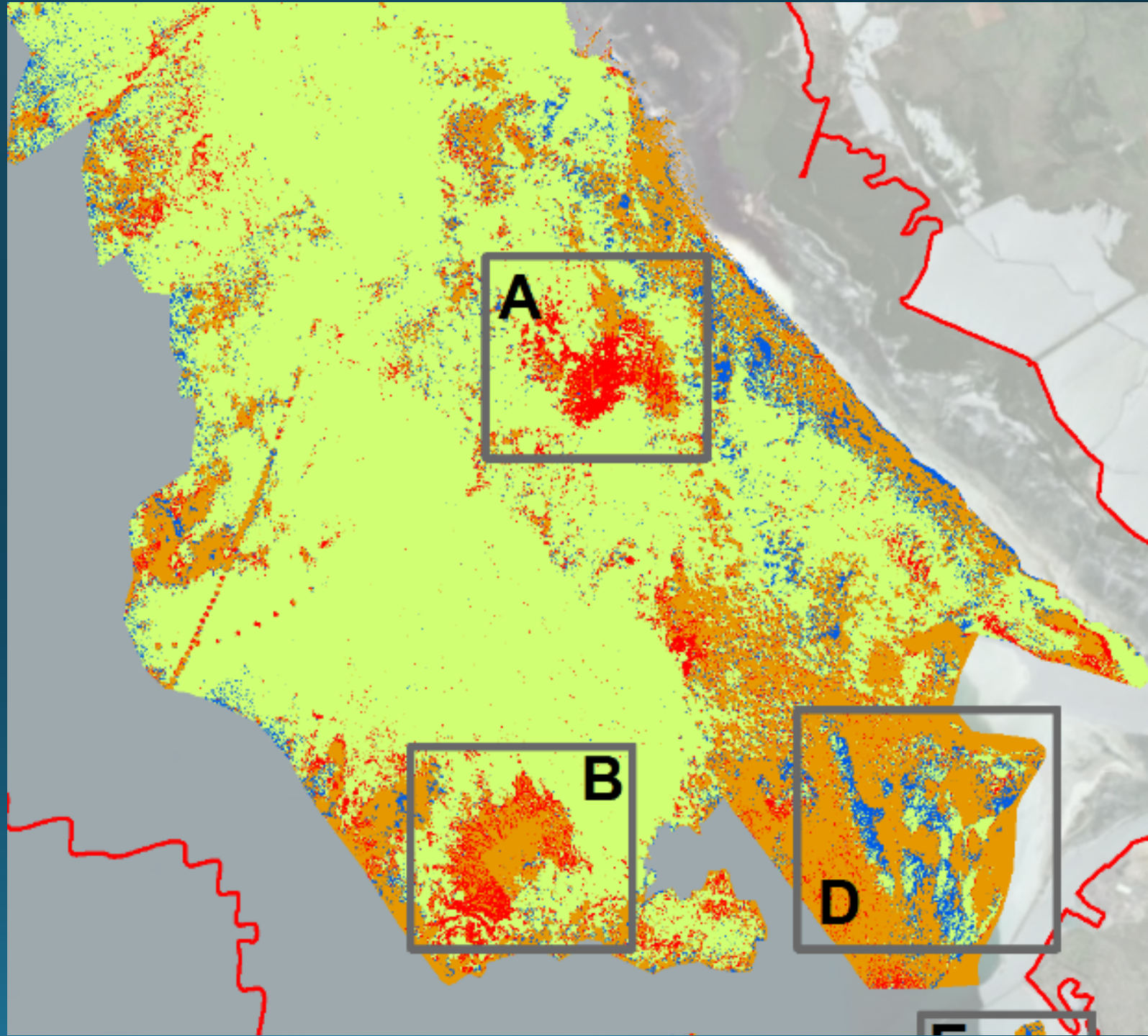
		Reference (field) data			
		Non-substrate	Bare substrate	Total	Users accuracy
Mapped cover	Non-substrate	30	1	**31**	**97 %**
	Bare substrate	0	9	**9**	**100 %**
	Total	**30**	**10**	**40**	
	Producers accuracy	**100 %**	**90 %**	**Overall accuracy**	**98 %**

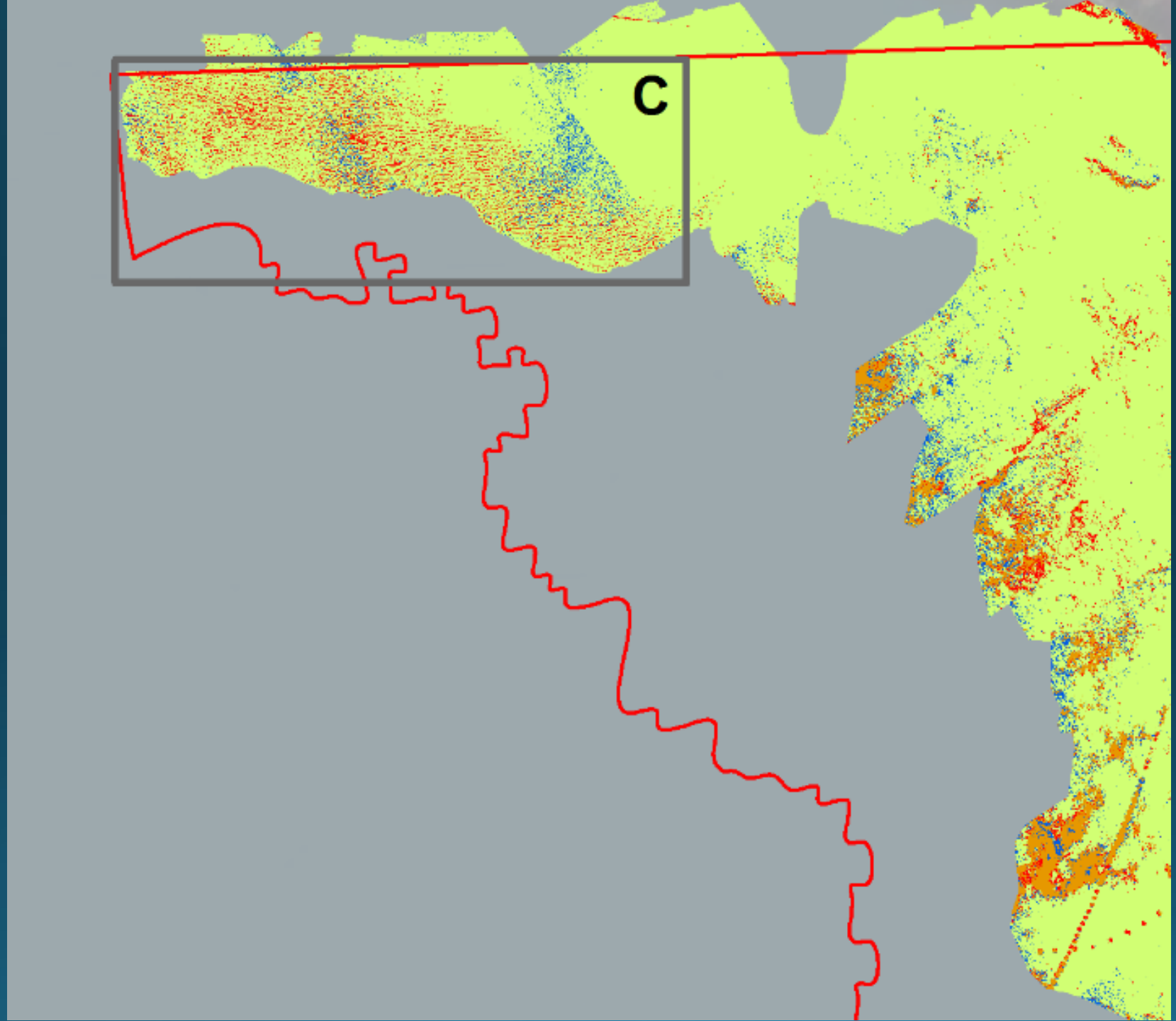


Change in benthic cover:
2013 – 2018
2007 – 2013

Cover change class	Change from 2007 to 2013 Area (ha)	Change from 2007 to 2013 Proportion of total area	Change from 2013 to 2018 Area (ha)	Change from 2013 to 2018 Proportion of total area
Non-substrate – no change	19,903.68	63.5 %	31,182.77	73.3 %
Bare substrate – no change	8,986.02	28.7 %	6,551.67	15.4 %
Probable seagrass gain (Non-substrate – gain)	1,608.53	5.1 %	3,129.37	7.3 %
Probable seagrass loss (Non-substrate – loss)	831.54	2.7 %	1,699.56	4 %
Total area	31,329.76		42,563.37	




A
B
D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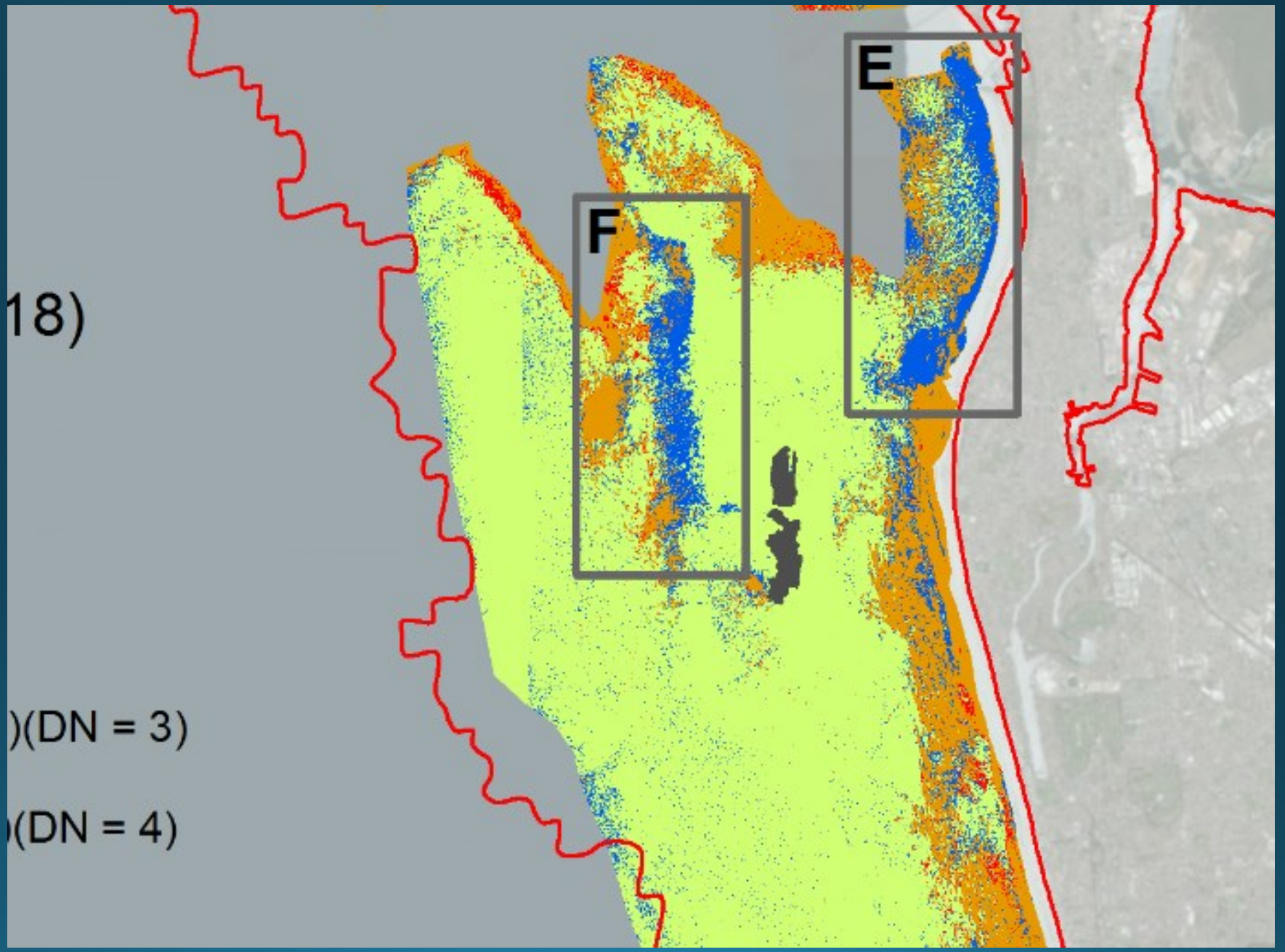
18)
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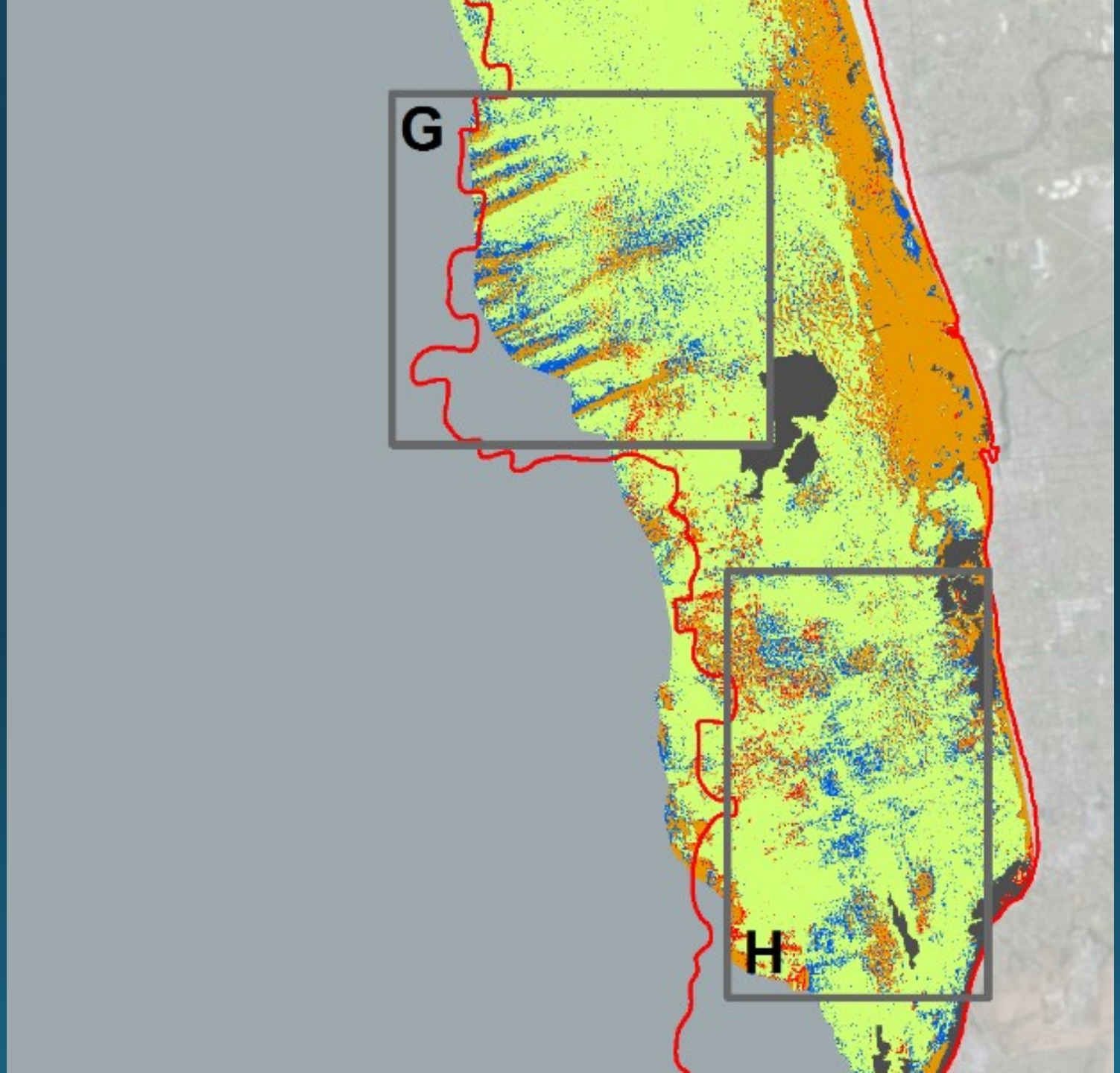
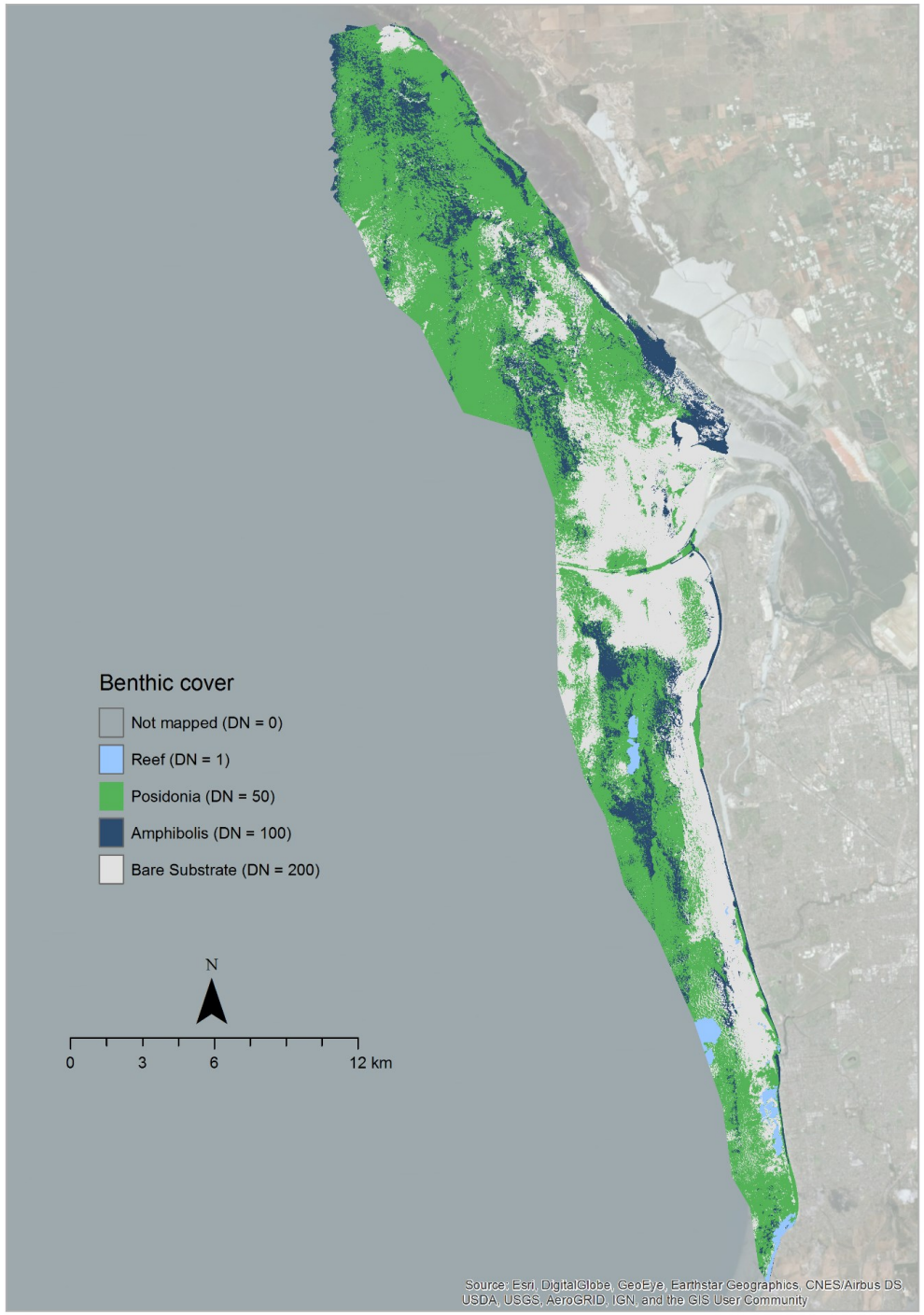
F
E


G
H

Genus level benthic cover extent in 2018

		Reference (field) data				
		***Amphibolis* spp.**	***Posidonia* spp.**	**Bare substrate**	**Total**	**Users accuracy**
Mapped cover	***Amphibolis* spp.**	10	0	1	11	**91 %**
	***Posidonia* spp.**	4	14	0	18	**78 %**
	Bare substrate	0	0	5	5	**100 %**
	Total	14	14	6	34	
	Producers accuracy	**71 %**	**100 %**	**83 %**	**Overall accuracy**	**85 %**



Genus level benthic cover extent in 2018

		Reference (field) data				
		***Amphibolis* spp.**	***Posidonia* spp.**	**Bare substrate**	**Total**	**Users accuracy**
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	Total	14	14	6	34	
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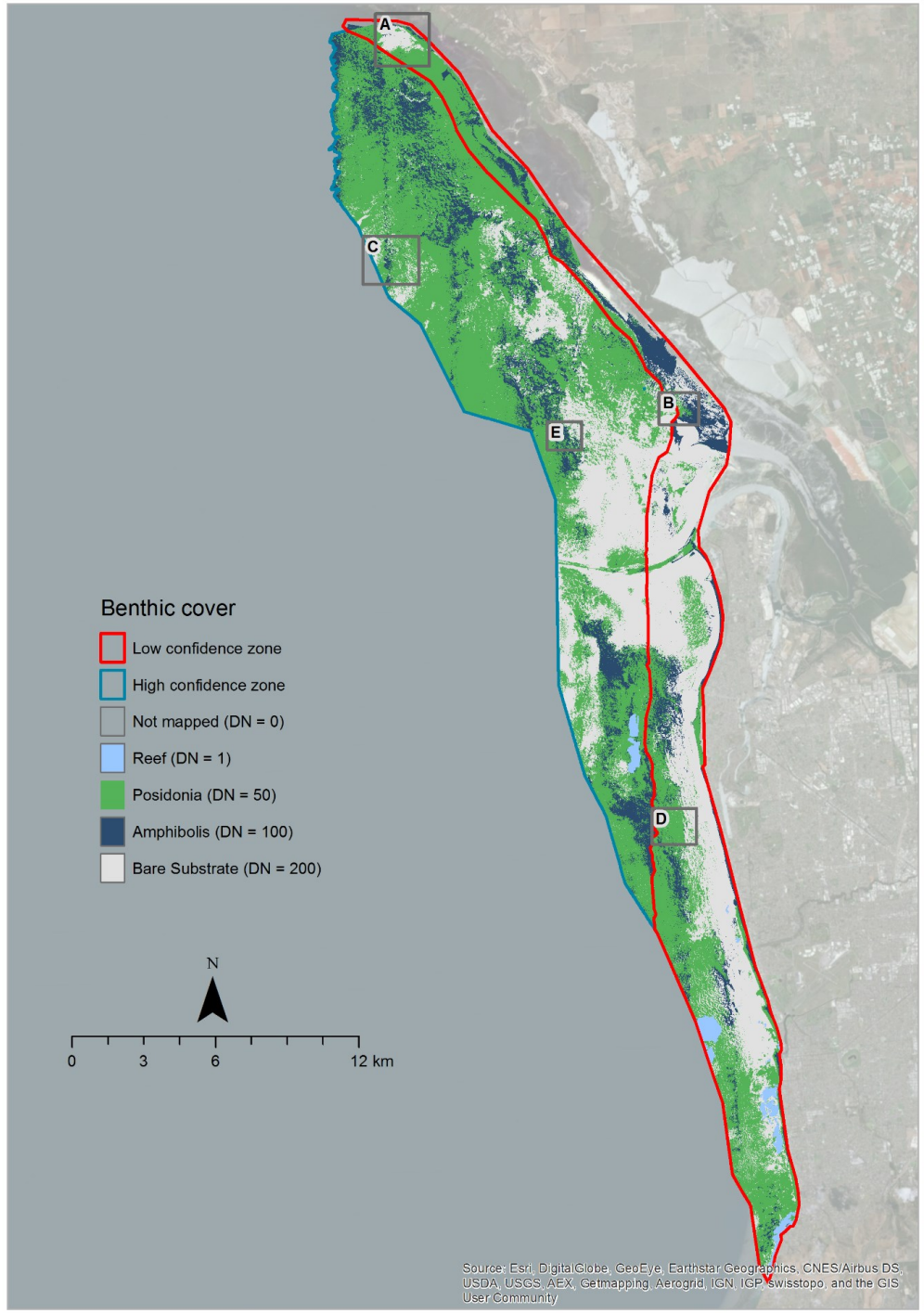
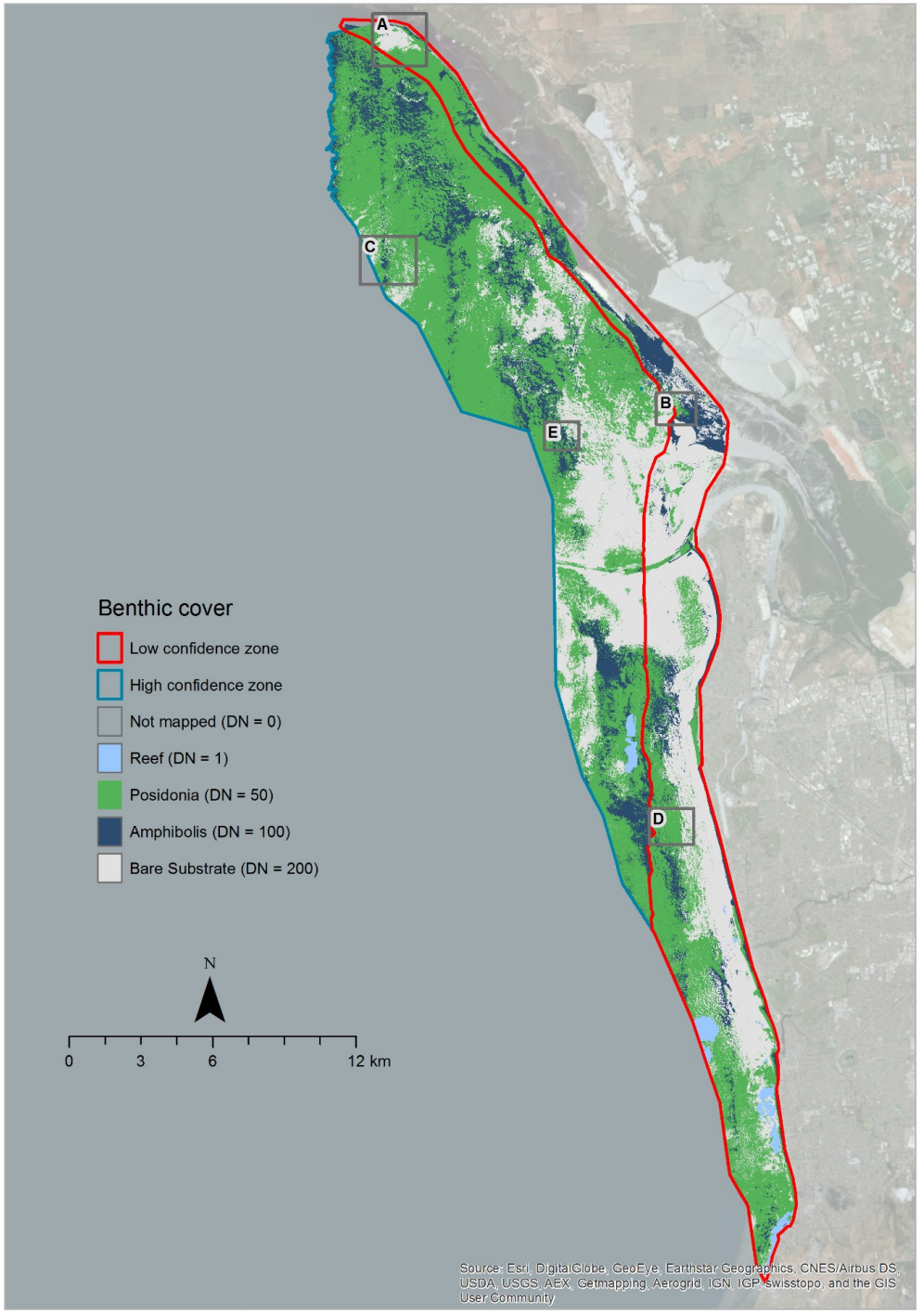


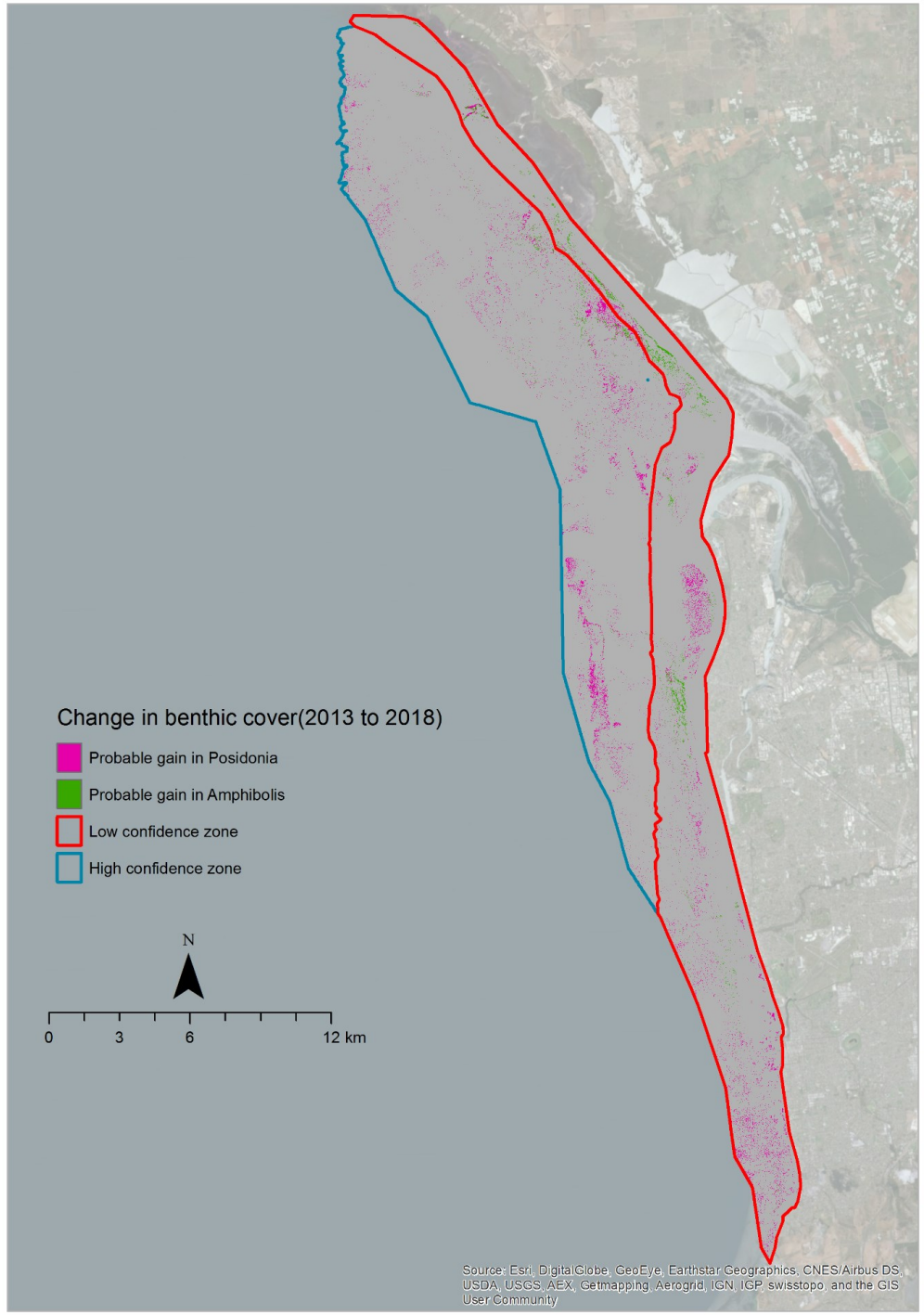
Genus level benthic cover extent in 2018

		Reference (field) data				
		Amphibolis spp.	*Posidonia* spp.	Bare substrate	Total	Users accuracy
Mapped cover	*Amphibolis* spp.	10	0	1	11	**91 %**
	Posidonia spp.	4	14	0	18	**78 %**
	Bare substrate	0	0	5	5	**100 %**
	Total	14	14	6	34	
	Producers accuracy	**71 %**	**100 %**	**83 %**	Overall accuracy	**85 %**

		Reference (field) data				
		Amphibolis spp.	*Posidonia* spp.	Bare substrate	Total	Users accuracy
Mapped cover	*Amphibolis* spp.	7	0	0	7	**100 %**
	Posidonia spp.	1	6	0	7	**85.7 %**
	Bare substrate	0	0	0	0	**NA**
	Total	8	6	0	14	
	Producers accuracy	**87.5 %**	**100 %**	**NA**	Overall accuracy	**93 %**

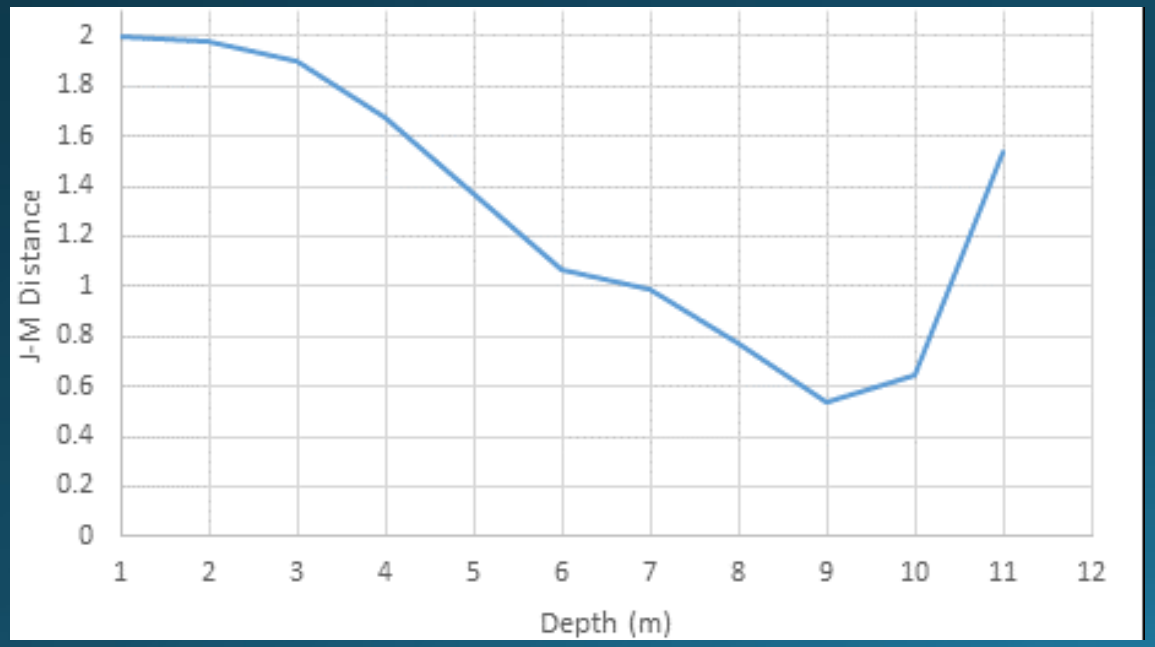


Genus level benthic cover extent in 2018



Spectral separability and depth

- Separability of *Amphibolis* spp. and *Posidonia* spp. in relation to water depth
- 2 = completely separable; 0 = not separable at all



Conclusions

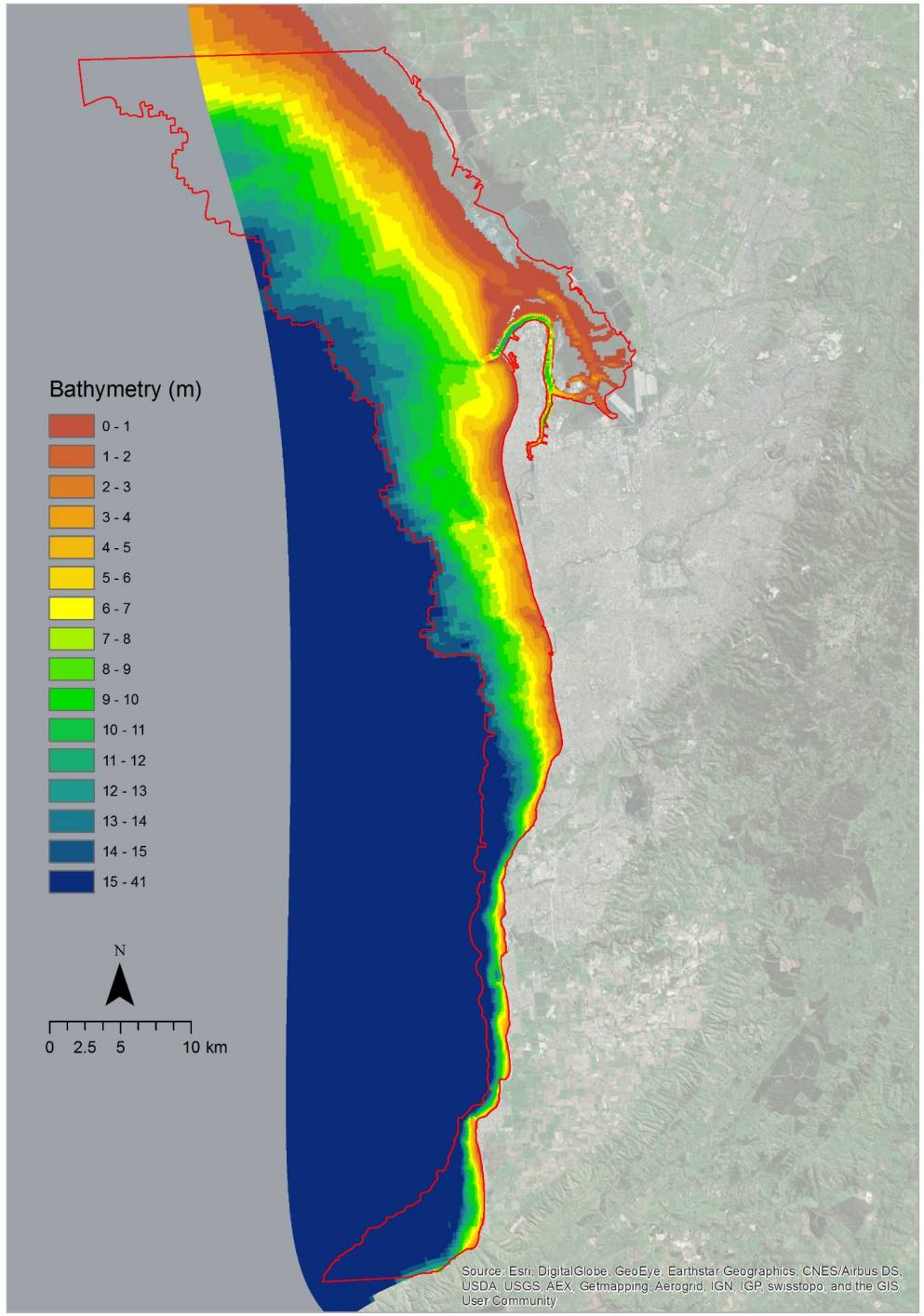
- Is hyperspectral better at mapping benthic exposure?
  - Yes
    - high accuracy in 2018
    - unknown accuracy in previous iterations, but probably lower
- Is it possible to map more cover types than just benthic exposure?
  - Yes (can map *Amphibolis* spp., *Posidonia* spp. and bare sediment; unsure for macroalgae)
  - Improve understanding of spatial distribution and ecology of these genera
  - Compare to known / suspected stressors – support improved management

Recommendations

- Do accuracy assessments
- Study the spatial (and maybe temporal) relationship of genera distribution and environmental variables
- Repeat this mapping (in 5 years?) to study the genus level changes in seagrass extent
- Hyperspectral benthos mapping success is very sensitive to imagery quality
  - sun-glint, illumination intensity, turbidity and sensor sensitivity all need to be carefully managed

What we're doing now

- Mapping change in annual seagrass cover along the Metropolitan Coast from 1988 – 2018
  - Landsat imagery
  - Look at seagrass loss / recovery


Bathymetry (m)
0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
7 - 8
8 - 9
9 - 10
10 - 11
11 - 12
12 - 13
13 - 14
14 - 15
15 - 41
N
0 2.5 5 10 km
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community