Westernport Bay Coastal wetland geomorphology

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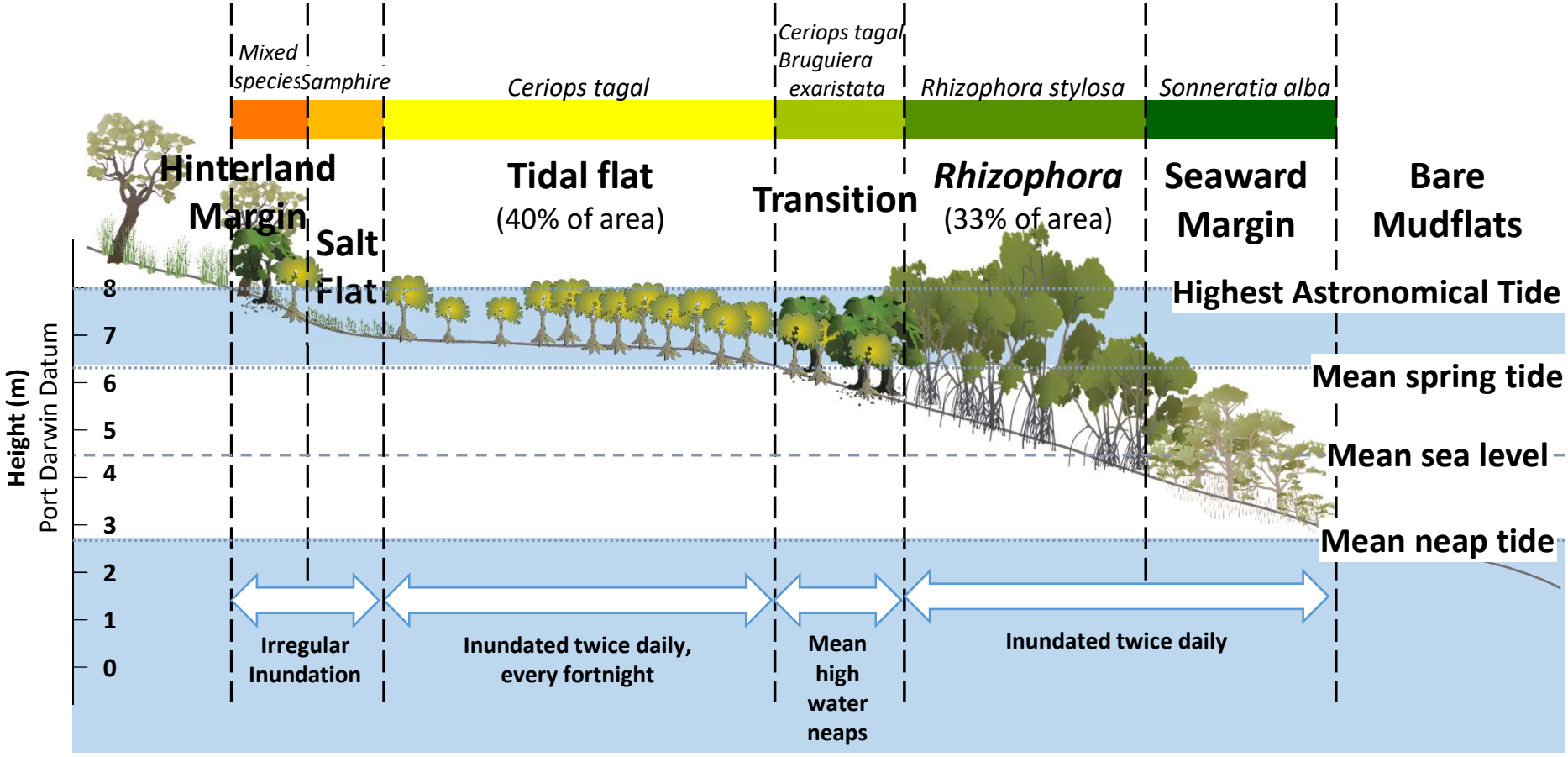
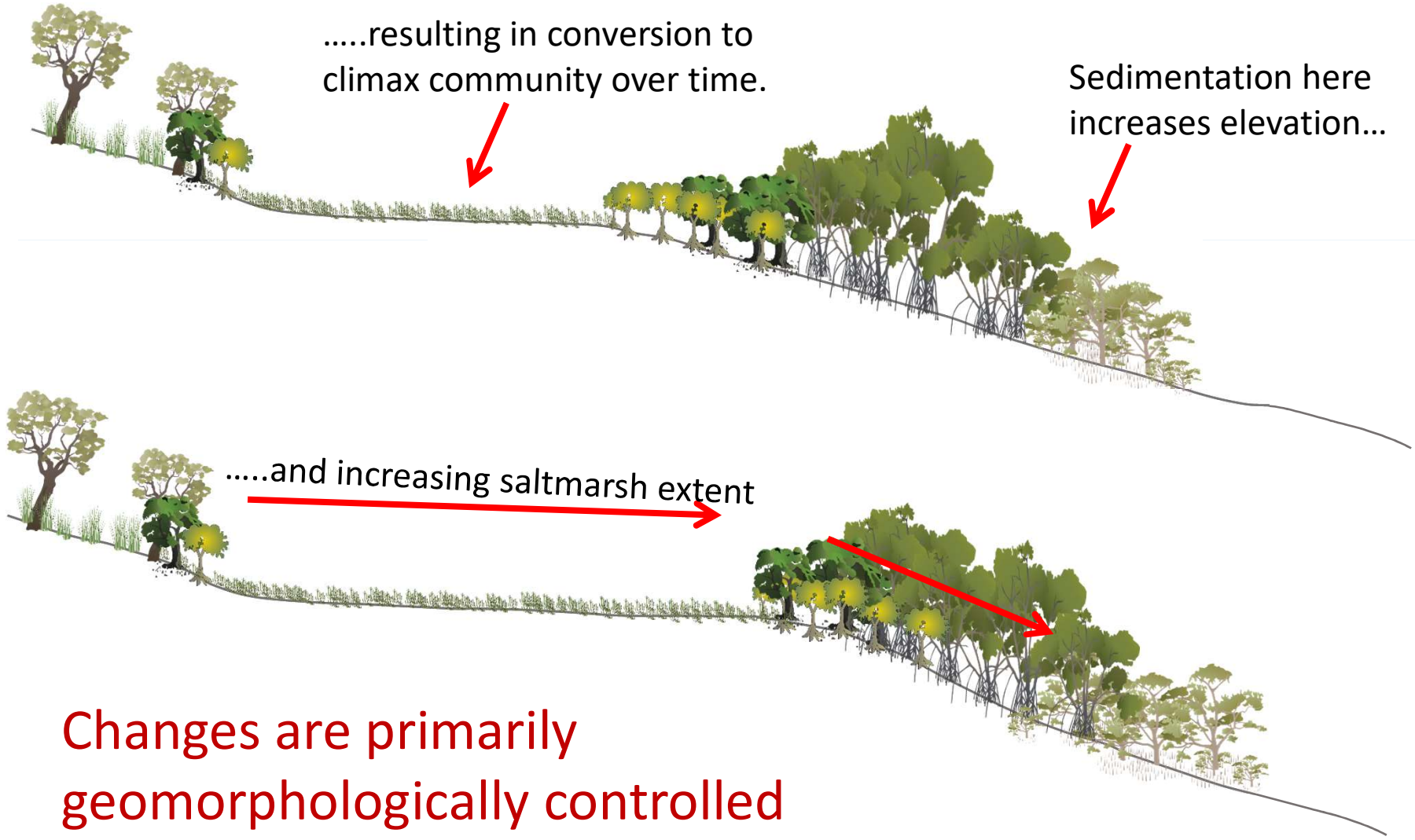
Background: Zonation & accommodation space



Adapted from: Brocklehurst and Edmeades (1996)

Background: Geomorphological evolution



Changes are primarily geomorphologically controlled

Background: Sea-level rise & accommodation space

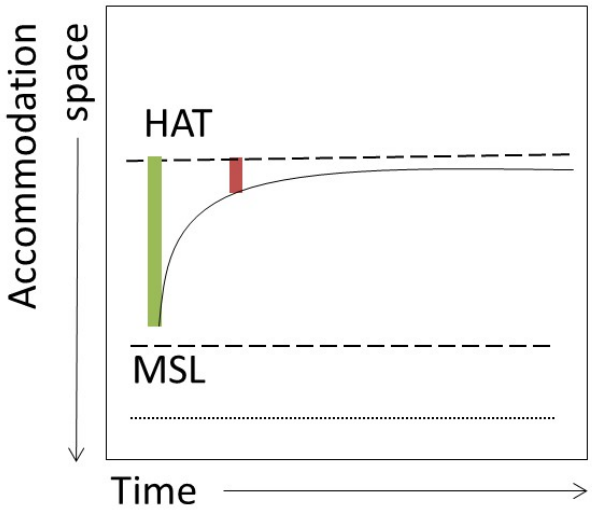
Dependent upon:

- Mineral sedimentation (S_{min})
- Organic matter additions (S_{org})
- Sea-level rise (M)
- Compaction (P)

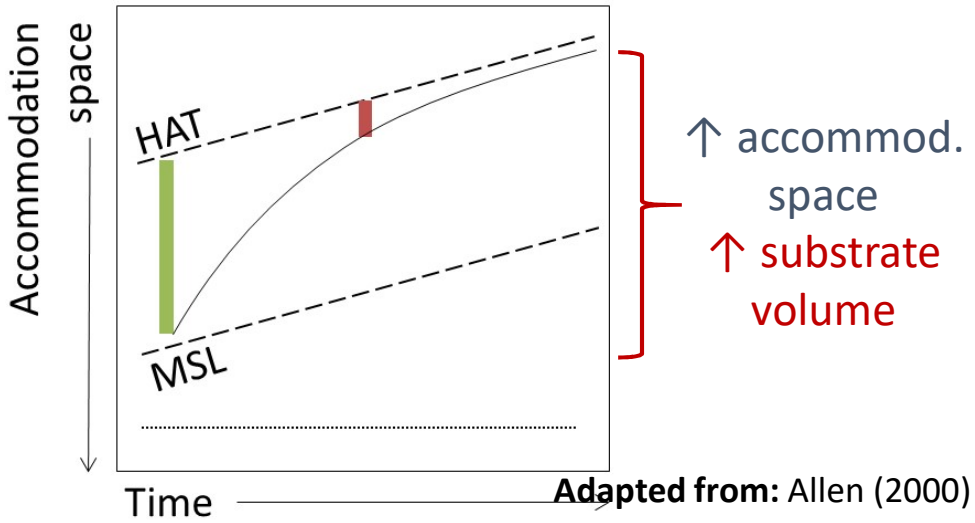
$$\Delta E = \underbrace{(\Delta S_{min} + \Delta S_{org})}_{\uparrow \text{ substrate volume}} - \underbrace{(\Delta M + \Delta P)}_{\uparrow \text{ accommod. space}}$$

Without RSLR

$$\Delta E = (\Delta S_{min} + \Delta S_{org}) - \Delta P$$



With RSLR



Adapted from: Allen (2000)

Aim

- To characterise the geomorphological wetland units around Westernport Bay

Objectives

1. First pass assessment of vulnerability to sea-level rise
2. Shoreline analysis to determine prograding and retreating shorelines

Available accommodation space is key to understanding the Holocene response of estuaries to sea-level rise

Framework of vulnerability assessments

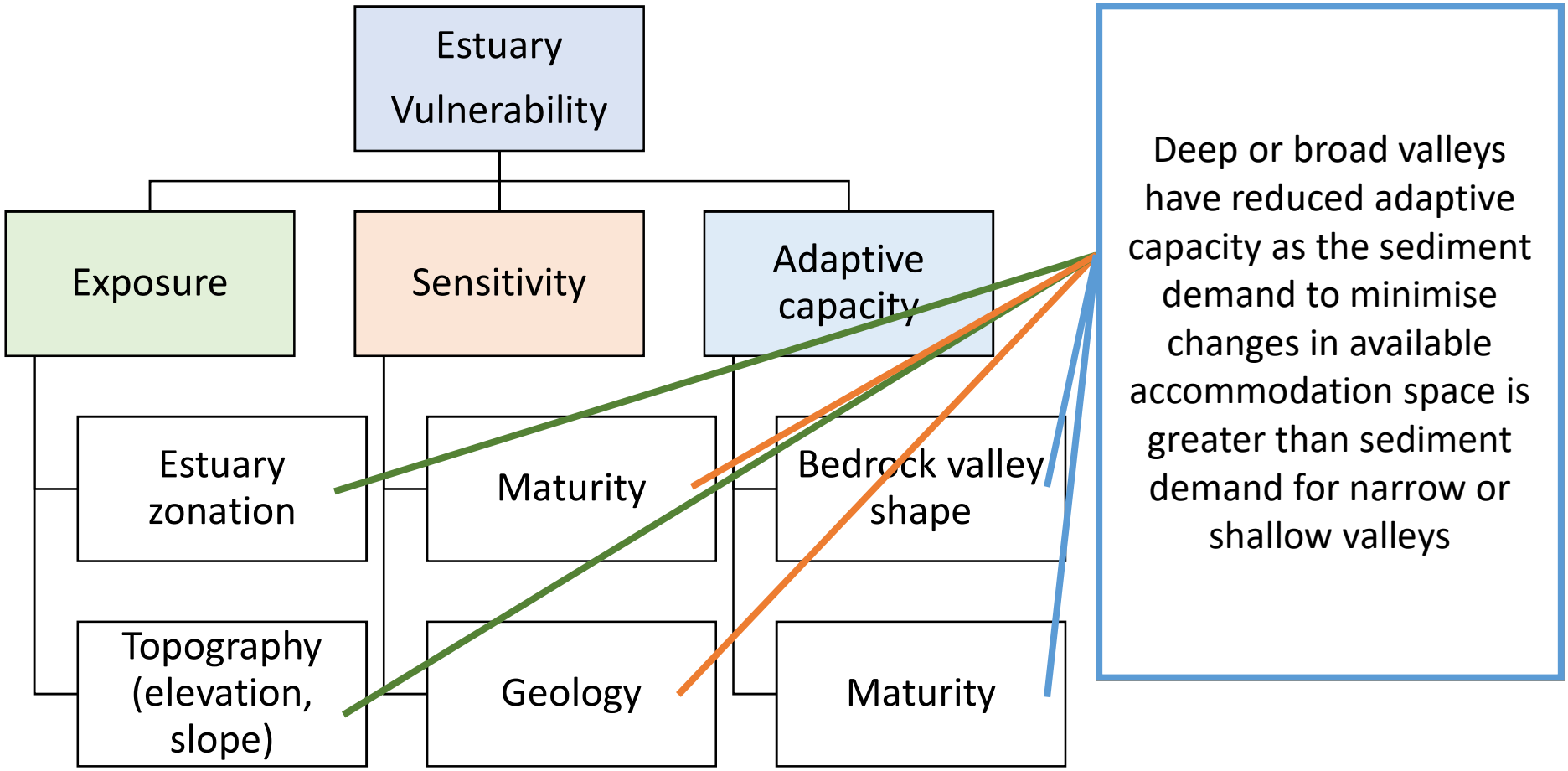
Vulnerability *is a function of the character, magnitude, and rate of climate change and variation to which a system is* ***exposed****, its* ***sensitivity****, and its* ***adaptive capacity****.*

(IPCC 2007)

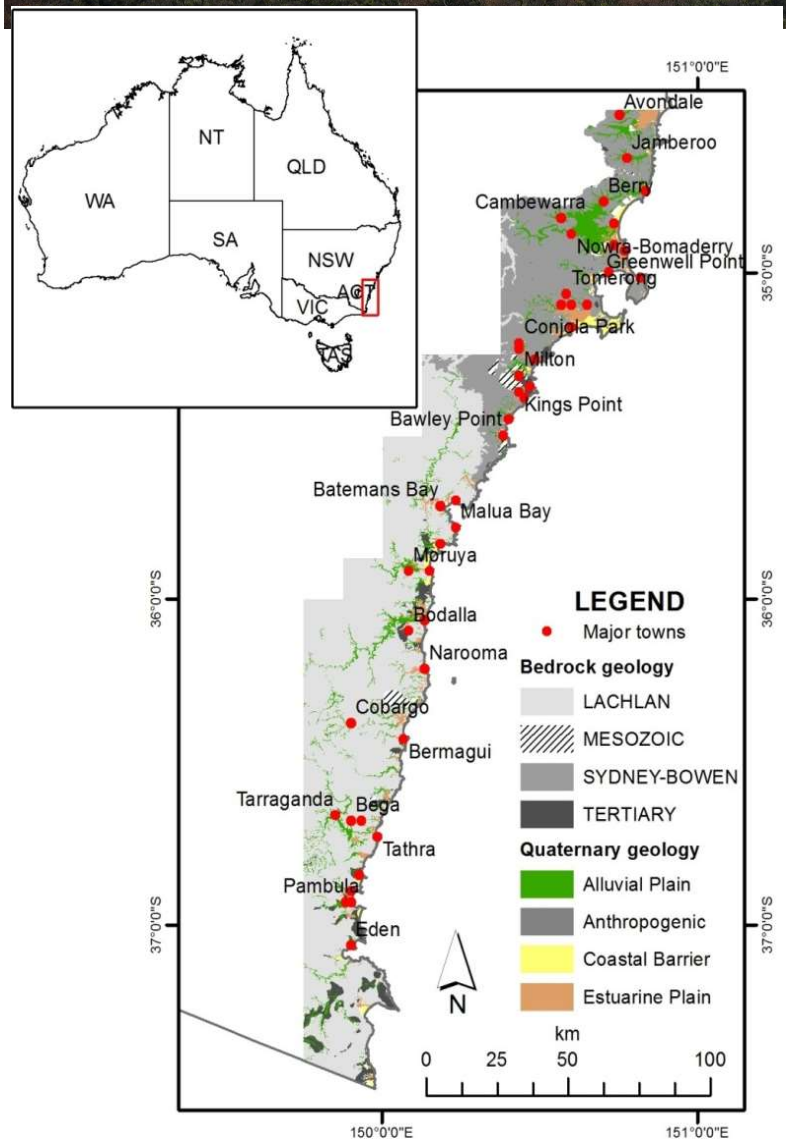
Vulnerability =

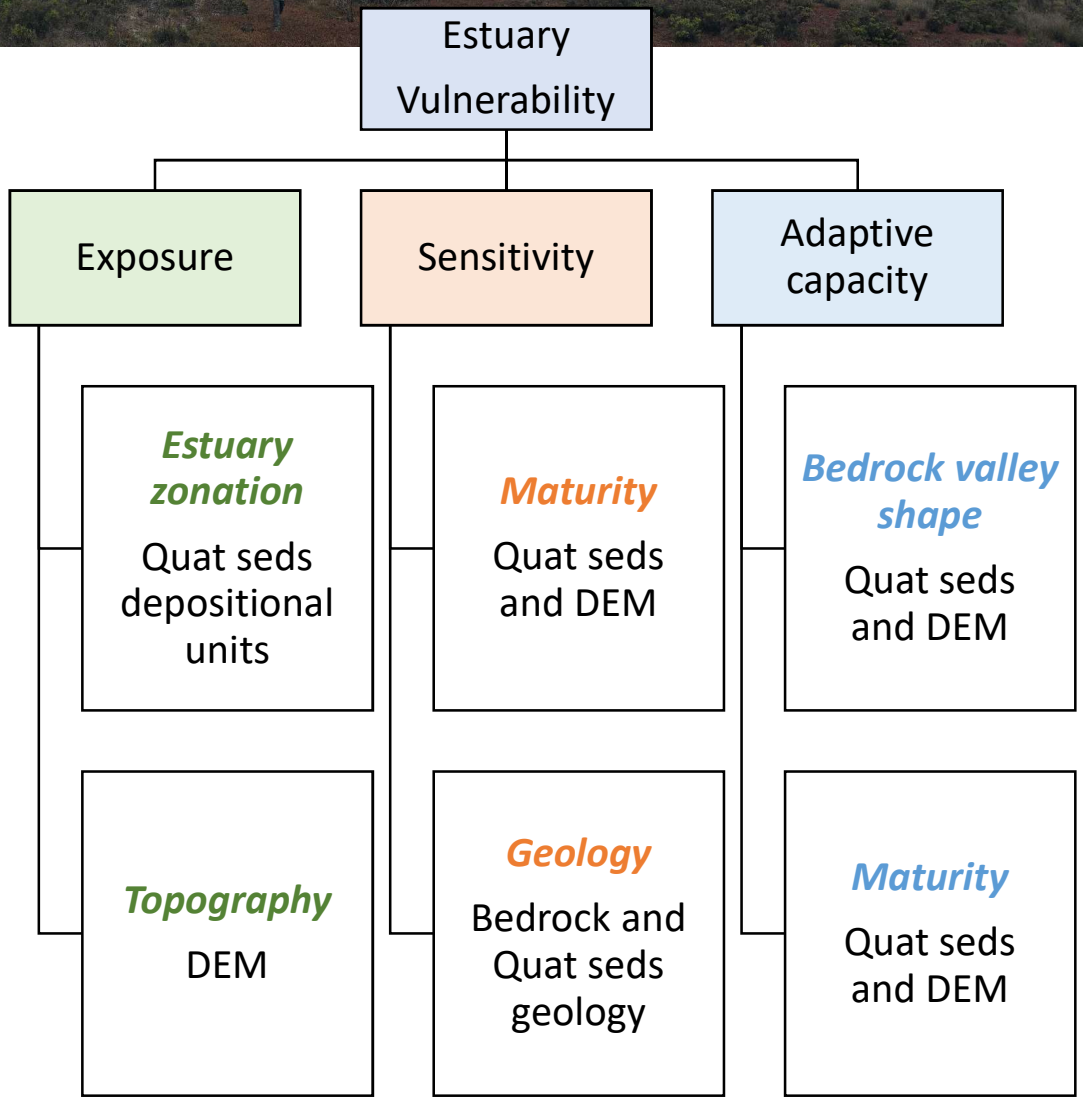
Exposure + Sensitivity + Adaptive Capacity

Integrating geomorphic and vulnerability frameworks

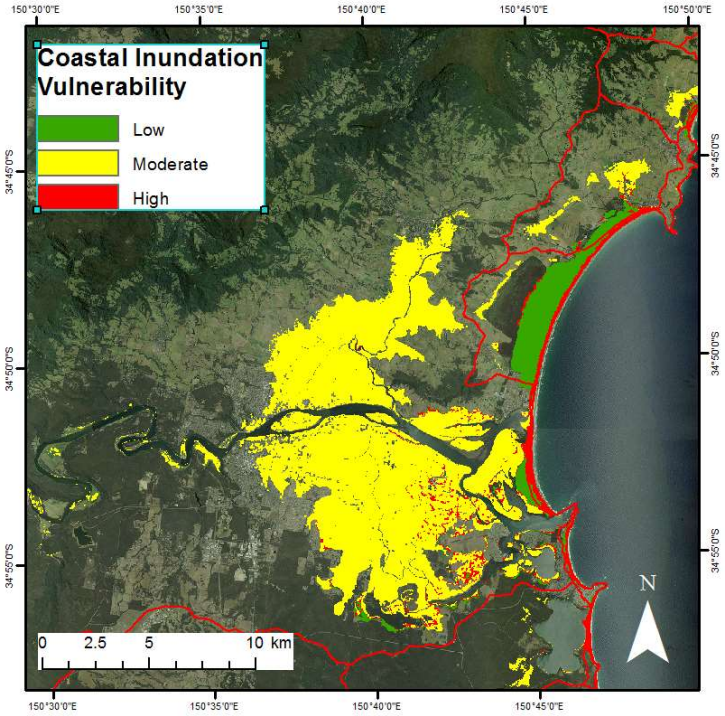


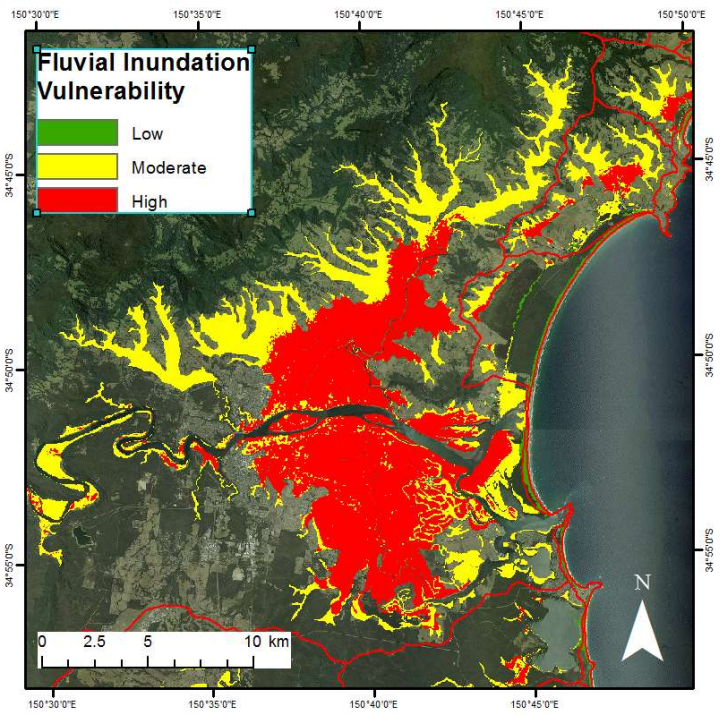
Spatial application

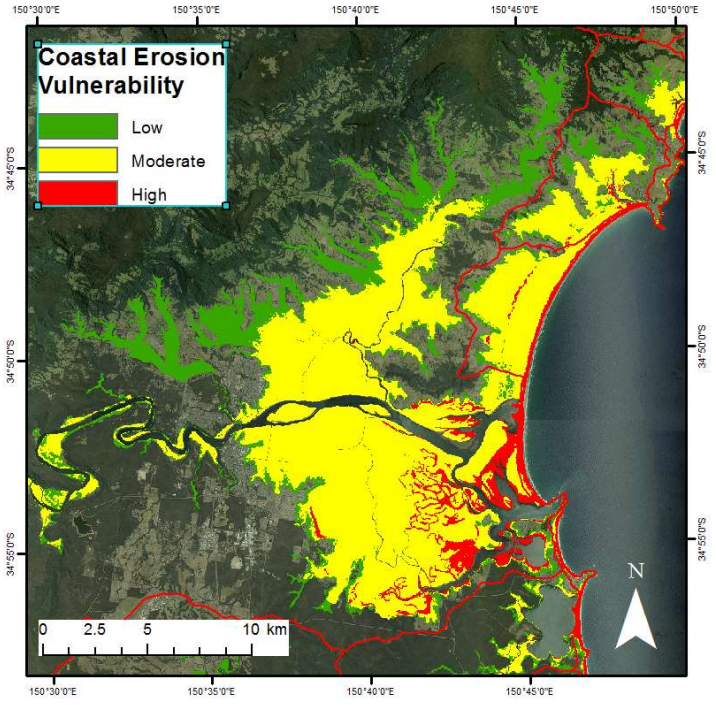


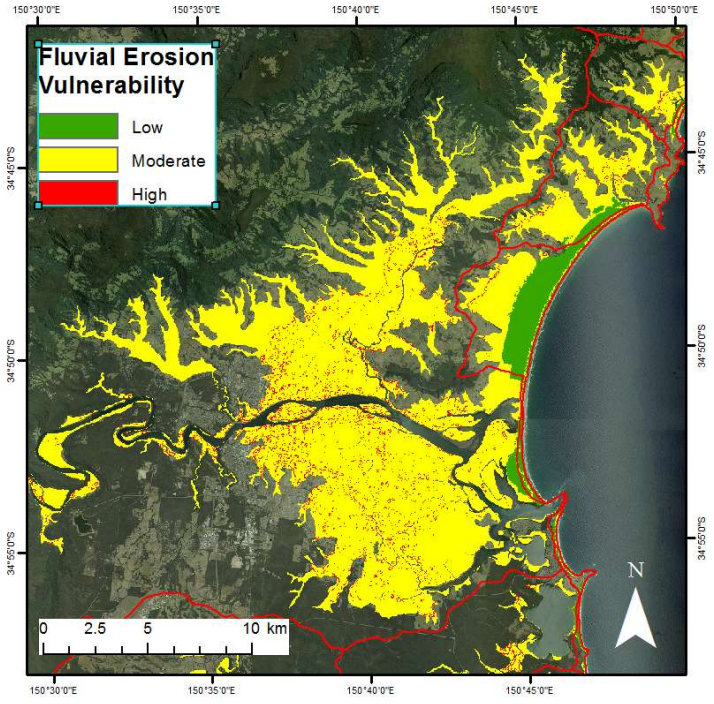


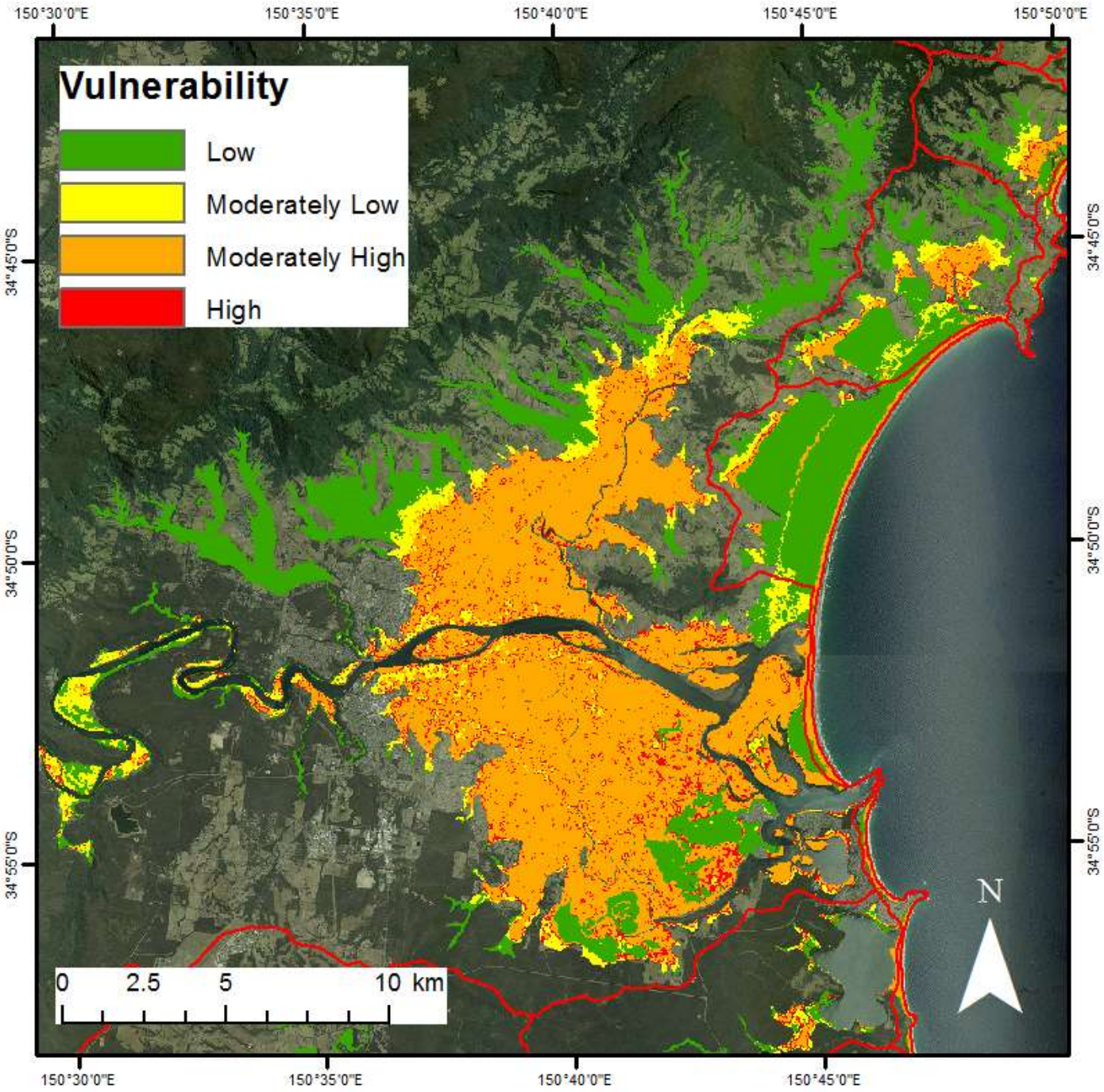
Rogers, K., & Woodroffe, C. D. (2016). Geomorphology as an indicator of the biophysical vulnerability of estuaries to coastal and flood hazards in a changing climate. *Journal of coastal conservation*, *20*(2), 127-144.


Coastal Inundation Vulnerability
Low
Moderate
High
150°30'0"E
150°35'0"E
150°40'0"E
150°45'0"E
150°50'0"E
34°45'0"S
34°50'0"S
34°55'0"S
0 2.5 5 10 km
N


Fluvial Inundation Vulnerability
Low
Moderate
High
150°30'0"E
150°35'0"E
150°40'0"E
150°45'0"E
150°50'0"E
34°45'0"S
34°50'0"S
34°55'0"S
0 2.5 5 10 km
N


Coastal Erosion Vulnerability
Low
Moderate
High
150°30'0"E
150°35'0"E
150°40'0"E
150°45'0"E
150°50'0"E
34°45'0"S
34°50'0"S
34°55'0"S
0 2.5 5 10 km
N


Fluvial Erosion Vulnerability
Low
Moderate
High
150°30'0"E
150°35'0"E
150°40'0"E
150°45'0"E
150°50'0"E
34°45'0"S
34°50'0"S
34°55'0"S
0 2.5 5 10 km
N


Vulnerability
Low
Moderately Low
Moderately High
High
150°30'0"E
150°35'0"E
150°40'0"E
150°45'0"E
150°50'0"E
34°45'0"S
34°50'0"S
34°55'0"S
0
2.5
5
10 km
N

2. Shoreline Change: discussion

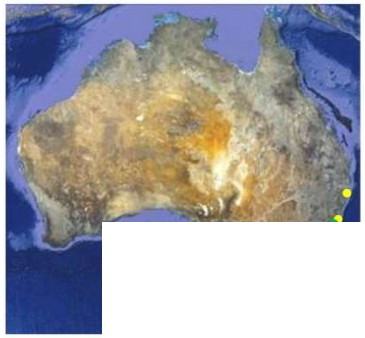
Aim

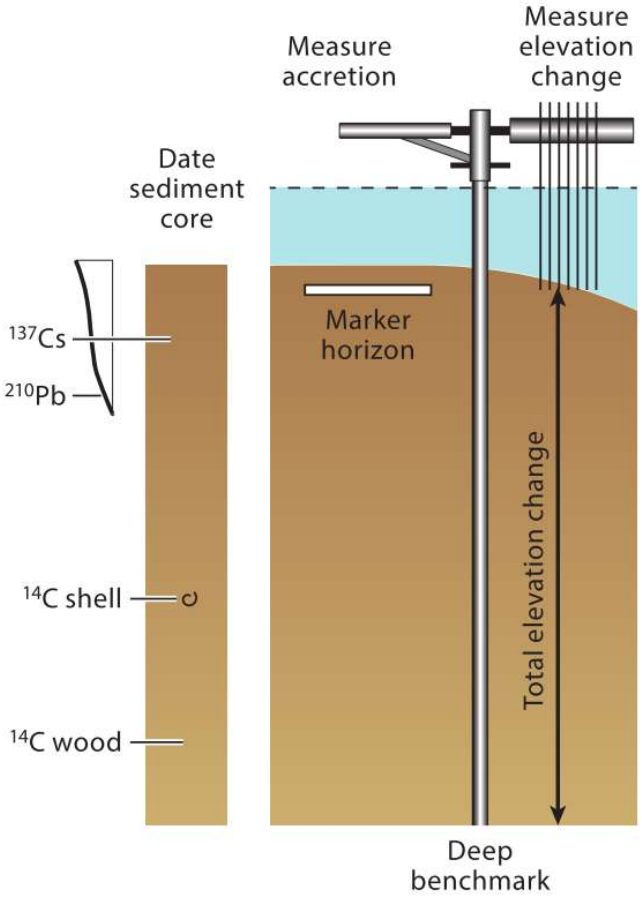
- To characterise the decadal to century-scale geomorphological response of coastal wetlands to sea-level change

Objectives

1. Determine contemporary erosion and accretion rates using existing SET-MH network
2. Quantify century-scale accretion characteristics
3. Characterise sediment composition (grain size etc.)
4. Measure and assess erosion at Lang Lang

Monitoring response to SLR



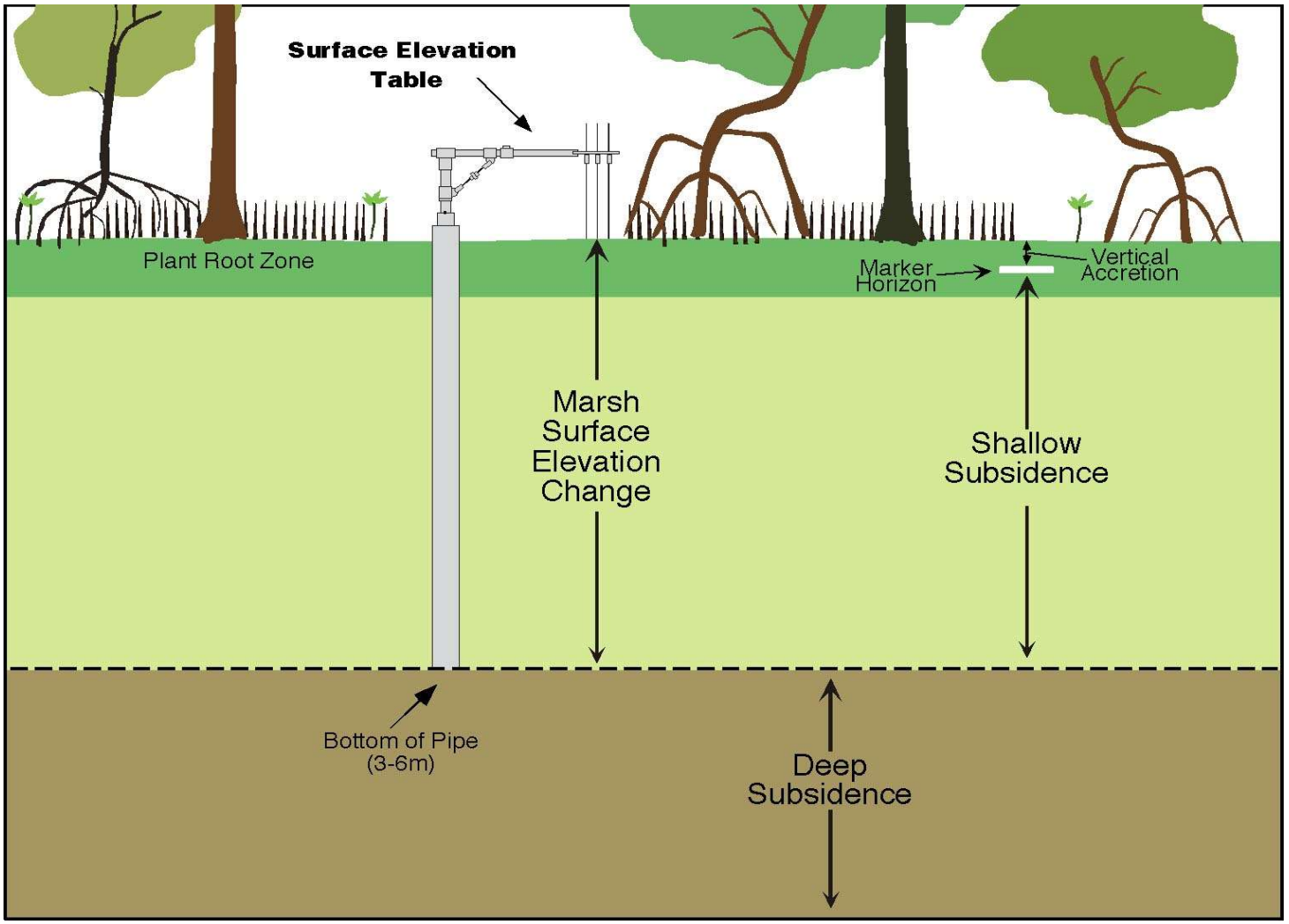


Position:
- RTK-GPS
- Water level loggers
- LiDAR DEM

Sediment:
- Grain size
- Bulk density
- LOI
- %C, %N
- $\delta^{13}C$, $\delta^{15}N$
- ITRAX

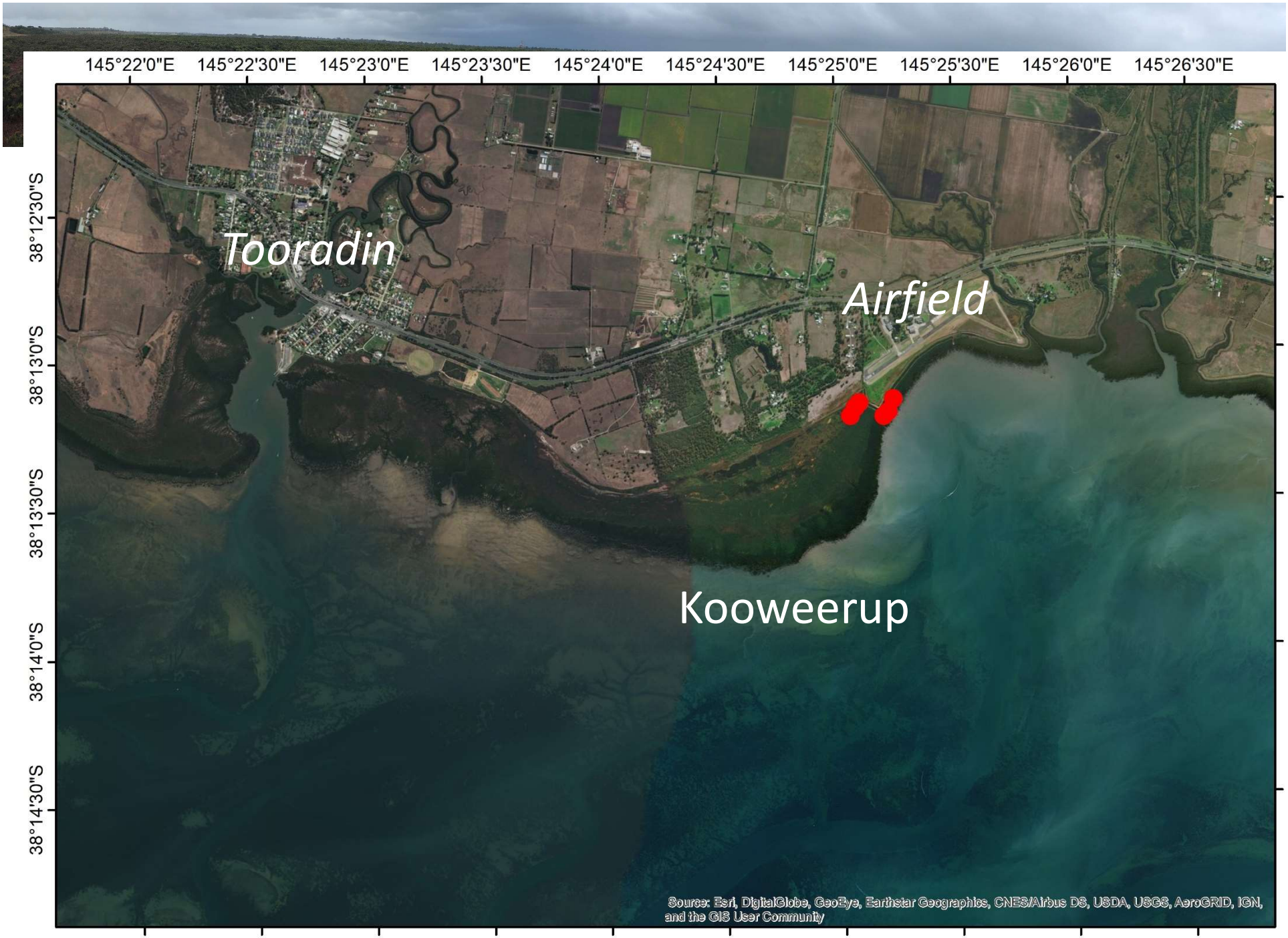
Dating:
- ^{210}Pb
- ^{137}Cs
- ^{14}C

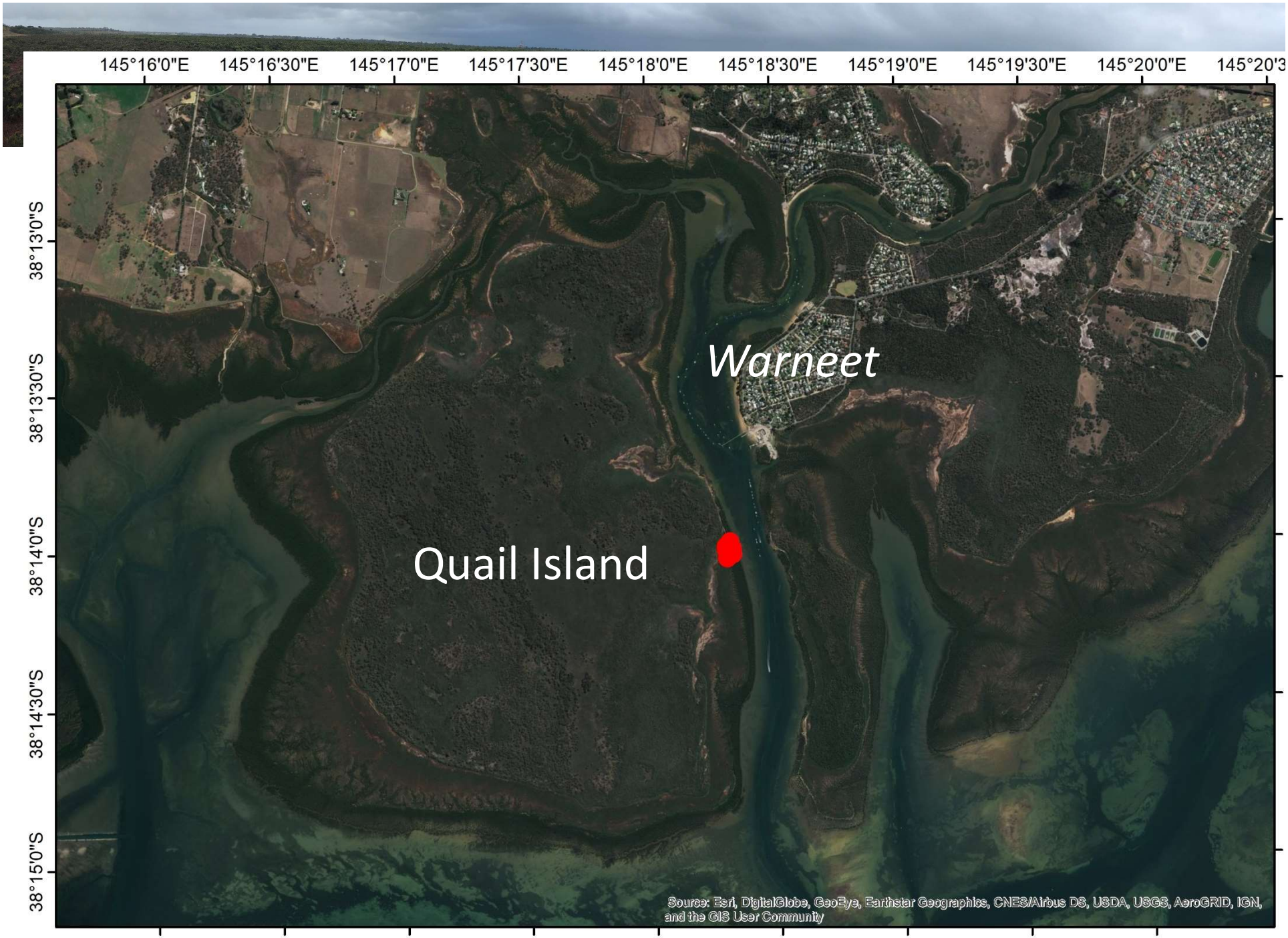
1. SET-MH technique

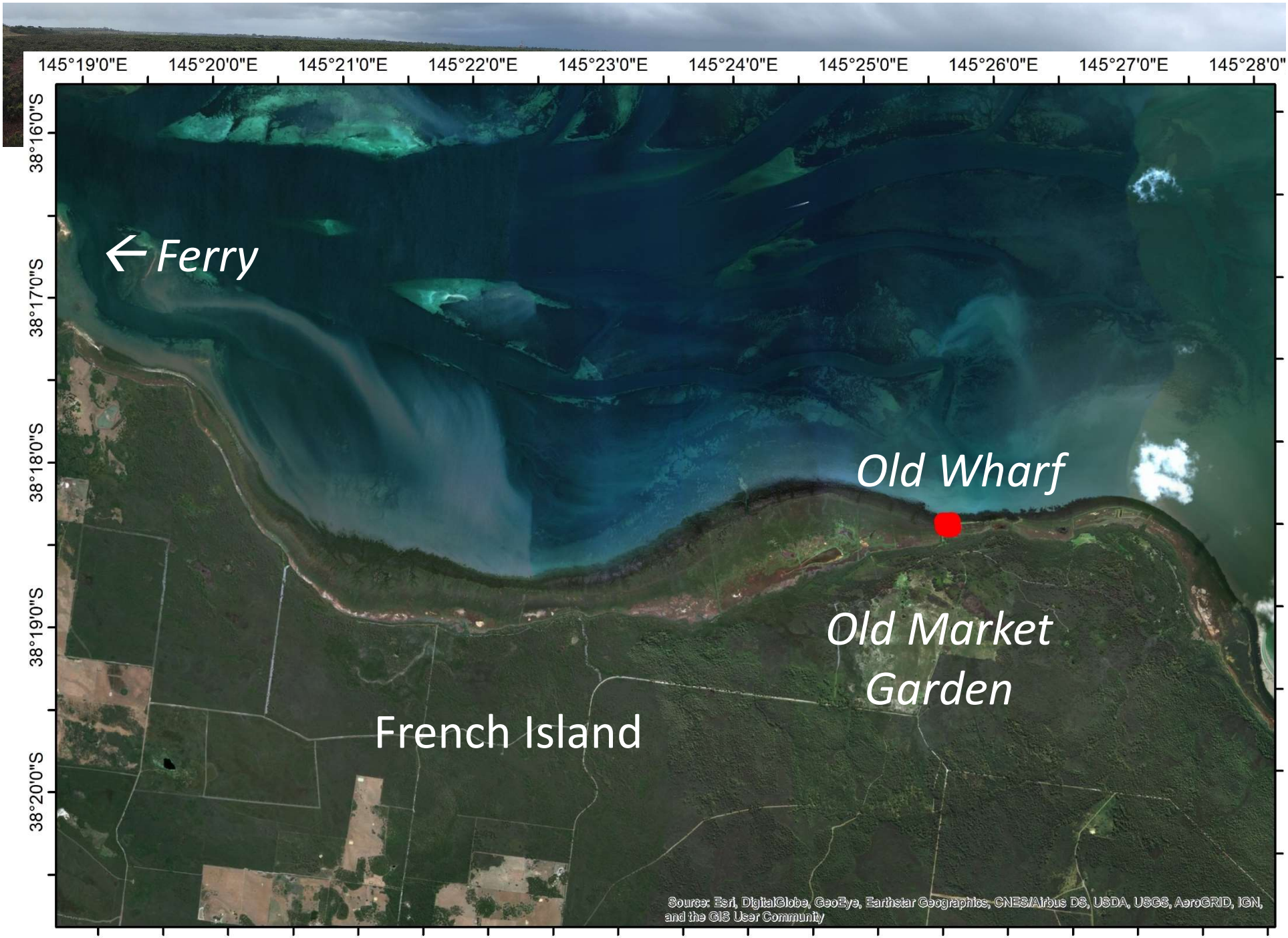


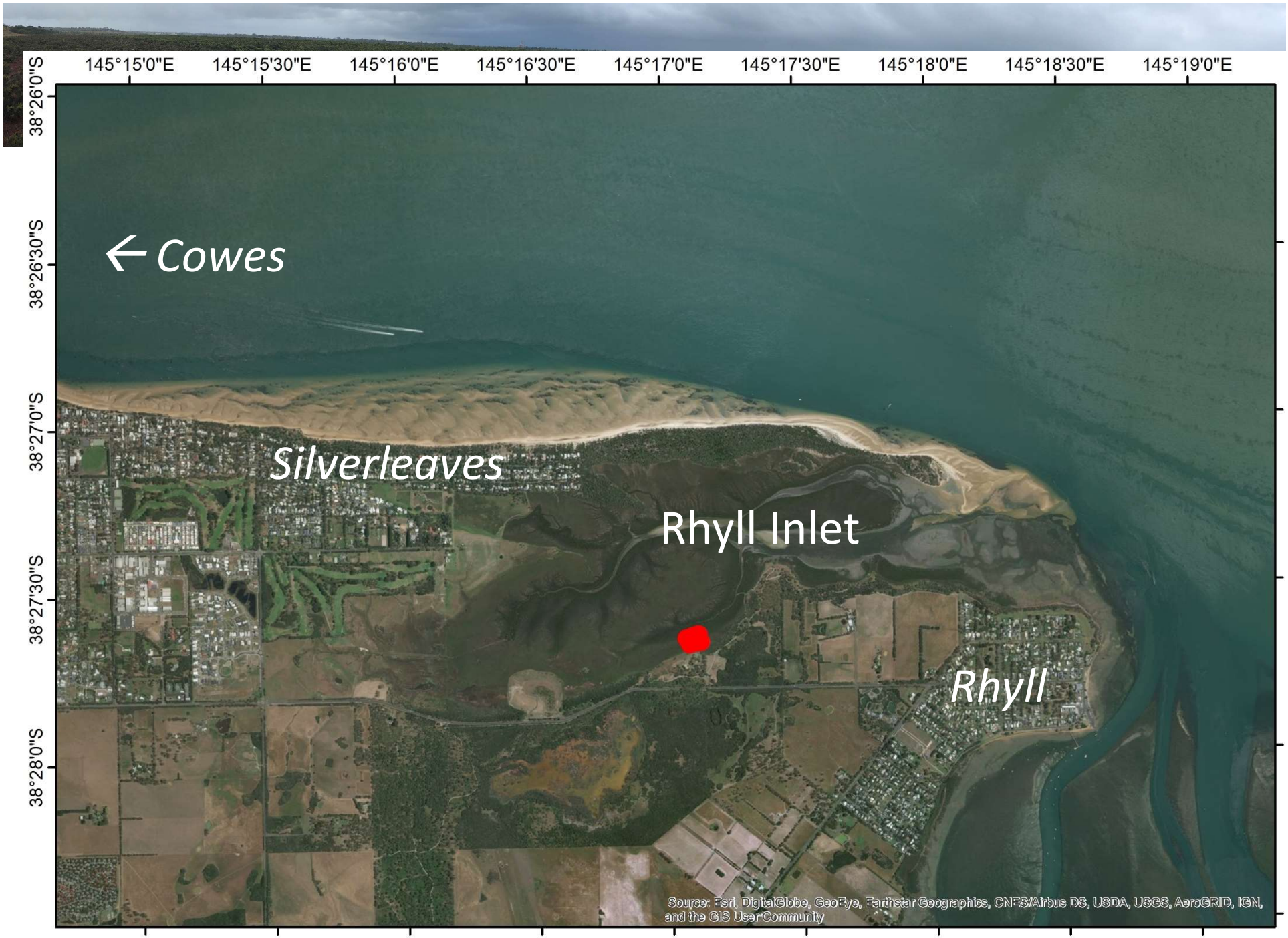
- 24 SET-MH established in October 2000.
- Part of SE Australian network of >100 SETs


145°10'0"E
145°15'0"E
145°20'0"E
145°25'0"E
145°30'0"E
145°35'0"E
38°15'0"S
38°20'0"S
38°25'0"S
Kooweerup
Quail Island
French Island
Rhyll Inlet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


145°22'0"E
145°22'30"E
145°23'0"E
145°23'30"E
145°24'0"E
145°24'30"E
145°25'0"E
145°25'30"E
145°26'0"E
145°26'30"E
38°12'30"S
38°13'0"S
38°13'30"S
38°14'0"S
38°14'30"S
Tooradin
Airfield
Kooweerup
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


145°16'0"E
145°16'30"E
145°17'0"E
145°17'30"E
145°18'0"E
145°18'30"E
145°19'0"E
145°19'30"E
145°20'0"E
38°13'30"S
38°13'30"S
38°14'0"S
38°14'30"S
38°15'0"S
Warneet
Quail Island
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

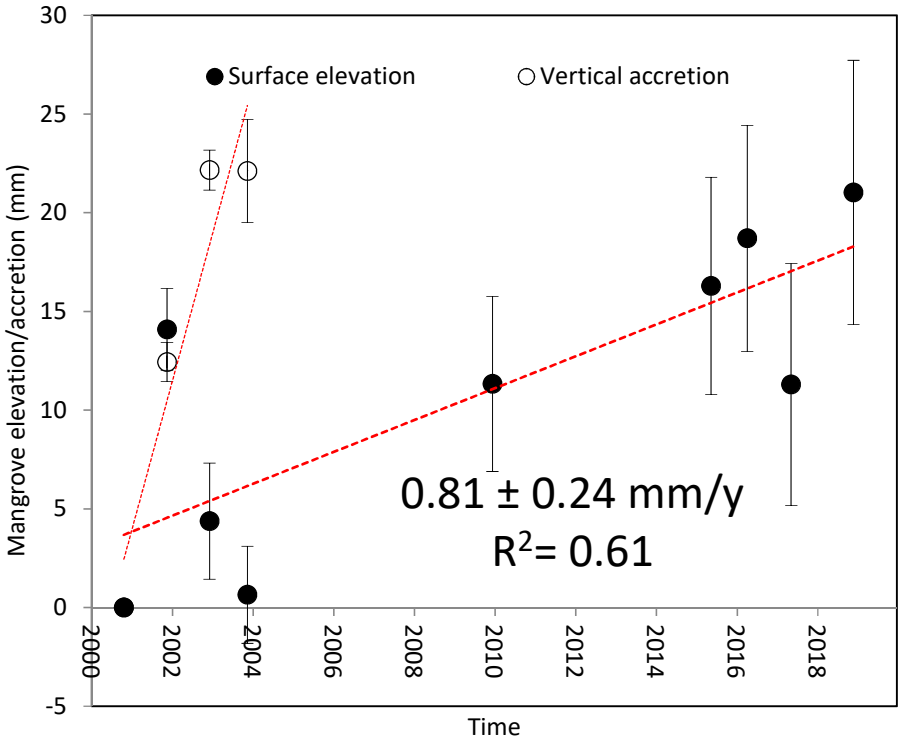

145°19'0"E
145°20'0"E
145°21'0"E
145°22'0"E
145°23'0"E
145°24'0"E
145°25'0"E
145°26'0"E
145°27'0"E
145°28'0"
38°16'0"S
38°17'0"S
38°18'0"S
38°19'0"S
38°20'0"S
← Ferry
Old Wharf
Old Market Garden
French Island
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

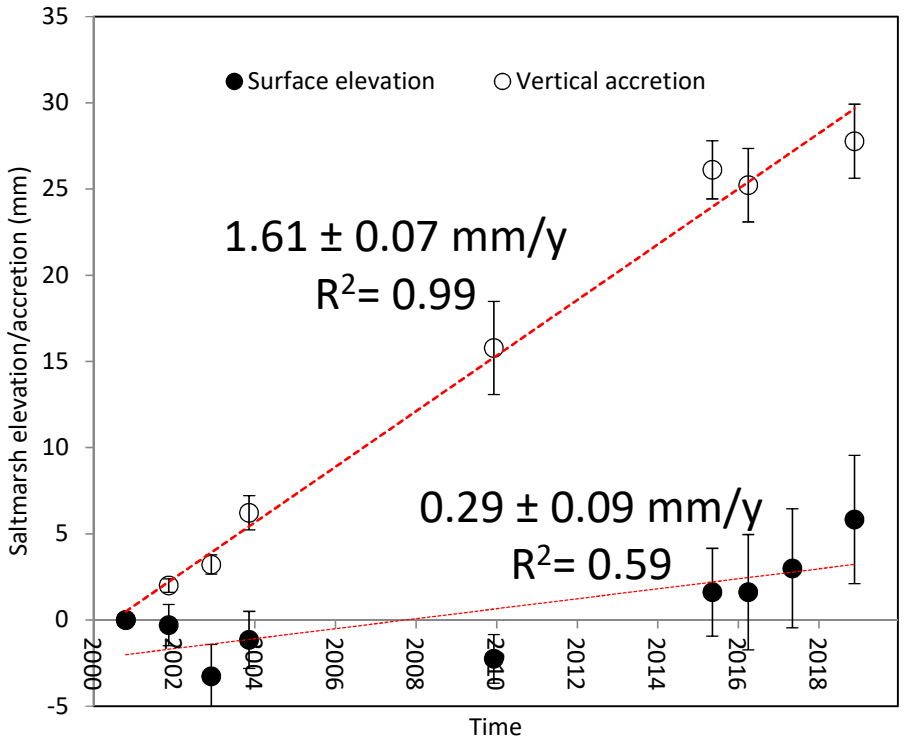

145°15'0"E
145°15'30"E
145°16'0"E
145°16'30"E
145°17'0"E
145°17'30"E
145°18'0"E
145°18'30"E
145°19'0"E
38°26'0"S
38°26'30"S
38°27'0"S
38°27'30"S
38°28'0"S
← Cowes
Silverleaves
Rhyll Inlet
Rhyll
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

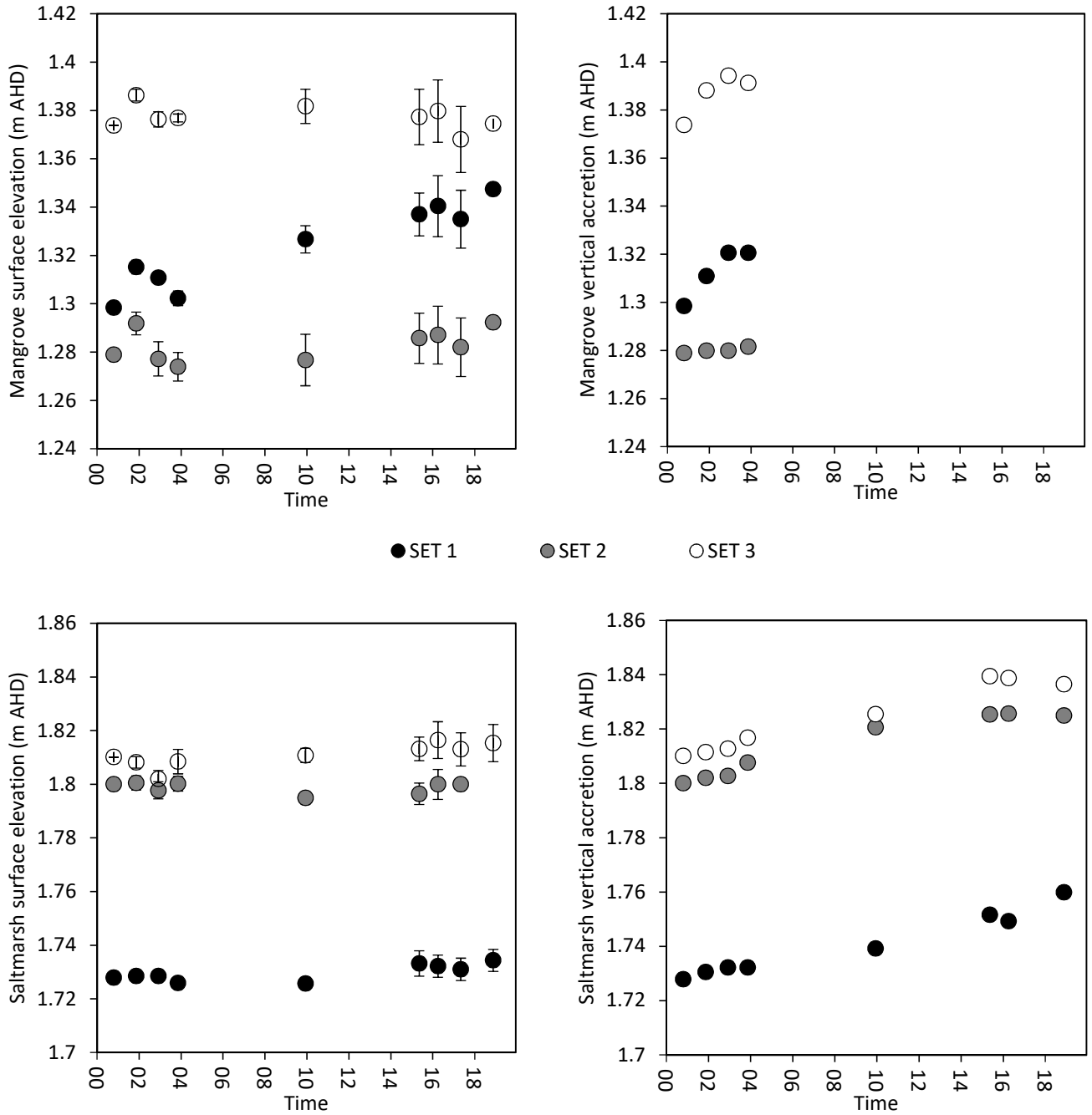
SETs

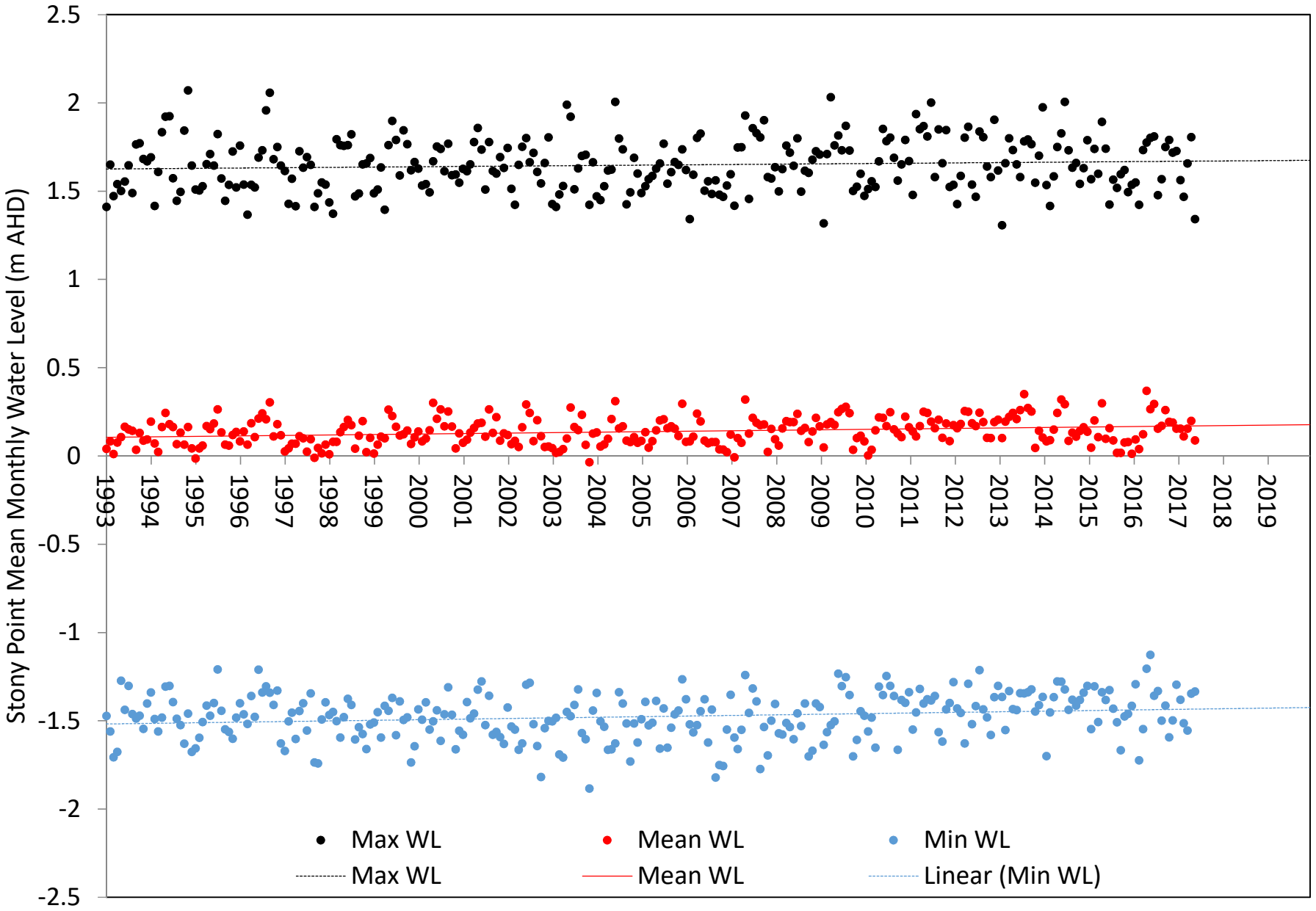
- 3 x high marsh
  Mean elevation ~1.8 m
  Tecticornia incursion

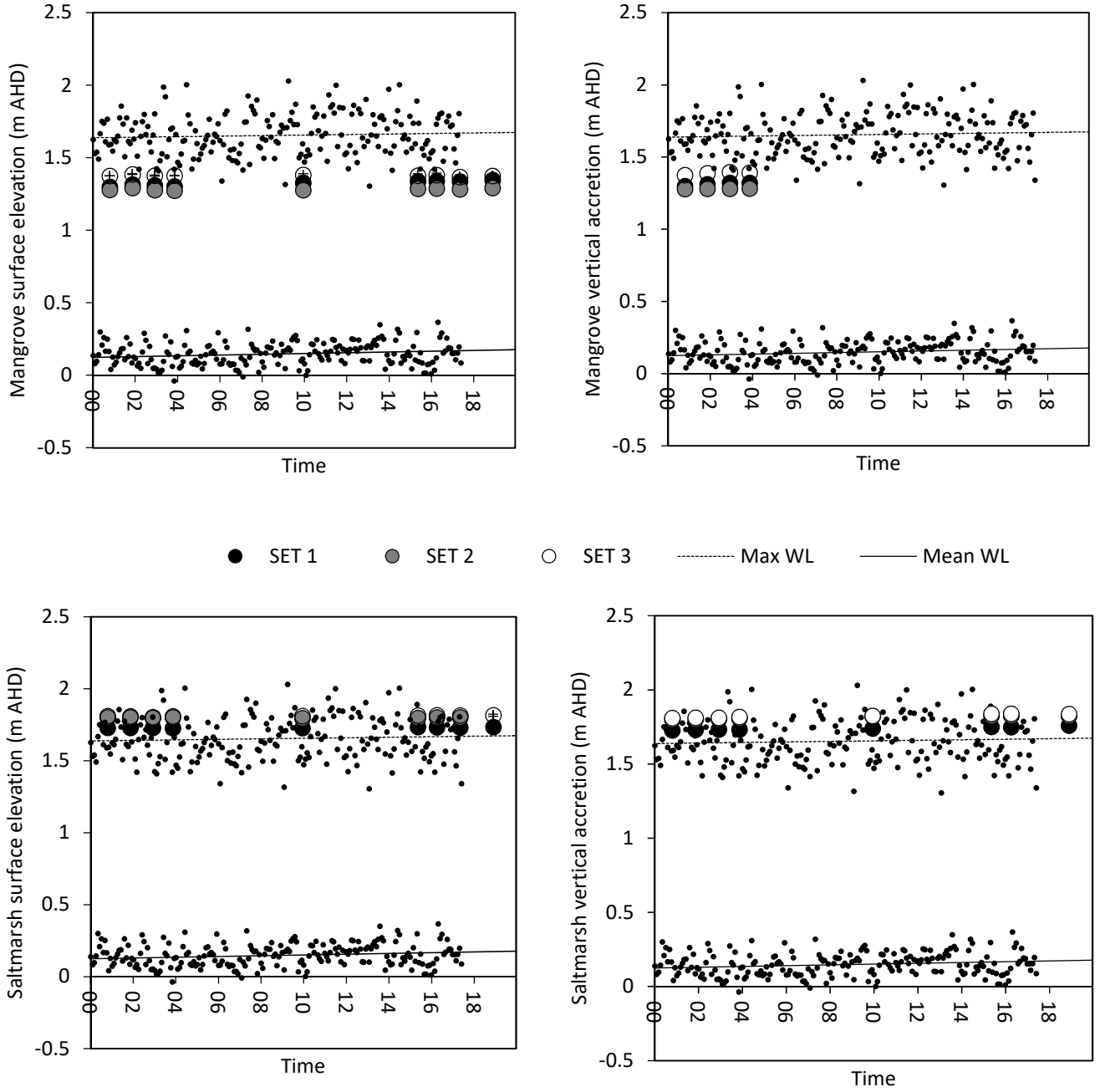
- 3 x high mangrove
  Mean elevation ~1.3 m
  Avicennia ~ 2.2 m ht





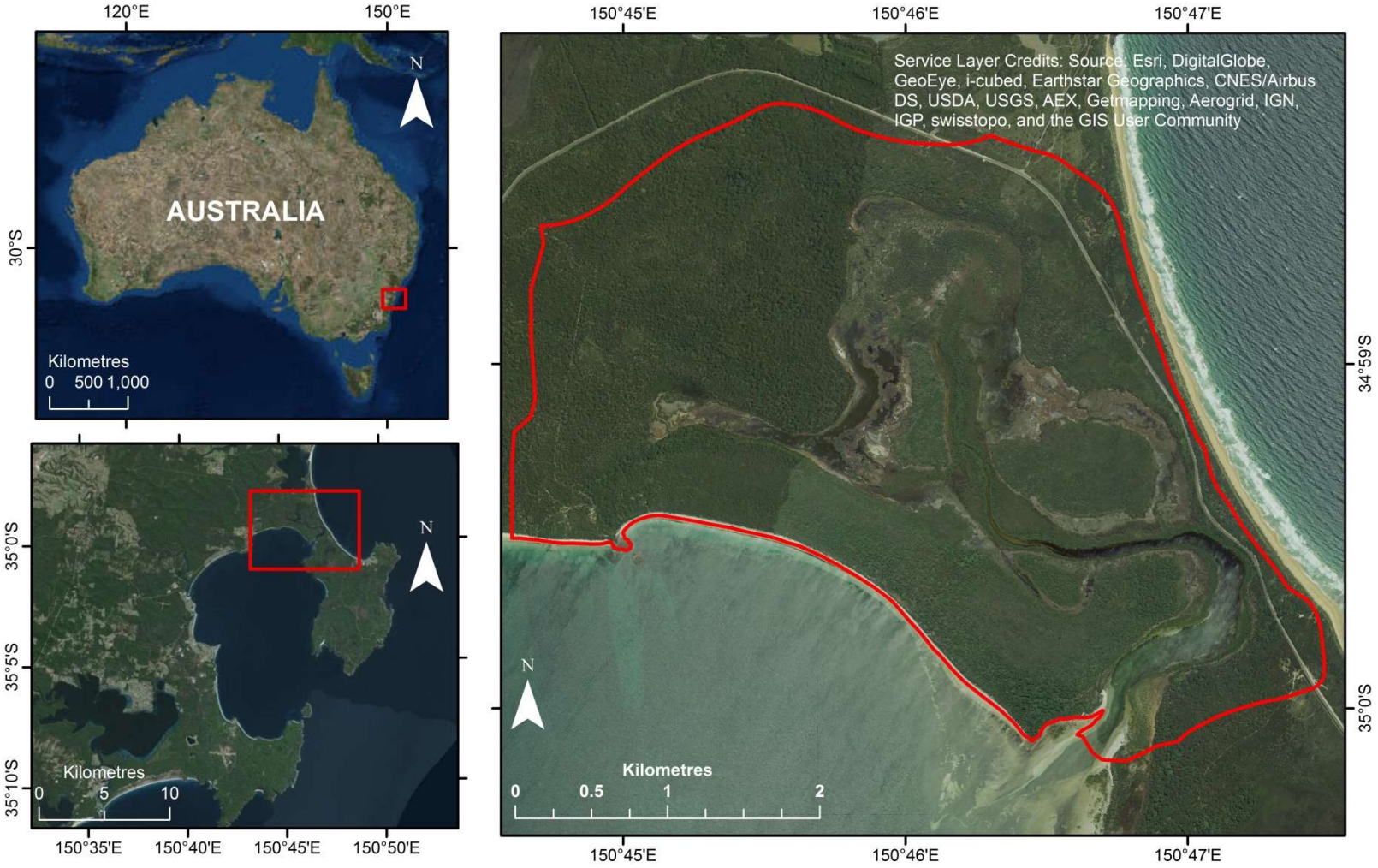

Mangrove surface elevation (m AHD)
Mangrove vertical accretion (m AHD)
Saltmarsh surface elevation (m AHD)
Saltmarsh vertical accretion (m AHD)
Time
SET 1
SET 2
SET 3


Stony Point Mean Monthly Water Level (m AHD)
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Max WL
Mean WL
Min WL
Max WL
Mean WL
Linear (Min WL)

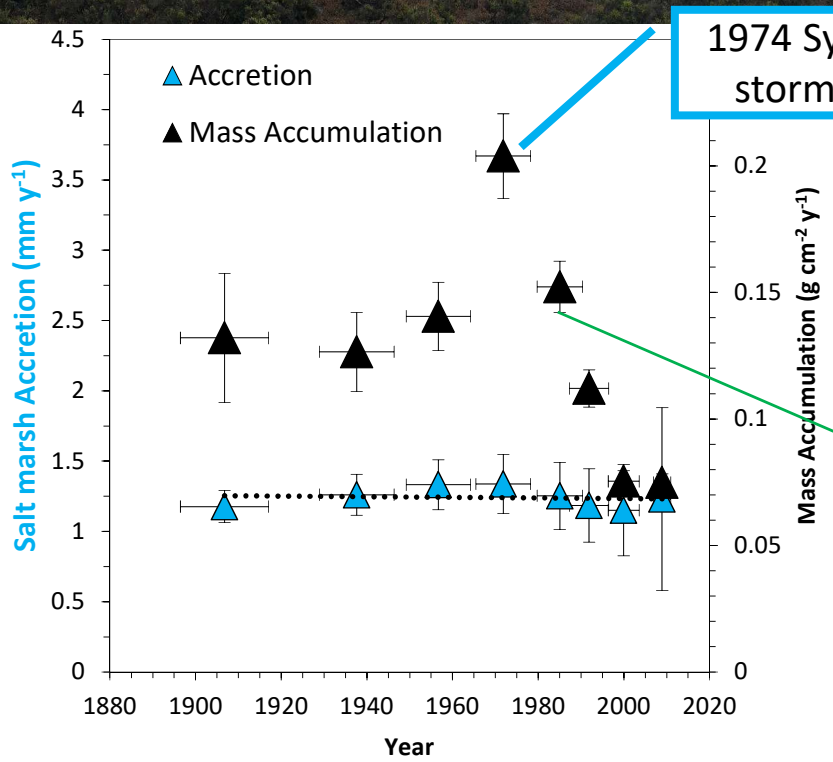

Mangrove surface elevation (m AHD)
Mangrove vertical accretion (m AHD)
Saltmarsh surface elevation (m AHD)
Saltmarsh vertical accretion (m AHD)
Time
2.5
2
1.5
1
0.5
0
-0.5
00
02
04
06
08
10
12
14
16
18
SET 1
SET 2
SET 3
Max WL
Mean WL

	Technique	Accretion/SE change	Period
Mangrove	SET	0.81 ± 0.24 mm/y R^2= 0.61	10/2000-2017
	^{210}Pb	11.75 mm/y***	13 years
Saltmarsh	SET	0.29 ± 0.09 mm/y R^2= 0.59	10/2000-2017
	^{210}Pb	1.68 mm/y***	92 years
Sea level change	Tide gauge (Stony Point)	3.14 ± 1.11 mm/y R^2= 0.04	10/2000-2017
	Tide gauge (Stony Point)	2.65 ± 0.62 mm/y R^2= 0.06	1993-2017
	Tide gauge (Williamstown)	1.73 ± 0.14 mm/y	~1920 - 2015

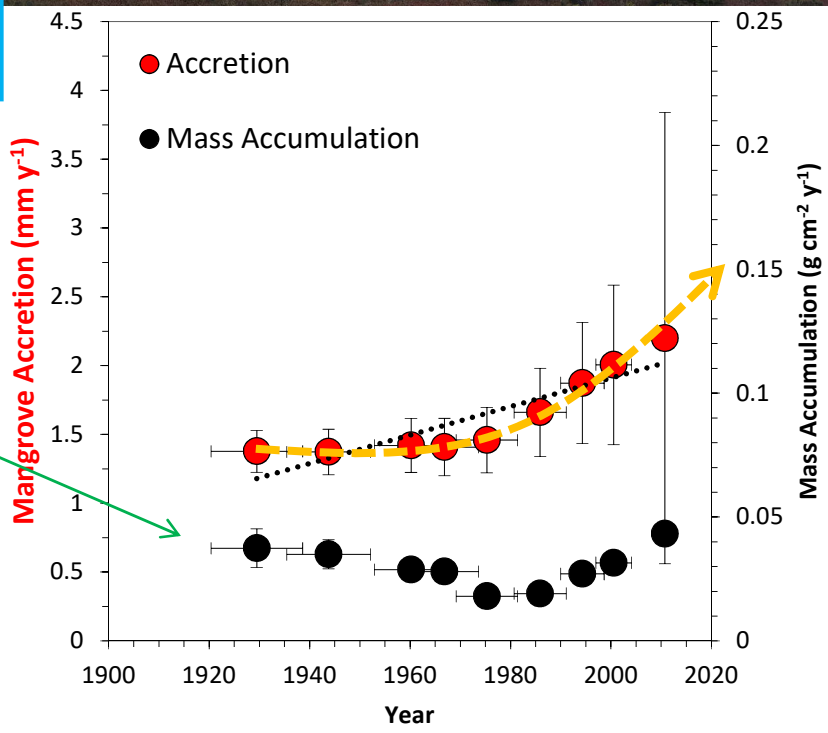
2. Century scale sedimentation example



2. Century scale sedimentation example



1974 Sygna storm??



Saltmarsh accretion over past ~105y

- Mean = 1.24 mm/y
- Max = 1.34 mm/y
- Min = 1.15 mm/y

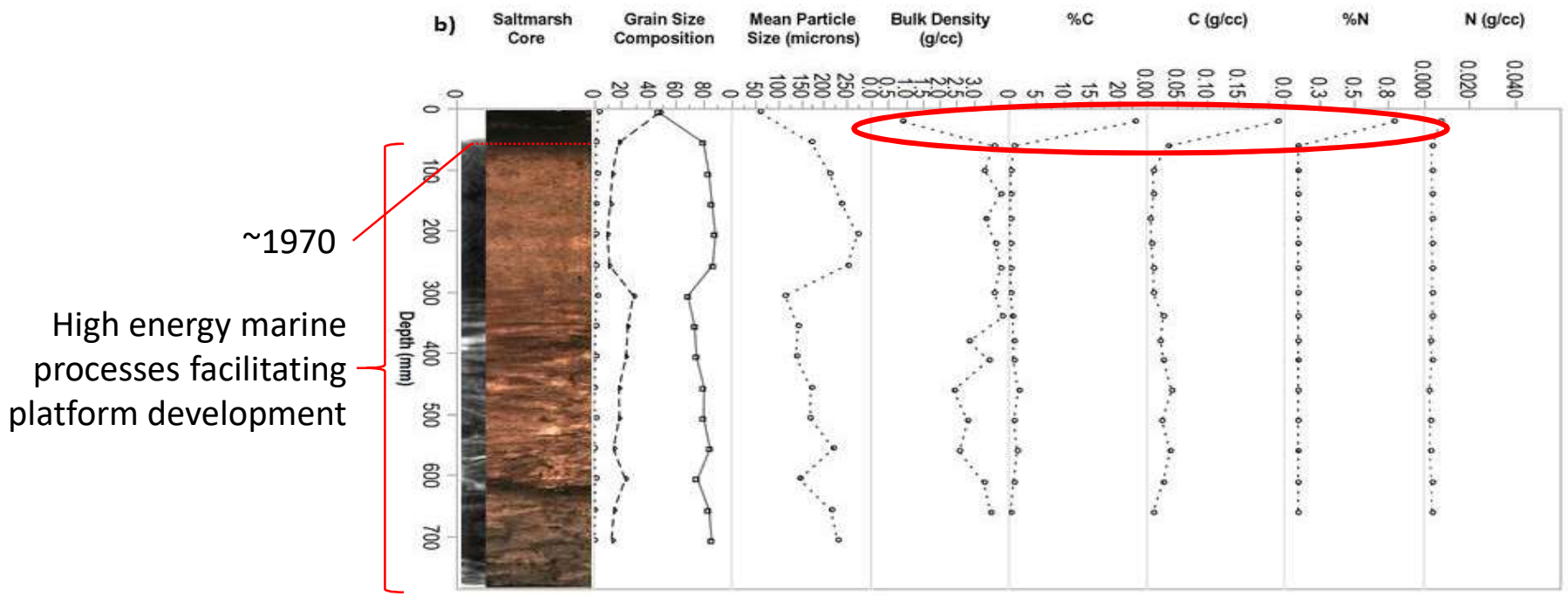
Mangrove accretion over past ~85y

- Mean = 1.6 mm/y
- Max = 2.2 mm/y
- Min = 1.37 mm/y

Mangrove accretion accelerating

Mass accumulation lower in the mangrove: More organic contribution??

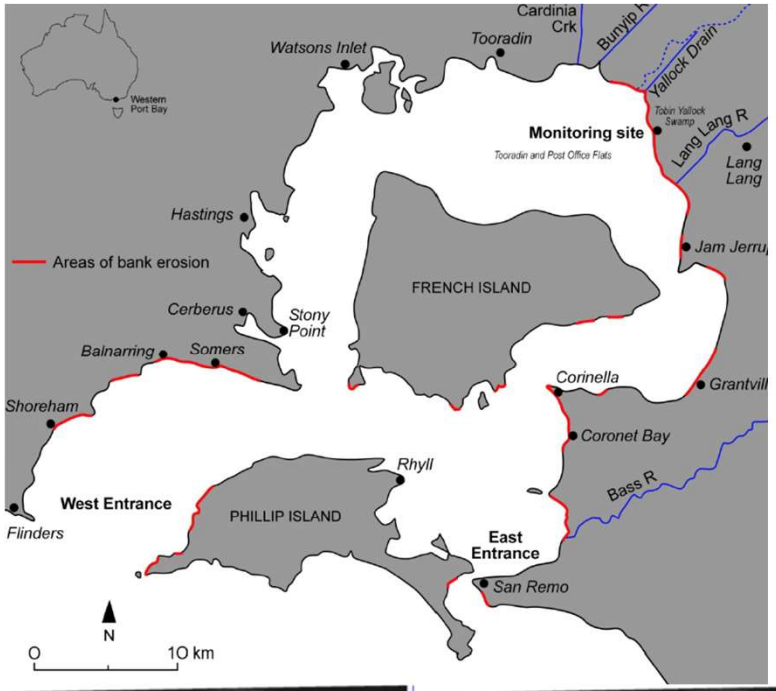
3. Sediment composition example

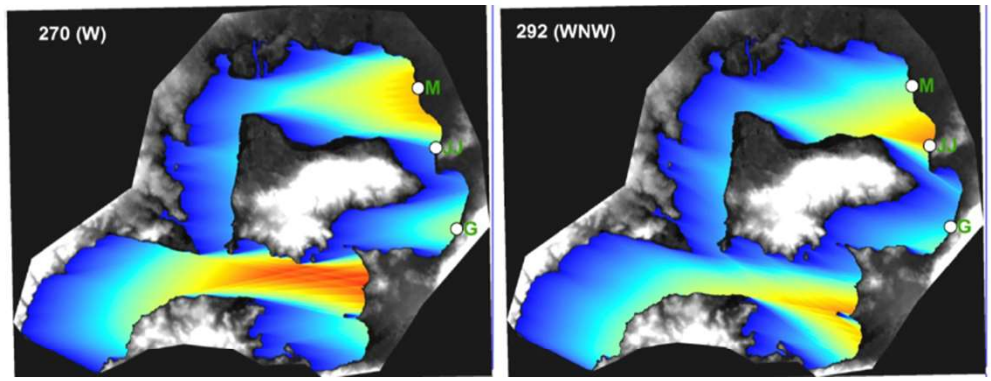


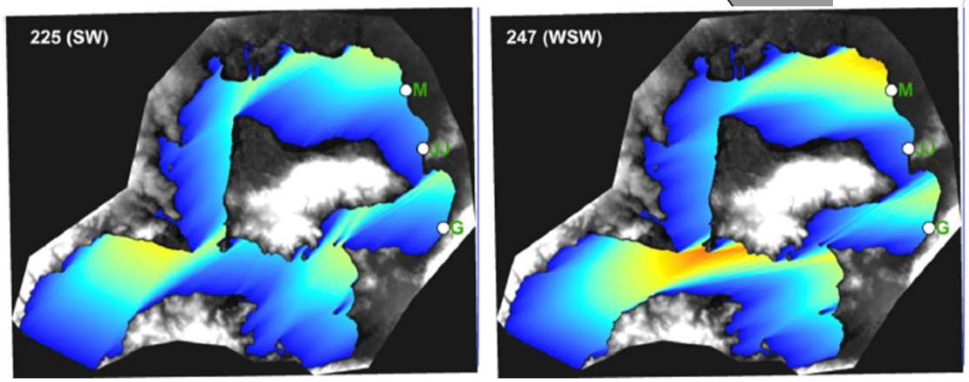
4. Erosion at Lang Lang

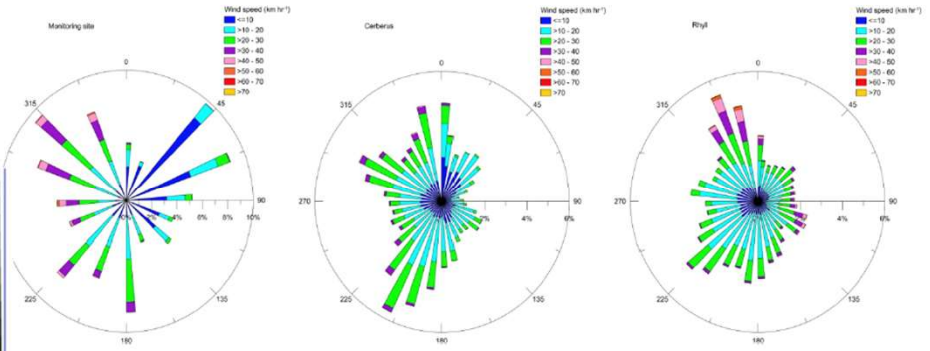
Comments on "Quantification of coastal bank erosion rates in Western Port"

Kerrie Tomkins, Gordon McLachlan, Rhys Coleman



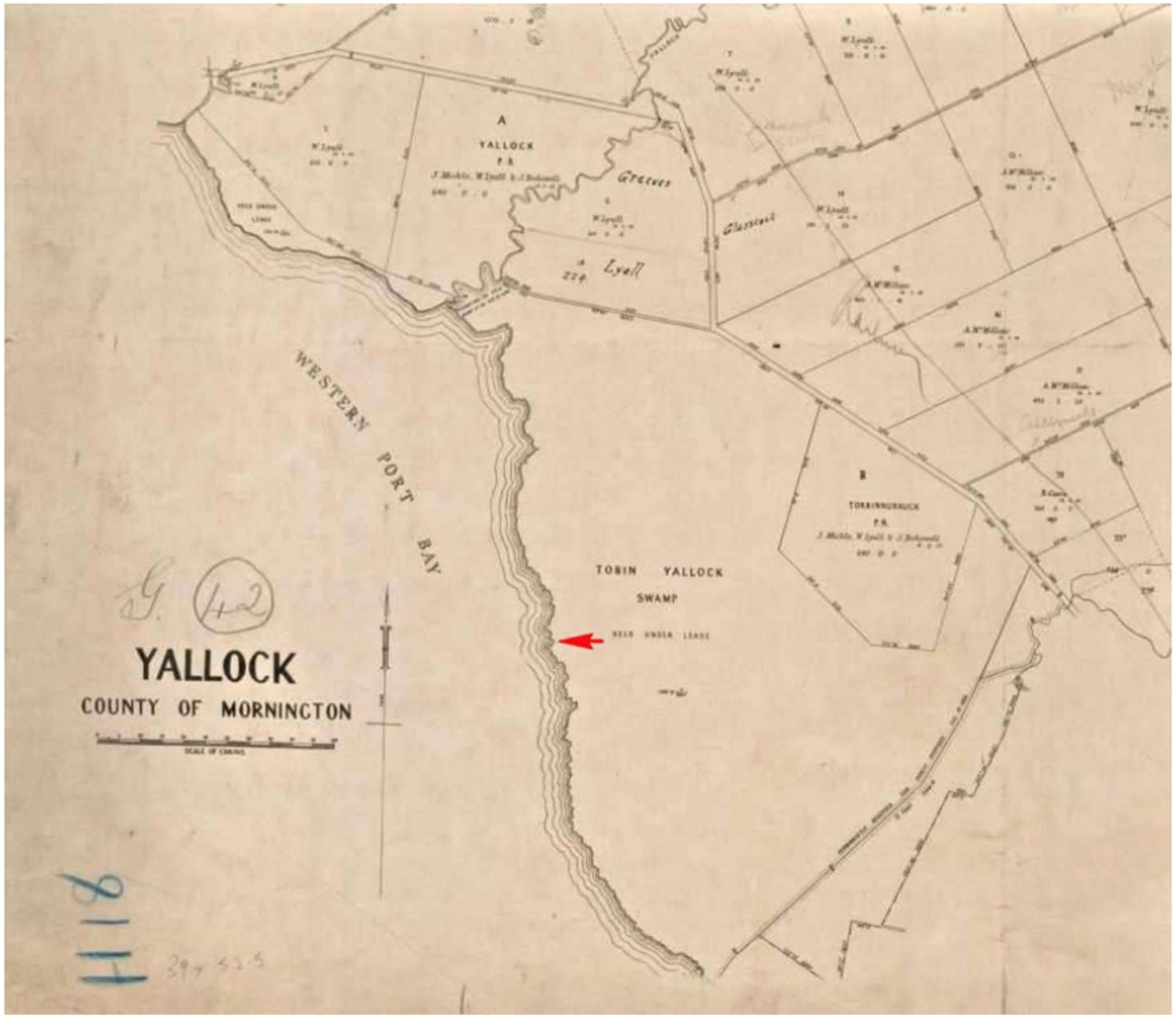




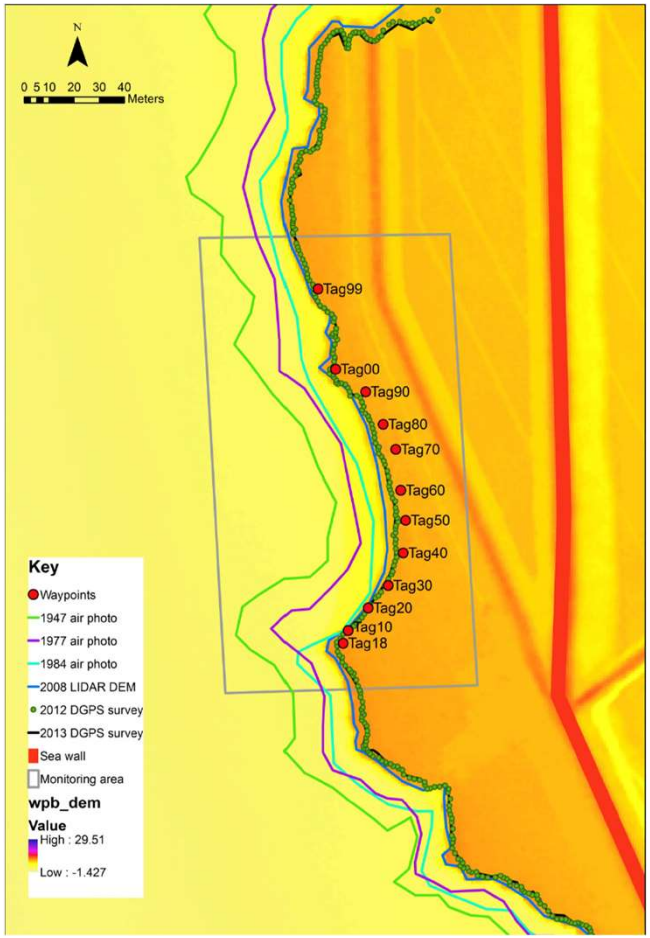


re 16. Patterns of average daily wind speed and direction at the monitoring site (~ 13 months data), Cerberus years data) and Rhyll (22 years data). The stacked colours represent increasing wind speeds, while the length of bars indicates the proportion of winds from each direction.

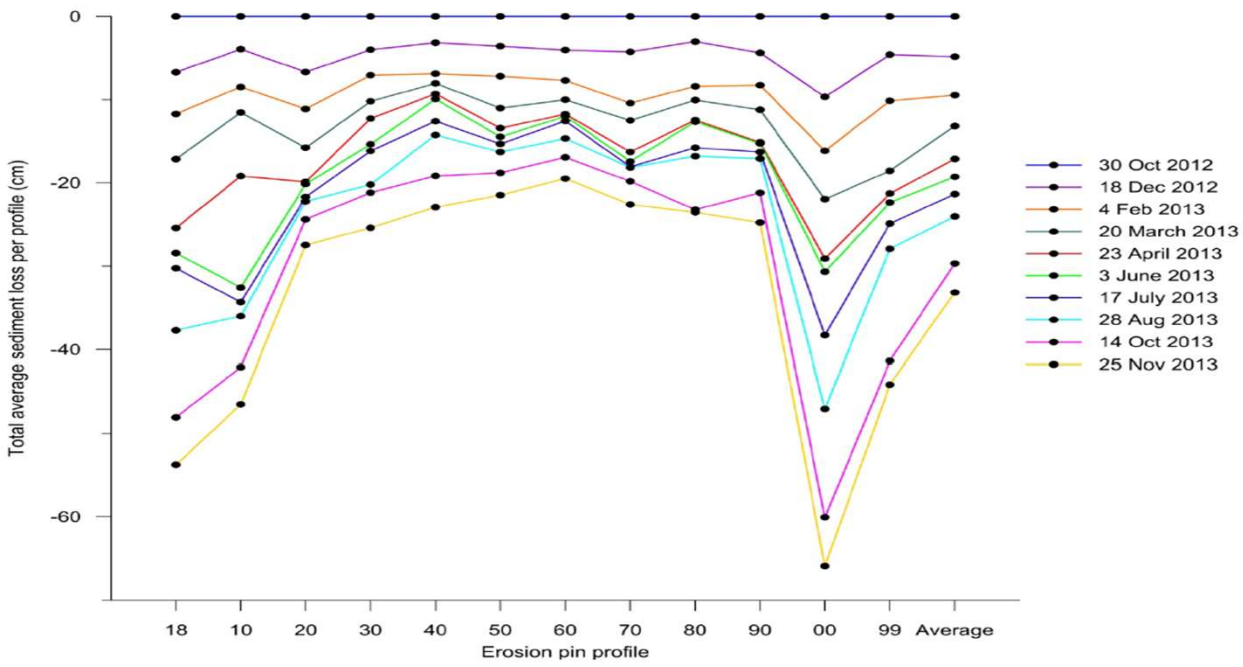
Long history of erosion: earliest surveys



Erosion Pins: 2012-2013



“Smoothing” of the coastline



Key Findings

- Erosion ~ 0.3m per year = 6.2 kT sediment
- This represents approx. one third of sediment inputs into the bay
- (270 000 tonnes since 1947)
- Primarily the result of orientation in relation to prevailing winds and longer fetch
- Seasonal rates related to evaporative drying during the summer rather than storminess

Suggestions for further research

- Re-measure erosion pins (concreted in- most should still be there)
- TLS profiling possible but would require a stable platform
- Shoreline change detection over the 8.6km high erosion section (2013-2020)
- Inter-decadal and inter-centurial changes in wind orientation
- Exposed swamp dating and palynology as a clue to Bay evolution

Exposed Swamp deposits