The Effect of Hurricane Irma Storm Surge on the Freshwater Lens in Big Pine Key, Florida using Electrical Resistivity Tomography

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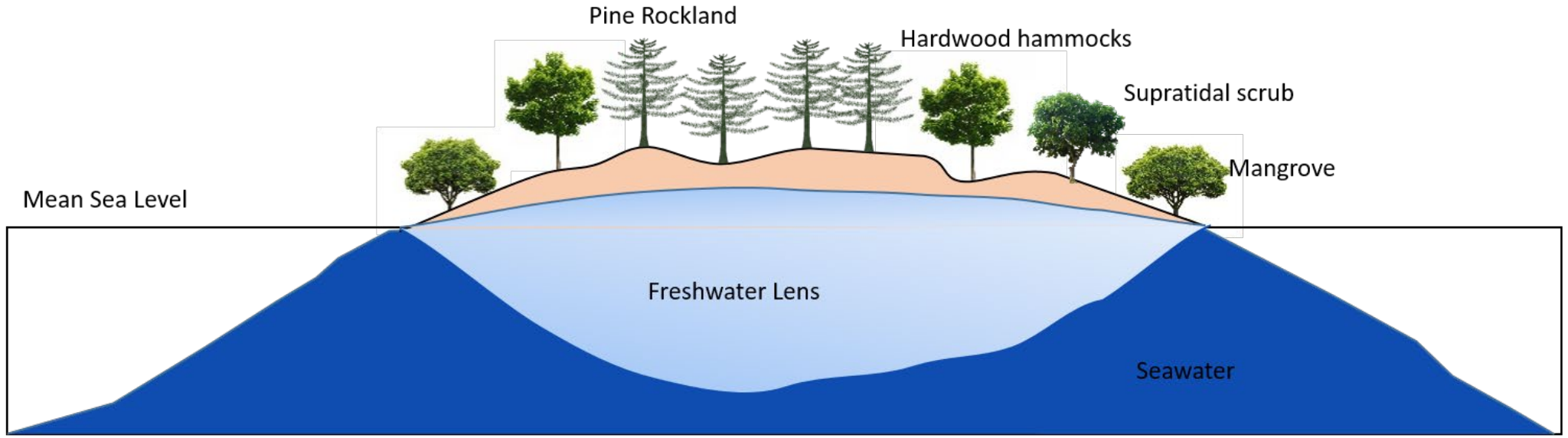
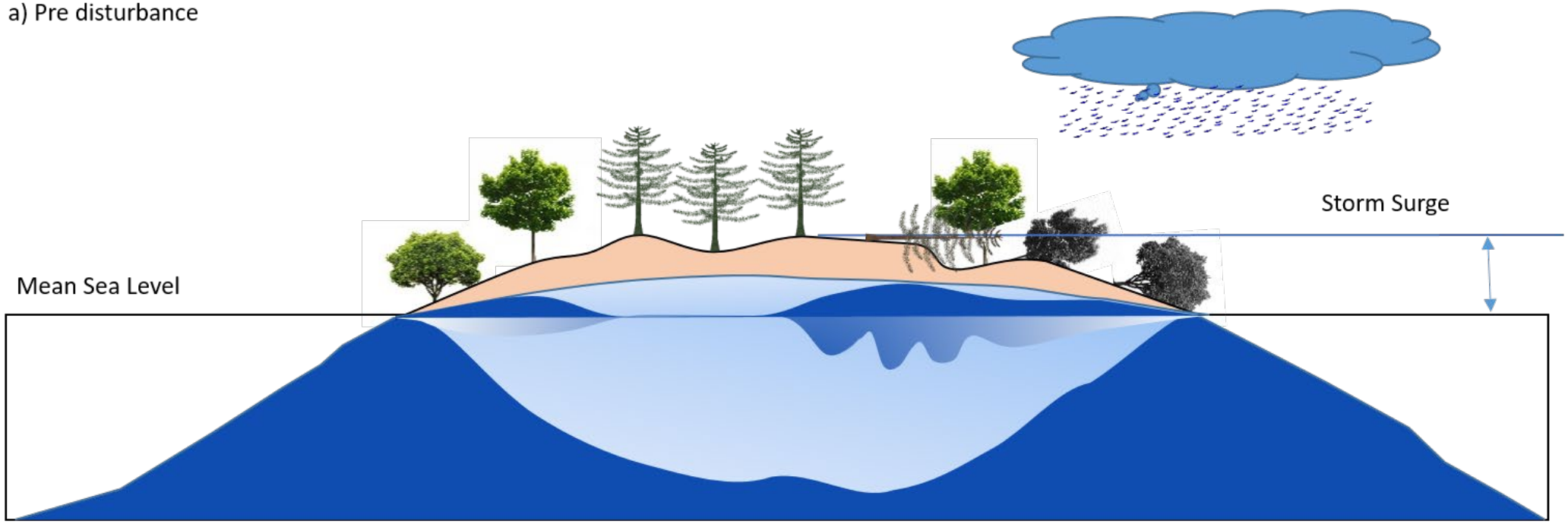
Introduction



a) Pre disturbance



b) Post disturbance

Objectives

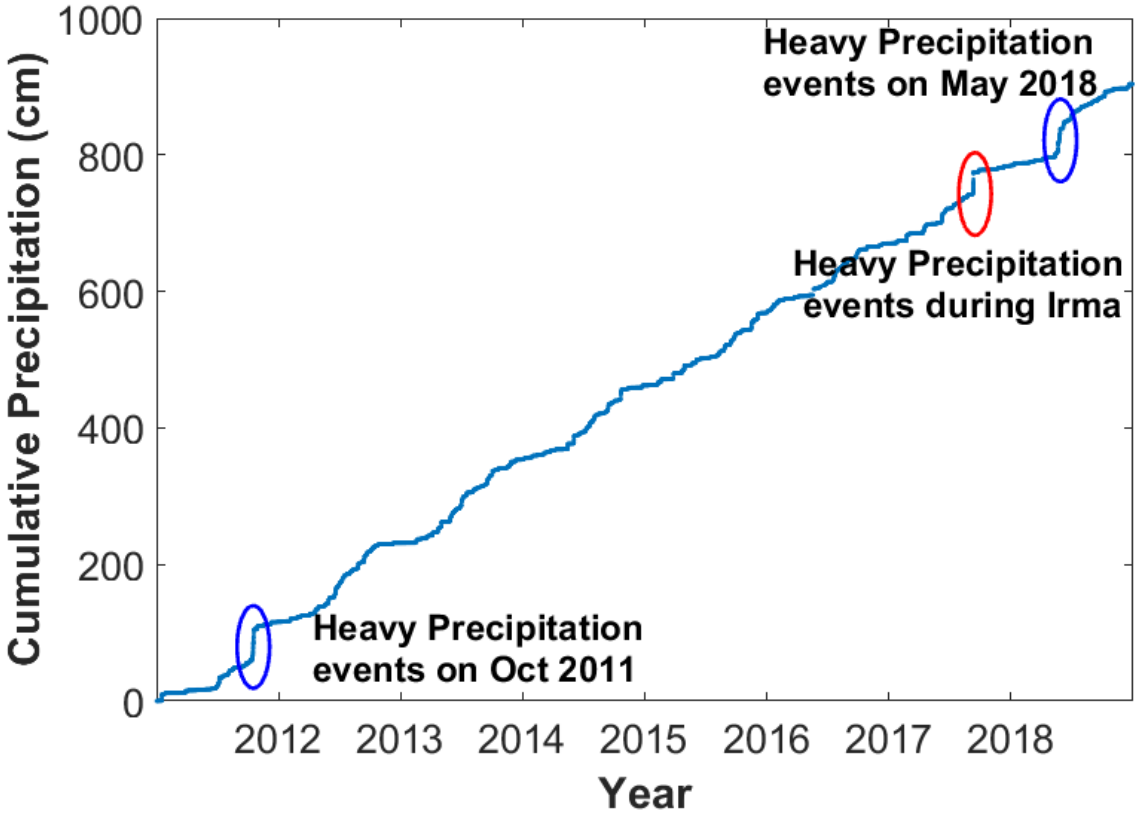
1. To assess the impact of hurricane Irma's storm surge on the freshwater lens in Big Pine Key, Florida

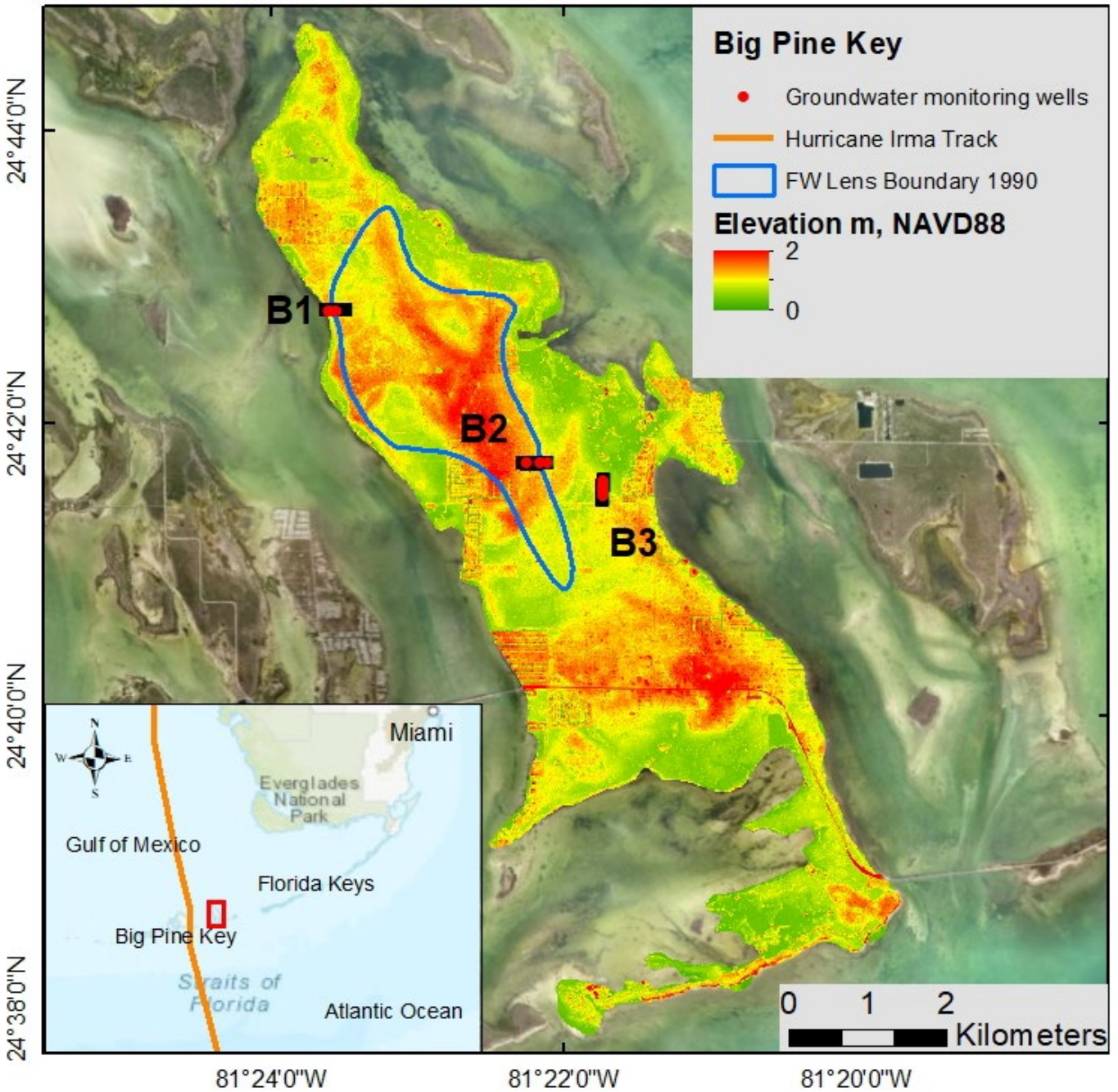
2. To document the recovery of the freshwater lens over time

Site Description

On September 10, 2017, Hurricane Irma made landfall in the Florida Keys as a category 3.

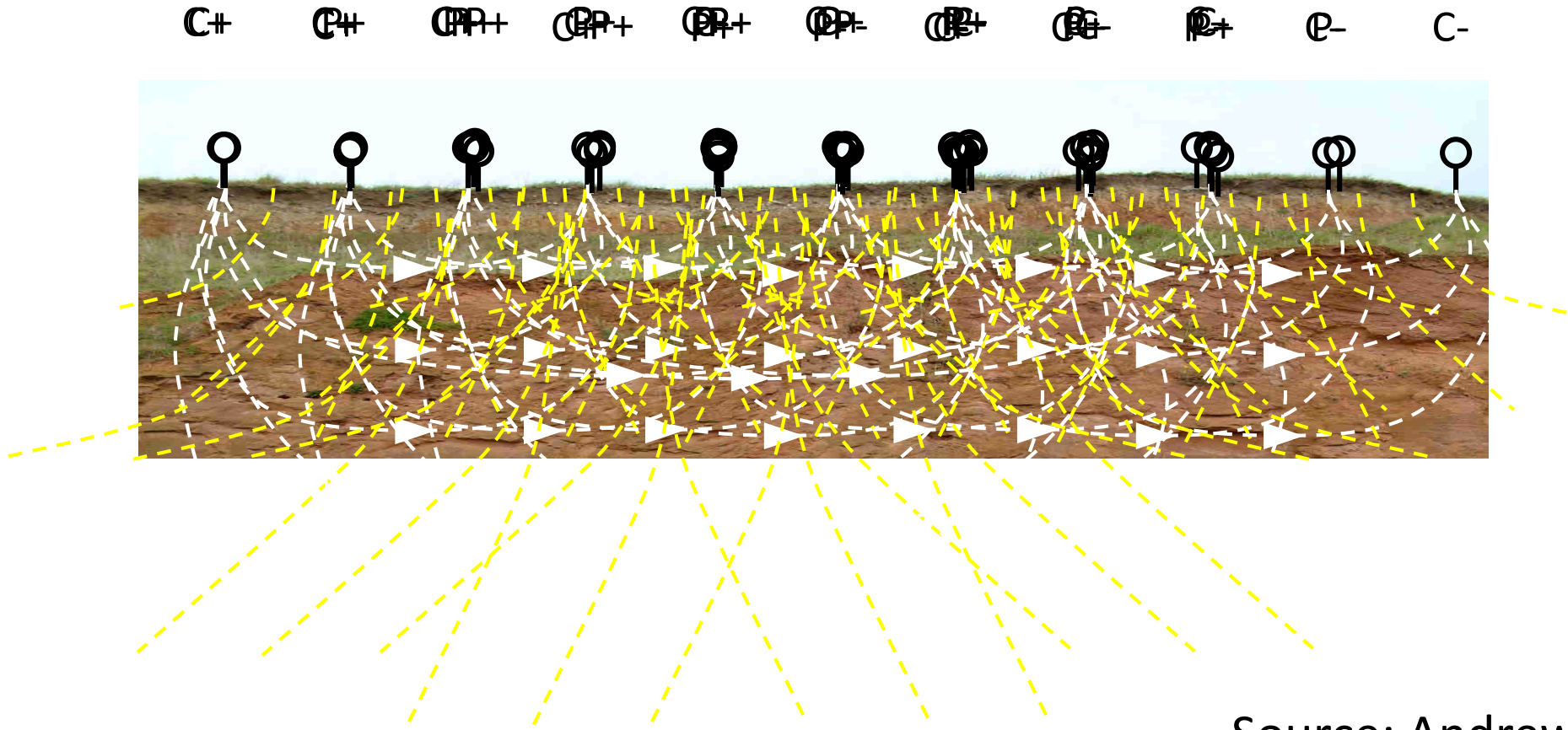
- ✓ Wind Speed= 59 m/s (115 kt)
- ✓ minimum pressure = 931 mb
- ✓ Storm surge height = 2.4 m





Electrical Resistivity Tomography (ERT)

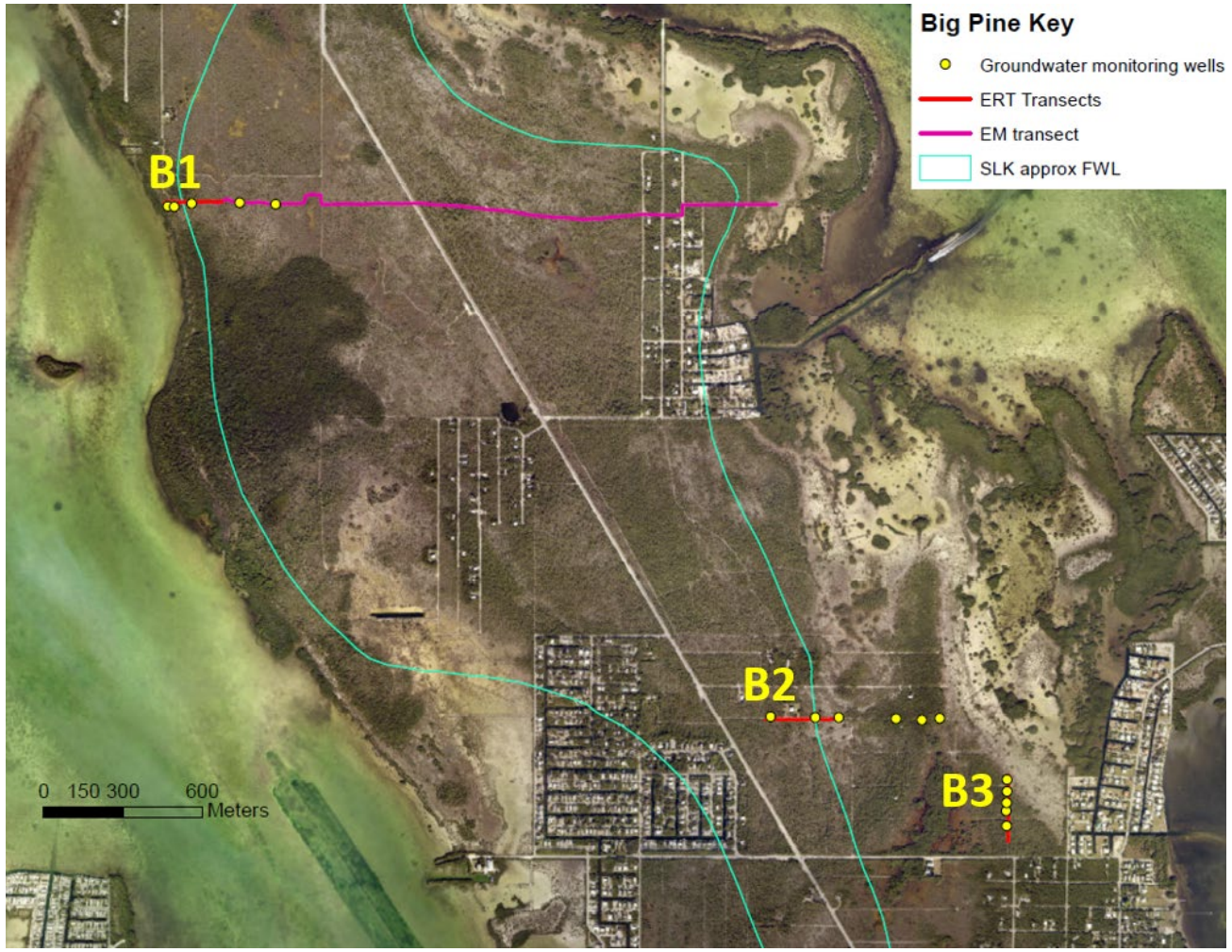
- ERT is a powerful tool to characterize spatial and temporal variability
- ERT provide a rapid and noninvasive set of techniques for monitoring groundwater



Source: Andrew Binley

Data Acquisition

- ERT surveys were collected on
  - Baseline: Nov 2011
  - Post Irma: Nov 2017/Jan 2018
  - Recovery: May and Dec 2018
- Transects of 220m, 250m and 280m
- Temperature, specific conductivity and salinity measured with YSI probe 1-m deep monitoring wells



Methods

Experimental setup

The survey was performed using:

- ✓ 28 electrode cable
- ✓ 2m spacing
- ✓ roll along Wenner array configuration

Data Processing

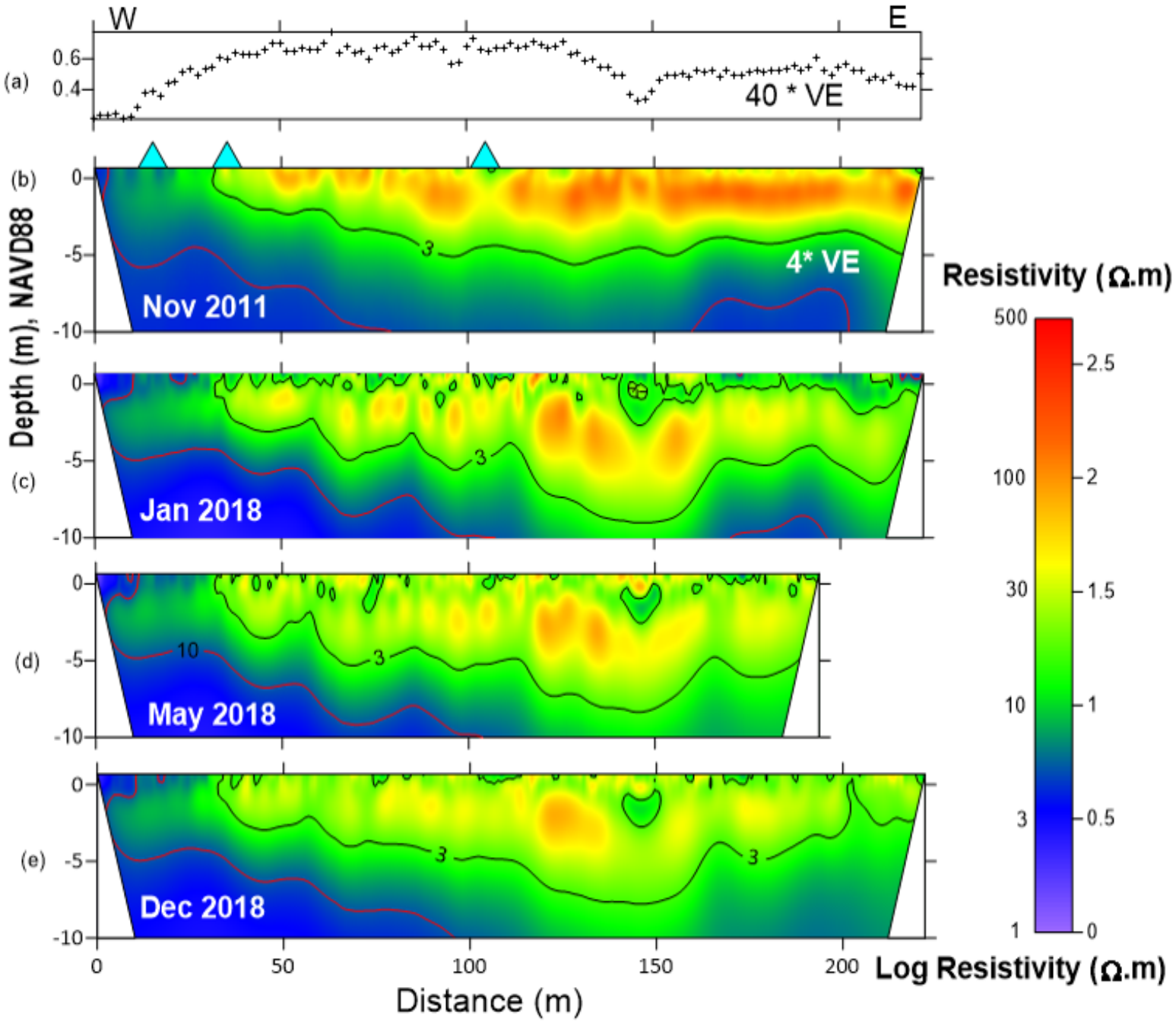
1. ERT data inverted using 2-D, R2 inversion program
2. Inverse solution obtained by minimizing an objective function combined with a weighted least squares
3. Data inverted using a difference inversion algorithm which uses the previous inversion results as a starting model
4. Resistivity models converted to pore fluid resistivity by applying an electrical formation factor of 9.5 for BPK (Tucker, 2013)
5. Pore water resistivity was converted to salinity using the empirical equations

ERT results along profile B1

The ERT data collected on November 2011 is used as a baseline.

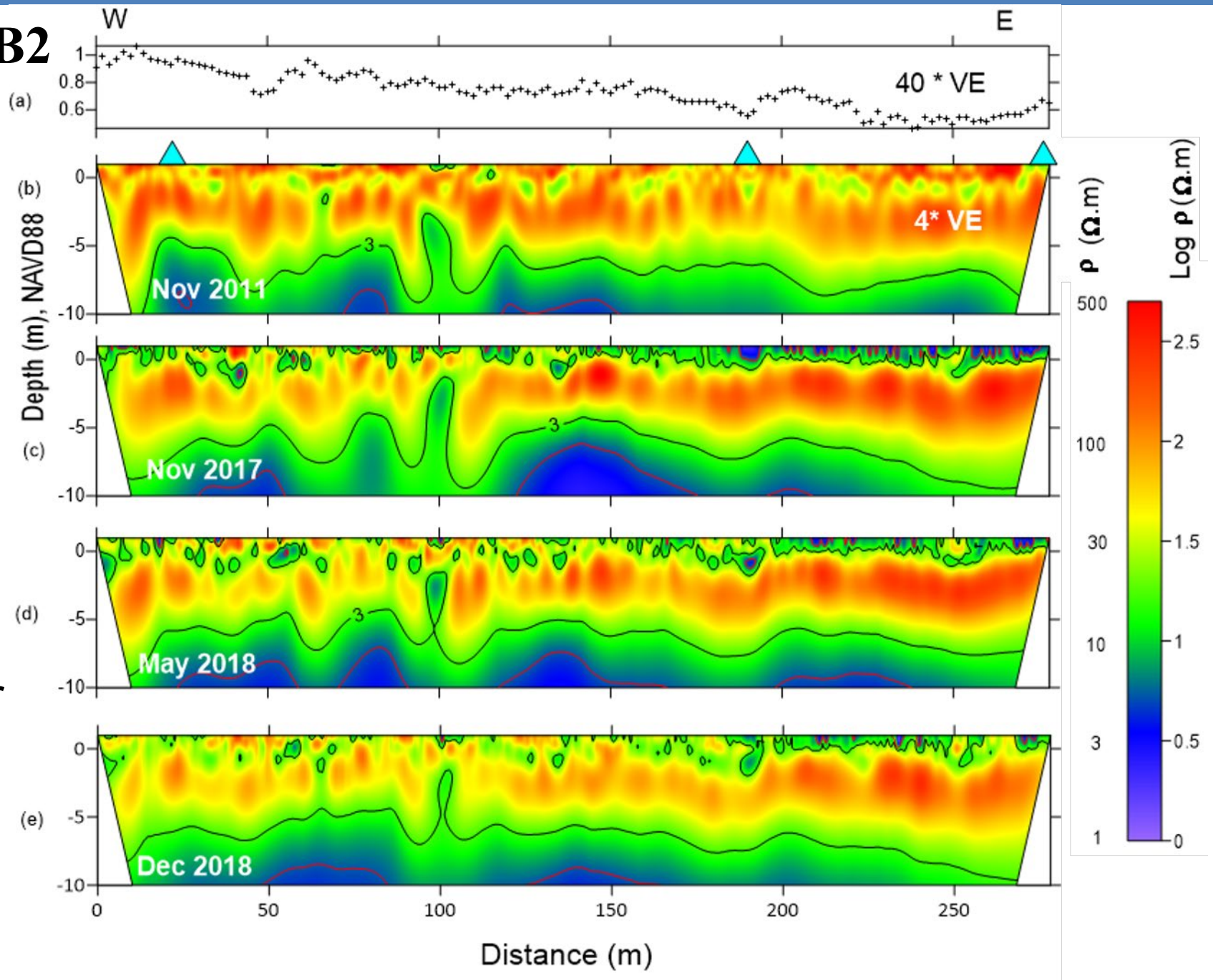
Salinity contours of 3 and 10 PSU are used to illustrate the boundary of the freshwater, brackish and saline groundwater

- Nov 2011: Freshwater lens above brackish and/or saline water.
- Jan 2018: Saline water deposited in lower elevation regions of profile
- May and Dec 2018: Some limited recovery of the freshwater lens, most pronounced east of 140 m.



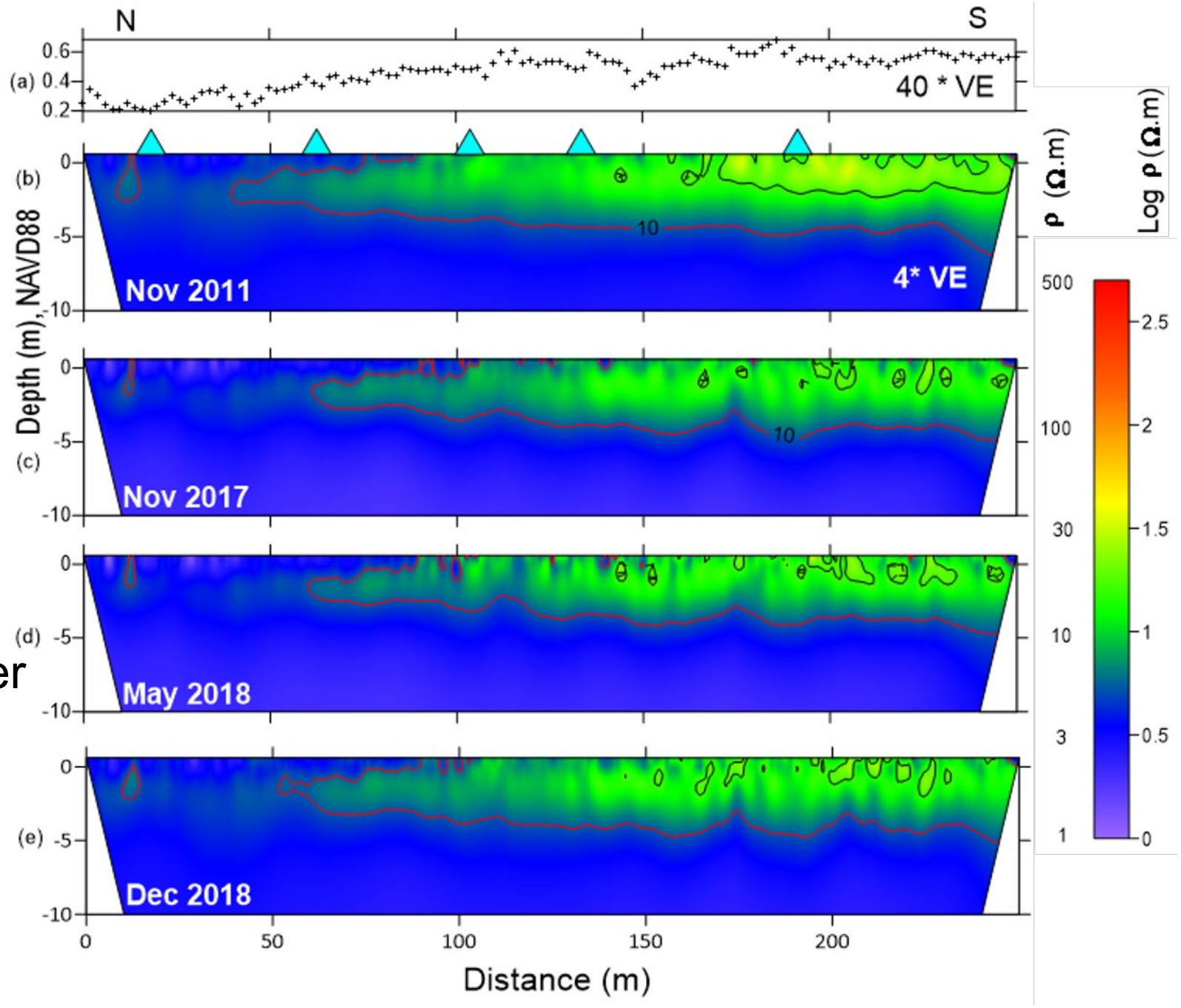
ERT results along profile B2

- Nov 2011: Freshwater lens above brackish and/or saline water.
- Nov 2017: Saline water deposited in the top 2m
- May and Dec 2018: Recovery of the freshwater lens, most pronounced east of 180 m.

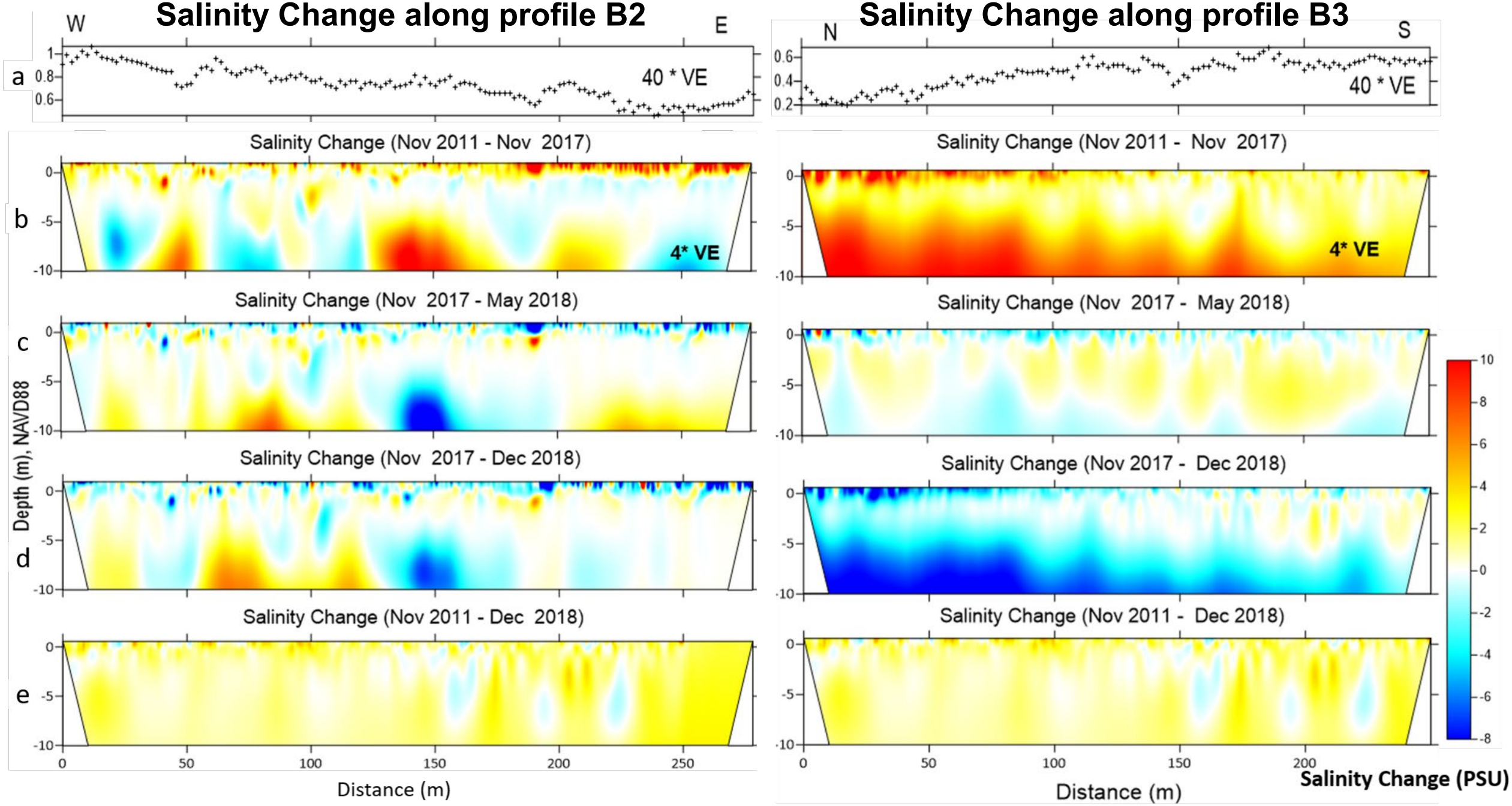


ERT results along profile B3

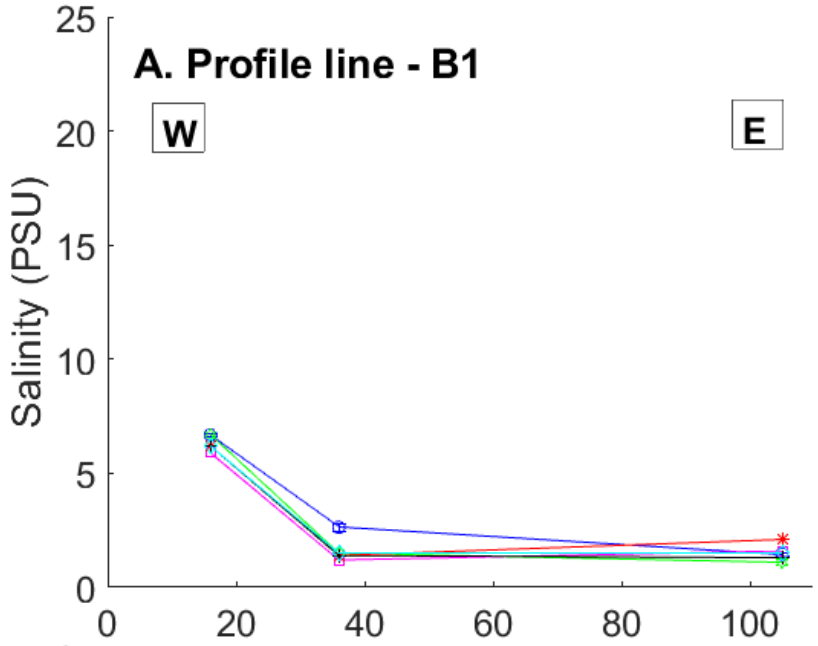
- Nov 2011: Freshwater lens situated south of 170 m.
- Nov 2017: Freshwater lens has all but disappeared, leaving only minimal pockets.
- May and Dec 2018:Freshwater pockets increased slightly in size, most pronounced south of 190 m.

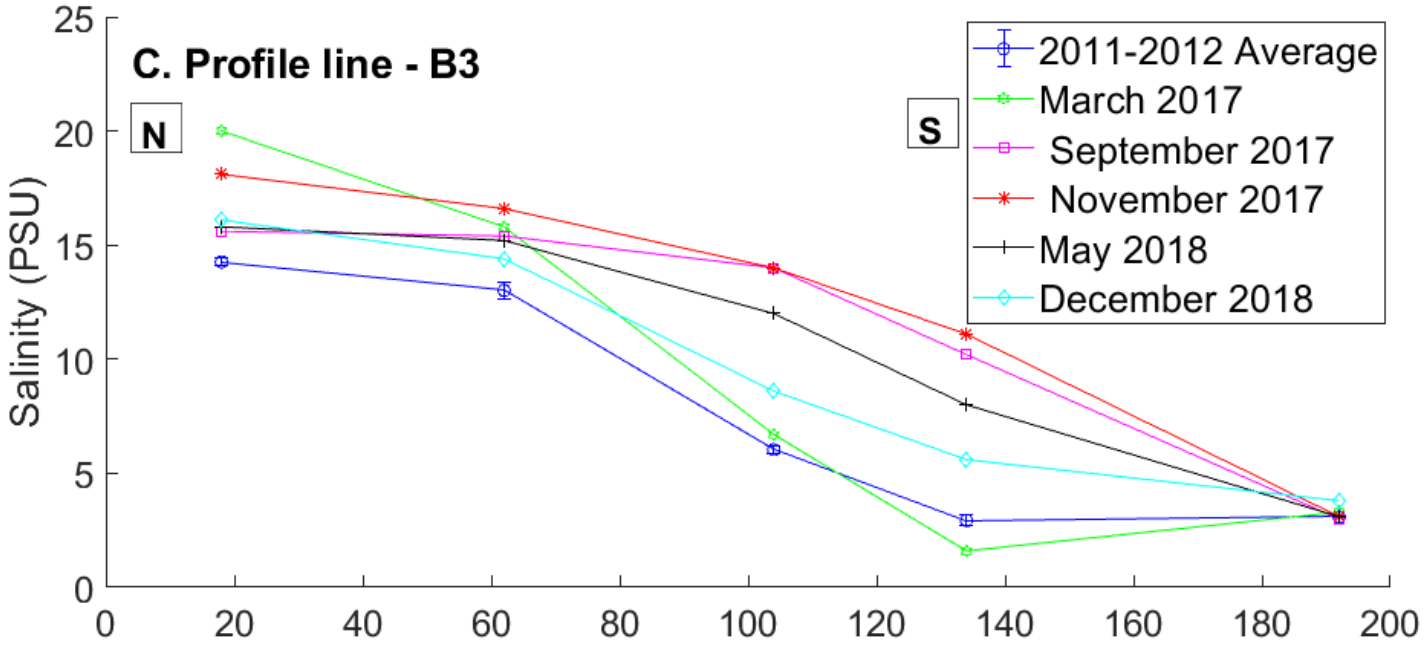


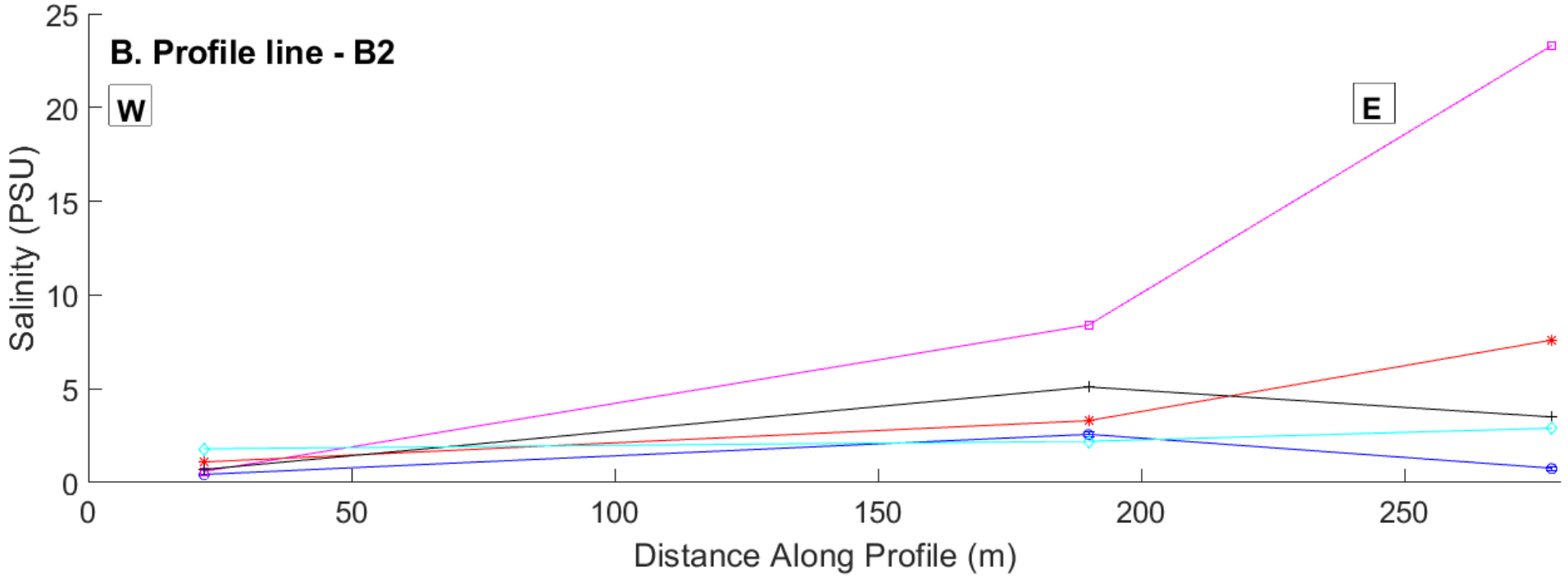
Results


Salinity Change along profile B2
W
E
a
40 * VE
Salinity Change (Nov 2011 - Nov 2017)
b
4* VE
Salinity Change (Nov 2017 - May 2018)
c
Salinity Change (Nov 2017 - Dec 2018)
d
Salinity Change (Nov 2011 - Dec 2018)
e
Depth (m), NAVD88
Distance (m)
Salinity Change along profile B3
N
S
40 * VE
Salinity Change (Nov 2011 - Nov 2017)
4* VE
Salinity Change (Nov 2017 - May 2018)
Salinity Change (Nov 2017 - Dec 2018)
Salinity Change (Nov 2011 - Dec 2018)
Distance (m)
Salinity Change (PSU)

Results







Well Data

The impact of the storm surge and recovery history

- The storm surge showed the deposition of saline water in the upper 2m, influenced by topography.
- The base of the freshwater lens as indicated by the 3 PSU contour depressed downward.
- Thin freshwater lenses are susceptible to being completely destroyed by a storm surge.
- The well and ERT results indicate recovery of the freshwater lens due to precipitation
  - Eight months (May 2018) after the storm : 40 % recovery
  - Fifteen months (December 2018) after the storm : 60 % recovery

Conclusions

1. The impact of the storm surge is more pronounced on the low-lying eastern side of the island.

2. All profiles showed low resistivity/high salinity zones in the upper 2 m suggesting the impact is most pronounced in the low elevation portions of the profiles.

3. The May and Dec 2018 ERT data showed some limited recovery of the freshwater lens due to precipitation, most pronounced in low elevation regions.

4. The impact of storm surge and the freshwater recovery are most pronounced in low elevation regions where both saline and fresh water can collect at the surface.

Acknowledgement

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- We wish to extend our appreciation to Nicole M. Tucker, Alejandro Garcia, Himadri Biswas, Temesgen Gebrekidane and Lazaro Oliva who contributed to the data acquisition.

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THANK YOU