

# Searching for Tsunami Deposits in the Santa Barbara Channel

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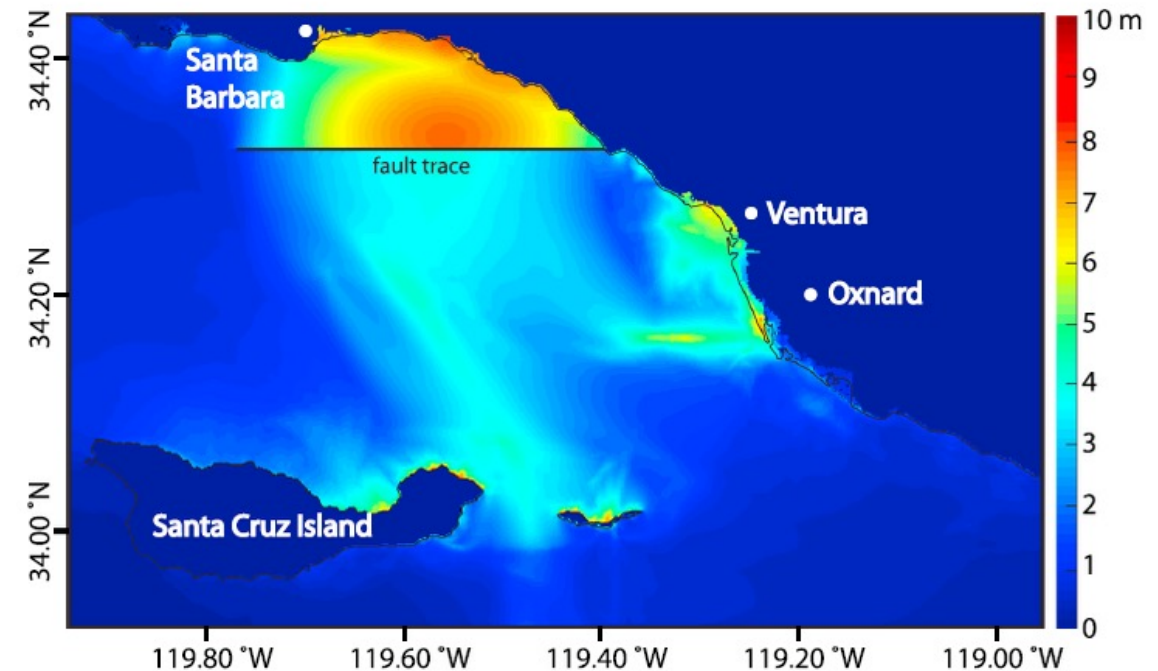
California State University Fullerton





# Motivation

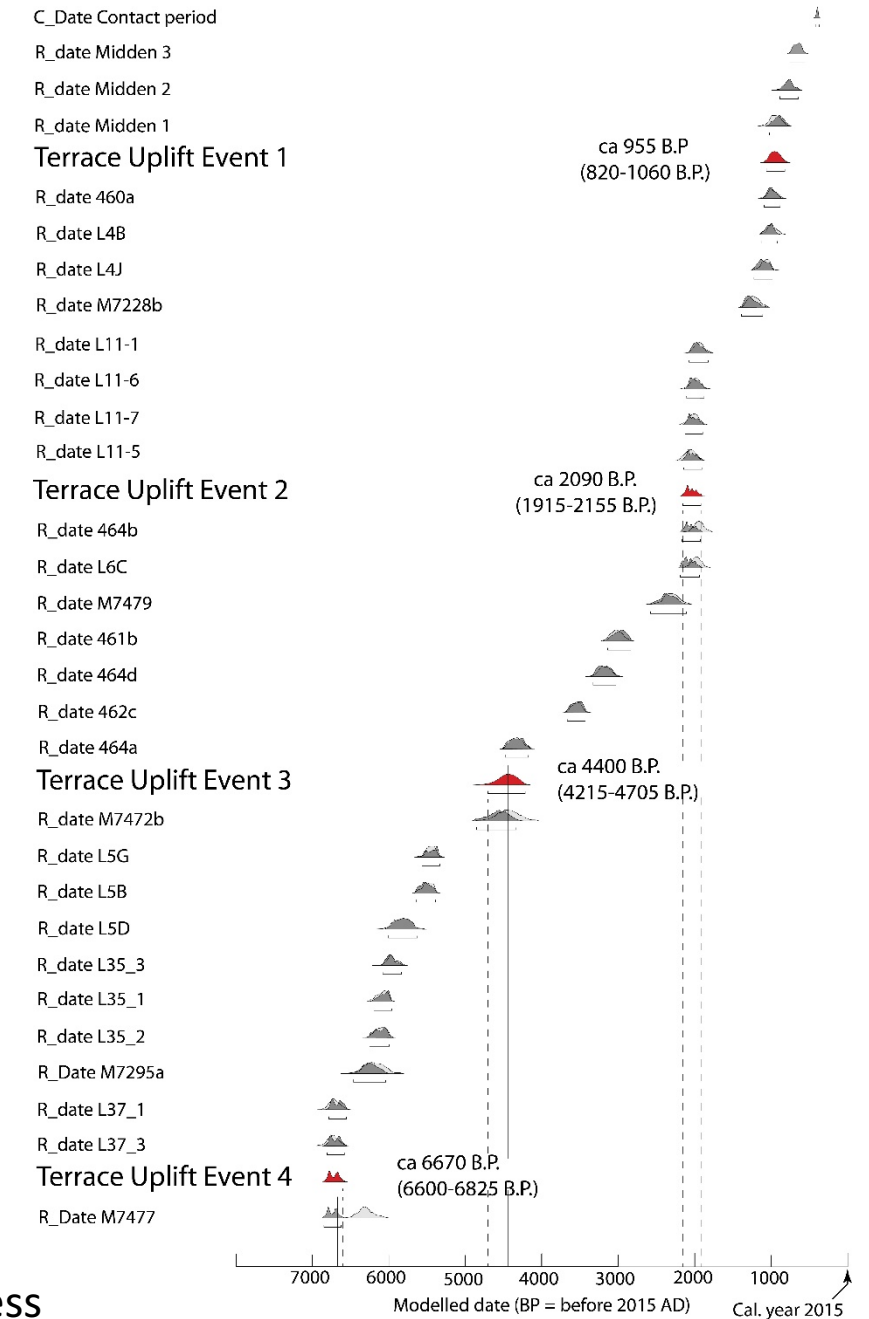
- Ventura Avenue Anticline-Pitas Point Thrust
  - Uplifted Holocene terraces (Rockwell et al., in press) presumably resulted from large earthquakes
  - Tsunami models provide tests of fault geometry and tsunami model parameters
  - Tsunami models based on Hubbard et al. (2014) fault model suggest large (>6 m) tsunamis
- Do we find evidence for tsunamis?



Ryan et al., 2015

# Earthquakes Occurrence

- Based on uplifted marine terraces
  - 0.9 ka
  - 2.1 ka
  - 4.4 ka
  - 6.7 ka
- Looking for evidence of marine inundation at these times



Rockwell et al., in press

# Methods

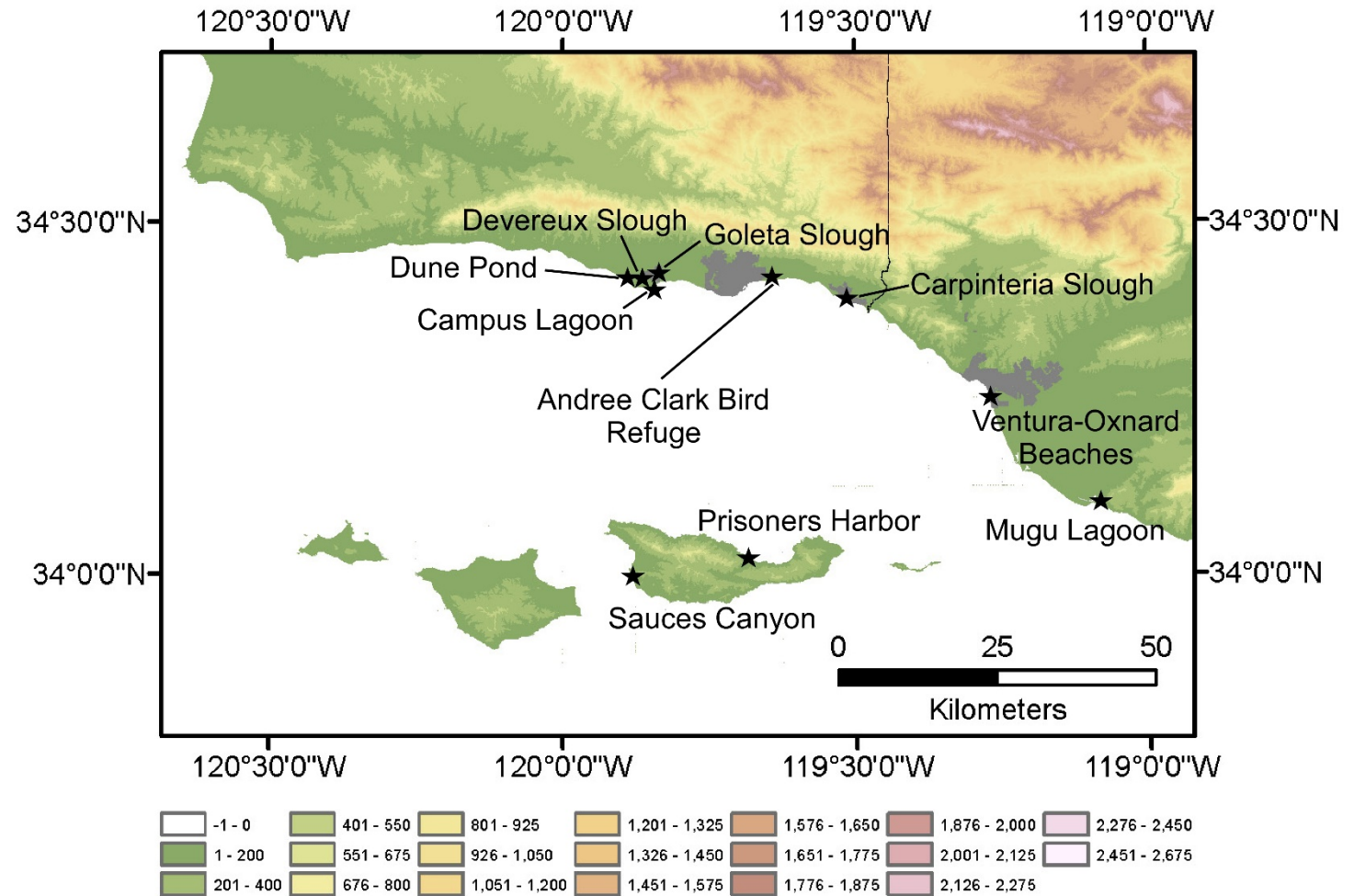
- 77 cores – 9 estuaries/lakes
  - 11 Deep (20+ m) Geoprobe
  - 66 Shallow (< 4 m) vibracores
- Chronology
  - Radiocarbon ages
    - 99 radiocarbon ages
  - Pollen, SCP,  $^{210}\text{Pb}$
  - Back to 15.8 ka
- Geophysics
  - Ground-penetrating radar





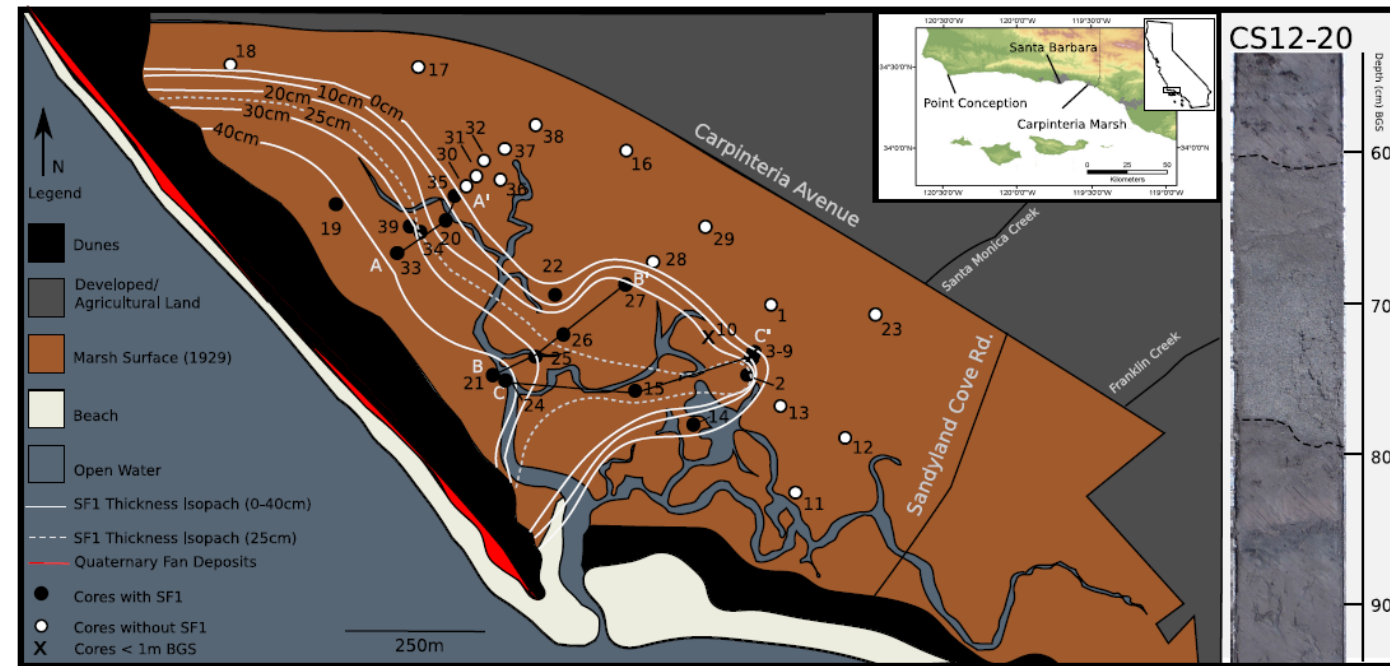
# Study Areas

- 6 locations w/ages
  - Carpinteria Slough (50)
  - Dune Pond (3)
  - Goleta Slough (2)
  - Devereux Slough (6)
  - Campus Lagoon (3)
  - Saucers Canyon (5)
- Preliminary Data
  - Andre Clarke Bird Refuge (2)
  - Mugu Lagoon (4)
  - Prisoners' Harbor (2)
  - Ventura-Oxnard Beaches



# Can these systems record marine events?

- 1861-1862 Storm
  - 45 days of rain
  - Significant coastal inundation
- Left a significant deposit in:
  - Carpinteria Slough (Reynolds et al., in Prep)
  - Dune Pond (Ejarque et al., 2015)
  - Campus Lagoon
  - Andree Clark Bird Refuge
  - Mugu Lagoon

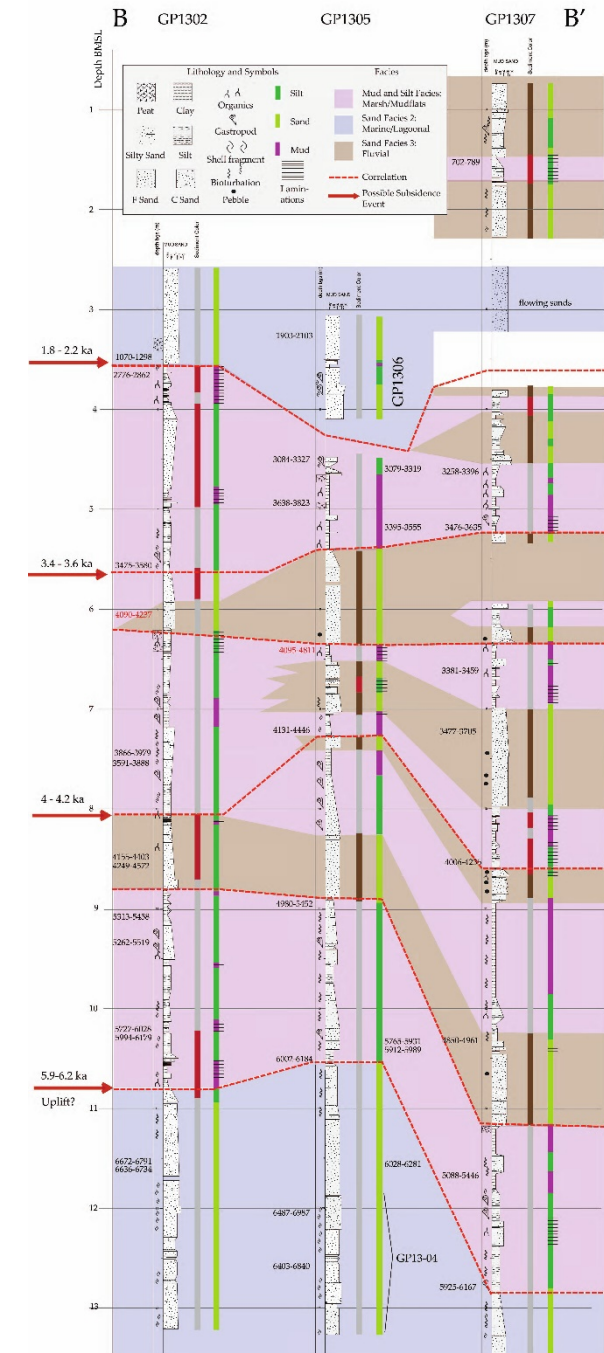


Reynolds et al., in Prep



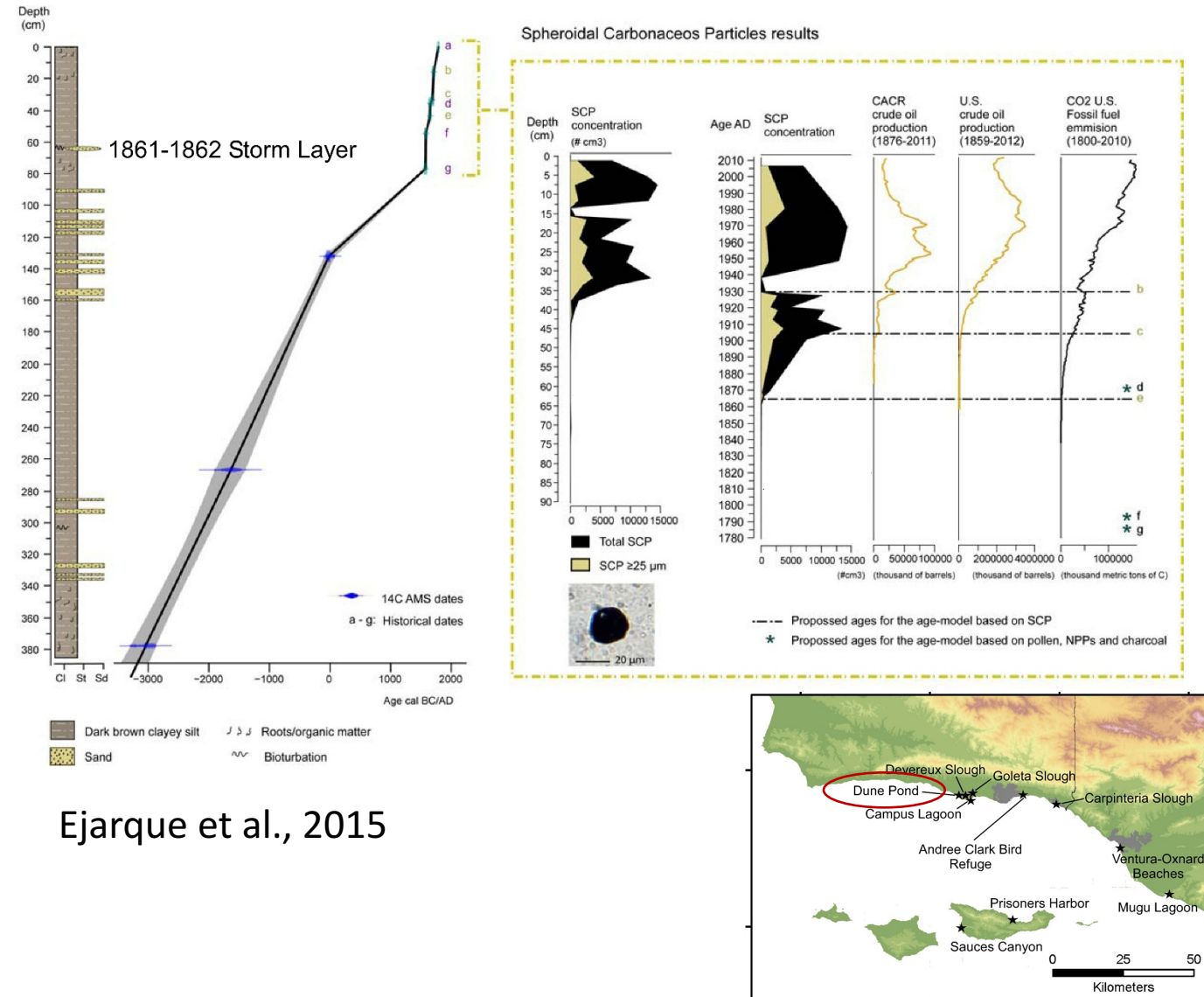
# Carpinteria Slough

- Sedimentary record spans 0-6.6 ka
- 2 major facies
  - Marsh Facies – easily records marine events
  - Subtidal Sand Facies – difficult to distinguish marine events
- Events:
  - Records the 1861-1862 storm
  - Facies change from 1.9 ka - ~0.3 ka
    - Something happened
      - Subsidence?
      - See Laura Reynolds poster tomorrow
    - Can't say no tsunamis (2.1 or 0.9 ka)
  - No record of the 4.4 ka event
  - Only other “marine event” ~3.5 ka



# Dune Pond

- Sedimentary record spans 0-5 ka
- Muddy lacustrine deposits
- Records the 1861-1862 storm
- Other gypsums
- No tsunami
  - No evidence for the 0.9, 2.1, or 4.4 ka events

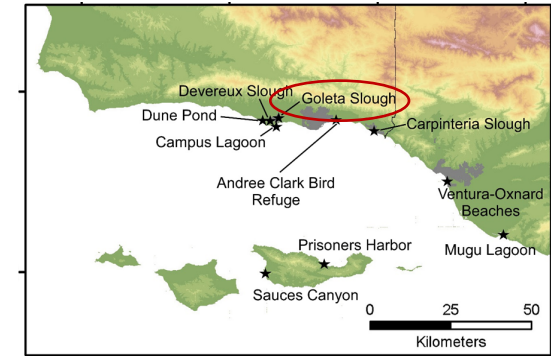
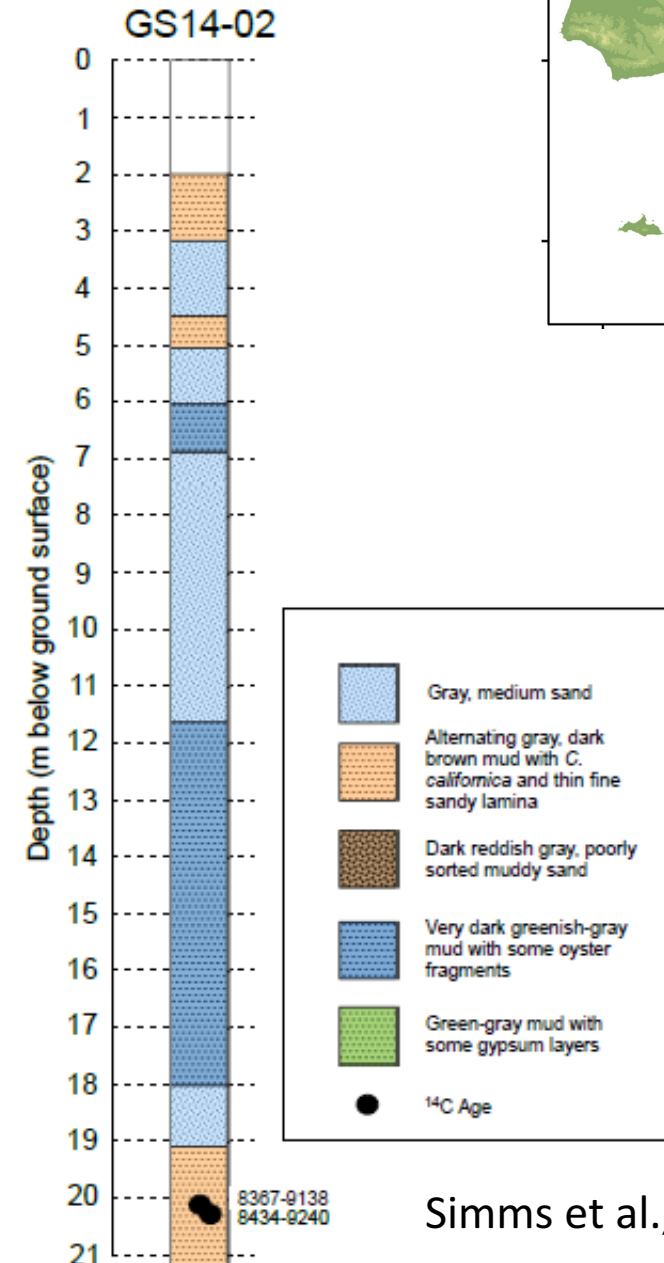


Ejarque et al., 2015



# Goleta Slough

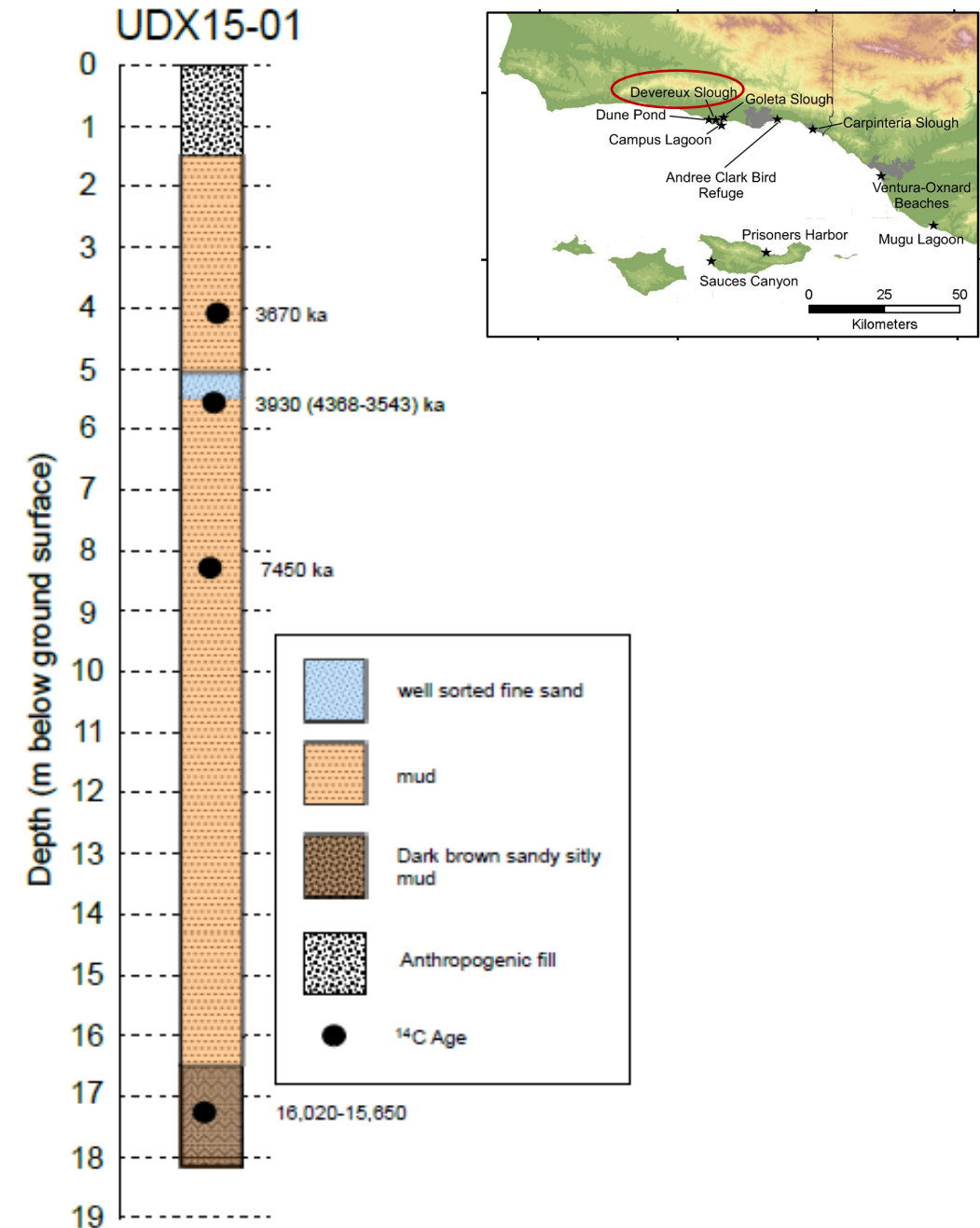
- Sedimentary record spans ~1-8.6 ka
- 2 Major facies
  - Muddy Marsh Facies
  - Silty Estuarine Central Basin Facies
- Events:
  - No 1861/1862 storm
    - But no recovery from this time interval (disturbed)
  - Something at 1.9 ka
    - But not obvious marine source
  - No tsunamis
    - 4.4 ka, 6.7 ka
    - Central basin at this time
      - Preservation issues (up north)



Simms et al., 2016

# Devereux Slough

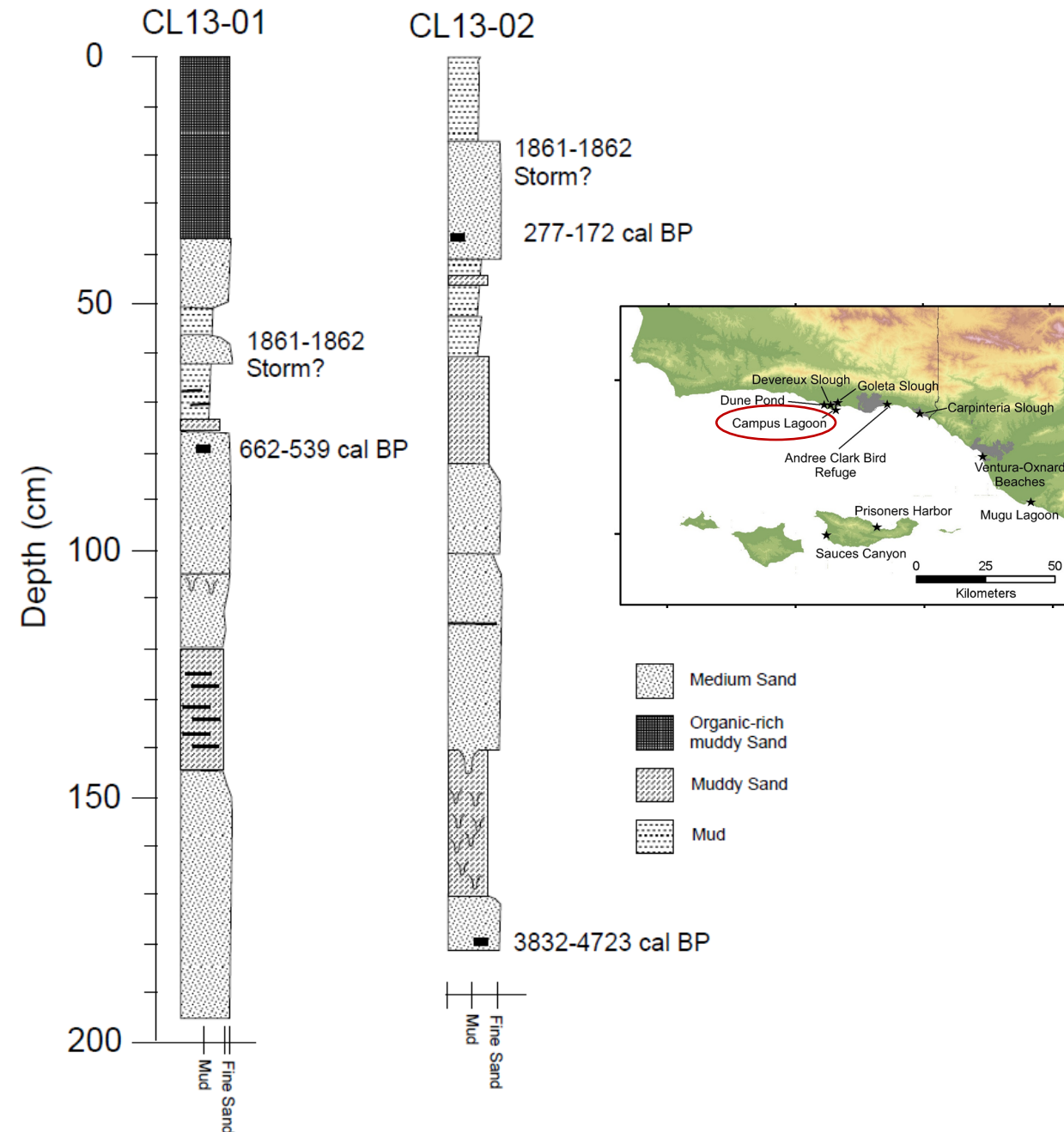
- Sedimentary record spans 0.5-15.8 ka
  - Two possible hiatus lower core
- Lacustrine/estuarine muds
- Events
  - No 1861-1862 storm
    - But surface highly disturbed
  - Something at 3.9 ka
    - Appears to have a marine source
    - Error (4368-3542) overlap with 4.4 ka
  - No tsunamis at
    - 0.9, 2.1, and 6.7 ka





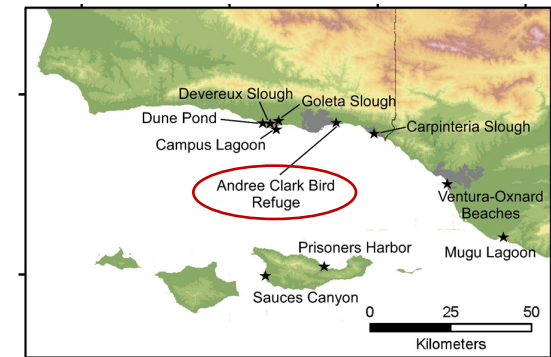
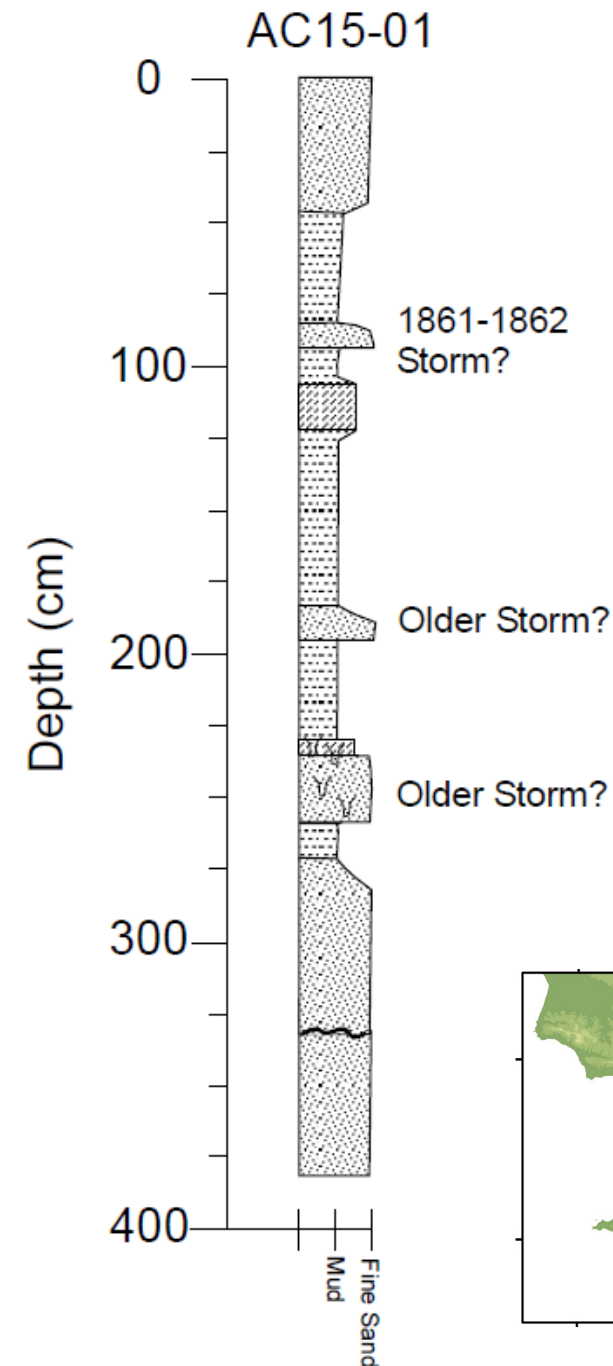
# Campus Lagoon

- Sedimentary record spans 0-4.3 ka
- Sand and mud flat deposits
- Events
  - 1861-1862 storm
  - No tsunamis at
    - No 0.9 or 1.9 ka tsunamis
    - However, very bioturbated and sandy



# Andree Clark Bird Refuge

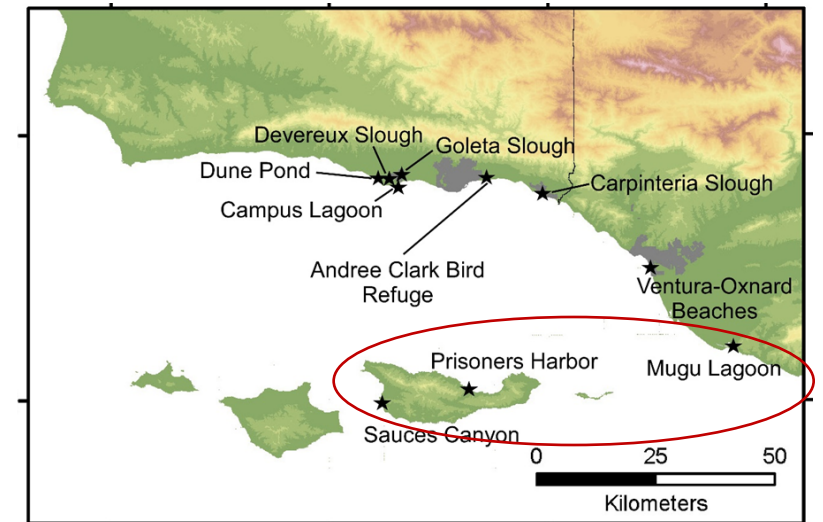
- Preliminary
- 4 m core (3-4 ka)
- Lacustrine-estuarine muds
- Events
  - 1861-1862 storm
  - 2 older undated events
    - Similar signature as storm
    - Hypothesize that they are older storms?



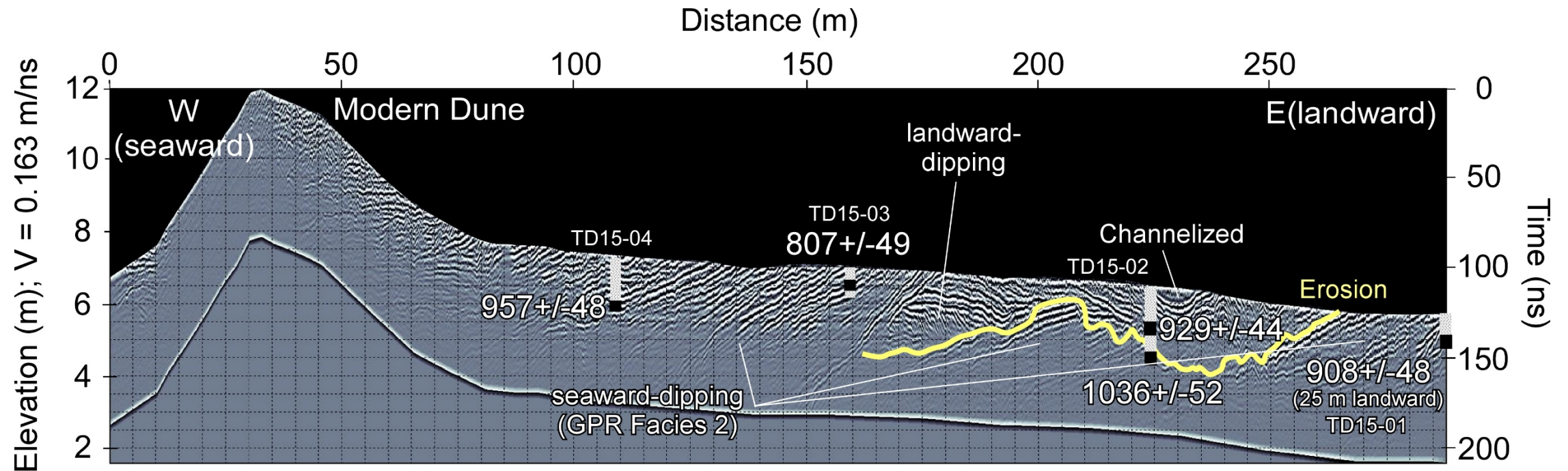


# Mugu Lagoon, Sauces Canyon, and Prisoners Harbour

- Mugu Lagoon
  - Muddy Marsh
  - One core cut
    - Bottoms out in the 1861-1862 storm
      - Based on elevation and similarity to Carpinteria Slough
- Sauces Canyon
  - Alternating muddy deposits and gravels
  - 5 events in historic times (whole record <100 years)
  - Likely big storms...
- Prisoners Harbour
  - Largely disturbed by human activities



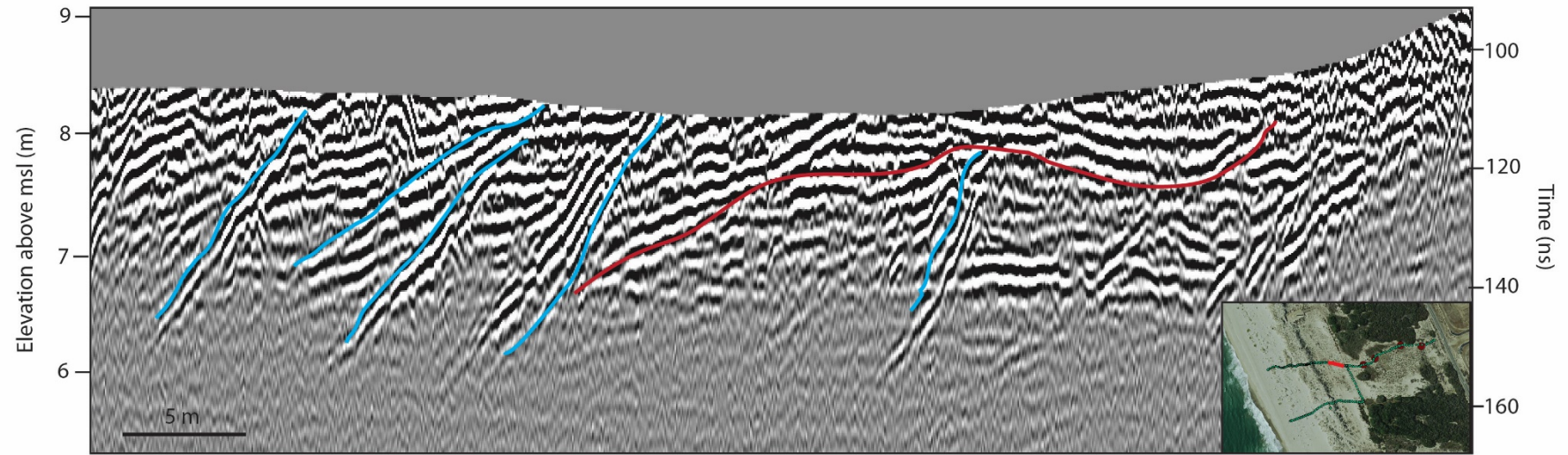
# Geophysical Evidence for Tsunami



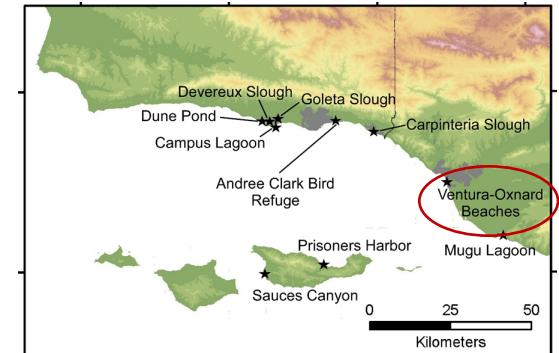
Simms et al., in review

- Analogue – Crescent City, California

# Preliminary



- 10 km of GPR
- Great data near coast
- One possibility
  - See Julie Zurbuchen's poster tomorrow
  - No chronology as of yet





# Conclusions



- 1861-1862 storm deposits are widespread throughout the marshes, estuaries, and coastal lakes of the Santa Barbara Channel
  - Estuaries do preserve marine events
- 0.9 ka Event – 0/3 (Dune Pond, Devereux, Campus Lagoon)
- Something happened around 2 ka (3/5)(Carpinteria, Goleta, Campus Lagoon/nothing - Devereux, Dune Pond)
  - Not an obvious tsunami – maybe some other type of event
  - Co-seismic subsidence, storms?
- 4.4 ka Event – 0.5/4 (Carpinteria, Goleta, Dune Pond, Devereux/Devereux)
  - Devereux Slough - a marine event at 3.9 (errors overlap with 4.4)
- 6.7 ka Event - 0/2 (Goleta, Devereux)
- Other marine events but not correlative with earthquakes
  - 3.5 ka, 3.9 ka (Pluvial Events – PEIII, IIIa? – Kirby et al., 2012)



# Acknowledgements

- Southern California Earthquake Center
- Santa Barbara Long Term Ecological Research (Coastal LTER)
- Many, many students in the field
  - Daniel Livsey, John Rice, Lauren Simkins, Elisabeth Steel, Josh Garber, Michael Truong,
- Andy Brooks, Christine Thompson, Cris Sandoval, Lisa Stratton, and the California State Parks – access to sites
- Phil Hogan - Fugro – access to data in Carpinteria





# Chronology

- Carpinteria: 61 radiocarbon, SCP, pollen,  $^{210}\text{Pb}$
- Dune Pond: 3 radiocarbon, SCP, pollen
- Goleta Slough: 16 radiocarbon ages
- Devereux Slough: 14 radiocarbon ages
- Campus Lagoon: 3 radiocarbon ages
- Sauces Canyon: 2 radiocarbon ages,  $^{210}\text{Pb}$