Stratigraphic Architecture and Evolution of a Barrier Seagrass Bank in the Mid-Late Holocene Shark Bay, Australia*

Giada Bufarale[1] and Lindsay B. Collins[1]

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[1]Department of Applied Geology, Curtin University, GPO Box U1987, Perth, WA 6845, Australia (giada.bufarale@postgrad.curtin.edu.au)

Abstract

Seagrass has been a key feature in the Holocene evolution of the marine ecosystem of Shark Bay (Western Australia), and in particular to the development of the Faure Sill. The presence of well-developed barrier banks, associated with a semi-arid to arid climate and a restricted water exchange produced and preserves the metahaline and the hypersaline conditions in the southern embayments of Hamelin Pool and L'Haridon Bight, providing a basis for the development of a variety of biogenic and physical structures, such as microbial mats, stromatolites, coquinas and oolitic shoals.

To investigate the Holocene development of the Faure Sill, remote sensing imagery, shallow acoustic stratigraphy and sedimentological information were combined, in order to correlate internal architecture, sediment body morphologies and lithofacies. The results indicate that the development of the Faure Sill has been controlled by pre-Holocene topography, seagrass and sea level fluctuations.

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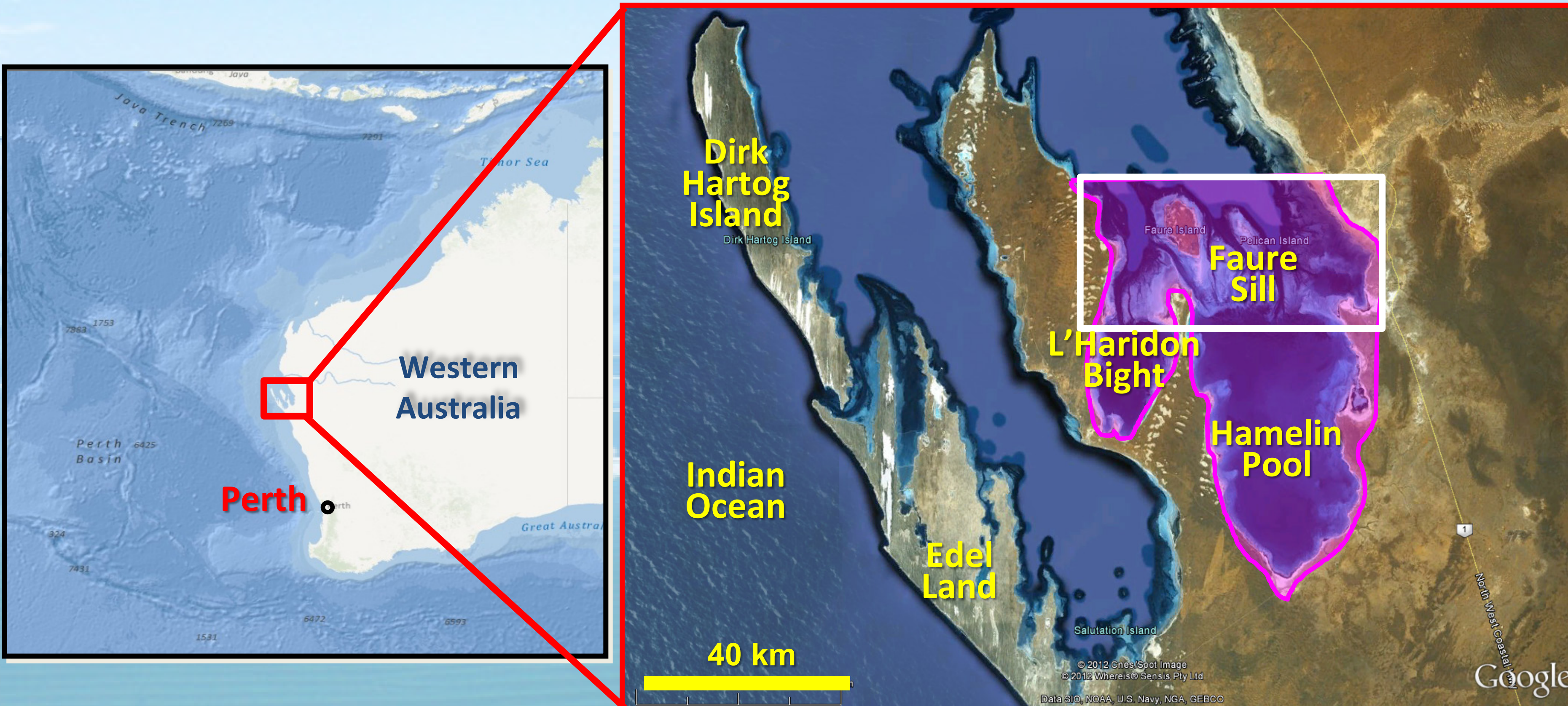
Stratigraphic Architecture and Evolution of a Barrier Seagrass Bank in the Mid-Late Holocene, Shark Bay, Australia

Giada Bufarale and Lindsay B. Collins

Curtin University
Department of Applied Geology
Perth (Western Australia)

Background photo: Faure Sill

Introduction: Shark Bay, WA



Microbial mats

Seagrass

Coquinas

Stromatolites

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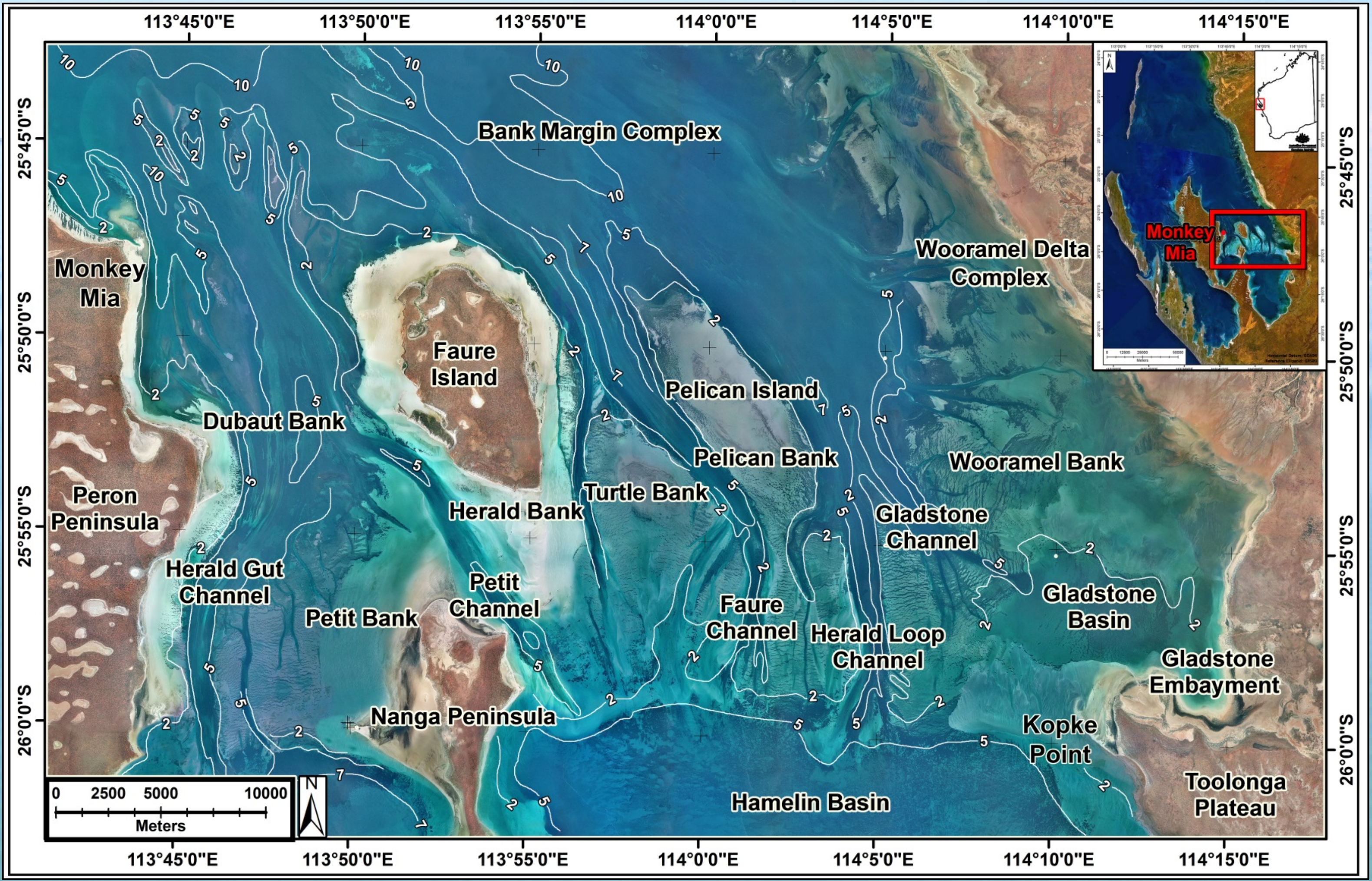
Introduction: Faure Sill (Shark Bay, WA)



Aerial view of the Faure Sill (mosaic of photos from Landgate, Western Australia and localities from Hagan and Logan, 1974)

Seagrass bank evolution is crucial for the development of the microbial communities and oolitic shoals

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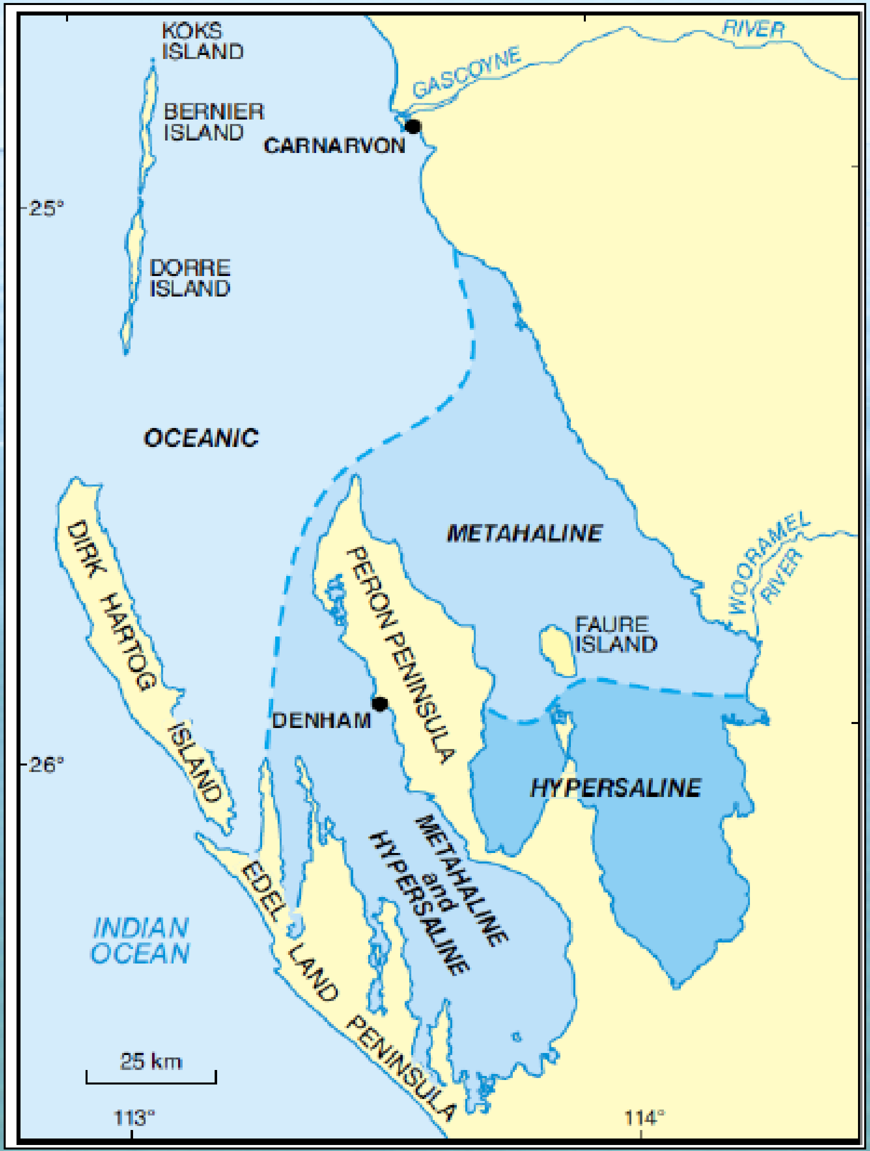
Salinity



- Semi-arid climate
  - → High evaporation Low precipitations
- Barrier banks and islands
  - → Restricted water exchange
- 50 to 65 ppt
  - → Metahaline to hypersaline

Playford et al. (2013); after Logan and Cebulski (1970)

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Methods

- Remote sensing analysis (high-resolution aerial photos & GIS)
- Geophysical survey (subbottom profiler, SBP)
- Ground truth sampling / coring
- Sediment analysis

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- Radiocarbon ^{14}C dating

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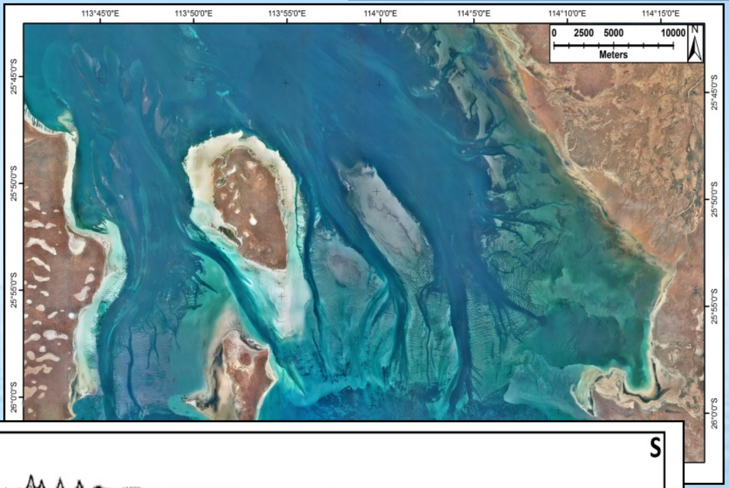
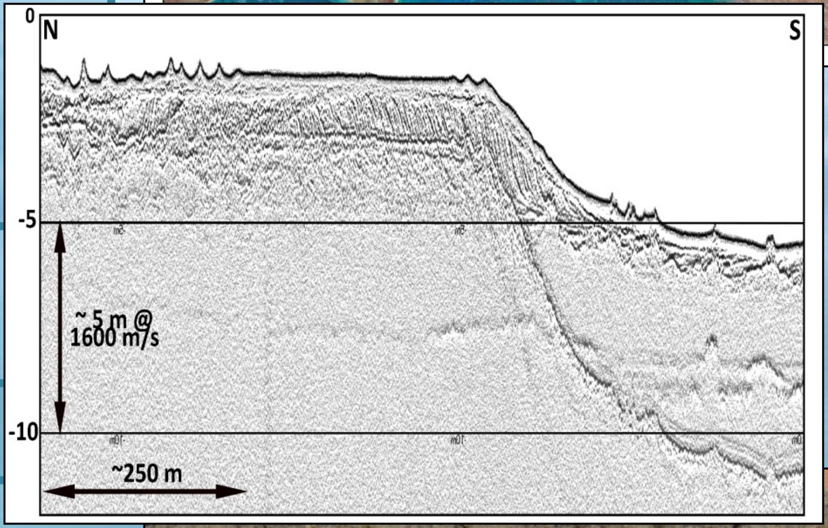
Model of the onset, evolution, internal architecture and chronology

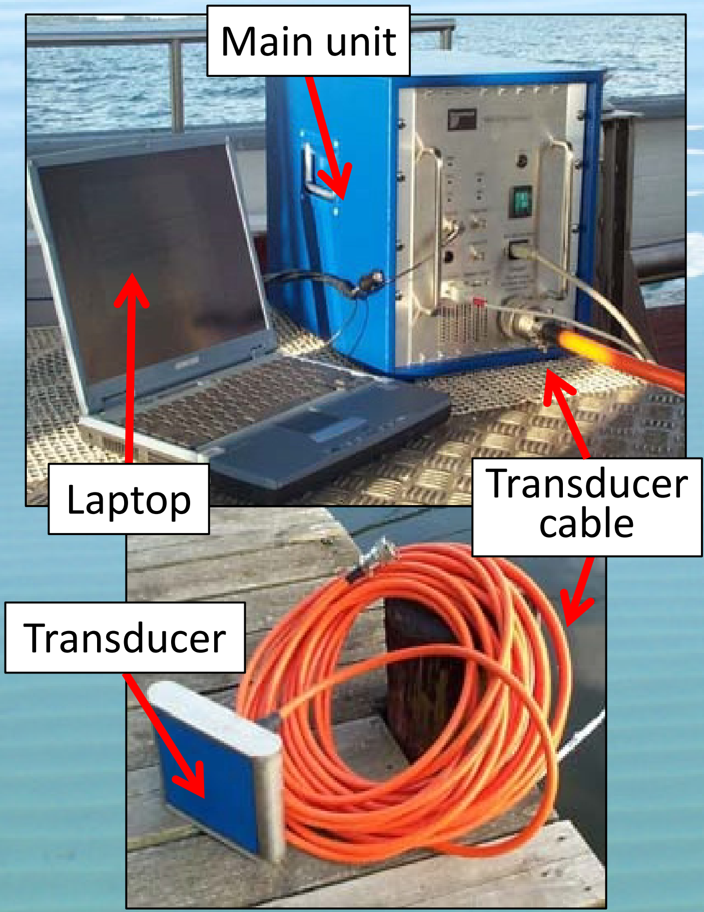


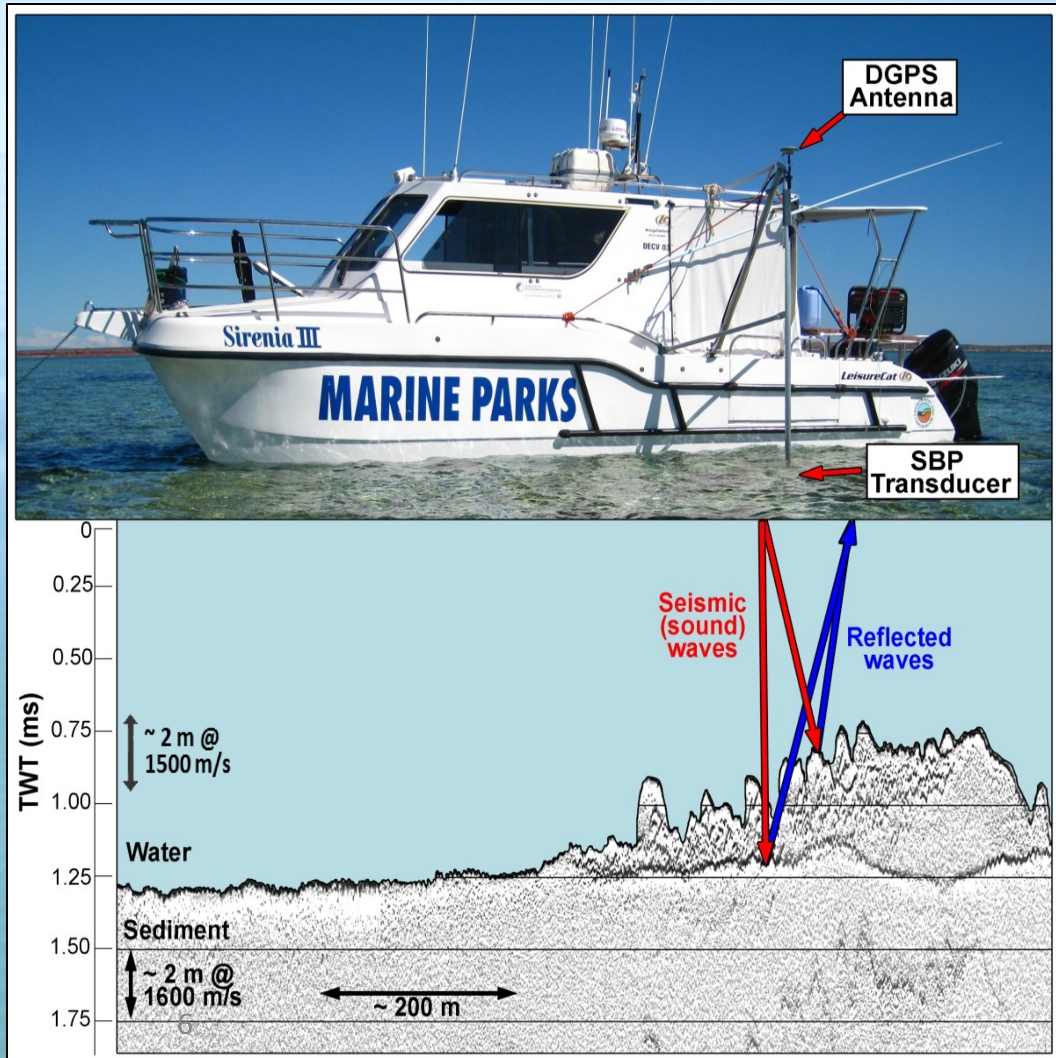


Shallow geophysical survey

Innomar SES-2000 compact SBP

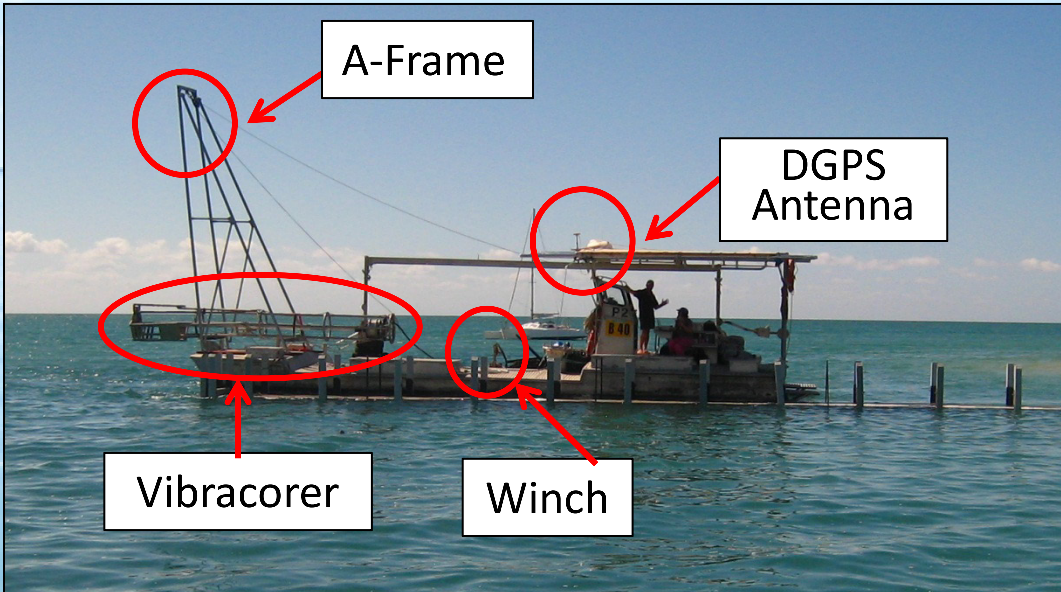
- Penetration: 10 - 15 m
- Resolution: 10 cm
- Very shallow water





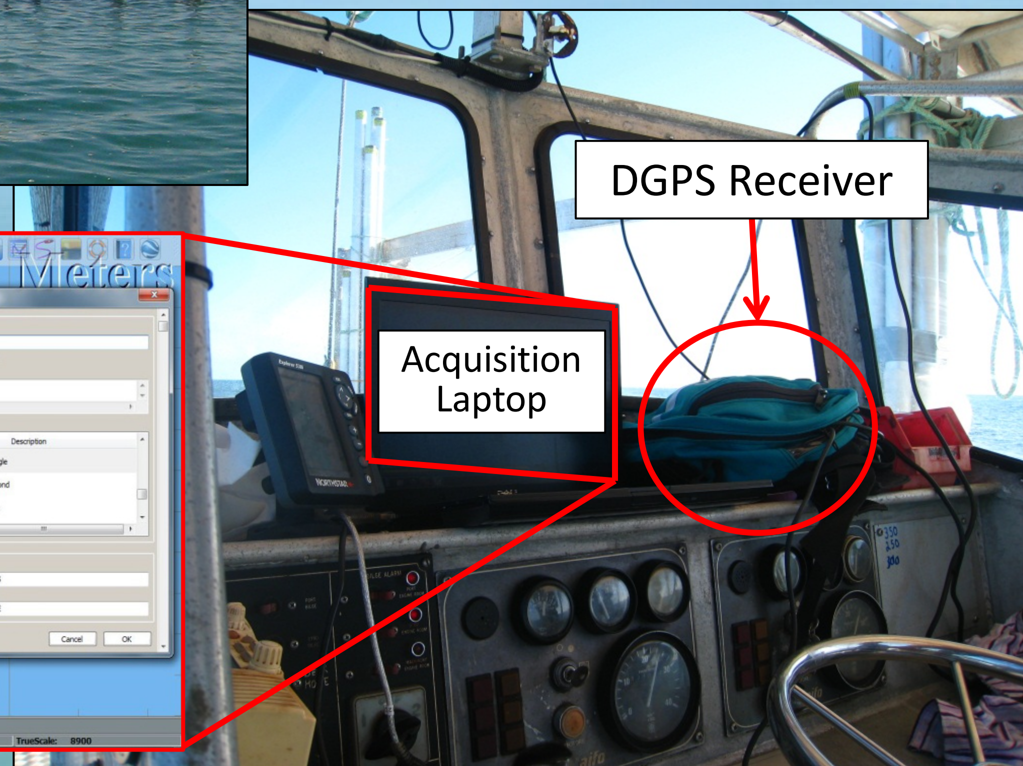
Registration of the time between the generation of the pulse and the recording of its reflection

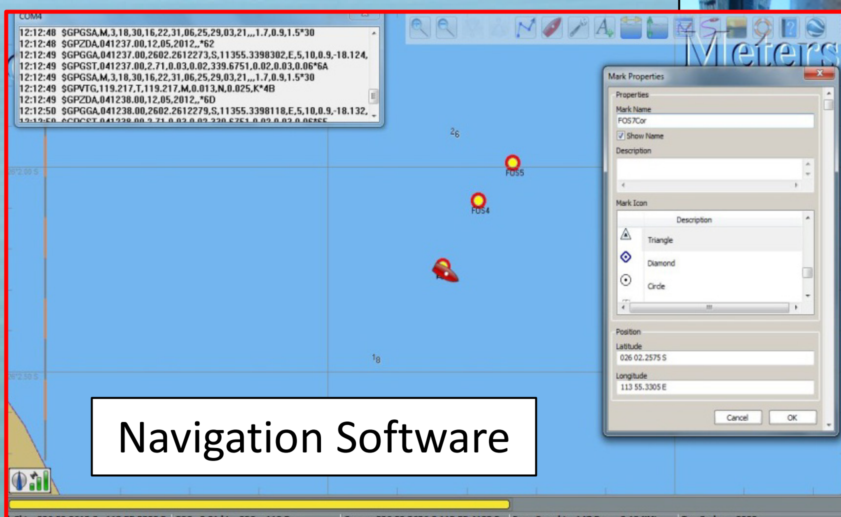
Coring survey



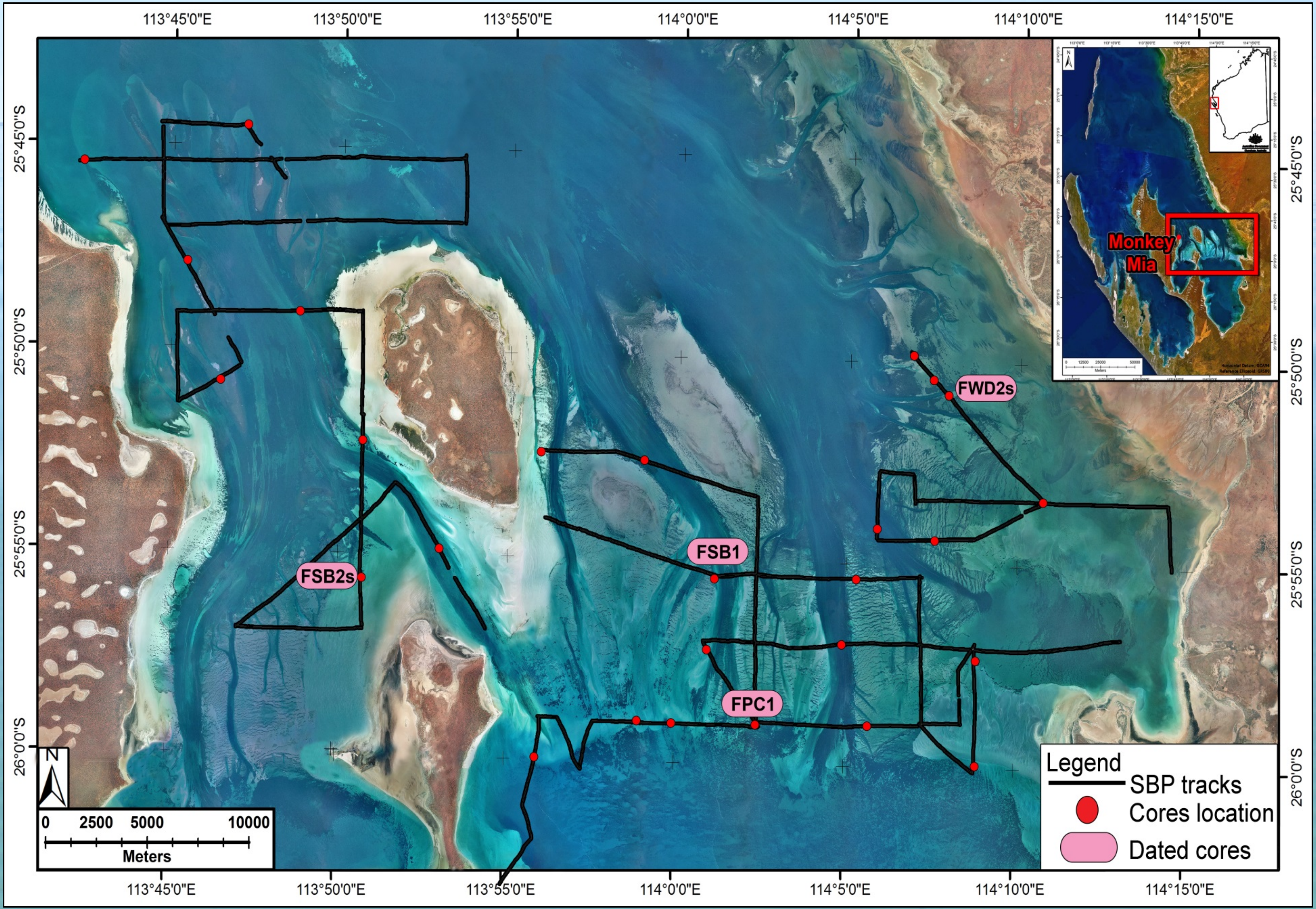
Vibracorer

- Max Penetration: up to 6m
- 32 cores

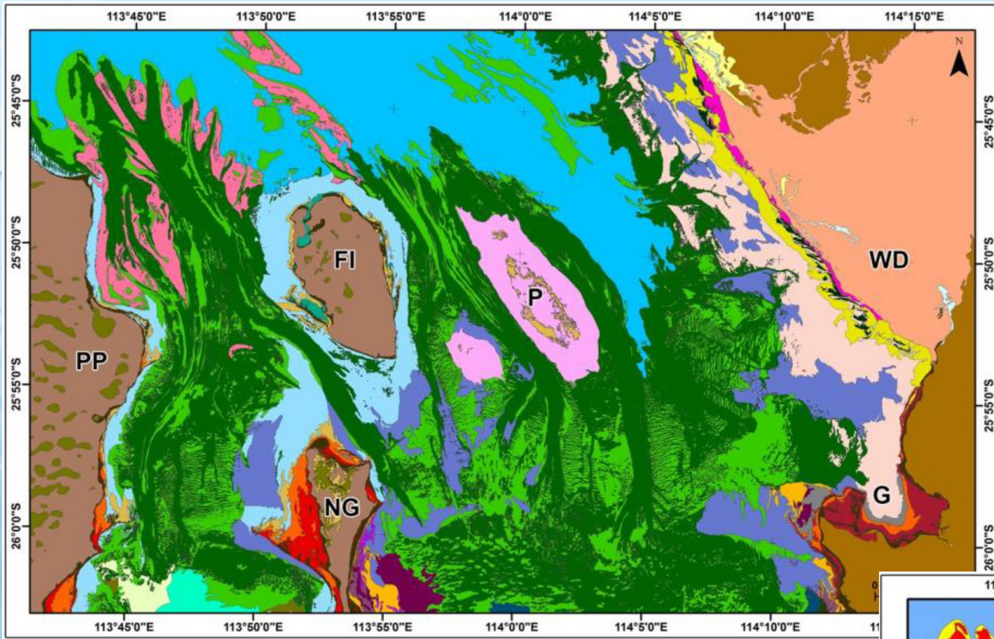




Coring survey

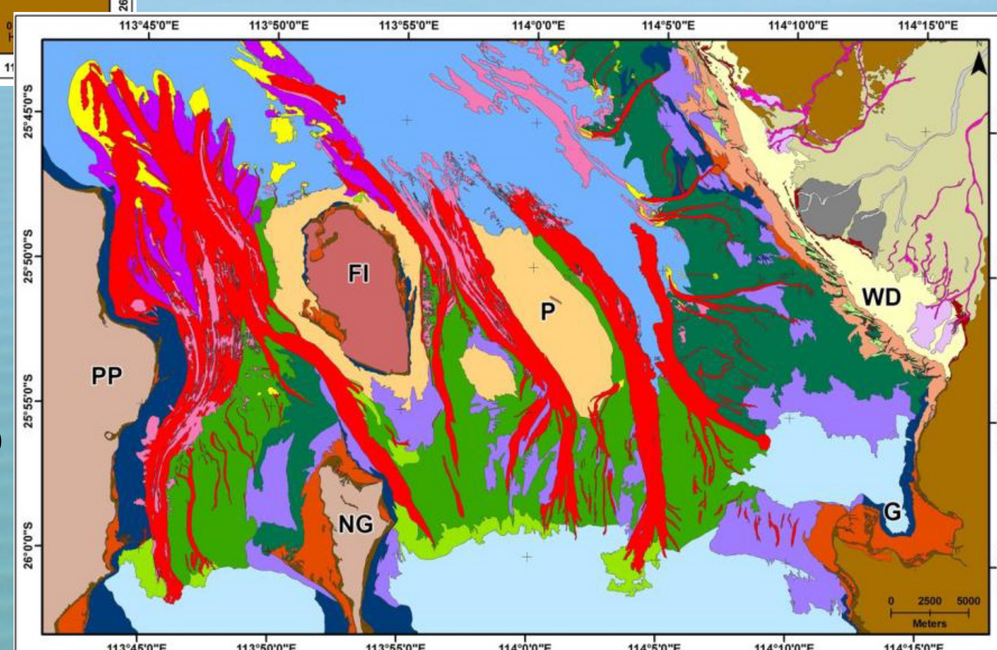


Results: morphology and substrate mapping



Bufarale & Collins, 2015 (modified)

- **Sediments and Benthic Substrates Map**
  - Green: seagrass-associated substrates
  - Pink-orange: Wooramel Delta

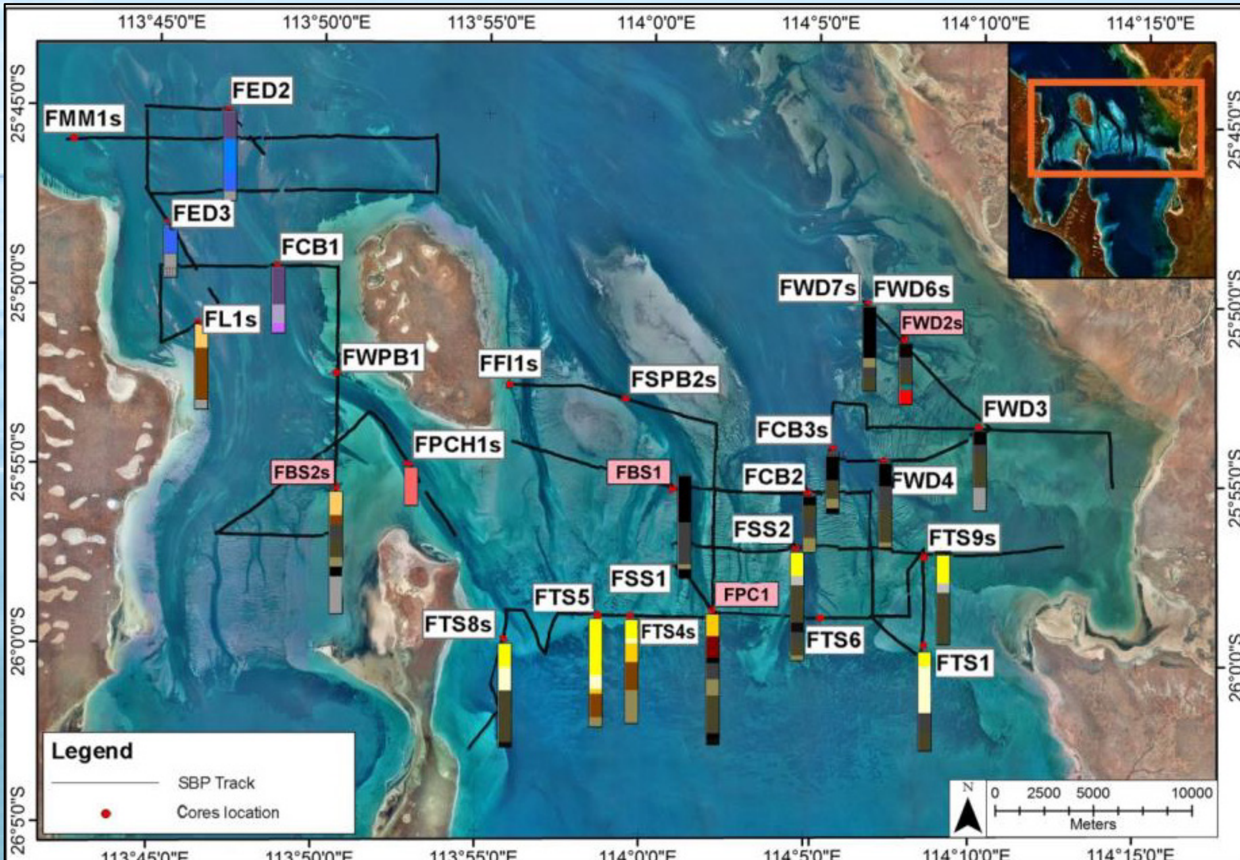


- **Morphological Elements Map**
  - Red: tidal channels
  - Green: banks
  - Yellow: tidal fans

Results: classification of sediment bodies

- **Bank Top**
  - Linear ridges
  - Flat-topped sand sheets
- **Channel Associated**
  - Longitudinal channel bars
  - Lateral spill-over sheets
  - Interdistributary channels
- **Tidal Fan Associated**
  - Distributary mouth bars
  - Ebb tidal fans
  - Levees
- **Shoreline-attached Sand Lobes**
- **Banks**
  - Patch banks
  - Fringing banks
  - Barrier banks

Results: sedimentological data



- Coarse Shelly Bioclastic Sand
- Coarse-grained Cross-bedded Bioclastic Sand
- Moderately Bioclastic Quartzose Silty Sand
- Fine-grained Silty Bioclastic with Thinly laminated Mud and Seagrass Peats
- Fine-grained Silty/Muddy Sand with Very Thinly Bedded Muddy Seagrass Peats
- Medium Muddy Bioclastic Sand
- Thickly laminated to Thinly Bedded Silty Bioclastic Sand and Weakly Bioclastic Mud
- Sandy Bioclastic Mud
- Weakly Bioclastic Burrow Mottled Carbonate Mud
- Strongly Bioclastic Carbonate Mud
- Weakly bioclastic Sandy Carbonate Mud, Clayey
- Moderately bioclastic Sandy Carbonate Mud, Clayey
- Disseminated Pyrite Kaolinite Clay
- Goethite Kaolinite Clay
- Weakly Bioclastic Quartzose Sand
- Mildly Bioclastic Silty Quartzose Sand
- Shelly Bioclastic Silty Quartzose Sand
- Bioclastic Cross-bedded Quartzose Sand
- Fine-grained Moderately Planar-bedded Bioclastic Quartzose Sand
- Medium-grained Silty Quartzose Sand
- Coarse-grained Shelly Sand

Sand

Mud

Clay

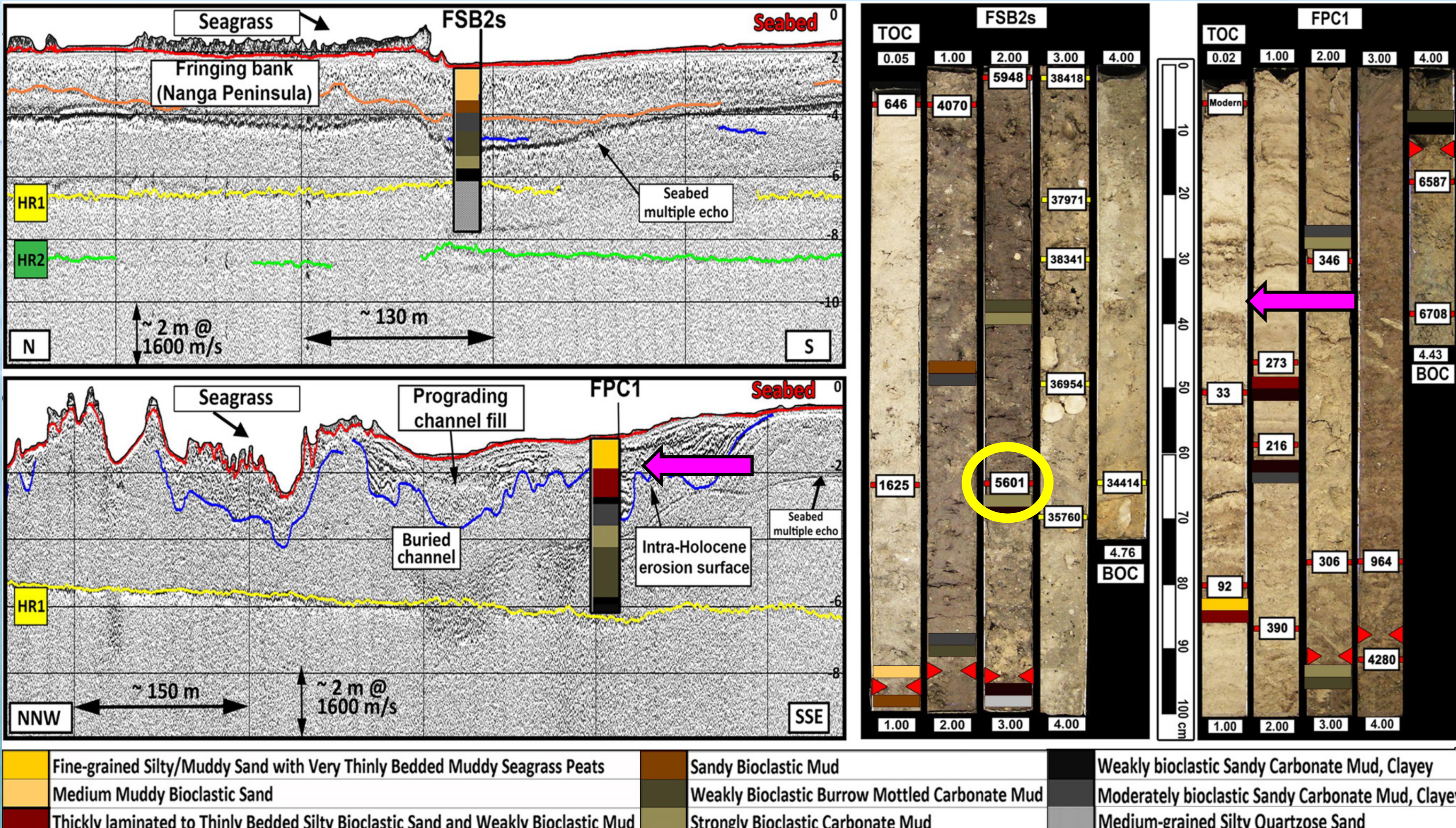
Carbonate (*in situ*):

- Bioclasts
- Ooids
- Seagrass peats

Terrigenous:

- Relict quartz (erosion)
- Terrestrial clays (from Wooramel Delta)

Discussion



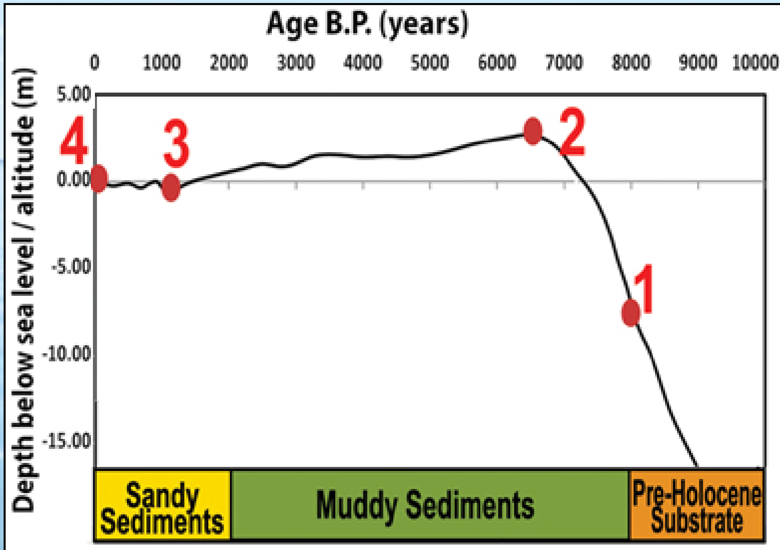
HR1 Bibra Limestone (Upper Pleistocene)

HR2 Dampier Limestone (Middle Pleistocene)

Late Holocene Palaeosurfaces

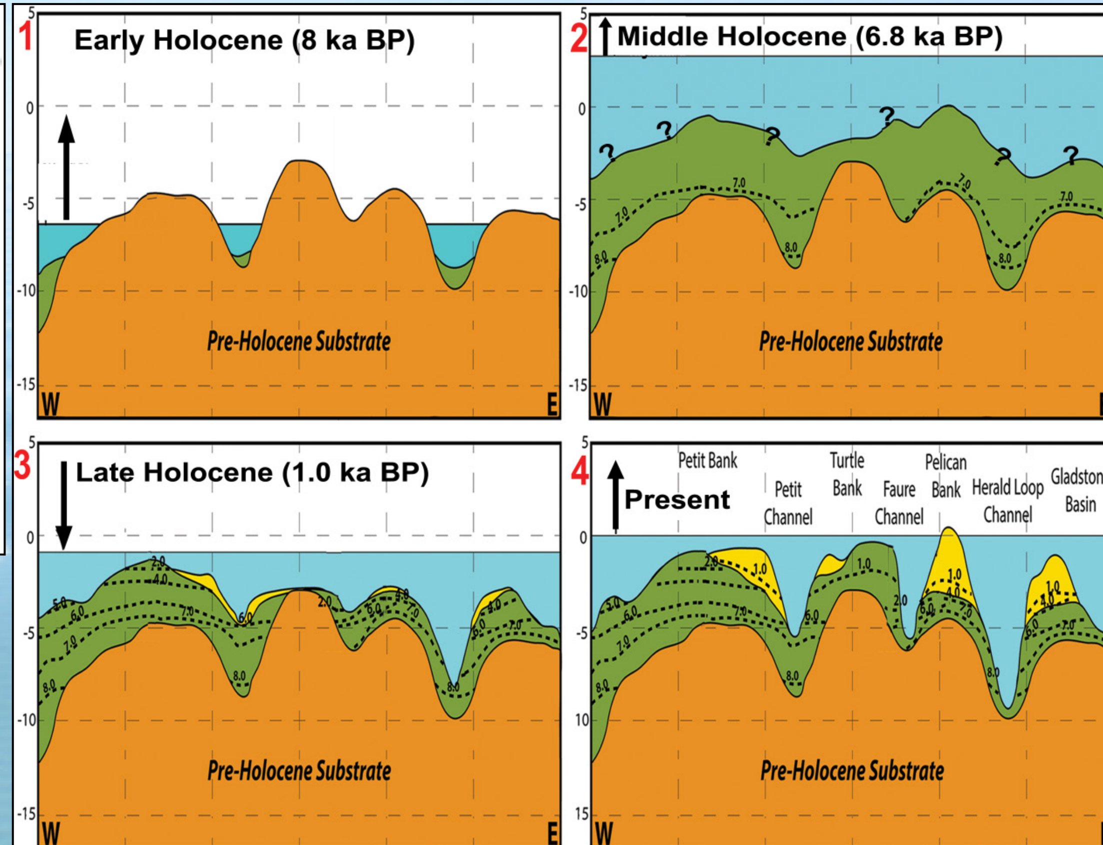
Bufarale & Collins, 2015 (modified)

Reconstruction of the Holocene chronology of the Faure Sill



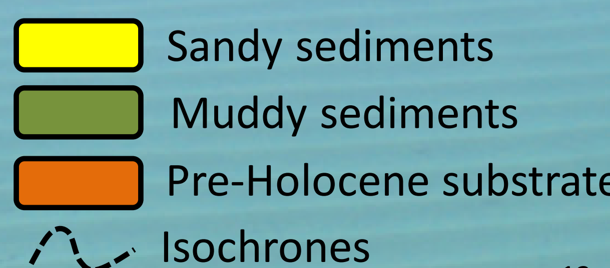
Holocene sea level curve

Collins et al. (2006); Jahnert and Collins (2013)



Bufarale & Collins, 2015 (modified)

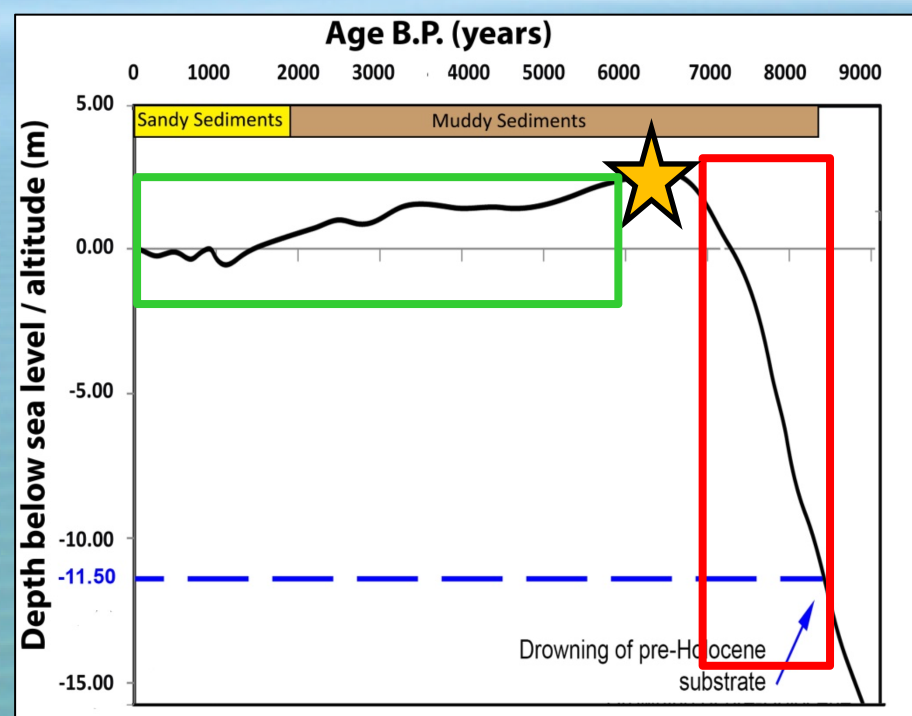
- **Range of accumulation rate**
  - **0.44 m/ka (Delta)**
  - **6.9 m/ka (Filled channel)**
- **Average accumulation rate**
  - **3 m/ka**
  - **1.3 m/ka (filled channel excluded)**



Conclusion

- Bank evolution controlled by:
  - Pre-Holocene topography
  - Seagrass
  - Sea level fluctuations

- Bank development phases:
  - Onset = early Holocene transgression
  - Max accumulation = around 6800 years BP
  - Fill available accommodation



Roles of the Faure Sill seagrass bank

- Hydrodynamic control→ hypersaline conditions → critical in the initiation and persistence of stromatolites, coquina, ooids
- Shelter and food for numerous species of molluscs, fish, crustaceans
- Breeding and feeding habitats for dugongs, loggerhead turtles, cetaceans, sharks
- Partial analogue for the Plover Formation, in the Browse Basin (North West Shelf, Western Australia)

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