NIWA
Taihoro Nukurangi

TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
UNIVERSITY OF WELLINGTON

THE UNIVERSITY OF
AUCKLAND
NEW ZEALAND

GNS
SCIENCE
TE PŪ AO

Paleoseismic constraints on earthquake behaviour of the Hikurangi margin

Jamie Howarth, Kate Clark, Alan Orpin and the HSM and SHIRE paleoseismology teams

EQC
EARTHQUAKE COMMISSION
Kōmihana Rūwhenua

NSF

MINISTRY OF BUSINESS,
INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

Outline

- Background – current patterns of deformation and historic seismicity

- The major questions being tackled using paleoseismology

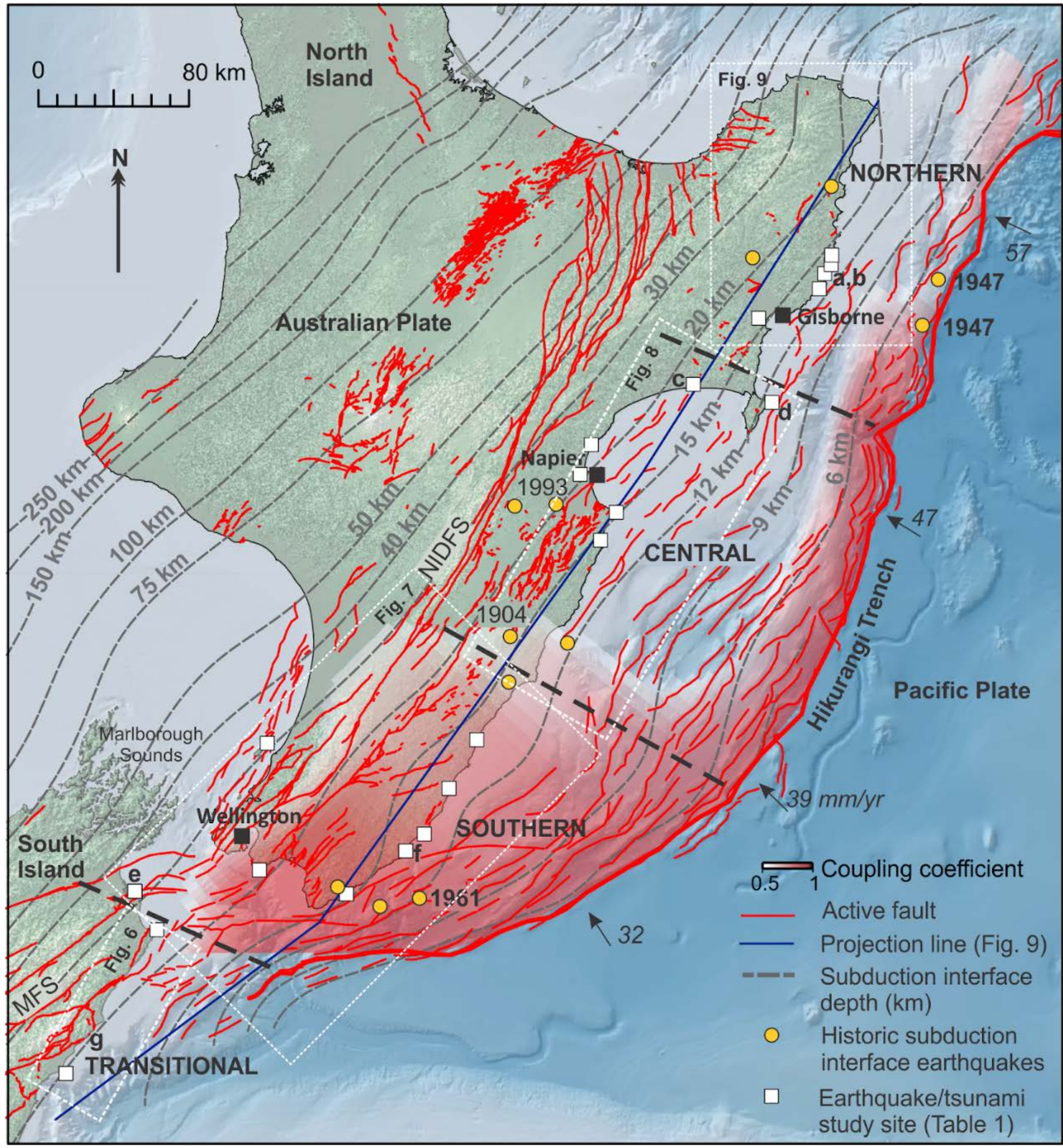
- A review of the current state of paleo-earthquake knowledge

- Research roadmap and summary of current initiatives:
    1. Coastal deformation paleoseismology and paleotsunami
    2. Turbidite paleoseismology

- Next steps and challenges.

Spatial distribution of locking and historical seismicity

- Spatial pattern of plate coupling defined from ~20 years of GPS data
- Historical earthquake record in short extends 150-200 years
- Few historical large interface earthquakes
- Māori oral traditions
  - Hao-whenua earthquake ~1460 A.D.
- Paleoseismology essential for understanding seismogenic behaviour of the margin at the scale of the large earthquake seismic cycle

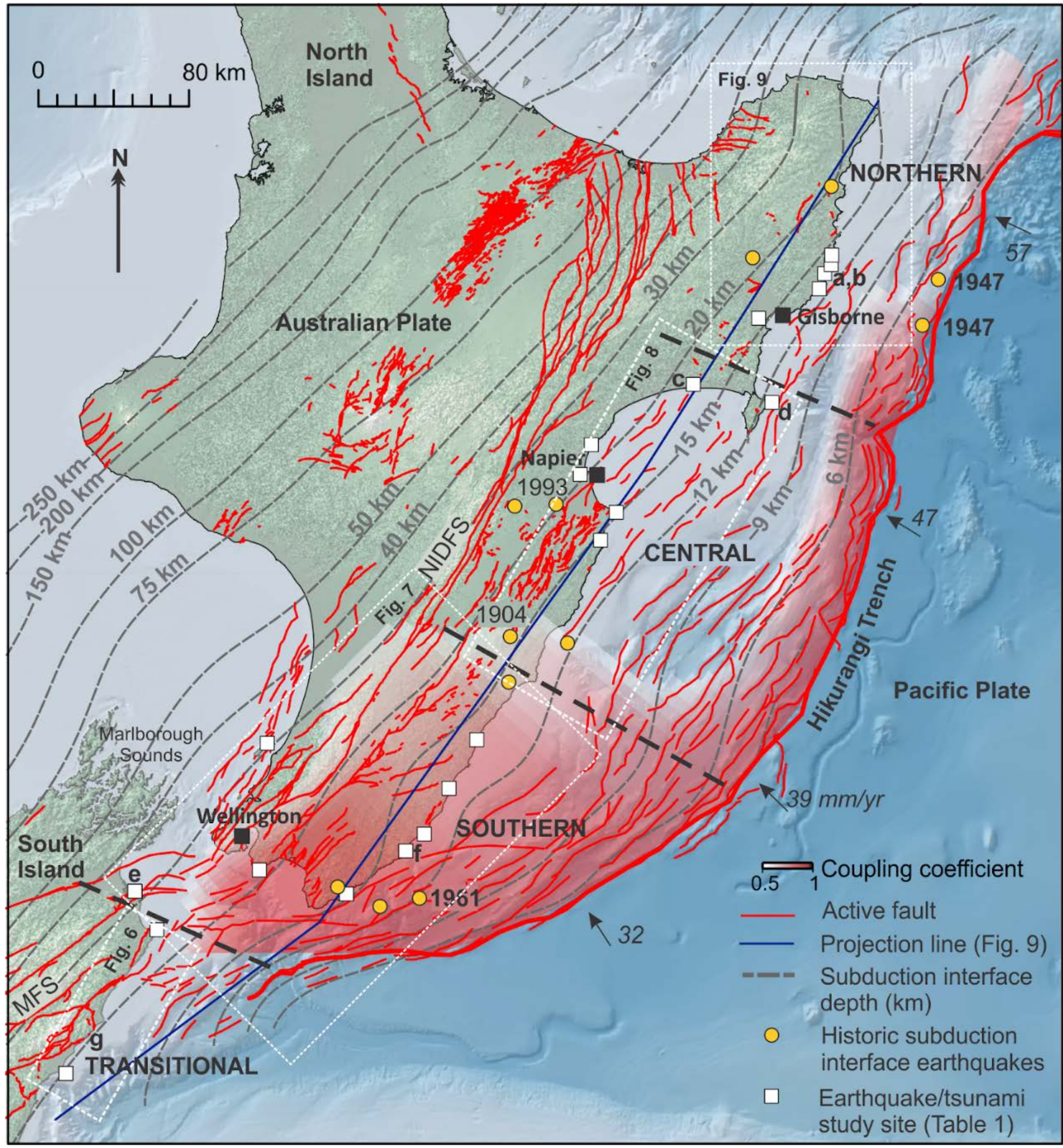


Clark et al. (submitted), Marine Geology

The key questions:

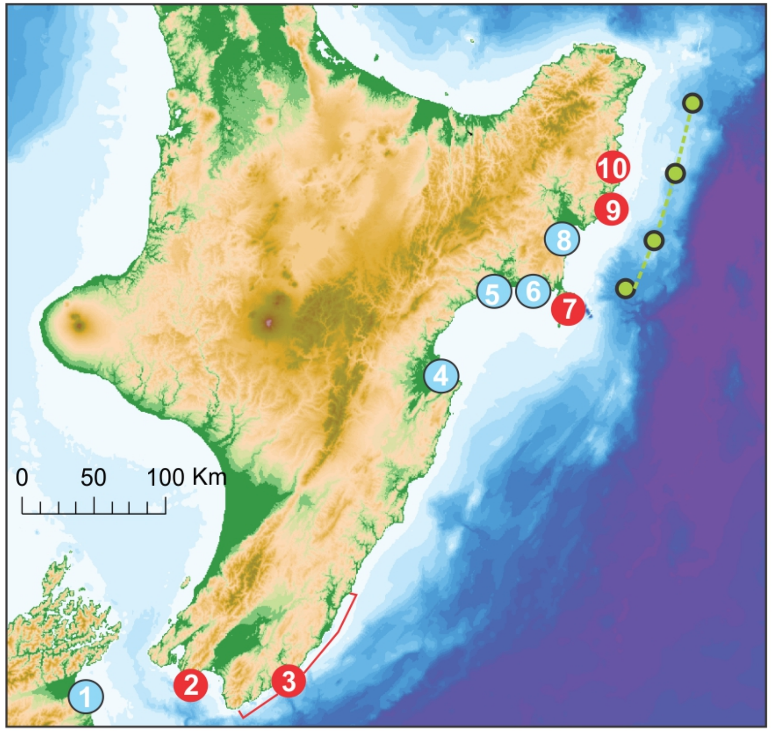
1. *Does the Hikurangi margin rupture in great (M >8) or giant (M >9) earthquakes, and if so, how often?*

2. *Does the contemporary pattern of plate coupling inform the spatial distribution of large earthquakes?*

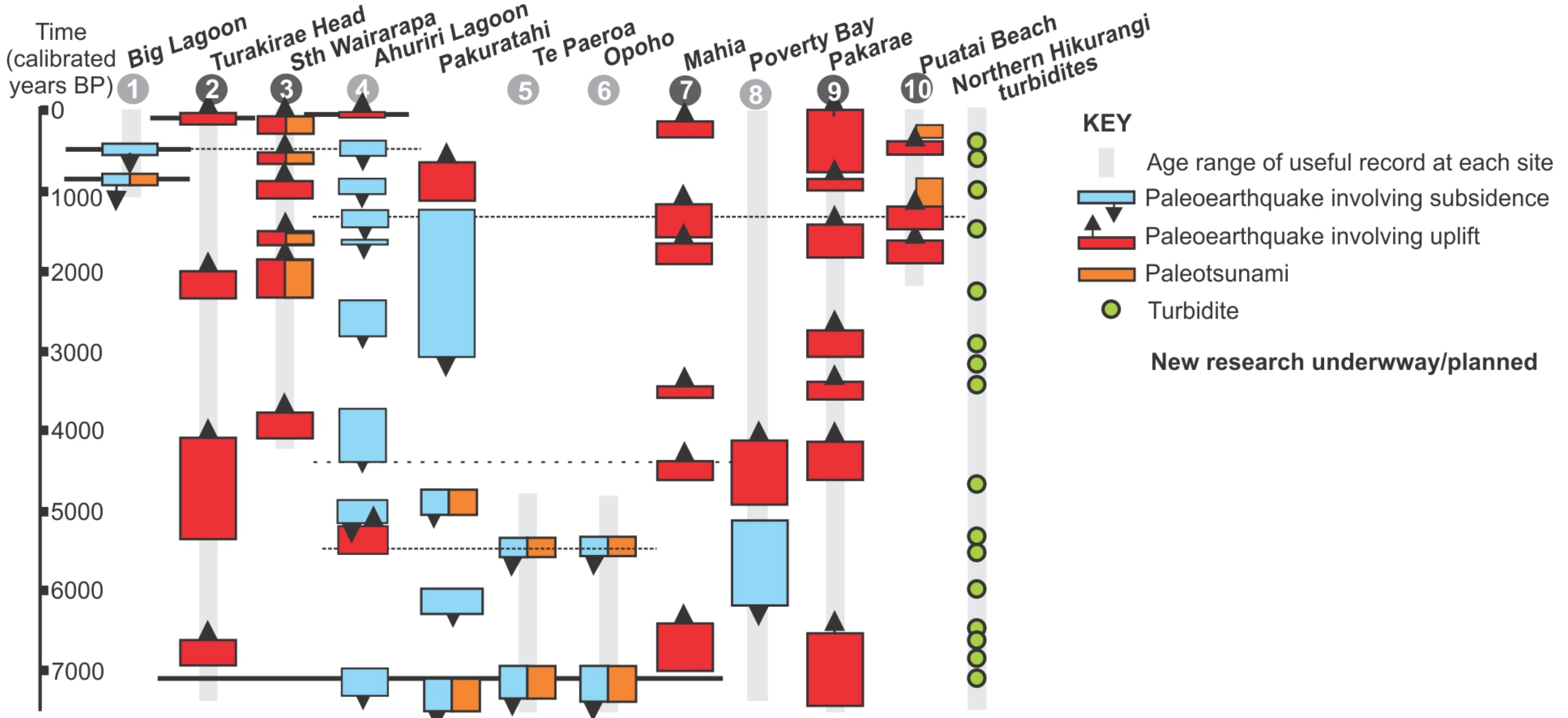


Clark et al. (submitted), Marine Geology

The published HM paleoseismic record



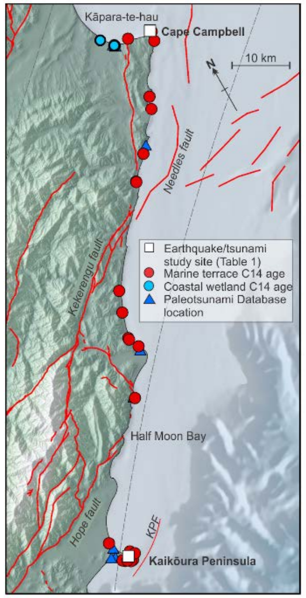
Clark et al., 2015; Wallace et al., 2015

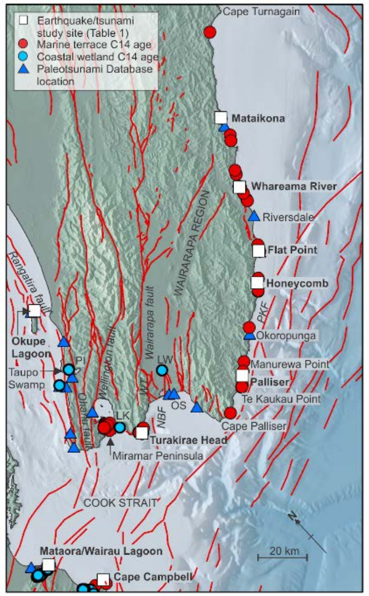


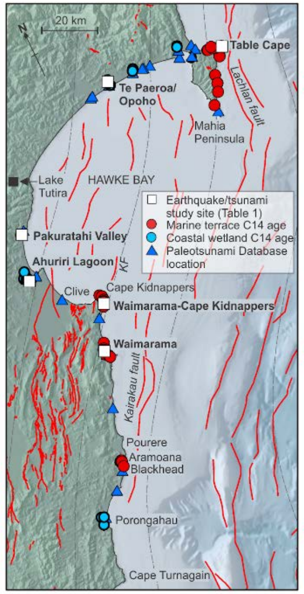
- Age uncertainties too large for reliable along-margin correlations
- Large spatial gaps
- Large temporal gaps

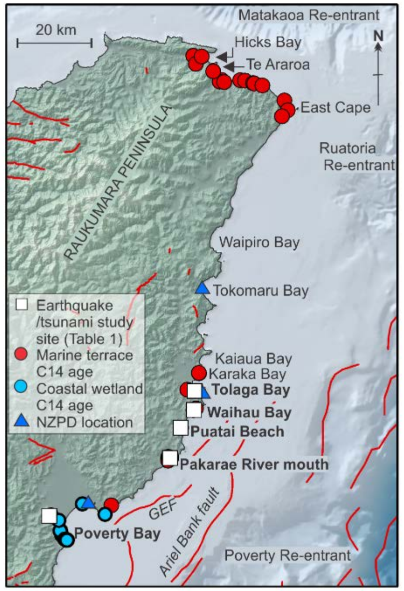
New paleoseismic synthesis

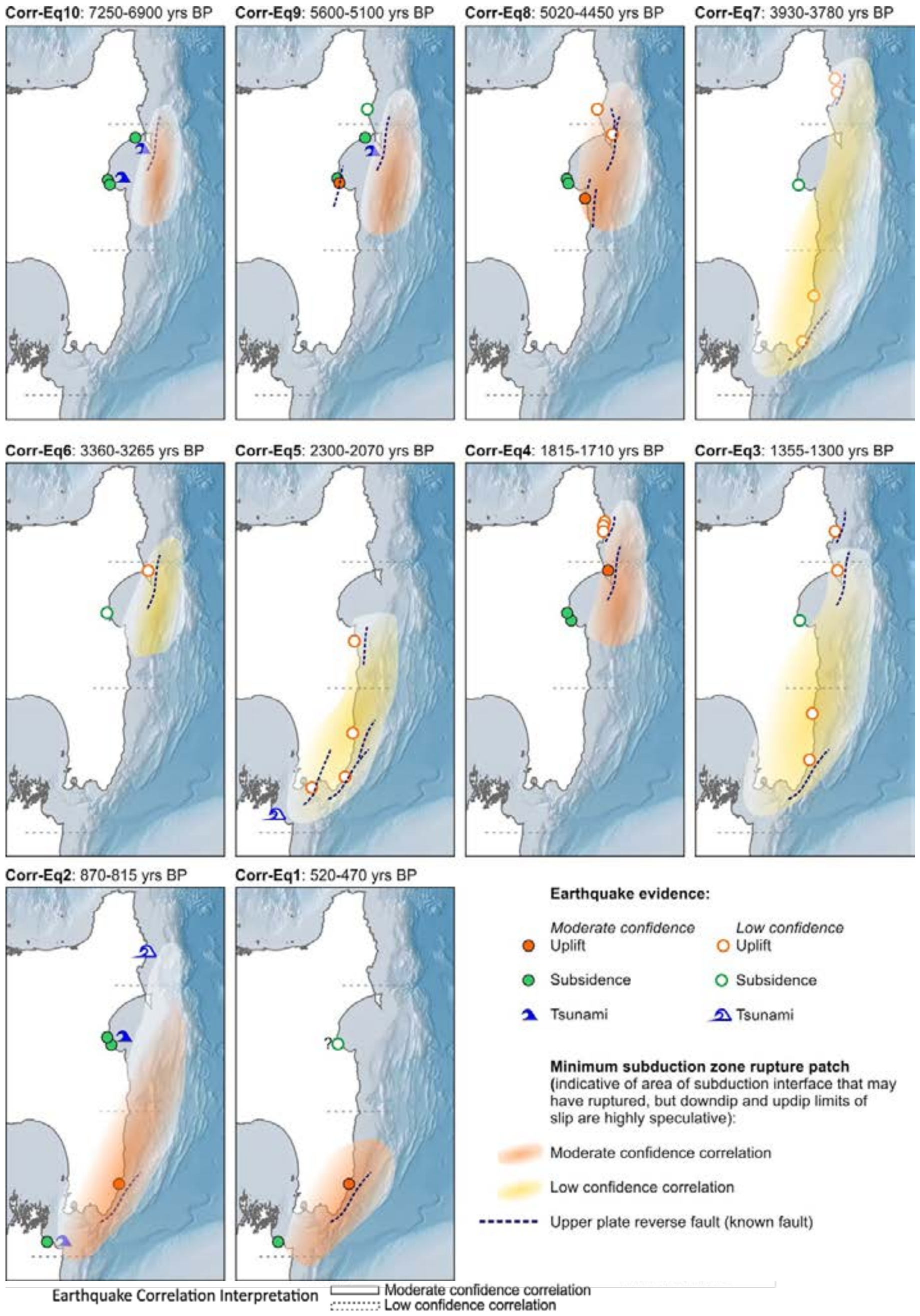
- Comprehensive review of all available data (Clark et al., submitted)
- Assessment of:
  - Type and quality of earthquake evidence
  - Quality of chronology
- 10 potential subduction zone events
- Chronology too imprecise for robust assessments of synchronicity











Clark et al. (Submitted), Marine Geology

Refining the earthquake history of the Hikurangi margin

Collect new field data

- Offshore
- Onshore

→

Identify earthquake signatures in the sedimentary record

→

Build high-resolution chronologies of earthquakes

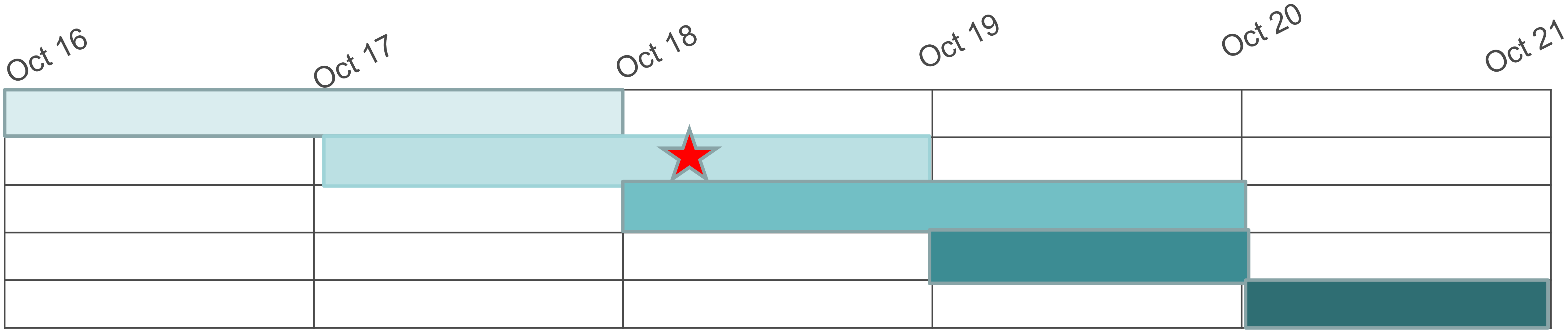
→

Develop a subduction earthquake record

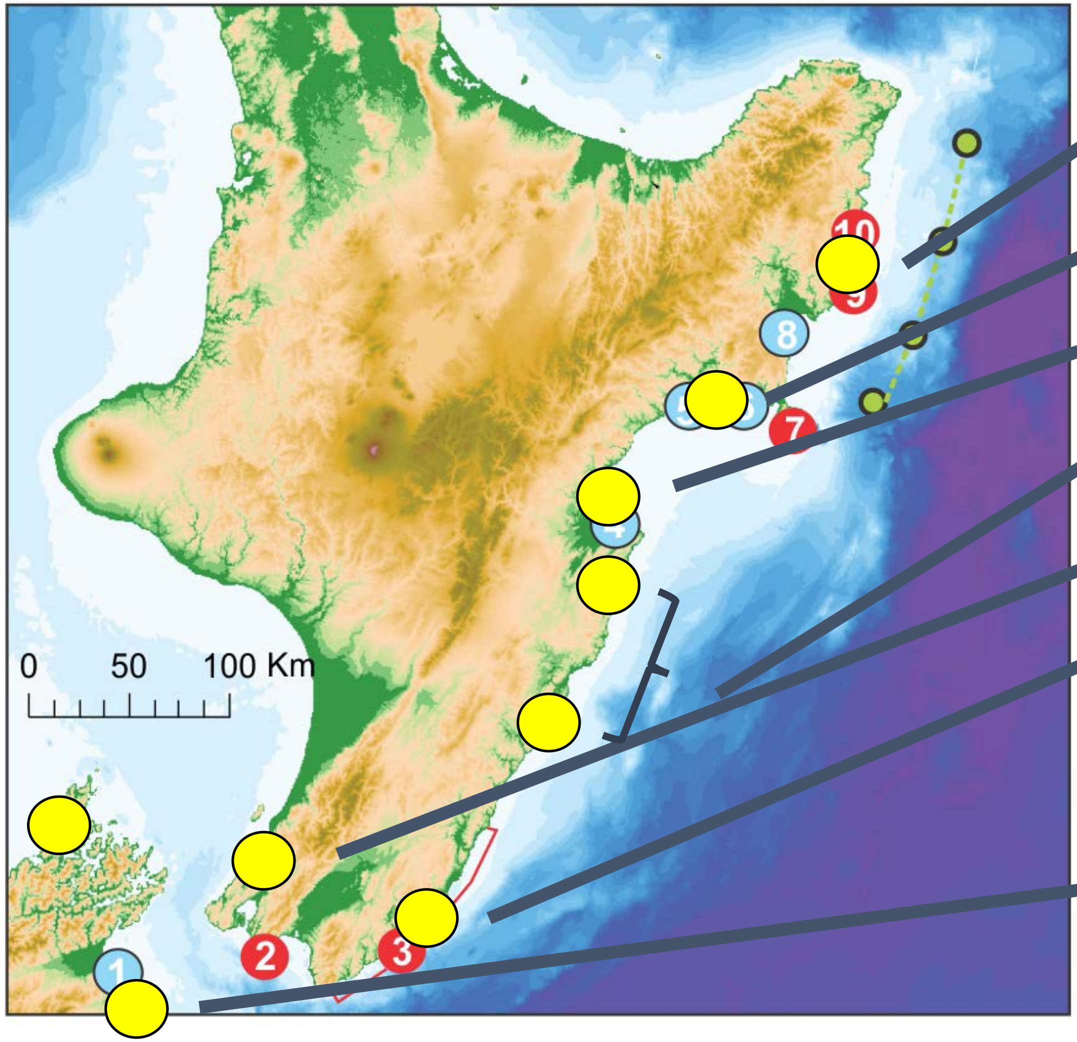
- Integration supported by modelling of fault sources & ground motions

→

Peer review and stakeholder communication



New onshore paleoseismic sites



- Nine new paleoseismic site investigations

  Puatai and Pakarae terraces 2016-2017 HSM and EQC

  Wairoa coastal plain - Jan 2018 SHIRE

  Ahuriri lagoon HSM and paleotsunami 2018 SHIRE

  Southern Hawkes Bay & Northern Wairarapa SHIRE

  Kāpiti coast 2018-2019 It's Our Fault

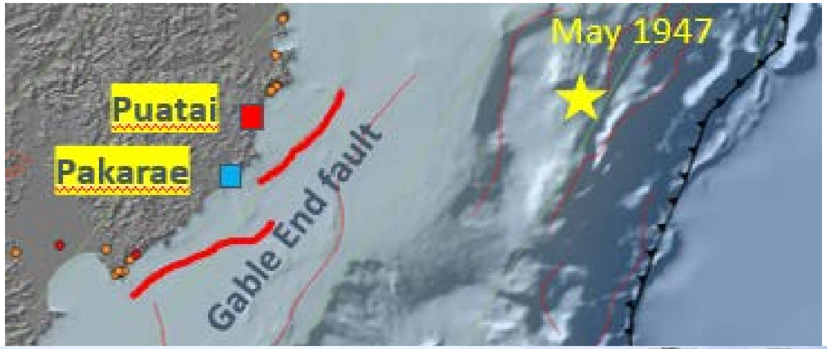
  Glenburn marine terraces 2018 HSM

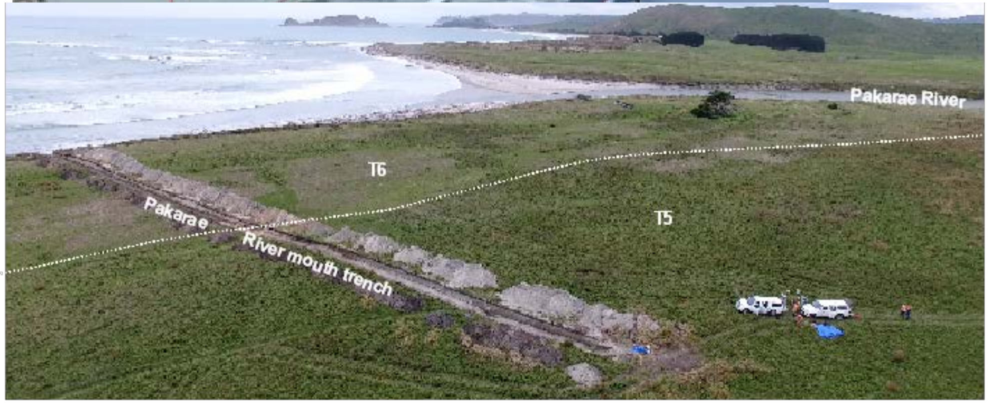
  D'Urville Island – 2017-2018 It's Our Fault

  Lake Grassmere – Charlotte Pizer (Durham University) MSc study.

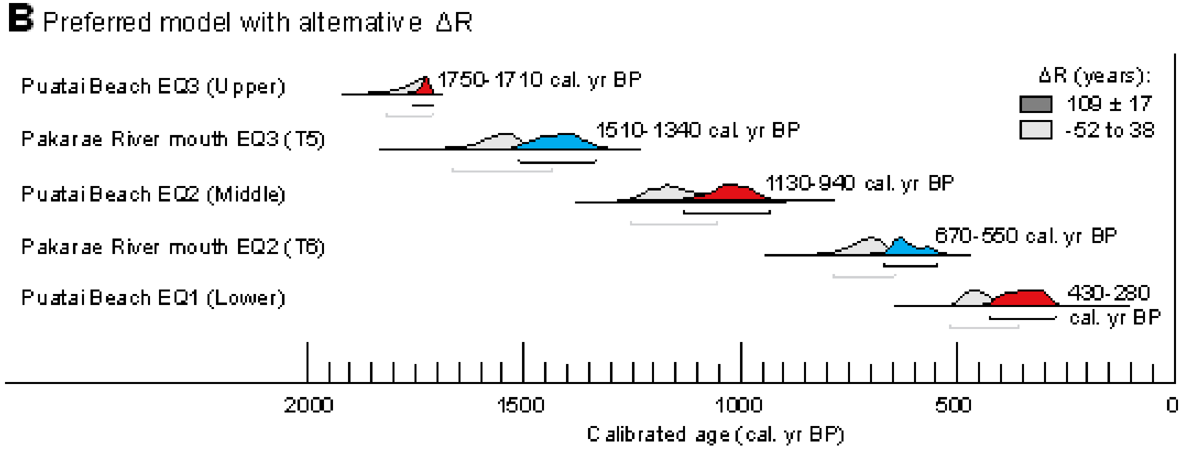
- Focus on developing high resolution chronology
  - Going from centennial to decadal uncertainties

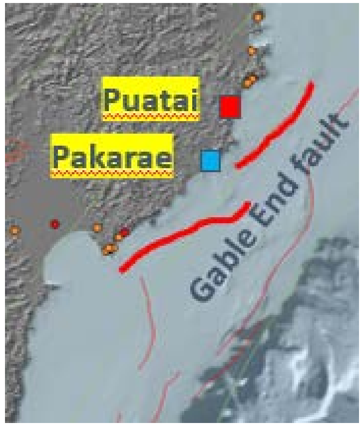
Example: northern margin – marine terraces

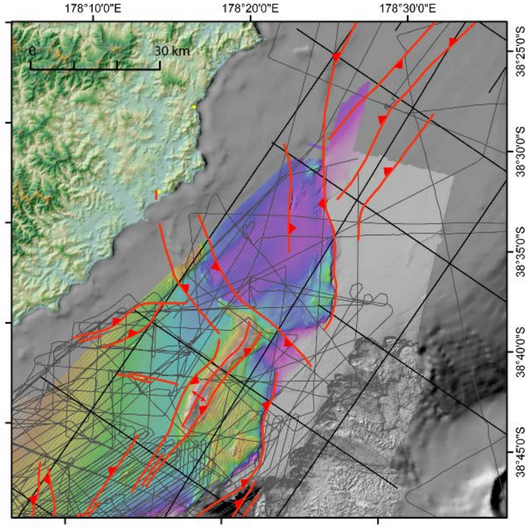




- Puatai and Pakarae terrace sequences had poor age constraint and equivocal inter-site correlations
  - Upper plate fault + subduction EQ record?
- Advantages of marine terrace trenching for identifying dateable material
- High resolution age models suggest asynchronous terrace formation at the two sites
- Discrete rupture on different segments of the Gable End Fault or other near-shore structures.

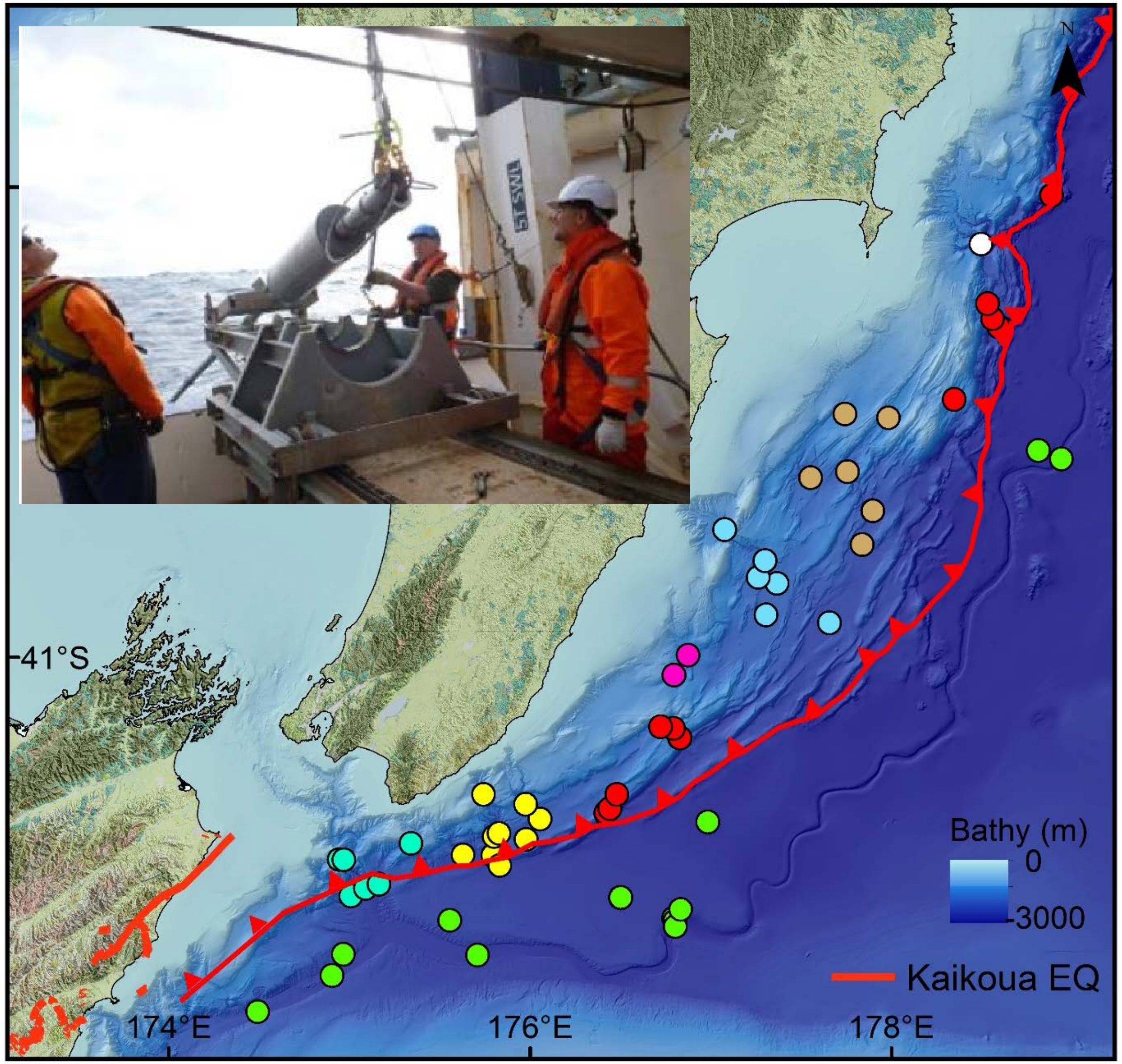






Litchfield et al. (In prep.)

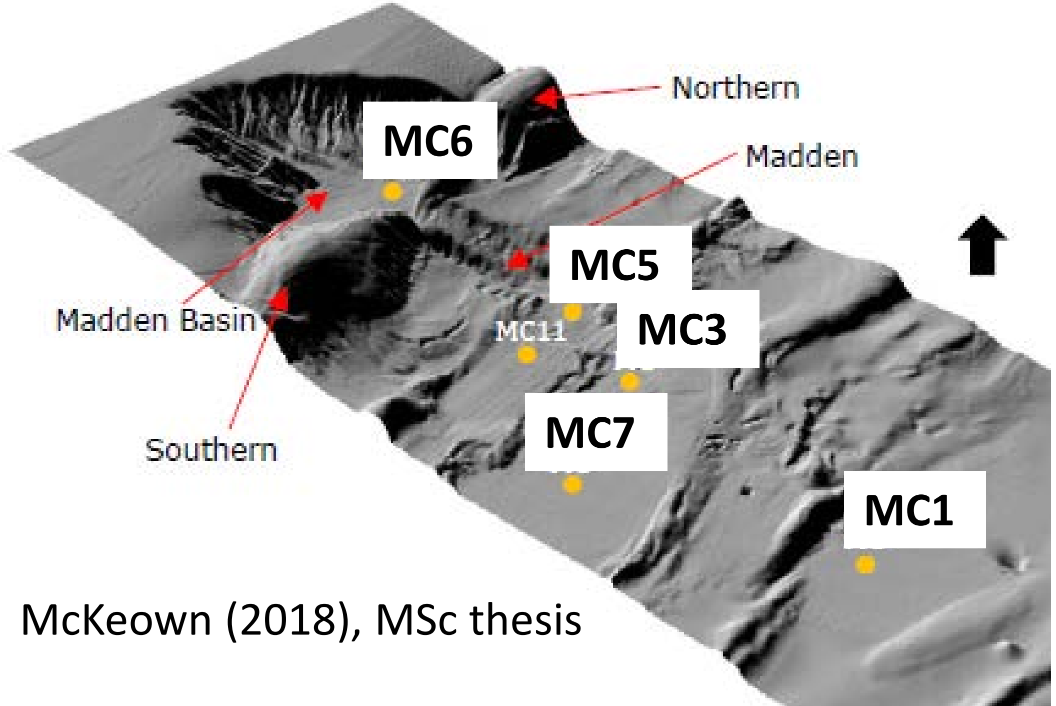
New offshore paleoseismic initiatives



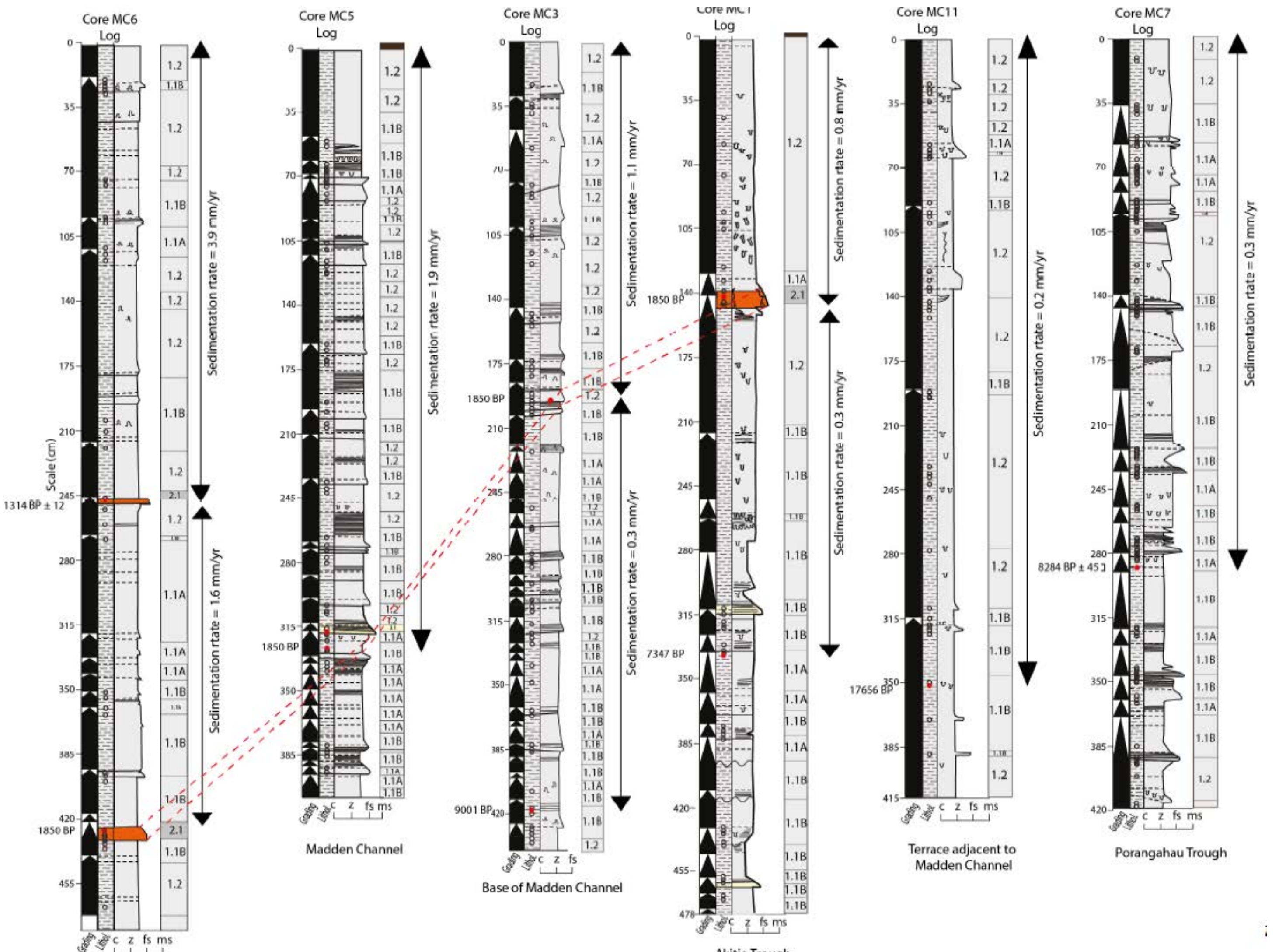
- 50 piston cores and 10 multicores in TAN1613.
- Sites selected using high resolution bathymetry, Topaz SBP and flow modelling.
- Sampling five discrete distributary systems across the transition in coupling.
- Turbidite-rich basin sequences identified in most distributary systems.
- Cores characterised by MSCL, CT, µXRF, grainsize and TOC
    - MSc student projects for each distributary system
- Preliminary chronologies from tephrochronology and ^{14}C

Example: Madden Canyon

- 4-6 m long cores, up to ~30 turbidites over the last ~9000 years
- Basal ^{14}C ages
- Need for high resolution chronology
  - Correlations within and between distributary systems



McKeown (2018), MSc thesis

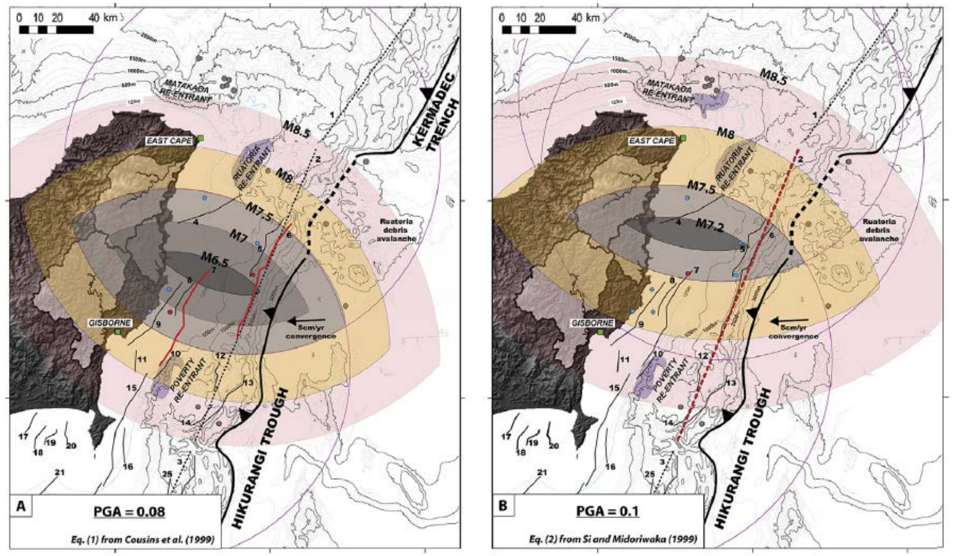


On going work and challenges

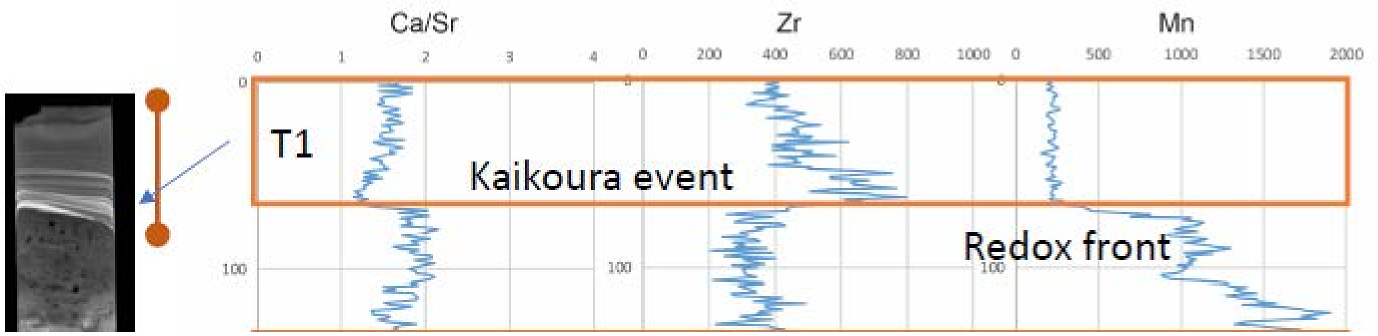
Build high-resolution chronologies of earthquakes

Develop a subduction earthquake record

- Integration supported by modelling of fault sources & ground motions



- Challenges for developing chronology offshore
  - Identifying hemipelgite
  - Reducing the mass of pelagic forams needed for ^{14}C dating



- Challenges with integration
  - Defining fault sources post the Kaikōura earthquake
  - Constraining the relationship between ground motions and turbidite emplacement

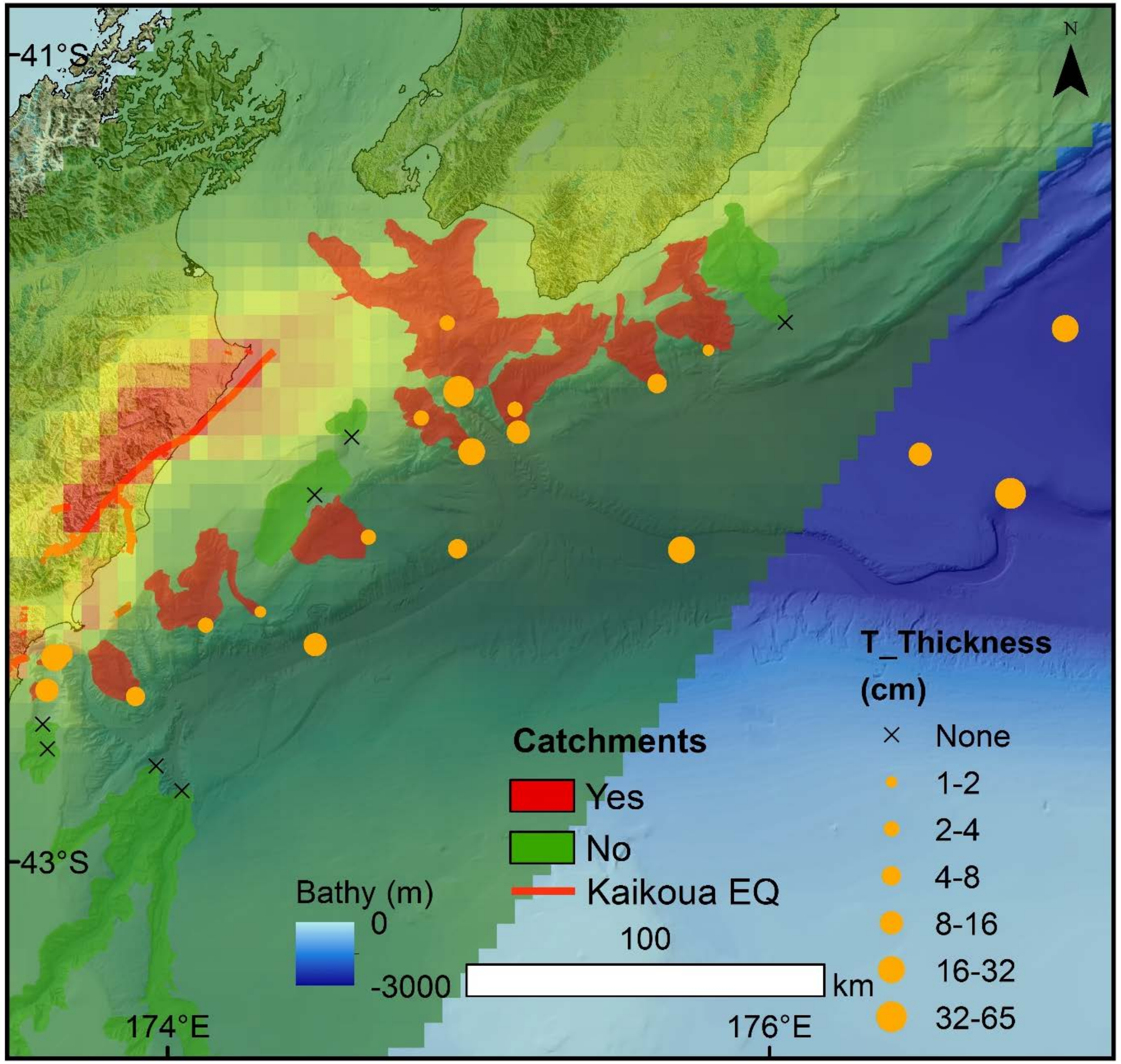
A calibrating the turbidite paleoseismometer

- Kaikōura earthquake provides a calibration of turbidite paleoseismology on the Hikurangi margin

- If you want to know more come to:

Calibrating the turbidite paleoseismometer on the Hikurangi margin, New Zealand, using the 2016 M_w7.8 Kaikōura earthquake

Date and Time: **Friday 13:40 - 13:55**
Session: **T53C: Subduction Zone Processes at the Hikurangi Margin, New Zealand I**
Location: **Marriott Marquis; Liberty N-P**



Summary

- Synthesis of data reveals 10 potential subduction earthquakes over the last 7.5 ka
  - Preliminary indication that these events don’t confirm to current ideas on segmentation
- Along-strike correlations are limited by imprecise chronology
- New initiatives will:
  - More than double the number of coastal and offshore sites
  - Greatly increase the precision on earthquake ages
- Integration of on- and offshore paleoseismology will help better distinguish subduction from upper plate fault earthquakes
  - Importance of good chronology, as well as fault source and ground motion modelling