The passage of sediment from mountain source to ocean sink:

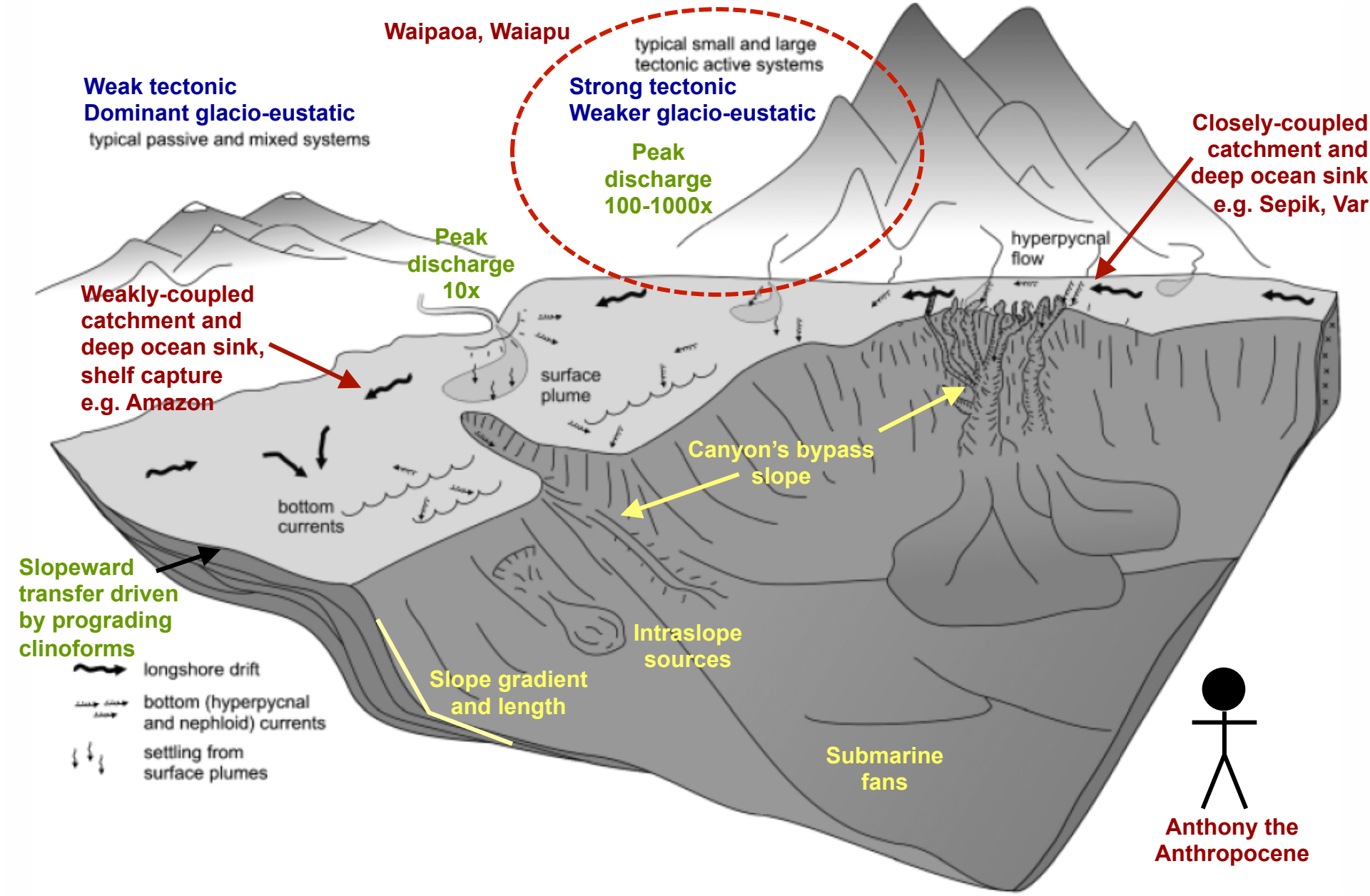
Results from the MARGINS S2S Waipaoa Sedimentary System, Hikurangi Margin

Alan Orpin & Source-to-Sink WSS Team

Photo: James Syvitski

T. O. Sømme et al.

Source-to-sink: a God's-eye view



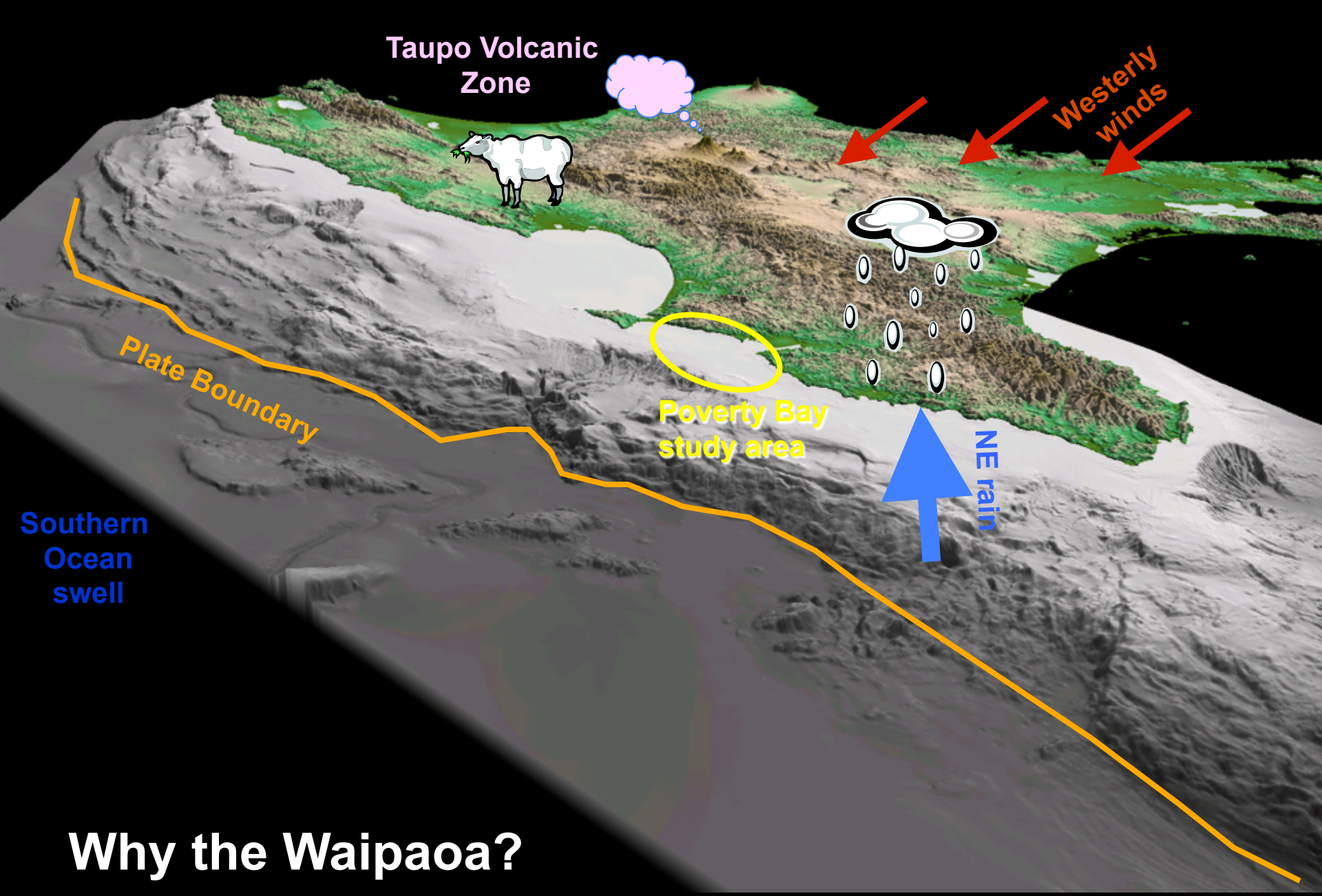
(Figure modified after Sømme et al., 2009)

“… develop a quantitative understanding of margin dispersal systems and associated stratigraphy, so that we can predict their response to perturbations, such as climatic and tectonic variability, relative sea-level change, and land-use practices”.

(Excerpt from MARGINS Source to Sink Executive Summary)

- ► Emphasis on quantification of processes and linkages
- ► Terrestrial and marine
- ► Limited to the last-glacial cycle, but emphasis on Holocene and Anthropocene records

Waipaoa River mouth.
Photo: James Syvitski



Why the Waipaoa?

(Image courtesy Josh Mountjoy)

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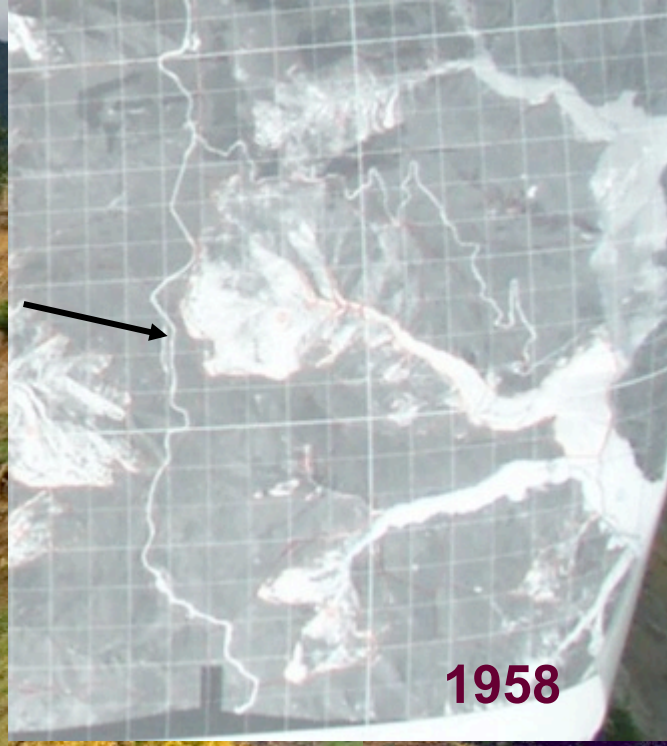
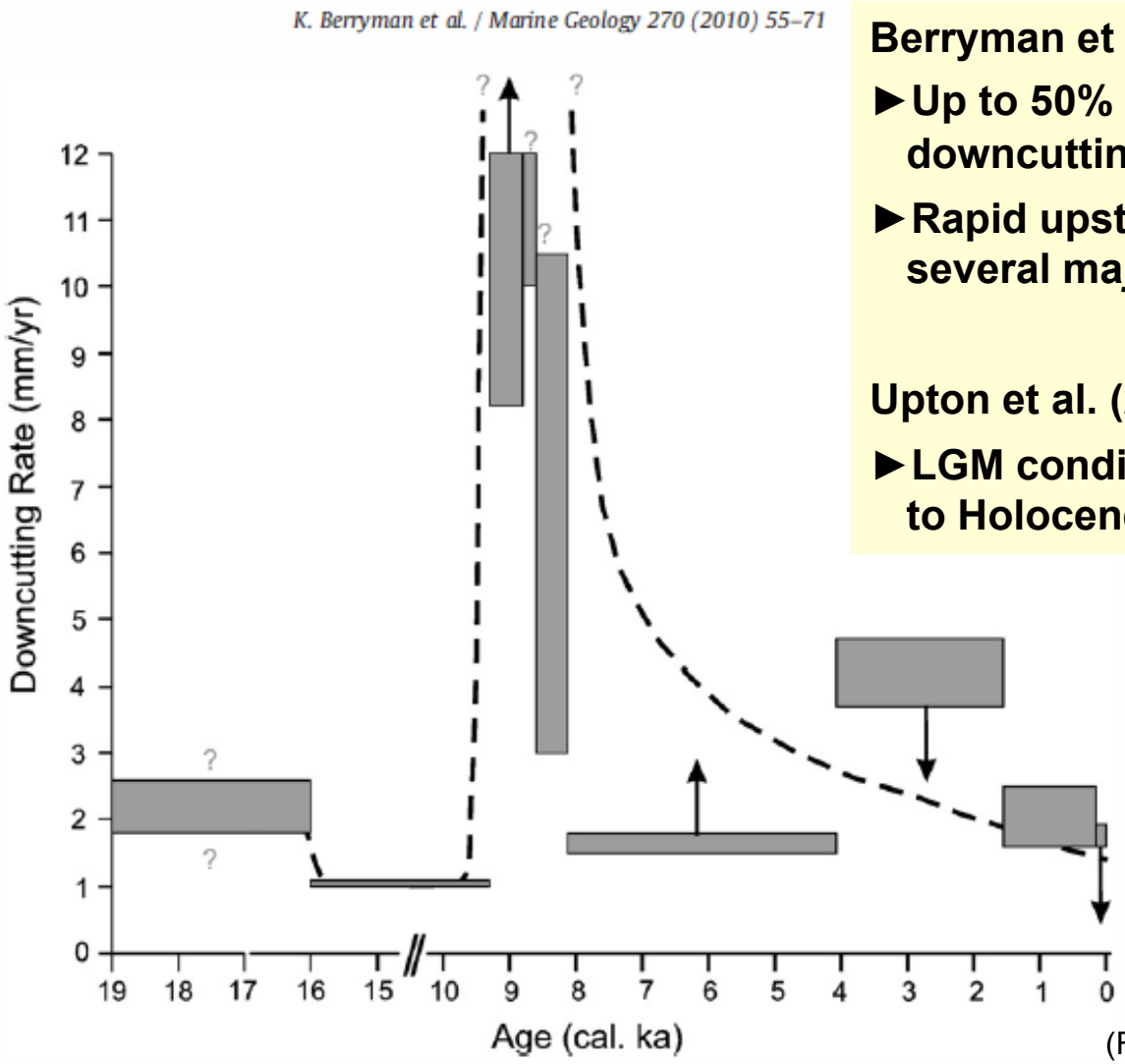


(Aerial photos C/- Landcare Research)

Dramatic changes in catchment behaviour: millennial scale



Berryman et al. (2010)

- ►Up to 50% of the post-glacial downcutting achieved between 10-8 ka
- ►Rapid upstream migration (~2 km/ka) of several major knickpoints

Upton et al. (2013)

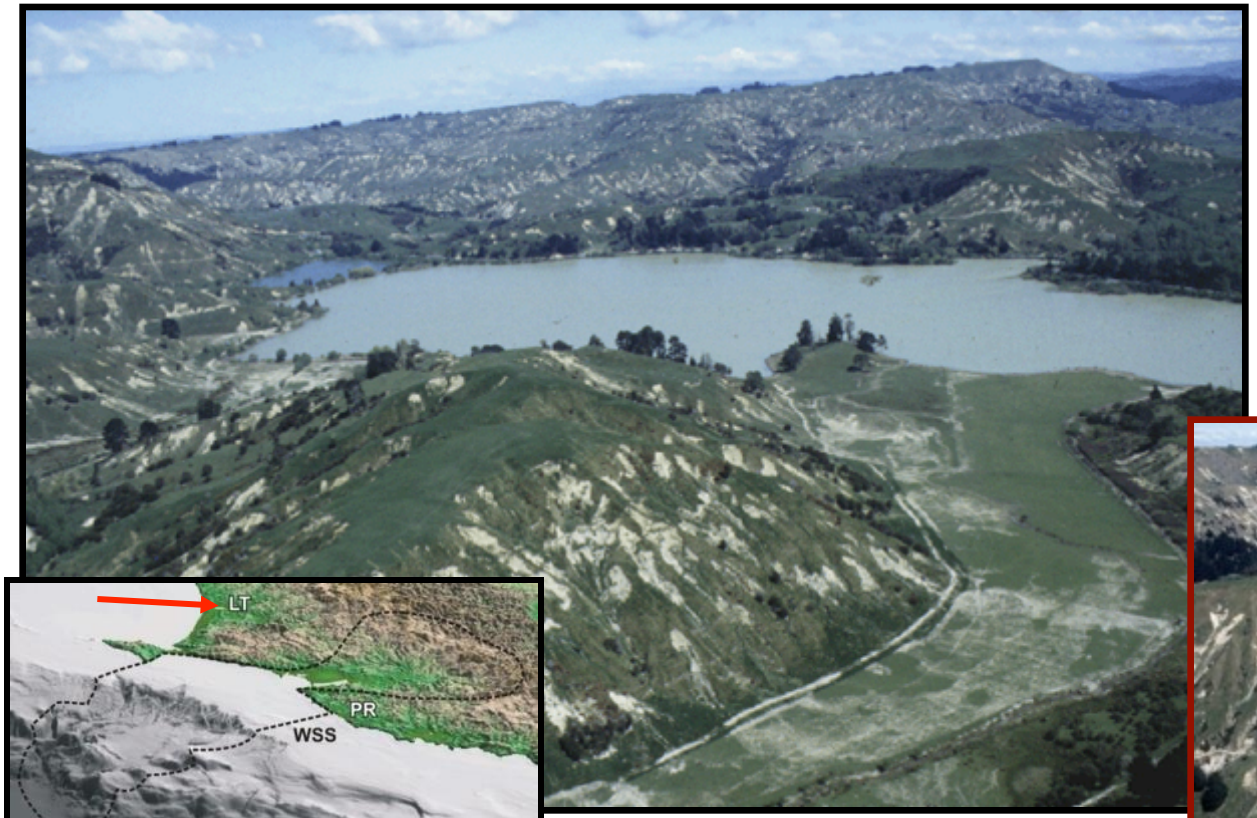
- ►LGM conditions more erosive compared to Holocene

Waihuka tributary of upper Waipaoa

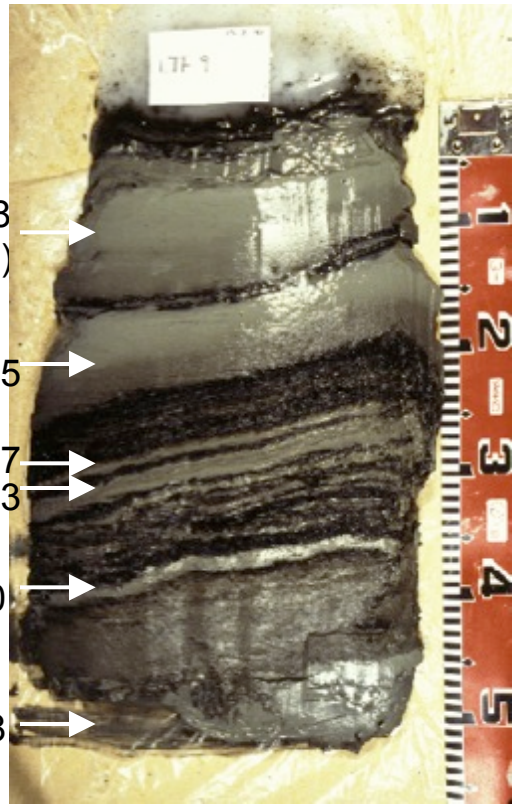
(Figure modified after Berryman et al., 2010)

Strong climate and environmental signals: event scale (10^{-2} to 10^{2} y)

- Gomez et al. (2011, 2013) - global climate teleconnections.
- Orpin et al. (2010) - intra-lake deposits and non-climate triggers.



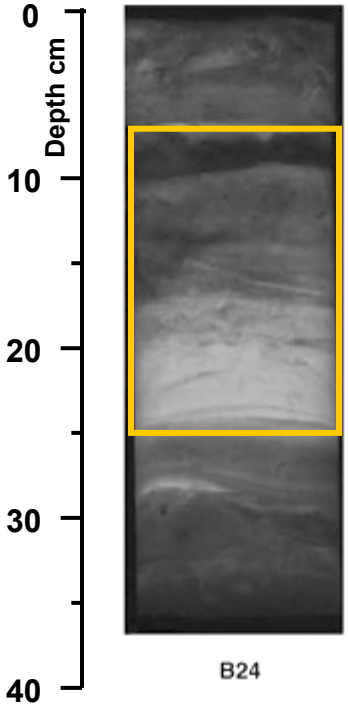
Lake Tutira catchment Post-cyclone Bola, 1988
(photos courtesy of Noel Trustrum)



LTF9 –frozen box core
(after Page et al., 1994)

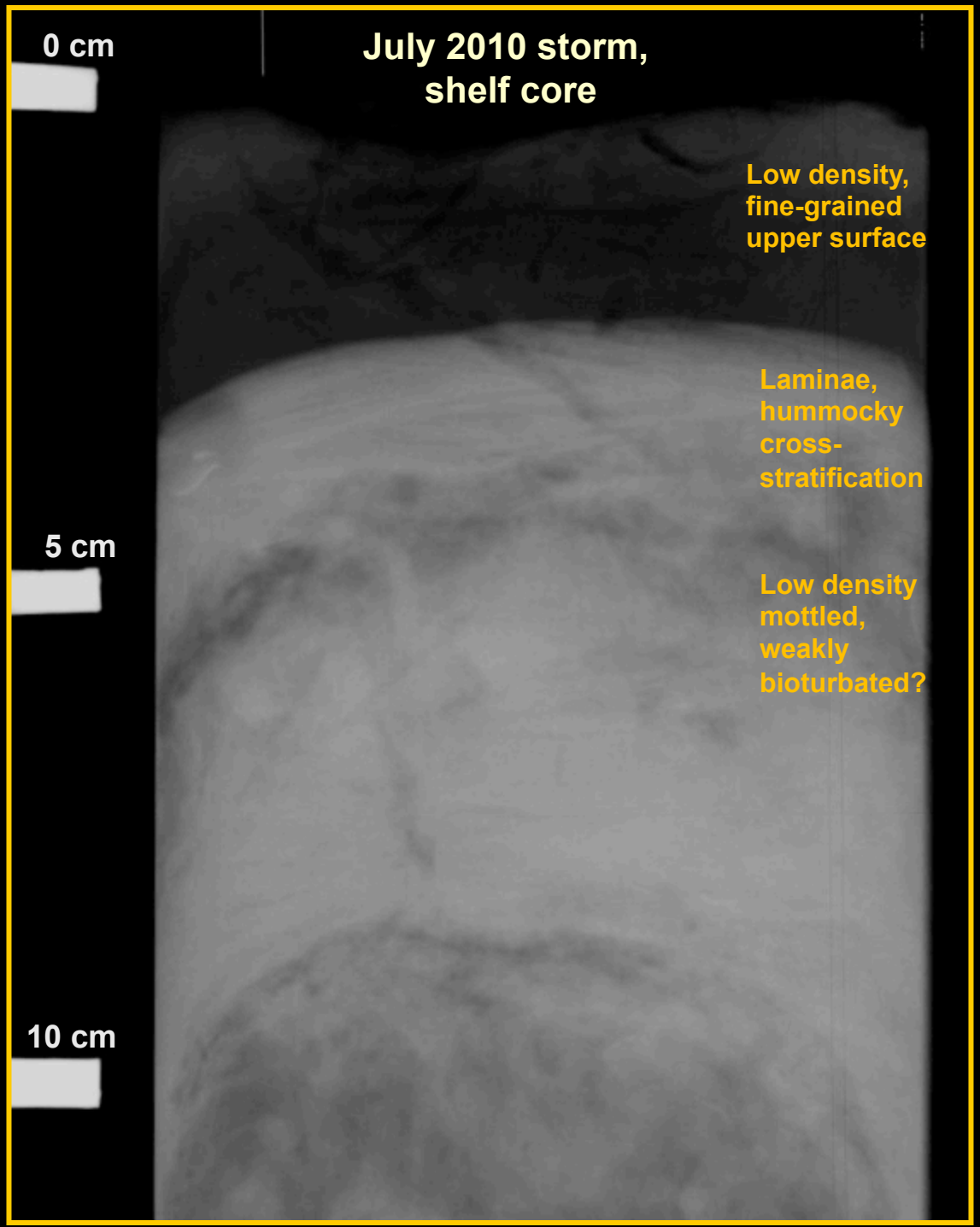
Event strata
(10^{-3} y timescales)

Bola-style event (Lila Rose Pierce & Steve Kuehl, PhD thesis)



(X-radiograph courtesy Rose & Kuehl, 2010)

Cyclone Bola event, shelf core



Coherence of event drivers: an annual view

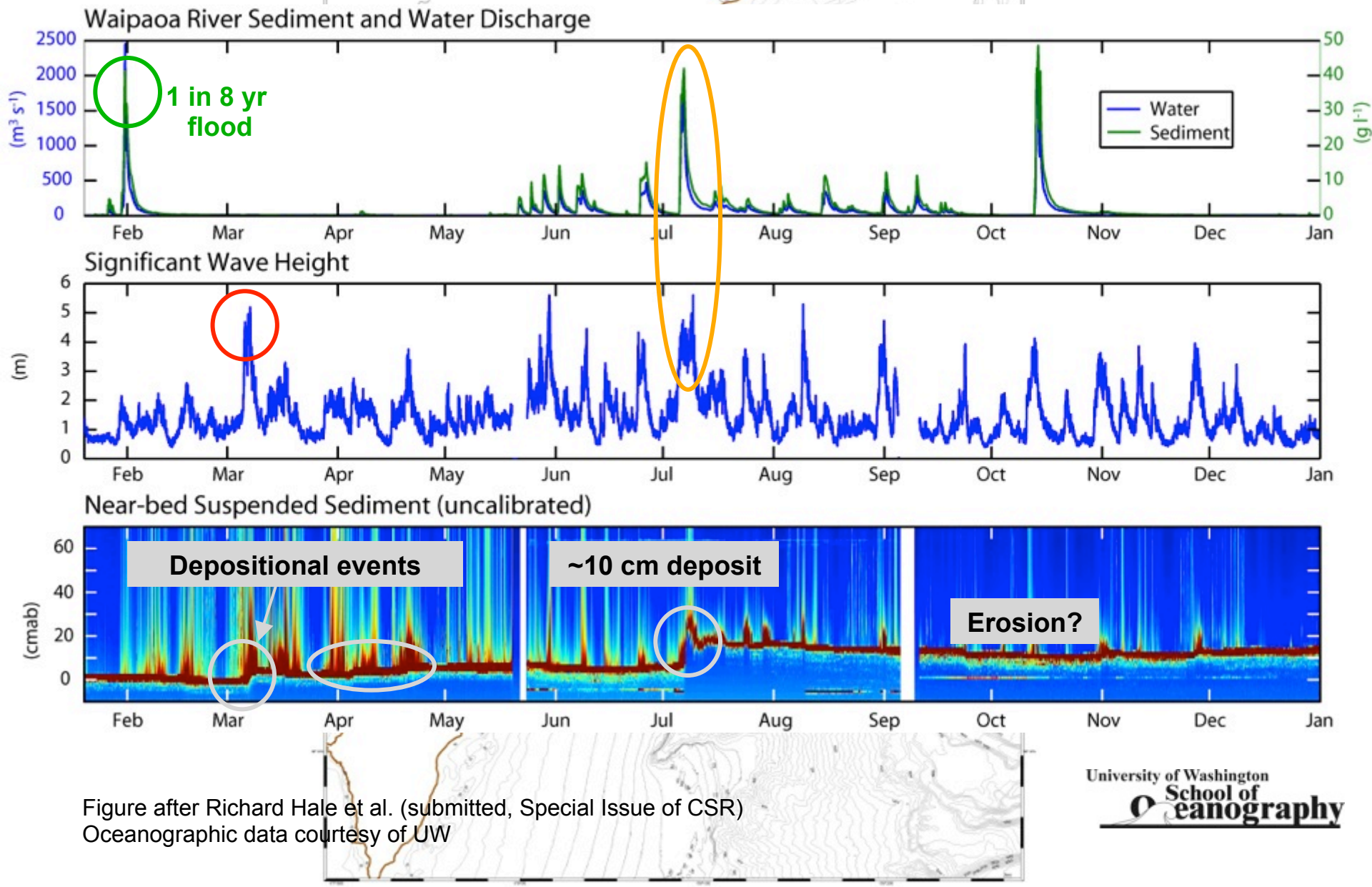
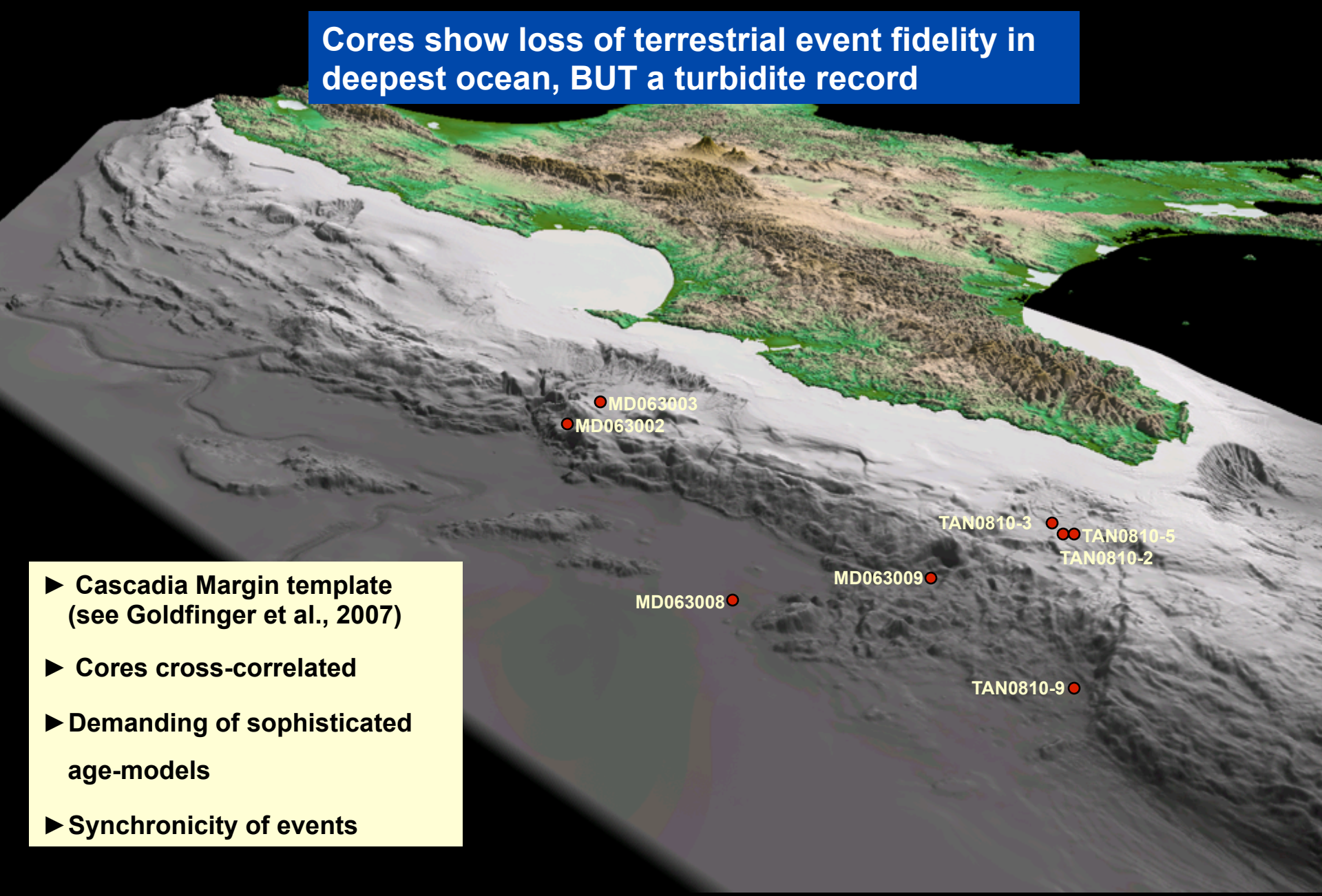


Figure after Richard Hale et al. (submitted, Special Issue of CSR)
Oceanographic data courtesy of UW

University of Washington School of Oceanography

Cores show loss of terrestrial event fidelity in deepest ocean, BUT a turbidite record



- ► Cascadia Margin template (see Goldfinger et al., 2007)
- ► Cores cross-correlated
- ► Demanding of sophisticated age-models
- ► Synchronicity of events

(Image courtesy Josh Mountjoy)

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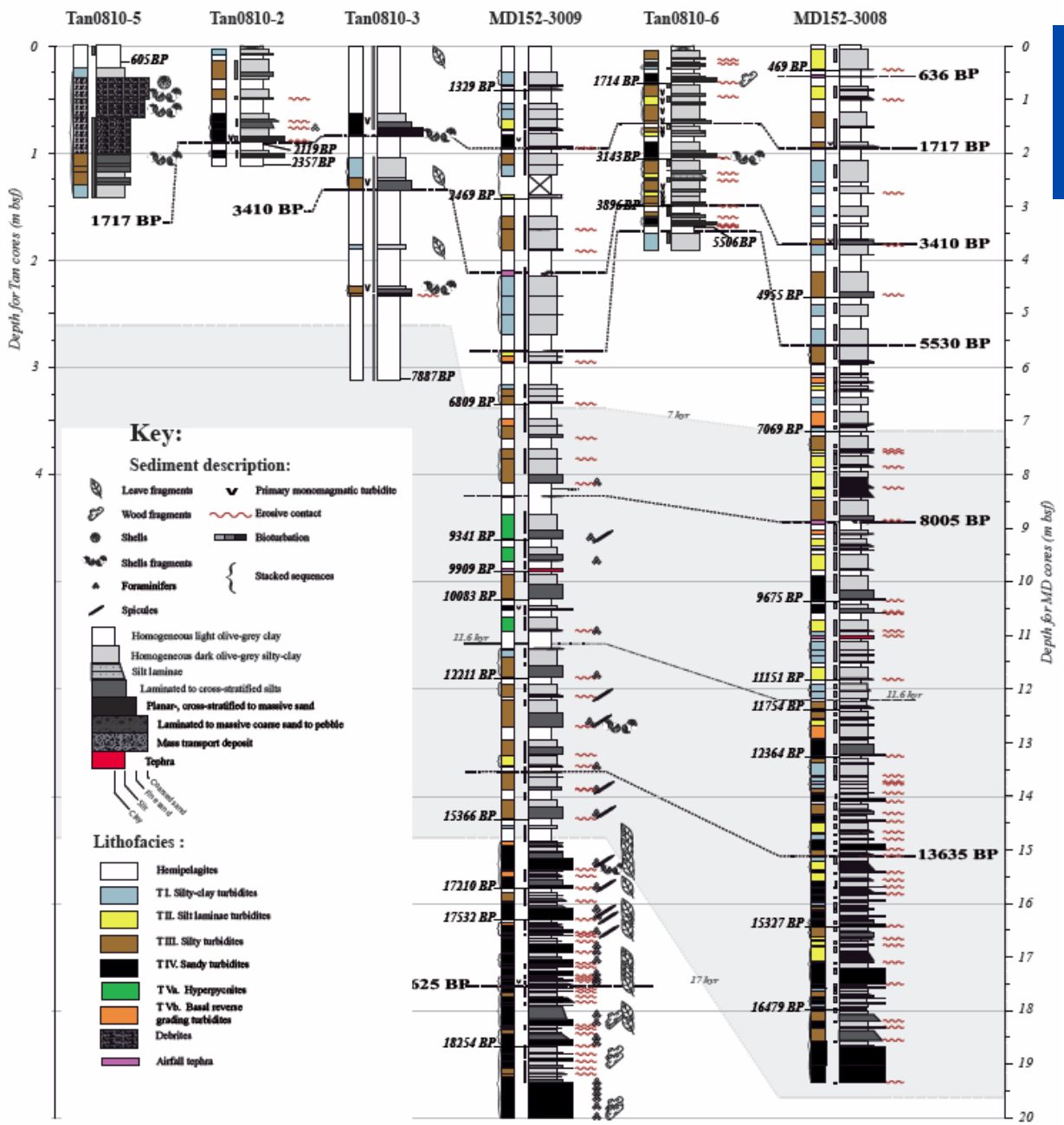
Characterising Hikurangi Margin turbidites since the LGM

Pouderoux et al. (2012a, b)



- ► 73 synchrononous turbidites
- ►5-fold reduction in slope sedimentation since LGM
- ►Hyperpycnites and debris flows rare
- ► Earthquakes most plausible trigger
- ►Poverty re-entrants return times c. 150-400 yrs
- ► Subduction interface earthquakes c. 800 yrs

After Hugo Pouderoux et al. (2012a, b) - *Marine Geology* and *Natural Hazards and Earth System Science.*

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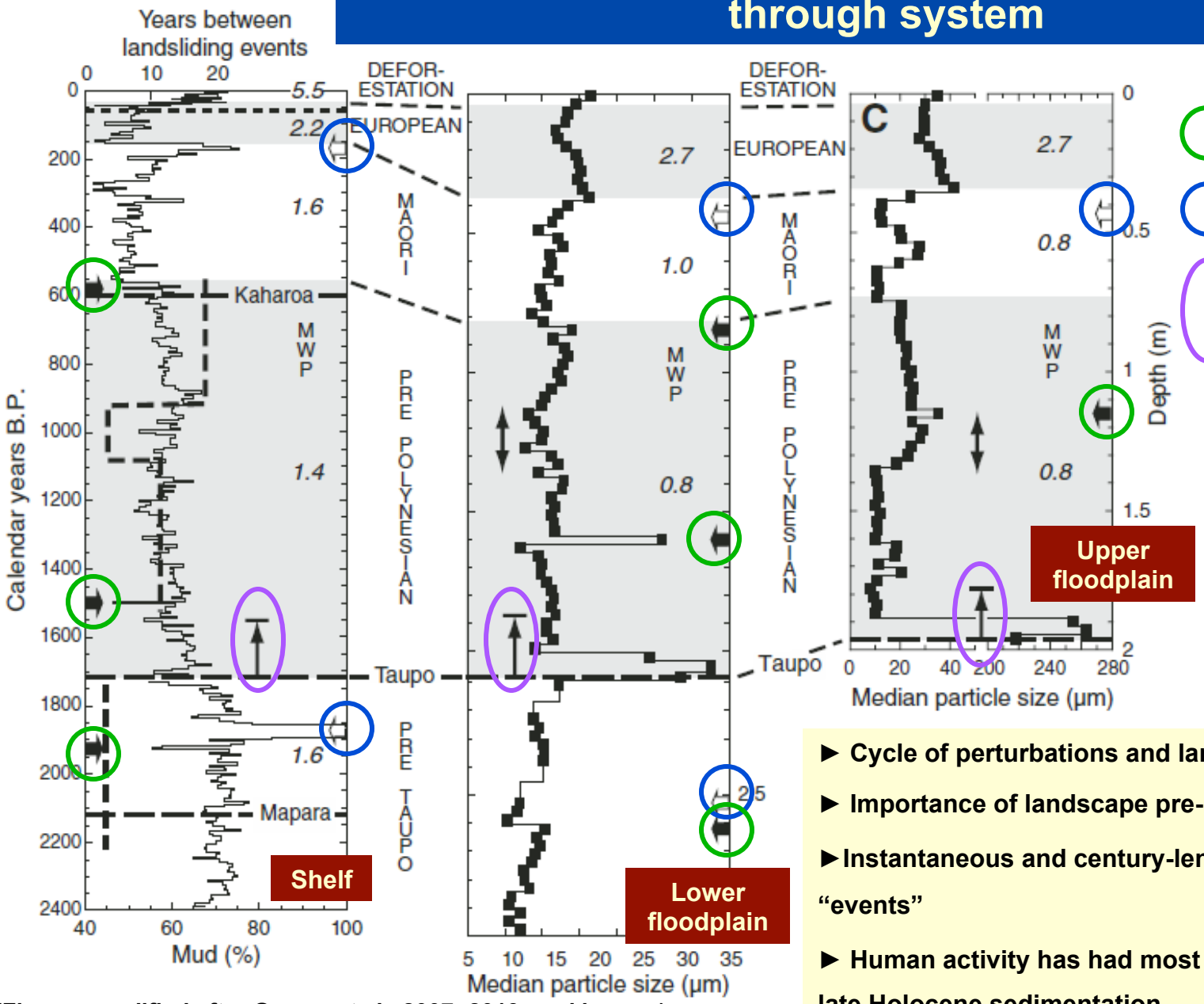
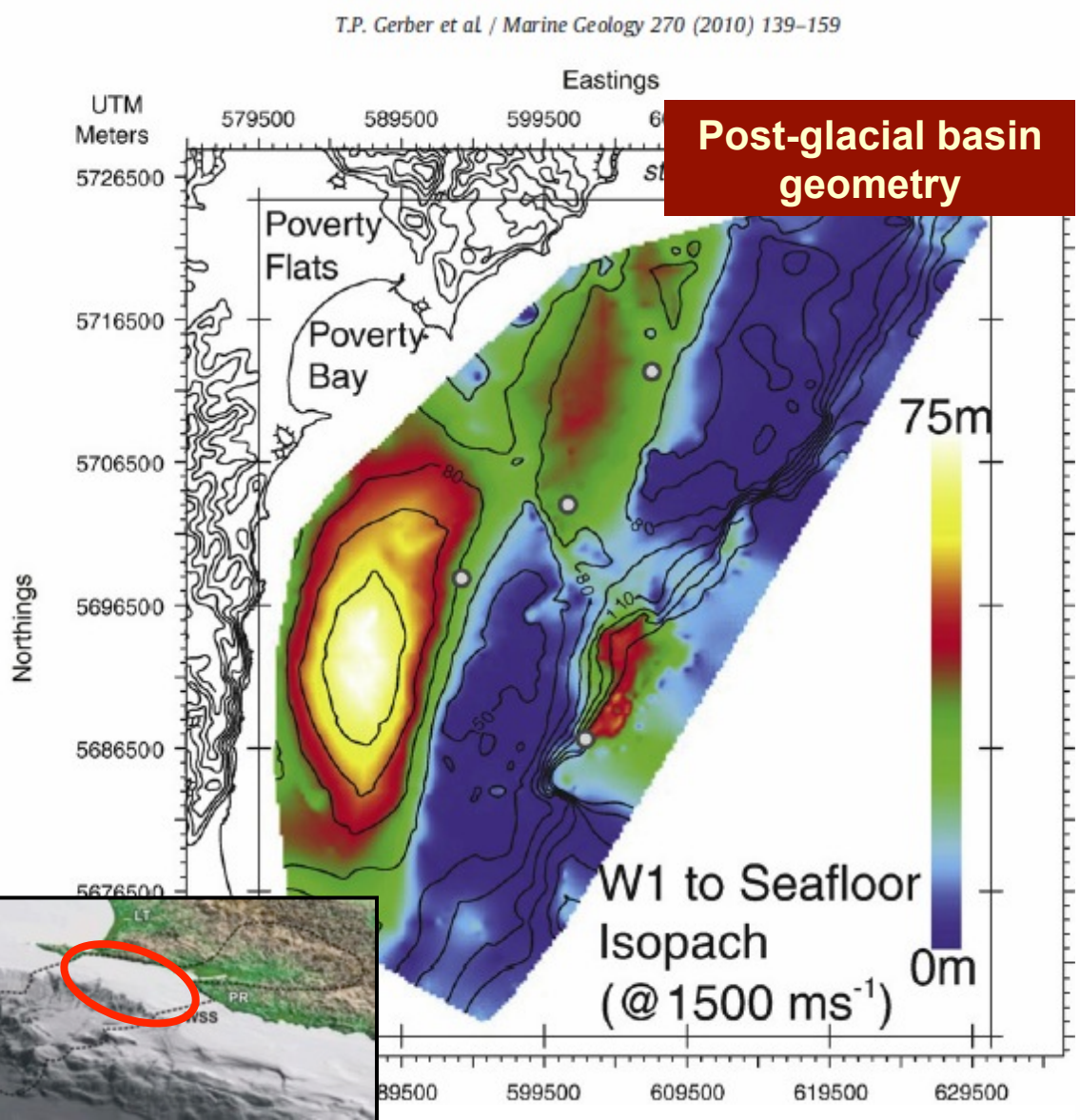
Cores allow inter-basin millennial-scale correlation through system



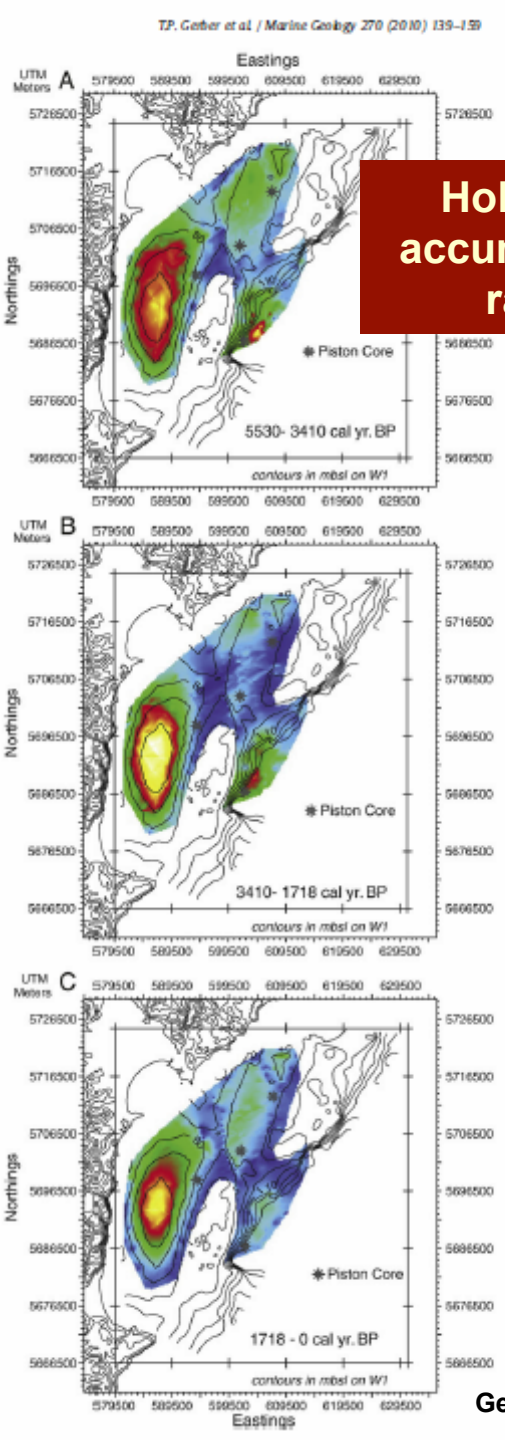
(Figures modified after Gomez et al., 2007; 2013; and in prep)

- ► Cycle of perturbations and landscape recovery
- ► Importance of landscape pre-conditioning
- ► Instantaneous and century-length scales for "events"
- ► Human activity has had most profound impact on late Holocene sedimentation

Closure of shelf sediment budgets (pre-human)



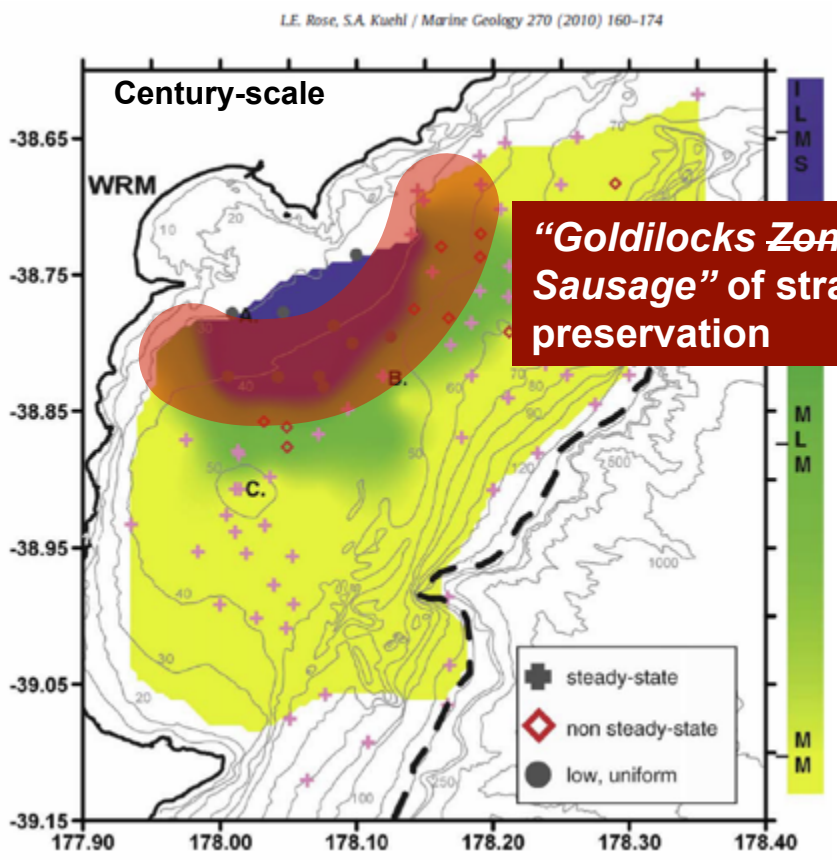
Post-glacial basin geometry



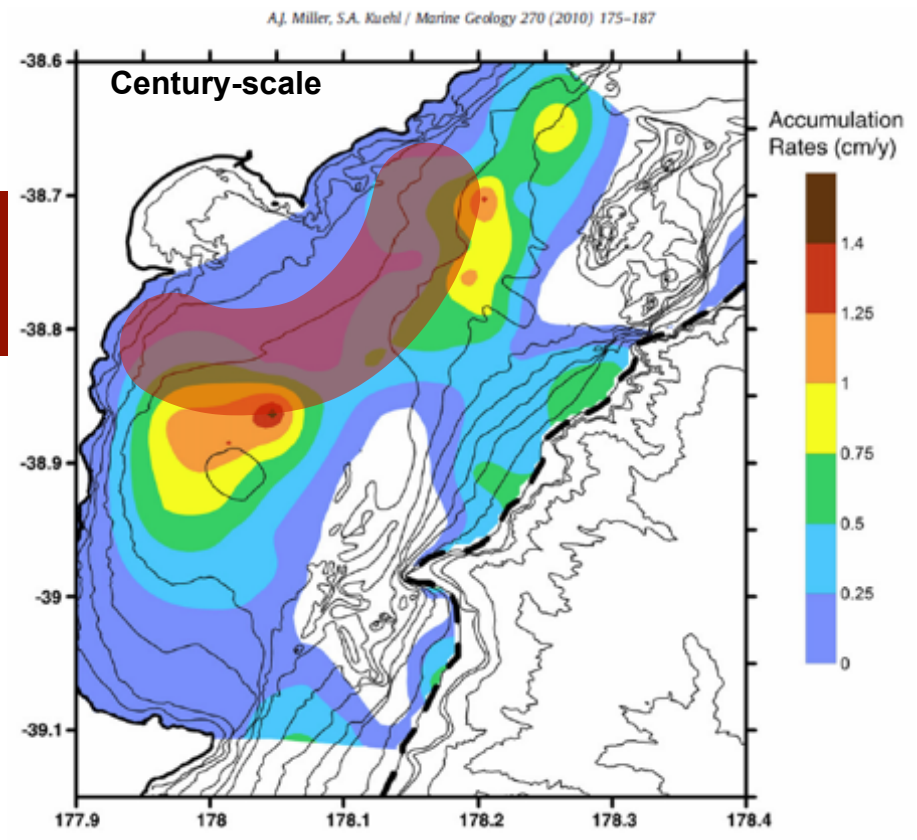
Holocene accumulation rates

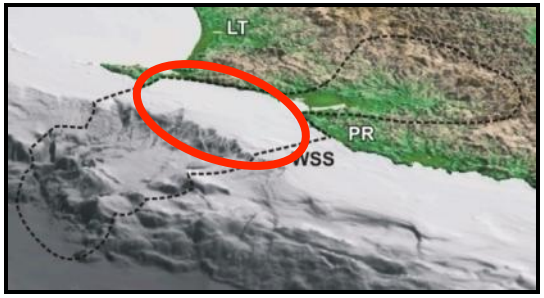
(Figures after Gerber et al., 2010)

Last-century budgets and deposition on Poverty shelf



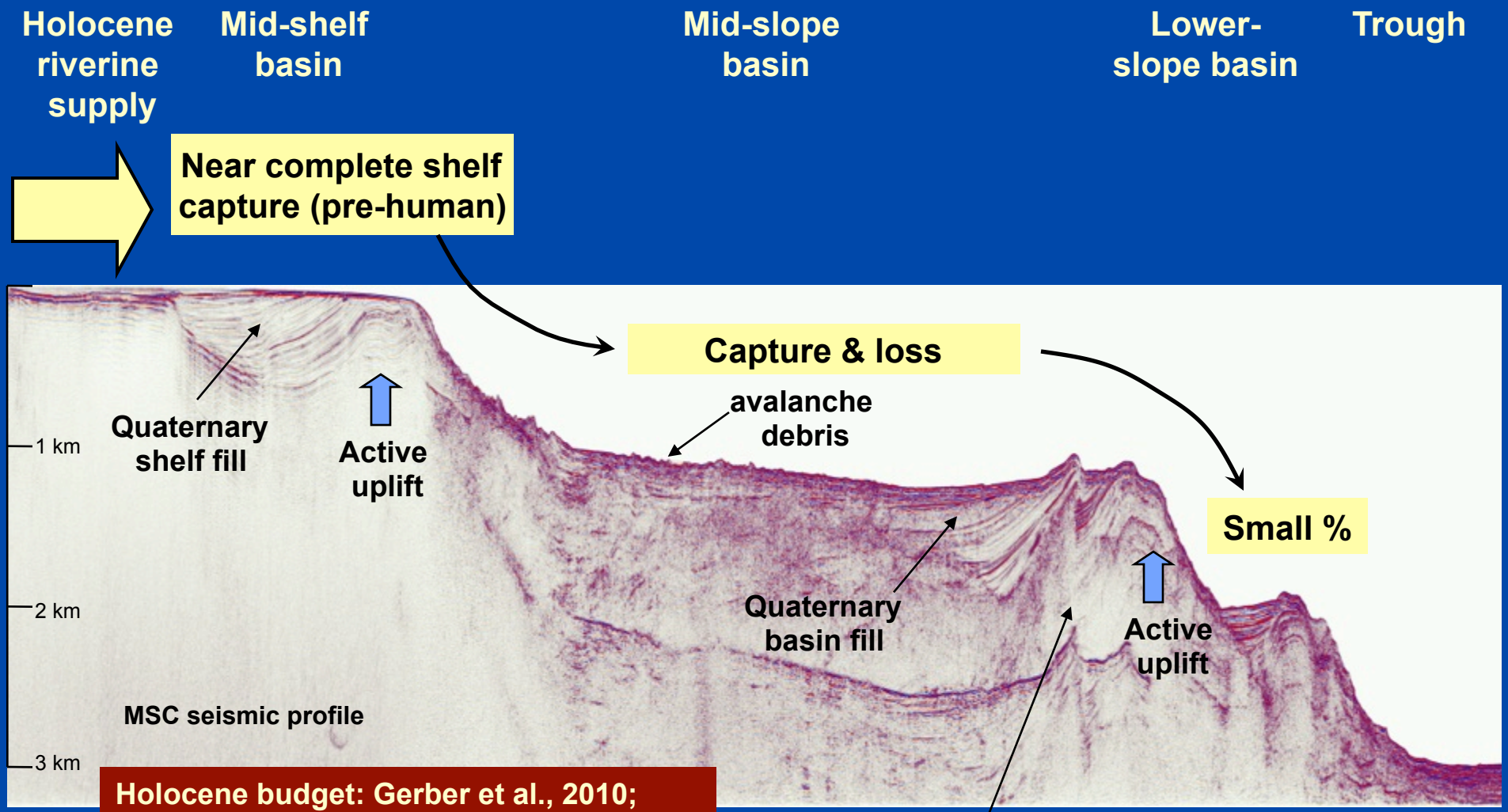
"Goldilocks ~~Zone~~ Sausage" of strata preservation





- Supply climate driven (floods)
- Big sediment signals
- At 10^2 yr timescales, perhaps only 25-50% stratigraphically complete (Sommerfield, 2006)

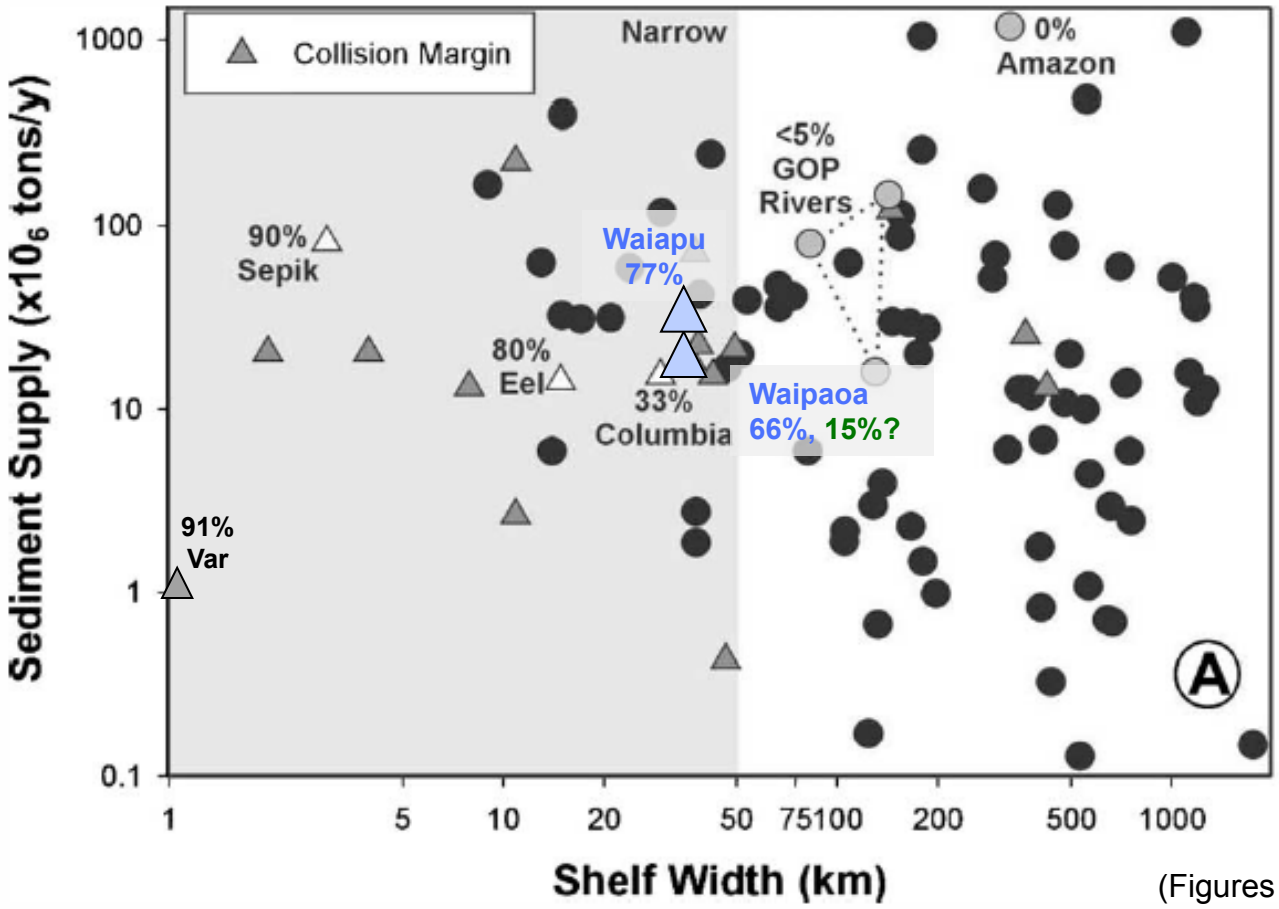
Basin capture and transfer across the Poverty margin

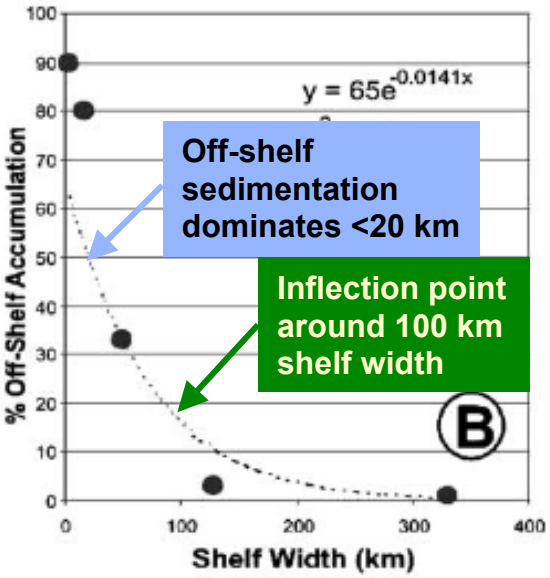


Holocene budget: Gerber et al., 2010; Alexander et al., 2010; Orpin et al., 2006.

Slope structure: Pedley et al., 2010.

Influence of shelf width and supply on off-shelf dispersal: have we tipped the scales?

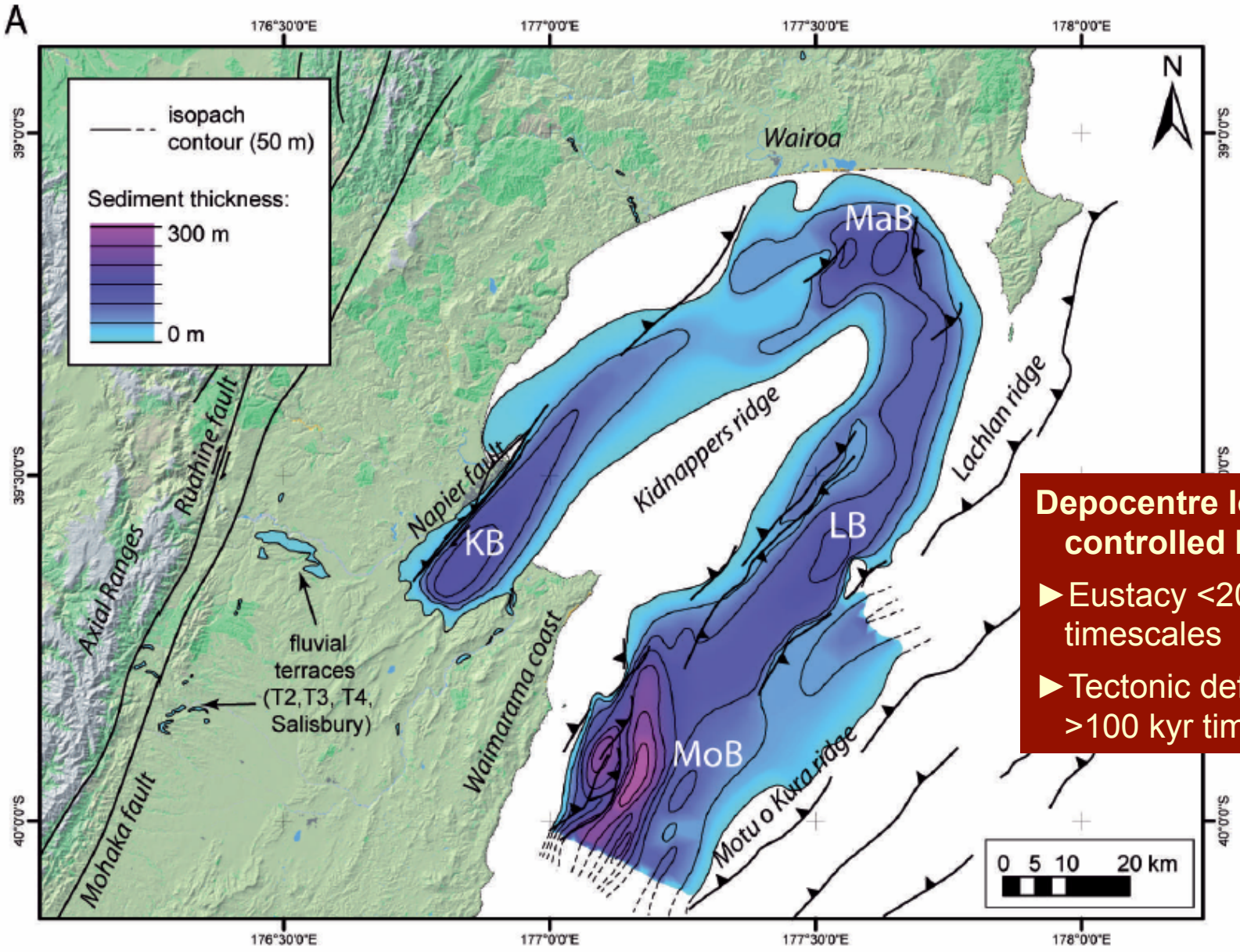




(Figures modified after Walsh & Nittrouer, 2003)

Have anthropogenic impacts overwhelmed margin morphology as the dominant control on off-shelf sediment transfer?

Tectonic-sediment interactions over 150 ka timescales, upper Hikurangi Margin



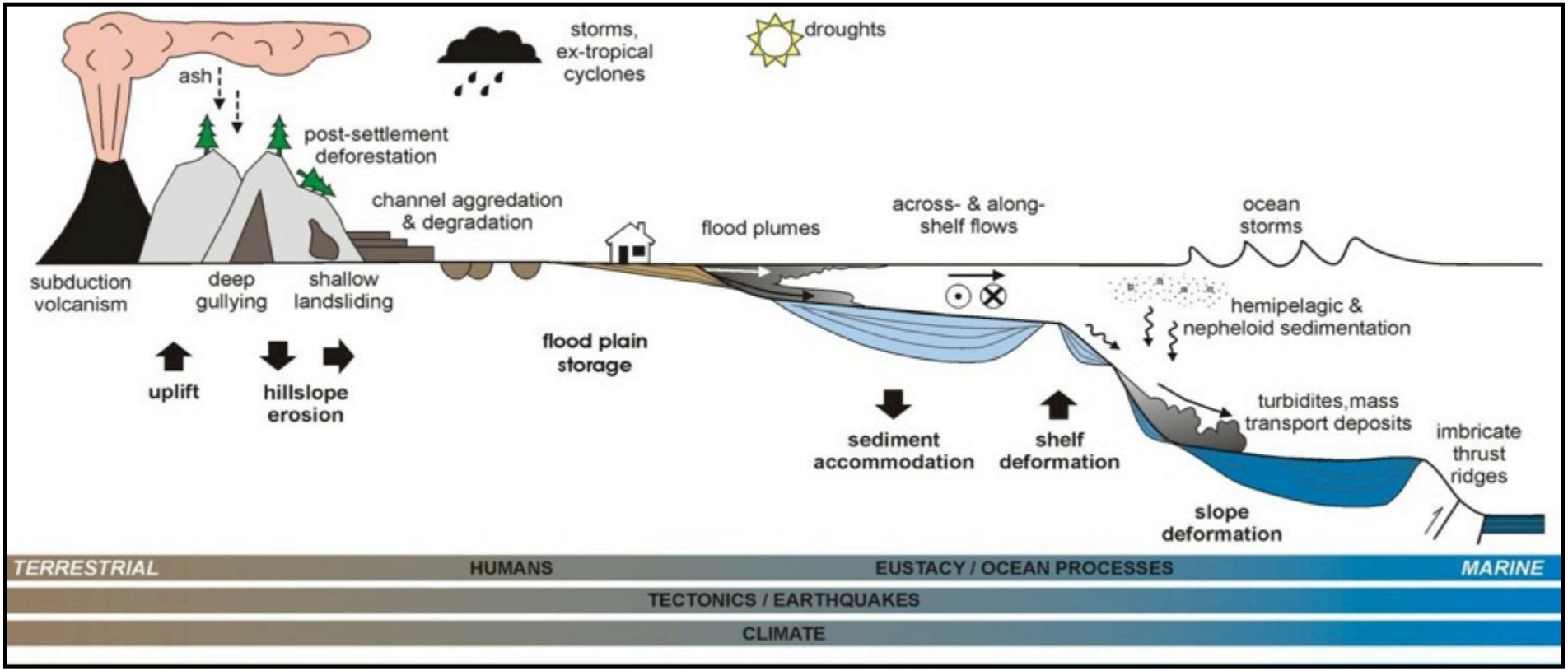
Depocentre location controlled by:

- ►Eustacy <20-30 kyr timescales
- ►Tectonic deformation >100 kyr timescales

(Figure from Paquet et al., 2009)

From mountain source to ocean sink: Waipaoa Sedimentary System

Supply **Move + store** **capture + move** **capture + move**



- ►Interconnectedness of source and sink, lithological coherence
- ►Ephemeral preservation of events, both marine and terrestrial
- ►Inter-basin fidelity at 10^{1+} y timescales
- ►Utility of budgets: rates, tectonic-sediment interactions, and unknowns
- ►Marine paleoearthquake record

Figure from "Mountain source to ocean sink", Special Issue of Marine Geology vol. 270, 2010