Dynamic seafloor processes within the Subtropical Frontal Zone on the Chatham Rise and implications for regional sediment and organic carbon budgets

S. Nodder[1], M. Clark[1], J. O'Callaghan[1], D. Leduc[1], C. Hickey[2], A. Rowden[1], C. Eager[2], R. Hale[3], P. Gerring[1], O. Price[1], F. Elliott[1], S. Searson[1], S. Deppeler[1], G. Frontin-Rollet[1], R. Ovenden[2]

[1] NIWA Wellington, [2] NIWA Hamilton, [3] NIWA Nelson

Climate, Freshwater & Ocean Science

Geosciences'20, Christchurch, New Zealand, 23-25th November 2020

NIWA
Taihoro Nukurangi

Introduction

- Sedimentation plays a key role in structuring benthic communities either:
  - ⬆ as a provider of fresh organic matter as a food & energy source, or
  - ⬇ by smothering benthos, with deleterious impacts on ecological functioning (metabolism, reproduction, feeding)
- Effects of sedimentation are important in both coastal and deep-sea environments
- Anthropogenic impacts can be related to resource utilisation, e.g., excess sediment in coastal systems due to land-use changes; fishing/mining impacts in deep-sea systems

Key elements for detecting environmental “change”

- Establish baseline conditions
- Measure and monitor degree of natural vs anthropogenic change & their variability/dynamics/interactions (in space and time)
- Short- and long-term effects of environmental change on the entire system
- Thresholds of change – how much or quickly can the system be loaded before deleterious effects occur?
- Trajectories/rates of recovery – re-establishing environmental equilibrium

Resilience **o**f deep-sea **b**enthic communities to the **e**ffects of **s**edimentation ("ROBES")

- MBIE Endeavour Research Programme 2017-21 ($750k/y)
- Principal objective: To determine impacts of, and measure recovery of benthic communities over time from, sedimentation effects
- 4 key questions:

➢ Can we determine and quantify effects of settled and suspended sediment from plumes on benthic communities *in situ*?

➢ Are some communities more resilient than others to various levels of particle sizes and concentrations?

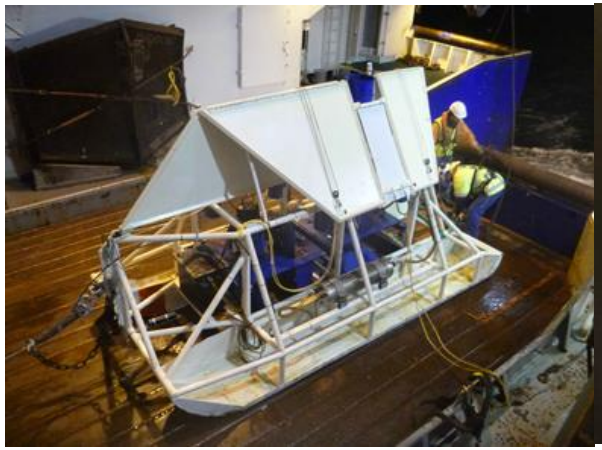
➢ Can thresholds of acute or sub-lethal levels of sedimentation be defined where impacts upon benthic communities become 'ecologically significant'?

➢ Can impacted benthic communities recover in the short- to medium-term?

- **FIELD CAMPAIGN-FOCUS:** Chatham Rise (potential site of future deep-sea mining, Chatham Rock Phosphate Ltd)

ROBES field disturbance focus – Chatham Rise

- Direct physical seafloor disturbance, monitor plume, sedimentation rates & composition, & biological effects over variety of spatial & temporal scales
- Three surveys, first disturbance, with two monitoring surveys (2018, 2019, 2020); temporal scales days-weeks, 1 year, 3 years

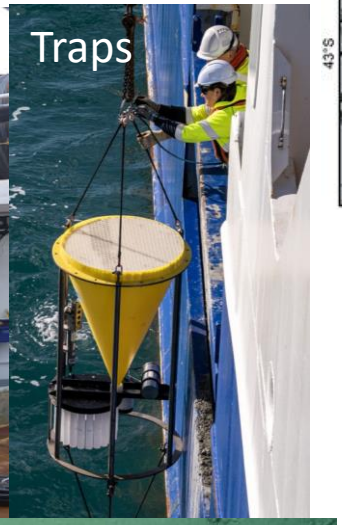


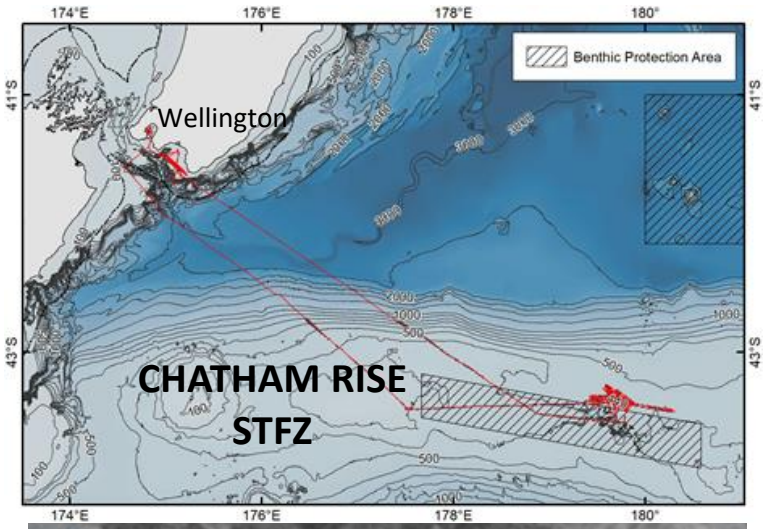

ROBES experimental disturbance focus – laboratory

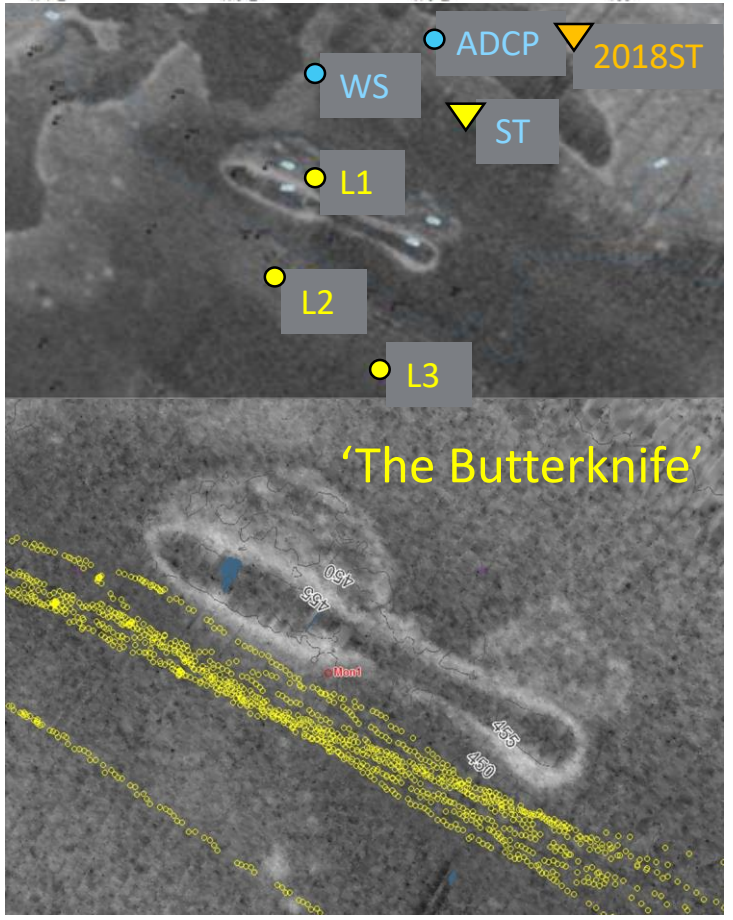
Methods – monitoring sediment plumes

- Sediment trap/ADCP/water sampler moorings
- Benthic landers
- CTD profiling
- Gliders
- Shipboard acoustics

- Multi-coring
- DTIS seafloor imagery

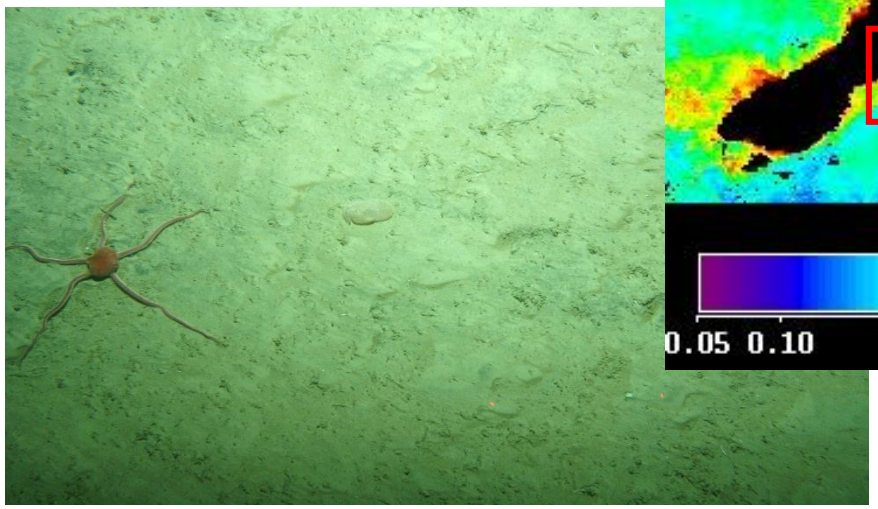


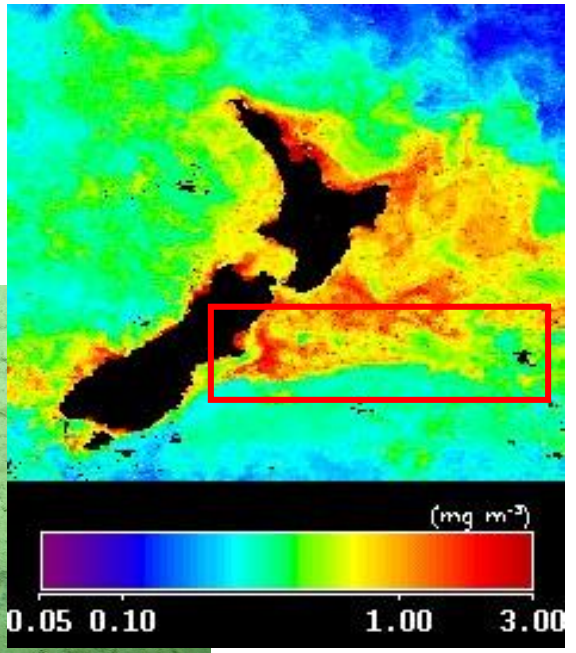


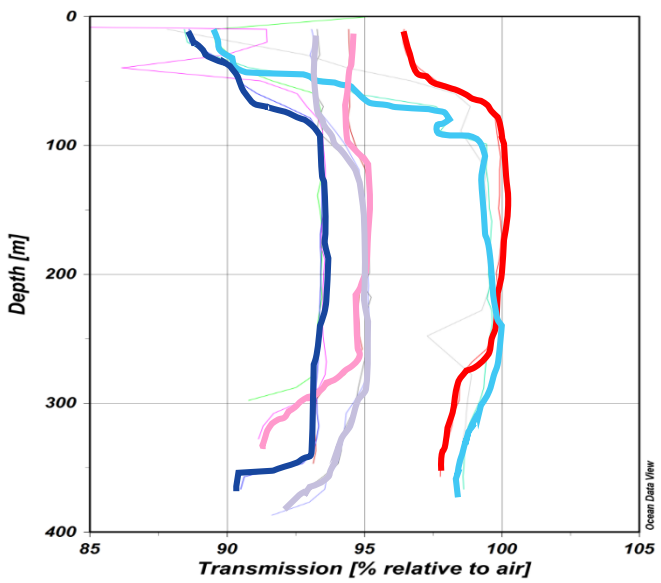


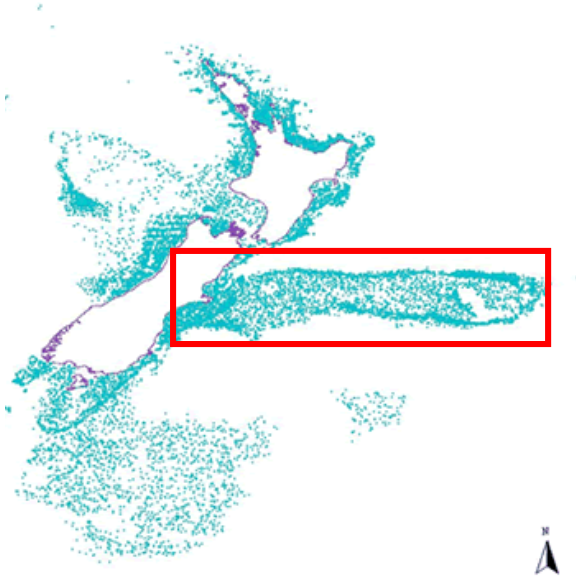
Baseline conditions – Chatham Rise

- **Physical oceanography**
  - Dynamic Subtropical Frontal Zone; high productivity
  - Strong currents & tides; vertical & horizontal mixing
- **Sediment properties**
  - ~50% sand/mud
  - Phosphorite nodules
- **Benthic communities – epi- and infauna**
  - Moderate benthic biomass & diversity
  - Encrusting corals & sponges –sensitivity to sed loading?
- **Particle fluxes – short- & long-term**
  - High near-bed fluxes; high OC deposition
- **High bottom-trawl fishing activity**







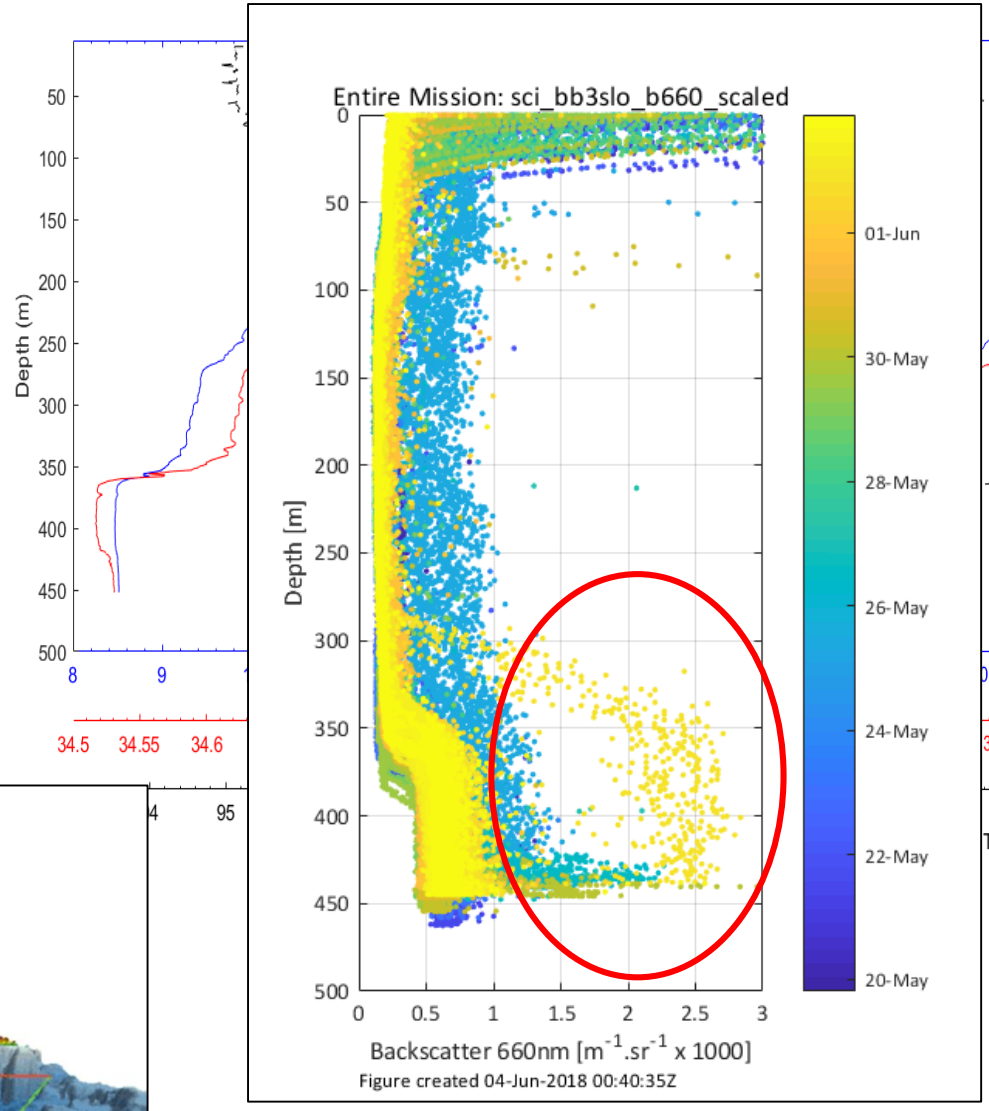


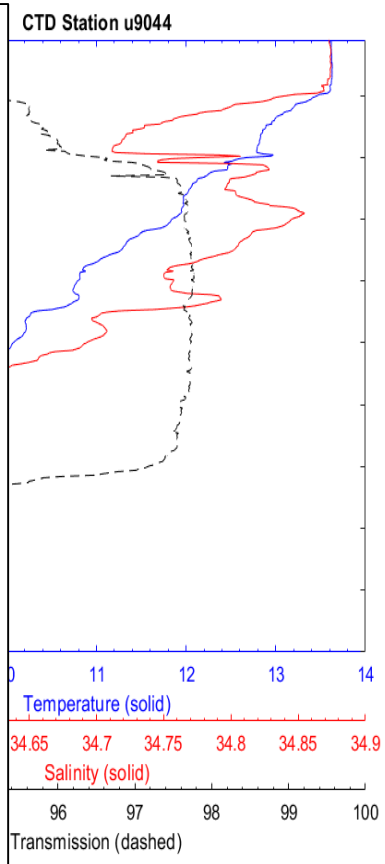
Chatham Rise water column structure, near-bed currents and particle transport

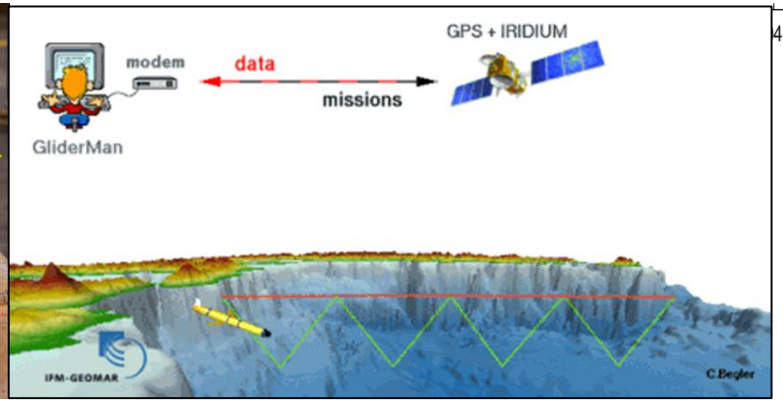
- Warm surface layer
- 50-100 m-thick BBL
- Subsurface salinity maximum; water mass interleaving
- Variability in BBL salinity higher than temperature after disturbance
- Thick BBL implies strong bottom currents (>30 cm/s)
- High BBL particle & CDOM loading

Baseline, pre-disturbance

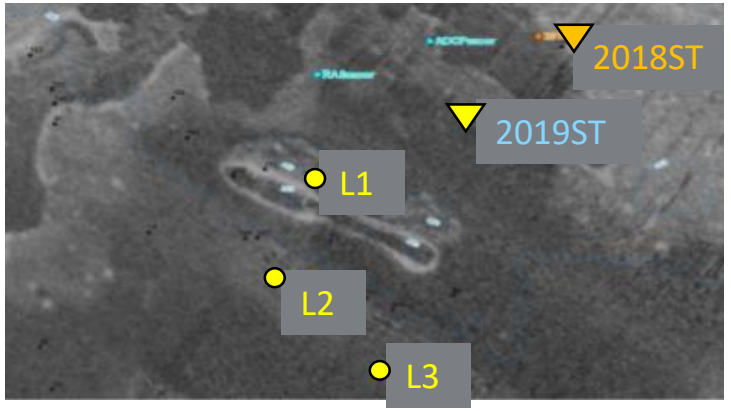
Post-disturbance

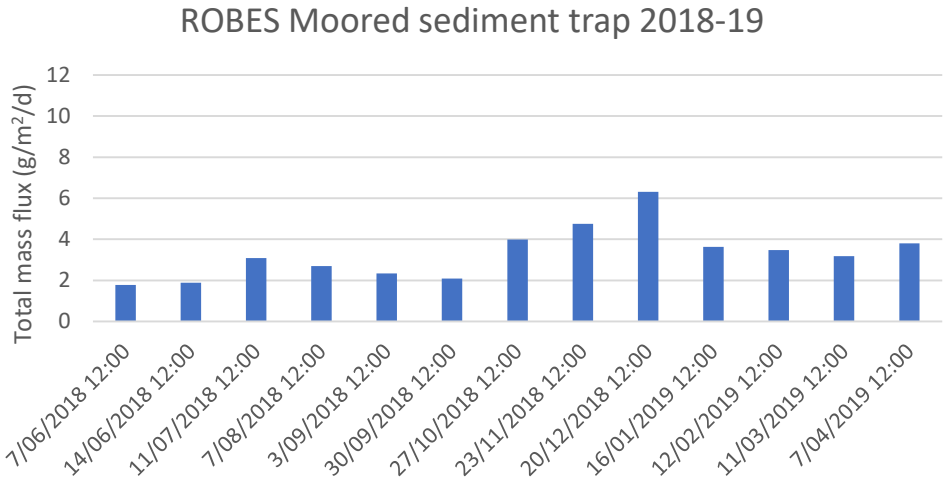


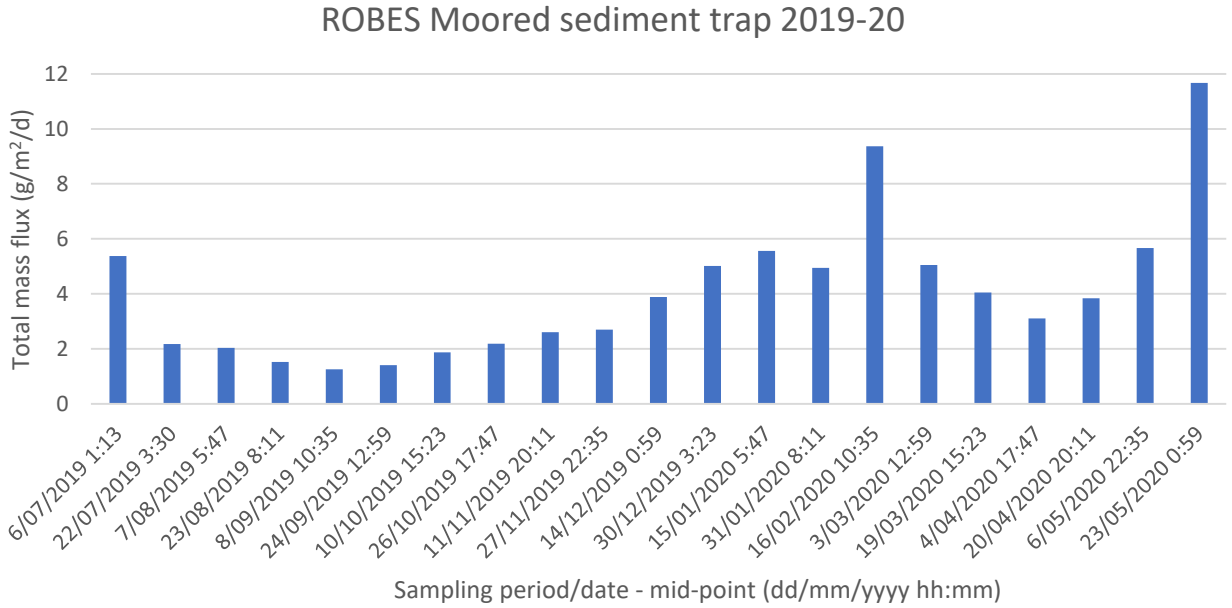




Chatham Rise long-term near-bed fluxes BASELINE



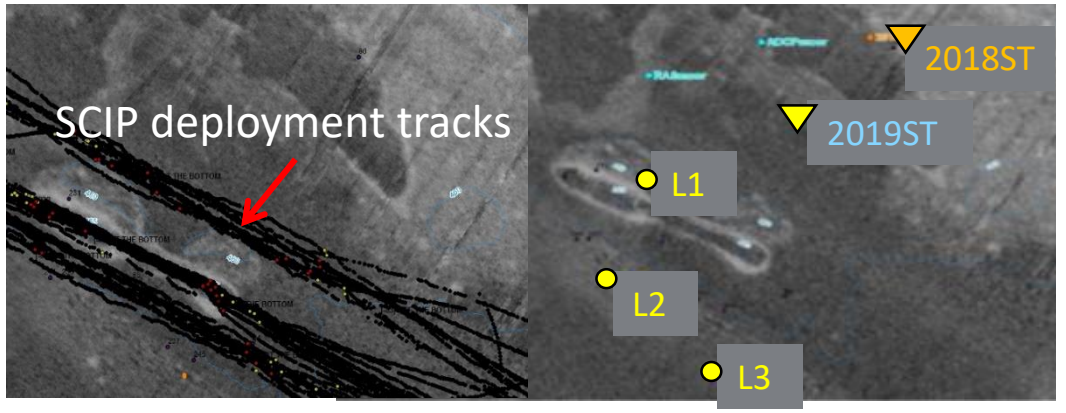


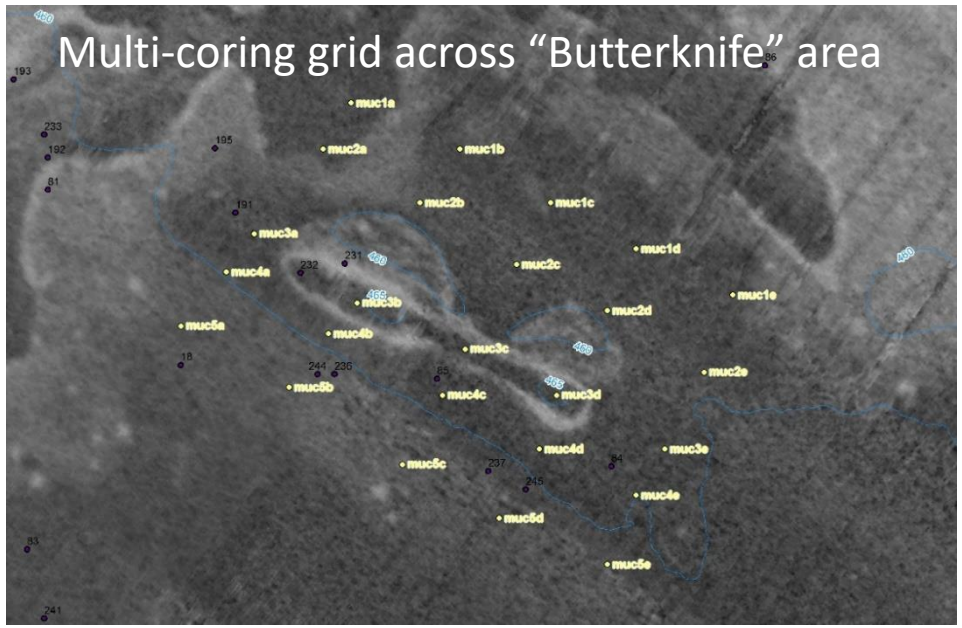


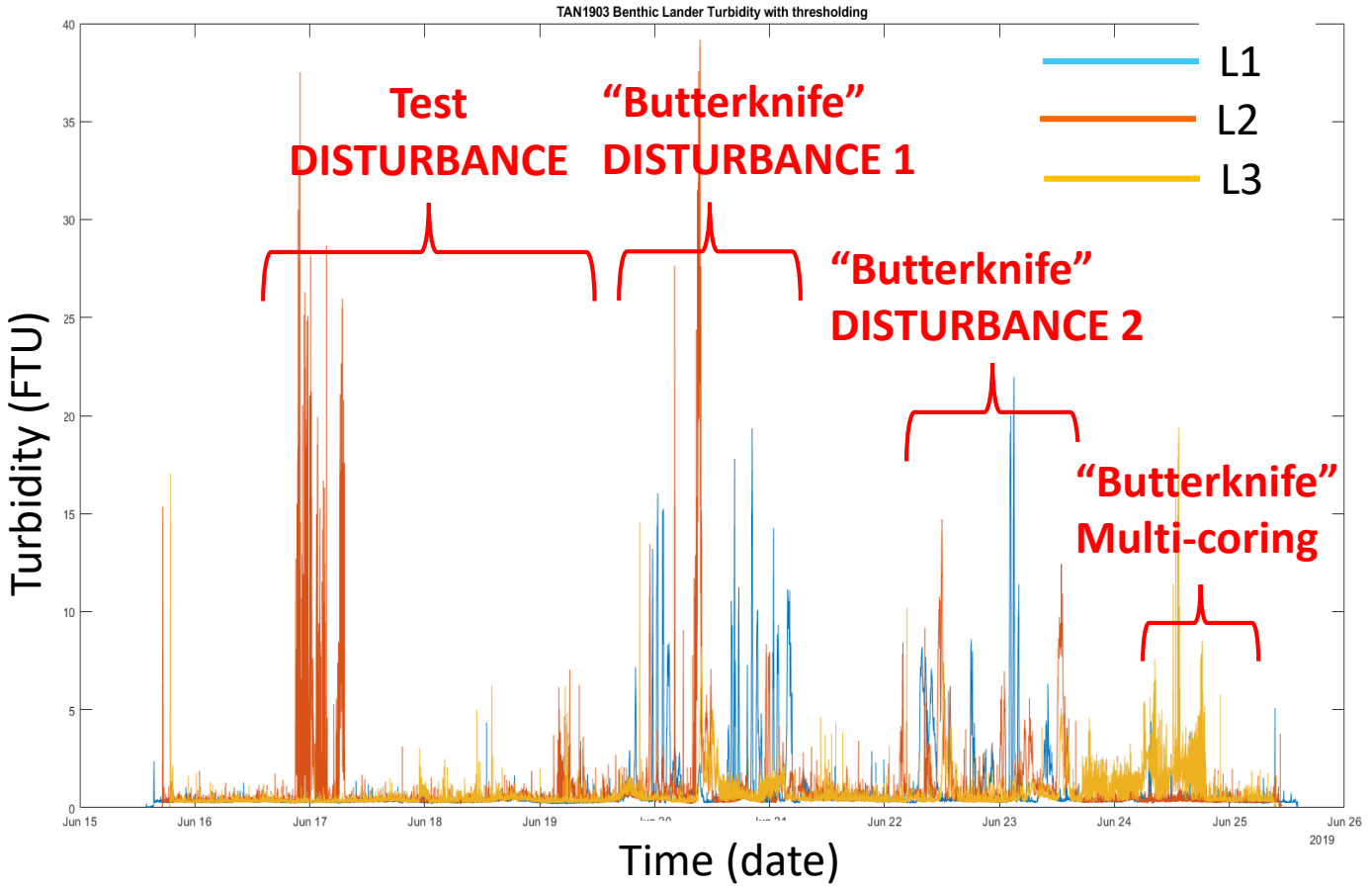
- Annual near-bed fluxes measured on rise crest for 1st time
- 2018-19 < 2019-20
- **Seasonality:** low fluxes in winter-early/mid-spring
- high fluxes in late spring/summer, and late autumn (2019-20 only?)

Short-term near-bed processes
DISTURBANCE

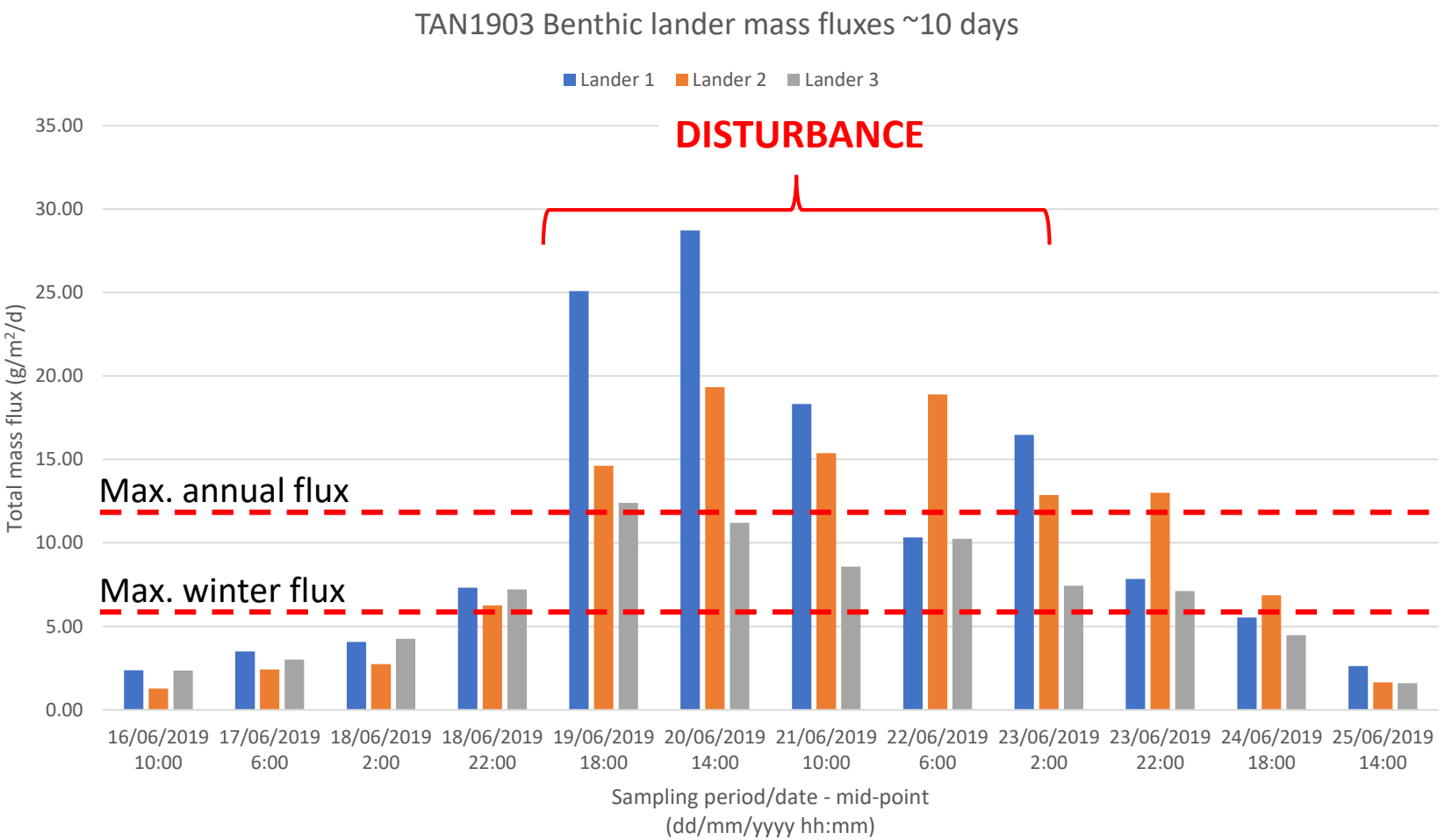
- Lander data (days to weeks)
- Turbidity (FTU)
- Evidence of effects of physical disturbances?





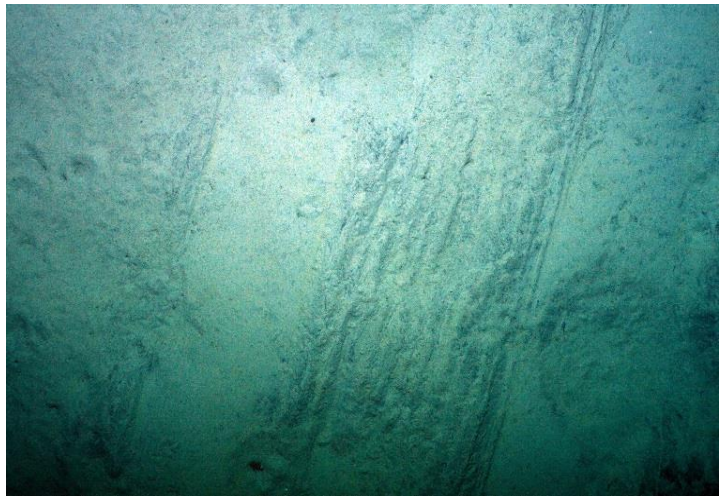


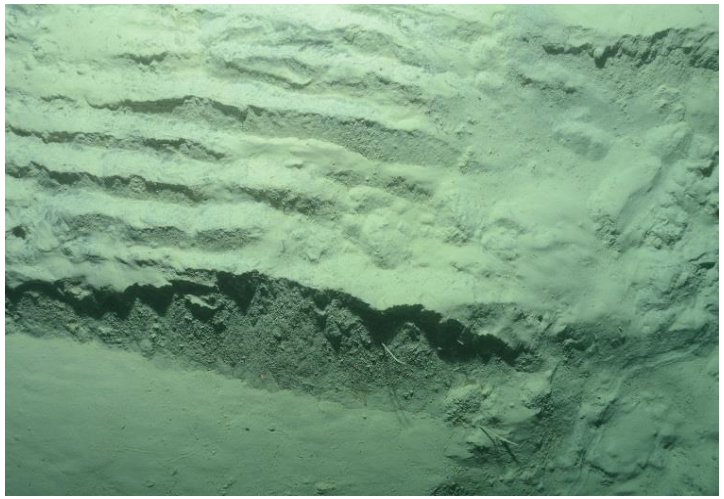
Chatham Rise short-term near-bed fluxes DISTURBANCE



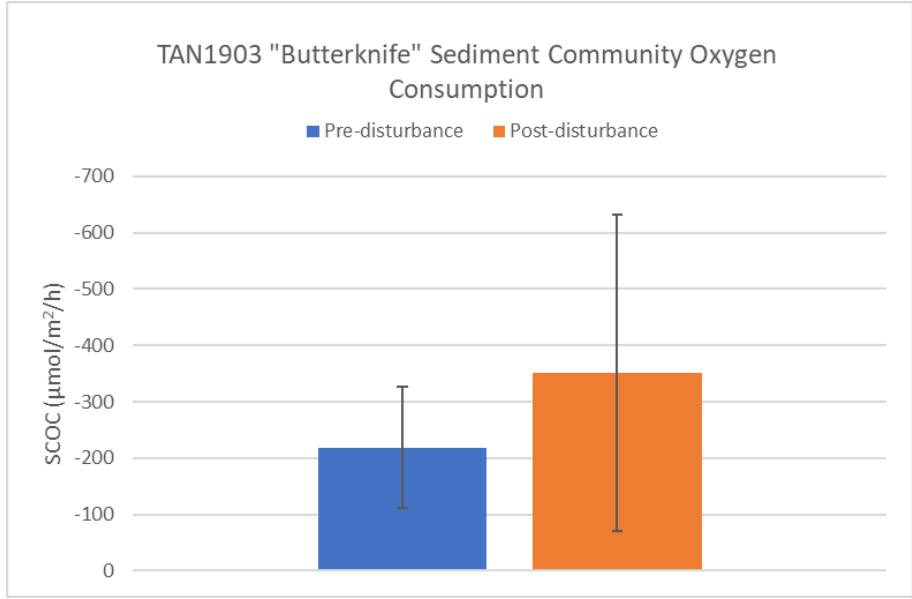
- Pre- & post-disturbance fluxes, relative to "Baseline"
- "Disturbance" fluxes up to 2x higher than annual maximums

Benthic responses to sedimentation impacts

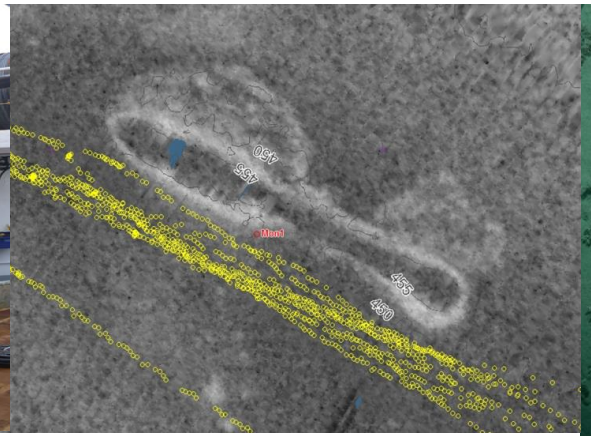




Physical impacts on sediment stability (short-term)



Conclusions



- Benthic communities on Chatham Rise seem to be accustomed to persistent, occasionally high sediment loading.
- Benthic flux time-scales range from diurnal (tides) to seasonal/annual (climate).
- Physical disturbance of sandy Chatham Rise sediments did generate a minor sediment plume, with marked effects on near-bed sediment fluxes & on benthic responses.
- <u>BUT</u> different time- and space-scales cf. proposed future phosphorite mining activities (e.g., max. measured SPM $conc^{N}$ = 3-5 mg/l cf. max. modelled mining SPM 10->100 g/l locally).
- Thus to characterise the spatio-temporal scales and relationships between physical, biological, chemical and geological processes on Chatham Rise further research is required.

Acknowledgements

Thanks to the scientific crew on the three ROBES voyages (2018-20), Malcolm Clark for his leadership of the project, and the officers, engineers, catering staff and deck crew of RV *Tangaroa*, plus NIWA Vessels Management. Acknowledgement is also given to the support shown by MBIE in funding the ROBES project, NIWA for capital expenditure to support the planned fieldwork (especially the development of new benthic landers technology in NIWA), and members of the ROBES Technical Advisory Group for their ongoing assistance in developing the project's direction.

Contact details: Scott Nodder (NIWA), scott.nodder@niwa.co.nz

Thank you to the conference organisers and participants in this strange COVID world