THE EFFECTS OF SEDIMENTATION IN THE DEEP SEA

Emerging results from the Chatham Rise on the impacts of seabed disturbance

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NIWA
Taihoro Nukurangi

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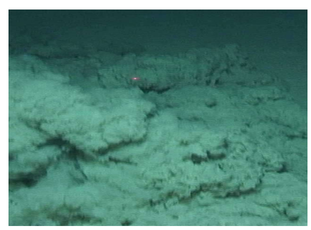
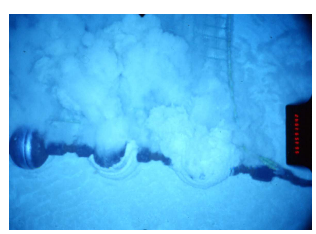
Background

- A large proportion of the offshore deep seas around New Zealand is soft sediment, which can be easily disturbed by human activities
- Impacts on biological communities have been studied in near-shore coastal environments, but little information exists on tolerances of fauna from deeper shelf waters
- Motivation for this work was twofold:
  - interest in offshore mining, uncertainty of the actual effects of sediment plumes on benthos (e.g. EPA decisions for TransTasman Resources and Chatham Rock Phosphate);
  - increased awareness of fisheries impacts (MSC certification of bottom trawl fisheries, e.g. hoki and orange roughy).
- An MBIE 5 year Endeavour project 2016-2021
  - ROBES: Resilience Of deep-sea Benthos to the Effects of Sedimentation





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Objectives:

- Principal objective
  - to determine impacts of, and measure recovery of benthic communities over time from, sedimentation effects
- Four 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?

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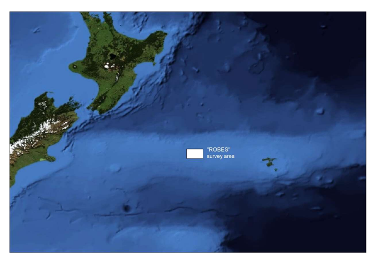
The Approach

- Two components
- **Field disturbance experiment**
  - Direct physical disturbance, monitor plume, sedimentation rates and composition, biological effects.
  - Three surveys:
    - Survey 1 (2018): baseline, disturbance, monitor
    - Survey 2 and 3 (2019, 2020): monitoring
    - Impacts over days-weeks, 1 year, 2 years
  - Chatham Rise survey area (400-500m)
- **Laboratory sedimentation experiments**
  - coral and sponge species in tanks
  - Manipulate sedimentation from low to high
  - Monitor over weeks to months



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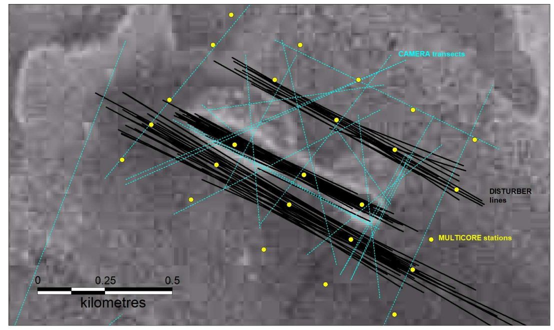
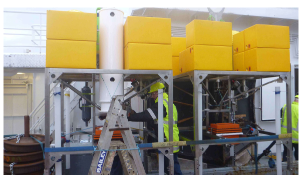
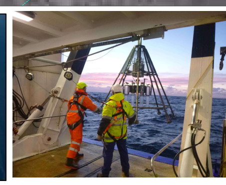
Field survey

- Disturbance
  - NOAA Benthic Disturber (2018) NIWA “SCIP” (plough) (2019)
  - Multiple transects run, >30 hr periods
  - Area termed “Butterknife
- Monitoring survey
  - Before, After (1 week), After (1 year, some 2 year))
- Oceanography (and water column)
  - Ocean glider, CTD, acoustics, ADCP moorings
- Sedimentation
  - Benthic landers, Sediment trap moorings, multicorer, acoustics
- Biological communities
  - Towed camera, multicorer, beam trawl, sled







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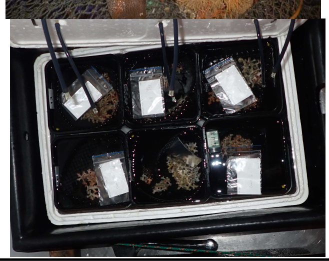
Laboratory-based experiments

- Experiments in NIWA’s Marine Environmental Manipulation Facility (Wellington)
- Live-capture of specimens during voyages (onboard aquaria)
- Two species

  Knobbly sandpaper sponge (*Ecionemia novaezelandiae*), stony coral (*Goniocorella dumosa*)
- Treatments
  - Control temperature, pH, water flow; based on in situ environmental data
  - Introduce various suspended sediment concentrations (0, 50, 100, 500 mg/l)
- Measure responses
  - survival
  - metabolism (respiration)
  - feeding activity (clearance rates, particle size)
  - structural damage
  - behaviour (mucous production/opening of valves)





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Work in progress

- Biological community responses
  - Infauna-macrofauna, meiofauna, bacteria (based on multicore samples)
  - Epifauna (largely MEMF experiments)
  - Genetic/microbiome responses to suspended sediment (linked to MEMF experiments)
- Sedimentation experiments
  - Sediment erosion, elutriation, sediment capping data analyses
  - Sediment community respiration analyses
  - DGT sample processing (trace metals)
- Sediment samples
  - Multicorer (pre- & post-disturbance, 3 sites) grain size, physico-chemical characteristics (TOM, water content, CaCo3, POCPN/isotopes, chl/phaeopigments)
  - Benthic lander data (Aquascat, Aqualogger, sediment sample calibration, sediment analyses (as per MUC), ADCP
- Water column dynamics
  - CTD water samples (nutrients, chl/phaeopigments, DIC/alkalinity, Ecotriplet & Aqualogger (DTIS as well))
  - Optics data-glider & CTD (cdom, fluorescence), DIC, DOC, water chemistry
  - Benthic Boundary layer (thickness, stability)-glider data
- Acoustic data
  - MBES and Fisheries sounders multifrequency (pre- and post-disturbance transects)
- Seafloor imagery
  - Natural sedimentation levels
  - Persistence of Disturber marks

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Illustrations-a range of some results

- Natural variability-necessary to separate natural from human-induced change
- Sediment cloud - what could we measure in terms of suspended sediment and settled sediment?
- Sediment experiments - effects of capping with fine sediment
- Infauna responses to disturbance of infauna-do they recover?
- Experimental exposure of corals-is there a threshold of suspended sediment when impact is serious?

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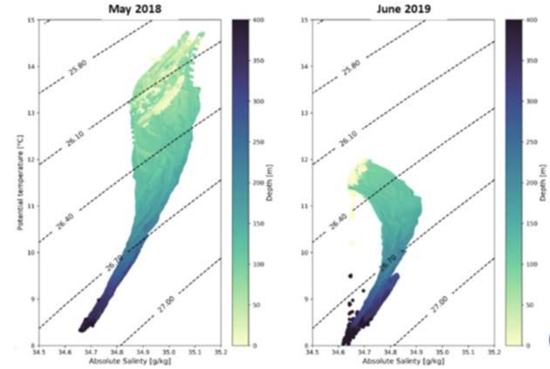
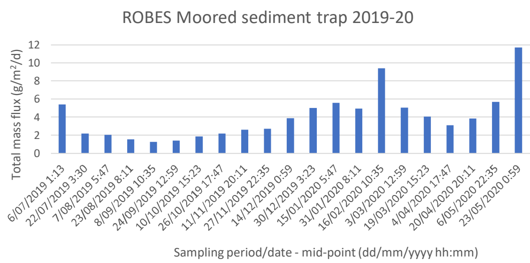
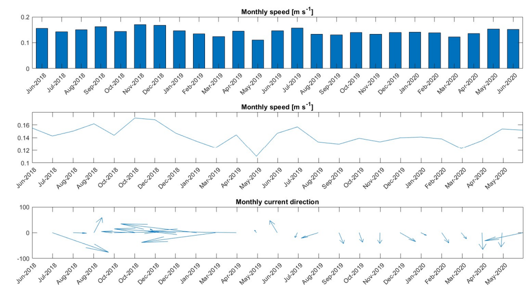
Natural conditions

- Oceanography
  - Strong surface water variability, differed 2018-2019 balance of STW/SAW
- Currents
  - Flow strength and direction seasonal, with strong tidal cycle, differed 2018 and 2019
- Flux to seafloor
  - Seasonal variability, strong Feb & May 2020







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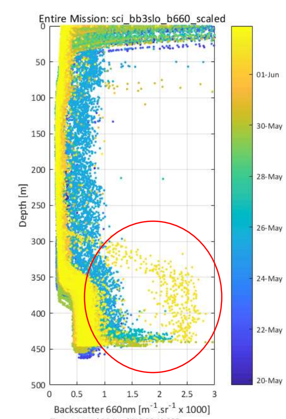
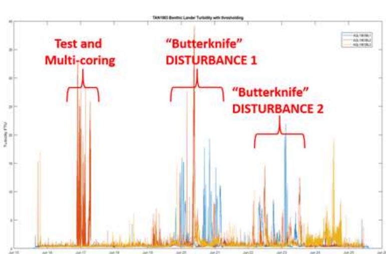
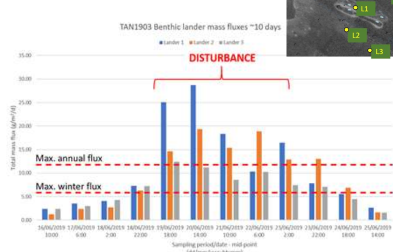
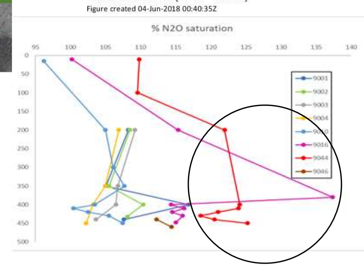
Sediment Plume

- Water column
  - Glider turbidity, plume 150m high
  - CTD gas measurements, N_20 spike post disturbance (max. 100m above seabed, but to surface)
- Benthic landers
  - Turbidity spikes associated with disturbance (both from Disturber as well as repeat multicoring)
  - Flux levels above ambient (2-3 times)









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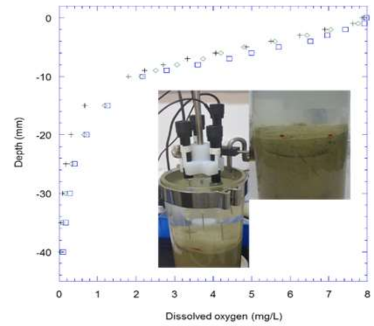
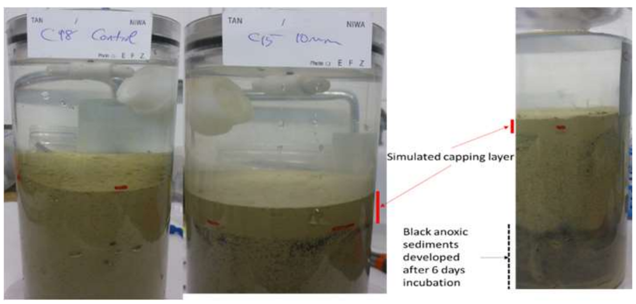
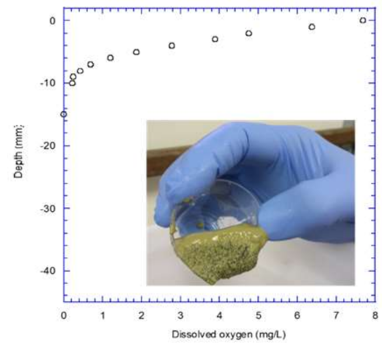
Sedimentation-onboard experiments

- Sediment capping
  - What is effect of blanketing seabed with fines?
  - 5mm, marked reduction in DO penetration
  - Development of anoxic sediments







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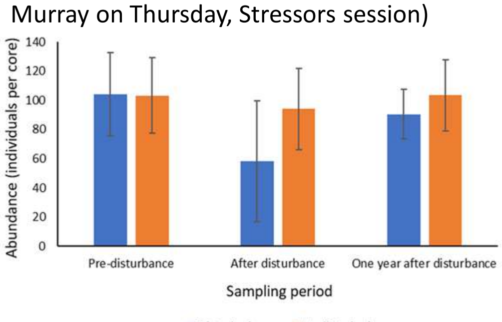
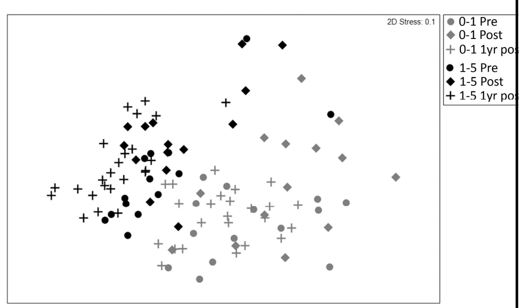
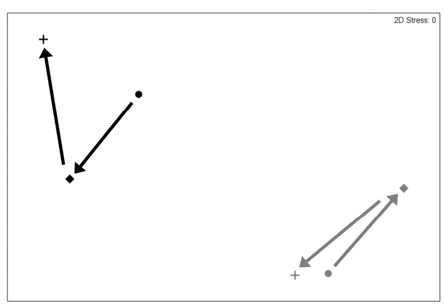
Benthic Infauna

- Multicore samples Before (Pre-), after (1 week Post), and After (1 year Post)
- Meio- and macro-fauna results
  - Meio: segregation of 0-1 cm and 1-5 cm communities, return to pre-disturbance 1 year after more in 0-1 cm than 1-5 cm (depth effect)
  - Macro: illustration of decrease in abundance after disturbance, but recovery 1 year (see talk by Campbell Murray on Thursday, Stressors session)







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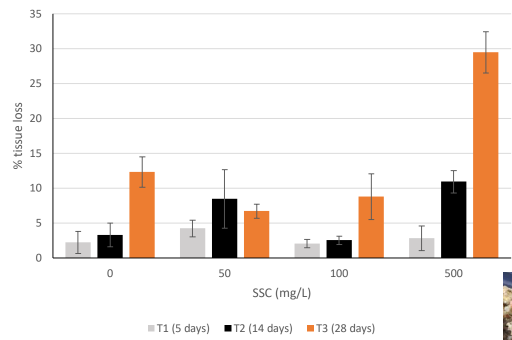
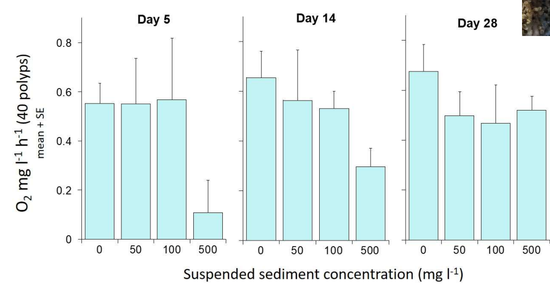
Laboratory experiments

- Stony coral *Goniocorella dumosa*
- Continuous exposure to suspended sediment for 4 weeks), 0, 50, 100, 500 mg/l
- Marked increase in tissue loss of coral polyps with time especially at 500 mg/l
- Respiration (measured over 2 hrs) showed an initial shut-down (day 5) at 500 mg/l, but then slow ?acclimatisation/sediment ingestion (under evaluation) towards end of experiment





Conclusions

- Programme has collected a huge amount of data across a wide range of environmental factors related to sedimentation and sediment effects
- Highly variable & dynamic environment on Chatham Rise-both spatially and temporally, with communities faced with persistent, occasionally high sediment loading.
- Shallow physical disturbance of Chatham Rise sediments generated a minor sediment plume, with marked effects on near-bed sediment fluxes and water column characteristics
- Impact on infauna was clear, but relatively quick recovery (within/at 1 year).
- Experimental results more informative for epifauna, showing impacts at high and prolonged suspended sediment levels (100 and 500 mg/l)
- Together results can provide a suite of information to assist management of human activities creating sedimentation in the deep sea.

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  - Oceanography: Joanne O'Callaghan, Charine Collins, Mark Hadfield, Cliff Law
  - Sedimentology: Scott Nodder, Peter Gerring, Chris Hickey, Chris Eager, Rachel Hale, Conrad Pilditch (UoW), Grace Frontin-Rollett
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