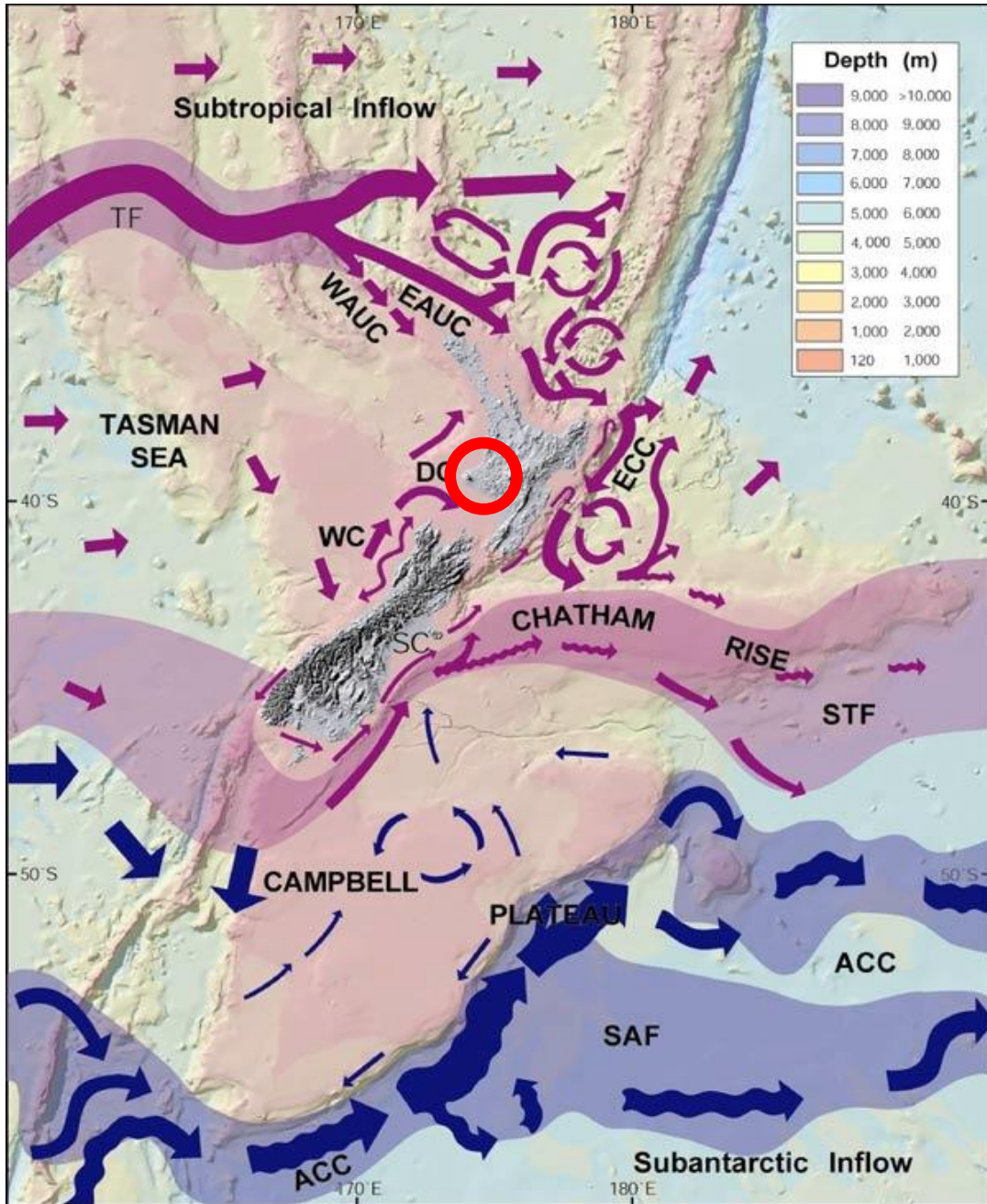


Coastal sponge diversity and demography integrates catchment nutrient supply, sedimentation and oceanography.

Sam Mc Cormack, Brendan Hicks, Terry Isson, Nicole Sturgess, Fenna Beets, Michelle Kelly, and Chris Battershill



New Zealand Oceanic Currents



Tasman Front (TF),

Subtropical Front (STF)

Subantarctic Front (SAF).

Antarctic Circumpolar Current (ACC)

D'Urville Current (DC)

(Te Ara Encyclopedia of New Zealand, 2021, Ron Heath).

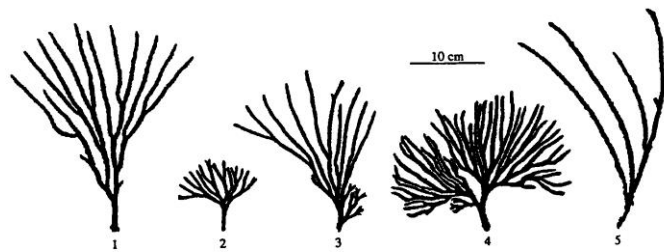
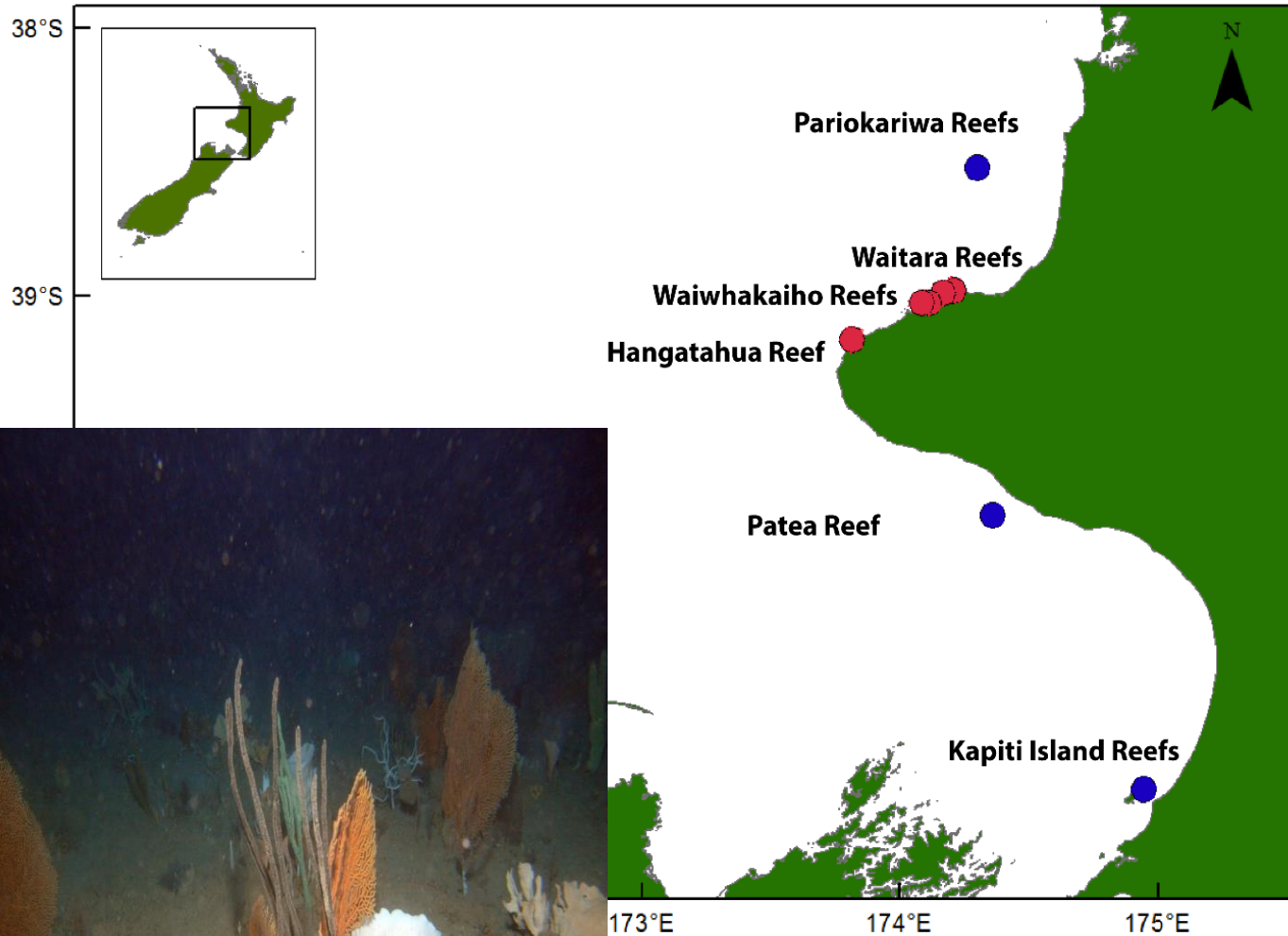


Fig. 1 Digitised images of five of the sponge specimens, showing a range of morphologies

West Coast Aotearoa biogeography not well understood especially in the nearshore coastal zone....

Will we experience biogeographic shifts like the eastern seaboard of Australia???

Sponge diversity, a perfect indicator of medium to long term biogeography –

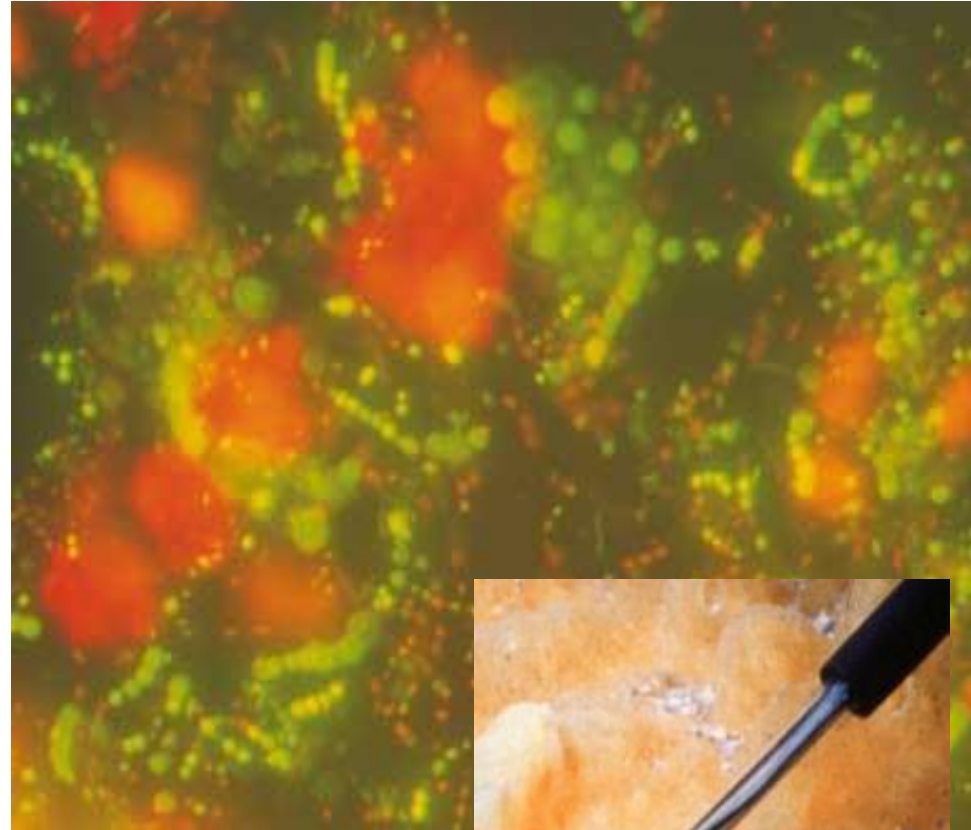
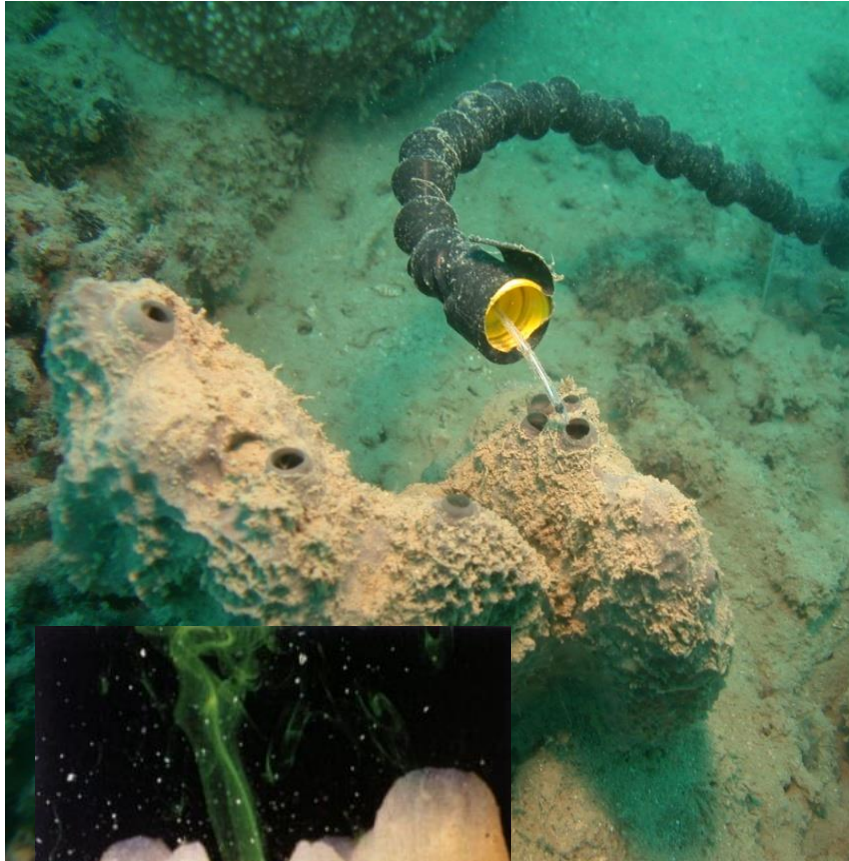
700 NZ/8,550 world species (8% global total) over 15% of worlds continental shelf area



110

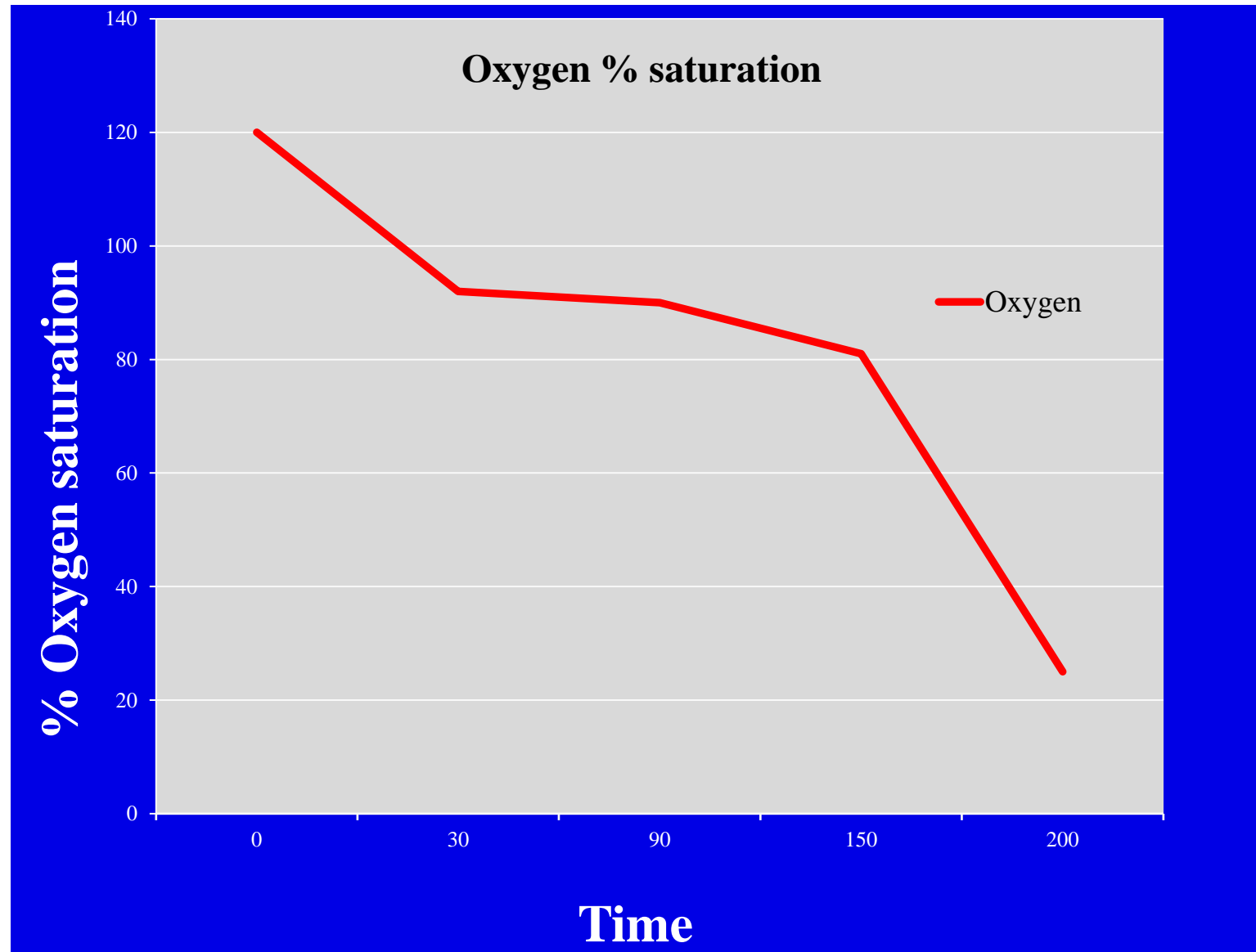


What do sponges take out of the water?



**Papers by Duckworth, Bell A,
Bannister, Battershill and
others**

20Kg *Lissodendoryx n.sp* (@50 individuals) in 1m³ agitated seawater



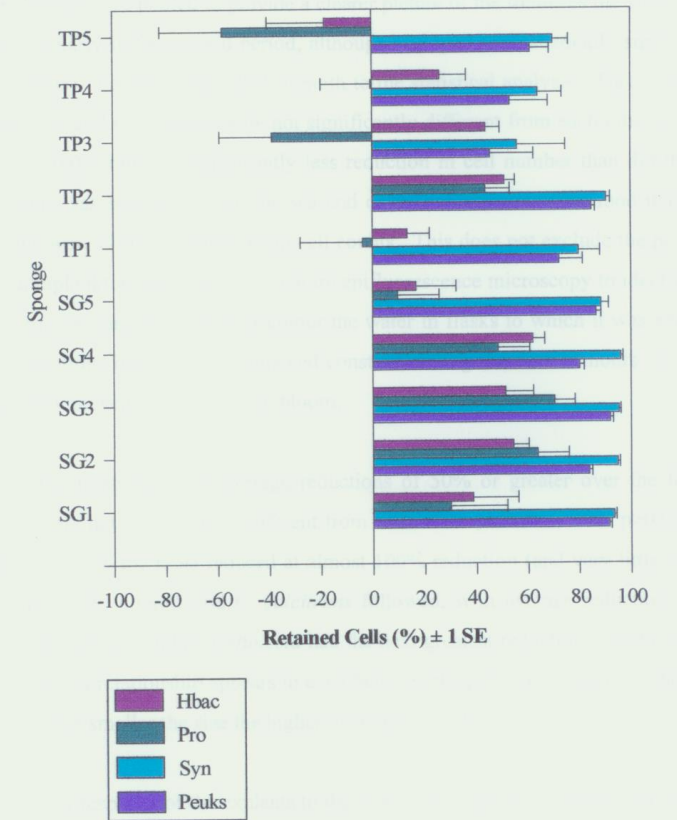
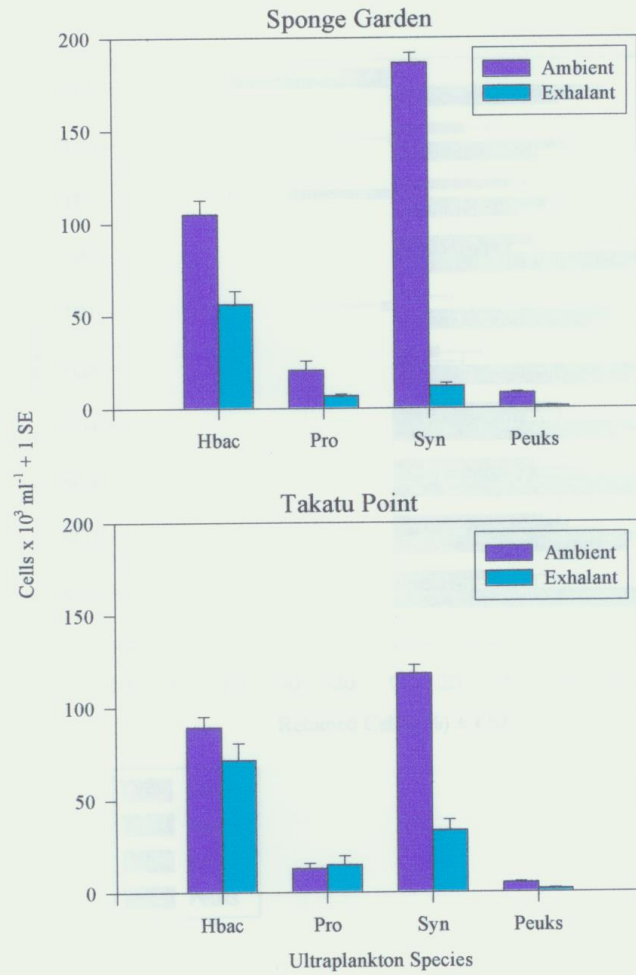
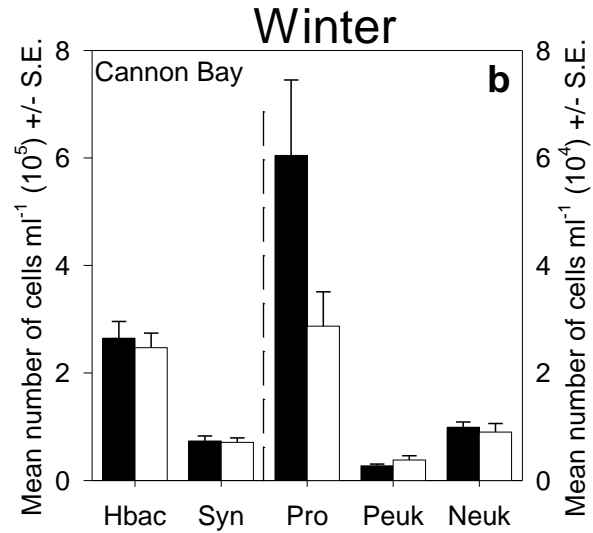
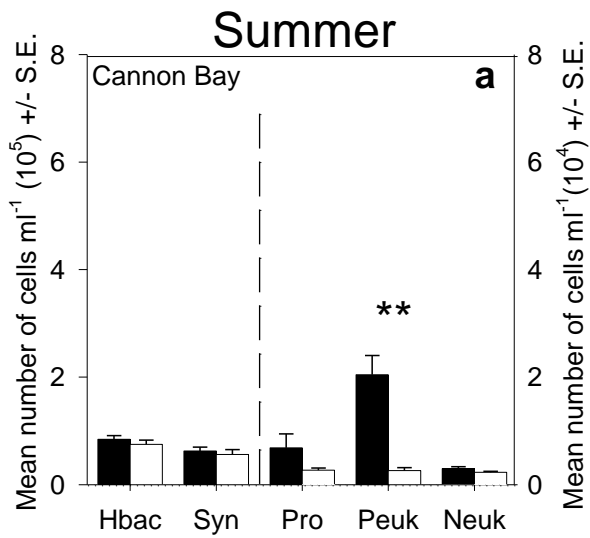


Figure 2.1 Mean cell concentrations (cells $\times 10^3 \text{ ml}^{-1} \pm 1 \text{ SE}$) of four ultraplankton species for exhalant and ambient water around *Polymastia croceus* at Sponge Garden and Takatu Point. Hbac = heterotrophic bacteria, Pro = *Prochlorococcus* sp., Syn = *Synechococcus*-type cyanobacteria, Peuks = autotrophic picoeukaryotes.

Figure 2.2 Average retention of ultraplankton cells ($\% \pm 1 \text{ SE}$) by *Polymastia croceus* at Sponge Garden (SG) and Takatu Point (TP). Hbac = heterotrophic bacteria, Pro = *Prochlorococcus* sp., Syn = *Synechococcus*-type cyanobacteria, Peuks = autotrophic picoeukaryotes.

Rhopaloeides odorabile feeding experiments

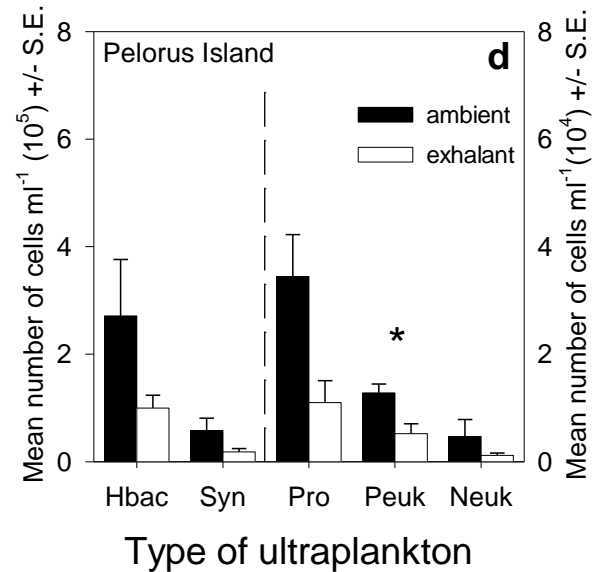
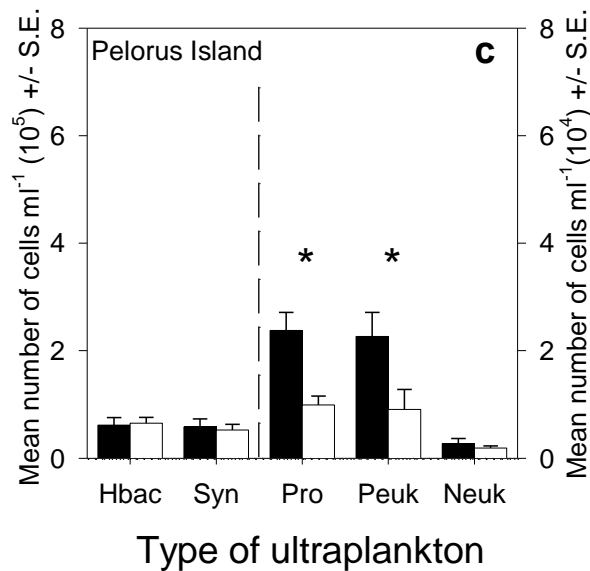


Hbac Heterotrophic
bact

Syn
Synechococcus

Pro
Prochlorococcus

Peuk Picoeukaryotes



Carbon consumption by sponge communities*:

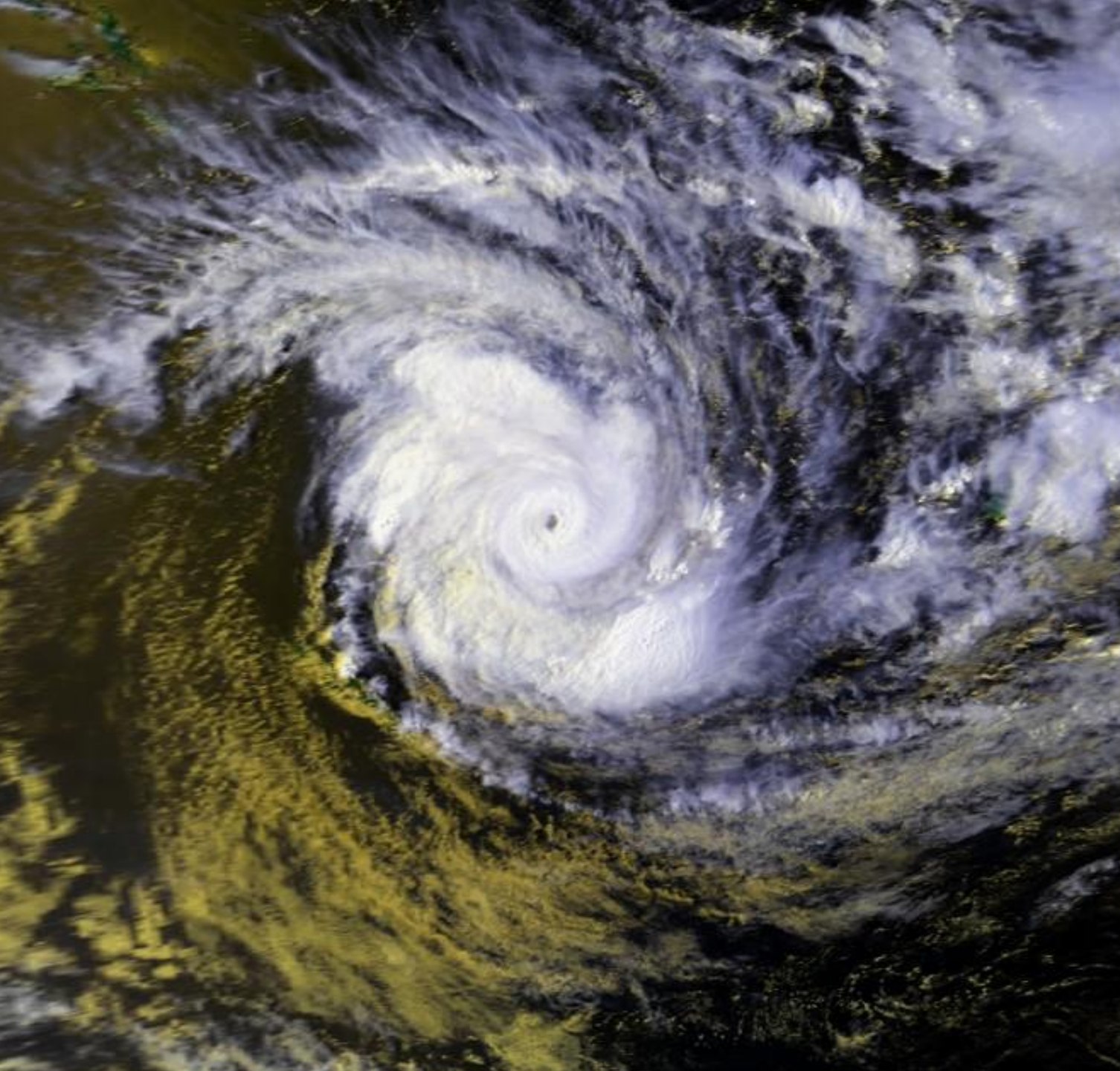
@ 100ml s⁻¹m⁻² Water throughput for average sponge field

@ 20 ug C.l⁻¹ POC retained

@ 120 ug C.l⁻¹ DOC retained

@ 360 ug C.l⁻¹ Ultraplankton retained

*Calculations based on published data from Bannister, Bell, Duckworth and Battershill
Sponge density over large areas conservatively estimated at @5 sponges /m²
(Battershill and Bergquist, 1986, 1989; Battershill et al 1992,3).



Muddy rivers:

Cyclone Bola: 1mt/day

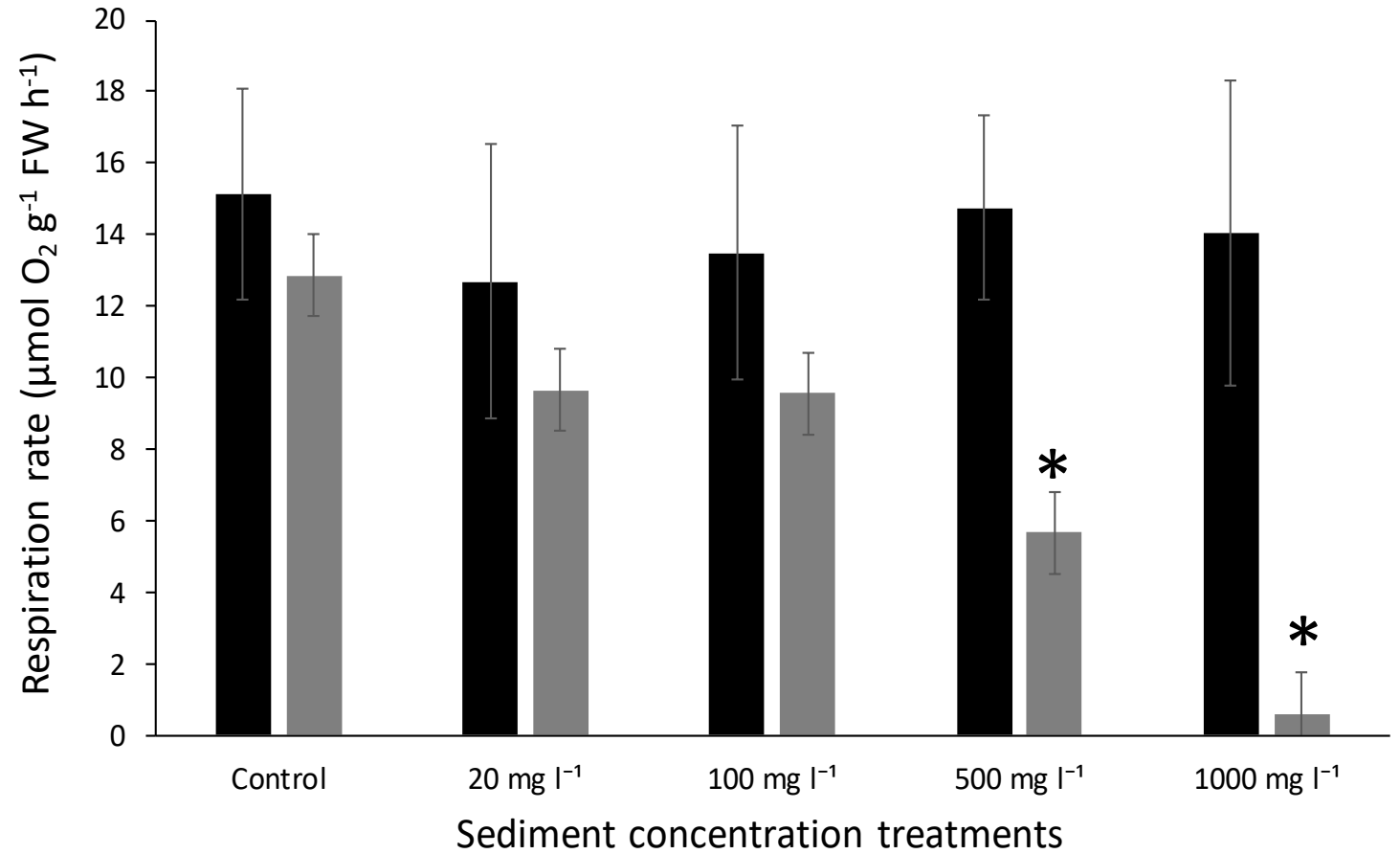
Waiapaoa: 15mt/yr

Waiapu: 35mt/yr

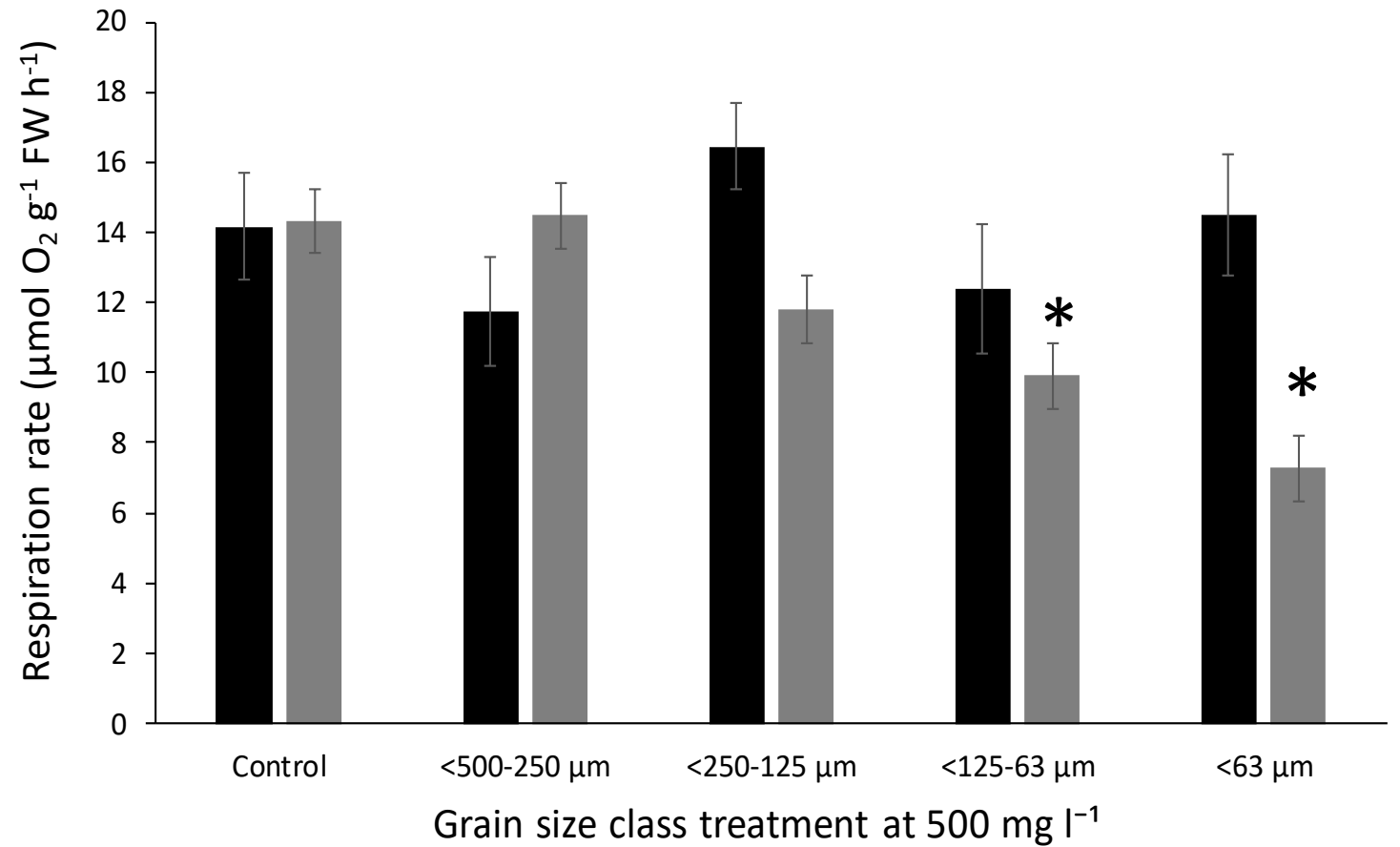
= 140m m² @25cm depth of soil

Or 80 dairy farms/yr





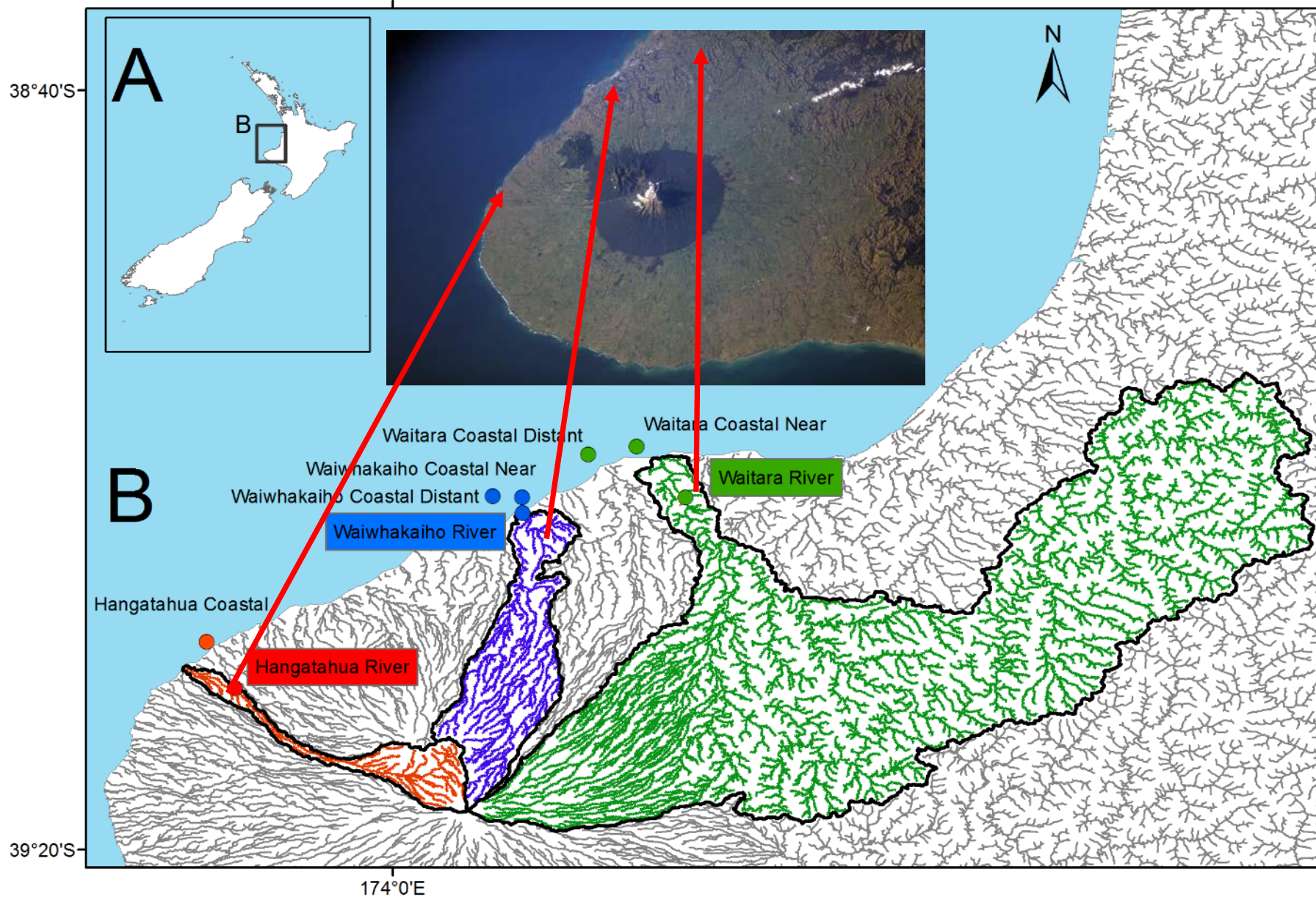
Black bars: mean pre-sediment respiration rate,
Grey bars: mean after-sediment respiration rate
(Error bars \pm SE) ($n = 6$)
*different to control at $p < 0.05$



Black bars; mean pre-sediment respiration rate,
Grey bars; mean after-sediment respiration rate
(Error bars \pm SE) ($n = 6$)

*different to control at $p < 0.05$

Catchment Size and Condition



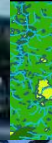
Waitara Catchment Large and mostly farmed characterised by serious erosion issues,

Waiwhakaiho catchment, intermediate size, runs through an urban area, but well afforested riparian areas,

Hangatahua catchment, smallest some farmed but well afforested, the most pristine.

Inshore and offshore sites sampled.

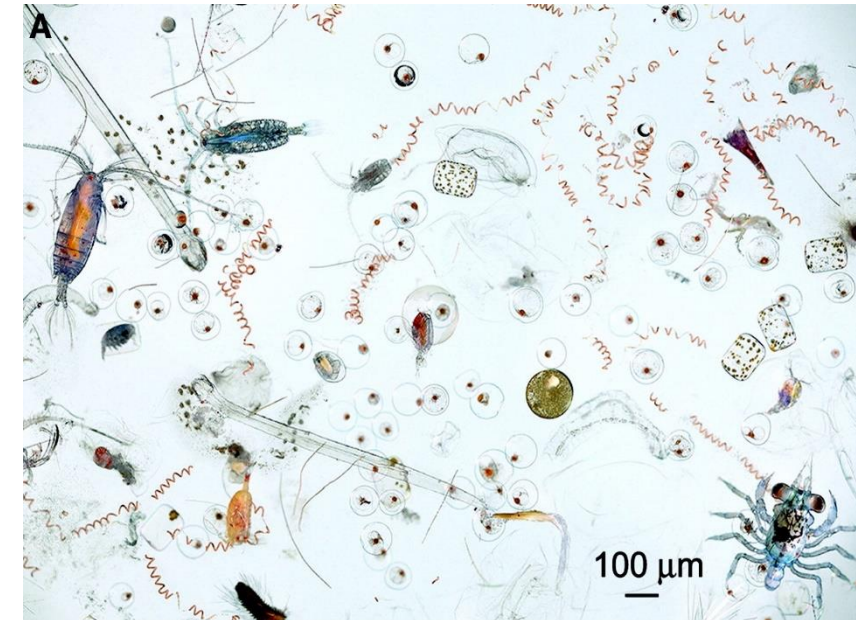
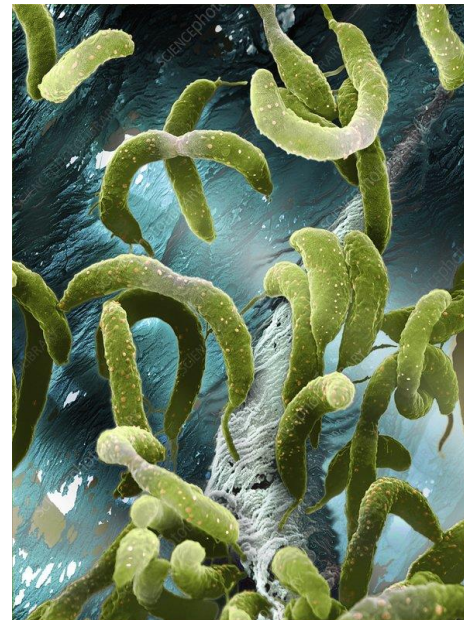
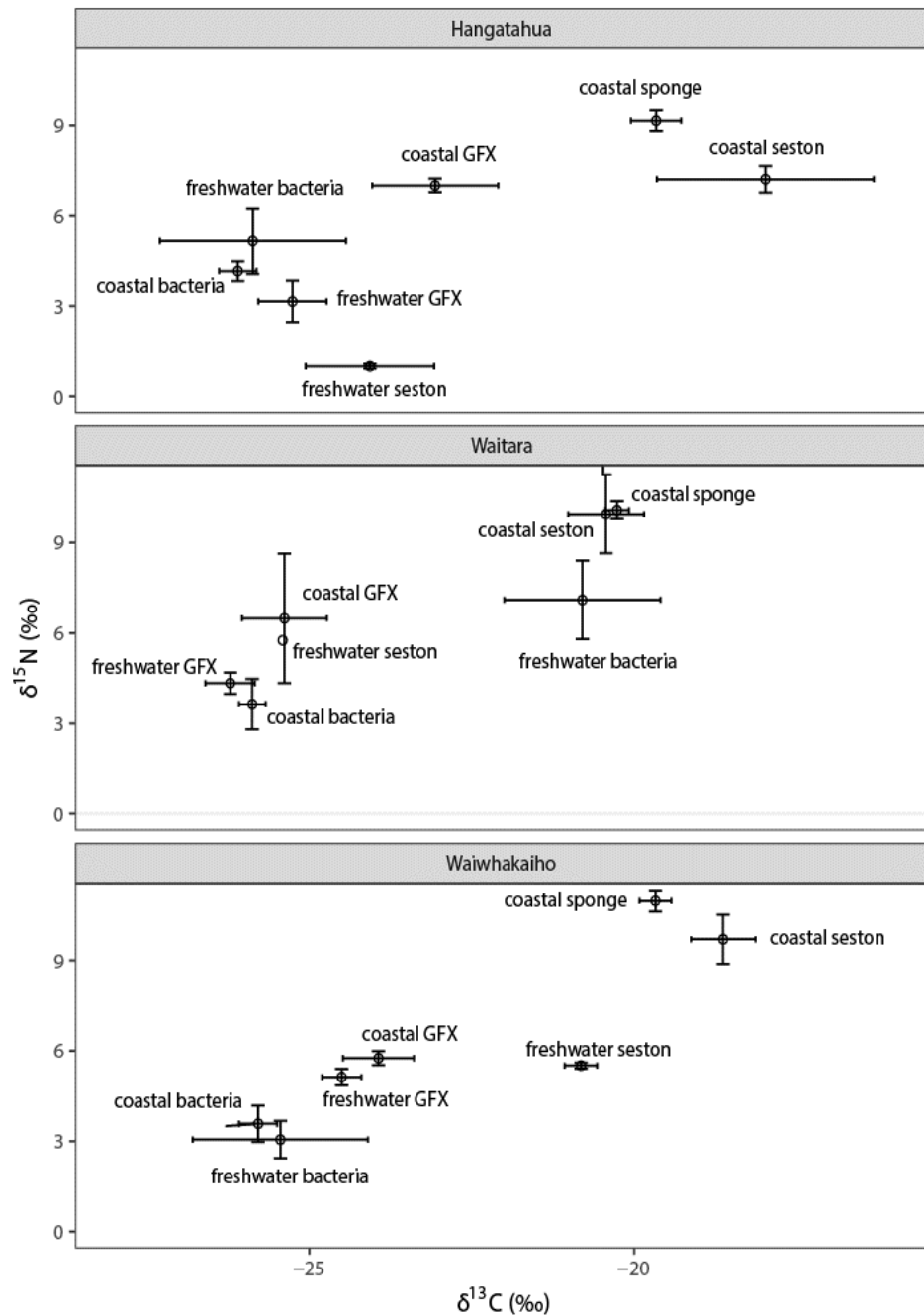
Study Locations

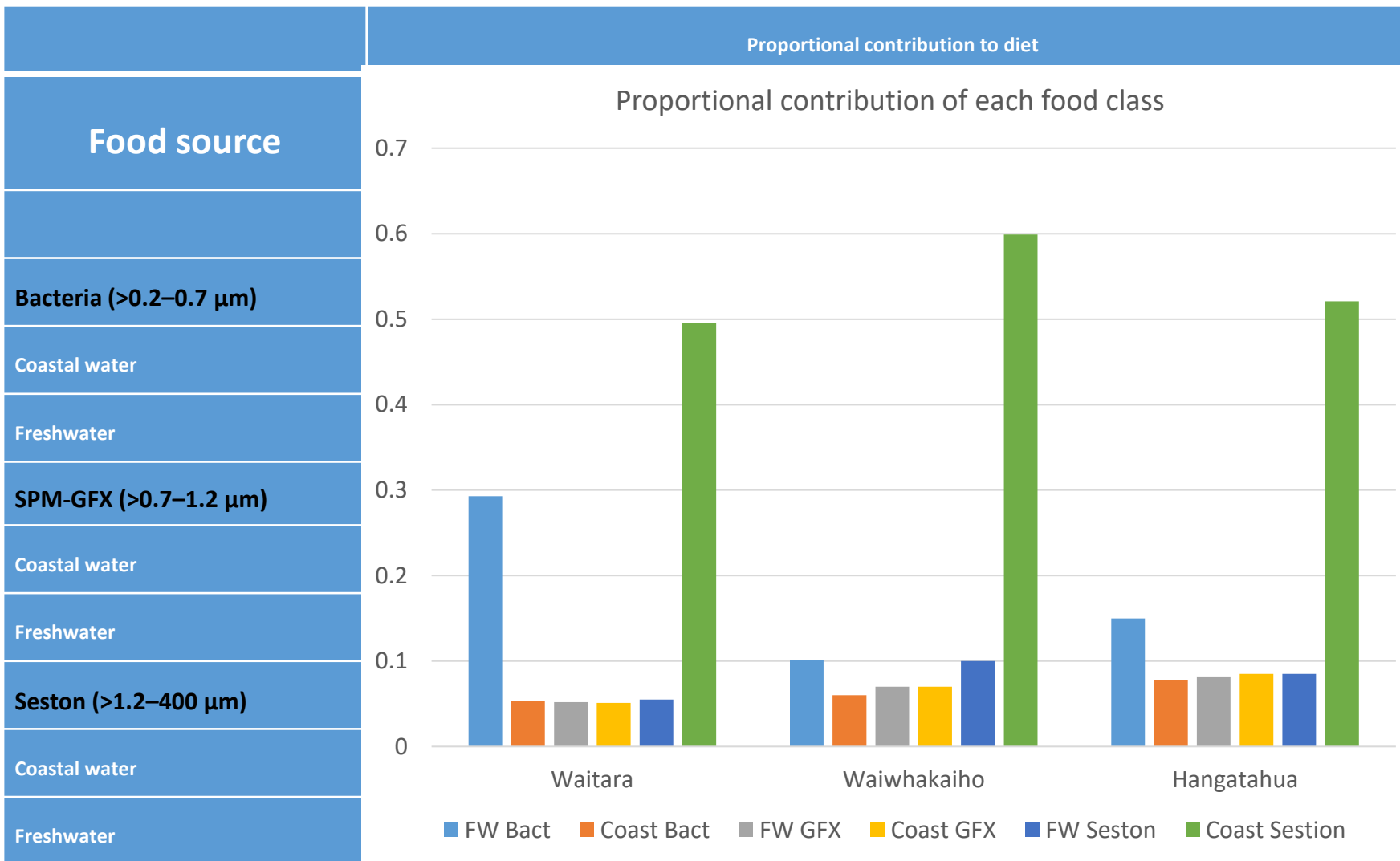


Land cover
Cover Data
catchments for the three rivers in this study (Waiwhakaiho and Hangatahua (Stony) rivers). Red dots represent geographic coastal locations sampled local rivers.

Stable Isotope Tracking of the Trophic Cascade

Mean \pm SE $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ for all sponges, freshwater and coastal seston from three transects, Waiwhakaiho, Hangatahua, and Waitara.





Across all stations, a **substantial fraction of the diet of sponges was coastal seston (50–60%) and freshwater bacteria (10–29%)**, followed by freshwater seston (6–10%), coastal GFX (7–9%), freshwater GFX (7–8%), and coastal bacteria (6–8%).

The proportional contributions of each food source varied among stations

Waiwhakaiho had the highest proportion of all stations of Freshwater Seston but Hangatahua close.

Increasing catchment size

Increasing catchment quality



A tradeoff between catchment size and quality

Bayesian mixing model mean estimates (\pm standard deviation, SD), of the percentage (%) proportional contribution of each food type to sponge diet at each reef. (SPM-GFX is suspended particulate matter collected on fine and coarse glass-fibre filters).

So What?

- All up, freshwater sources of food accounted for almost 40% of sponge diet especially freshwater bacteria >0.2-0.7 μm (10-29%). Accounts for some of the gaps in the literature.....the missing carbon...
- Feeding efficiency and metabolic experiments (NZ and Aus)*: average retention rate of 500 $\mu\text{g C L}^{-1}$ can be processed by sponges.
- Average sponge pumping efficiency is 187 $\text{mL m}^{-2} \text{s}^{-1}$ in a typical sponge meadow = @432 $\text{kg C km}^{-2} \text{day}^{-1}$ ingested. Paraninihi reef could be over 1,000 $\text{kg C km}^{-2} \text{day}^{-1}$ and up to 8,078 $\text{kg C km}^{-2} \text{day}^{-1}$ ingested for sponge rich meadows.
- Gili and Coma (1998) report ingestion rates of 29–1970 $\text{kg C km}^{-2} \text{day}^{-1}$ for a range of temperate and tropical sponges
- **Combining our estimated C processing rates with the isotopically-determined contribution of foods from terrestrial sources to the diet of coastal sponges (27–40%), suggests that sponge meadows may process approximately 2181-3231 kg of terrestrially-derived C $\text{km}^{-2} \text{day}^{-1}$.**

*(Bannister, 2008; Bannister *et al.*, 2007, 2012); (Battershill & Bergquist, 1990; Bell, 1998),

Conclusions

- We have now a benchmark of species level taxonomy of sponges which are good indicators of medium to long term prevailing biophysical conditions around the Taranaki Coast. We should be able to pick up on any biogeographic shifts
- We have observed a very high level of patchy endemism and uniqueness in assemblages at small spatial scales associated with particularly impacted catchment systems.
- Contributions from land are significant in terms of food supply for benthic communities as characterised by sponges.
- Not all muddy rivers appear to devastate sponge meadows, however they do substantially influence diversity and biomass. **But**, are some of the impacted marine communities close to a tipping point?
- There is likely a trade-off between the food delivered by catchments (quality) and the metabolic energy required to keep sponges from being inundated by fine sediments.
- We are seeing highly modified diversity in our coasts directly linked to land condition, where arguably resilience to other stressors is likely to be low (marine heat waves for instance).

Acknowledgements



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Taranaki Regional Council
Barry Watkins Marine Services



TOITU TE MOANA, TOITU TE TANGATA
Sustainability of the Sea, Sustainability of the People



THANK YOU!