Intraspecific variation in thermal tolerance, and restoring Australia's endangered giant kelp forests

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We acknowledge the Traditional Owners of the lands and waters on which this research was conducted, and pay our respects to Elders, past and present.

Collaborators

CSIRO
OzFish Australia
TNC California & Australia
University of Otago
weetapoona Aboriginal Corporation

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Anusuya Willis
Beth Strain
Catriona Hurd
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Scott Bennett
Scott Ling
Stefan Andrews
…. & many more

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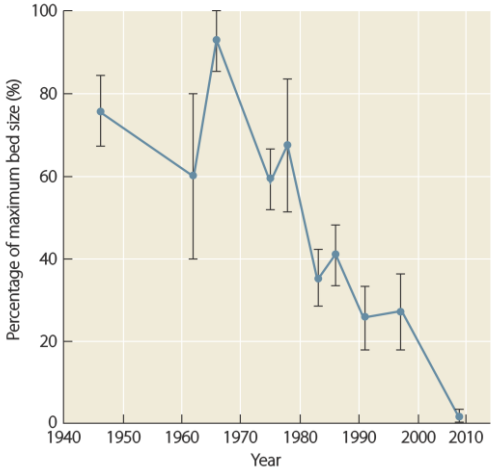
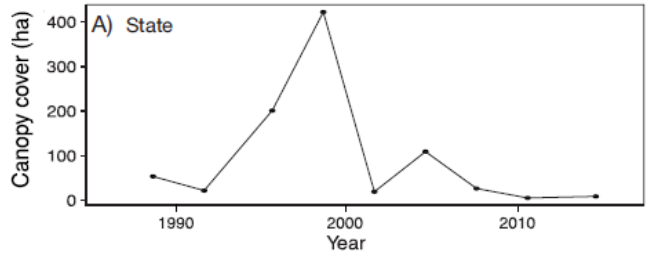
Disappearing giant kelp forests
under pressure

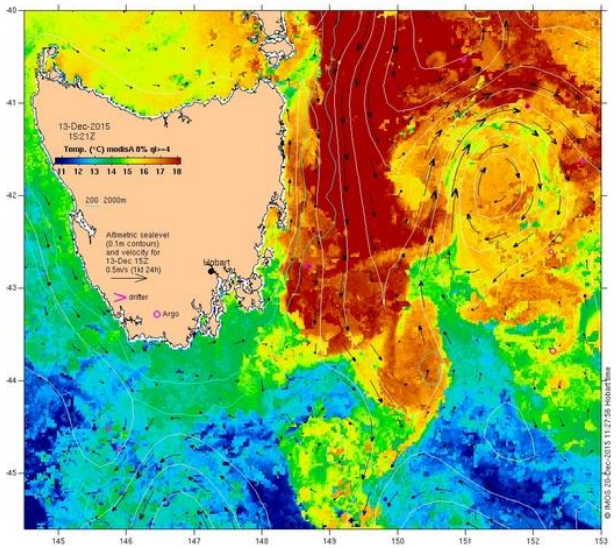


Steneck & Johnson 2014

- ~95% reductions in giant kelp forest cover in Tasmania since 1960's
  - changing oceanography = increased temperature & decreased coastal nutrients
  - SE Australia = global ocean-warming hotspot
- Nationally listed as a *threatened ecological community*

Butler et al. 2020





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Help for our kelp?

habitat restoration

Is restoration possible?

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Help for our kelp?
habitat restoration

First, we need overcome & understand the drivers of decline

↓

Is there intraspecific variation in the thermal tolerance of the remaining giant kelp?

↓

If so, can more tolerant families be used for restoration trials?

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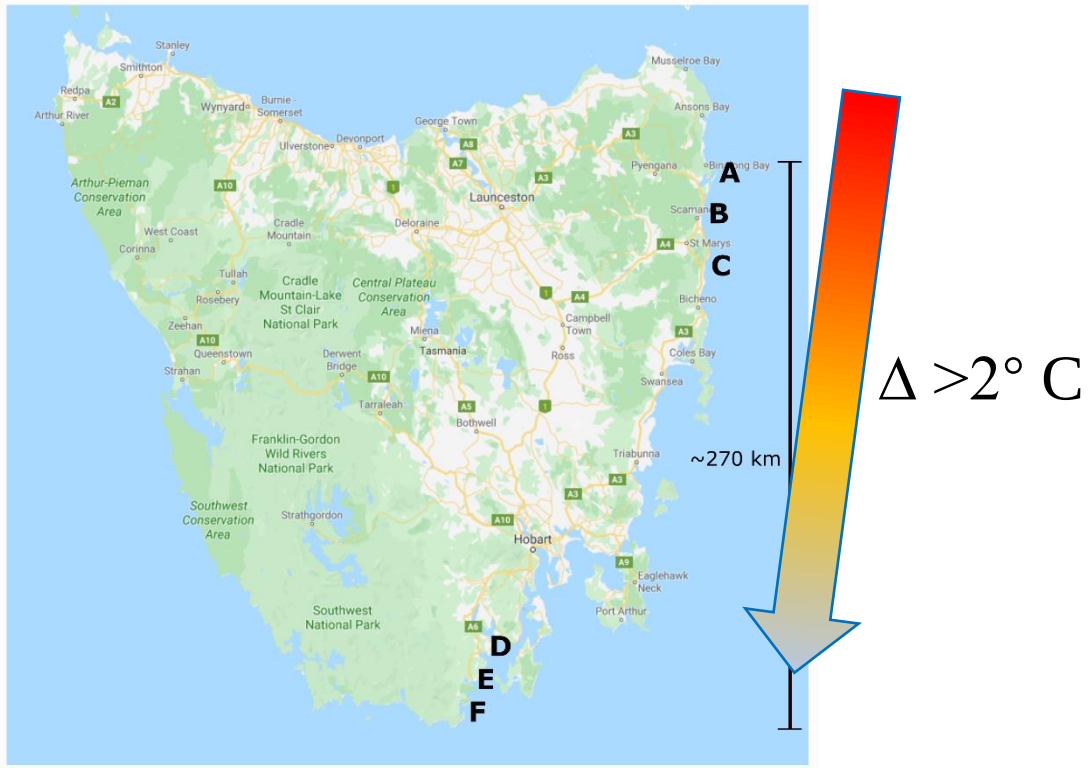
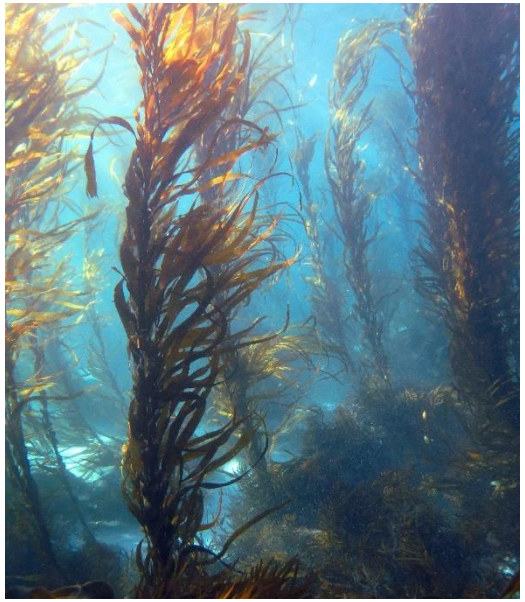
Remnant giant kelp forests
adaptation and acclimation?

- spores collected from 6 remnant populations
- >50 family-lines as ongoing gametophyte cultures
- long term ‘seed bank’ collection (genetic conservation & as a backup)





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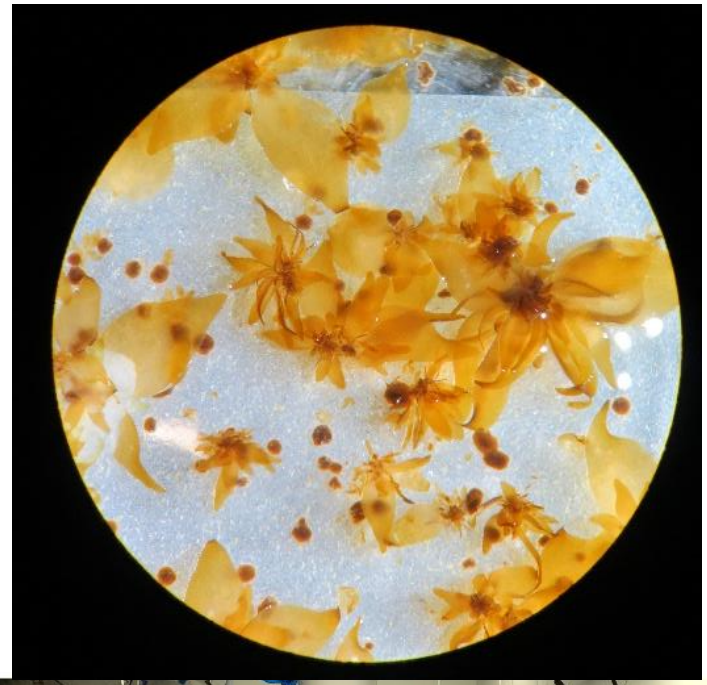
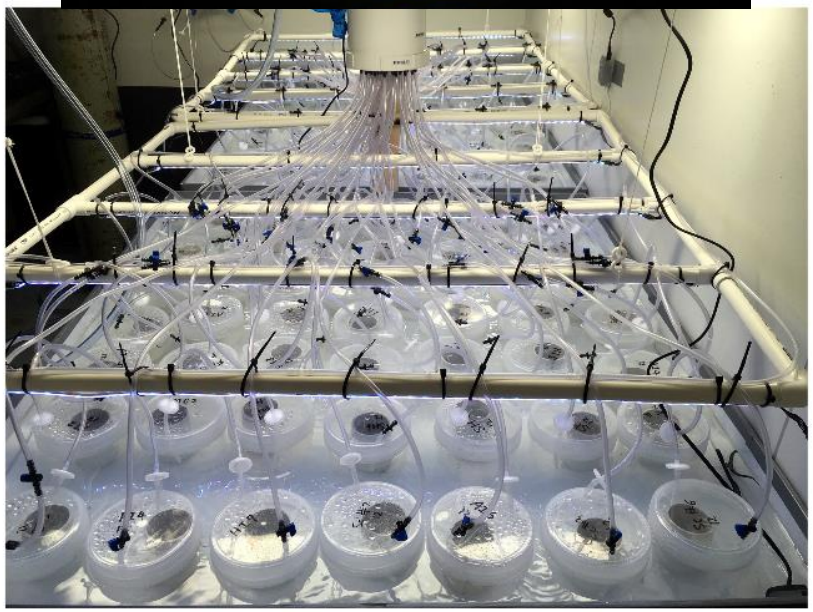
Intraspecific variation in thermal tolerance
testing and selecting

'Common garden' experiment (repeated twice*):

- four temps 12–24 °C and ambient nutrient levels (~1 μmol/L NO_3)
  - 42 selfed family-lines & 7 outcrossed family-lines
- assessed density and size of microscopic/juvenile sporophytes





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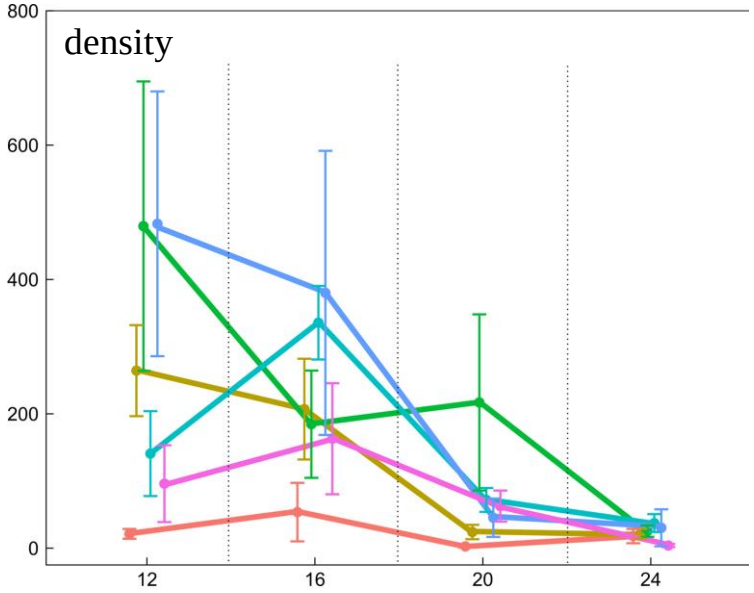
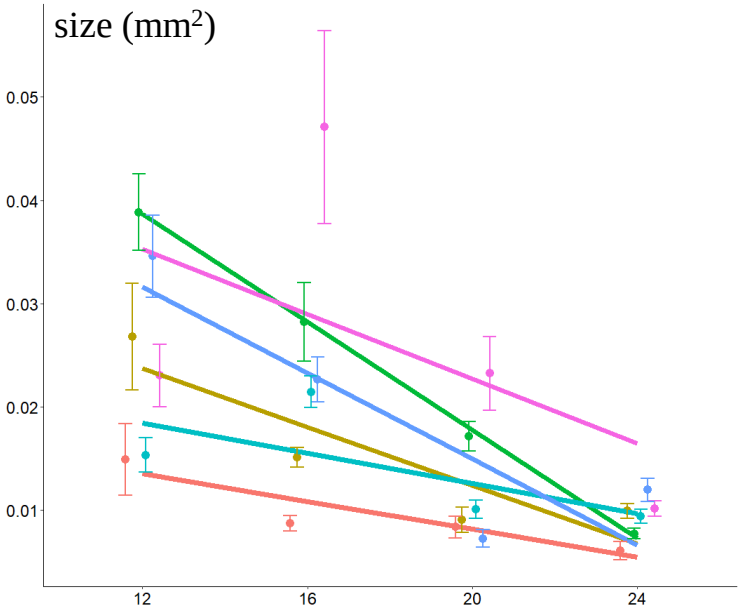


RESULTS

- declining density and size with increasing temperature
- survivors at 20 & 24°C!
- high intraspecific and intra-site variation
- weak site effects, but no regional effect
- weak effects of selfed vs outcrossed*
- ~20% of family-lines displayed higher thermal tolerance



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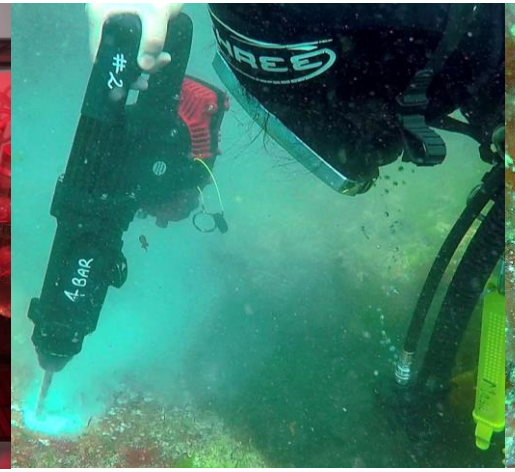
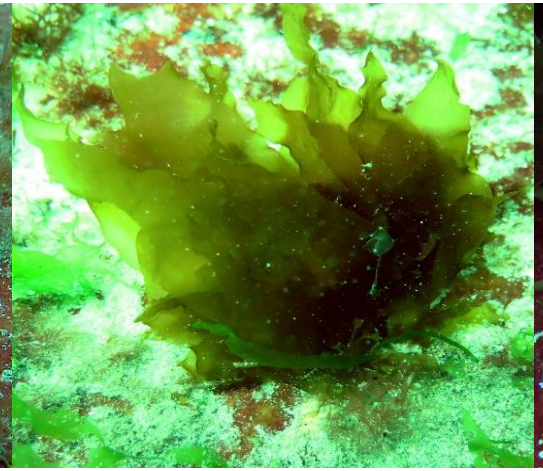
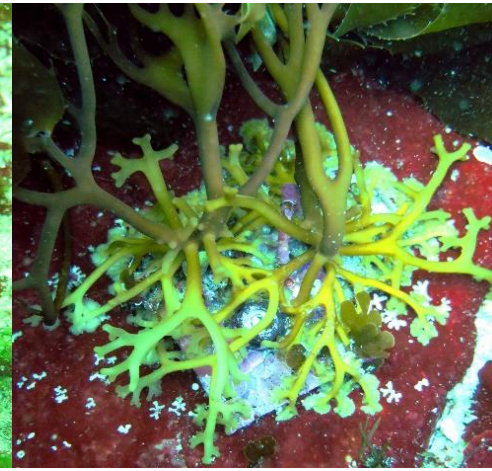
Restoration trials
outplanting the most tolerant family-lines

- **Aim:** self-supporting and self-expanding ‘seed patches’
- Monitoring demographic and community responses.
- Oct 2020 → three 150 m^2 trial patches, cleared of competitors and consumers
  - High initial survivorship and growth over 12 months at two patches (~40 individuals, average size ~3 m, max size ~12 m)
  - Followed by slow declines, and kelp becoming reproductive

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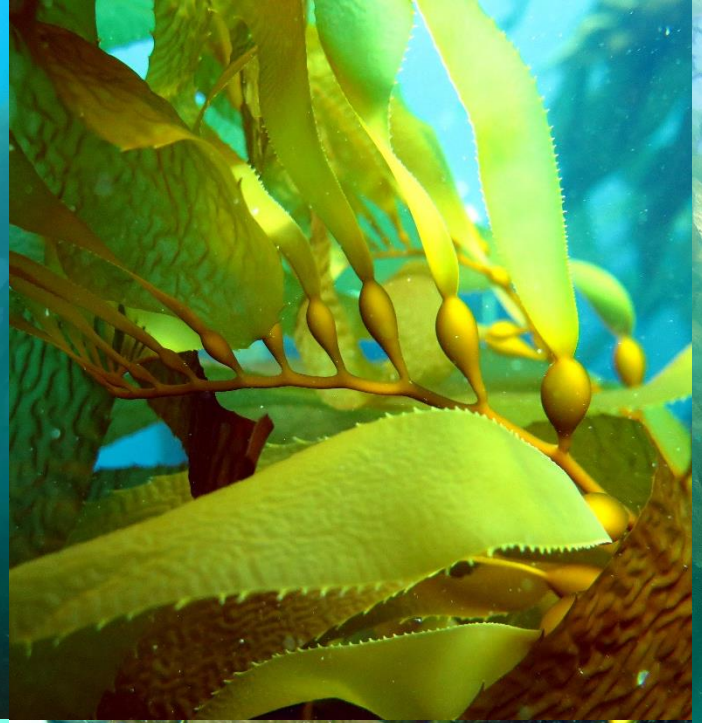


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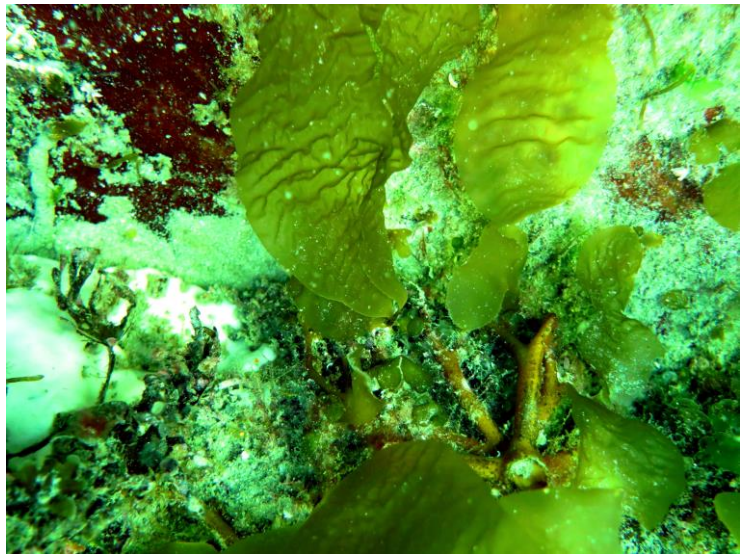
  - Followed by slow declines, and kelp becoming reproductive
- **Now also seeing natural recruitment (>100 juveniles) from our planted kelp at one of the sites**



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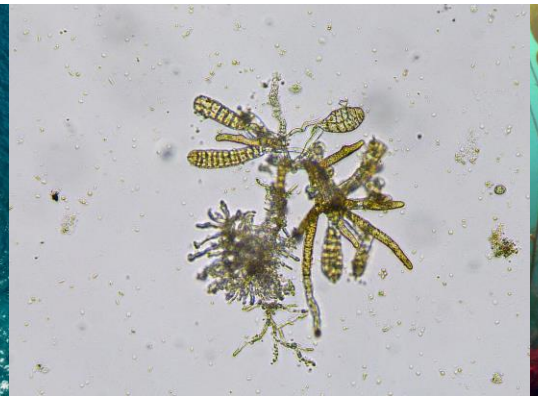
Additional projects

physiology, breeding, ecology, genetics

1. **Physiology of thermal tolerance**
   - adaptable fatty acids & more efficient users of N (and re-confirmation of thermal tolerances)
2. **Ongoing breeding and selecting**
   - trials and plantings of second generation (i.e. juveniles derived from the best of the 2020 outplanted adults)
3. **Population genetics, and genomics (Cintia Iha, Anusuya Willis)**
   - north/south regional separation, & full genome
4. **Forest-scale restoration and *Ecklonia* interactions (Scott Bennett, Scott Ling, Beth Strain, Jeff Wright, Eaglehawk Dive, Sea Forest)**
   - 7,000 m^2 area, testing gravel vs twine & canopy competition/facilitation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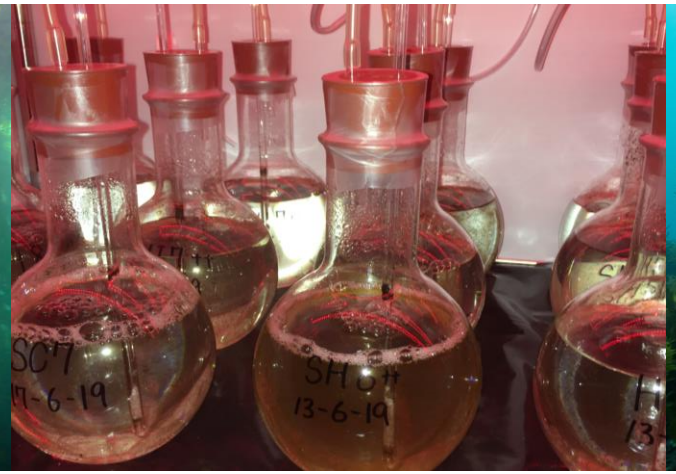
Conclusion

Take home messages

- Substantial intraspecific variation in thermal tolerance of TAS *Macrocystis*, but not related to site nor region.
- Increased warmwater tolerance of some family-lines may aid restoration efforts (in the short term).
- Laying a foundation of practice and knowledge for restoration and future-proofing:
  - ➢ crawling → walking → running
- Much more work to be done!

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