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Effects of warm ocean temperatures on bull kelp forests in the Salish Sea

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Evaluating Thermal Tolerance of Kelp Forests in the Salish Sea

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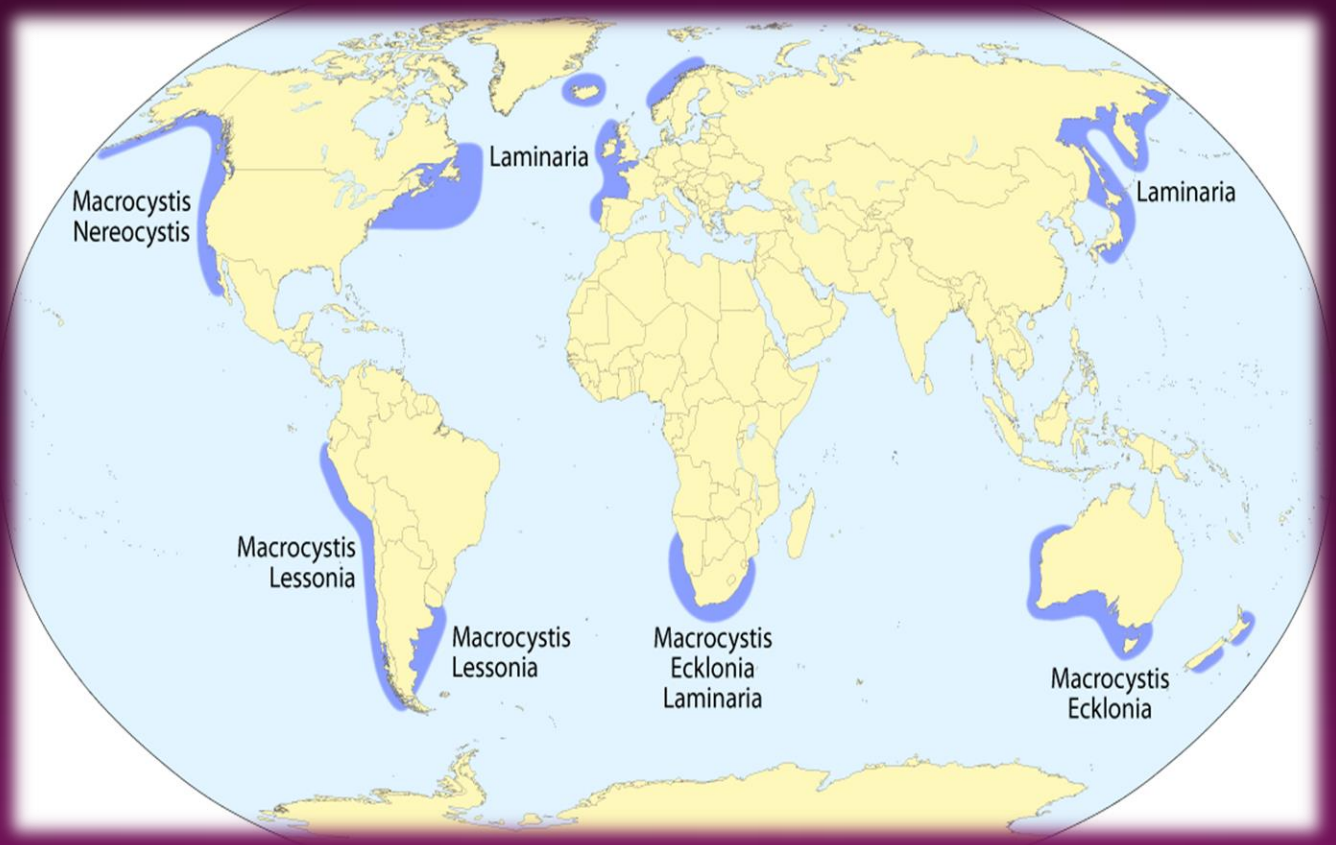
Kelp Forests

- Habitat + Foundation
- Nurseries
- Food source
- Blue carbon
- Cultural Importance

Global Kelp Declines

- Regime shifts - Tropicalization of temperate communities
- Range shifts/ distributional limits
- Changes to competitive advantages
- Future temp and carbon regimes give turfs advantage and impact recruitment



Steneck, R., and J. M. Erlandson. 2002
Connell and Russell,2010
Wernberg et al. 2016

Kelp Declines

- N. California
  - 93% reduction
  - Mean temp increased 3.5°C by power plant outflow and killed 97% of *Nereocystis*
- Perfect storm
  - Algal blooms
  - Seastar wasting
  - Urchin barrens
  - Ocean warming

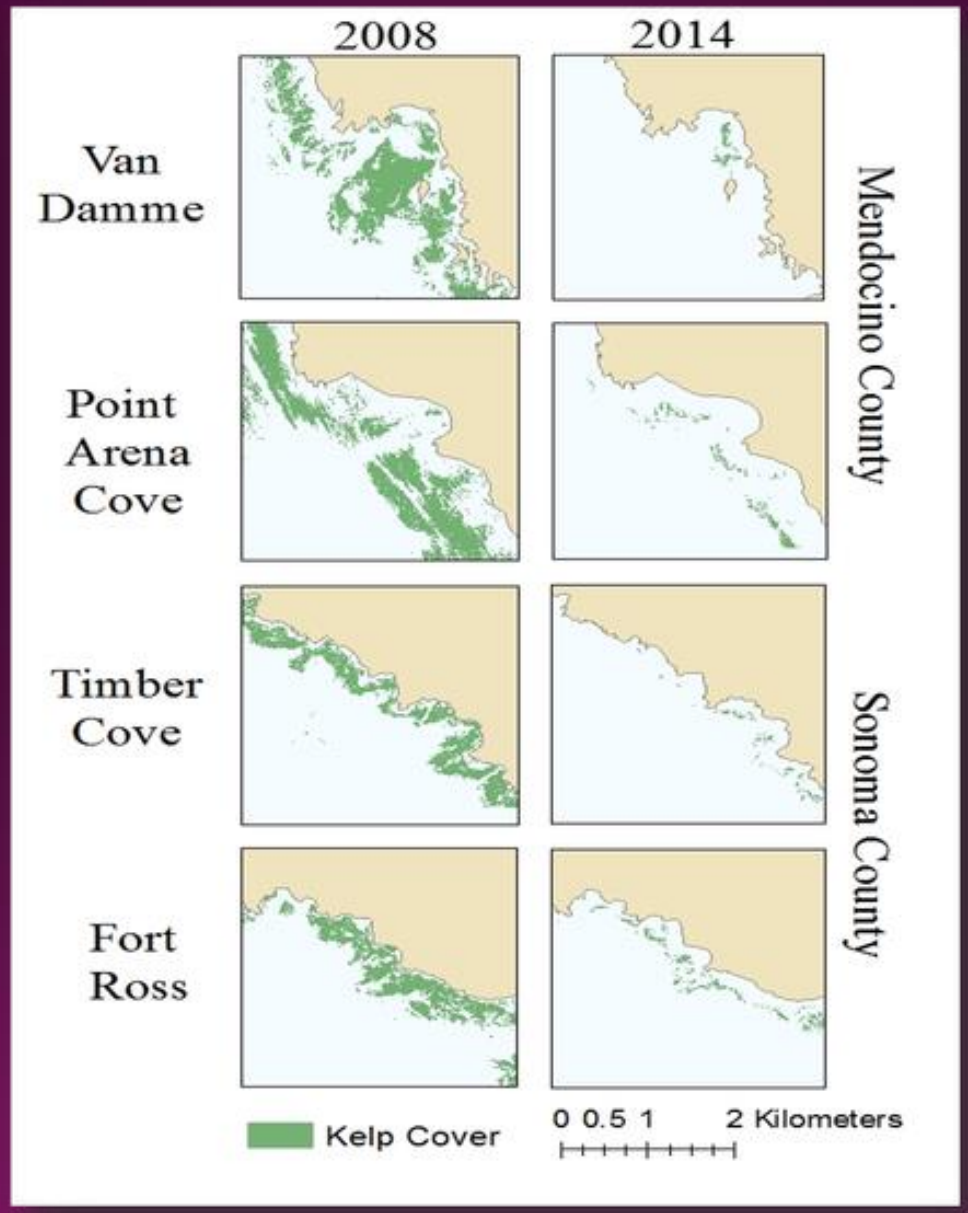
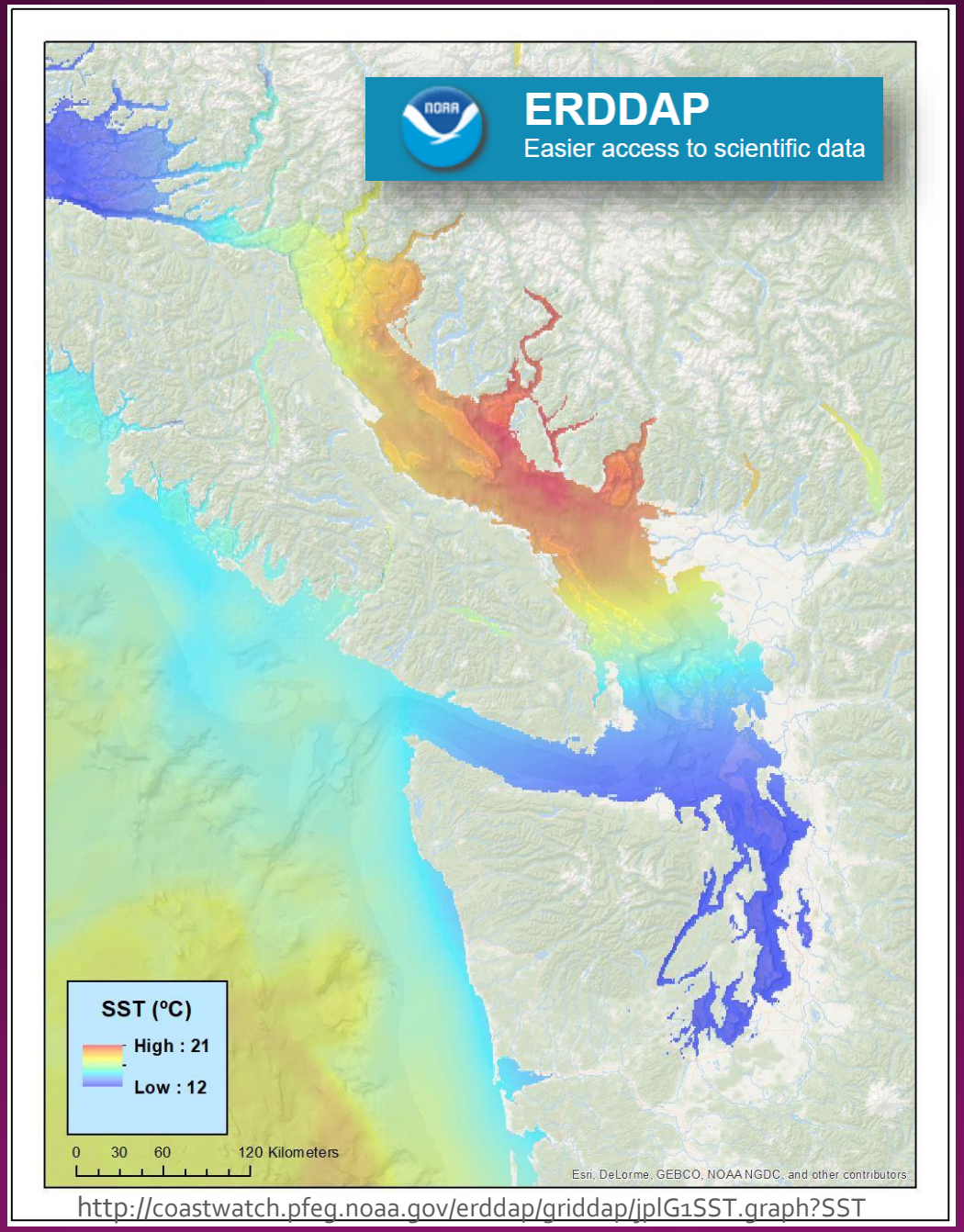


Image Courtesy of: M. Fredle-CDFW Aerial Surveys
Schiel, Steinbeck, and Foster, 2016, Ecology

Salish Sea

- Canopy forming species
- Nereocystis/Macrocystis
- During summer months, the SST in the Central Strait of Georgia is 5 or 6°C warmer on average than the Strait of Juan De Fuca



http://coastwatch.pfeg.noaa.gov/erddap/griddap/jplG1SST.graph?SST

Project Goals

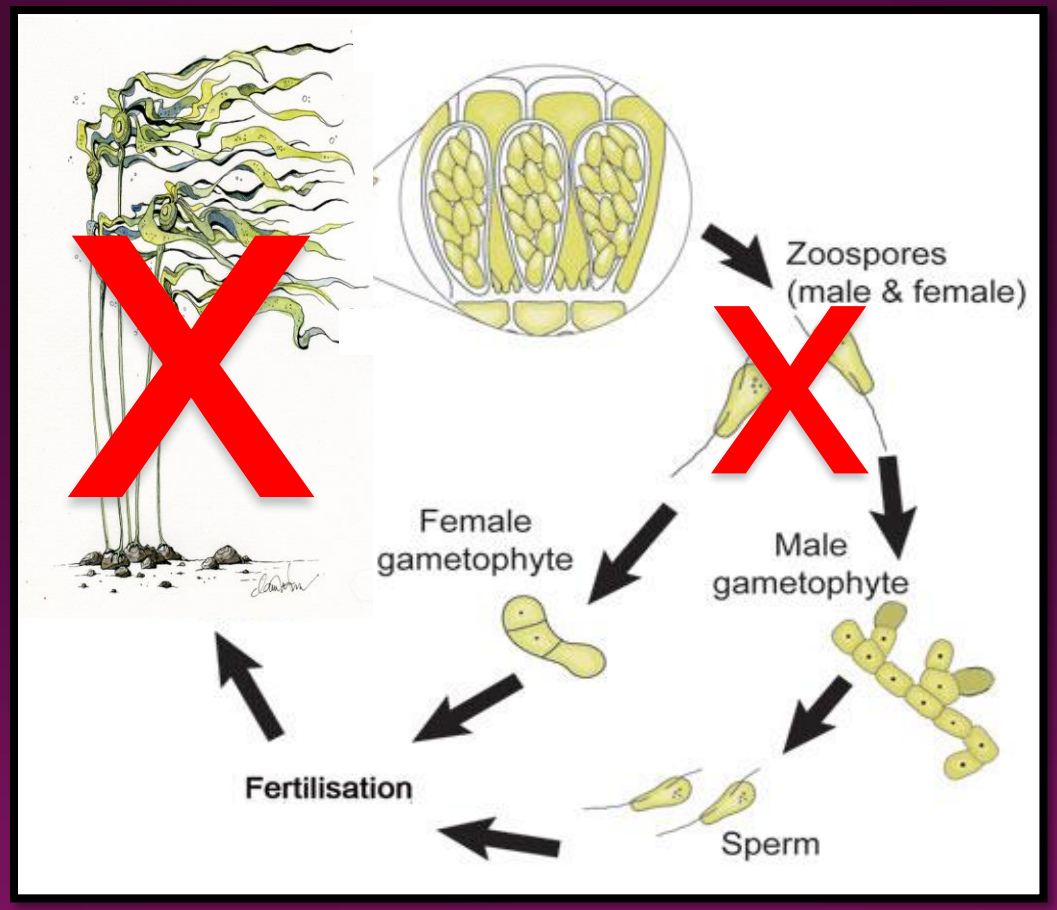
1) Identify temperature limits for early reproductive success in *Nereocystis*

2) Evaluate whether certain kelp populations exhibit a resiliency to warm temperatures
   - old idea, new ecosystem
   - establishing best measures

3) Establishing/Continuing Restoration
   - evaluating conditions/progress

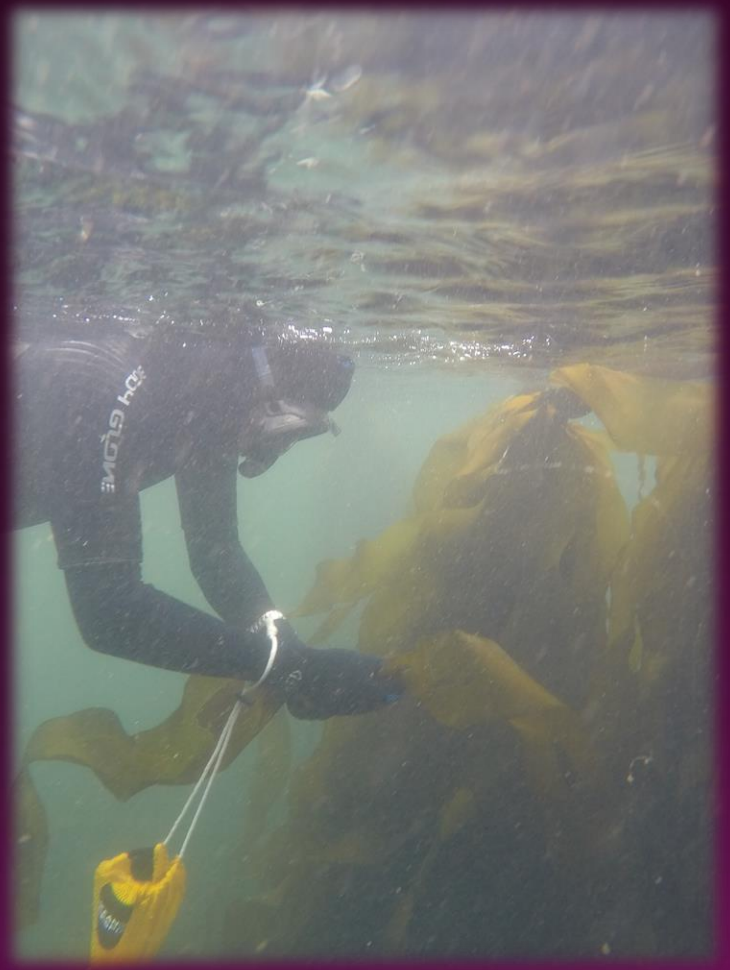
Stress Resiliency

- Most susceptible stages
- Annual life cycle
- Rapid recovery in cool climate
- Suppressed recovery for up to two year from warm climate
- Canopy required to facilitate new recruitment
- Increased temperature may affect:
  - early developmental stages
  - sporophytic growth
  - cellular/tissue maintenance

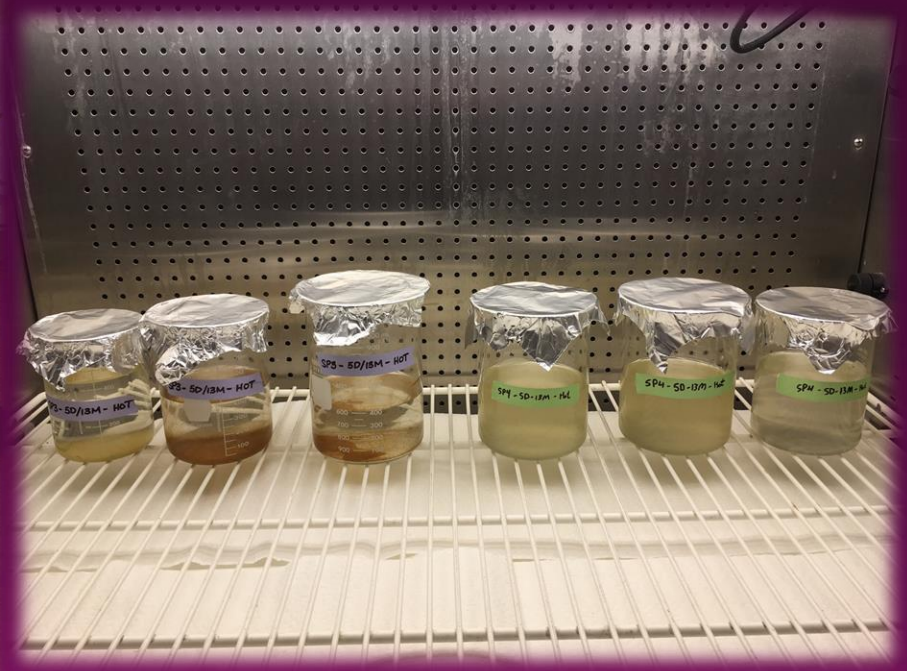


Graphic: Erika Mackay
Wernberg et al, 2010

Collections

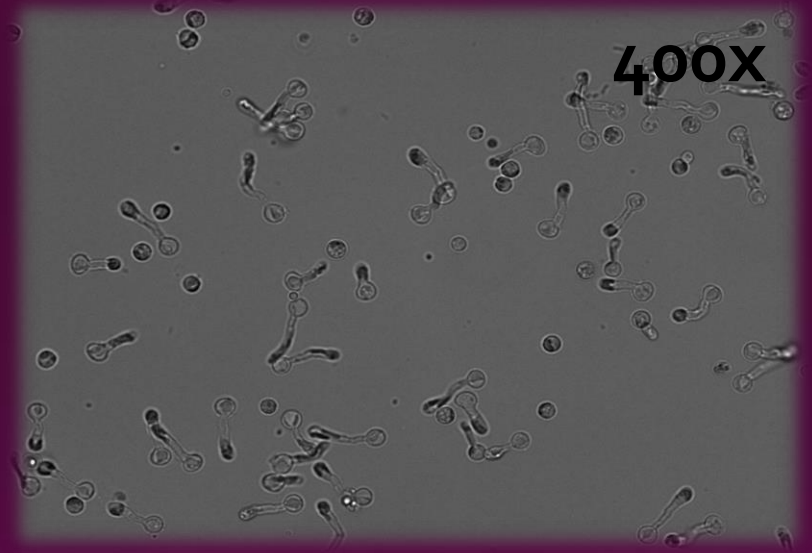


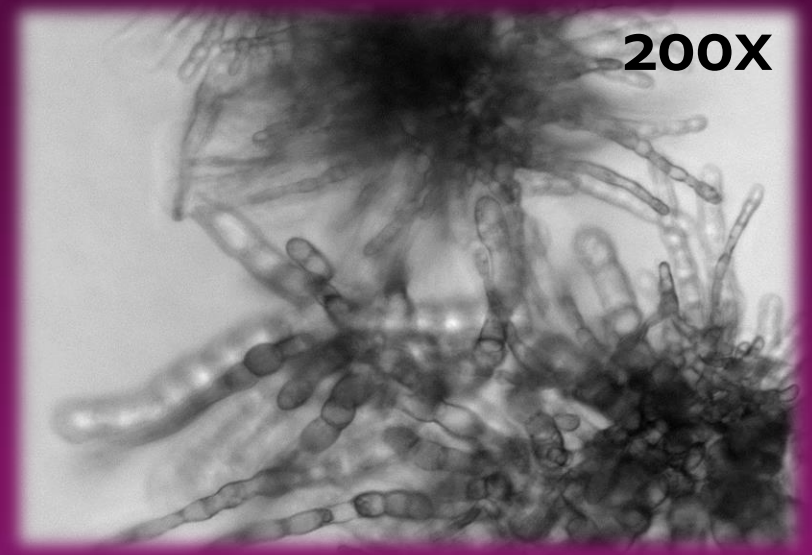
Preparation



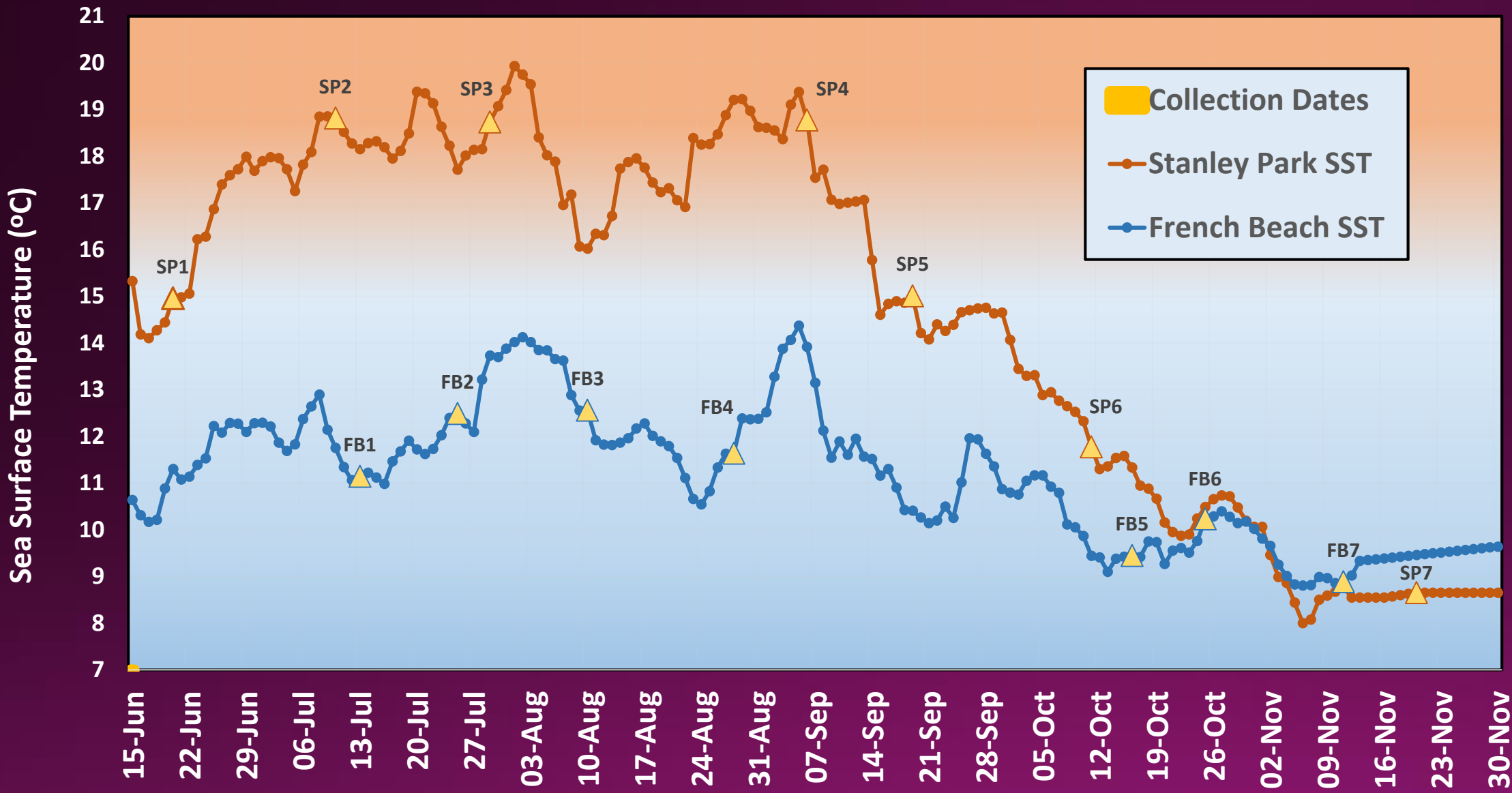
Evaluating Stress Resiliency In Kelp

- Quantitative measures:
  - spore density
  - germ tube formation/germination
  - gametophyte formation
  - viability
- Compare across populations/temp
- Does spore resiliency change as season progresses?

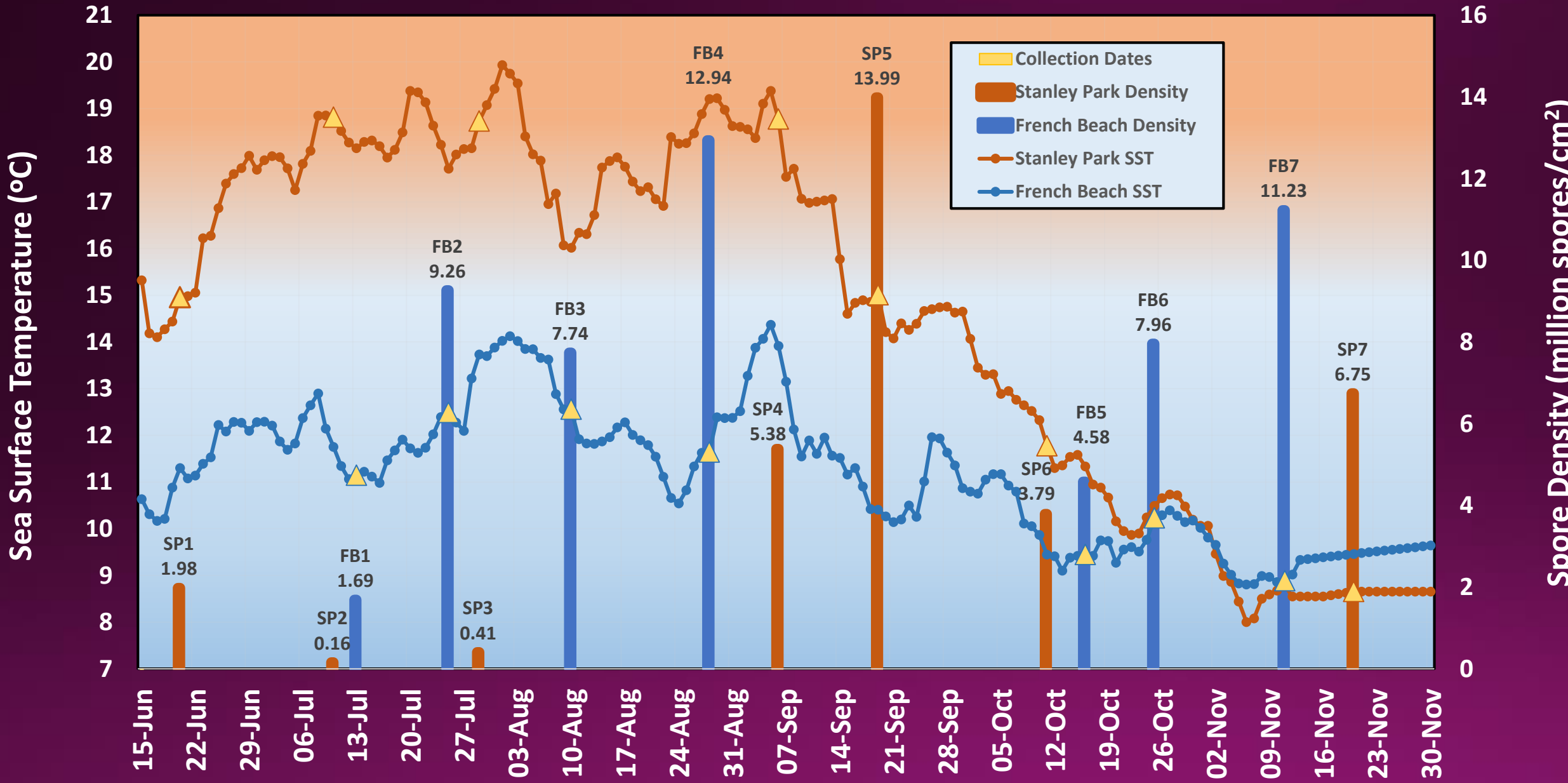




2017 SST for Stanley Park and French Beach

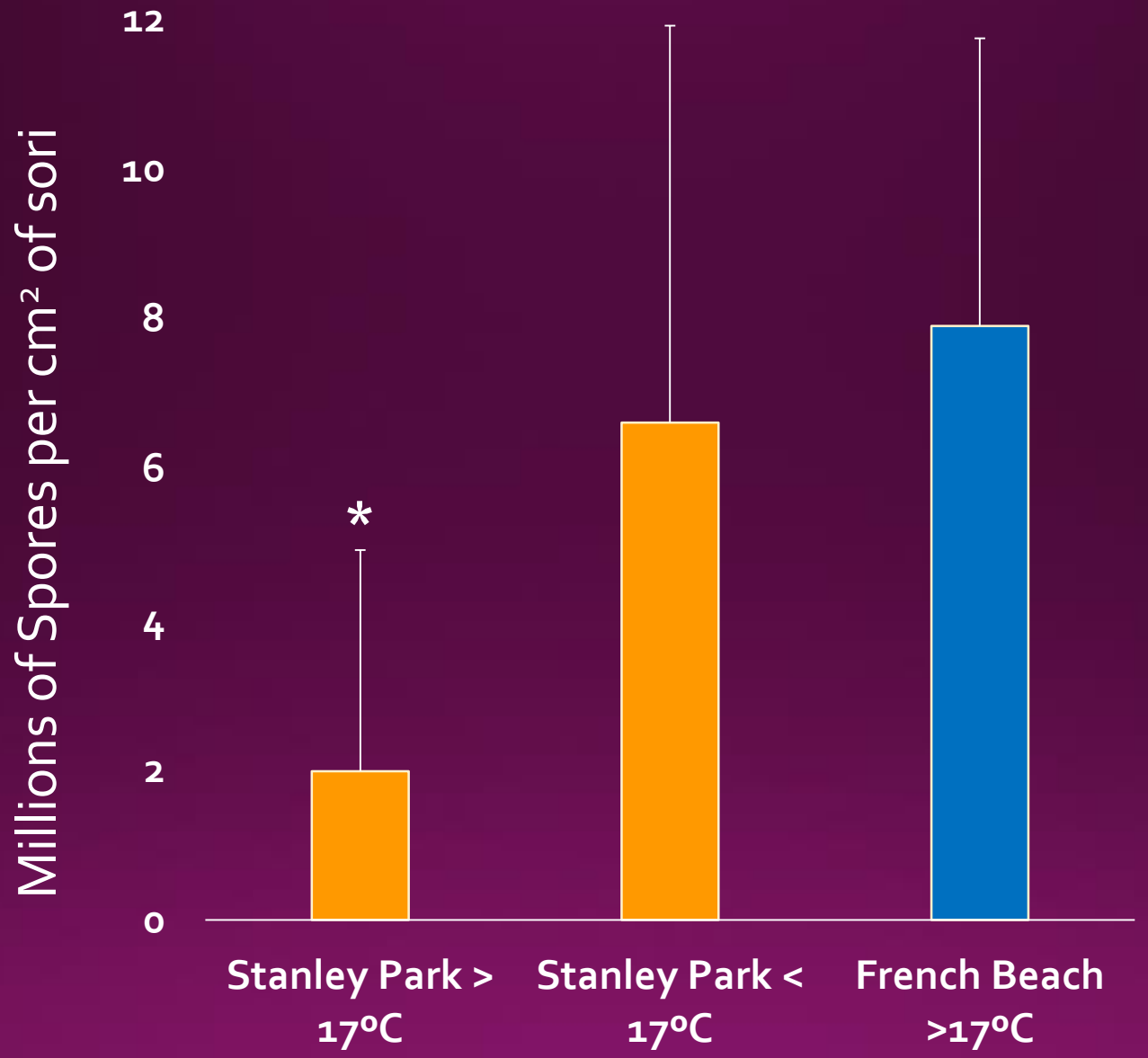


Salish Sea SST with Spore Densities

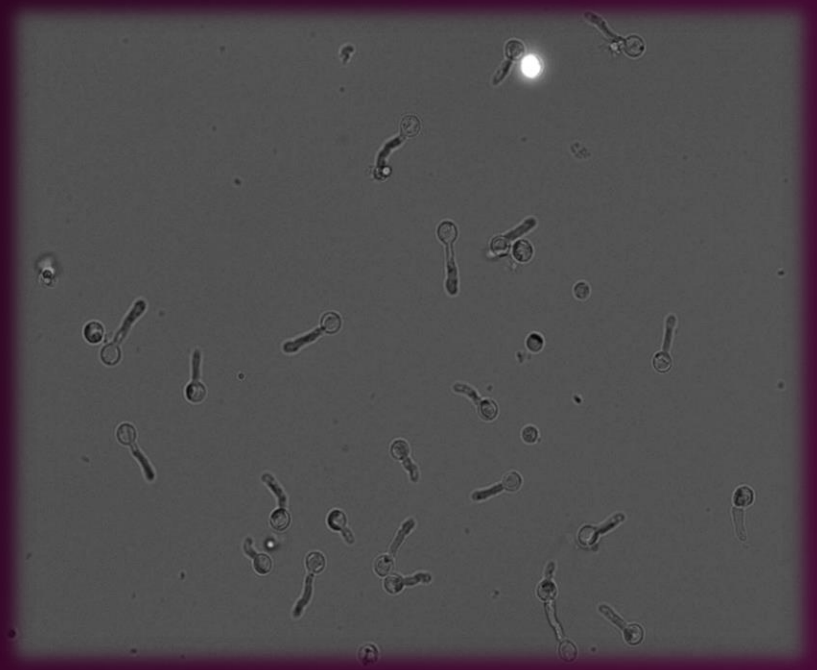


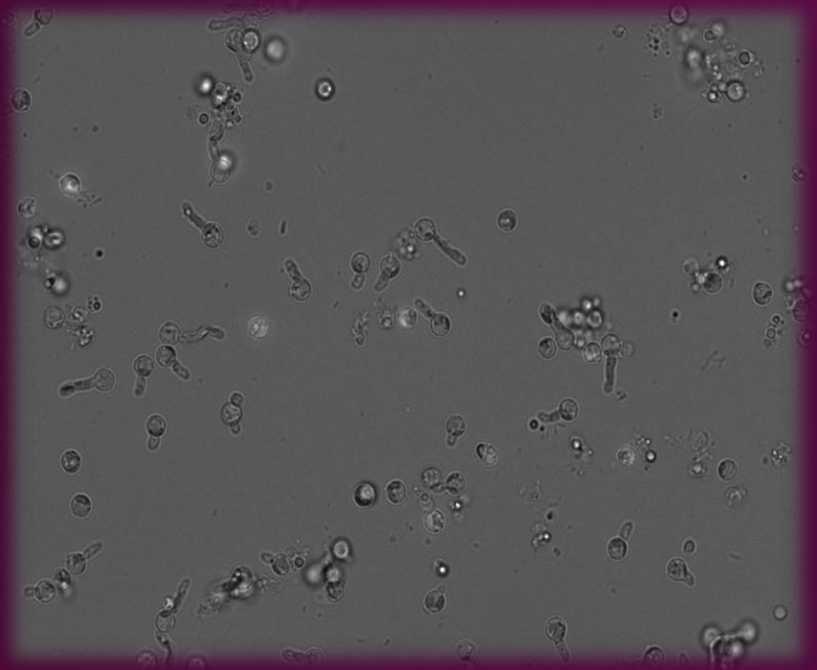
Spore Density

- Difference in spore release with warm SST
- 17°C appears to be approaching the upper limit for spore production
- Direct or indirect effect?



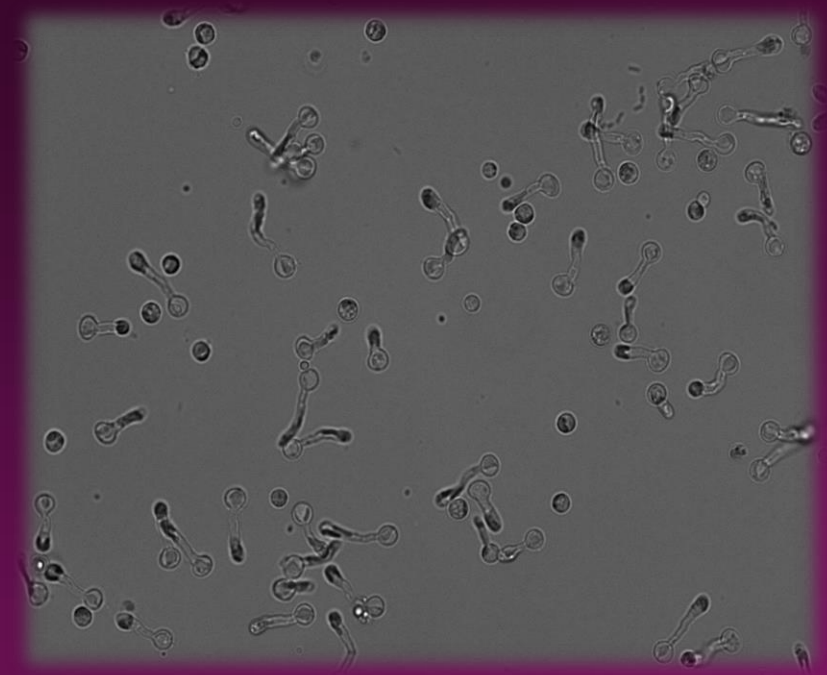
10°C

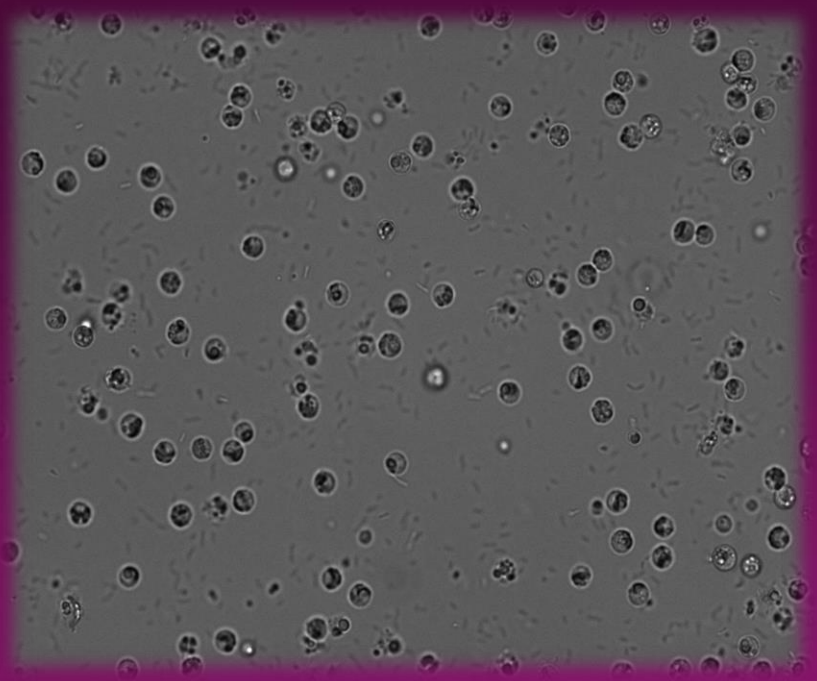




17.5°C

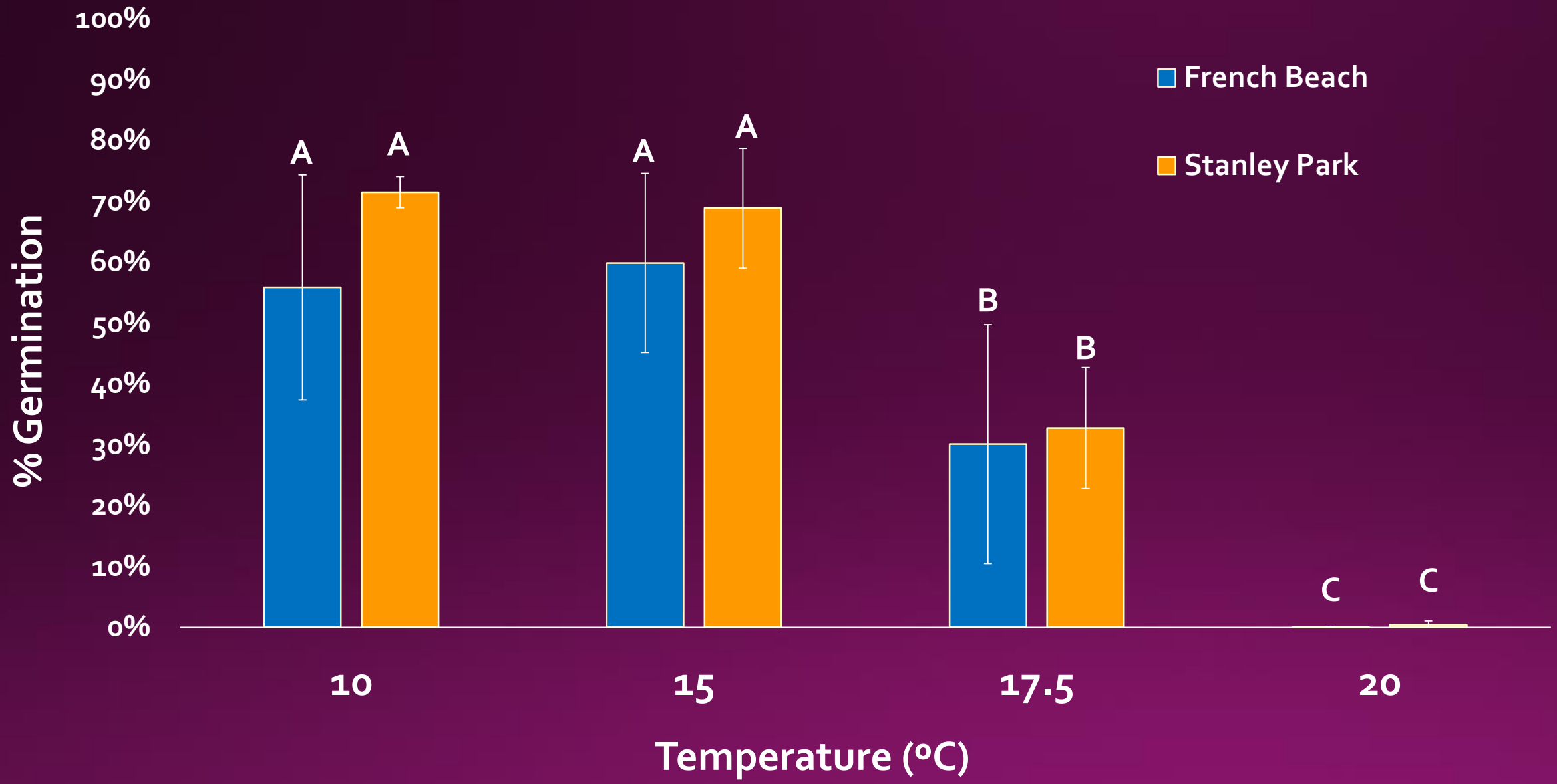
15°C





20°C

Overall Germination %



Conclusions

- Salish Sea is exposed to different temperature regimes throughout the summer
- 17°C appears to be the upper limit for spore formation
- At 17°C spore germination also decreases significantly, whereas 20°C kills off spores
- Warm conditions lead to shortened reproductive season for *Nereocystis*, potentially impacting recruitment

Acknowledgements

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- Tommy Kim and Mary Clinton


Questions?