Potential of the HyspIRI mission for monitoring the physiological condition of giant kelp forests

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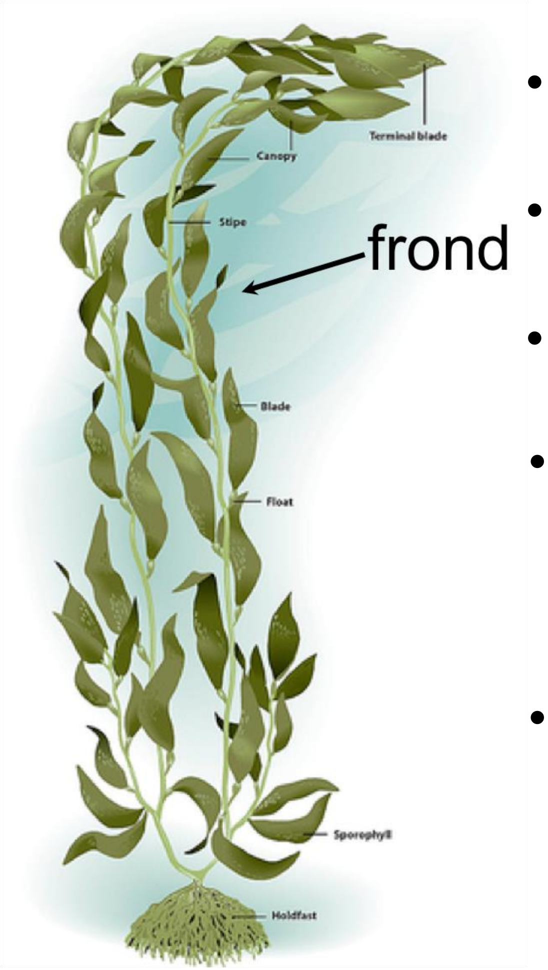
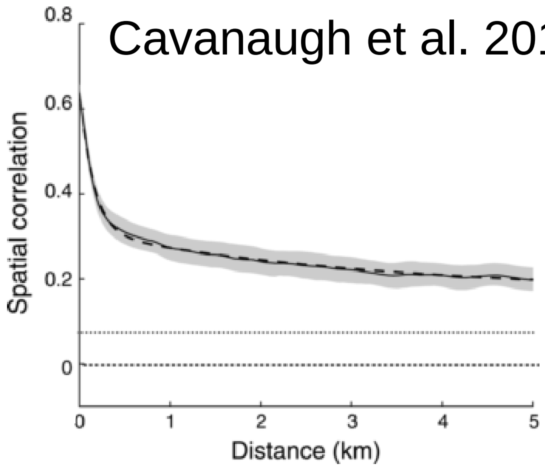
Photo: Stuart Halewood

Giant kelp is highly dynamic… and important

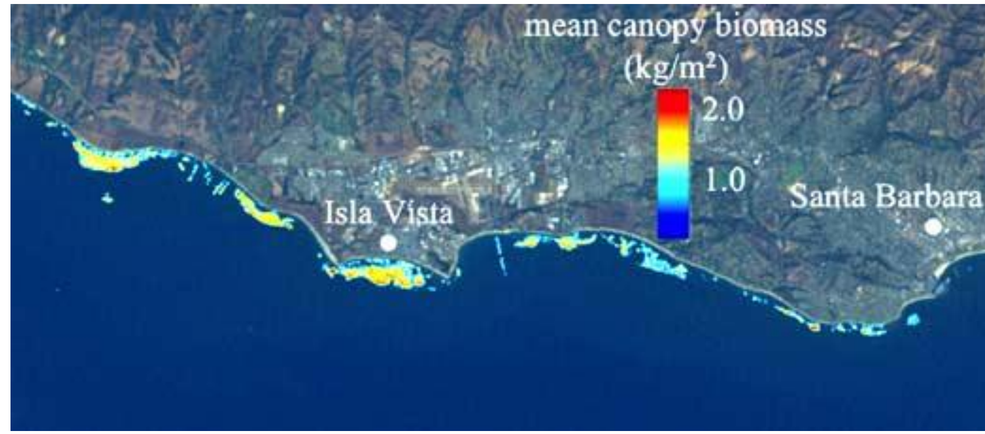


- Thallus lifespan: ~2.5 yr
- Frond lifespan: ~4 months
- Frond growth rate: 0.5 m d^{-1}
- Food and habitat for important species
- Canopy amenable to remote sensing

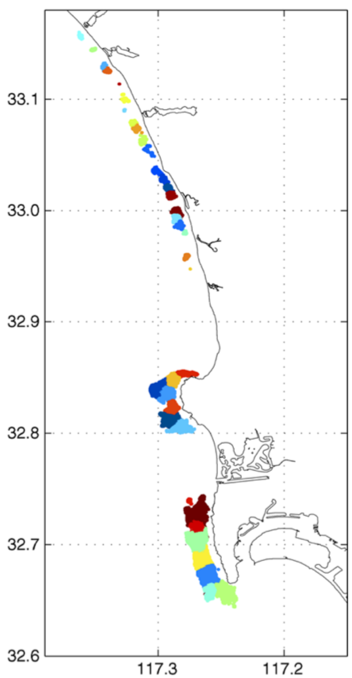
Landsat kelp canopy biomass timeseries



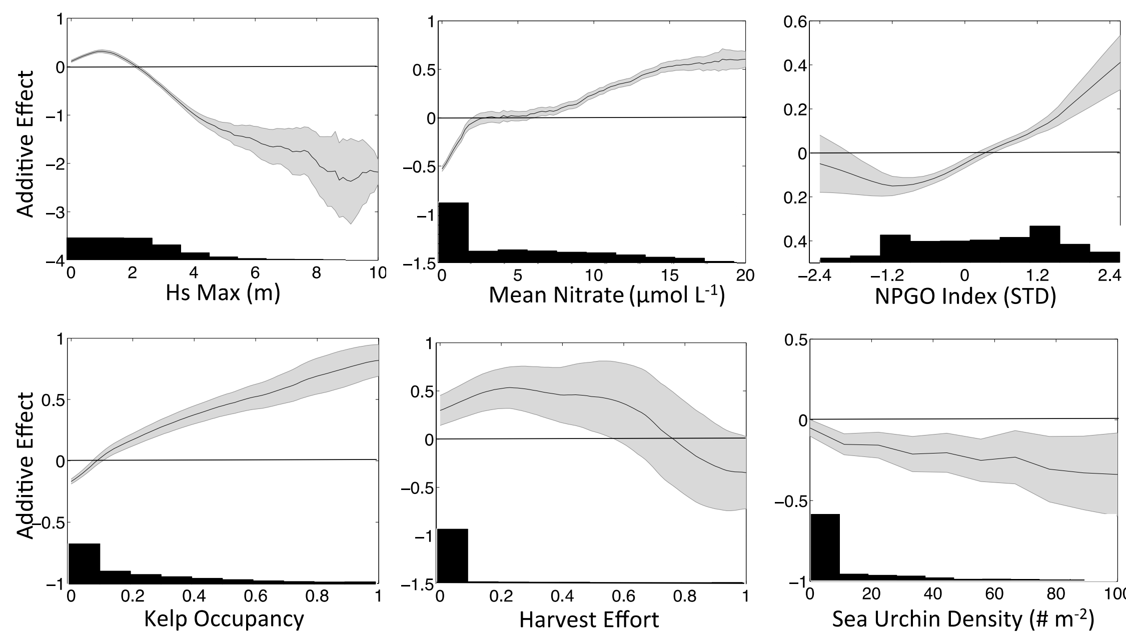
Cavanaugh et al. 2013



Cavanaugh et al. 2011



Cavanaugh et al. 2014



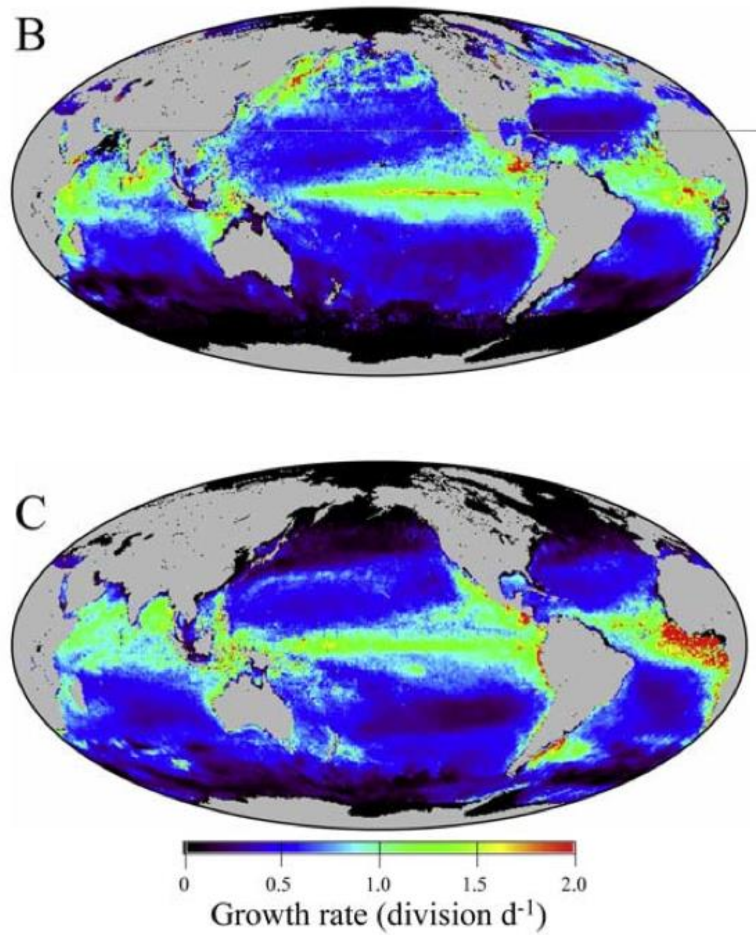
Bell et al. 2015

Physiologic state of marine flora is dynamic

- Aquatic photosynthetic organisms respond to changes in
  - Light
  - Nutrients
  - Temperature

- Quantify response by changes in the ratio of chlorophyll to carbon (Chl:C) (Geider 1987)

- Chl:C = physiological condition

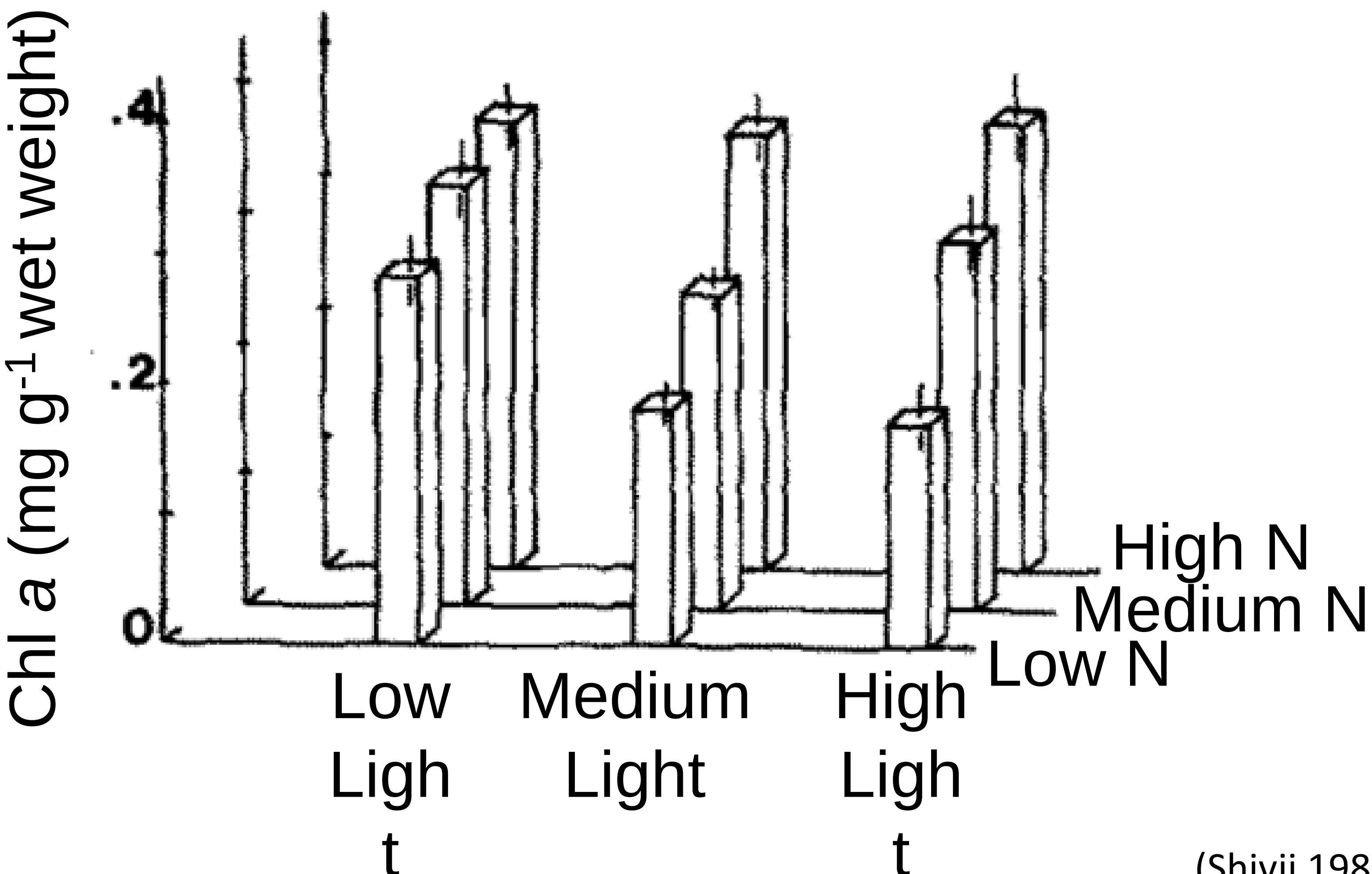


(Behrenfeld et al. 2005)

Physiological state (Chl:C) dynamics are unknown for giant kelp

- Affect photosynthetic rates and net primary production
- Alter energy flows and change interaction strengths between kelp forest species
- Deterioration of fronds hinders ability to provide biogenic structure and withstand disturbance
- Likely to vary over time and space

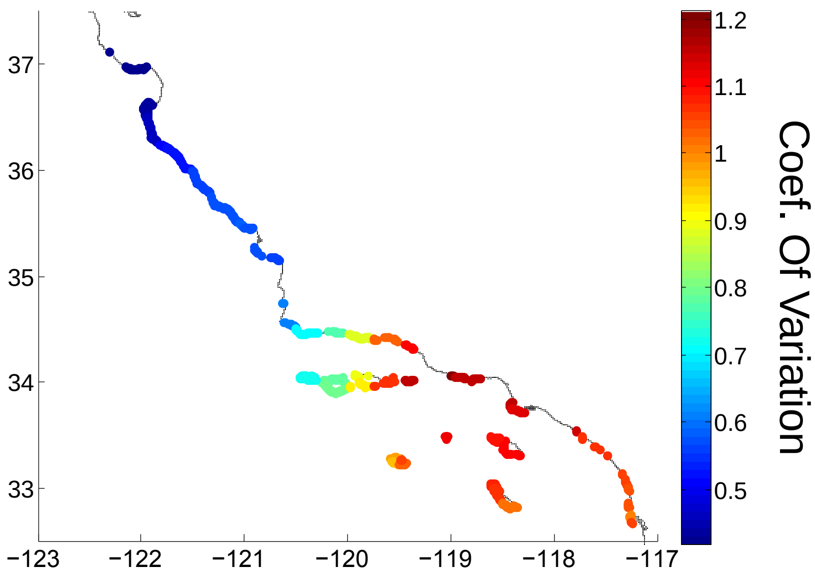
Low light and high nutrients increase Chl *a* in giant kelp



(Shivji 1985)

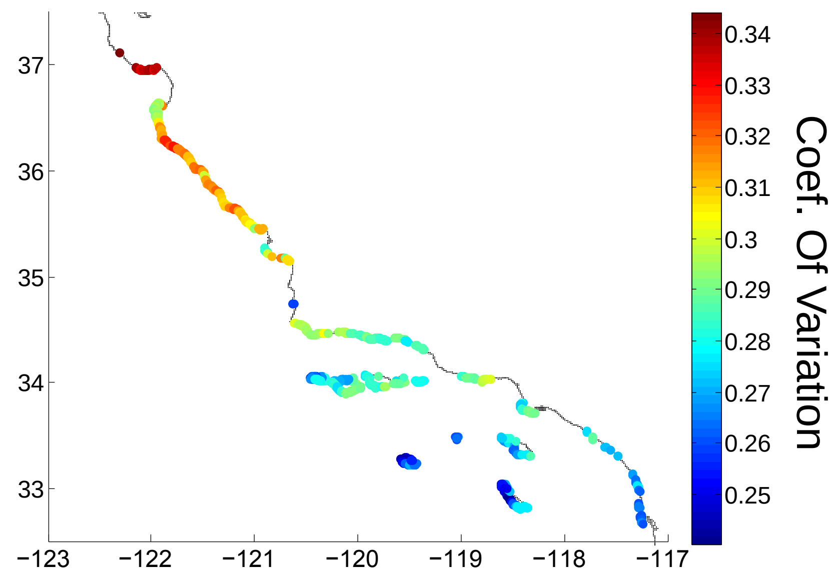
Giant kelp exists in a variable environment

Surface NO_3 (1987 – 2011)



(NO_3 estimated from SST; AVHRR)

PAR (1987 – 2011)



(AVHRR)

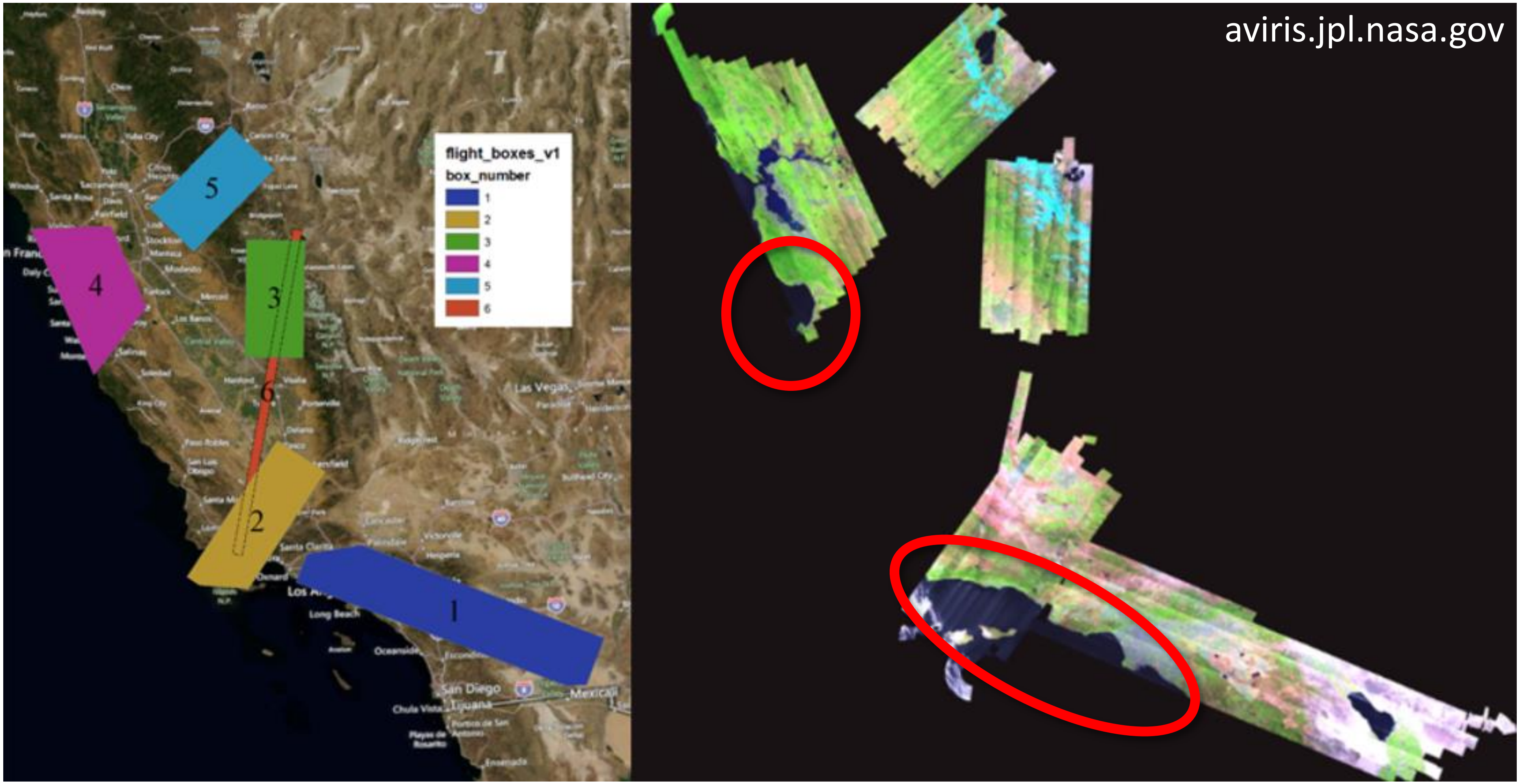
Giant kelp blade color changes in time

Mohawk kelp forest blades
(Santa Barbara, CA)

March 2013

October 2014

HyspIRI Preparatory Airborne Campaign



Determining blade reflectance and Chl:C

- 3 Santa Barbara forests monthly (15 blades)
  - Arroyo Burro
  - Arroyo Quemado
  - Mohawk

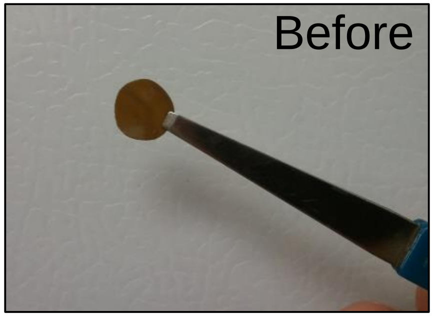
- San Diego & Santa Cruz seasonally (15 blades)

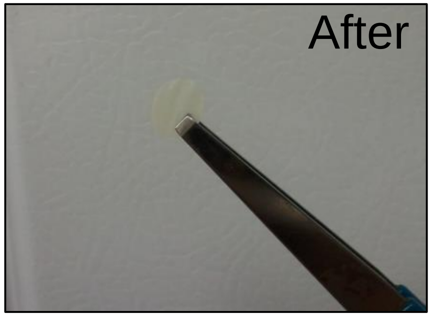
- Reflectance, transmittance from 350 – 800nm

- Chl *a*, Chl *c*, fucoxanthin extracted and determined by spectroscopy (Seely et al. 1972)

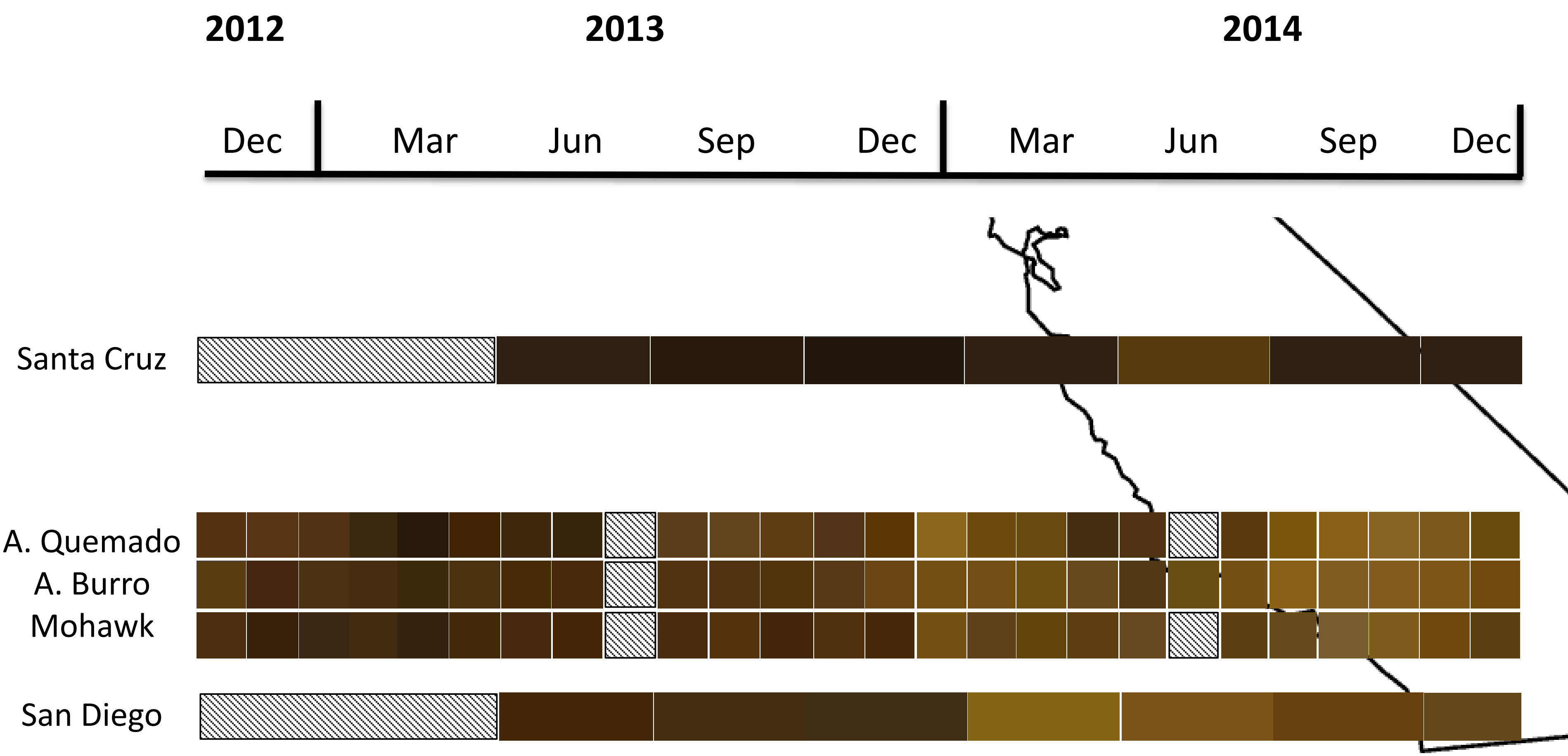
- Pooled C/N analysis

- Timeseries continuing

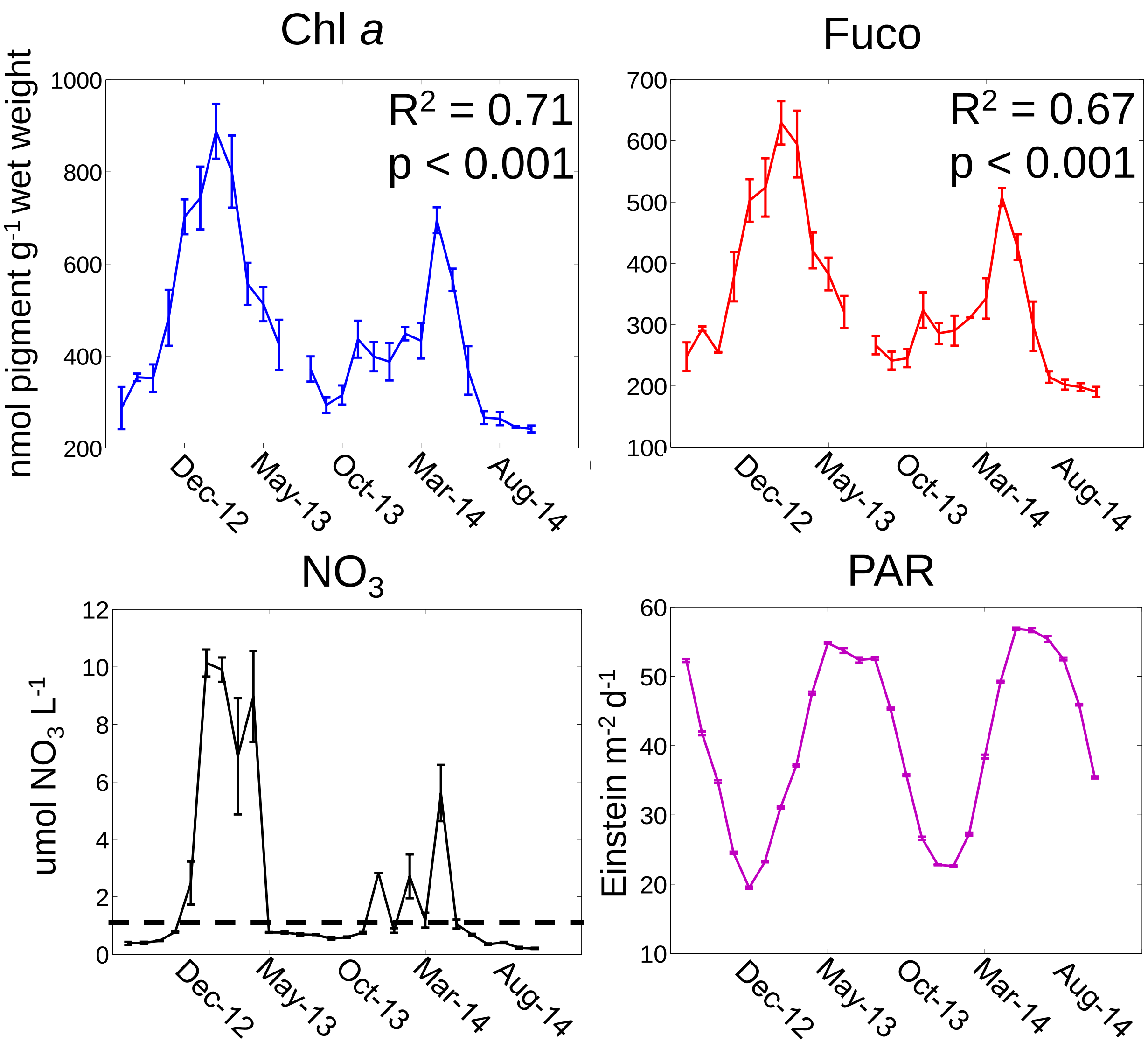




Surface blade color has changed seasonally and interannually



Pigments in the SB Channel resemble nutrient patterns more than insolation



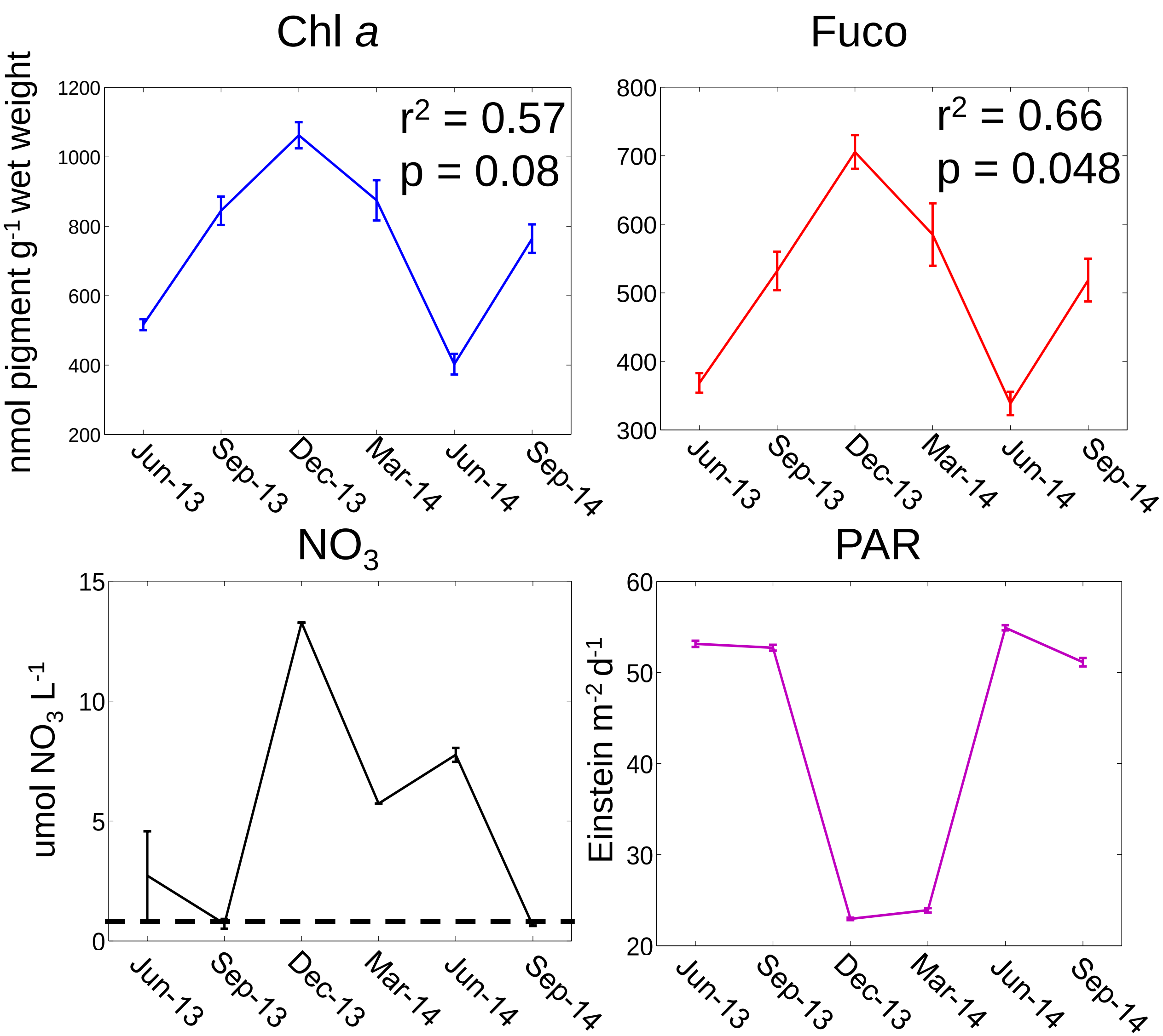
NO_3 estimated from SST (MODIS)

Multiple linear regression against NO_3 and PAR

	Chl *a*	Fuco
NO_3	0.67	0.69
PAR	-0.23	-0.18

Coefficients estimated using ridge regressions

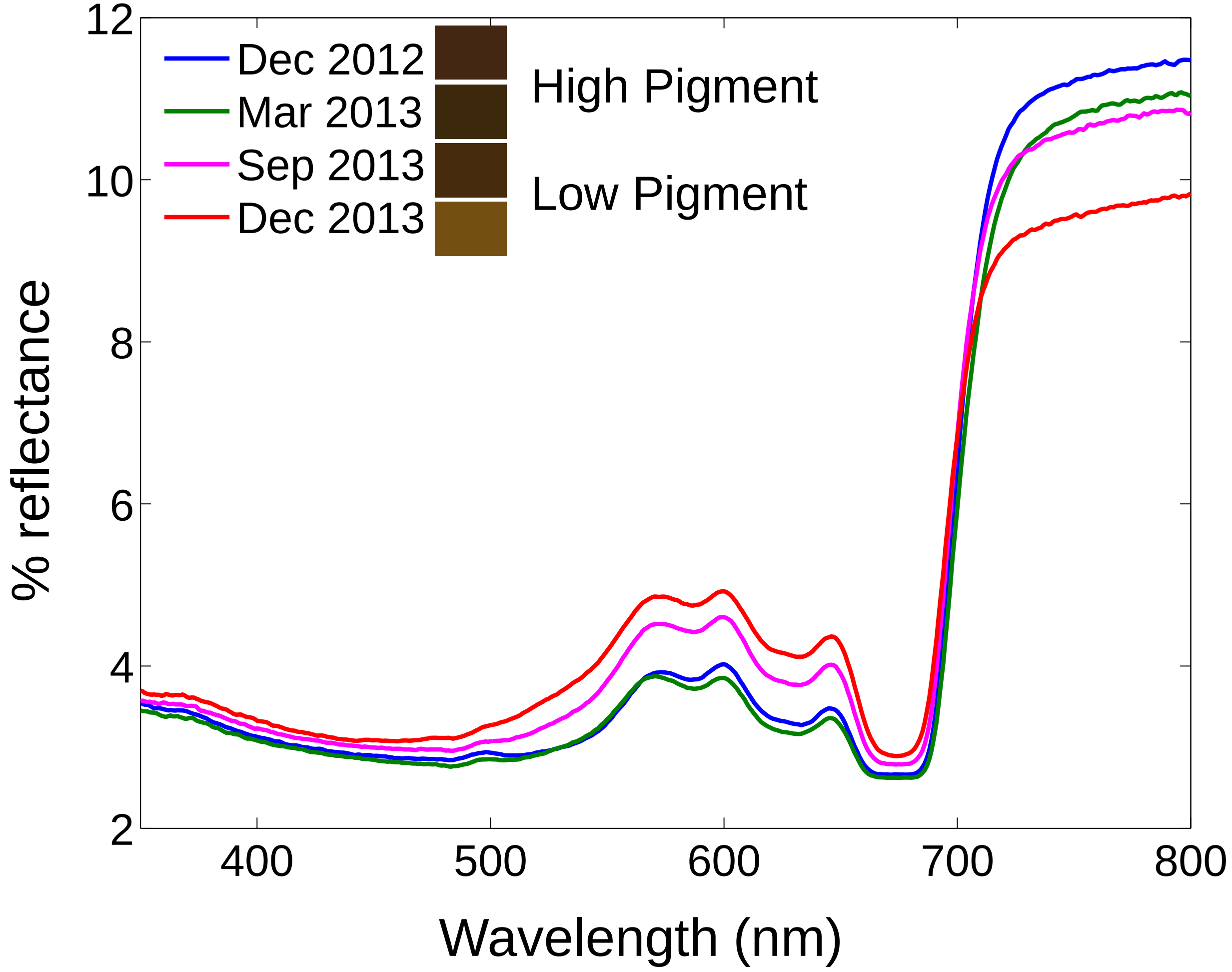
Pigments in Santa Cruz more closely resemble changes in insolation



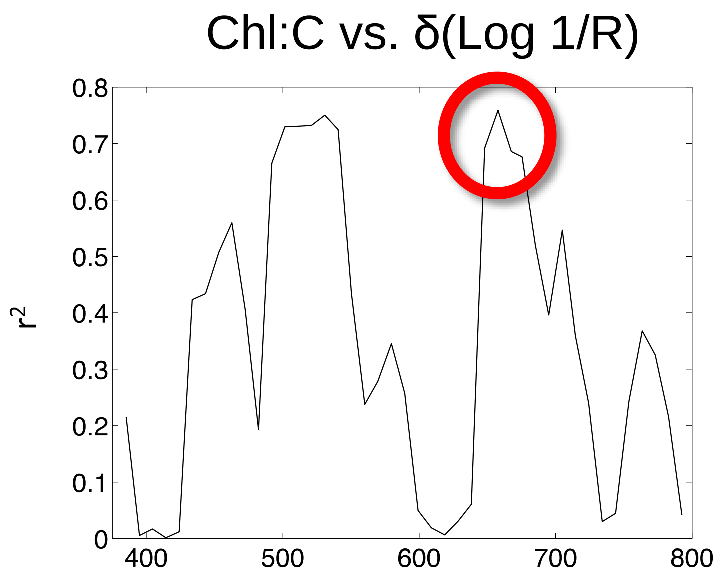
Simple linear regression against PAR

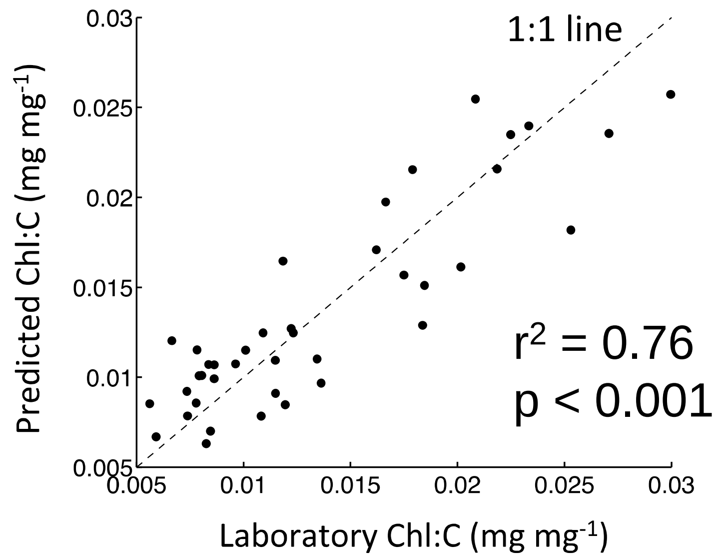
NO_3 estimated from SST (MODIS)

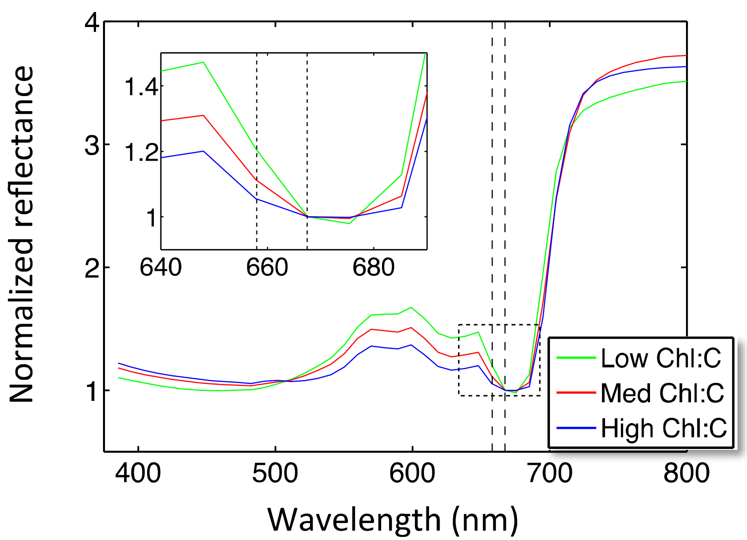
Blade reflectance changes through time

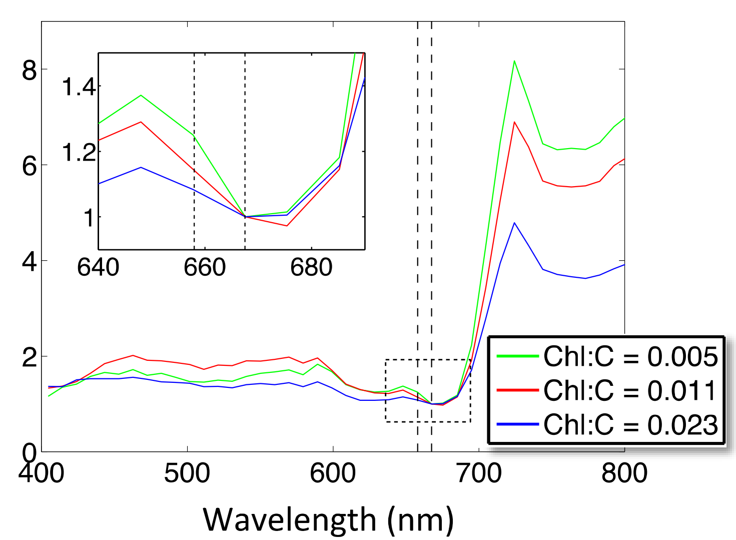


Spectral slope from 658 – 667nm relates to Chl:C



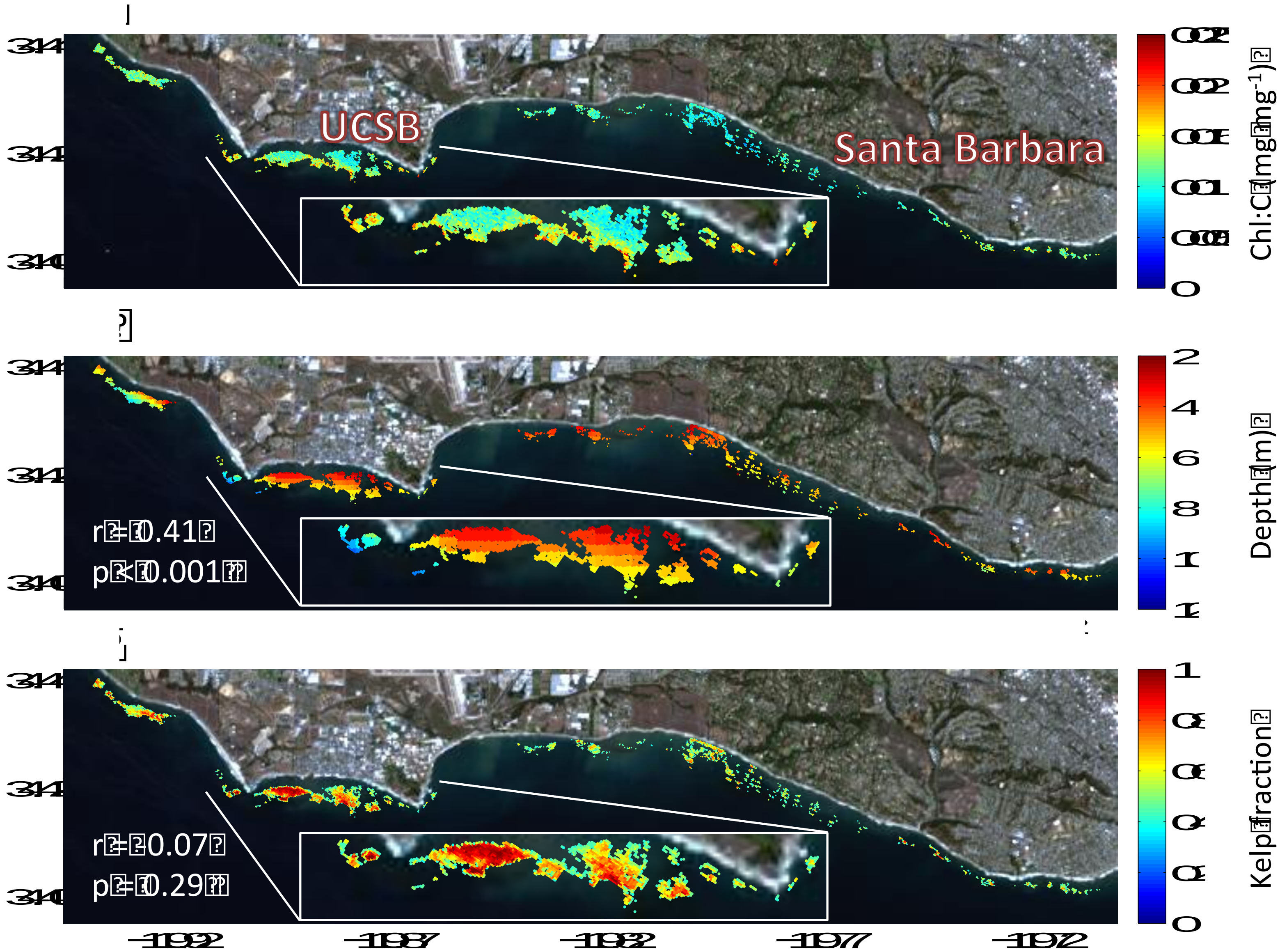






Santa Barbara box (4/11/2013)

Giant kelp canopy physiological condition varies over local scales

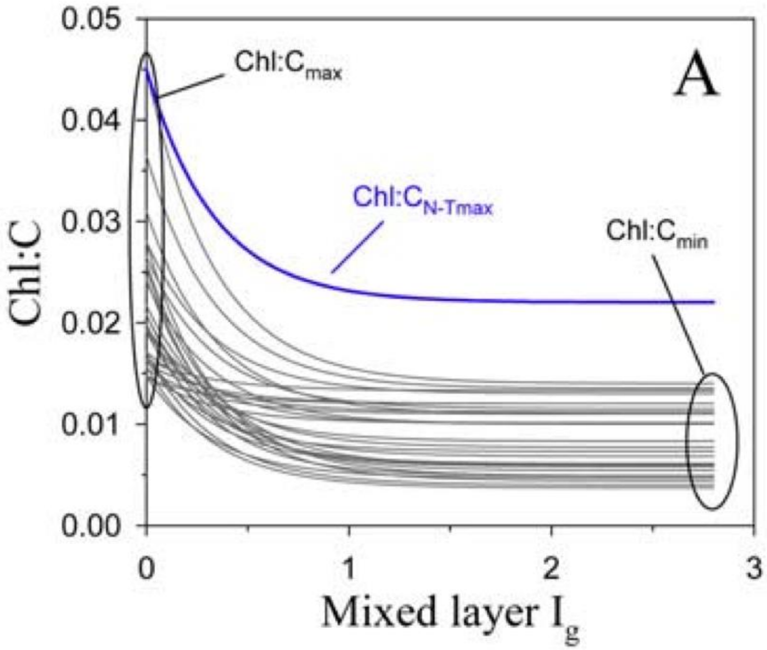


From Chl:C to NPP

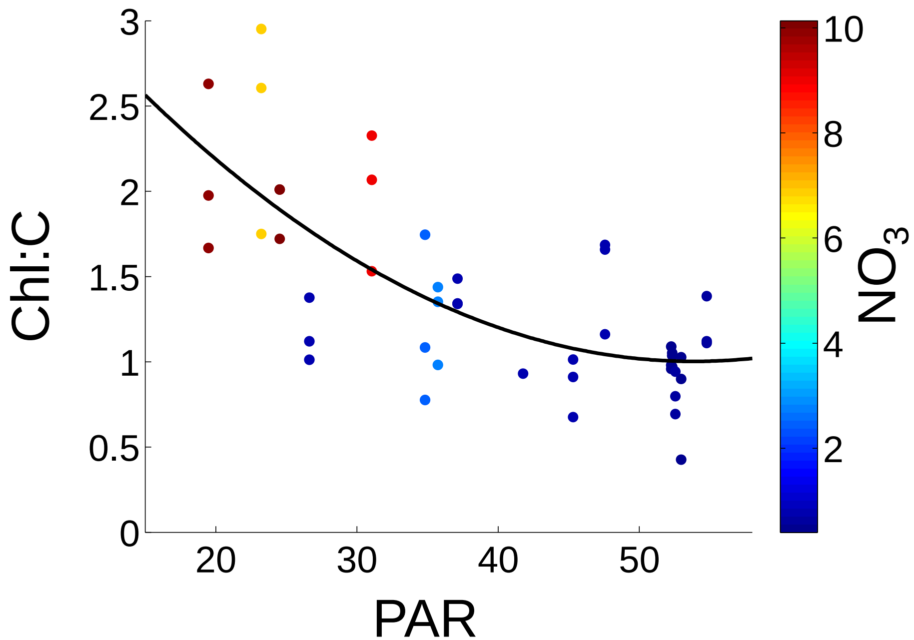
Landsat (Cavanaugh et al. 2011)

$$NPP = \mu * biomass$$

$$\mu = \mu_{max} * [Chl{:}C/Chl{:}C_{max}] * g(PAR)$$



(Behrenfeld et al. 2005)



Giant kelp (this study)

Future directions

- Apply algorithm to all giant kelp canopy in HyspIRI Prep. Imagery
- NPP estimates of kelp canopy
  - Compare to diver estimated NPP from the SBC LTER

Acknowledgements

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Thank You!

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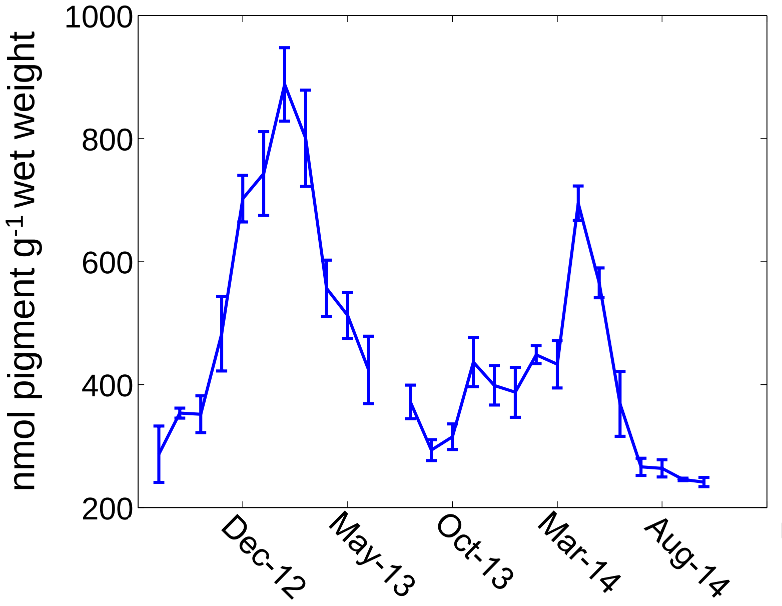
Photo: Kenneth Kopp

HyspIRI will provide at least one seasonal cloud-free image in the vast majority of giant kelp's range

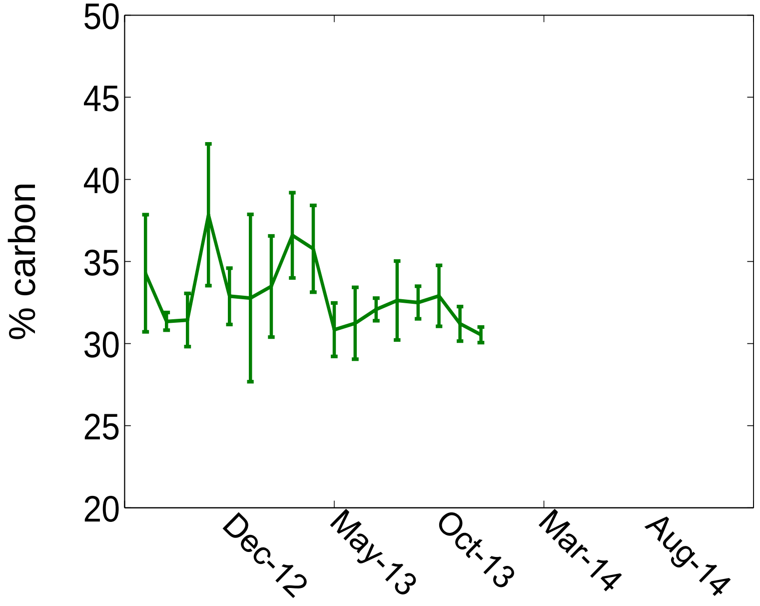
	Region							
	NW North America	SW North America	South America	Falkland Islands	South Africa	Tasmania	New Zealand	Sub-Antarctic Islands
HyspIRI only								
Jan-Mar	1.0 (0.2)	2.0 (0.5)	1.0 (0.6)	1.1 (0.2)	2.5 (0.8)	1.5 (0.4)	1.4 (0.4)	0.6 (0.3)
Apr-Jun	1.3 (0.3)	2.0 (0.5)	1.1 (0.4)	1.1 (0.3)	2.1 (0.6)	1.4 (0.4)	1.4 (0.4)	0.7 (0.3)
Jul-Sep	1.5 (0.6)	2.3 (0.7)	1.1 (0.3)	1.0 (0.2)	2.1 (0.6)	1.3 (0.4)	1.4 (0.4)	0.9 (0.4)
Oct-Dec	1.0 (0.2)	2.2 (0.6)	0.9 (0.5)	1.1 (0.2)	2.2 (0.7)	1.3 (0.3)	1.2 (0.3)	0.6 (0.2)
HyspIRI & Landsat 8								
Jan-Mar	2.2 (0.4)	4.4 (1.0)	2.1 (1.3)	2.5 (0.5)	5.4 (1.8)	3.2 (0.8)	3.0 (0.9)	1.3 (0.7)
Apr-Jun	2.9 (0.6)	4.3 (1.2)	2.4 (0.8)	2.3 (0.6)	4.6 (1.3)	3.0 (0.8)	3.0 (0.9)	1.6 (0.7)
Jul-Sep	3.4 (1.4)	4.9 (1.6)	2.4 (0.7)	2.2 (0.5)	4.6 (1.4)	2.9 (0.8)	3.0 (0.8)	1.9 (0.9)
Oct-Dec	2.1 (0.5)	4.8 (1.3)	1.9 (1.0)	2.5 (0.5)	4.8 (1.6)	2.8 (0.7)	2.6 (0.6)	1.3 (0.5)

Variability in Chl *a* dominates the Chl:C

Chl *a*



Carbon



Equation

$$Chl{:}C = 0.0353^{-7{:}53x}$$