Phytoplankton absorption from ac-9 measurements

Julia Uitz

Ocean Optics 2004

Objective

- Study phytoplankton “eco-physiology”, by using $a(\lambda)_\phi$ as a proxy
- ac-9 $a(\lambda)_p$ data to derive $a(\lambda)_\phi$
- Model developed by Roesler et al.,L&O (1989)

$$a(\lambda)_\phi = a(\lambda)_p - a(\lambda)_{NAP}$$

Data & Method

- ac-9 data from Cruise 1 data: station 1 (shallow waters), and station 2 ~ dock (reference) + spec data from dock and Cruise 2
- Raw data from ac-9 and spec measurements are calibrated before being used
- Particulate absorption calculated from:

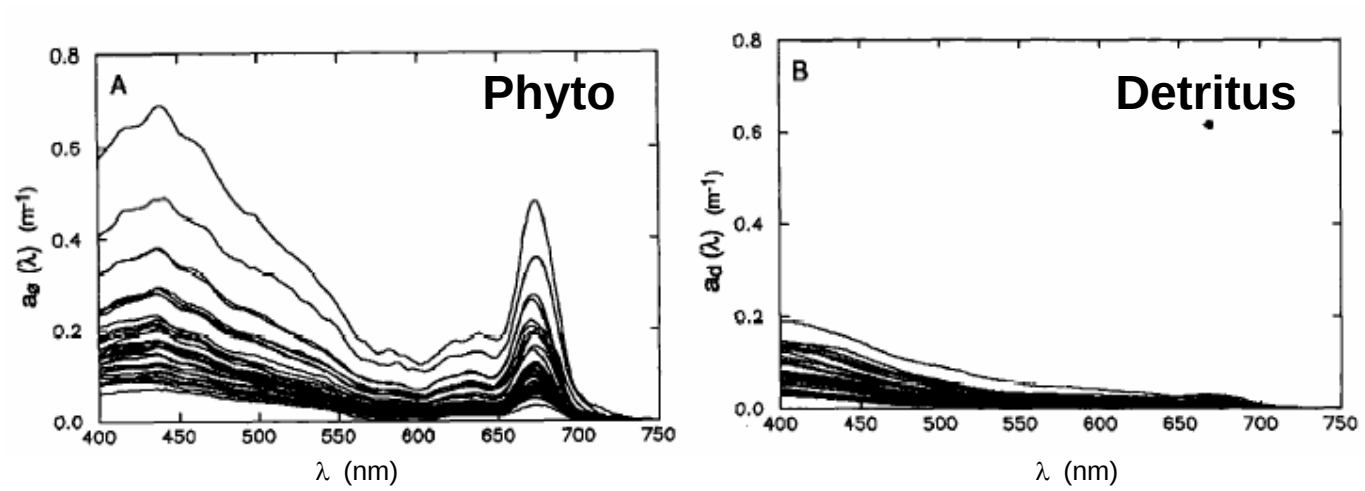
$$a(\lambda)_p = a(\lambda)_{\text{whole sample}} - a(\lambda)_{\text{sample filtered over } 0.2\mu m}$$

Model: Knowledge and Assumption

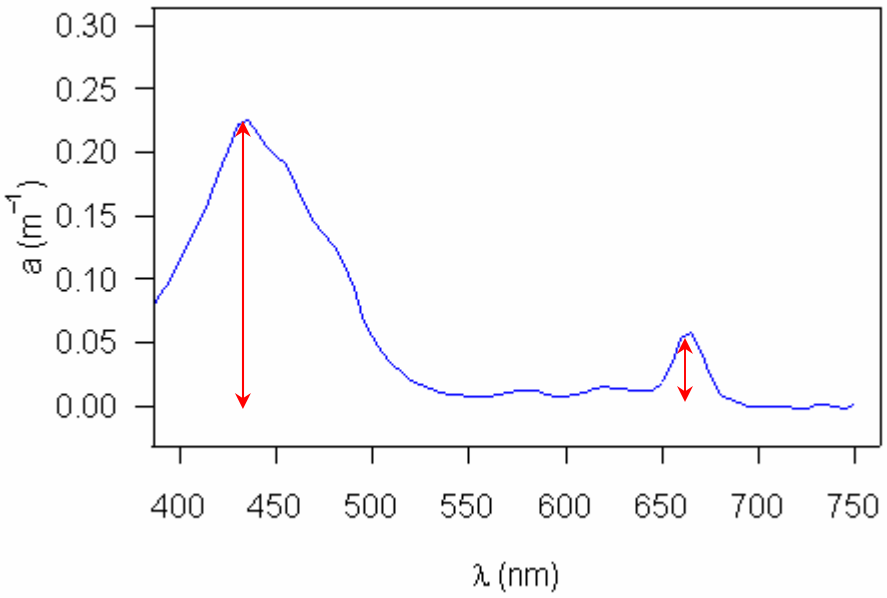
- $a(\lambda)_{NAP}$ variations restricted to blue region of the absorption spectrum, usually modeled as

$$a(\lambda)_{NAP} = a(\lambda_o)_{NAP} \exp\{-S\ (\lambda-\lambda_o)\}$$

- S varies in a small range (~ 0.009 – 0.0178, from Babin et al., JGR, 2003)
- Need to find a λ_o for which a_{NAP} can be identified



From Roesler et al., L&O (1989)



Model: Knowledge and Assumption

- $a(\lambda)_\phi$ is highly variable (magnitude and shape)
- All pigments absorption is comprised in $a(676)_p$
- Only pigments absorption contributes to $a(676)_p$

$$a(676)_p \sim a(676)_\phi$$

- The $\phi_{440:676}$ ratio is well known or can be estimated (varies ~ 1.1-2.1)

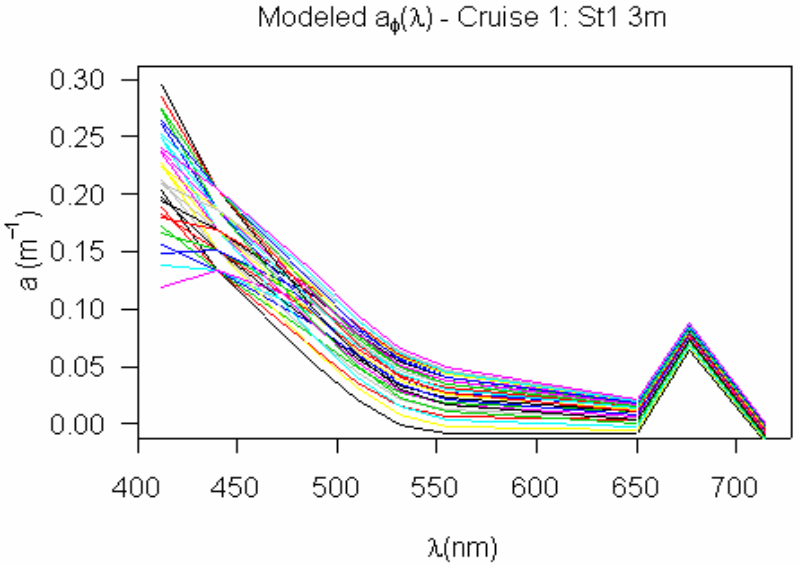
Model:
Knowledge and Assumption

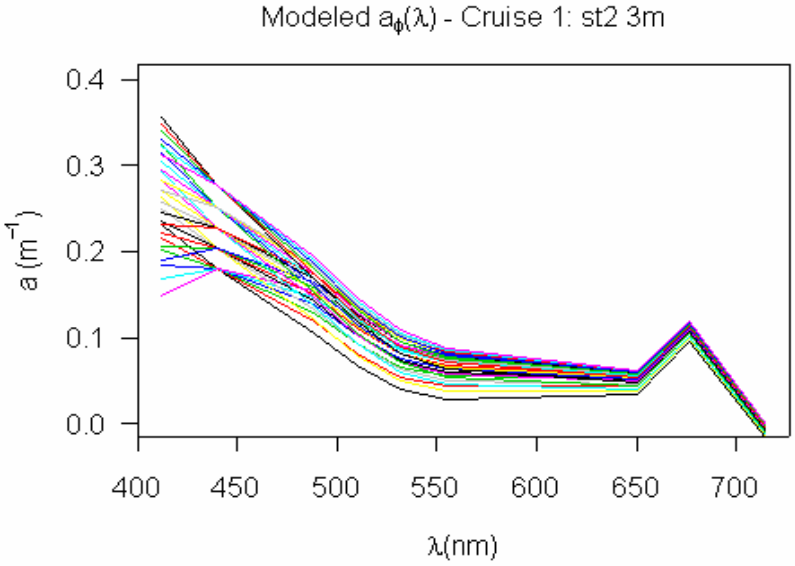
- $a(440)_{\phi}$ is known: $a(676)_{\phi} * \phi_{440:676}$
- $a(440)_{NAP} = a(440)_{p} - a(440)_{\phi}$
- $a(\lambda)_{NAP}$ can be computed
- Finally: $a(\lambda)_{\phi} = a(\lambda)_{p} - a(440)_{NAP} * \exp\{-S\ (\lambda-\lambda_{o})\}$

Application to ac-9 data

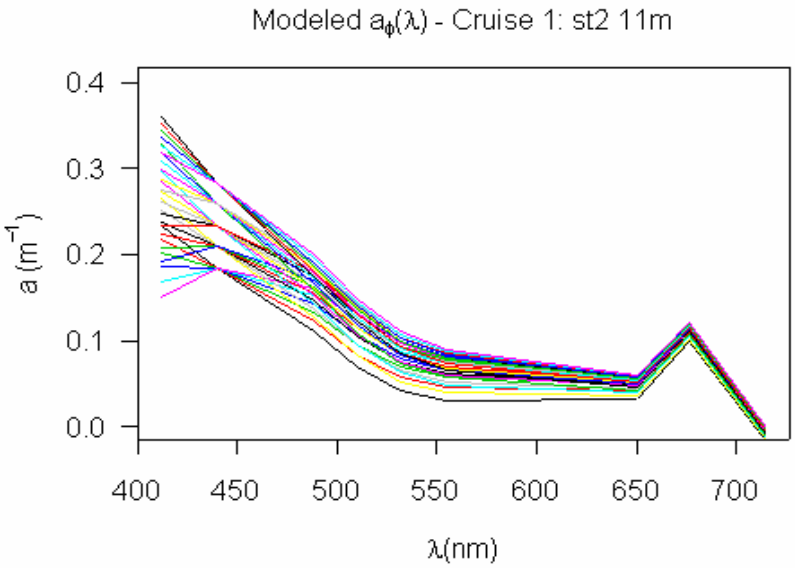
- Wide range of values of $\phi_{440:676}$ and S were tested (plausible values and out of range)
- $\phi_{440:676}$: 1.5, 1.7, 1.9, 2.1, 2.3
- S: 0.0089, 0.011, 0.013, 0.015, 0.017, 0.019
- $\phi_{440:676}$ = 1.5 and S = 0.011 are the parameters calculated from spectrophotometer measurements (Dock)

Range of $a(\lambda)_\phi$ values

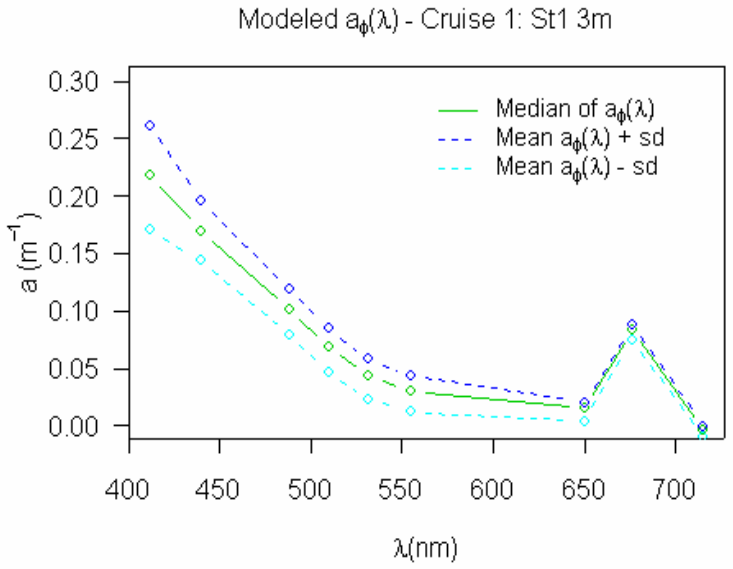


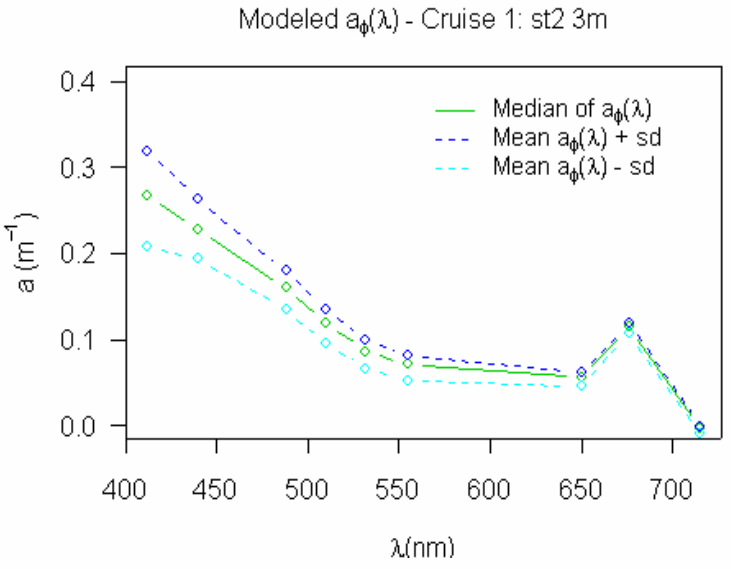


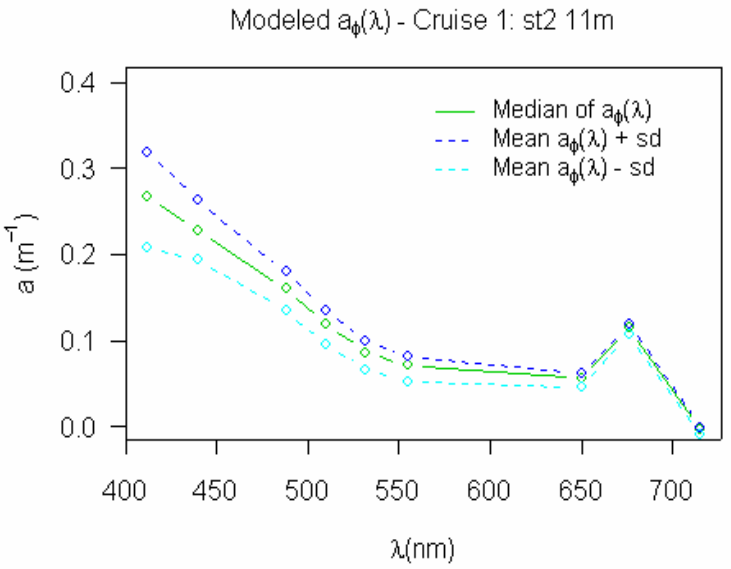
- Shape expected with spec parameters not obtained
- More “typical shapes” for S steeper than expected



Average $a(\lambda)_\phi$ values

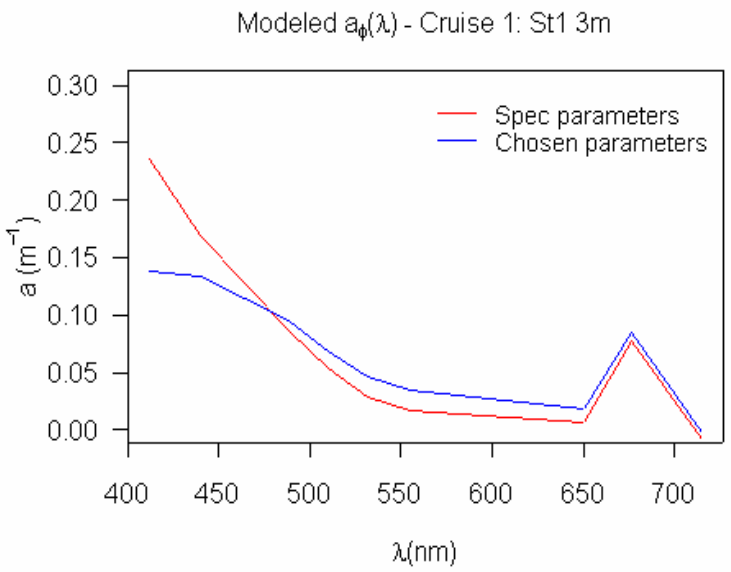


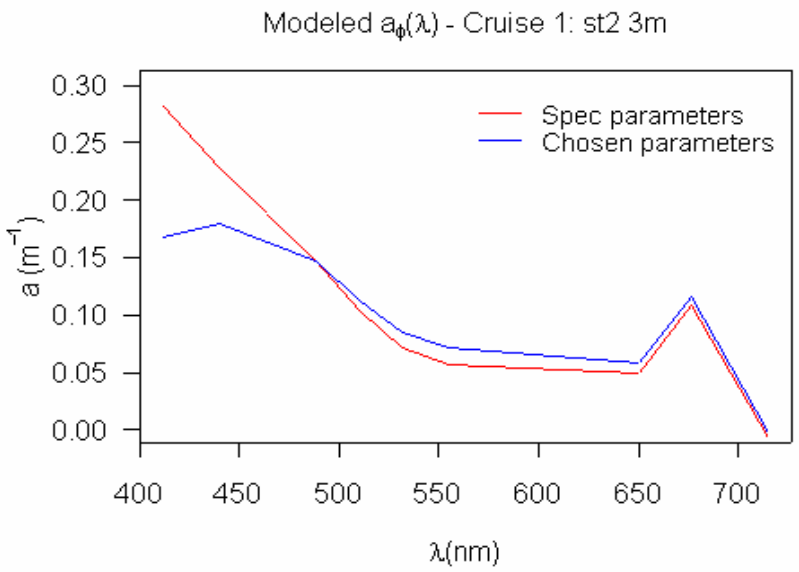




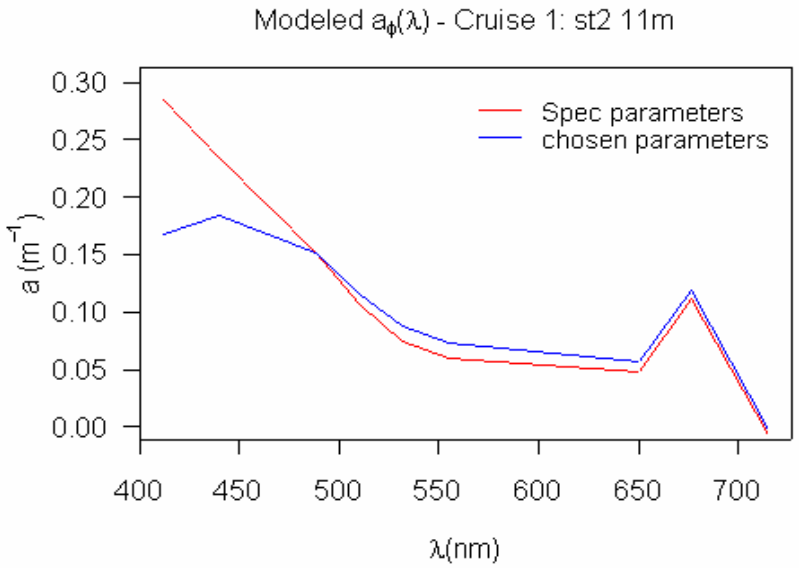
- Shape is not what was expected
- Chlorophyll peaks?
- Use extreme values

Extreme parameters vs Spectrophotometer parameters

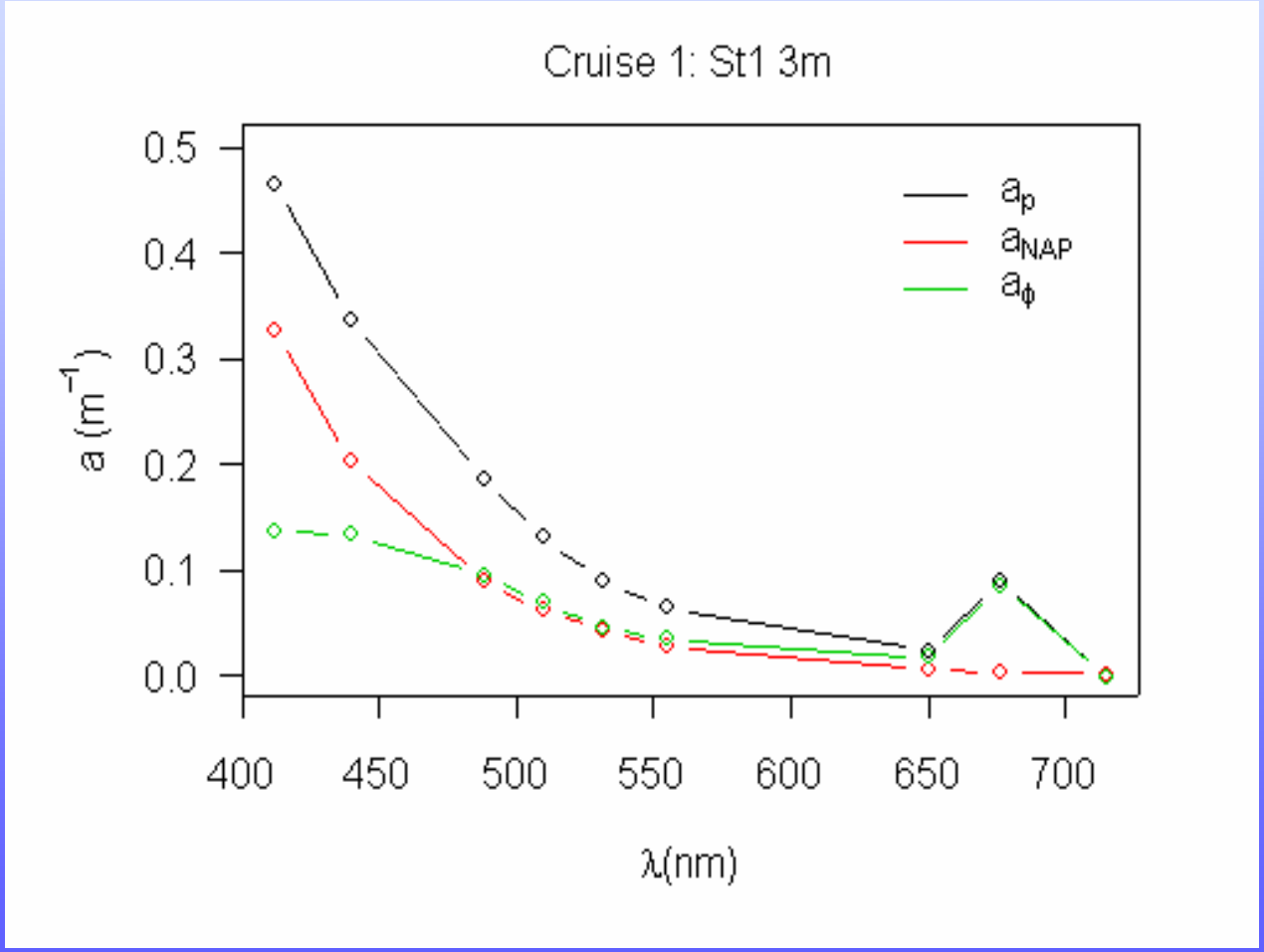




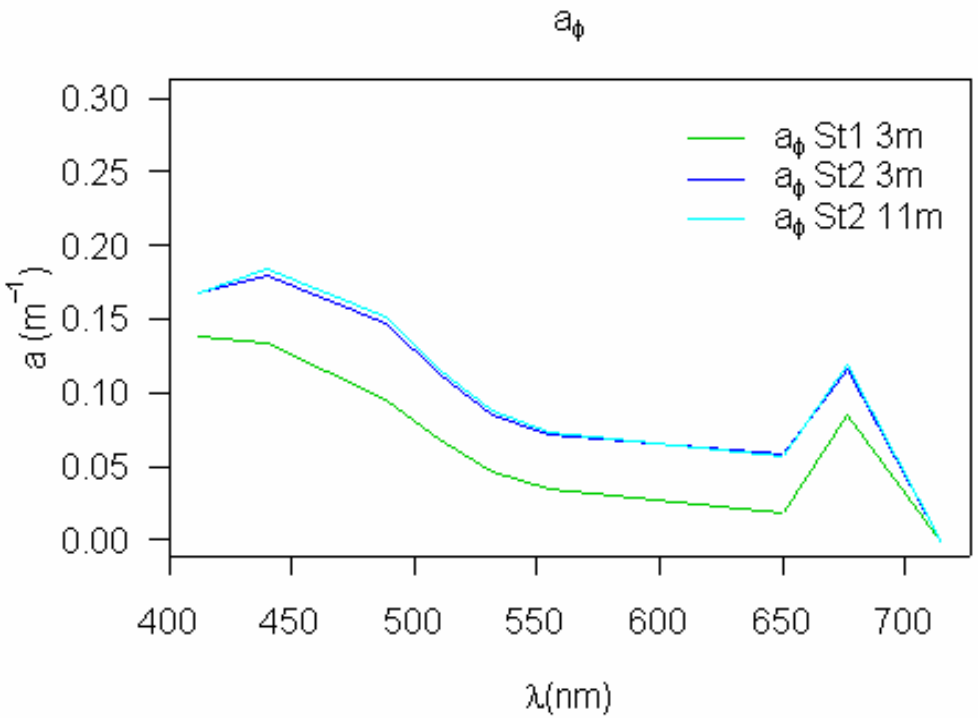
- Spec (dock sample): $\phi_{440:676}$ ~ 1.9 and S ~ 0.011 / Chosen: $\phi_{440:676}$ = 1.5 and S = 0.017
- Slope >> than given by spec
- In the range of published values, but extreme values!
- Shapes of st2 reliable?



Different a(λ) spectra derived from ac-9 measurements

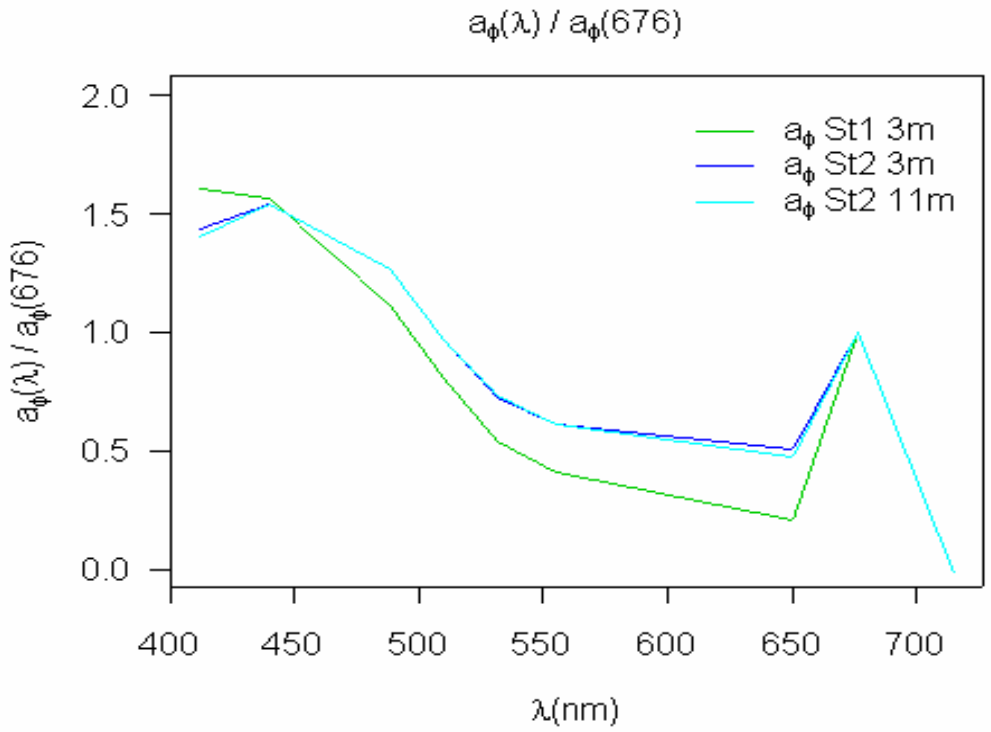


What can we learn from these spectra?



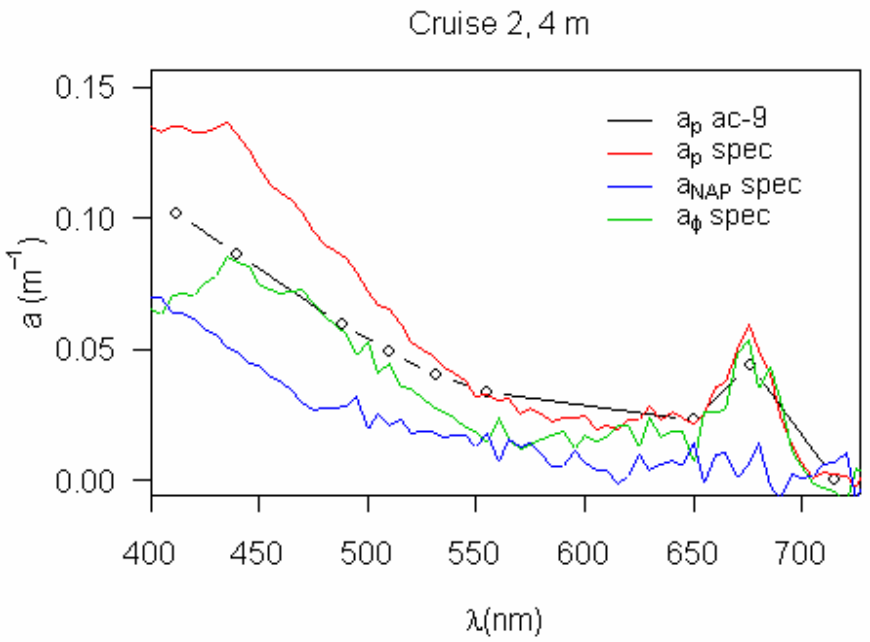
- St2 ~ homogeneous
- a_ϕ higher at st2 which may suggest more biomass
- Consistent with our knowledge of the sites

What else can we learn from these spectra?



- Compare shapes: normalized to red absorption
- At both stations: accessory pigments
- More PPC at st2?
- Are these spectra reliable enough?

Comparison ac-9 vs spectrophotometer data for Cruise 2

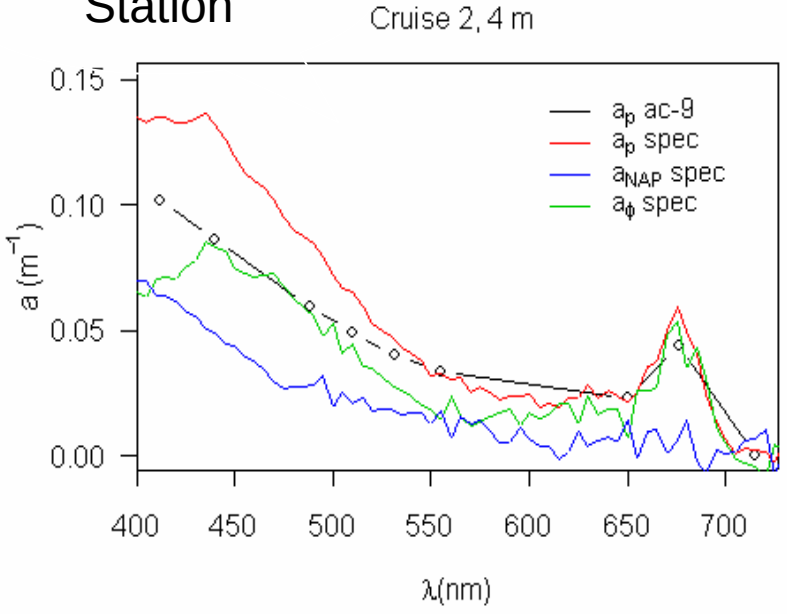


- Different scattering correction: spectral for ac-9 vs flat for spec
- Are spec data less accurate?

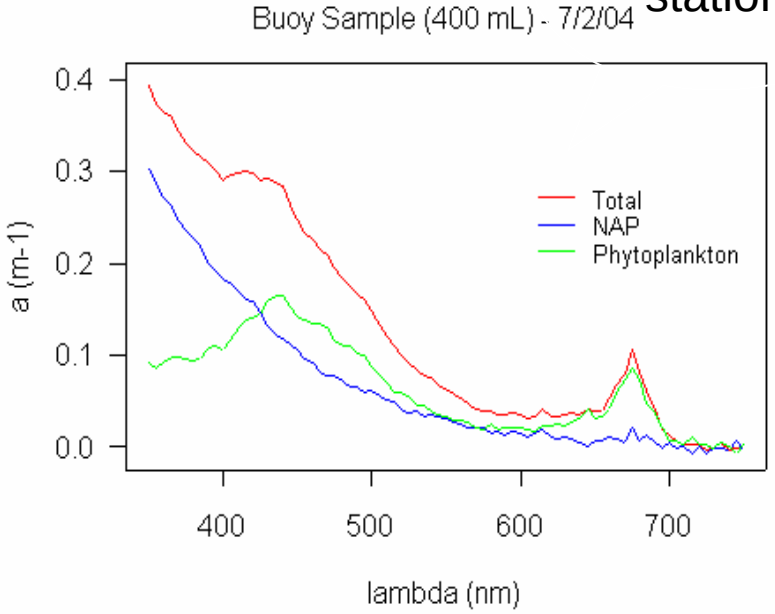
- a_ϕ from ac-9 are questionable
- a_p spectra need to be compared to independent measurements (spec)
- Disagreement between a_p from spec and ac-9
- May be due to different filters (0.2 μm for ac-9 vs 0.7 μm for spec)

Comparison of spectrophotometer data from two different sites

"Ocean" Station



"Coastal" station



- Cruise 2 (4 m): high contribution of phytoplankton
- Buoy sample (surface): contribution of NAP >> phytoplankton
- High concentration of NAP > 0.7 μm contributing to the spec a_{NAP}, and to the ac-9 a_p
- May explain the steep slope of $a(\lambda)_{NAP}$

Using $a(676)_\phi$ to estimate Chla concentration

Station	Mean	sd
St1 3 m	5.8 mg m^{-3}	0.5
St2 3 m	8.0 mg m^{-3}	0.4
St2 11 m	8.3 mg m^{-3}	0.4

- $a(676)_\phi$ / a_{Chl}^* = [Chl]
- Average a_{Chl}^* ~ 0.014 m^2 mg^{-1}
- a_{Chl}^* from other proxy (fluo) ~ 0.015 m^2 mg^{-1}
- St1 3m seems ~ consistent
- St2 3m and 11m: higher values than expected from other proxies
- $a(676)\phi$ is reliable
- [Chl] more sensitive to a_{Chl}^*

Conclusions

- **Choice of the proxies**
  - $a(\lambda)_\phi$ for phyto: not really evaluated through this work
  - $a(676)_\phi$ for [Chla]: must be relatively reliable, but sensitive to a_{Chl}^*

- **Method**
  - The model is robust
  - If analysis shows too high sensitivity to the parameters, then something may be wrong in the data
  - Useful indicator of the quality of the dataset
  - If applied to a good dataset, an “in situ” $a(\lambda)_\phi$ can be estimated (high vertical resolution, quick measurements, …)

- **Improvement**
  - Need to be compared to other proxies
  - More data!