Investigating the relationship between phytoplankton fluorescence and bloom composition in Harpswell Sound

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Project goal

To identify taxonomic changes in phytoplankton blooms between the common, harmless diatoms and potentially Red-Tide-forming dinoflagellates using pigmentation and fluorescence response differences. Accumulations of the dinoflagellate *Alexandrium funyense* (**Fig. 1**), known as Red Tide events, cause Paralytic Shellfish Poisoning, are toxic to humans that ingest shellfish, and thus cause massive closures of shellfish beds across Maine. Blooms occur every summer, and appears first in Harpswell Sound.

Background

Phytoplankton are single-celled aquatic photosynthesizers, which use *Chlorophyll-a* (*Chl-a*) to convert light into chemical energy. *Chl a* cannot absorb green underwater light, so phytoplankton produce taxonomically-unique green-absorbing accessory photosynthetic pigments. The accessory pigments fucoxanthin and peridinin are indicators of diatoms and dinoflagellates, respectively, as they only appear in those types of phytoplankton.. These accessory pigments change absorption spectra and associated fluorescence response, allowing for taxonomic identification

Materials and methods

- The Instrument:
  - The 3x1m (3 eXcitation, 1 eMission, **Fig. 2**) releases light at three wavelengths (435nm, 470nm, 532nm) and records fluorescence at one wavelength (695nm).
- Calculations:
  - Fluorescence readings at 435nm are used to calculate *Chl-a* concentration, which indicates phytoplankton concentration (**Fig. 3**)
  - Samples are sent to a lab for High Performance Liquid Chromatography, to obtain the exact concentrations of *Chl-a*, the diatom-specific accessory pigment fucoxanthin and the dinoflagellate-specific accessory pigment peridinin.

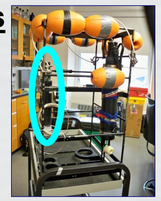
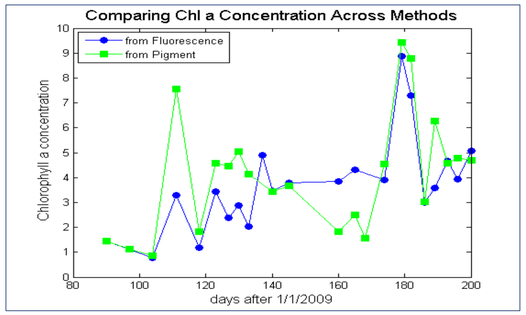
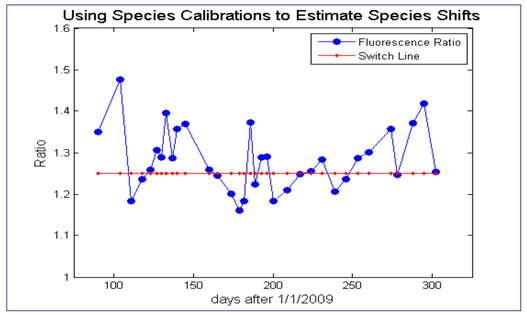


Figure 2. The 3x1m is attached to a metal profiling frame, which can be lowered into the water from the side of a boat. Readings are taken weekly, at high and low tides.



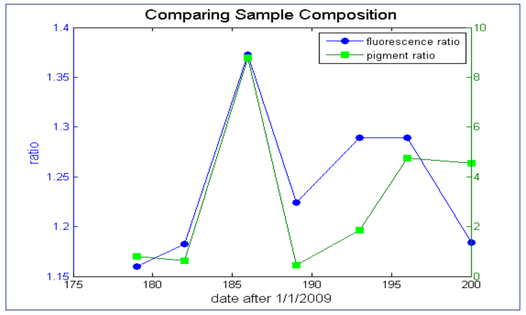
Comparing Chl a Concentrations

Figure 3. The concentration of *Chlorophyll-a* (*Chl-a*) was calculated using fluorescence data from 2009, and then compared to the concentration of *Chl-a* from High Performance Liquid Chromatography. The same pattern of two blooms, one in mid-April and one in late June, is shown in both methods. Differences are due to fluorescence quenching at high light levels and differences in species composition.



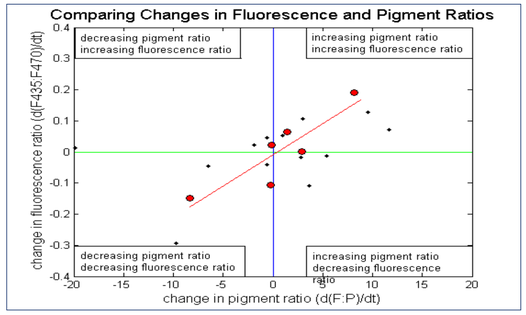
Estimating Species Shifts

Figure 4. Species calibration data (Procter) indicates that a higher ratio of the fluorescence reading at 435nm to the reading at 470nm indicates a population that contains more diatoms, and that a lower ratio indicates more dinoflagellates. This predicts that the population transitions from mostly diatoms to mostly dinoflagellates when the ratio is approximately 1.25.



Comparing Species Shifts

Figure 5. Both the fluorescence ratio of the readings at 435nm:470nm and the ratio of the accessory pigments of diatoms and dinoflagellates, fucoxanthin:peridinin, respectively, decrease with the presence of dinoflagellates, and increase with the presence of diatoms. Both methods indicate that the bloom which occurred contained a dinoflagellate bloom, a diatom bloom and a mixed bloom.



Validating the Relationship

Figure 6. Comparing the changes in ratios over time (with the late-June bloom period in red) using non-parametric statistics showed that 56% of the overall variation and 83% of the variation over the period of the bloom could be attributed changes in pigment and thus, to changes in population composition, even including the natural variability of the ocean ecosystem and the many non-pigment-related environmental factors which effect fluorescence.

Results

- *Chl-a* concentration calculated from fluorescence can predict phytoplankton blooms (**Fig. 3**).
- Environmental factors affect the efficiency of *Chl-a* fluorescence (**Fig. 3**).
- Fluorescence ratios exhibit variations that are coherent with population variations, such as an early diatom bloom replaced by dinoflagellates, followed by another diatom bloom (**Fig. 4**).
- The relationship between the fluorescence and pigment ratios is statistically significant (**Figs. 3 and 4**) and thus can be used to predict phytoplankton composition.

Conclusions

- The 3x1m instrument can be used to predict species shifts quickly, relatively inexpensively and in real time.
- This would allow us to predict Red Tide blooms in Harpswell Sound .
- As Red Tide appears first in Harpswell Sound when it blooms, this would further allow us to predict when Red Tide will appear in other areas.

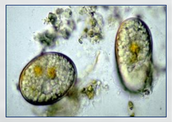


Figure 1.
A. Cell of *Alexandrium fundyense*, the phytoplankton which causes Red Tide
B. *Alexandrium fundyense* cysts, which fall to the ocean floor in the fall, and germinate into Red Tide in the spring.

Literature cited

Proctor, C. S. R. A. C. W. 2010. New insights on obtaining phytoplankton concentration and composition from in situ multispectral chlorophyll fluorescence. Limnology and Oceanography Methods **in press.**

Pictures:
- Background: Coastal Studies Center Buoy Deployment. Bowdoin College.
- Fig. 1A: Wikfors, G. Image of a living *Alexandrium fundyense* cell, a common cause of toxic algal blooms, swimming in water. National Oceanic and Atmospheric Administration.
- Fig. 1B: Woods Hole Oceanographic Institute. Image of microscopic *Alexandrium fundyense* cysts. National Oceanic and Atmospheric Administration.

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For further information

please contact *cjstratt@bowdoin.edu*. More information on this and related projects can be obtained at *http://www.bowdoin.edu/earth-oceanographic-science/index.shtml* or *http://www.bowdoin.edu/student-fellowships/undergrad-research/recipients/10-11-undergrad.shtml* .