FLuorescence for Ocean Research & Observations

Multi - functional lidar measurements to identify and characterize marine debris

"The ocean is dark – we need a light"

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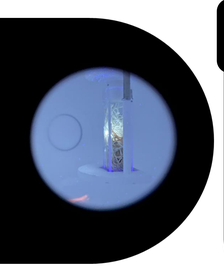
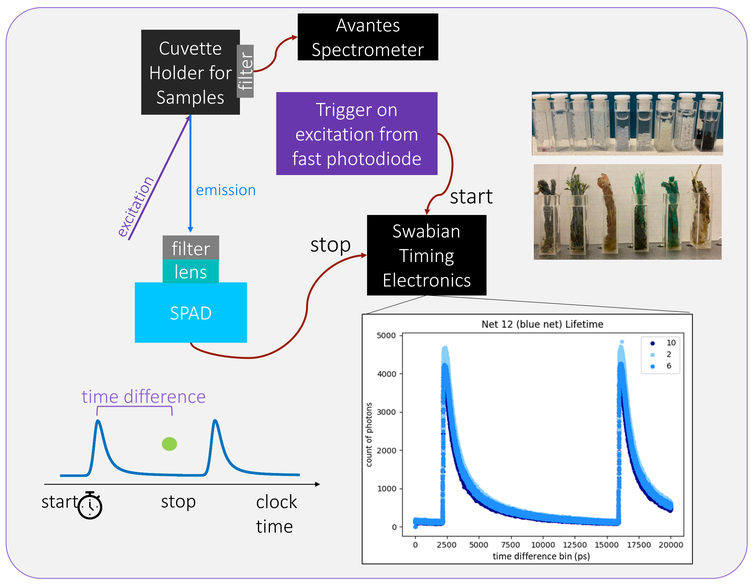
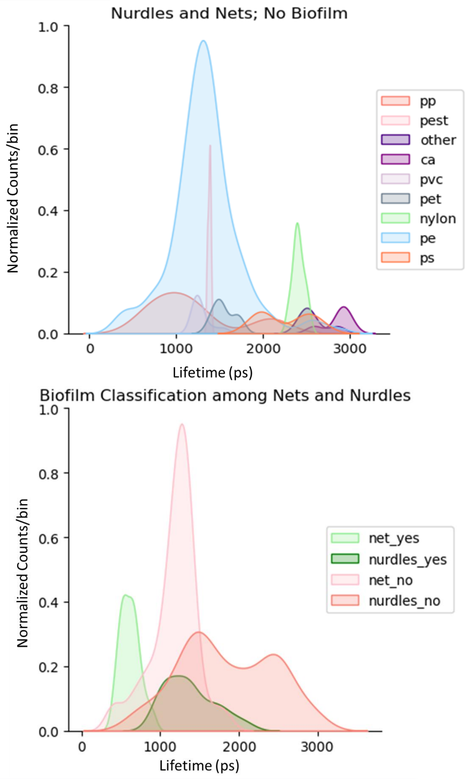


Project Objectives – What We are Looking for and Why

- Collect calibrated lab measurements (including fluorescence spectra and lifetime) of marine debris-relevant plastics (pre-production pellets called nurdles from Hawaii Pacific University's Polymer Kit 1.0 and NOAA recovered fishing nets from the North Pacific in 2021)
- Simulate lidar like retrieval and include water effects through a tank experiment
- Model the performance of an instrument for airborne/spaceborne demonstration

What we found – Lifetime, Intensity and Spectral Results



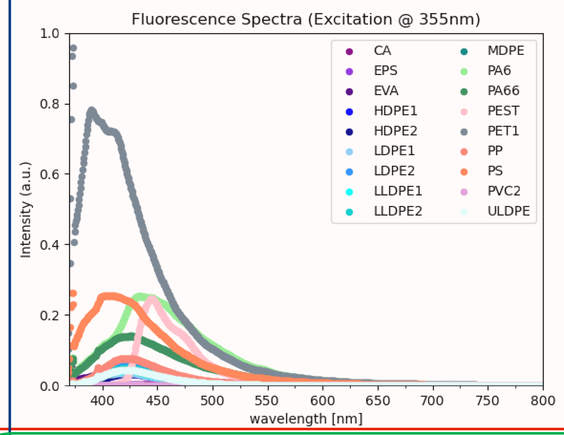


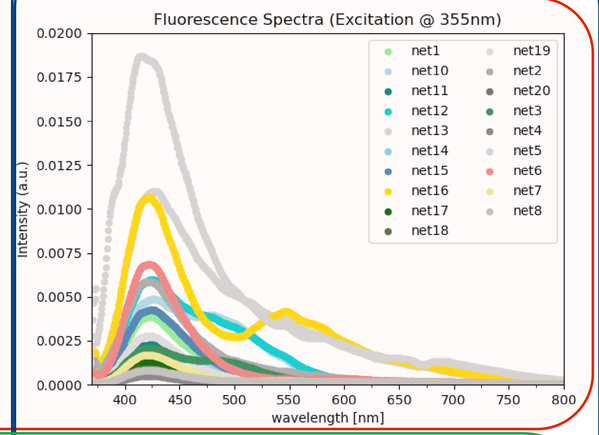
- Samples with a biofilm had shorter lifetimes vs their dry counterpart
- Biofilm on material does weaken the fluorescence response but the wavelength (spectral info) is a way to separate signal contributions
- Lifetime + spectral information is used to classify plastic material type
- Plastic material fluorescence is larger in intensity than from CDOM

PRE-PRODUCTION PLASTIC NURDLES

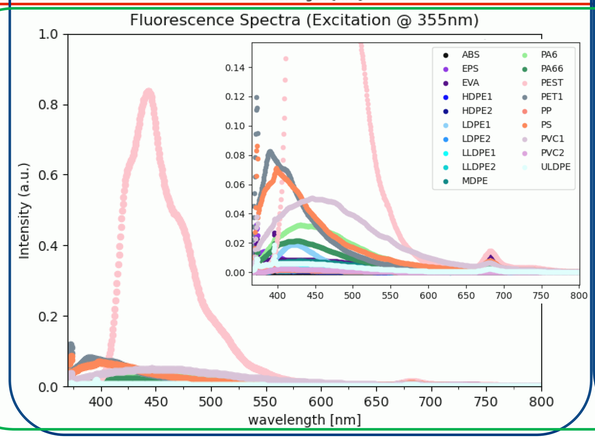
NOAA RECOVERED FISHING GEAR

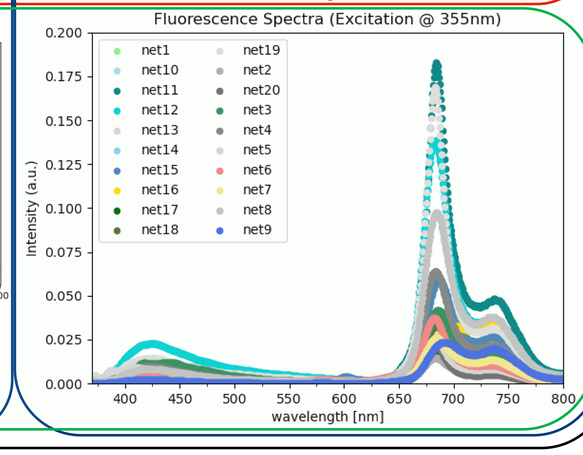
DRY SAMPLES



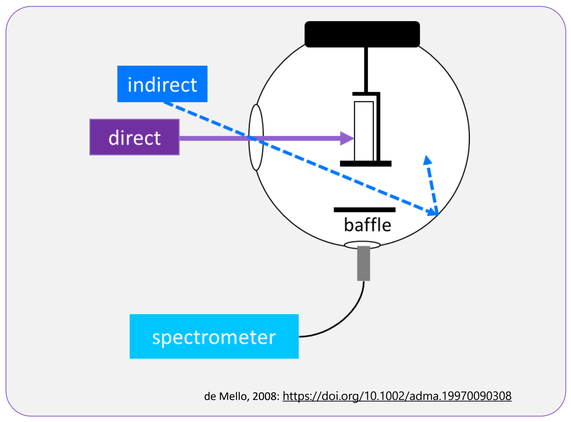


BIOFILM PRESENT



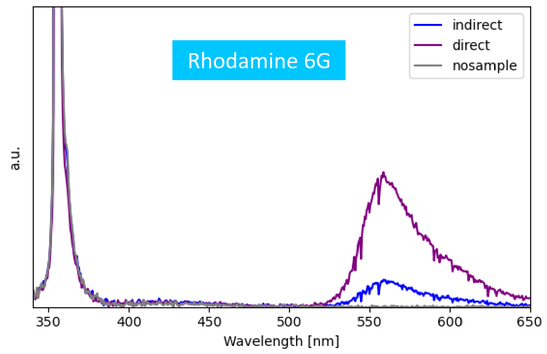


Photons In vs Out – Quantum Yield (QY)

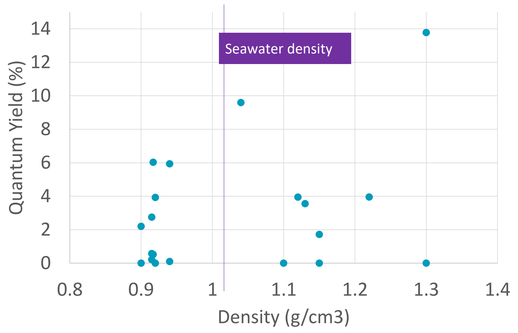


de Mello, 2008: https://doi.org/10.1002/adma.19970090308

Example Integrating Sphere Returns for QY DeMello Method



QY vs Density with Excitation at 355nm

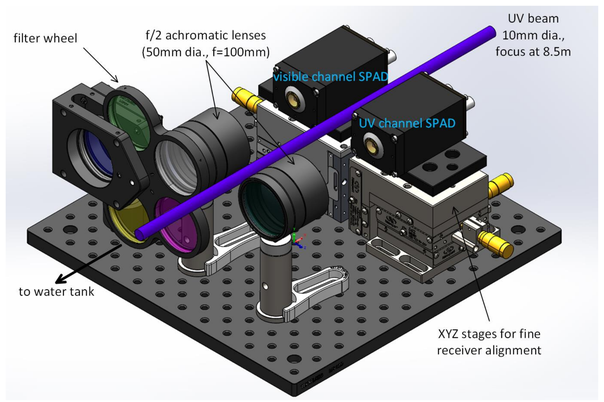


$$QY = \frac{(P_{direct} - P_{blank}) - (1 - A) * (P_{indirect} - P_{blank})}{L_{blank} * A}$$

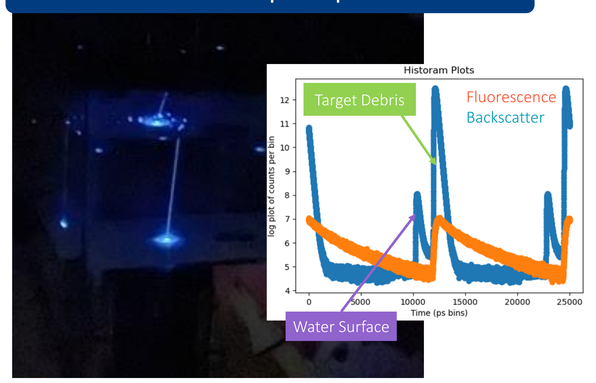
$$A = 1 - \frac{L_{direct}}{L_{indirect}}$$

- QY calculations based on the DeMello method for solid material
- QY measurement *grounds* modeling by quantifying how many photons are converted to fluorescence
- Results:
  - We found that the QY of the NOAA recovered materials is lower than the noise floor of our setup
  - Also, the QY of recovered materials (fishing gear, beached trash) is less than pre-production plastic nurdles

Looking Forward - Tank Experiment of Lifetime and Spectra



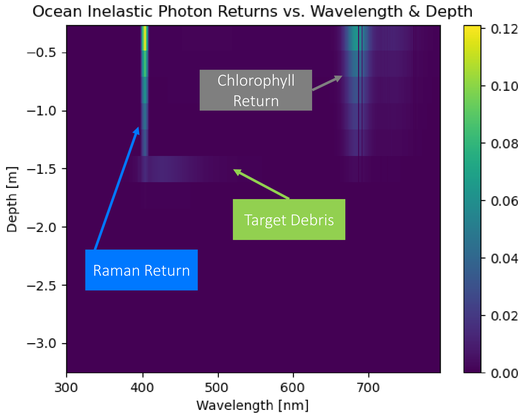
PA6 Ocean Cleanup Sample in Water



Project Observations and Implications

- Fluorescence signals (intensity) weaken as pristine materials weather, degrade and/or are biofouled
- Spectral information provides first order classification of plastic groups and separability from chlorophyll-a response
  - Plastic fluorescence response with excitation of 355nm is centered at 425nm
- Moving forward, we are using the lab measurements to design the *future sensor* to vertically resolve fluorescence photons in the water column

Ocean Inelastic Photon Returns vs. Wavelength & Depth



Modeled inelastic returns in Jerlov 1C coastal waters of HDPE at a depth of 1.5 meters, with a cross-section coverage of 50%, and excitation of 50mJ at 355nm

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