Optical sensing of HABs in Optically Complex Waters

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This presentation will focus on *in situ* optical approaches for detecting HABs in complex coastal waters often supporting patchy distributions of algae comingled with other constituents affecting optical properties such as colored dissolved organic matter and suspended sediments. Optical techniques effective in detecting harmful algae may exploit morphological, physiological, and ecological signatures and can include:

- Hyperspectral absorption – usually for specific pigment composition;
- Scattering, employing multi-/hyper-spectral, multi-angle, diffractometry, polarization, and/or holographic wave front interference aspects – for organism/colony morphological information and densities;
- Florescence, both excitation and emission spectra – for photosynthetic pigment composition;
- Imaging with machine learning classification methods – for morphological/organism identification;
- Bioluminescence – many harmful algae have distinct bioluminescence emission signatures;
- Optical Settling Tube (OST) – for particle size distributions, particle densities, settling velocities, fluxes;
- Ocean color reflectance – for resolving algae signatures associated with convolved backscattering and absorption; and
- Lidar, which may be multi-spectral and use fluorescence – for remotely resolving vertical distributions of algae.

All of the above techniques have been adapted to *in situ* sensing technologies, often supporting deployment on a wide range of sampling platforms. Sensors are often relatively simple optically, autonomous capable, and robust. Sampling patchy, sometimes layered distributions can be a challenge. Dilution with other constituents affecting optical properties can also be a challenge, depending on the approach, although regional and historical knowledge can constrain interpretation.