Submersible Hydro-optical Applications for Light - Limited Oceanography (SHALLO) Work

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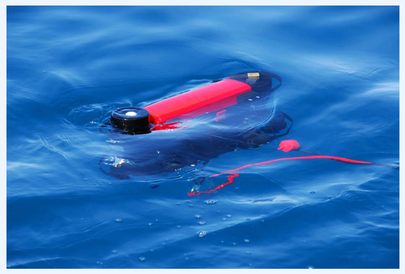
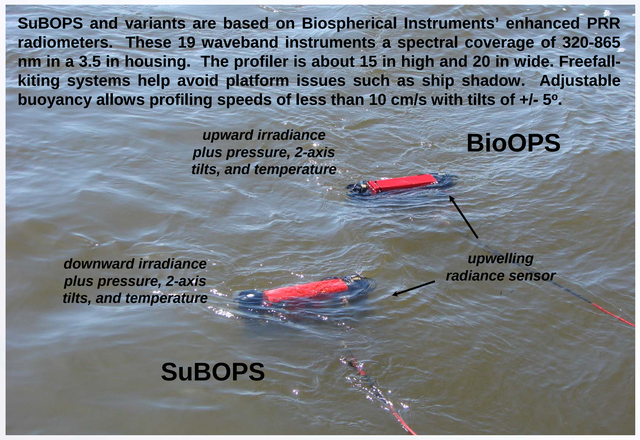


ABSTRACT. Over the time span of the SeaWiFS mission, there has been increased attention paid to ocean color field activities in coastal waters and a continuing commitment to produce better instrumentation. Shallow waters pose special challenges for typical oceanographic profiling systems. In-water legacy systems are not always well suited for properly resolving the optical complexity near shore, principally because of overall instrument size, proximity of the sampling platform, or rate of descent. To meet the needs of researchers interested in coastal AOP measurements, Biospherical Instruments has produced a new series of instruments specifically designed to deploy in shallow waters. The first of several optical profilers, called SuBOPS for Submersible Biospherical Optical Profiling System, is mounted to a kite-like free-fall backplane, specifically designed for stability at low fall rates. SuBOPS includes separate sensors to measure (simultaneously) multichannel downward irradiance and upwelling radiance at depth, plus global solar irradiance above the water's surface. SuBOPS, and a variant for measuring upward irradiance and downwelling radiance (BioOPS), was recently deployed in the riverine, estuarine, and near-coastal waters associated with Great Bay, New Hampshire. Irradiance and radiance vertical profiles were collected in stations with depths of less than 4 m of water, using freefall profiling techniques with speeds less than 10 cm/s and vertical resolutions of less than 1 cm. Deeper profiles collected at a station off the Isles of Shoals (Gulf of Maine) provided a more oceanic comparison.



SuBOPS and variants are based on Biospherical Instruments' enhanced PRR radiometers. These 19 waveband instruments a spectral coverage of 320-865 nm in a 3.5 in housing. The profiler is about 15 in high and 20 in wide. Freefall-kiting systems help avoid platform issues such as ship shadow. Adjustable buoyancy allows profiling speeds of less than 10 cm/s with tilts of +/- 5º.

Distinguishing features of the SuBOPS radiometers (and variants) are:

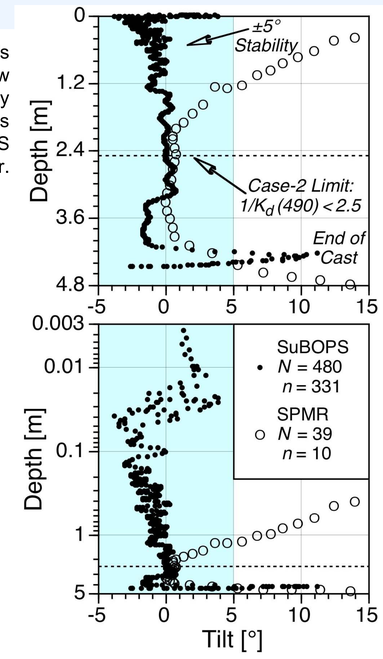
- Wide spectral coverage (19 wavebands 10 nm FWHM bandwidths);
- High-speed, low-noise, 3-stage amplification and 16-bit digitization circuitry (each detector is individually amplified by an electrometer grade FET operational amplifier with variable gain (10^5, 3×10^7, and 10^{10} V/A) that covers more than nine decades of light levels
- Minimum detectable signals are less than 10 fA and 1.3μV for the least significant bit;
- Out-of band blocking greater than six decades
- Very wide dynamic range (the system does not saturate at natural light levels even when the radiance aperture is pointed directly at the solar disk);
- Irradiance cosine departure of less than 2% from 0 - 65º and less than 10% from 65 - 85º.

Field Comparison

Rocket-shaped legacy instruments depend upon rapid descent speeds for stability. In contrast, the kite-shaped SuBOPS is designed for low speed descent. Unprecedented buoyancy control and low-speed stability allow safe deployments in shallow, optically complex waters. The profiles shown below display tilt angles of SuBOPS and a Satlantic SeaWiFS Profiling Multichannel Radiometer (SPMR) cast in less than 5 m of water. The Case-2 limit of $1/K_d(490)$ in this example is <2.5 m.

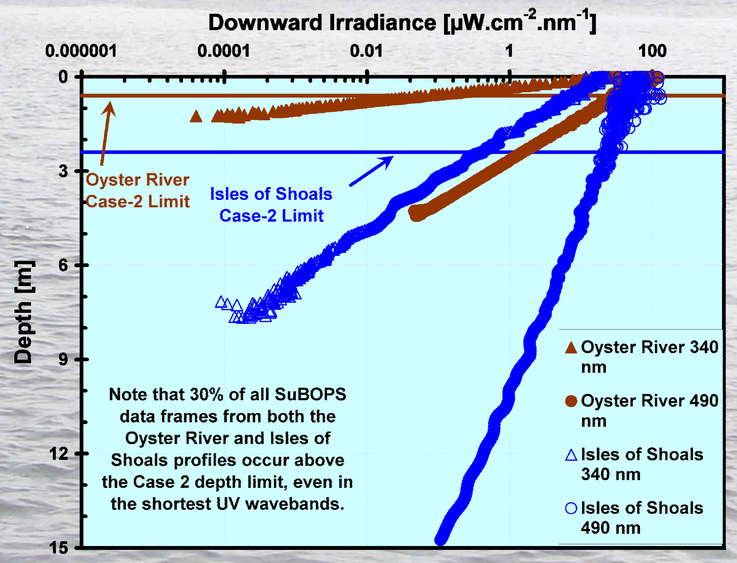
Upper Panel. Of the 480 spectra acquired by SuBOPS during the cast, 331 are within the Case-2 limit and well within the acceptable tilt envelop of +/- 5º (blue region). In contrast, of the 39 spectra acquired during the SPMR cast, 10 were within the Case-2 limit.

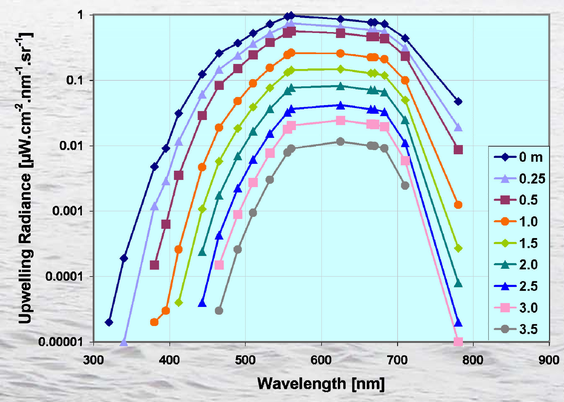
Lower Panel. Even data acquired very near the surface is within acceptable limits (note that depth is plotted on a log scale for emphasis near the surface). Vertical resolution for SuBOPS in this cast is 1.1 cm; 15.8 cm for SPMR. In this example, terminal velocity for SuBOPS is 20 cm/s; 80 cm/s for SPMR.



Legacy Instruments

In-water legacy systems are not always well suited for properly resolving the optical complexity of shallow waters, principally because of overall instrument size, proximity of the sampling platform, or rate of descent.





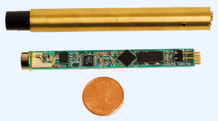
Left: Vertical profiles of downward irradiance at Oyster River (a riverine station associated with Great Bay, New Hampshire) and Isles of Shoals (more oceanic station, Gulf of Maine), just two of 23 stations sampled near Great Bay, New Hampshire in April, 2008. The electronic sensitivity of SuBOPS supports data acquisition even in the UV well below the Case-2 depth limit at all stations. 1% light level for Oyster River station is 4.1 m; Isles of Shoals is 12.5 m. Above: SuBOPS upwelling spectral radiances at different depths near the UNH Great Bay Buoy.

Moving Ahead in 2008

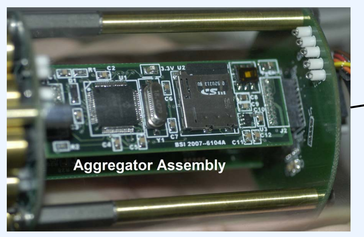
With support from the NASA SBIR NNG06CA03C, in 2008, Biospherical Instruments will introduce a series of new, expandable, *in situ* sensors based on an entirely new technology: the *microradiometer*. A microradiometer consists of a photodetector, preamplifier with controllable gain, high resolution analog to digital converter (24 bit ADC), microprocessor, and an addressable digital port, all on one small, thin circuit assembly. Clusters of microradiometers, matched with front end optics (collector/window/filter stack) and coordinated by an aggregator assembly form small, fast, less expensive multiwavelength radiometers ideal for a variety of applications. Multiple microradiometers matched with front end optics (collector/window/filter stack) is the basis for C-OPS, the Compact Optical Profiling System. C-OPS multiwavelength radiometers offer a smaller, faster, and less expensive profiling alternative ideal for a variety of applications – even hyperspectral measurements.

Smaller instruments afford unique deployment strategies. Above, an internally recording scalar profiler is retrieved using a fishing rod.

Full-sized microradiometer. The brass sleeve provides structural support.



Microradiometer-based Instruments. A 19-channel C-OPS, based on microradiometers (radiance head shown at left) will be introduced in mid-2008. The system has an outside diameter of 2¾" and is operational to 350 m depth.



A cluster of microradiometers, arrayed to an aggregator assembly (above) with battery and on-board microSD memory form a stand-alone multichannel radiometer (right).