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A low cost set-up to measure underwater spectral irradiance in aquaria

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Introduction

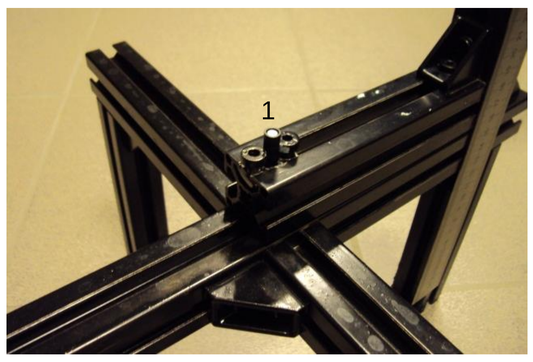
- Scientific literature about building and calibrating devices for underwater spectral irradiance measurements refers to obsolete technology*
- A “build your own” set-up based on a modern low cost digital spectrometer is presented

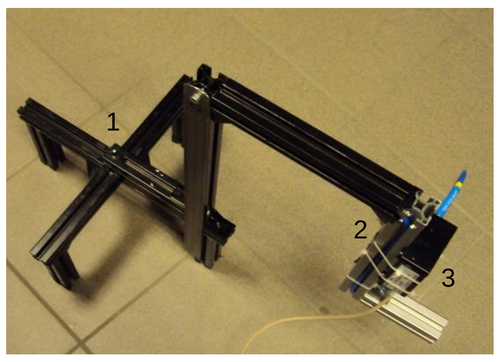
Construction of the set-up

- Digital spectrometer: USB-650 Red-Tide (Ocean Optics)

- Laptop computer (power, data acquisition and control of the spectrometer via USB-port)
- A cosine corrected waterproof irradiance probe (CC-3-UV-T, Ocean Optics) is connected to the spectrometer by a 1.5m optical fibre and a 90° custom probe

- All components are rigidly attached to a black metal frame to make sure the calibration remains valid and for easy handling in and near aquaria (the spectrometer is not waterproof!).





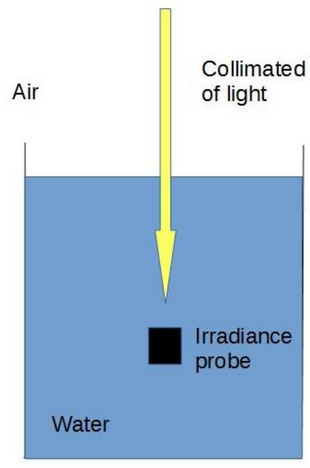
The set-up showing the irradiance probe (1), the optical fibre (2) and spectrometer (3) attached to the frame. The four legged support structure is not part of the set-up, during experiments the frame is detached from the support structure.

Calibration in air

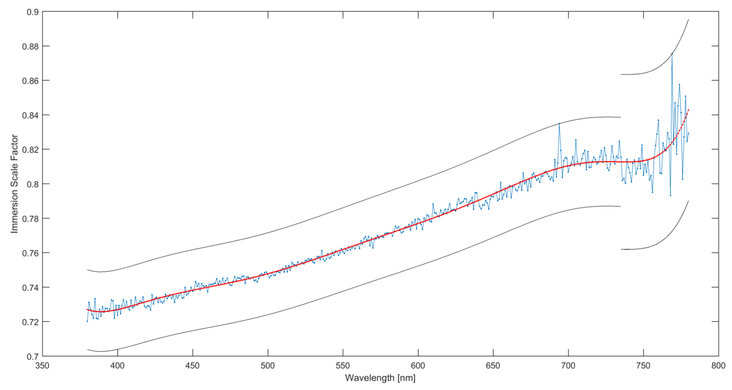
- The spectrometer is wavelength pre-calibrated by the manufacturer. This was verified with a mercury lamp.
- Absolute irradiance calibration with a Bentham Spectral Irradiance Standard (measurement of spectral irradiance (mW/m^{2}nm) at 0.5m from the Standard).

The immersion effect

- The refractive index of the probe’s diffuser matches better with the index of water than the index of air. Therefore more light is scattered back from the bulk of an immersed diffuser than from a diffuser in air.
- A wavelength dependent correction can be determined from measuring the response of the probe to a collimated beam at different water levels in a test tank.
- The spectral data gathered by the immersed probe need to be divided by the immersion factor to obtain the actual underwater spectral irradiance.

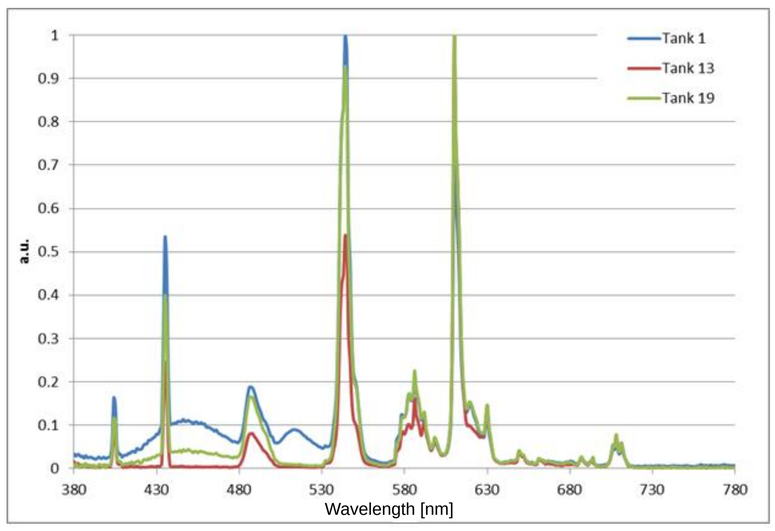


Immersion factor



Measurements and results

Spectra normalised to peak irradiance to allow comparison



- Irradiance spectra measured at the bottom of crayfisch (*Astacus astacus*) living tanks under three different types of fluorescent lighting (CCT=2700K, CCT=4000K, CCT=6500K)

*Kawana Kichiichiro, Spectral Distribution of Underwater Irradiance, Bull. Fac. Fish. Hokkaido Univ. 26(3),235-248, 1975