Proposal for an IOCCG Working Group on Conducting Benthic Reflectance Measurements

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Benthic reflectance is a measurement describing the color of the seafloor, and is an essential parameter for mapping marine habitats in optically shallow water using remote sensing techniques. It is quantified as the upwelled irradiance reflected from the seafloor normalized to the incident downwelling irradiance. Benthic reflectance has relevance in remote sensing methods for assessing shallow-water bathymetry and benthic habitats. Methods generally involve inversion of the remote-sensing reflectance profile to simultaneously fit both the inherent optical properties of the water column and the bottom spectral reflectance profile (Lee et al. 1999; Dekker et al. 2011). Hyperspectral data, which provides a near-continuous spectral measurement across near-ultraviolet, visible, and near infrared wavelengths, offers the best results for discrimination of benthic habitats and specific benthic types such as corals, algae, sand (Mumby et al. 1997; Hochberg and Atkinson 2003). With the advent of new hyperspectral satellite and airborne missions, the need for libraries of high quality benthic reflectance spectra is becoming increasingly important for algorithm development and the ability to optically discriminate properties of benthic aquatic habitats.

A recent review of optically shallow remote sensing by Kutser et al. (2020) concluded that optical properties of major bottom types are similar in tropical and temperate as well as freshwater and oceanic environments. Specifically, characteristic features in reflectance spectra of major groups, like brown algae, tend to be similar across diverse habitats, and are related to variations in accessory pigments that occur in the major groups (e.g., fucoxanthin, peridinin, etc…) (Hedley and Mumby 2002). Indeed modeling and sensitivity analyses based on field and laboratory measurements of reflectance spectra reveal that spectral separation of benthic types based on hyperspectral reflectance is possible (Lubin et al. 2001; Hochberg and Atkinson 2003; Hedley et al. 2012). A recent study using hyperspectral PRISM imagery, for example, provided >90% classification accuracy at differentiating bottom types (Garcia et al. 2018).

In addition to separation of the major benthic groups, understanding the variability within a group can also be important to understanding characteristics about the health of the organism including the amount of pigment, concentration of symbionts, and the presence of epiphytes. Using reflectance measurements *in situ* can be a valuable method to assess symbiont concentration in corals, for example (Russell et al. 2016). Moreover, the variability in sediment types is vast going from bright white carbonate sediment to dark clay muds and there is no standard endmember for “sediment.” The amount of algal film on the sediment is also an important factor in assessing benthic reflectance and characterizing benthic habitats (Dierssen 2010).

Presently, there are many different instruments and techniques for making benthic reflectance measurements and no recommendations for the best practices for each method and potential uncertainties inherent to the measurement. Various instruments are used including instruments with closed path, internal lighting and others with open path that use natural sunlight (Kutser et al. 2020). Laboratory methods in air are also used, and have limitations in terms of which substrate can be assessed and how to account for differences between samples measured in air and in water. The use of a new radiative transfer model relating spectral reflectance signatures measured in air to the underwater environment also warrants consideration in methodology (Fournier et al. 2018). Some methods use a plaque underwater and others take simultaneous upwelling and downwelling measurements. Spectralon performs differently in a water media compared to air and few studies have characterized these differences. Some methods suggest blocking of the direct beam to prevent glint and others orientation of measurement at specific angles to minimize glint. Certain environmental conditions limit the use of sunlight such as when the sea surface is too wavy and incident light fluctuates with the passing of each waves and/or the measurements are too deep for adequate penetration of certain wavelengths of light.

Recent modeling work shows that the three-dimensionality influences the benthic reflectance from shadowing in a manner that is related to the rugosity of the benthic structure (Hedley et al. 2018). Assessing the structure of the coral and solar conditions during fieldwork may provide important information in assessing the variability in benthic reflectance across a habitat and the uncertainty in remote sensing methods to estimate benthic reflectance.

Goals:

The intent of this working group would be to document how these different methods work and attempt to characterize the uncertainties inherent to the measurements. Recommendations would be made as to best practices for each method in order to minimize the uncertainty. A chapter would also include recommendations for relevant metadata to be included for each dataset. Benthic reflectance can also vary with different times of day and under different environmental conditions and hence, accurately documenting the conditions of the measurement will be important to assess uncertainties of new algorithms. If feasible, recommended practices in field validation for benthic remote sensing would also be useful.

Proposed Membership:

Membership will be international. An announcement will be made and researchers can apply to join providing a short list of qualifications and experience in benthic measurements.

Timeline:

A kick-off meeting will likely take place in February 2021, and a draft report should be ready for review by July 2022.

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