Benthic Reflectance IOCCG Report (150 p. report)

PART 1 – Introducing the Problem (Heidi, Arnold)

Preface (Dierssen)

i. Purpose
ii. Who should read this report?
iii. How to read this report

1. What is Benthic Reflectance? (Dierssen)
    - 1.1 What is Benthic Reflectance?
        - i. Historical perspective
    - 1.2 Why Benthic Reflectance?
        - 1.2.1 Importance for Remote Sensing (Barnes)
        - 1.2.2 Other applications for benthic reflectance (Hestir)
        - 1.2.3 Coral watch/coral health chart/citizen science (Chris)
    - 1.3 Acronyms and jargon
2. Overview of theory (George)
    - 2.1 Physics of Bottom Reflectance (George)
    - 2.2 Radiative transfer of optically shallow water (Peter)

PART 2 – Overview of instrumentation and methods (Dick)

3. Overview of instrumentation and platforms (Dick)
    - 3.1 Instrumentation
        - 3.1.1 Hardware constraints: diffraction grating, slit size (Eric)
        - 3.1.2 Integration times
        - 3.1.3 Point Spectrometer vs. Imaging Spectrometer (Peter)
    - 3.2 Platforms
    - 3.3 Lighting considerations (Eric, Ved)
        - 3.2.1 Natural light
        - 3.2.2 Artificial light
            - 3.2.2.1 Artificial only
            - 3.2.2.2 Artificial plus natural light
        - 3.2.3 Shading effects
        - 3.2.4 Damage from lighting
    - 3.4 Wavelength considerations (Peter, Julian)
        - 3.4.1 Spectral sampling vs. Spectra resolution (Natascha)
        - 3.4.2 Spectral ranges needed
    - 3.5 Radiometric considerations (Peter, Natascha, Eric) – Integration times, signal to Noise considerations based on habitat and measurement distance, calibration considerations – making a good “picture”
    - 3.6 Geometric considerations (Peter, John, Natascha, Jaime) – Field of view, BRDF, Glint, Self shading,
    - 3.7 Uncertainty in instrument and platform (brief summary) (Peter and Geir)
        - 3.7.1 Sensor calibration (stray light, nonlinearity, etc..)
        - 3.7.2 Platform – Positioning (GPS underwater)

4 Documentation and metadata (Arnold)
    4.1 Data formats and Identification
    4.2 Standardized metadata required
    4.3 Environmental Field Template
        4.3.1 Minimum
        4.3.2 Ideal
    4.4 Database templates in appendix
5 Overview of measurement (Arnold, Dick, Chris)
    5.1 Measuring the incident light (Brandon, Arnold)
        5.1.1 Direct measurements (diffuser)
        5.1.2 Plaques (Brandon)
    5.2 Measuring the reflected light
    5.3 Proximal to target in water (Julien add hydrolight)
    5.4 Proximal to target in air
    5.5 Distant from target in water (Eric, Geir, Julien add hydrolight)
        5.5.1 Slit spectrometer
        5.5.2 Hyperspectral camera
    5.6 Inelastic processes (fluorescence, raman) (John)
    5.7 Sample preparation
        5.7.1 Rinsing, drying, scraping, centrifugation, sorting for age class, layering, phenotype (age class)
        5.7.2 Sampling container/background
    5.8 Auxiliary measurements
        5.8.1 Photographs
        5.8.2 Key environmental variables
    5.9 Uncertainty related to natural and geometric variability
6 Overview of processing (Eric)
    6.1 Calculation of R
    6.2 Smoothing
    6.3 Resampling
    6.4 QA/QC
7 Spectral databases (Arnold)
    7.1 SeaBASS templates (CMECS) (Heidi, Brandon
    7.2 Specchio
    7.3 Ecosis (Townsend)
    7.4 Other general: Pangea/(BCO/DMO0

PART 3 – Examples of Benthic Reflectance (Tiit, Chris)

8 Benthic Reflectance by Scale (Steve and Dick leads)
    8.1 Microscale (um-scale)
    8.2 Point (cm-scale)
    8.3 Organism
    8.4 Canopy
    8.5 Aquascape

9 Benthic Reflectance by Habitat (Chris)
- 9.1 Sediment
  - 9.1.1 Intertidal (mud flats) (Jaime)
  - 9.1.2 Submerged mud
  - 9.1.3 Submerged sand
  - 9.1.4 Algal films and mats (Stuart and Chris)
- 9.2 Coral habitats (Eric)
  - 9.2.1 Shallow “
  - 9.2.2 Intermediate
  - 9.2.3 Deep sea (Geir)
- 9.3 Minerals and rubble
  - 9.3.1 Shallow (Eric)
  - 9.3.2 Deep sea (Geir)
- 9.4 Submerged aquatic vegetation (aquatic vascular plants includes inland)
  - 9.4.1 Seagrass (Dick)
  - 9.4.2 Freshwater vascular plants (Erin)
- 9.5 Macroalgae (Tiit, Natascha, Eric, and Dick, Gema)
  - 9.5.1 Brown algae (Phaeophyceae) (Dick, Kelp)
  - 9.5.2 Green algae (Chlorophyta)
  - 9.5.3 Red algae (Rhodophyta)
- 9.6 Detritus, wrack, and debris (Arnold, Tiit)
  - 9.6.1 benthic drifting mats of detrital matter: broken seagrass, macroalgae (Tiit)
- 9.7 Shadows (John)
- 9.8 Others
  - 9.8.1 Benthic invertebrates (Geir)
  - 9.8.2 Sponges (Tiit, Arnold)
  - 9.8.3 Melt ponds (Natascha, Julien, Peter)
  - 9.8.4 Deep water soft habitats (Geir)

PART 4 – Environmental Influences on Measurements (Heidi)

10 Measurement artifacts and guidance to minimize (Summarizing published studies)
- 10.1 Glint and hot-spot effects (John, Ved)
- 10.2 Air-sea Interface and Caustics (Ved)
- 10.3 Turbidity impacts
  - 10.3.1 When is it too high to approximate R_B
- 10.4 Plaque usage above and underwater (bubbles form underwater, etc..)
- 10.5 Self-Shading of measurement
- 10.6 Fluorescence
- 10.7 Interaction with seafloor (creating plumes that interfere with measurement) ☺

PART 5 – Applications using Benthic Reflectance (Erin)

11 Remote sensing and mapping of benthos (Natascha, Eric, Dick, Peter, Barnes)
- 11.1 Influence on Water Surface Reflectance
  - 11.1.1 Separating optically shallow and optically deep pixels (Arnold)
  - 11.1.2 Issues with dark seafloor (darker than optically deep) (Charles)
- 11.2 Use of "ideal" endmember in a model
  - 11.2.1 pores, shadows, detritus, films, etc.. –
  - 11.2.2 spectral dependence
  - 11.2.3 Impact of "ideal" on inversion models
    - 11.2.3.1 bathymetry
    - 11.2.3.2 water-column IOPS – e.g., particulate backscattering (TSM)retrievals
- 11.3 3-Dimensionality of corals (John, Karen)
  - 11.3.1 Shading and Solar Zenith Angle and Shading Influences
- 11.4 Representing BRDF (John and Jaime)
  - 11.4.1 When is it important and when is it not.
- 11.5 Scaling up from point to pixel

12 Ecology (Dick, Eric and Geir)
- 12.1 Organisms
- 12.2 Communities
- 12.3 Biodiversity
- 12.4 Ecosystem function (biogeochemistry, primary production)
- 12.5 Biogeography (includes Migration)

13 Ecosystem Services (Goods) (Erin)
- 13.1 Carbon sequestration (Natascha)
- 13.2 Shoreline protection
- 13.3 Fisheries

14 Global change (Natascha)
- 14.1 Loss of Biodiversity
- 14.2 Habitat degradation
- 14.3 Climate impacts
- 14.4 Other (Eutrophication)

15 Marine Geology and Archeology (Geir)
- 15.1 Detection of abiotic objects and structures
- 15.2 Minerology

PART 6 –Looking Forward

16 Emerging Technology (Steve)
- 16.1 Platforms
  - 16.1.1 Submersibles (Geir and Erin has a colleague in lakes)
  - 16.1.2 Surface vehicles (Steve, Peter and Tiit)
  - 16.1.3 Airborne Vehicles and Drones (Karen and Ved)