Hyperspectral Coral Reef Classification (HCRC)

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The Dutch Caribbean island Bonaire has protected its marine resources for more than 35 years and has been ranked as one of the Caribbean's top dive destinations much due to its wide range of easy accessible diving sites, clear waters and relatively healthy coral reef ecosystem. The importance of coral reefs is multifunctional and provides ecosystem services not only to attract tourism and therefore income, but also as a natural barrier to protect the coast, and as a habitat for many species, providing food as well.

The general consensus is that the extent and biodiversity of Bonaire's coral reef is decreasing due to local and regional anthropogenic and global climate pressures. However, the last extensive study of the coral coverage of the reef ecosystem was performed in 1985 by Van Duyl who created an underwater atlas of Bonaire and Curaçao. In order to update this atlas of Bonaire's coral reefs, a hyperspectral mapping campaign was performed in October 2013 using the Wageningen UR Hyperspectral Mapping System (HYMSY) with 101 spectral channels.

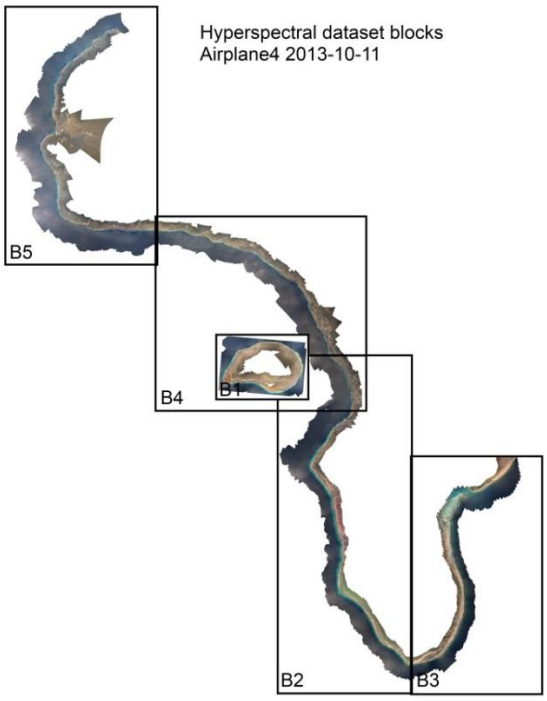

Figure 1 The hyperspectral data were recorded on 11th October 2013 by the HYMSY camera mounted on a Cessna airplane and were mosaicked and georectified to form a hyperspectral image of the coastline of Bonaire. Data were processed in 5 hyperspectral dataset blocks.

In June 2016, with the help of STINAPA Bonaire, Sander Mucher and Erik Meesters were able to perform an extensive diving campaign to collect in-situ information in 18 transects perpendicular to the coastline across the western coast. Detailed photographs of the sea bottom were taken by diving from a depth of 20-30 meters towards sea level on the coast. Photographs were geotagged by another person snorkelling exactly above the diver with a GPS in a waterproof box and making overview pictures of the sea bottom as well. This in-situ information was used to interpret the hyperspectral imagery made by the HYMSY camera.

The HYMSY camera consists of a custom pushbroom spectrometer (range 450–950nm, FWHM 9nm, ~20 lines/s, 328 pixels/line), a consumer camera (collecting 16MPix raw image every 2 seconds), a GPS-Inertia Navigation System (GPS-INS), and synchronization and data storage units. The weight of the system at take-off is 2.0kg allowing it to be mounted on varying platforms. On Bonaire the system was flown on two platforms: 1) on a Cessna airplane to provide a coverage for whole coastline, and 2) on a kite pulled by boat or car to provide a subset coverage in higher resolution. With the Cessna the whole west coast of the island was mapped. The Aerial images were collected at 150mm ground sampling distance (GSD) and the hyperspectral data in 2m GSD. The data were mosaicked and geo-rectified to form hyperspectral maps of the western and southern coastal area of Bonaire.

In order to interpret the data more consistently, the hyperspectral data were corrected for the water depth into at-ground-reflectance factor units. A bathymetric model was used for the calibration of the hyperspectral imagery based on a former field campaign by measuring water depth at specific locations along the western coast. The final bathymetric model that we used was based on extrapolation of the terrestrial digital elevation model through fitting with additional in-situ bathymetric measurements on sea. A more detailed bathymetric model would of course have been preferred to calibrate the hyperspectral data with a 1 meter spatial resolution. Due the limited penetration of green and red light though the water, it was decided to use only the first 15 hyperspectral bands in the violet-blue -cyan till green range (Band 1 = 450.0 nm to Band 15 = 520.0 nm). This means that spectral measurements can be made to a maximum depth of 20 – 30 meters.

The classification of the hyperspectral data is almost finished and is classified in simple classes such as sand, pavement, rubble, soft and hard corals and various mixtures of these at a pixel level of 1 meter spatial resolution. Examples of the coral reef hyperspectral classification are given below. Once the new map is finalised it will be freely accessible in the DCBD.(www.dcbd.nl)

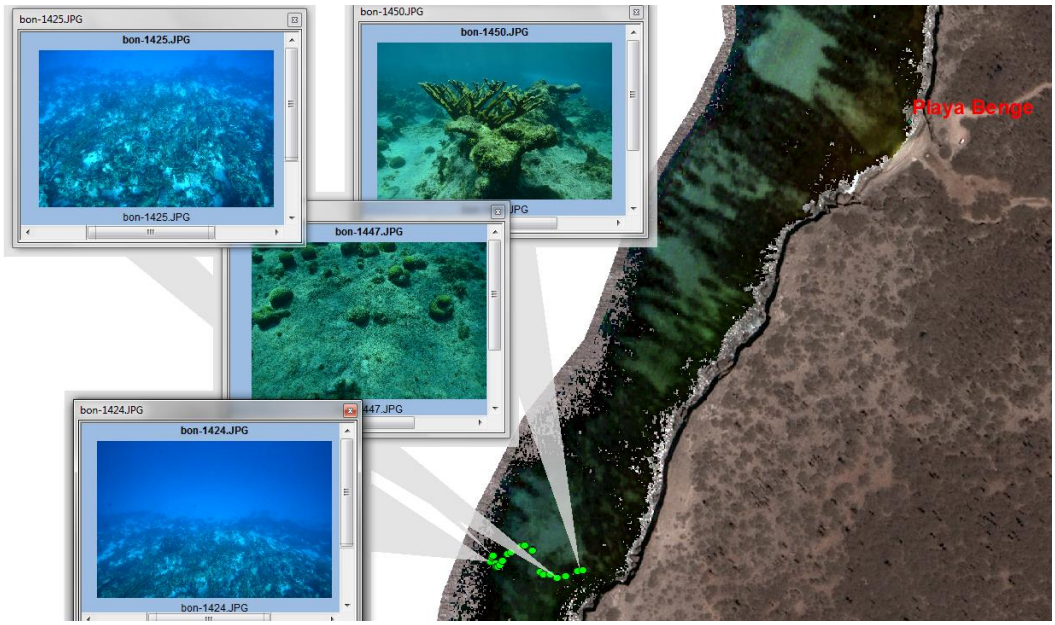

Figure 2. HYMSY hyperspectral spectral imagery (RGB: 520 nm, 480 nm, 476 nm) with green dots showing this year's most northern diving transect with help of STINAPA Bonaire. Image behind the hyperspectral image is a Pleiades satellite image (brown to greyish colours) with 50 cm resolution.

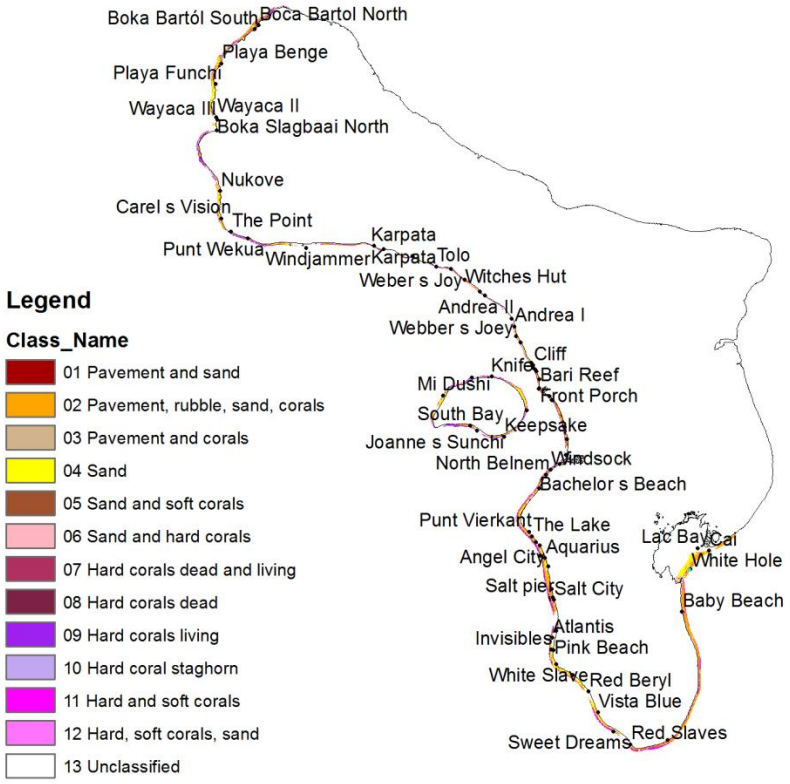

Figure 3. Overview of the Hyperspectral Coral Reef Classification (HCRC)

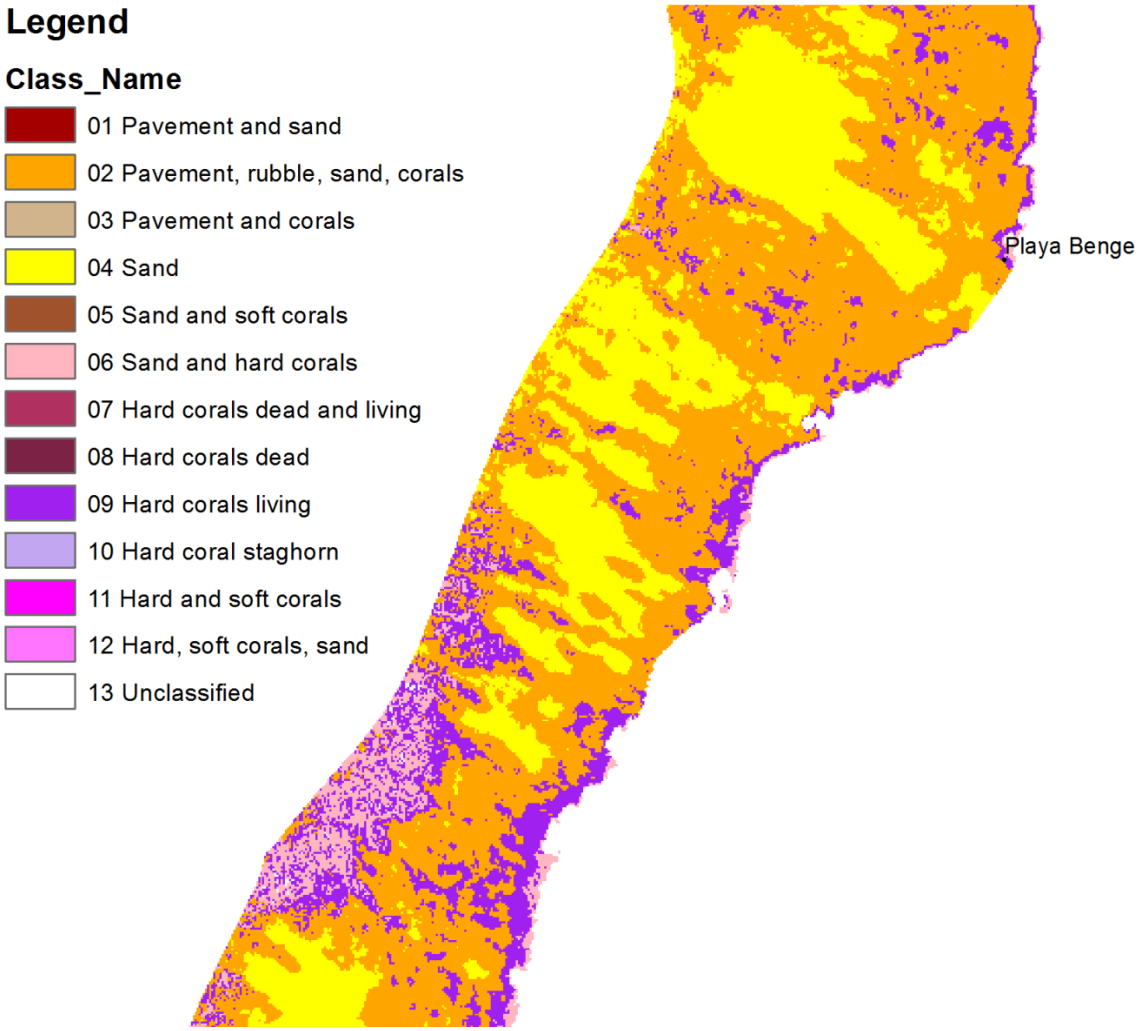

Figure 4. Detail of the Hyperspectral Coral Reef Classification (HCRC) near Playa Benge on the Northern coast of Bonaire.