Spectral discrimination of coral species and habitats in Hong Kong

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Abstract. Four spectra of coral species in the genera *Acropora*, *Goniopora*, *Pavona* and *Platygyra*, and coral habitats, sand and rock, were collected in the field and laboratory. The pure coral spectra show two reflectance peaks at ~600nm and ~650nm, and less distinctive peaks between 470nm-520nm whereas that of coral habitat show gentle slopes with shoulders at ~630 nm for rock and ~650 nm for sand. The reflectance spectra of coral species and habitats on the substratum drop dramatically at 565nm in local waters. The two distinctive spectral peaks of coral species and coral habitats are much less discriminative underwater. These results indicate a significant water column effect even in the region of good water quality in Hong Kong. Classification of sand and rock at the land surface showed that Landsat 7 is more effective than SPOT 5 in mapping coral habitats.

Objectives

This paper briefly investigates

1) the spectral distinctiveness of coral species and coral habitats; and
2) the impact of three determining parameters:
   - the effectiveness of simple water column correction;
   - the effectiveness of spectral bands in SPOT 5 and Landsat 7 using Spectral Angle Mapper; and
   - the effectiveness of subpixel analysis using Mixture-tuned Matched Filtering.

Methods and Results

Spectral distinctiveness of coral species and coral habitats

(a) (b)

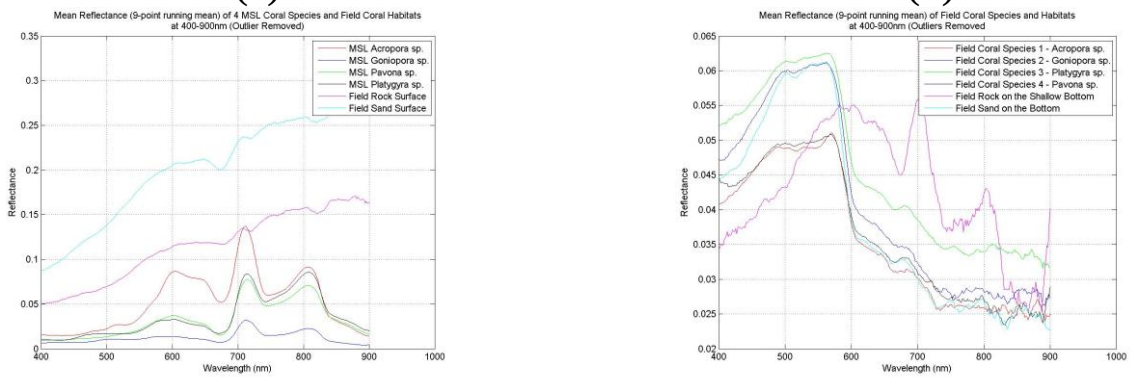

Figure 1: The reflectance spectra of corals species and habitats a) on water surface (the distinctive shoulders of the coral spectra at 600nm and 650 nm), and b) underwater (abruptly attenuation from 570nm-605nm).

According to the bottom profiles of in the study site (Tung Ping Chau at the easternmost of Hong Kong waters), three main classes are found, they include sand, stratified rock and corals. By both Wilcoxon rank sum test and t-test, it is found that the reflectance spectra of all coral species were statistically different from sand and three of them are similar to rock to some extent. *Acropora* sp. shows the most distinctive features among all coral species. Both *Pavona* sp. and *Platygyra* sp. are similar to each other (Fig. 1).

(a) (b)

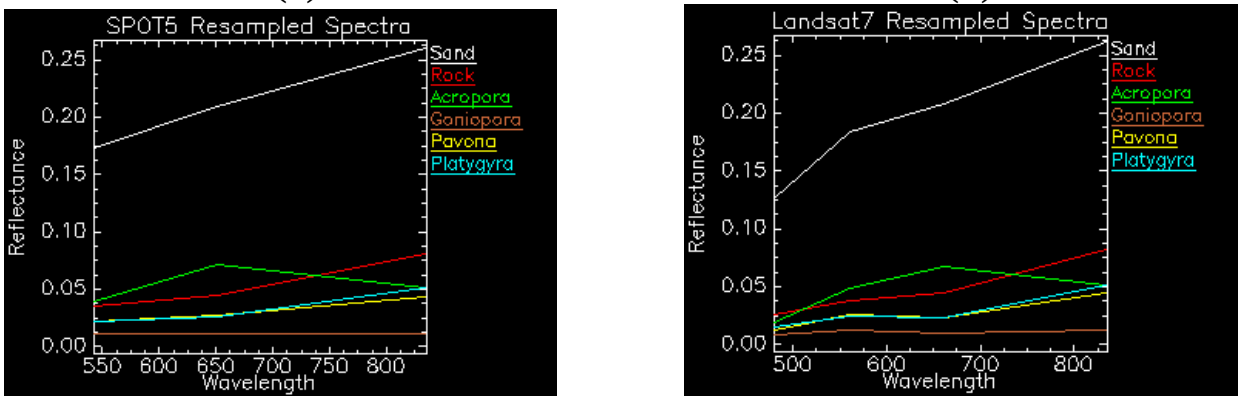

Figure 2: The spectra of coral species and coral habitats are resampled to a) SPOT 5 and b) Landsat 7 spectral resolution. The distinctive shoulders of reflectance spectra at 600nm and 650nm are much reduced. The small peaks of reflectance spectra from 480nm -520nm were also reduced in Landsat 7 resampled spectra and they were totally lost in SPOT 5 due to the unavailable bands at less than 500nm.

(a) (b) (c)

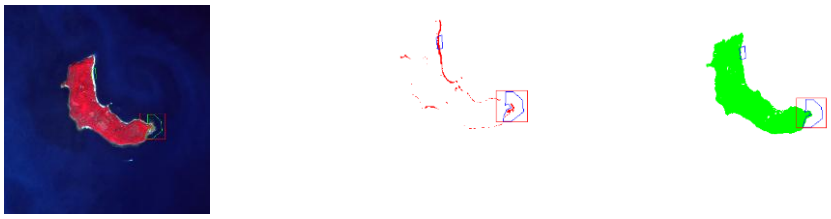

Figure 3: a) SPOT 5 imagery in false colour using G, R NIR bands. The upper area of the island is sandy beach whereas the lower one is the shore mixed with sand and rock. b) Sand pixels in red were classified at 0.24 SAM maximum threshold with acceptable accuracy and c) rock pixels in green were classified at 0.3 SAM maximum threshold with serious confusion with terrestrial vegetation (Details in Fig.4).

(a) (b)

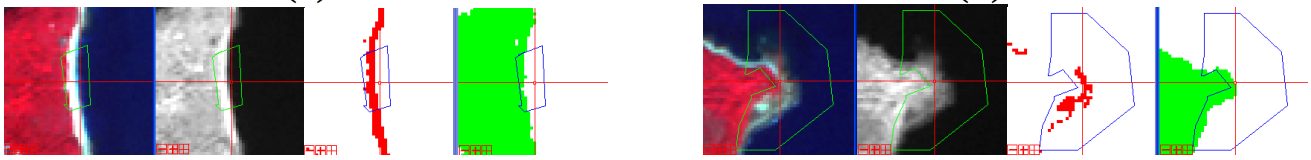

Figure 4: The sand (red) and rock (green) classification. The NIR imagery shows the exposed area (white) and submerged area (black) on the shoreline. a) In the upper area, sand pixels were classified accurately whereas rock pixels were misclassified to vegetation. (b) In the lower area, the sandy portion of the shore was classified satisfactorily to sand class by visual assessment. Rock pixels were not detectable in SPOT 5.

(a) (b) (c)

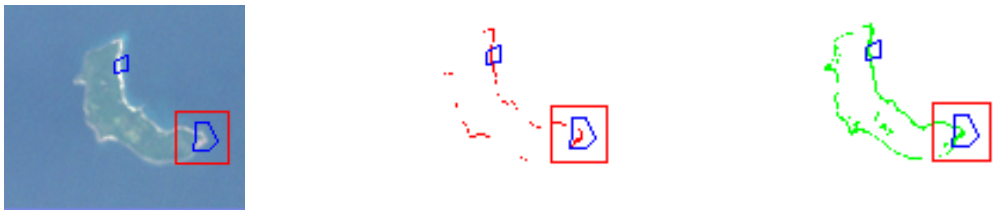

Figure 5: Landsat 7 imagery in true colour using B, G, R bands. b) Sand pixels in red are classified at 0.2 SAM maximum threshold with acceptable accuracy and c) rock pixels in green are classified at 0.21 SAM maximum threshold. Both showed acceptable accuracy by visual assessment and the confusion between sand and rock pixels existed but it was not serious (Details in Fig. 6).

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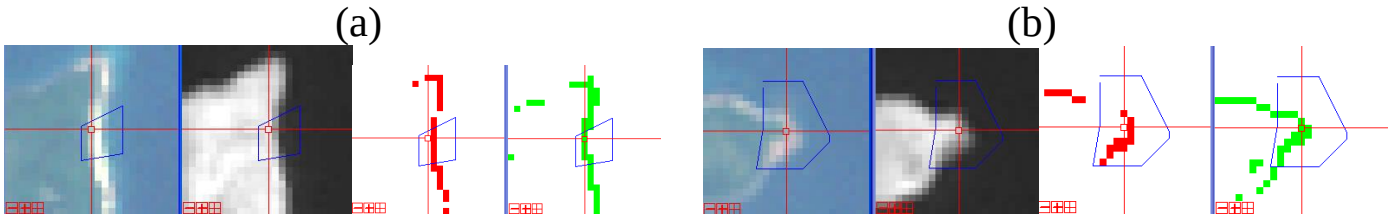

Figure 6: The sand (red) and rock (green) classification. (a) In the upper area, the sand pixels were classified satisfactorily whereas rock pixels were misclassified to the submerged zone. (b) In the lower area, both sand and rock pixels were classified satisfactorily with some pixel confusion between the two classes.

Discussion

Water Column Effect

In the previous stage of this study, a simple water correction was carried out in SPOT 5 imagery using the Lygenza equation (1978). Depth invariant indexes were derived from the two band pairs. It was found that the band combination is restricted by the three available bands (green, red, NIR), more band pairs and more visible bands are required (Huen & Zhang 2011)

Spectral effect

Excluding the submerged zone due to no water column correction, two land areas were selected in the imagery for examining the classification results. Generally, Landsat 7 gave a better classification result than SPOT 5. Although sand spectra have higher magnitude than rock spectra, SAM is insensitive to the level of reflectance. Their distinctiveness showed at the shoulders at ~650nm in sand and ~630nm in rock. The bandwidth/band-range and band numbers of Landsat 7 and SPOT 5 in the visible range may attribute to the difference in the classification results (Fig. 2-5).

Spatial effect

The subpixel analysis, MTMF, was not feasible in Landsat 7 shown by the Matched Filtering scores (which estimate the abundance of the known spectra and relative degree of match) near zero. It was also not feasible in SPOT 5, which had no classified pixels in the shore region. Hong Kong coral communities are very small, with sizes usually ranging from a few meters to only tens of meters wide from the shore, up to a depth of 5 meter or less (Ang *at el*. 2005). The infeasible classification at subpixel level in both SPOT 5 and Landsat 7 may reflect the appropriateness of the selected method or the types of satellite imagery.