Algae mapping and habitat classification in the intertidal zones of Helgoland using hyperspectral remote sensing techniques

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Introduction

Change detection and monitoring of intertidal vegetation is a key element that can help us improve our understanding of the structure and function of coastal ecosystems. The use of hyperspectral imagery is rapidly gaining acceptance in biological research, setting new standards for vegetation mapping. Hyperspectral images provide high resolution spatial and spectral data in the visible to near infrared regions of the electromagnetic spectrum. Using 100 to 200 individual channels, each "band" from a hyperspectral image can measure spectral reflectance over a very narrow frequency range. By combining and comparing selected bands, very slight changes in land cover can be detected, and the resulting spectral signatures can allow the discrimination and identification of otherwise cryptic features.

This poster presents the first steps in testing the use of hyperspectral imagery for the mapping of different algal habitat types in the intertidal zones of the island of Helgoland/Germany (Figure 1).

A first look at the spectral response in the intertidal zone shows significant reflectance variation in both near infrared areas as well as visible light bands (Figure 2). This variation in spectral reflectance can often be used to help identify habitat-types and changes in the algal coverage.

Figure 1: Photo from the intertidal zone of the north section of the island (Photo: I. Bartsch)

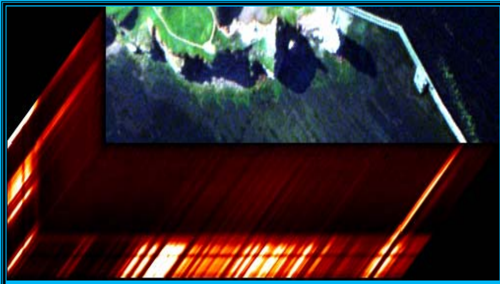


Figure 2: 3D-Cube depiction along a transect in the intertidal zone of the hyperspectral image. The red stripes show differing spectral response which may correspond to different habitat types. Generally the bright areas in this image correspond to the near infrared frequencies.

Reference data used for this project

- ROSIS Images from the western part of Helgoland recorded on 16 July 2002 during low tide; image resolution: 1.2 meters covering the spectra from 430 to 830 nm in 101 bands (German Aerospace Center/DLR Oberpfaffenhofen, Germany)
- Digitized field plots (Figure 8) by I. Bartsch, K. Doelle (AWI Bremerhaven, Germany) and I. Tittley (The Natural History Museum London, Great Britain)
- Air photo of the northern part of the island used as background image in Figures 7 and 8; resolution: 0.28 meters (LVM Schleswig-Holstein, Germany)
- Digital Elevation Model (DEM) for the northern intertidal area from T. Kersten (Hochschule für Angewandte Wissenschaften/HAW Hamburg, Germany) (Figure 7)

Procedures

Steps were taken to investigate algal classes/habitats using remote sensing software ENVI 3.6 (Figure 3):

With no prior knowledge of the algal classes, an unsupervised extraction of pure pixels (i.e. endmembers) was done. The pure pixels were identified in the n-Dimensional Visualizer Tool using the MNF-transformed image with the help of the pixel purity index which calculates the purest pixels in an image.

The result of the first analysis were 21 endmembers which could be reduced to 13 endmembers corresponding to existing habitats in the intertidal zone. With these endmembers, a classification was done for the entire image using the Spectral Angle Mapper of ENVI. To avoid land interference, the surface of the island was masked out for the automated classification.

To improve the results of the unsupervised classification the results were exported to the ArcMap Geographical Information System (GIS). In ArcMap the ENVI results were linked to the field data on habitat types which was previously digitized. Areas of agreement and disagreement were compared.

With this additional field based habitat information, the classes in ENVI were adapted and new "supervised" classes were derived.

After the supervised adaptation of the classes with known field data the 13 spectral classes were refined to eleven including the feature "sand" as a verification class since this feature can be seen very well in the true color image (Figure 4). With these new classes the Spectral Angle Mapper calculation was run again for the final classification image (Figure 6).

As an example for further analysis with GIS the area of the surface of the different classes was calculated using ArcMap 8.2 (Figure 5). This enables the quantification of the distribution of the habitat types.

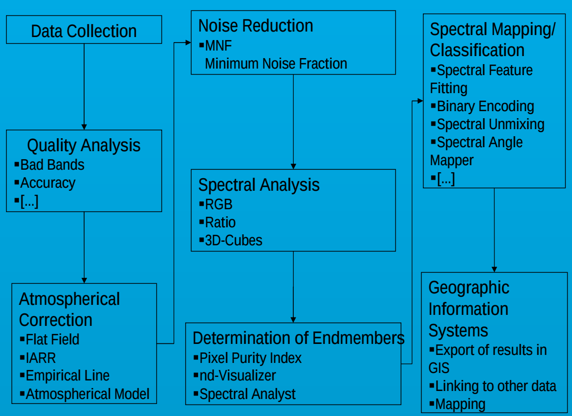


Figure 3: Overview of the processing steps in the hyperspectral image analysis

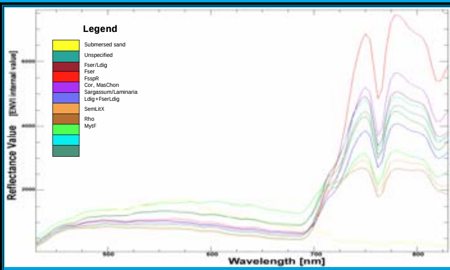
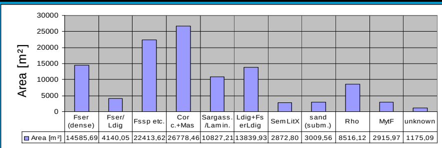


Figure 4: Spectral Plots from the derived habitat classes (430 to 830 nm) The plots represent the mean reflectance spectrum of all pixels in a class.



	Fser (dense)	Fser/ Ldig	Fssp etc.	Cor c.+Mas	Sargass. /Lamin.	Ldig+Fs erLdig	SemLitX	sand (subm.)	Rho	MytF	unknown
Area [m²]	14585,69	4140,05	22413,62	26778,46	10827,21	13839,93	2872,80	3009,56	8516,12	2915,97	1175,09

Figure 5: Distribution of ENVI-derived algal classes

Results

The most important result is the knowledge that hyperspectral imagery is a suitable method for supervised vegetation classification in intertidal zones such as algal biotopes with the use of common remote sensing software.

In most cases the classification results respond well to the reference data which was recorded in the field. In some cases there are obvious limits to computerized classification since not every class can be distinguished. Further investigation of spectra of the algal classes show that in many cases there are no significant differences between the species and that one of the problems might be the heterogeneous areas which have not as clear reflectance spectra as assumed. The spectral plots of the classification results (Figure 4) represent the mean spectra for the classes.

Classification results can be exported and used with existing data in a GIS environment (Figure 8). The GIS data layers also support further investigation in the field using mobile GIS (e.g. ArcPad) linked to a Differential Global Positioning System (DGPS).

It is essential to have reliable georeferenced base images which was an issue with the Helgoland data since there were technical problems with the onboard GPS while taking the ROSIS images.

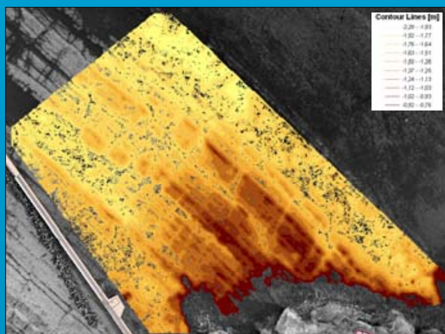


Figure 7: Elevation data from the intertidal zone of the north section of the island

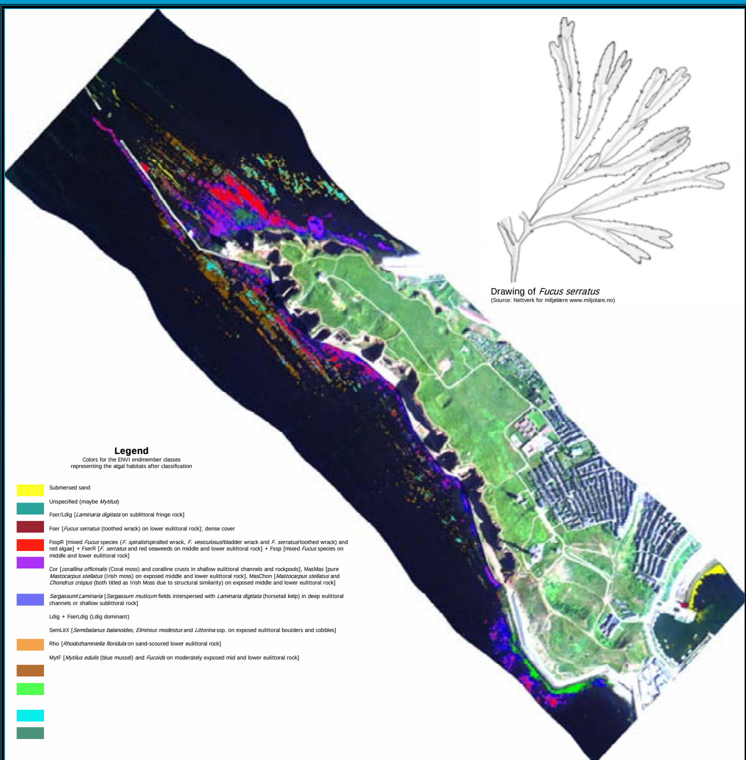


Figure 6: Classification results displayed in ENVI on a true color view of the ROSIS scenery

Future perspectives

Since these results are based on only one ROSIS image of Helgoland area, other available data should be checked for usable classification results.

Using the knowledge of these classification tests, a future task is to build a well trained spectral library of the habitats based on atmospherically corrected images. This was not available at the time of this research.

Using a spectral library may bring good results for multitemporal analysis of images in the region. It might also produce useful results in comparing different regions with similar biotopes, but this remains to be tested.

The quality of the classification results must also be verified with the use of ground-truth data (e.g. field-based spectroscopic measurements, [D]GPS based field sampling) which are more accurate than the data available from the digitized field recordings. Further visualization and mapping can also be done using a digital elevation model (DEM) (Figure 7). The DEM could be used for further classification of existing classes based on differences in the elevation.

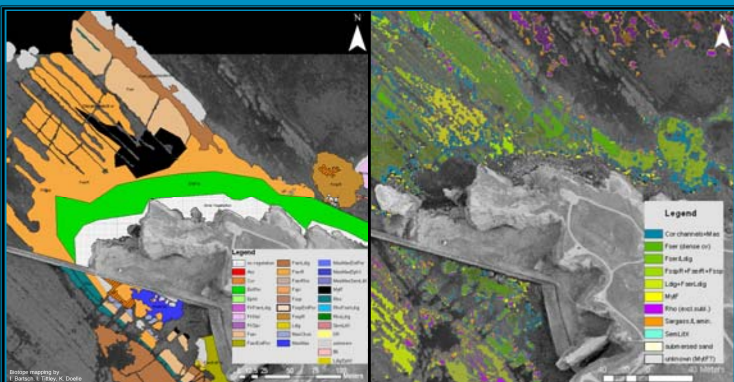


Figure 8: Digitized GIS data from field recordings (left) and converted polygons from the ENVI Classification results (right)