Advancements in CARIS SIPS Backscatter and Seabed Classification

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Introduction

Following the public release of SIPS® Backscatter, a new algorithm for processing multibeam backscatter imagery, Teledyne CARIS® has continued investment in this approach to provide reliable backscatter mosaics that can be used to support a variety of seabed mapping tasks. Defining areas on the ocean floor with similar characteristics is a complex task involving several variables beyond pure sonar reflectivity: it is common practice to also define underwater environments using delineation parameters such as water depth and slope. With that in mind, CARIS HIPS® and SIPS® is currently able to provide a single raster product containing depth, slope, and intensity. In terms of seabed classification, this raster can be used as input to create acoustic classes based on the combination of layers such as depth, uncertainty, slope, aspect and intensity. A case study using multispectral data will be presented.

Material and method

A classic classification task can be broken down into the following steps: acquisition, data processing, feature extraction and classification. A HIPS workflow of the last 3 steps is presented in Figure 1.

Acquisition

SIPS Backscatter support:

- Reson (.s7k)
- Kongsberg (.all)
- R2Sonics[1] (including multispectral Sonic 2026)
- Single/dual-head
- Beam average/time series

Dataset:

- Sonic 2026 (100, 200, 400 kHz)
- Provided by R2Sonic
- Patricia Bay, Vancouver Island
- November 2016

Preprocessing

The pre-processing step in Figure 1 includes the application of geometric and radiometric corrections (Leblanc and Foster, 2015) to the raw soundings to produce the depth, slope, aspect and intensity layers.

Feature extraction

Feature extraction is often the most crucial step in classification problems. The challenge is to extract features from the data that contain information best suited to distinguish between classes, keeping computational complexity and noise sensitivity in mind.

The depth, slope, aspect and intensity layers can be combined into a single multilayer raster at the desired resolution using the *New Mosaic* tool. *Compute Layer* then allows the creation of custom new layers by applying logical and arithmetic operations on a combination of several input layers. In this case, binary maps of low vs high intensities were created for the 100 kHz and 400 kHz band.

Classification

During the classification step, a category is assigned to each georeferenced pixel. *Compute Layer* was used to create simple classes combining the point of view of the lowest and highest frequencies to exploit their different sediment response. Different machine learning techniques (Anderson et al., 2008) can be used to perform this task and they prove to be powerful in terms of automation and objectivity. However, it is sometimes useful for the user to determine their own classification system, based on their experience and knowledge. For example, if one was interested in mapping potential habitats of a species known to live on a hard, flat seabed, within a specific depth range, the proposed workflow has the ability to combine backscatter, slope and depth layers to assign an index of likelihood of this species occurring at the pixel level.

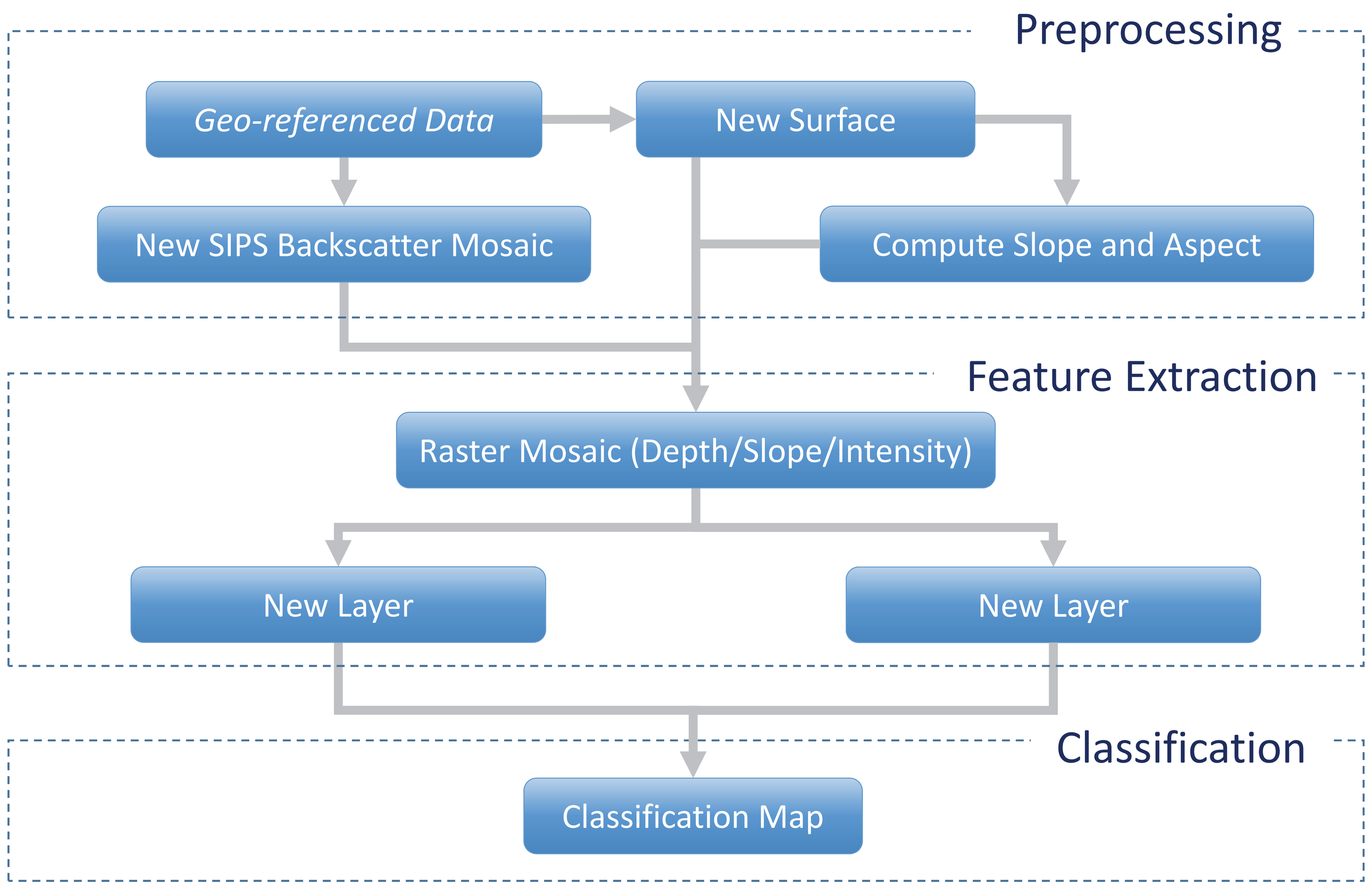

Figure 1: Seabed classification workflow in CARIS HIPS and SIPS.

Results and discussion

Bathymetry derived products

Figure 2 presents the bathymetry and derived slope and aspect for the studied area. A resolution of 5 m was chosen for smoother slope and aspect values.

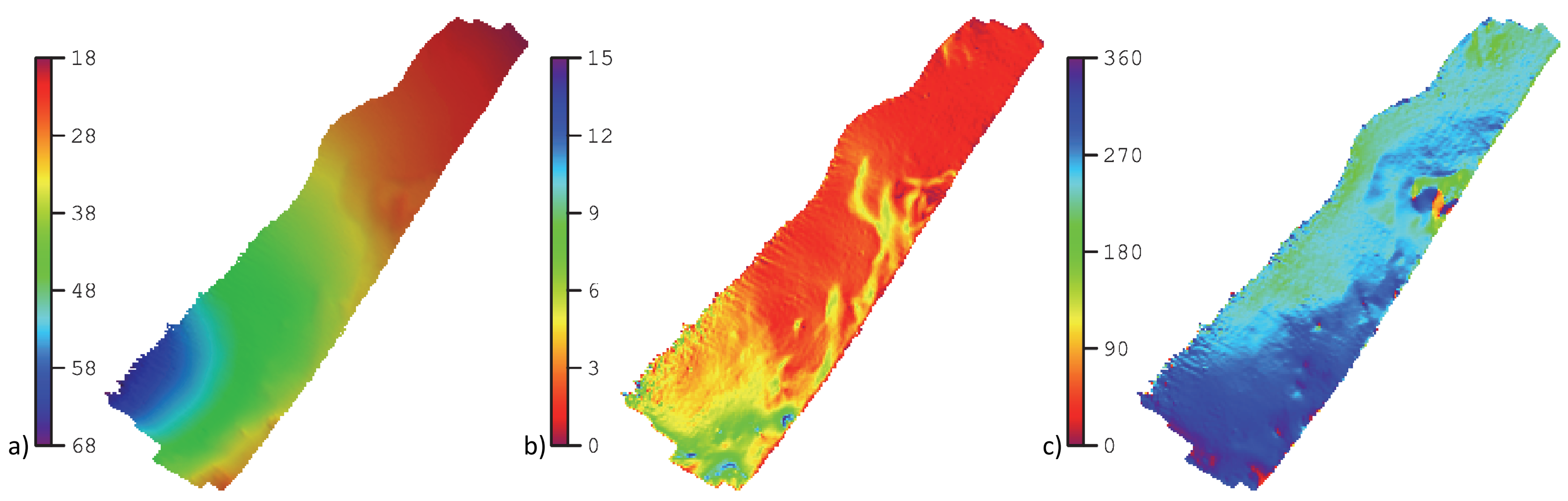

Figure 2: a) Bathymetry (metres); b) Slope (degrees); c) Aspect (degrees from North).

[1]To be released in HIPS and SIPS 10.3.

Backscatter derived products and multispectral view

Figure 3 shows the different backscatter response at each frequency. Interestingly, the contrast is poor between zones 1 and 2 at 100 kHz, and good between zones 2 and 3. At 400 kHz, we can very easily distinguish between zones 1 and 2, but zones 2 and 3 are confounding.

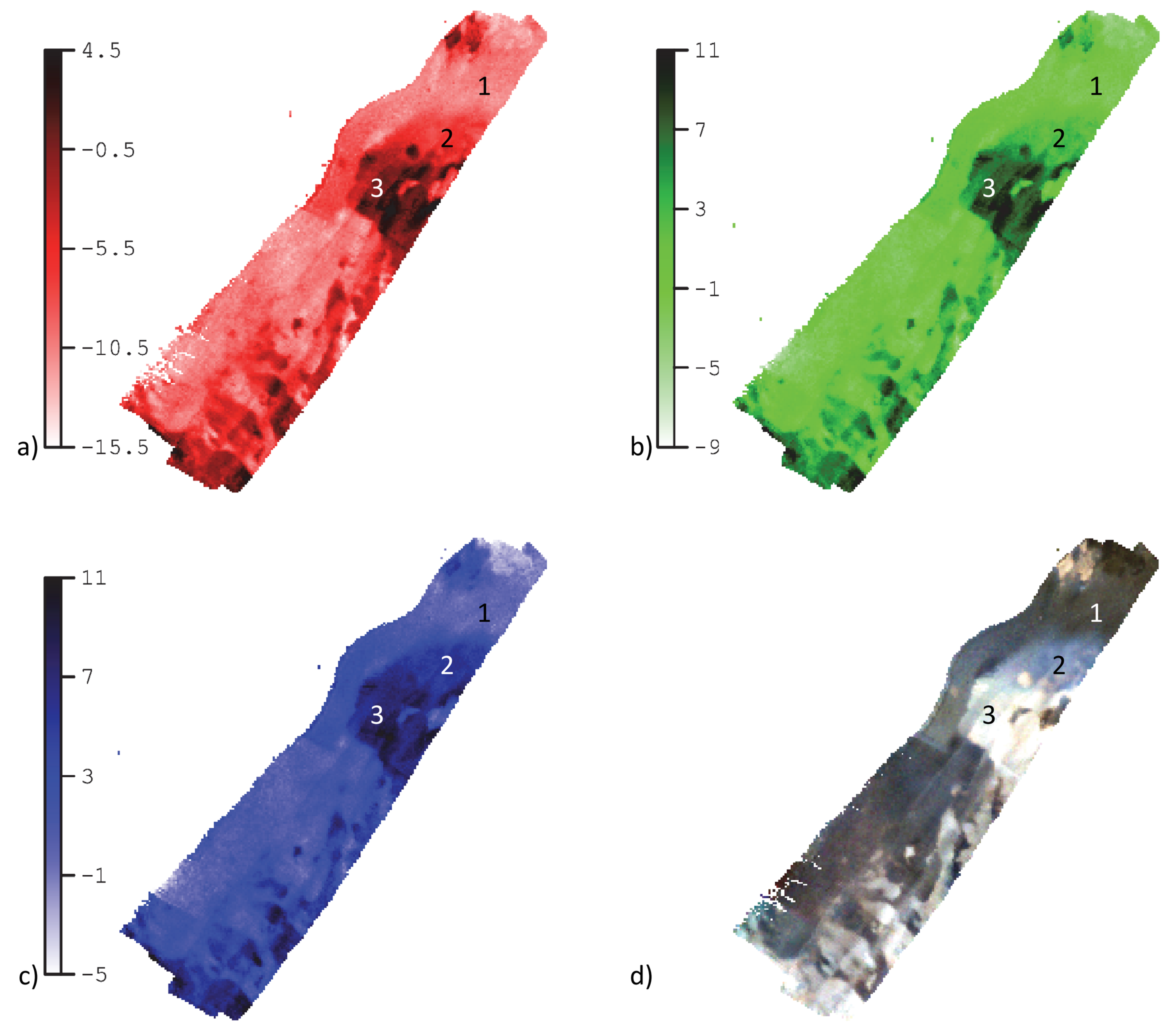

Figure 3: a) Mosaic (dB) for the 100 kHz band; b) Mosaic (dB) for the 200 kHz band; c) Mosaic (dB) for the 400 kHz band; d) Colour mosaic created from the 3 frequency bands, rescaled between 0 and 255, after removing 2 sigma outliers. White represents areas where the 3 frequencies have a high return (harder sediment) and black, areas where they all have lower return (softer sediment). In between, additive color logic applies, i.e red, green or blue would represent area of respectively a predominant return on the 100, 200 and 400 kHz, whiles tones of cyan, magenta and yellow, areas with a poor return on the same frequencies.

The color image in (d) provides this information at a glance. The dark region 1 would suggest softer sediment, and near-white region 3, hard sediment. Region 2, with its bluish color is harder to interpret, but we can surmise that this constitutes a different sediment type, information that could have been lost by looking at only one frequency. Figure 4 shows the color image draped over the bathymetry, and we can see what looks like an accumulation of softer sediments in 2 small depressions.

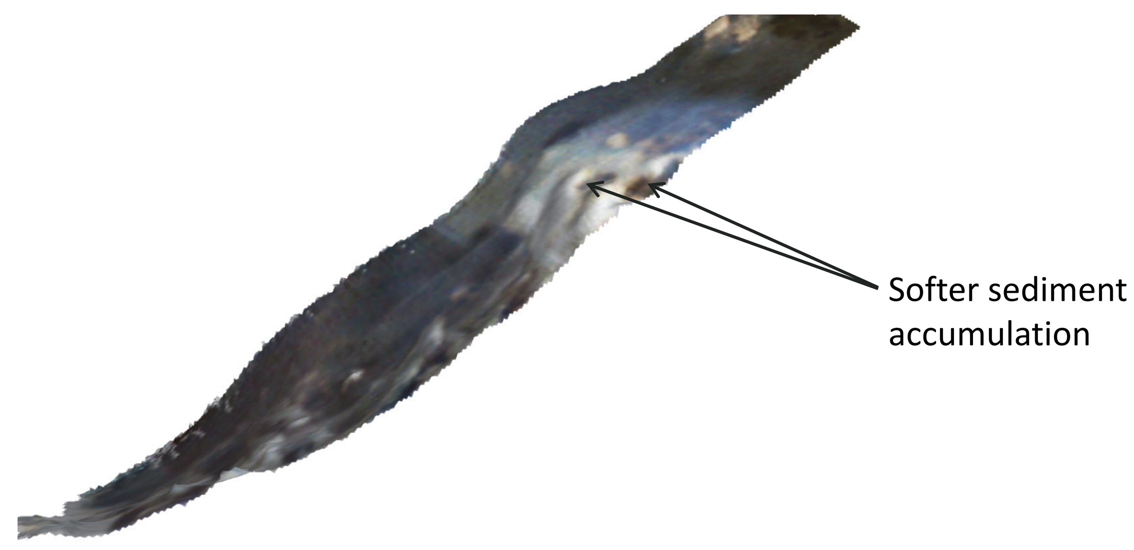

Figure 4: Multispectral image draped over the bathymetry (vertical exaggeration = 10).

Classification and validation

In Figure 5 a) and b), binary maps were created for the 100 and 400 kHz bands, using threshold values of respectively -5 and 4 dB in *Compute Layer* to distinguish between low and high intensities, based on the *Compute Statistics* histograms. In c), the binary maps are combined to create 4 acoustic classes.

Some grab samples available for Patrica Bay (Biffard et al. 2006) are also presented in Figure 5 c), but the limited number of samples that fell into the area of interest and the 11 years gap made it impossible to draw solid conclusions. The two sand and gravel samples, the hardest sediment type found, fell into areas where both frequencies indicated high intensity. However, some samples of silt and clay were also found in such areas. The heterogeneity of the seafloor where the silt and clay was found suggests it might be more subject to changes over time and could explain this incongruity. Unfortunately no samples fell in the blue class, an area where only the 400 kHz saw a high return. More ground-truth data, acquired during the same period as the multibeam survey would be necessary for a more thorough interpretation.

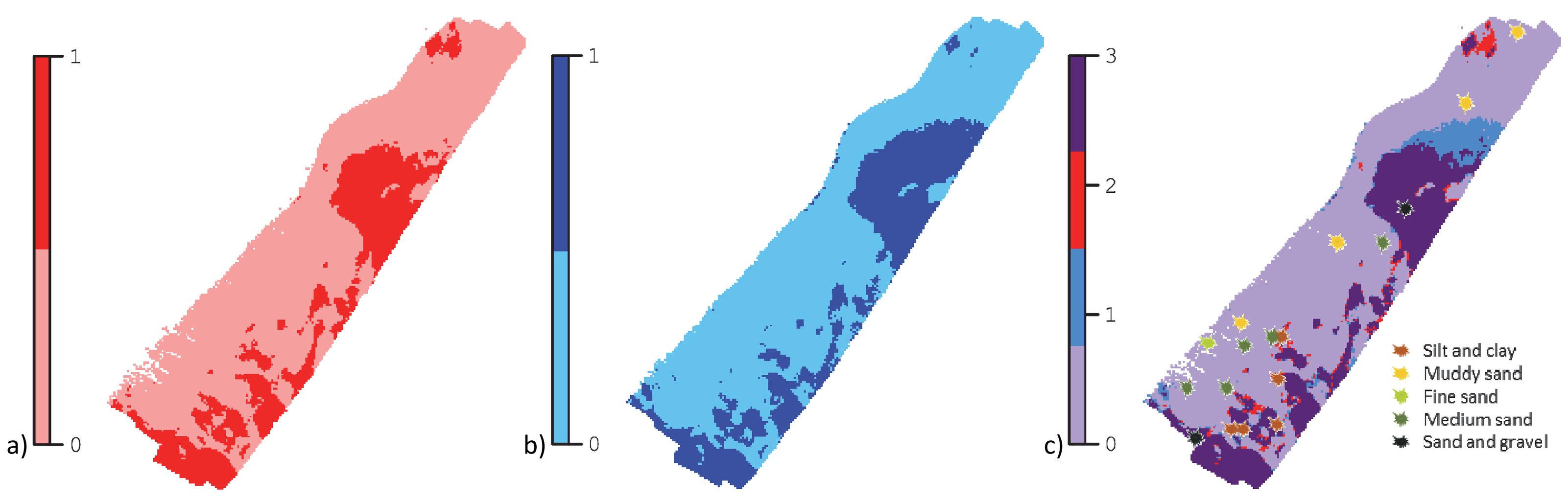

Figure 5: a) Binary mosaic for the 100 kHz band, 0 = low, 1 = high; b) Binary mosaic for the 400 kHz band, 0 = low, 1 = high; c) Classification map with grab samples, 2 shades of purple where the 2 bands "agree" on low (class 0) or high (class 3) return, and blue (class 1) or red (class 2) where only those respective bands have high intensity.

Conclusion

This poster presented the tools currently or soon to be available in CARIS HIPS and SIPS to perform seabed classification in a single software package. An overview of the different data types and format supported was presented, along with the different bathymetry and backscatter feature extracting and classification capabilities. These tools constitute a solid framework that will be extended in the future, with a focus on automation. Finally, a case study was performed on a multispectral dataset, showing how all these tools can be used to come up with a seabed classification map.

References

Anderson, John T., D. Van Holliday, Rudy. Kloser, Dave G. Reid, and Yvan Simard. 2008. "Acoustic Seabed Classification: Current Practice and Future Directions." ICES Journal of Marine Science 65 (6): 1004–11.

Biffard, Ben R., Steve Bloomer, Ross Chapman, J.M. Preston, and James L Galloway. 2006. "Single-Beam Seabed Characterization: A Test-Bed for Controlled Experiments." ICES Journal of Marine Science, no. July. https://www.researchgate.net/publication/228952585_Single-beam_seabed_characterization_A_test-bed_for_controlled_experiments.

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