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, 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:
• R2Sonic
• R2Sonic 2 (including multispectral Sonic 2026)
• Single/Dual-Head
• Beam average/time series

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, 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 uses the Geo-refereced Data layer as input to customize 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 distinct signal response. Different machine learning techniques (Anderson et al., 2006) 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.

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 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.

Backscatter derived products and multispectral view
The color image (a) provides this information at a glance. The dark region 1 would suggest softer sediment, and near the black region 4, hard sediment. Region 2, with its lighter color is harder to interpret, but we can assume 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.

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 0.5 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 Patricia Bay (Billett 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 12 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.

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 extraction 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