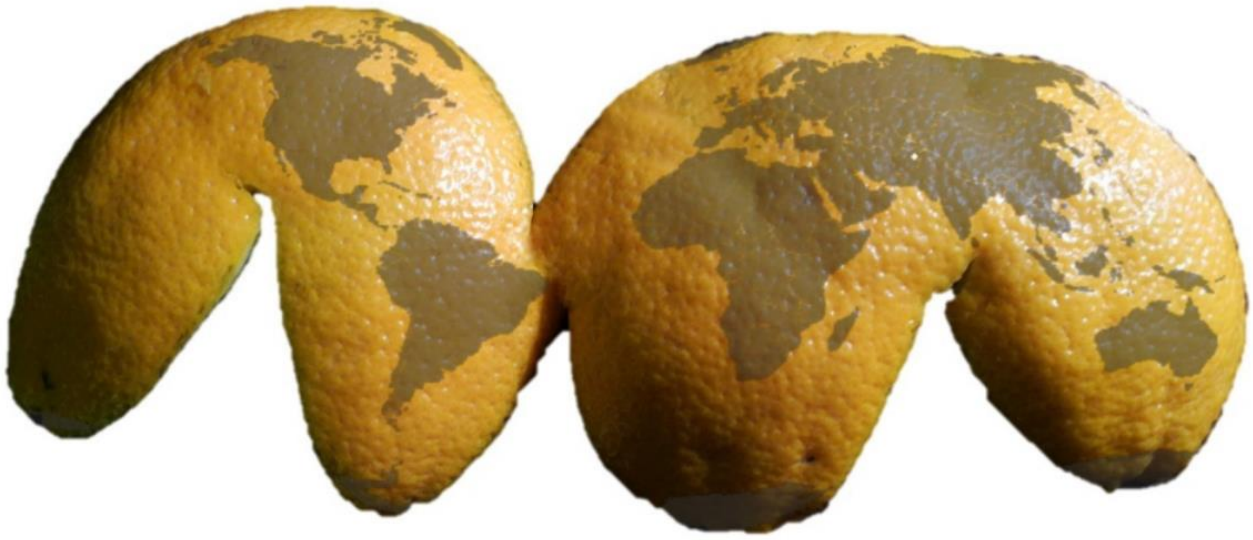
GEOHAB 2021

Marine Geological & Biological Mapping

PROGRAM AND
ABSTRACT BOOK



GeoHab Nodal Conference of the Americas (GNCA)

3rd and 4TH of May 2021

GEOHAB 2021

Marine Geological & Biological Mapping

Americas Node

3rd and 4th May 2021

(All times are given in Atlantic Daylight Time Zone – UTC -3hrs)

3rd May	***DAY 1***	
12:00	Craig Brown and Brian Todd	Welcome remarks
12:10	Sponsors comments	
Session Chair: Katleen Robert ***Session Theme: Shallow Water Habitats***		
12:20	Nkouamen Nemzoue et al.	Mapping and characterisation of the marine geohabitats of the eastern continental shelf of Ceará, Brazil
12:40	Sneep et al.	Mapping and characterizing eelgrass beds in Placentia Bay and Trinity Bay, Newfoundland and Labrador, Canada
13:00	Overly and Lecours	Mapping queen snapper (*Etelis oculatus*) suitable habitat in Puerto Rico using ensemble species distribution modeling
13:20	de Oliveira N et al.	Shelf-incised valleys as mesophotic habitats in a tropical mixed shelf
13:40	Charmley et al.	Seasonal change between benthic habitat maps in sub-Arctic ecosystems
14:00	Gomes et al.	Characterization of ichthyofaunal geohabitat: a preliminary approach for a Marine Protected Area - the Alcatrazes Archipelago region, São Paulo, Brazil
14:20-15:00	**BREAK**	
Session Chair: Helenice Vital ***Session Theme: Habitat Modelling***		
15:00	Mackin-McLaughlin et al.	Comparing the accuracy of two machine-learning algorithms in predicting benthic invertebrate species assemblages across coastal Placentia Bay, Newfoundland, Canada
15:20	McHenry et al.	Modeling the biodiversity enhancement value of seagrass beds
15:40	Nemani et al.	A multi-scale feature selection approach for predicting benthic communities
16:00	Meijer et al.	Using maximum likelihood to maximize efficiency: semi-automating seabed classification on the British Columbia Coast
Session Chair: Helenice Vital ***Session Theme: Habitats in the Anthropocene***		
16:20	Fulton et al.	Retrieval of abandoned, lost, and discarded fishing gear in southwest Nova Scotia, Canada: environmental and economic impacts to the commercial lobster industry
16:40	Goes et al.	A sensitivity seafloor index to oil spills response plans in tropical marine protected areas
17:00-18:00	**VIRTUAL ICEBREAKER**	

4th May	***DAY 2***	
12:00	Craig Brown and Brian Todd	Day 2 greeting
12:05	Spnsors comments	
Session Chair: Tereza Araújo ***Session Theme: Mapping Strategies***		
12:10	Menandro et al.	Exploring multifrequency backscatter response in soft bottom habitat using a three-front approach
12:30	Ilich et al.	Mapping offshore hardbottom areas on the west Florida shelf using multiple spatial scales of analysis
12:50	Haar et al.	Harmonizing multi-source backscatter data using bulk shift approaches to generate regional seabed maps: Bay of Fundy
13:10	Boni et al.	Reef and inter-reefal mapping using automated supervised classification
13:30	Espriella et al.	Optimizing intertidal habitat classification at multiple scales using open-source tools
13:50	Leite et al.	Applying semi-automated methods for identifying seabed circular depressions at the Brazilian outer-shelf
14:10	Da Silveira et al.	Coral reef mapping using satellite imagery: a contribution for seascape mapping
14:30-15:00	**BREAK**	
Session Chair: Narelle Maia de Almeida ***Session Theme: Mapping Strategies (cont)***		
15:00	Hintenlang et al.	Nadir and oblique imaging to observe intertidal oyster populations using UAS photogrammetry
15:20	Andrade et al.	Evaluation of images obtained with the PlanetScope system for bathymetry estimation in optically shallow waters
Session Chair: Narelle Maia de Almeida ***Session Theme: Deep Water Habitats***		
15:40	Oxton et al.	High-resolution habitat mapping of cold-water coral and sponges in the Northern Gulf of Mexico
Session Chair: Narelle Maia de Almeida ***Session Theme: Seabed Geomorphology***		
16:00	Costa et al.	Submarine morphological features of the continental slope adjacent to the Jaguaribe River, Brazilian Equatorial Margin
16:20	Silva et al.	A new geomorphological insight at Canal do Varador, Amazon Continental inner shelf, Brazil
16:40	Gary Greene	Closing remarks
17:00 – Close of Conference		

Evaluation of Images Obtained with the PlanetScope System for the Bathymetry Estimation in Optically Shallow Waters

L.C. Andrade[1], I.O. Ferreira[1], V.G.Teixeira[1], F.C.M. Santos[1] , L.P. Pinheiro[1]

1. Federal University of Viçosa, Brazil

The use of optical remote sensing in bathymetry is notorious nowadays. The need to map locations that pose a risk to the ship's crew or those that are very shallow, makes it impossible for a traditional bathymetric survey to be carried out with echo sounders and large vessels. In addition, the use of acoustic systems is time consuming in its entirety, expensive and also requires a great deal of experience from the operator. In a different scenario, with the technological evolution, several orbital systems are able to provide centimetric accuracy at a lower cost compared to the echo sounders.

In this context, researchers seeks to use a vast sample of bathymetric points to estimate depth with orbital images, using indexes such as NDWI (Normalized Difference Water Index) or ANNs (Artificial Neural Networks). However, the inevitability of the existence of a high number of random bathymetric points can make these procedures less viable and less attractive.

Thus, the present work proposes a methodology to estimate depths from orbital images of the PlanetScope system, using bathymetric methods by spectral response, with the NDWI index and bathymetric points spaced by 500 meters in the Casquinha Dam Reservoir, local expected to be used by the Federal University of Viçosa as its independent source of electricity.

A comparison was made with bathymetric data of the study area, obtained through conventional survey, quantifying the vertical uncertainty using RMSE (Root Mean Square Error) estimator and also comparing the volumes calculated by the reference bathymetric data and the bathymetry estimated by spectral response. The results show a high resemblance with the real data, since presented a vertical uncertainty of 0.9 meters. In addition, the difference of 6% between the volumes shows the potential of the methodology for primary studies for the improvement of environmental management in the reservoir, which can generate benefits in a short term and at reduced costs.

The study revealed that the points contained in the sections are quite efficient for the extraction of bathymetry with orbital images, especially with the use of the NDWI index. In addition, it is important to emphasize that this methodology not only reduces the amount of random points to estimate the depth, but also the work on collecting bathymetric data.

Inter-Reef Mapping Using Automated Supervised Classification

G.C. Boni[1], A.C. Lavagnino[1], F.V. Vieira[1], L.X. Maia[1], M.D.A. Leite[1], N. Oliveira[1], P.S. Menandro[1], A.C. Bastos[1]

1. Marine Geosciences Lab - Federal University of Espírito Santo, Brazil

A group of reef structures have been recently mapped using a multispectral multibeam echosounder. The "Forgotten Reefs" are located at the southern part of the Abrolhos Shelf and their origin and habitat/ecological significance are still under investigation. Here, we describe their morphological heterogeneity for the first time by mapping reef and inter-reef habitats. The survey was conducted using an R2Sonic 2024 (170–280–400 kHz) MBES. Ground-truth was obtained using drop cameras, ROV, and scuba observations (for benthic cover analysis). Here, we present multibeam sonar bathymetric and backscatter data for the 170 kHz frequency only.

Two automatic supervised techniques were applied based on multibeam dataset: i) BRESS (Bathymetric and Reflectivity-Based Segments); ii) RSOBIA (Remotely Sensed Object Based Image Analysis). BRESS is a research tool developed by Center of Coastal and Ocean Mapping (University of New Hampshire), which performs an initial analysis of geomorphometric properties and landforms from bathymetry. Backscatter is then analyzed to derive seafloor segments based on similarity. RSOBIA is an ArcGIS toolbox that performs image segmentation and classification based on slope, rugosity and backscatter.

The morphology and backscatter values of the seabed range from 12–24 m and -29 to -14 dB, respectively. There are more than 900 reefs varying in size (up to 12 m in height) and distributed throughout three main regions. These regions indicate a SE–NW reefs alignment with some coalesced structures (already described in the Abrolhos Shelf). Erosional bedforms known as furrows were observed with lengths exceeding 1 km and width ranging from 3–24 m.

Both classification methods provided results that were consistent with the observed habitat heterogeneity. BRESS discriminated eight classes. It is visually possible to group them in three essential ones: reef structures, inter-reef seabed, and seabed associated with bedforms (furrows). One of the three reef classes occurs primarily on the southern sector of the study area. Two classes are clearly related to the landforms, guided by crests/valleys of the furrows. The RSOBIA approach distinguished four classes: two reef classes, and two inter-reef classes. Furrows were not successfully identified with RSOBIA. The inter-reef seabed was divided in two classes, most likely due to backscatter but also to macroalgae coverage observed in drop camera footage. The southern reefs were also labelled as a different class (greater values of slope and rugosity) using this technique.

Future work will involve mapping and ground truthing of adjacent areas. We will keep focusing on habitat mapping, exploring the potential complementarity of these techniques, trying to understand the uniqueness of the Forgotten Reefs, as well as the link between furrows and the geomorphological and hydrodynamic influence of the reefs.

Seasonal Change Between Benthic Habitat Maps in Sub-Arctic Ecosystems

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Habitat mapping of benthic environments rarely incorporates a temporal aspect into its construction. This is despite the fact that it is well researched that motile organism can express temporal spatial patterns; for example, some organisms' habitat selection is likely linked to zooplankton assemblage patterns. Construction of habitat maps involve the association of full coverage acoustic layers with *in situ* samples (ground truthing), which are often image and/or video data showing biological communities and sediment characteristics. Since studying benthic ecosystems is an expensive and time-consuming task, most current habitat mapping studies are built off a single ground-truthing event. This makes the maps a simple snapshot of the ecosystem and does not consider temporal variability.

In collaboration with Fisheries and Oceans Canada (DFO) and the Marine Environmental Observation, Prediction, and Response Network (MEOPAR), a seasonal repetition of ground-truthing of a sub-Arctic bay in Newfoundland and Labrador, Canada was carried out to quantify the level of spatio-temporal changes in benthic communities by comparing the production of habitat maps across seasons. In each season, drop camera videos were collected at 78 sites to assess the megabenthic species composition and substrate type. Environmental data were derived from previously collected bathymetry and backscatter data at a variety of scales using both the Benthic Terrain Modeller and TASSE toolboxes in R. These environmental variables were then associated with the community data to create full coverage season specific habitat maps using machine learning algorithms.

We compared the season specific species assemblage maps using a pixel-to-pixel approach and evaluated the extent to which these maps changed between seasons. The indicator species for the species assemblages remained constant across the seasons and were all motile species. However, across the seasons, the size and locations of the predicted assemblages changed.

This study is one of the first to produce predictive maps based on a spatio-temporal seafloor dataset for a sub-Arctic benthic community in Canada. Such maps will allow us to identify the level of variation characterizing different habitat types, ensuring efficient use of both time and money by changing sampling frequency of specific habitats according to the level of spatio-temporal heterogeneity. Moreover, this study will help us quantify the normal fluctuation range of sub-Arctic coastal ecosystems to aid in early detection of future perturbations. This will help us manage these marine areas effectively so they can remain biodiverse and economically productive.

Characterizing Submarine Morphological Features of the Continental Slope adjacent to the Jaguaribe River, Brazilian Equatorial Margin

D.S. Costa[1], N. Maia de Almeida[1], M.L.S. Nogueira[2], G.S.S. Freire[1], H. Vital[3], L. Jovane[4]

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2. Federal University of Ouro Preto (UFOP), Brazil
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4. University of São Paulo (USP), Brazil

The seafloor morphology of the continental slope of the western portion of the Potiguar Basin, adjacent to the Jaguaribe River on the Brazilian Equatorial Margin (MEB), is still unknown. The Potiguar Basin is located at the eastern end of the MEB, encompassing part of Rio Grande do Norte and Ceará States. It is limited to the west by the Fortaleza High and to the east by the Touros High. The morphological characterization of the study area is necessary to support geohabitats studies, installation of submarine cables and pipelines, naval underwater operations, recognition of possible geohazards, and to assist in the mapping of possible deposits of economic importance, such as submarine fans analogous to turbidite and contourite reservoirs, especially in view of recent discoveries in the counterpart African margin, Guianas and Suriname. Thus, the morphological characterization of the study area is necessary. In this study, we focused on the western portion of the Potiguar Basin, which is part of the geological context of the Meso-Cenozoic Basins, and used seismic interpretation. Specifically, we mapped the seismic horizon that represents the seabed using 3D seismic data (0276_BCE2_BPOT_100) granted by the National Agency of Petroleum, Natural Gas and Biofuels (ANP), through the use of Petrel software.

Firstly, the quality of the seismic data was evaluated. Secondly, the seismic volume was cut in order to focus on the area of greatest interest for the seabed characterization. Thirdly, the mapping of the seafloor horizon was conducted using the automatic interpretation tool (3D autotracking). Simultaneously, an evaluation of the autotracking interpretation with manual correction was performed.

Through morphological studies, a continental slope may present features of three different stages of evolution and development. In the study area, features of stage two and three were interpreted. The Stage 2 (transitional) was interpreted due to the presence of gullies on the continental slope, which are short and shallow morphological conduits that indicate bottom erosion. Six gullies were interpreted. The Stage 3 (mature) was represented by nine submarine canyons that are V– or U–shaped features that incise the continental slope from top to bottom, presenting a high sinuosity index and terraces along their margins. In addition, some depressions were observed that are arranged on the ocean floor either individually or as aligned sequences of discrete depressions. Thus, this study presents preliminary results in the description and understanding of submarine morphological features of a deep-water region on the Brazilian Equatorial Margin.

Coral Reef Mapping Using Satellite Imagery: a Contribution for Seascape Mapping

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3. Instituto Recifes Costeiros (IRCOS), Brazil

Mapping habitat complexity is essential to assist strategic decisions regarding use and protection of coral reef ecosystems. Satellite-based remote sensing has frequently been used to derive environmental values in spatial scales large enough to depict entire ecosystems at once. Additionally, high-resolution datasets have recently become available and cost-effective, making these ideal tools to map coral reef areas, if calibrated with reliable field data.

We used high and medium resolution datasets (*i.e.* WorldView-03 and Landsat-8 OLI), photos and videos acquired in situ to map topographical and ecological relevant features in a shallow, topographically complex coral reef area in the Northeast Coast of Brazil. In addition, human use was mapped based on sampling of in situ presence of tourism and fisheries. The study area is located in a region where three Marine Protected Areas overlap, and is historically subjected to human-related impacts such as sedimentation, fishing, growing tourism and coastal development.

A WorldView-03 scene was used in the habitat mapping of the reefs, using Vector Machine Classifier and approximately 1500 field points (overall accuracy = 79%). Fifteen spectrally different benthic classes were identified, and related to benthic classes such as seagrass, macroalgae, sand, rubble, branching coral, and others. WorldView-03 and Landsat-8 scenes were used to derive bathymetric models of the area, as well as derivative layers (*e.g.* diversity of habitats per area, slope, bathymetric position index, distance to shore). We were able to identify areas of increased biodiversity, like the no-take zone in our study area (maximum of 14 habitats/0.01 km^2).

Furthermore, we used these ecological (*e.g.* benthic cover, habitat diversity per area), topographical (*e.g.* bathymetry, rugosity) and local (*e.g.* distance to shore, turbidity) variables to analyse the distribution of a shallow water dominant hydrocoral species in the region, the branching fire coral *Millepora alcicornis*. Habitat suitability for the occurrence of the species was calculated using MaxEnt (AUC > 0.98). We have also assessed the relevance and effectiveness of the only no-take zone in the region for coral distribution. The model identified topographical limiting factors to the settling and growth of coral colonies in the area, such as the distance to the shore and depth. The most important variables were ecological, showing the importance of maintaining high biodiversity values in a coral reef ecosystem. Integrating the habitat suitability model with absence data and human use maps suggests the impact of direct human use, namely fishing and tourism, as potential inhibitors to coral growth.

Results in this study reinforce the importance of a no-take zone and protective measures for the maintenance of local biodiversity. Furthermore, it offers the first detailed mapping of the coral reef complex of Tamandaré, which may be used as a basis for marine spatial planning in the MPA.

Shelf-Incised Valleys as Mesophotic Habitats in a Tropical Mixed Shelf

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Habitat mapping is based on an interdisciplinary analysis of the seafloor in order to understand which are the dominant and determinant variables that control benthic habitat distribution. Short to long-term derived shelf morphology can be crucial for benthic habitat distribution. Sea-level fluctuations determine shelf exposure and flooding, which combined with sediment input and carbonate production rates defines shelf morphology heterogeneity. Thus, geomorphology-controlled habitats can be a legacy of sea-level rise and fall cycles, that combined with modern processes, define the complexity of mesophotic habitats. Knowing that geomorphology is an important component used to define and understand the benthoscape, association between these parameters is important to develop a mosaic of habitats. In this context of sea-level changes influencing shelf morphology, shelf-incised valleys become features of great potential for the formation of mesophotic habitats, considering their prominent relief and potential association with distinct water physical parameters such as, temperature, light, etc.

The Costa das Algas Marine Protected Area (CAMPA), on the Espírito Santo continental shelf, southeastern Brazil, is characterized by a flat seafloor with 5 shelf-incised valleys. Here, our main goal is to classify distinct habitats associated with the geomorphological features of these valleys, including flank, bottom and margin, and to define the associated benthic community. The study comprises the integration of multibeam sonar bathymetry data, video imaging, physical-chemical parameters of the water column, sediment carbonate and mud contents, morphometric data from Benthic Terrain Modeler (BTM), multivariate statistical analysis (Principal Components Analysis, PCA) and segmentation by Object Based Image Analysis (OBIA).

Bathymetric data revealed five main incised valleys, all extending across the continental shelf to the shelf break. The valleys have steep walls, often associated with reef banks originated by carbonate bioconstructions that can also be found sparsely in the bottom of the valleys. The area between the channels showed different features, such as submerged terraces, ridges, aligned crests parallel to the coastline and small circular depressions. The analysis of the images defined five classes of bottom types: bioincrustations (BIOC- hard bottom rich in benthic coverage), Unconsolidated sediment (SED- fine and coarse sediments), Rhodoliths (R>40% - more than 40% of rhodolith coverage in the frame), Mäerl (carbonate fragments) and rhodoliths with sediments (R<40% - less than 40% of rhodolith coverage in the frame). The frames showed a varied benthic community, where the groups of observed organisms were classified into rhodoliths (covered by crustose coralline algae), macroalgae, geniculate corallines algae, sponges, corals, bryozoans, ascidians, biofilm and others organisms (such as echinoderms).

PCAs identified the determining parameters controlling habitat distribution for each morphological region of the valleys. In the bottom portion, 60.72% of the total variance is explained by water temperature and depth. In valley flanks, 67.06% of the variance is explained by carbonate content and gradient. Along the shelf adjacent to the incised valleys, 79.17% of the variance is explained by water temperature, mud content and carbonate content. The OBIA led to the segmentation of the area into six classes. The subsequent combination of these results with classes identified by means of frame, allowed the production of the CAMPA habitat map. Seventeen classes were identified, thirteen of which are associated with the valleys' relief (valley floor and valley margins) suggesting that these features have great potential for biodiversity, with various habitats.

Optimizing Intertidal Habitat Classification at Multiple Scales Using Open-Source Tools

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Along Florida's Gulf of Mexico coastline, intertidal habitats such as oyster reefs and salt marshes provide vital ecosystem services, including shoreline erosion control, habitat provision, and water filtration. However, these systems face significant change as a result of anthropogenic stressors like coastal development and environmental stressors such as sea-level rise and disease. Oyster reefs, in particular, have experienced a significant decline in the region (> 65% since 1982). Traditional *in situ* oyster habitat monitoring techniques are expensive and time-intensive, thus limiting how often these resources are mapped and hindering effective management. There is a critical need to develop effective and reproducible approaches to map and monitor oyster resources in Florida.

Unoccupied aircraft systems (UAS) are an option to rapidly, safely, and inexpensively collect data in difficult-to-access coastal areas. We used a UAS to collect very-high-resolution (0.66 cm) imagery of intertidal habitats in a Florida estuary. Structure-from-motion photogrammetry techniques were used to generate an orthomosaic and a digital surface model from the imagery. These products served as inputs to a Geographic Object-Based Image Analysis (GEOBIA) workflow to classify three types of intertidal habitats: mudflats, salt marshes, and oyster reefs. The initial classification was conducted in the eCognition proprietary software and produced an overall accuracy of 79%. To inform the classification, a feature-space optimization was conducted to select the 10 of 31 tested variables that allowed the highest level of separability between classes. These variables included spectral and geometric information.

The workflow in eCognition is stored in a shareable ruleset that enhances the reproducibility of the study. However, to make the work more accessible and increase the likelihood of consistent monitoring, the work was expanded to construct a classification using open-source tools; the SegOptim package in R was used to combine the optimization of segmentation parameters, image segmentation, and supervised classification in one workflow. To further streamline and improve the process of UAS imagery collection and processing for monitoring purposes, the orthomosaic was resampled at spatial resolutions ranging from 1 cm to 31 cm, and our workflow was applied to each resolution to explore which are the most appropriate for habitat mapping applications. The open-source workflow produced similar accuracies to the eCognition-based workflow. Overall accuracies ranged from 75% to 82% across the resolutions. Coarse resolutions performed just as well or better than finer resolutions, indicating that very high-resolution imagery may not be essential for habitat mapping and monitoring purposes in this type of ecosystem. This has implications for management agencies that may want to use this workflow, as using coarser resolutions reduces the computational requirements necessary to apply it. Of note is that when taking a habitat-focused approach instead of an ecosystem-based approach, the classifications of individual habitat types performed best at different spatial scales, highlighting that the patterns and processes associated with one type of habitat are not necessarily captured at the same spatial scale as those of other habitat types. For example, mudflats are best captured using a coarser resolution than oyster reefs.

Future work will focus on trade-offs between sensors. Lidar and RGB imagery will be collected over intertidal systems to conduct a holistic comparison and inform managers what sensor may be more appropriate for a given application. Multibeam sonar data will also be collected on subtidal oyster reefs to compare the characteristics of intertidal and subtidal oyster reefs. Overall, this work will provide tools and information to managers and will encourage consistent, repeatable, and robust monitoring of critical habitats like oyster reefs and salt marshes.

Retrieval of Abandoned, Lost, and Discarded Fishing Gear in Southwest Nova Scotia, Canada: Environmental and Economic Impacts to the Commercial Lobster Industry

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Southwest Nova Scotia (SWNS) is the most productive lobster (*Homarus americanus*) fishing region in Atlantic Canada with reported abandoned, lost, and discarded fishing gear (ALDFG) distributed throughout. ALDFG causes numerous environmental and economic impacts, including habitat degradation, entanglement, indiscriminate fishing of target and non-target species (including at risk species), decreased catches, and generation of marine debris. This study is the first baseline assessment of the environmental and economic impacts of ALDFG on the commercial lobster fishing industry in SWNS. In September and October 2020, five vessels conducted a total of 60 at-sea retrieval trips in selected areas which were informed through fisher's local knowledge and government records. Over 2824 km were towed searching 1523 km^2 of the seafloor, during which seven tonnes of debris was removed, where lobster traps represented 66% of the total weight. Of the 239 lobsters released from retrieved gear, 67% were market sized, and of the seven groundfish released, five were species-at-risk. Based on gear retrieved and market-sized lobsters released, decreased lobster catches associated with ALDFG in SWNS are estimated to cause more than CAD $175,000 in commercial losses annually. Although this is a baseline assessment of ALDFG, it is estimated that these economic losses are an underestimate given several factors. Additional metrics collected showed that lobster traps fish effectively until roughly four years after loss, or until traps degrade and become biofouled. Once they become degraded and disarmed (ceasing to fish lobster and other species effectively), derelict lobster traps may provide some physical protection for certain species. However, they may not create high-quality marine habitat. In spring 2021, side scan sonar will be deployed to map and characterize seafloor substrate, morphology and habitat characteristics to explain relationships between hotspots of gear loss and the benthic environment. The acoustic imagery of the seafloor will also inform locations for at-sea retrieval. In the summer and fall of 2021, 69 additional at-sea retrieval trips will be conducted, collecting more data on ALDFG and by-catch, producing a variety of informative spatial analyses for various uses. Furthermore, additional metrics such as bottom-type and physical properties of the marine environment will be investigated to further inform impact assessment of ALDFG in SWNS. Overall, this research will be used to support environmental stewardship practices and inform ALDFG management in SWNS to uphold fisheries sustainability for future generations.

A Sensitivity Seafloor Index to Oil Spills Response Plans in Tropical Marine Protected Areas

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Oil spills are a global environmental problem with dramatic effects on local and regional scales. In 2019, a major oil spill from an unknown source reached the Brazilian margin and strongly affected marine habitats on high tropical biodiversity sectors.

The environmental sensitivity index (ESI) is an essential component for oil spill response planning, with well-defined methodological criteria for the shoreline, but not defined for underwater habitats. It is urgent to establish a quick and accessible approach to assist decision-makers during and in post-spill responses. The aim of this paper is to conduct one first approach for mapping seafloor sensitivity to oil spills for continental shelf areas with limited resources and materials.

The assessed area extends over 933 km² to the90 m isobath and is localized in the southern Pernambuco Continental Shelf. This area has a strategic position for world shipping routes, which allows significant maritime traffic in the region, increasing the risks for an oil spill. The case study was conducted through a pre-existing bathymetric dataset on megahabitat and mesohabitat scales (Fig. 1). Both analyzes were carried out in ArcGIS.

From the megahabitat-scale analyses, the greatest topographic complexity areas were isolated on a mesohabitat-scale (104.5 km²). Results show that 12.7% of this scale present high seafloor sensitivity index (SI*seafloor*), 28.7% present relative of moderate sensitivity, and 58% have low sensitivity. The seafloor sensitivity approach presented can be used as a base to prepare recovery operations and monitoring plans, and for the future establishment of submerged ESIs.

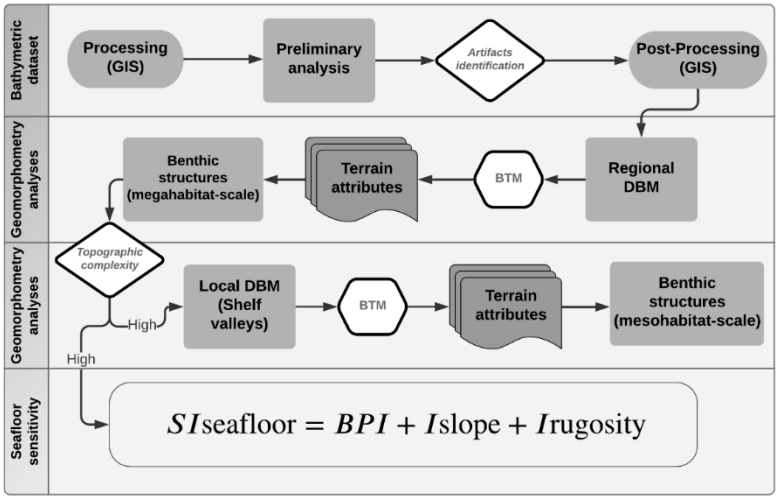

Figure 1 – Methodological flowchart.

Characterization of Ichthyofaunal Geohabitat: A Preliminary Approach for a Marine Protected Area - the Alcatrazes Archipelago Region, São Paulo, Brazil

R.R. Gomes[1], J.F. Dias[1], M.M. Mahiques[1]

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Studying the relationship between the background morphology, its sedimentological characteristics and the abundance and occurrence of demersal ichthyofauna species allows a better understanding of the ecological interactive processes between them and their environment.

The Alcatrazes Archipelago region is located on the north coast of the state of São Paulo (24° S) in the Southeastern Brazilian Bight. Alcatrazes Archipelago is part of two marine protection areas (MPAs): the Ecological Station Tupinambás and the Wildlife Refuge of Alcatrazes, managed as a unit by ICMBio. The creation and maintenance of MPAs play fundamental role to preserve biodiversity and ecosystems. The objective of this study is to evaluate bottom surface features as possible habitat for species of demersal ichthyofauna, as the region is used by species of economic and ecological importance.

An integrated geological and biological survey was performed in 2019, onboard R/V *Alpha Delphini*. Side-scan sonar was used for the acoustic survey. Sediment sampling was done with a modified van Veen sampler and the samples were frozen on board for analysis in the laboratory. The ichthyofauna sampling was carried out using bottom trawls at a constant speed for ten minutes. The Actinopterygii were euthanized with a 400 $mg.L^{-1}$ eugenol solution, frozen on board and brought to IOUSP for identification and data collection. The captured elasmobranchs were measured, weighed, photographed on board for later identification, and released alive.

Interpretation of the side-scan sonar indicated that the bottom surface in the archipelago's innermost region is more homogeneous than the outer zone. Grain-size analyzes indicated the predominance of fine sediments (except for two stations). A total of 1910 organisms of 61 species were captured. The n-MDS diagrams and CCA analyzes identified distinct groups of stations formed by biological abundance and environmental parameters that possibly influenced fish distribution.

The results obtained indicate that integrating side-scan sonar information with biological data is a valid approach to evaluate possible benthic habitats. As the geohabitat investigation can also be considered a mapping of environmental sensitivity, it is recommended that more environmental variables should be added for analysis for a more robust understanding of the patterns of organisms' distribution concerning the background features.

Harmonizing Multi-Source Backscatter Data using Bulk Shift Approaches to Generate Regional Seabed Maps: Bay of Fundy, Nova Scotia, Canada

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Advances in acoustic sonar technology have revolutionized our ability to map the seafloor. However, differences between historic and modern data pose new challenges when analyzing multi-source datasets. Multibeam sonar data were collected in the Bay of Fundy from 1996 to 2009 using a variety of survey vessels and sensors including Kongsberg EM1000, EM1002, EM3002, and EM710 echosounders. In addition to bathymetric data, multibeam sonar systems record the intensity of echoes returned from the seabed (i.e. backscatter strength). Once the appropriate geometric and radiometric corrections have been applied, computed backscatter strengths represent the acoustic reflectivity of the seafloor, which is commonly used as an indicator of seabed substrate properties. Due to a lack of standardized calibration, backscatter measurements are often relative to discrete surveys, and consistency between multi-source backscatter datasets may be poor. Bulk shift approaches have been developed as a solution for harmonizing legacy backscatter datasets using areas of mutual overlap for relative statistical calibration. Here, bulk shift harmonization was applied to a collection of backscatter datasets from the Bay of Fundy to support the mapping of benthic habitats and substrates. This method has previously been effective at harmonizing datasets of disparate operating frequency. However, this becomes increasingly difficult given a large number of surveys. Harmonization quality was evaluated using statistics from the bulk shift procedure and visual analysis, and the utility of the fully harmonized layer was explored using ground-truth seabed observations. Additionally, approaches for the *post hoc* correction of anomalous backscatter lines within backscatter datasets were explored, and results suggested such procedures may be beneficial for inter-survey harmonization.

Nadir and Oblique Imaging to Observe Intertidal Oyster Populations Using UAS Photogrammetry

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In Florida, intertidal oyster habitat is not comprehensively monitored nor managed as a fishery. Challenges to intertidal oyster habitat monitoring include access, tides, and fishery-independent monitoring that, together, have precluded historical data collections and analyses from informing future monitoring and restoration plans. The multidecade decline in oysters and oyster habitat in Florida highlights the need for the collection of baseline data and subsequent temporal monitoring of these important habitats.

Unoccupied aerial systems (UAS) are increasingly used to support coastal habitat mapping and assessment and may offer a viable approach to overcoming intertidal restoration monitoring barriers. UAS-based data collection can facilitate access to remote or sensitive field sites and provide on-demand remote sensing capabilities with higher spatial and temporal resolutions than satellite or occupied aircraft sensors. With a variety of platforms and payloads available, UAS can be customized to fit niche restoration and monitoring needs. For example, while fixed-wing UAS are often limited to capturing habitats from above (*i.e.*, at nadir), multi-rotors UAS can hover at low-altitude to capture habitats from oblique angles. Structure from Motion (SfM) photogrammetry can then be used to provide accurate orthomosaics, which can be further rendered into centimeter-scale 3D models of habitat structure.

This pilot project utilized SfM photogrammetry to subsample intertidal oyster habitat at the level of the oyster cluster, which in turn can provide estimates of larger habitat area. Here we designed an experiment to compare abundance estimates in oyster habitats from different UAS configurations. Five oyster clusters, acting as proxies for future subsampled reefs, were manually imaged at nadir in a transect pattern of four flight lines, akin to what a fixed-wing UAS would capture, and in a 360º pattern, simulating multi-rotors UAS. A total of 16 photos was taken at low altitude for each survey design and oyster cluster. The images were then imported into Agisoft Metashape to render 3D texturized habitat models. All the oysters visible in the models with both valves intact were counted and compared to a complete count obtained via more traditional destructive sampling.

While both oblique and nadir methods underestimated the total number of oysters present on each cluster by 60% and 72%, respectively, they did so with consistency, achieving a standard deviation of 12% and 5%, respectively. While the oblique camera angles allowed for more accurate counts (*i.e.*, closer to the "truth"), the images taken at nadir offered more precision (*i.e.*, less variability). Such aspects are important to consider when extrapolating data to larger reef areas. A linear trend was fit to the oblique and nadir datasets to determine the percent error for each cluster. Mean percent error for both oblique and nadir methods were -1.7% and -1.8%, respectively, indicating that the methods may in fact be comparable. The experiment will be repeated using 24 photos for each survey design and oyster cluster to compare the outputs of higher resolution 3D models and refine the distinction between the UAS survey designs. These experiments will allow quantification of the detection probability of similar UAS systems to produce more accurate abundance estimates of entire oyster habitat systems that can inform habitat-based conservation, restoration, and management efforts.

Mapping Offshore Hardbottom Areas on the West Florida Shelf Using Multiple Spatial Scales of Analysis

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The West Florida Shelf (WFS; Gulf of Mexico, USA) is an extremely important area for both commercial and recreational fisheries. However, the lack of detailed habitat maps in this area makes planning fisheries independent monitoring surveys difficult and hinders the ability to manage and monitor fish stocks and ecosystems over time. As of 2015, less than 5% of the WFS had been mapped in high resolution (10 m grid size or finer) using a multibeam echosounder. The Continental Shelf Characterization, Assessment, and Mapping Project (C-SCAMP) was launched in 2015 to begin filling this data gap. One of the goals of the C-SCAMP project was to develop robust methodologies to map the locations of offshore hardbottom areas on the WFS that serve as essential fish habitat using a combination of multibeam data and high-definition towed underwater video.

A methodology to predict substrate (sand vs rock) across the extent of a multibeam survey area was developed for an 88 km^2 multibeam survey using four representative video transects spanning 19 km in a highly fished offshore area on the WFS known as "The Elbow." A balanced random forest model was fit to predict substrate by using georeferenced video observations of substrate as the response variable, and the multibeam data along with their derivative features as the predictors. Derivative features included the local mean and standard deviation of bathymetry and backscatter, aspect (decomposed into eastness, northness), slope, topographic position index, and several backscatter texture metrics derived from gray-level co-occurrence matrices. We utilized a multi-scale analytical framework where each derivative feature was determined via a moving window analysis on the bathymetry or backscatter. Each of these predictors was derived at eight different spatial scales by varying the window size from a 3 x 3 cells to a 69 x 69 cells (scale factors ranging from 30-690 m), where the radius of the window was determined using the Fibonacci sequence. Unimportant and redundant features were then removed via the Boruta selection algorithm and by removing predictors that were highly correlated ($|r| > 0.8$) with another more important predictor. The final model included predictors related to both bathymetry and backscatter, as well as predictors derived at several different spatial scales. The final substrate map for this area contained 83.8 km^2 of sand and 3.8 km^2 of rock. These predictions were tested on a spatially independent set of ground-truth substrate observations obtained from the video. The results of this accuracy assessment indicated "substantial agreement" between predictions and observations with a Cohen's Kappa of 0.75. Additionally, for rock, the model had a producer's accuracy of 82.1% and a user's accuracy of 71.9% and near perfect (>98%) user's and producer's accuracy for sand. This methodology was also found to perform significantly better ($p = 0.001$; $\alpha = 0.05$), via a Monte-Carlo permutation test of the Kappa statistic, than an unsupervised procedure on the same data utilizing *k*-means clustering and dimension reduction via Principal Components Analysis.

For this presentation, we plan to present some of these results as well as extend this analysis framework to characterize substrate across other areas on the WFS where high-resolution multibeam data exists. Over the course of the C-SCAMP project, we have collected 2,350 km^2 of new multibeam data across four different study areas bringing the total high-resolution multibeam mapping coverage on the WFS to about 9,000 km^2. We have also collected over 300 hours of underwater video transects

spanning approximately 2,500 km in length. Using these data, we will fit and test models using the analysis framework described above, as well as predict substrate to all areas on the WFS where high-resolution multibeam data exist to provide a unified map of substrate for the WFS across these survey areas.

Applying Semi-Automated Methods for Identifying Seabed Circular Depressions at the Brazilian Outer-Shelf

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Over the last decades, seabed mapping has undoubtedly contributed to several fields of application. The tools currently available are able to obtain data with increasingly higher resolution, thereby changing the way we are able to image, map, and study benthic ecosystems. Here we present data acquired from an area located on the outer-shelf of eastern Brazil in depths ranging from 43 to 300 m. This region is morphologically characterized by incised-shelf valleys with a heterogeneous seabed composed of rhodoliths and mixed/carbonate sediments.

In this study, a semi-automated mapping approach was applied using ArcGIS tools to analyze the morphology and distribution of circular depressions from a dataset consisting of acoustic data (MBES bathymetry and backscatter) and ground-truth video. The MBES survey comprises an area of 230 km², and the multibeam dataset was gridded at 2 m horizontal resolution for analysis. The circular depressions were classified by Bathymetric Position Index (BPI). Sequential use of several standard ArcGIS tools allowed the delineation and characterization of these features by extracting water depths, backscatter intensity values, and morphometric information for each depression.

Approximately 3700 circular depressions were mapped at water depths ranging from 46 to 85 m, with the majority of them located between 46 to 65 m. The bathymetric transects across the circular depressions predominantly displayed a V-shape morphology, with a median vertical relief of 0.9 m (interquartile range - IQR: 1.52–0.58). The maximum vertical relief mapped reached 5.2 meters. The depression area varied from 50 m² to 460 m², with a median value of 160 m^2 (IQR: 122.86–190.07). Backscatter intensity values tended to be lower inside the features than in the adjacent regions, with median values of -22.71 dB.

The circular depressions are distributed in between the shelf valleys. A spatial analysis of the distribution of the depressions did not show a clear trend in terms of any environmental or geological control. Seabed images revealed that the depressions occur in either mixed sediments or rhodolith bottom. It was possible to observe accumulated macroalgae inside the depressions that could be affecting the response of the backscatter.

The semi-automated identification approach of those features is still being enhanced, and the accuracy and analysis has not yet been tested. In parallel, the origin of these features is still an unknown matter, as they appear in different seabed types and do not follow any geological control. It can be either relict pockmarks or a modern feature with the presence of algae and rhodoliths. Nevertheless, this initial phase will contribute to guiding future direct investigations about the role of this microhabitat at a regional scale.

Comparing the Accuracy of Two Machine-Learning Algorithms in Predicting Benthic Invertebrate Species Assemblages Across Coastal Placentia Bay, Newfoundland, Canada

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Placentia Bay is a southern embayment of Newfoundland, Canada, that has been recognized as an Ecologically and Biologically Significant Area (EBSA) that supports benthic invertebrate diversity, capelin spawning beaches, and structure-forming habitats of eelgrass and soft corals. These important ecological regions are overlapped by anthropogenic activities including established commercial and recreational fisheries and developing oil/gas shipping routes and aquaculture sites. Building a baseline informing the distribution of the megabenthic assemblages and their associated environmental conditions can help mitigate cumulative negative effects resulting from the growing use of coastal ocean space. The purpose of this study was 1) to identify dominant benthic invertebrate assemblages along four coastal survey sites cited for their ecological importance and 2) to test a new machine-learning algorithm for its potential in boosting the accuracy of distribution mapping.

Four dominant assemblages were identified using UPGMA agglomerative clustering on species density data derived from drop-camera video footage. Bathymetric and backscatter data were collected via multibeam echosounder (MBES) surveying across all four survey sites, at a 5 x 5 m resolution. Terrain and texture attributes were derived from bathymetry and backscatter data over a range of scales, to encompass a wide spectrum of ecological processes. The distribution of established assemblages was predicted through supervised learning using both Random Forest and LightGBM machine-learning algorithms. Random Forest is a common decision-tree algorithm employed for benthic habitat mapping. LightGBM shows potential in its handling of large datasets with efficient speed, but does require careful tuning of hyperparameters to improve model accuracy and avoid model overfitting.

Performance of both model approaches was compared using kappa statistics and accuracy. Maps developed by LightGBM algorithm showed better overall accuracy and kappa, as well as per class accuracy for the rarer sand dollar-dominated assemblage, which was found in only one of the four survey areas. The remaining three assemblages were prominent across all survey sites. The most abundant cluster was dominated by species of the class Ophiuroidea, while only the sea urchin, *Strongylocentrotus droebachiensis*, and a single species of porifera were found across all four groups. This study provides a general analysis of the benthic invertebrate assemblages supporting the local habitat, an understanding that becomes important when monitoring long-term ecosystem integrity. This knowledge acts as a baseline from which assessment and monitoring programs can draw from, informing management considerations as coastal ocean activity continues to grow.

Modeling the Biodiversity Enhancement Value of Seagrass Beds

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Seagrass beds provide essential habitat for many fish and invertebrate species, which play a role in enhancing the biodiversity of coastal marine ecosystems. However, spatial variation in the enhancement effect of seagrass beds is poorly resolved, limiting our ability to set priorities for habitat conservation and restoration in the face of mounting environmental changes, such as sea-level rise (SLR). Here we estimated the biodiversity enhancement value of seagrass beds, using spatial models and detailed long-term monitoring datasets from seagrass ecosystems in the Florida Gulf Coast. We used these models to describe the distribution, total cover, and species composition of seagrass beds and to estimate their effects on spatial patterns of faunal species richness under three scenarios. Specifically, we: 1) quantified the biodiversity enhancement value of current seagrass beds, 2) inferred the biodiversity enhancement value of potential restoration areas, and 3) projected potential changes in the distribution and biodiversity enhancement value of seagrass beds due to SLR using low (+0.50m) and high (+1.0m) SLR forecasts for 2100. We found that current seagrass beds supported 43–64% more species than unvegetated habitats, even when accounting for spatial variability in predicted faunal richness due to other environmental, seascape, temporal, and geographic factors. Seagrass restoration in potential habitats would also increase biodiversity in the near-term (i.e., 43–45% above unvegetated levels). However, model projections indicate that SLR could result in significant losses of current seagrass beds and potential restoration areas, caused by contracted distributions and lower seagrass cover. Overall, these changes could result in significant reductions in the enhancement value provided by seagrasses. Although there could still be many suitable locations for seagrasses by 2100, with some having either comparable or potentially increased enhancement value. Our findings highlight the importance of considering spatial variation in biodiversity benefits when planning for habitat conservation and restoration and when managing the impacts of climate change.

Using Maximum Likelihood to Maximize Efficiency: Semi-Automating Seabed Classification on the British Columbia Coast

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The Geological Survey of Canada is undertaking the production of seabed characterization maps for large areas of Canada's continental shelf using multibeam sonar bathymetry, sediment samples and subbottom acoustic data under the Marine Geoscience for Marine Spatial Planning Program. Objectives of this program are to advance marine spatial planning and evidence-based regional environmental assessment in the offshore as part of the government's modernized approach to environmental assessments and regulatory review.

Recent acquisition of multibeam sonar bathymetry data has been extensive on Canada's Pacific Coast producing large volumes of data that require time-intensive interpretation. This prompted the creation of a model to semi-automate the bounding of seabed types into polygons that would act as a first pass delineation for geological mapping. These polygons may be edited to a finalized map by the user in less time than by manual classification. A model based on Maximum Likelihood Classification was used to produce either supervised classification with inputted grainsize samples or unsupervised classification through Iterative Self-Organizing clusters. This model was produced as a workflow using the Model Builder function in ArcGIS, and comprises a number of ArcGIS geoprocessing tools and Python scripts. Different versions of the model incorporate different input combinations selected from: slope, acoustic backscatter, and rugosity. The results of the supervised classification model highlight the importance of having quality grainsize data available, as a multitude of acquisition techniques over the past century have produced varied results, greatly affecting model outputs. The unsupervised classification method is not affected by this issue and, as a result, is more suitable for delineating the boundaries between features where ground-truth data are sparse or of poor quality. The model runs on a survey-by-survey basis, allowing relative backscatter to be used.

Model strengths include efficiently creating continuous classification surfaces that interpret seafloor features, precisely delineating polygon boundaries of basic feature classes, and providing a considerable workflow shortcut for the interpreter.

Here we present model outcomes and show applications for seabed classification of bedrock, glacial units, and post-glacial mud in Marine Protected Areas including Rockfish Conservation Areas, and glass sponge reef structures (bioherms). Seabed classification of Rockfish Conservation Areas has a strong focus on the characterization of seabed surface features. The model is reliable and efficient at delineating basic characterizations for the interpreter to place into representative feature classes based on backscatter and bathymetry. As such, this classification method is very useful for mapping Rockfish Conservation Areas compared to the conventional manual classification approach. Glass sponge reefs are morphologically complex and tend to have anomalously low backscatter. Variations in morphology and low backscatter signature will not always be interpreted as a separate feature class by the model, presenting a challenge to automation. The model is especially useful in drawing boundaries around the backscatter pattern of the glass sponge reef feature, but the interpretation is left to the interpreter.

Exploring Multifrequency Backscatter Response in Soft Bottom Habitat Using a Three-Front Approach

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Over the last two decades, multibeam echosounder (MBES) has positioned itself as the most important tool for acoustic remote sensing of the seabed and has been widely used for hydrographic purposes, as well research applied on continental shelves and deep-sea. Besides the bathymetry, MBES also provides the backscatter (BS), which plays a major role as a surrogate for seabed properties in habitat mapping. The recent implementation of MBES multispectral by R2Sonic allows for bathymetry and BS acquisition at multiple frequencies running simultaneously. Here, the main purpose is to describe and analyze multispectral backscatter data on a multiple methodological framework (value-based, image-based, angular dependence-based), exploring the potential for improvement of the seabed discrimination.

The study area comprises part of the inner shelf adjacent to the Doce River Delta, located on the Espírito Santo Continental Shelf, situated on the southeastern Brazilian coast. It is characterized by a mud deposit that displays an increase in sand content in areas deeper than 20 m. Bathymetry and backscatter were acquired by an R2Sonic 2024 echosounder, configured to collect data at 170, 280, 400, and 700 kHz operating frequencies on sequential pings, in equiangular mode. The data set was assessed during the survey to ensure data quality using the QPS Qimera software suite, and post-processing was carried out using QPS Qimera and QPS Fledermaus Geocoder Toolbox Version 7.9.5.

The mapped area shows depths ranging from 10 m up to 32 m in a gentle slope from the prodelta towards offshore. Considering the entire set of depth values for each frequency, a difference of 1 cm in the average depth of each frequency was observed. These values do not reflect the real variation of bathymetric difference between the frequencies (which reach up to 20 cm), but they indicate that greater depths are detected with lower frequency.

From the visual analysis of the BS mosaics, two seabed types were identified. The differences in some regions with low BS values are difficult to recognize. In contrast, it is clear that the frequency of 400 kHz results in higher BS intensities when compared to the other frequencies. From the image-based analysis, the general trend is indicated by the variance, which shows coherence with other indexes such as dissimilarity and contrast. The angular range analysis (ARA) results demonstrated, for most of the area, a tendency toward a decrease BS level as the incidence angle increases. For oblique angles, the BS loss occurs also in terms of frequency, i.e., higher frequencies tend to lose more intensity when compared to low frequencies. The exception occurs over an oblique feature, which marks a region with high acoustic impedance and slight BS level loss due to angular variation. All parameters calculated from the image-based analysis (GLCM script) indicated better discrimination of two main sets of data as the frequency increases, which is consistent with the value-based analysis, as well as the ARA results.

The integrated outcome shows that the scattering interface is a more important factor in sandy bottoms, while the volume homogeneity of the deposit is dominant for the acoustic response in silty bottoms. Although the investigation performed in this study did not involve accurate metrics based on ground truth, an increase in sand content is well stablished for the study area in areas deeper than 20 m. The use of multispectral technology was fundamental to understand the acoustic response of each frequency in this region of soft-bottom habitat, making it possible to detect different influences (volume scattering and interface scattering) from the range of frequencies used and observe the acoustic response both in the curve of BS values, in the parameters analyzed by the image-based approach and in the angular range analysis.

A Multi-Scale Feature Selection Approach for Predicting Benthic Communities

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Maps of seafloor habitats are an important management tool as they delineate distinct regions of the seabed based on their biophysical properties. Spatially continuous bathymetry and backscatter derived terrain variables can be used to predict seafloor communities by acting as surrogates for environmental conditions and processes that affect species distribution. Multi-scale approaches are increasingly applied to assess the relevant scales at which species co-occur. As the most optimal scale(s) may be unknown, variables can be calculated at multiple successive scales; however, this results in a large number of highly correlated features that can negatively impact model performance.

To address this increased dimensionality, feature selection approaches are recommended to identify the most relevant variables. Here, techniques are assessed to reduce highly dimensional multi-scale data using both filter and wrapper approaches, and we propose two methods to further sub-set these features: i) by scale factor, and ii) variable type.

Terrain variables describing the seabed were calculated across 10 scales ranging from 10 m to 210 m at two coastal sites in Newfoundland, Canada, and ground truthing samples from underwater videos were used to identify the dominant species assemblages, resulting in five distinct classes. Feature sub-sets were assessed using the two feature selection methods and the set of chosen features were modelled using three machine learning algorithms: extreme gradient boosting, random forest, and support vector machines. The model with highest accuracy was the subset of features selected per scale using the Boruta wrapper algorithm. Bathymetry, backscatter, slope, and textural features derived from the backscatter at broader scales of >100 m were the most influential factors affecting the distribution of communities. These results provide an approach to feature reduction for highly dimensional multi-scale data in habitat mapping.

Mapping and Characterisation of the Marine Geohabitats of the Eastern Continental Shelf of Ceará, Brazil

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Mapping the seabed can bring several benefits, such as the understanding and protection of national economic interests and marine and coastal habitats, ensuring the safety of life at sea, supporting oil and gas exploration and the installation of communication cables, monitoring environmental changes over time and, fundamentally, to advance scientific understanding of the characteristics of the seabed. We combined methods from acoustic and optical remote sensing and carbonate sediment sample analyses to map and characterize geohabitats on the tropical continental shelf of Ceará (eastern portion), Northeastern region of Brasil.

Two scenes of Landsat 8 images (216/63 of 06/16/2016 and 217/62 of 13/08/2017) were processed through the ENVI software in order to carry out specific colored compositions bands,such as RGB321 and RGB124, in order to highlight the morphology of submerged features as transverse, oblique, and longitudinal dunes, a line of beach rock, and coral reefs.

The single beam bathymetric data used in this study was provided by several projects (Geocosta, Geomar and Granmar) developed since 1985. The survey was carried out in 0°Az profiles with an approximate equidistance of 1 to 4 km. The bathymetric map was elaborated with the ArcGis software, using the geostatistical method of Inverse Distance Weighting (IDW) to create a interpolated surface of the continental shelf of the study area. These data were used to generate a slope map which reveals that the declivity of the continental shelf is smooth and flat (0.04-0.07°) with the predominant orientation toward north and northeast.

The 3D bathymetric model integrated with remote sensing products showed the presence of coral reefs and dune fields. Additionally, longitudinal bathymetric profiles exhibited some persistent V and U-shaped negative reliefs interpreted as paleovalleys which appear in the outer shelf till the shelf break.

The granulometric and the calcium carbonate content analyses carried out on twenty-two samples allowed to classify the sediments in five classes of facies: bioclastic sand, bioclastic gravelly sand, bioclastic sandy gravel, biolithoclastic gravelly sand, and biolithoclastic sand. Qualitative analyses of the biogenic fraction identified eight taxonomic groups: calcareous algae, fragments of Bryozoa, Cnidaria, Arthropoda, Echinodermata, Foraminifera, Mollusks and Porifera.

The description of the biotic components and granulometric data integrated with bathymetric and remote sensing data analyses supported the characterization and mapping of the marine habitats of the eastern continental shelf of the Ceará State. The results showed different seabed morphologies, different types of sediments and several types of organisms. This information is important as it can contribute to delimit and manage potential geohabitat areas of conservation (i.e. coral reef areas), environmental monitoring, and the advancement in scientific knowledge of this poorly studied region and to the Decade of Ocean Science for Sustainable Development.

Mapping Queen Snapper (*Etelis oculatus*) Suitable Habitat in Puerto Rico Using Ensemble Species Distribution Modeling

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Queen snapper (*Etelis oculatus*) is of interest from an ecological and management perspective as it is a targeted component of the commercially important deep-water fishery found throughout Puerto Rico and the Caribbean. Yet little is known of its detailed distribution patterns and the habitats it utilizes. As a relatively deep-water species (100–500 m), it is difficult to develop expansive occurrence datasets due to limited opportunities and costly field sampling.

In this work, we investigated the use of ensemble species distribution modeling to predict queen snapper distribution along the coast of Puerto Rico. Legacy bathymetric data from various surveys were compiled and mosaicked in three target locations: the west (30 m resolution), and the northeast and southeast regions (8 m resolution). Multiple terrain attributes (*e.g.*, slope, benthic position index (BPI), rugosity) were derived from the bathymetry in each location. Occurrence data collected between 2018 and 2020 via fishery-independent video and hook and line methods were incorporated in modeling. A total of 150 sites were sampled in each region over the two-year survey. Correlation analyses were performed, and only uncorrelated variables were included in the models. The SSDM package for R was used to develop ensemble models to analyze fish distribution and fish-habitat relationships at different spatial scales using three approaches: maximum entropy (MaxEnt), random forest, and multivariate adaptive regression splines (MARS). A measure of uncertainty was calculated for each ensemble model.

Results show that the ensemble models for the three regions in Puerto Rico provided 'excellent' predictive capability, with AUC values >0.8. In general, areas with a higher probability of occurrence generated higher degrees of uncertainty (Figure 1). Variable importance differed across spatial scales and between regions. The three most valuable variables in predicting queen snapper probability in the west and southeast were bathymetry, slope, and fine-scale BPI, whereas the northeast was driven by bathymetry, northerness, and profile curvature. It was hypothesized that the two eastern regions would show similar variable importance because of identical resolutions, but the differing bathymetric features in the northeast are what likely drove the differences in variable importance. Overall, our findings support the limited ecological knowledge we have regarding queen snapper, including the idea that they prefer rocky habitat types. However, these results further highlight the importance of investigating spatial scales and other contributing factors that influence species-environment relationships.

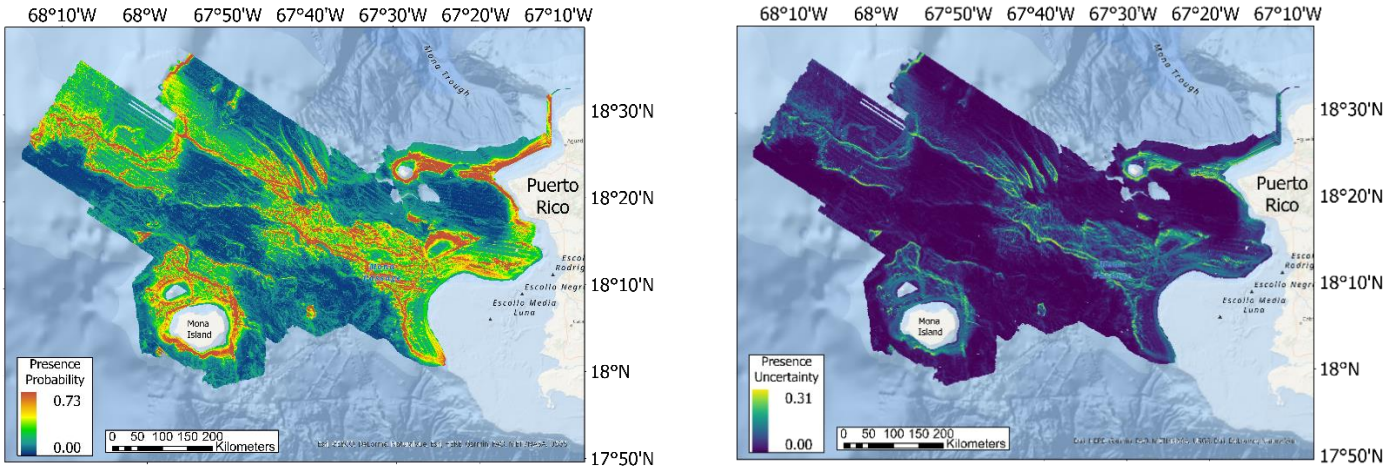

Figure 1: Ensemble probabilities of occurrence (left), and the uncertainty in those predictions (right) for queen snapper on the west coast of Puerto Rico.

High-Resolution Habitat Mapping of Cold-Water Coral and Sponges in the Northern Gulf of Mexico

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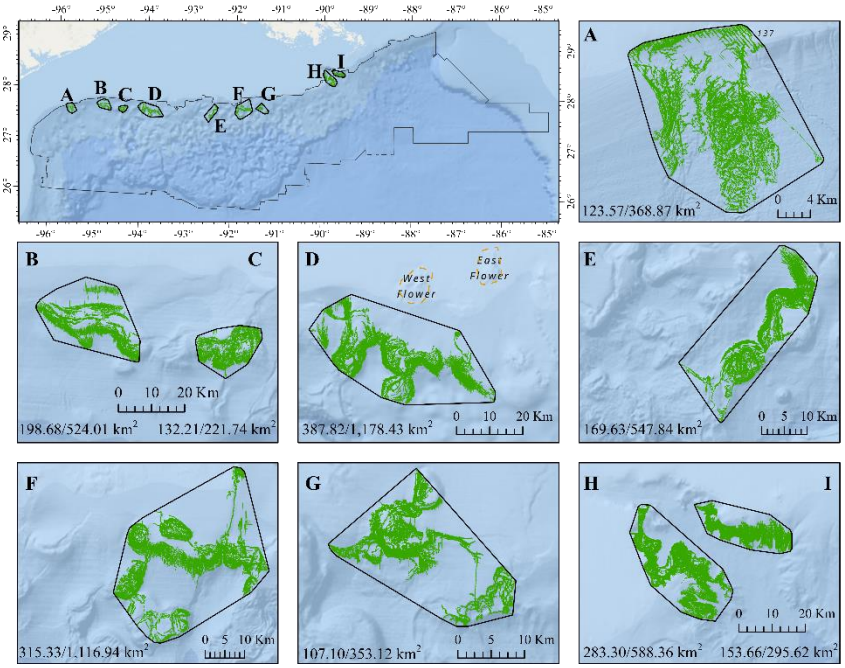
The northern Gulf of Mexico hosts several orders of cold-water corals and sponges that form three-dimensional benthic habitats. The complex biogenic structures provide a variety of ecosystem services, such as protection from predators as well as nursery and spawning sites for various species. However, the northern Gulf of Mexico also has extensive networks of oil and gas infrastructure, such as platforms and pipelines, that surround known areas of corals and sponges. The pressures that corals and sponges face highlight the need to identify hotspots as potential conservation sites. This study aims to identify such sites in the northern Gulf of Mexico. Bathymetry and bathymetric derivatives such as slope and rugosity were used with presence-only cold-water coral and sponge data classified into two phyla and nine orders to produce 11 distribution models using a maximum entropy approach. Oil and gas infrastructure layers with two kilometers and four kilometers buffer zones were imposed over models to identify relatively undisturbed biodiversity hotspots as potential conservation sites.

Our results show that the amount of suitable habitat and the driving factors of the distributions are highly order-dependent. A "summary" model including all available data regardless of order was driven mostly by depth and slope and identified more than 7,350 km^2 of suitable habitat (*i.e.*, areas with a probability of occurrence greater than 0.60). However, almost 1,500 km^2 of that suitable habitat is located within a two-kilometer zone of influence of existing oil and gas infrastructures. By considering only the suitable habitat located at least four kilometers away from existing infrastructures, we identified nine areas greater than 100 km^2 that hold potential for successful conservation and could help create a network of connected protected areas in the northern Gulf of Mexico (see Figure below).

This study provides the most spatially-precise cold-water coral and sponge habitat suitability maps of the Northern Gulf of Mexico so far, with predictions made at a relatively fine spatial resolution (about 12 m) and over a very large area (over 200,000 km^2). The maps produced have the potential to inform discussions among stakeholders to reach the best conservation and management outcomes while considering other ecological, social, economic, and governance factors.



New Geomorphological Insight at Canal do Varador, Amazon Continental Inner Shelf, Brazil

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The Amazon continental shelf extends from the mouth of the Amazon River to the border of Brazil with French Guiana. This shelf is under the influence of a unique dynamic environment, resulting from the superposition of several factors, such as geographic, physical, oceanographic, and climatic factors, adding to the fresh water and sedimentary discharges from the Amazon River. Although this shelf is connected to the biggest river by volume in the world, the last stages of evolution of this system and its basic geomorphology are still unknown. Part of the response of this river evolution could be related to several existing paleo-drainages in the coastal plain, whose records for the submerged area have not yet been studied. The aim of this work is to analyze the geomorphology of the paleo-drainages submerged in the erosional coast of Amapá State and its inner shelf, near the mouth of the Amazon River.

The study area is situated in the Maracá–Jipioca Ecological Station (EEMJ), a conservation unit covering 2 km², located at Amapá City, Brazil. The EEMJ encompasses the continental coast (limited by the Flechal River mouth), the North and South Macará islands, the Varador and Turluri channels, and an oceanic area. Both Macará islands exhibit a rich fauna that includes jaguars, shorebirds, alligators, and agoutis, and complex environments such as mangroves and saltmarshes.

Different techniques were applied, such as remote sensing (LANDSAT 8 OLI and RADAR PALSAR images) and hydroacoustic (chirp SBP512i, 6 to 12 kHz and a single beam echosounder ODOM Hydrotrack, 235 kHz) methods and surficial sediments samples, collected using a van Veen sampler.

Bathymetric and high-resolution seismic data were integrated and interpreted in different software to obtain a geomorphological map, which indicates the presence of several drainage sets, both actives and buried, at the Canal do Varador area. They were divided into three sets of paleodrainages considering geographic position and the interconnection among them, by visual analysis. One set is near North Maracá Island and two sets are near South Macará Island. A predominance of muddy sediments was observed along the entire length of the Varador Channel, but sandy mud was also observed in the SE and NW portions of the channel. A predominance of clayey and silty mud was observed in the central portion of the Varador Channel.

These results could help to elucidate the history of the last stages of Amazon River mouth in the Amapá coast, enable to increase the Buffer Zone from the Maracá–Jipioca Ecological Station and provide basis for geohabitat maps in this area.

Mapping and Characterizing Eelgrass Beds in Placentia Bay and Trinity Bay, Newfoundland and Labrador, Canada

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Seagrass habitats provide key ecosystem services in coastal regions, including sequestering carbon, providing nursery habitat, and stabilizing shorelines. Seagrasses are declining globally at rate of ~110 km^2yr^{-1}, but effective environmental management based on knowledge of seagrass distribution and its environment helps support local recoveries of meadows. However, the distribution and dynamics of seagrass remains poorly known in many regions of the world, including Canada. Eelgrass, a species of seagrass, has been declining in Placentia Bay, on Canada's east coast, an area of high biological diversity experiencing increasing development. This decline has been attributed to the invasive European green crab (*Carcinus maenas*), which has yet to spread to nearby bays, such as Trinity Bay. This research provides baseline information on the distribution and characteristics of eelgrass beds at seven sites of Placentia Bay and three sites of Trinity Bay.

Eelgrass beds were mapped using an unmanned aerial vehicle (UAV), which allows collecting very high-resolution (2.8 cm) imagery. Image mosaics of each site were classified using Object-Based Image Analysis and the random forest classifier. Training and validation samples were obtained from underwater videography and photo interpretation. Visual analyses of the aerial imagery and underwater videography was also conducted to characterize sites for the presence of physical disturbances and qualitative abundance of epiphytes.

Eelgrass beds at ten sites varied in size and spatial arrangement. Preliminary results indicate that the proportion of eelgrass at each site ranged from 0.5% to 93% of each study site. Contiguous eelgrass beds were typically observed in shallow coastal lagoons, whereas eelgrass beds were smaller and typically occupied a narrow fringe in harbours. We observed minimal physical disturbance caused by human activity at all sites and generally a greater amount of epiphytes at sites adjacent to communities.

The resulting eelgrass distribution maps contribute to our understanding of the extent of eelgrass in Placentia Bay and Trinity Bay and help address the lack of information regarding Canadian seagrass. This baseline data on the distribution of eelgrass will enable monitoring of temporal trends and help quantify loss, degradation, or expansion in response to specific events.