APPLICATION OF HISTORICAL DATA FROM SATELLITE IMAGERY TO IMPROVE UNDERSTANDING OF COMPLEX NEARSHORE DYNAMICS

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INTRODUCTION

Collection of nearshore data such as bathymetry and benthic surveys are a requirement to all coastal projects. Typically, surveys are conducted in advance of a modelling exercise so as to replicate in-situ and existing conditions. These surveys only show one snapshot in time and as such do not represent conditions that are out of equilibrium from either seasonal or long-term changes. In these locations, an assessment of a timeseries of surveys would benefit the understanding of nearshore coastal dynamics. However, timeseries of nearshore data are seldom available. Traditional coastal survey technology, e.g., bathymetry from acoustic means or airborne lidar, are expensive and time consuming, and as such they are rarely conducted on a regular basis.

Satellite data offers a novel solution by allowing access to very high-resolution data generated over a 20-year time period stored in easily accessible archives, including a convenient web-based application. This paper describes the application of historical satellite data to understand coastal change to a dynamic sand spit feature in Pigeon Point in Southwest Tobago.

BACKGROUND

The Southwest coastal region of Tobago has been subject to increasing erosion and vulnerability of critical tourism infrastructure. In recognition of the importance of the natural beauty of this coastline to both the economy and livelihood of the people of Tobago, the Tobago House of Assembly, contracted Smith Warner International Limited (SWI) to conduct studies and develop designs for climate-resilient coastal protection and management.

Pigeon Point (Figure 1), located within the project domain, is of particular interest given its popularity for tourism and leisure. Pigeon Point falls within the Ramsar-designated Buccoo Reef Marine Park, and is bordered by Buccoo Reef and Bon Accord Lagoon on its sea- and land-ward sides. The natural environments (coral reef-seagrass-mangrove ecosystems) adjacent to the beach contribute to the complex nearshore dynamics, as well as serve to provide vital ecosystems services including coastal protection, habitats, and nurseries for a diversity of fish and invertebrates.

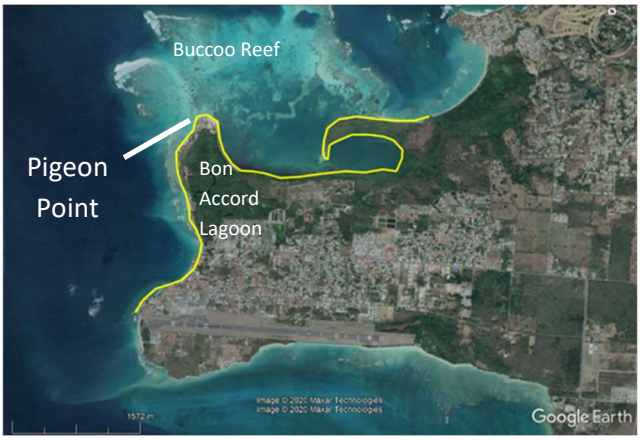

Figure 1 - Project Domain in SW Tobago

The northern end of Pigeon Point features a sand spit formation that fluctuates in position and alignment over time with periods of erosion and accretion. These shoreline fluctuations appear to be from both seasonal and updrift anthropogenic shoreline interventions. An understanding of the nearshore dynamics in and around the sand spit, as well as the larger Buccoo Reef system, is necessary in advance of concept development to improve the shoreline problems being faced.

METHODS

Recent advances on satellite sensor hardware and analytics have allowed the once crude methodology (developed in the 1970s) to be efficiently applied into practice – in particular very high-resolution satellite data availability and the sound understanding on the physical modelling of the lightpath from the surface/seafloor to the sensor. EOMAP has developed a unique physics-based procedure which allows mapping of water quality parameters, shallow water bathymetry, seafloor characteristics and topography in dense spatial grids.

EOMAP extracted satellite data through a unique physics-based procedure which allows mapping of water quality parameters, shallow water bathymetry, seafloor characteristics and topography in dense spatial grids. Data provided included:

- Satellite derived bathymetry (SDB) for Dec 2004, Aug 2013, Oct 2015, Jan 2021, Apr 2022
- Benthic Mapping for Dec 2004 and Jan 2021
- Shoreline Mapping for Dec 2014, Aug 2013, Oct 2015, Feb 2017, and Jan 2021.

A comparison of successive years of the SDB allowed for a quantification of bathymetric evolution over time. Similarly, benthic mapping evolution visualized in GIS allowed for an understanding of the coral reef and seagrass changes from

2004 to 2021. The shoreline mapping complemented the assessment to depict changes in the upper beach area. The temporal changes observed from satellite data is then compared with numerical modelling to further the understanding of the complex nearshore dynamics and environment.

RESULTS

The combined shoreline and SDB comparison between 2004 to 2022 show a distinct correlation between upper beach erosion and nearshore accretion, which suggests the upper beach sand has migrated to the immediate nearshore water (Figure 2). These results indicate that most of the sand remains within the Buccoo reef system and could be further investigated as a valid source of sand to re-nourish starved areas of the upper beach.

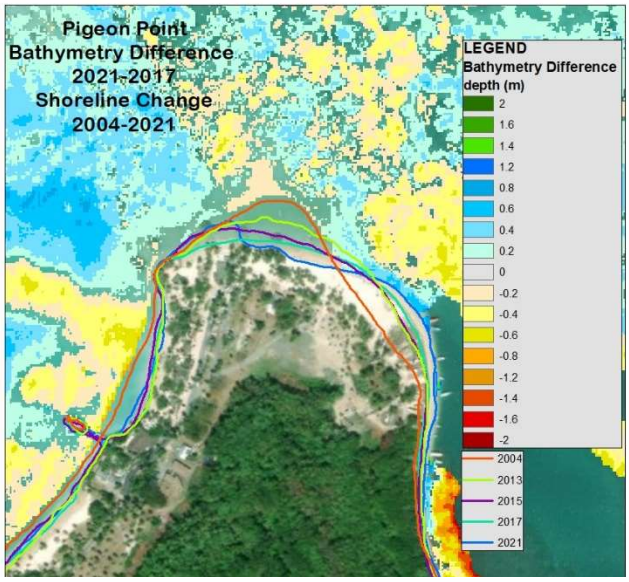

Figure **Error! No text of specified style in document.**2 - Shoreline evolution with seabed changes extracted from SDB

An incremental assessment of the SDB data allows a better understanding of the mechanisms of sand distribution and movement that play an important part into the health and sustainability of the upper beach width. The bathymetric changes of a unique ridge of sand deposit demonstrates the importance of an offshore-to-onshore contribution of sand into the nearshore area.

The sand movement is appreciated within the satellite-derived benthic mapping comparison (2004-2021), which also shows changes to critically important hardbottom, coral reef and seagrass areas. Notably, an overall increase in seagrass area is quantified, with particular appreciation of new seagrass meadows within the inner reef basin.

Coastal modelling demonstrates the effects the combined seabed and benthic community changes have on waves, currents and subsequent erosive forces on the active upper beach.

The satellite data are presented in a convenient web application that allows for overlaying data of bathymetry, sea floor classification, and importantly, modelling results. The webapp allows for data to be extracted along user-defined transects. This allows for a quick check and comparison between bathymetric change measurements and modelled sediment transport patterns to better understand the nearshore dynamics.

A simplified webapp is separately made available for public access to promote public transparency of the assessment and increase project awareness and support. The webapps in turn act as a stable repository of data as well as a facility to update with more recent data as it becomes available.

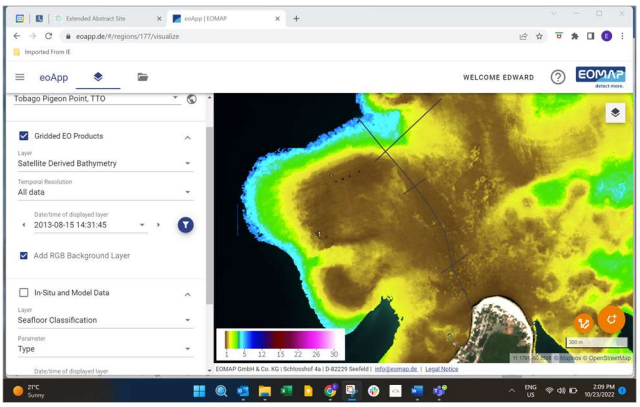

Figure 3 - EOMAP's eoAPP visual analysis and demonstration tool

CONCLUSION

The satellite derived products accessed from historical imagery stored in archives can aid in mapping coastal change on the shoreline as well as the nearshore environment. The bathymetric observations allow for quantification of seabed movement and a better understanding of nearshore dynamics. The benthic community observations assist to understand the changes to the nearshore critical habitats and allow for consideration into feasible nature-based solutions to coastal erosion.