



## Remote Sensing and GIS in monitoring macrofaunal populations in intertidal habitats

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### Abstract

In the past few decades, satellite remote sensing techniques have progressed tremendously providing more accurate geospatial data about coastal ecosystems. The repetitive and synoptic coverage of inaccessible/larger areas in time series can be produced to help in the study of intertidal organisms and mapping their habitats in a more precise manner. This article presents the progress of remote sensing and Geographical Information System (GIS) in assessing the population structure of intertidal molluscs. The databases generated by using these novel techniques form a scientific tool for various scientists, stakeholders, policymakers, and governments to employ suitable strategies for the conservation of intertidal habitats and coastal resources.

**Keywords:** Macrobenthos, Molluscs, Threat, Disturbances, Management

### Introduction

Coastal biodiversity plays a vital role in maintaining ecosystem services, and biodiversity loss can interrupt ecological processes (Yang *et al.*, 2022) [24]. The dominant component of marine benthic assemblages is macrobenthos (larger than 500  $\mu\text{m}$ ) which includes some of the most speciose groups *viz.*, annelids, crustaceans, molluscs, etc. It is important to know the diversity of macrobenthos in the coastal zones because human disturbances threaten the coastal ecosystems. Due to this, the shoreline changes, urbanization onshore, and tourism also affect their biodiversity.

In the last two decades, remote sensing and GIS techniques have gained importance in mapping coastal habitats and assessing the changes in different time periods thus to evaluate the population decline of the microbenthic fauna. Remote sensing and GIS have been employed in marine habitat mapping, shoreline change detection along the coasts, and the relationships between benthic macrofauna and their habitats in the coastal zones (Godet *et al.*, 2009) [9]. Choi *et al.*, (2011) [2] produced habitat maps of crustaceans and molluscs from the Hwangdo tidal flat, Korea. They found that the GIS-based weights-of-evidence model was suitable for mapping habitats of macrofauna. They inferred that the combination of GIS and remote sensing with field observations is effective in determining the localities of macrofaunal species in a tidal flat. The analysis of the spatial distribution of faunal diversity in marine habitats has received attention, however, the smaller size and cryptic nature of many marine organisms prevented the broad use of recent technological innovations. Clarke *et al.*, (2007) [3] investigated biogeographical and macro-ecological patterns of molluscs from the Southern Atlantic Ocean and opined that geographical information is a powerful tool for the analysis of spatial distribution of organisms.

Remote sensing and GIS are widely used to monitor marine ecosystems (Uma Maheshwari *et al.*, 2006) [21], to identify ecologically sensitive locations (Saxena *et al.*, 2012) [19], and to delineate shoreline changes along the coasts. Remote sensing has been used to quantify habitats that influence the distribution of biodiversity on rocky shores of Australia and impacts of sea level rise on intertidal rocky reef habitats are analysed (Thorner *et al.*, 2014) [20]. The application of

remote sensing to study the habitat structure of marine invertebrates in general (Cleary *et al.*, 2016) [4] and molluscs in particular is improperly known. Indian shorelines have been assessed for the changes occurring over a period of time (Kumar and Jayappa 2009; Samantha and Paul, 2016) [15, 18]. Besides, these techniques aid in interpreting time series land-use/land cover changes wherein environmental deterioration and urbanization along the coastal region can be addressed (Jayanth *et al.*, 2015; Kaliraja *et al.*, 2017) [13, 14]. The shoreline and land use changes can be linked with the variations in macrofaunal population. Recently, study has been carried out from the west coast of India by procuring time series IRS-Resourcesat 1-LISS-III satellite data, to assess land use changes in understanding the seasonal variation in molluscan diversity (D'Souza *et al.*, 2022) [6]. Quantification of land use changes and shorelines has helped in the evaluation of the decline in the macrofaunal population and possible threats due to urbanization.

Besides molluscs, oyster reef mapping across northeast Florida has been carried out using these techniques (Garvis *et al.*, 2020) [8]. The first baseline map of oyster distribution will be an effective tool for the management of reef ecosystems. GIS and Remote Sensing can be used in mapping future changes to the coral reefs to identify the impacts of coastal change on the habitats. The recent studies indicating the application of satellite data in mapping macrofaunal habitats are presented in Table 1. Roman *et al.*, (2023) assessed the potential of high-resolution Unmanned Aerial Vehicle (UAV) multispectral data to retrieve spatial information on oyster-farming areas from Bourgneuf Bay in France. Their study suggested that UAV technology is beneficial for shellfish farmers and coastal managers as it helps to monitor characteristics of oyster-farming intertidal areas regularly in a rapid, and non-destructive way. Brunier *et al.*, (2022) [1] showed the possibility of mapping the spatial distribution of polychete reefs from UAV-based multispectral high-resolution data.

GIS has proven effective in characterizing intertidal systems and fractal dimensions to compare the *Mytilus edulis* assemblages (Crawford *et al.*, 2006) [5]. El-Naggar *et al.*, (2022) [7] integrated field data and remote sensing for the assessment of anthropogenic disturbances to the epifaunal

macrobenthos diversity along the west coast of Egypt. Van der Wal *et al.*, (2008) <sup>[22]</sup> analysed environmental variables from airborne hyperspectral remote sensing and correlated them to the spatial distribution of macrobenthos. The response models generated were applied to the remote sensing-derived maps of the environmental variables that contributed to the prediction of the spatial distribution of macrobenthos indicating the changes in their distribution. This shows that the synoptic remote sensing techniques combined with field data contribute to efficient mapping and monitoring of coastal environments. Ha *et al.*, (2024) acquired high-resolution visible light imagery Matrice 300 RTK drone equipped with a Zenmuse P1 RGB sensor to procure the burrow opening measurements of crab

species from tidal flats of Korea. Van der Wal *et al.*, (2004) <sup>[23]</sup> used space-borne Synthetic Aperture Radar (SAR) data to analyse the relationships between the sediment characteristics and macrofaunal density. Jansen (2008) <sup>[12]</sup> used Landsat 7 satellite images to predict the macrobenthos abundance in the intertidal regions of Mauritiana. Ryu and Lee (2018) applied SAR interferometry technology to monitor the tidal flats of Korea. The thematic maps generated during remote sensing have helped in improving policy decisions regarding the management of tidal flats. They suggested the use of unmanned aerial vehicles (UAV) and a new satellite system for the further enhancement of the data.

**Table 1:** Studies on intertidal macrobenthos using remote sensing and GIS techniques.

SI. No	Place	Satellite/Technique used	Reference
1	Mauritiana	Landsat 7	Jansen 2008 <sup>[12]</sup>
2	Westerschelde, Netherlands	Synthetic Aperture Radar, European Remote Sensing Satellite	Van der Wal <i>et al.</i> 2004, 2008 <sup>[22, 23]</sup>
3	Korea	SAR interferometry	Ryu and Lee 2018
4	Dakshina Kannada, India	IRS-Resourcesat 1-LISS-III	D'Souza <i>et al.</i> 2022 <sup>[6]</sup>
5	Aqaba Gulf, Egypt	Landsat Thematic Mapper (TM) and Sentinel-2	El-Naggar <i>et al.</i> , 2022 <sup>[7]</sup>
6	France	Unmanned Aerial Vehicles	Roman <i>et al.</i> , 2023

Overall, remote sensing combined with GIS has proven useful in monitoring ever-changing coastal environments. The information generated using these techniques is helpful for the scientific community to employ management strategies for the conservation of intertidal habitats and associated macrofaunal populations.

### Conclusion

The review highlights the importance of remote sensing and GIS techniques in the delineation of shorelines, and land use patterns that impact the macrofaunal diversity. Studies have focussed on habitat mapping of macrofauna in the intertidal regions at the global level. Apart from the use of Landsat and Resourcesat data, acquiring drone-based imageries or unmanned aerial vehicle (UAV) or Synthetic Aperture Radar (SAR) data would be beneficial in monitoring the timely changes in intertidal habitats with more accuracy. Moreover, the review stresses the need for high-resolution multispectral synoptic information to characterize the intertidal habitats to know the macrobenthos distribution.

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**Conflict of Interest:** The author declares that there are no conflicts of interests.

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