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Automated detection of small vessels on waterways for actionable insights

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Abstract: Around the globe, waterways are popular places for various human activities including boating, fishing, wildlife watching and water sports. Small vessels, ranging from recreational boats to ferries, represent a significant yet under-monitored portion of this activity. Unlike commercial vessels, which are often required to have their position tracked via global positioning systems, small recreational vessels generally operate without automated observation, creating a substantial data gap on the spatial and temporal distribution of vessels. This lack of information complicates governance, risk assessment, and planning for marine parks, biodiversity protection, and social use of waterways. Traditional monitoring approaches are logistically challenging and resource-intensive, particularly over large areas. As such, there is a need for scalable, automated approaches that provide consistent and cost-effective insights into small vessel activity (Zucchetta et al. 2025).

We describe the development of an automated detection pipeline that integrates satellite remote sensing with machine learning methods. This pipeline uses daily PlanetScope imagery at 3m spatial resolution, combined with a YOLOv5 convolutional neural network, to detect small vessels within sheltered waters. A case study was conducted in the Moreton Bay Marine Park (Quandamooka Sea Country) in South-East Queensland, Australia. This location is characterised by diverse ecological values, cultural significance, and high recreational use. The pipeline was trained on manually annotated imagery, processed through a tiling and clustering workflow, and then validated against independent test sets.

The pipeline enabled the first spatially and temporally explicit assessment of boating activity across Moreton Bay. From 2018 to 2023, we identified consistent hotspots of vessel traffic, including Bribie Island, Peel Island, and Tangalooma, alongside widespread usage across southern bay islands. This new time-series vessel location data revealed long-term increases in boating activity, including surges during COVID-19 lockdown periods when local recreational use intensified. Seasonal variation was observed, but overall activity levels in 2023 exceeded long-term averages. These insights, visualised as cumulative heatmaps and daily detection time series, provide a new evidence base for marine park management.

The pipeline provides an efficient and reproducible method to monitor small vessels at regional scales. The approach complements existing monitoring methods (on-site manual counts) and is particularly valuable where regulatory vessel-tracking data are absent. For Moreton Bay, the outputs inform the upcoming revised marine park zoning plan, navigational risk assessments, and the protection of ecologically and culturally significant sites. More broadly, the approach can be adapted to other sheltered waterways worldwide, supporting governance objectives that span conservation, tourism, and community wellbeing.

Our results demonstrate that deep learning applied to high-resolution Earth observation imagery can overcome long-standing barriers to understanding human activity on coastal waters. By making these outputs publicly accessible, the study provides a practical model for data-driven, evidence-based management of waterways, contributing to more sustainable and resilient marine systems.

REFERENCES

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