



Potential of Earth Observation for the German North Sea Coast

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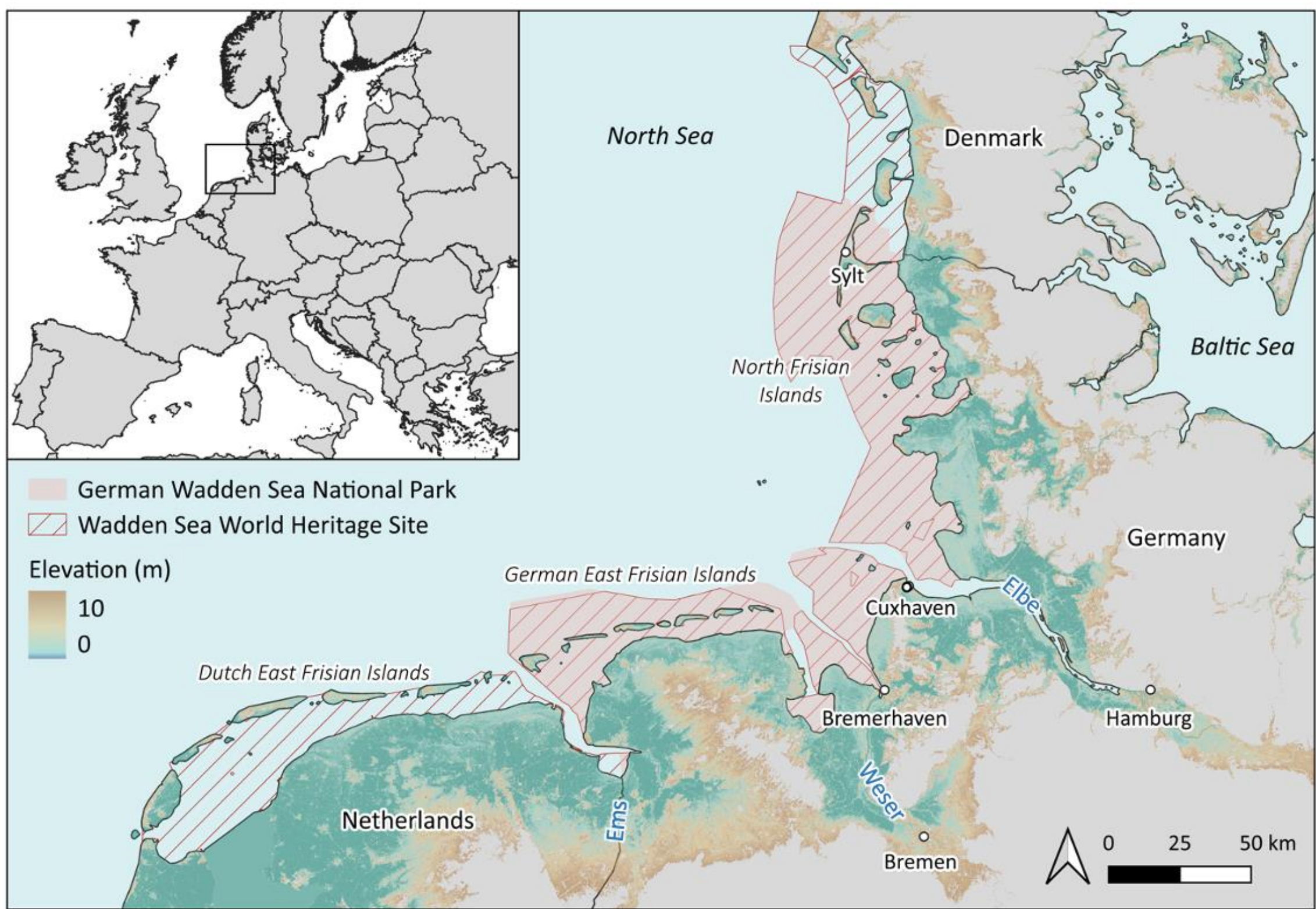
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Summary

Climate change poses multiple threats to coastal areas, making their monitoring even more critical. This study, which analyzes 97 publications from 2000 to 2024, reviews the potential of Earth Observation (EO) for the German North Sea coast. We summarize characteristics and findings of previous research as well as identify gaps for future research.



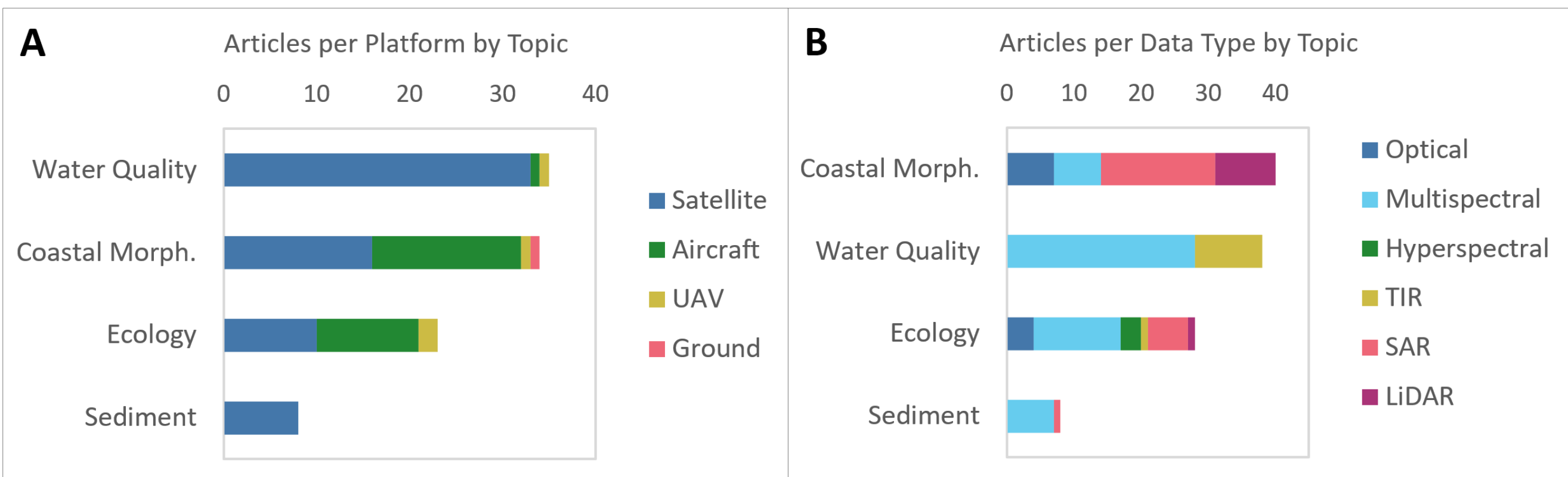
Background

The German North Sea coast is of immense economic, environmental, and cultural importance. Substantial human activity (including shipping, fishing and agriculture, tourism, and renewable energy generation) occurs within the German Wadden Sea National Parks and its regulation is coordinated by the international Trilateral Wadden Sea Cooperation agreement. This region is characterized by diverse coastal landscapes as well as a highly engineered shoreline that protects large extents of low-lying land.

Findings

Data from a variety of sensors were analyzed with diverse methods:

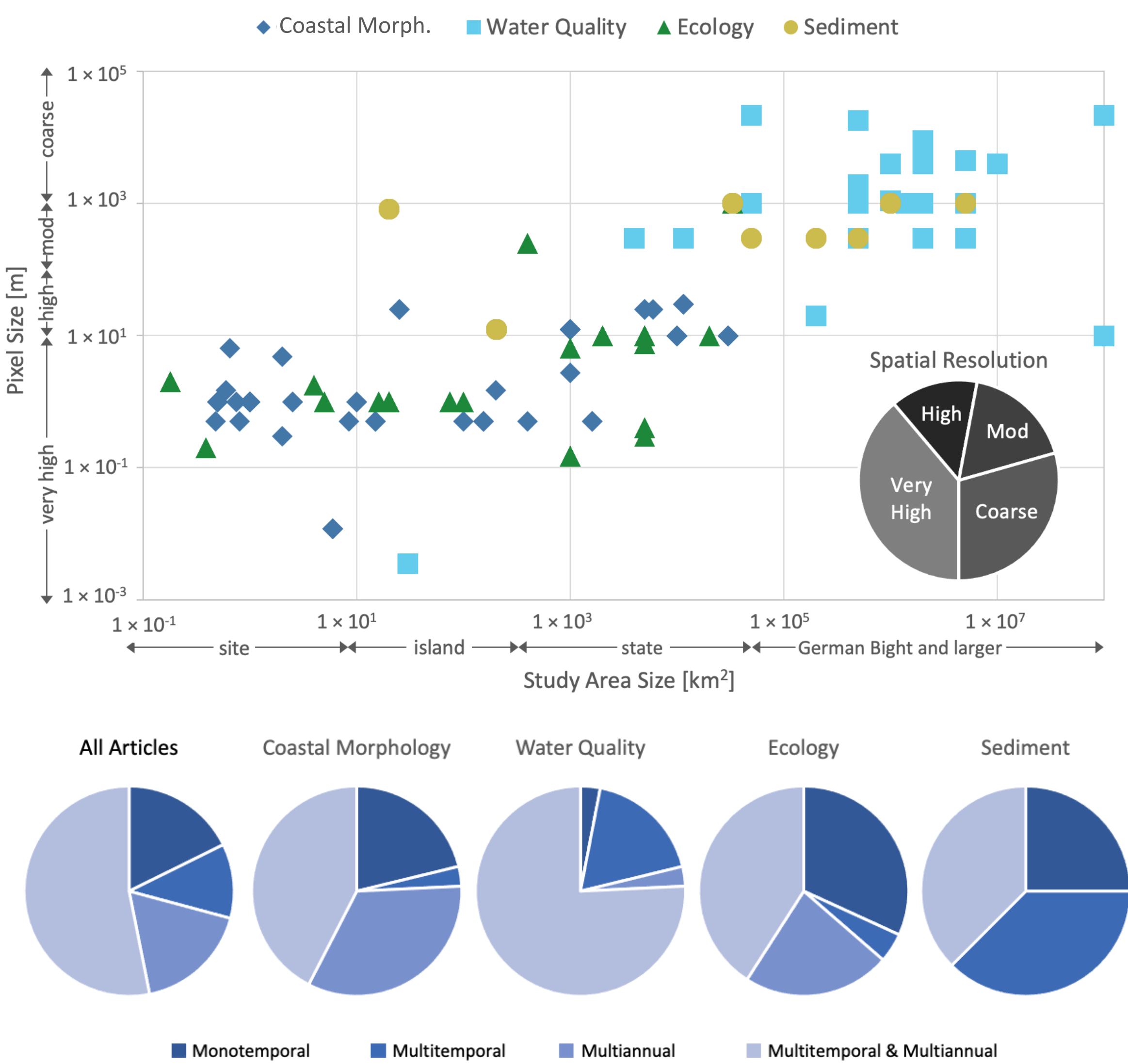
- Most papers (69%) used satellites, one third (29%) used aircrafts, and few (4%) used uncrewed aerial vehicles (UAVs).
- Very-high-resolution data was predominantly from airborne and UAV sensors.
- Pixel-based image analysis was most frequently used (56%) whereas deep learning was rarely used (5%).



Findings (cont.)

Studies examined a variety of topics and covered nearly the entire German coastline:

- Research questions covered 30 sub-topics—most frequently intertidal topography (21%), bivalves (7%), marshes (6%) and chlorophyll (6%).
- Some areas were more frequently studied (e.g. Sylt, North Frisian islands) than others (e.g. Halligen, Lower Saxony, Schleswig-Holstein).



Gaps

Few topical gaps were identified. Instead, the majority of gaps appear to be in depth rather than breadth:

- Topical gaps include vertical land motion, land cover and land use, forecasting, coastal erosion, and flooding.
- Few high- or very-high-resolution satellite sensors (e.g., Sentinel-2, Sentinel-1, Planet) were used despite their increasing availability.
- Few studies in coastal morphology and ecology occurred over large areas or at sub-annual temporal resolution.
- Coastal morphology and ecology studies relied largely on manual methods rather than digitized and/or automated methods.

Remote sensing was found to already play an active role in monitoring the German North Sea coast, although mostly over small areas. However, temporal and spatial coverage of satellite Earth Observations offer substantial opportunity to fill currently existing research gaps in this region.