A7 Deliverable - Pressure maps from pilot areas

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Introduction

This deliverable is part of the BIODIVERSEA Action 7: *Identifying pressures affecting marine environment and actions that mitigate those pressures* and presents preliminary results of sub-action A7.2. *Pressure maps from pilot areas*.

Human activities create pressures which may exert impacts on species and habitats, such as habitat loss, sedimentation, noise, and pollution. In general, these impacts can be mitigated through management actions that either directly or indirectly regulate activities that create pressures. BIODIVERSEA Action 7 concentrates on identifying those pressures and threats facing marine biodiversity that can be managed and controlled by local actions and management measures.

One of the aims of A7 was to pilot object detection methods and Earth Observation to identify activities that may exert considerable local impact on marine biodiversity. One potential source of impact comes from recreational boating. Small vessels are not required to use Automated Identification System (AIS), and therefore their locations are not known. Identification of recreational vessels would be essential for coastal management and conservation, as they may enter shallow areas (e.g. lagoons, flads), which may hold potential conservation value. For instance, anchoring, mooring or wakes from propellers may cause adverse effects, such as habitat loss and disturbance (e.g. through sedimentation), in enclosed and shallow bays and lagoons.

In A7 we tested the object detection framework You Only Look Once (YOLO) v8 to identify and quantify the movement of small-sized vessels in the Archipelago Sea. We shortly describe the analysis path and the results in the following sections, but details can be found from Mäyrä et al. (preprint).

Data and methods

We selected five study areas along the coast of Finland that covered environmental gradients in both turbidity (i.e. ocean color) and coastal morphology, to train and test the object detection method (Fig. 1).

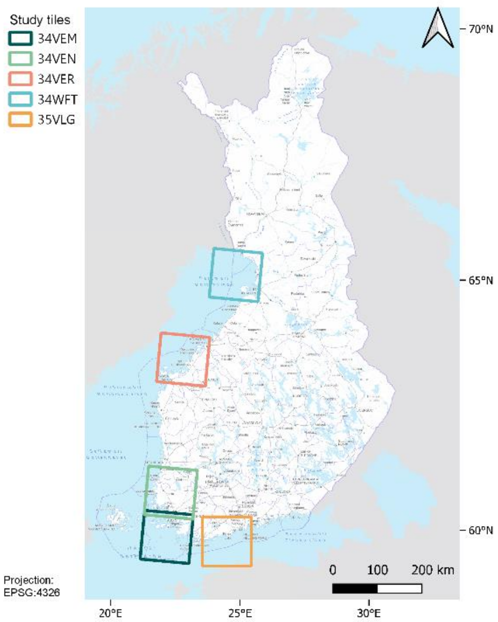

Figure 1. Locations of the study areas along the Finnish coast and their respective Sentinel-2 image acquisition tiles. Background map: National Land Survey of Finland.

For each study area we acquired Sentinel-2 images. We opted for cloud-free and wakeless scenes to make vessel annotation easier. We annotated manually all vessels of the images that were easily identifiable by drawing bounding boxes around them. As smaller vessels may be mixed up with stationary objects, such as maritime traffic signs or underwater rocks, we filtered those out based on available geoinformation. Most of the vessels were clearly visible from their surroundings, and we were able to annotate in total 7,807 vessels of varying sizes. Most vessels were found from the Archipelago Sea and Gulf of Finland, known to be popular for recreational activities, including leisure boating (Paulus et al. 2024).

We trained a You-Only-Look-Once object detection model YOLO8 with the identified vessels (Redmon et al. 2016; Jocher et al. 2023). The idea was to have a model that could be used to identify all moving vessels from Sentinel-2 scenes. We set aside the Kvarken and Bothnian Bay areas for testing how the YOLO8 model works, trained with Archipelago Sea and Gulf of Finland data. All models were trained for maximum of 200 epochs, so that the training was stopped if the validation metrics did not improve for 30 epochs. The model checkpoint with best validation score was saved in addition to the last model. We used Adam optimizer (Kingma and Ba, 2017) with initial learning rate of 0.001 and linear learning rate scheduling with a factor of 0.01. Model performance was evaluated based on standard object detection metrics, precision and recall, the ratio of true and false positives and negatives.

Results and discussion

On average, the model performances achieved high accuracy, with a precision of 0.82 (ratio of true positives) and recall of 0.78 (ratio of true negatives). When comparing to the with-held test data from the Kvarken and Bothnian Bay, the model performances were also high, with a mean average precision of 0.82.

Considering vessel traffic in the Archipelago Sea, the most active days were Saturday 2022-08-13 (2,150 detected vessels), Friday 2022-06-24 (1,581 detected vessels) and Tuesday 2022-07-19 (1,544 detected vessels). Based on the results, more traffic is observed during summer weekends (1,007 identified vessels) than weekdays (613 identified vessels). Large fraction of the detected vessels was focused on marine fairways, or near the main harbors, such as Turku or Naantali (Fig. 2). Traffic was concentrated closer to the coast in both June and August, which may reflect the holiday season in July. During July, recreational boating is primarily focused on the middle Archipelago Sea area, which offers marinas and larger islands with services for vacationers (Paulus et al. 2024).

Our results show that this type of object detection method is suitable for identifying marine traffic even from satellite images of 10 m horizontal resolution. Most of the detected boats and vessels leave a wake when they move, which also helps their identification. Also, the stationary or slower moving vessels are considerably brighter than their surroundings, making it possible to detect targets smaller than 10 meters from these data. Our results also show the high season of recreational boating during the active summer months.

Next steps within A7 are to 1) extend the study period from 2018 to 2024 2) filter out commercial vessels with AIS information, 3) combine the information from the locations of recreational vessels with satellite-based turbidity before the season starts and when it ends within shallow bays, and 4) connect the information with biological inventory data to estimate potential pressure exerted due to recreational boating on marine biodiversity.

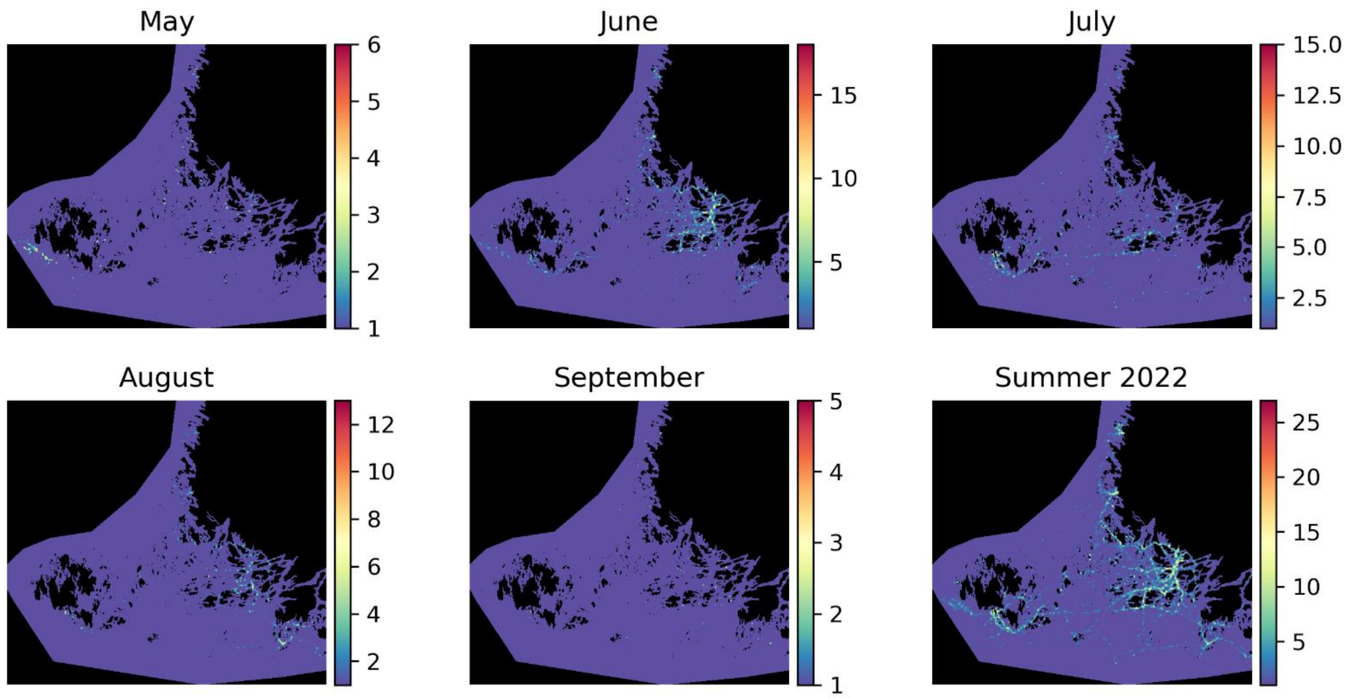

Figure 2. The number of detected vessels within 1 km^2 grids in 2022.

References

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Mäyrä, J., Virtanen, E, Jokinen, A-P, Koskikala, J. Väkevä, S., & Attila, J. (preprint). Mapping Recreational Marine Traffic from Sentinel-2 Imagery with Yolov8. Available at SSRN: http://dx.doi.org/10.2139/ssrn.4827287

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