VLIZ pioneer in marine science

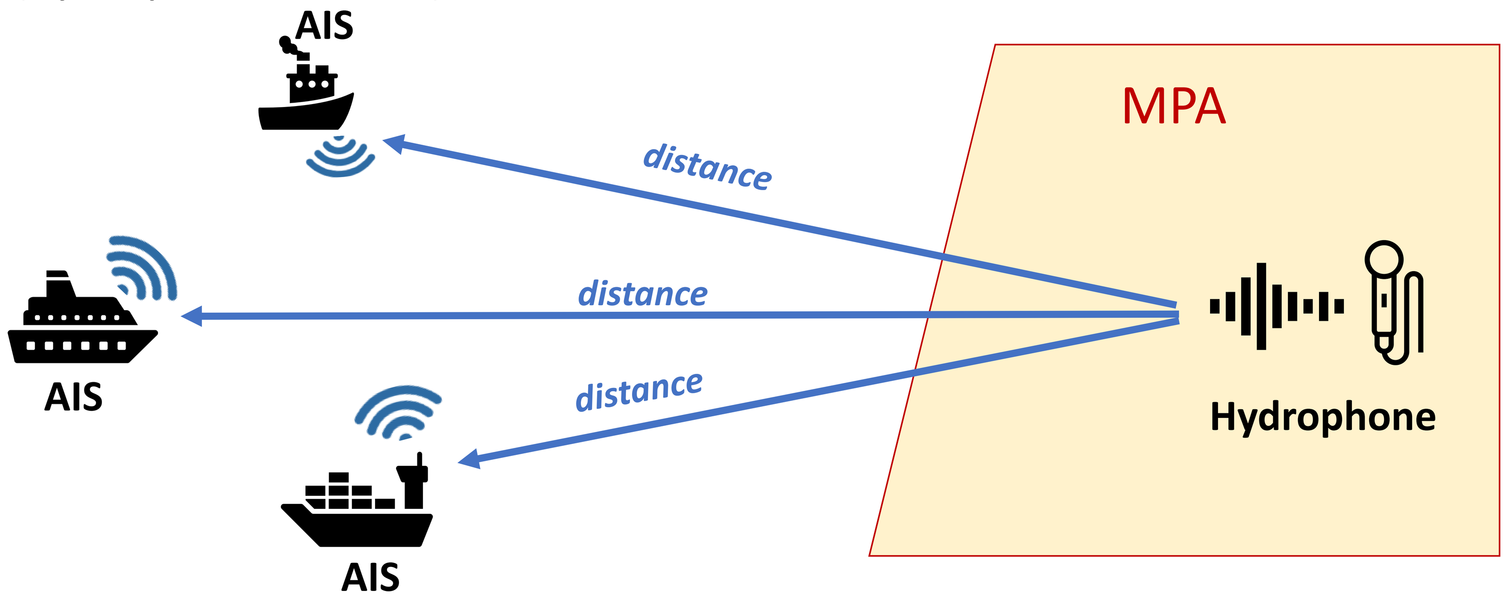
Classifying vessels using CNNs based on underwater acoustics

Decrop Wout, Parcerisas Clea, Schall Elena, Debusschere Elisabeth, Deneudt Klaas

1 Goal: Implement machine learning techniques for vessel detection and classification using underwater sound to effectively monitor human activities in areas such Marine Protected Areas (MPAs) or windmill parks.

2 How: Creation of the database

By combining the coordinates of marine vessels from the VLIZ AIS database with the coordinates of our hydrophone stations at sea, we can calculate the distance between the source (vessel) and the receiver (hydrophone station).



AIS data:
Coordinates
Timestamp
vessel information

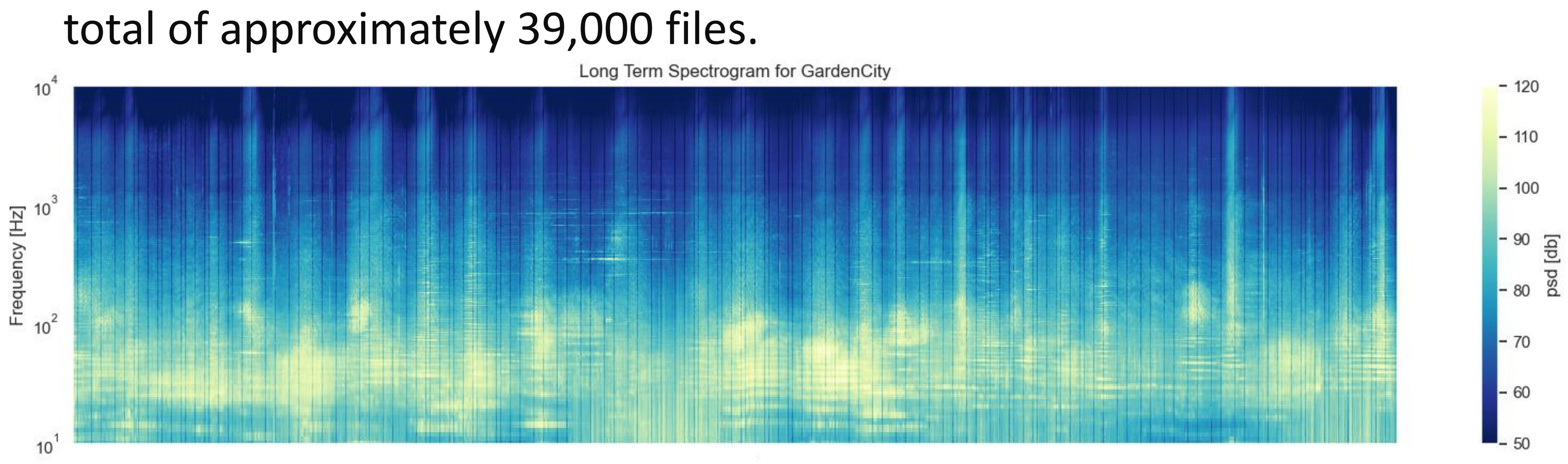
\+

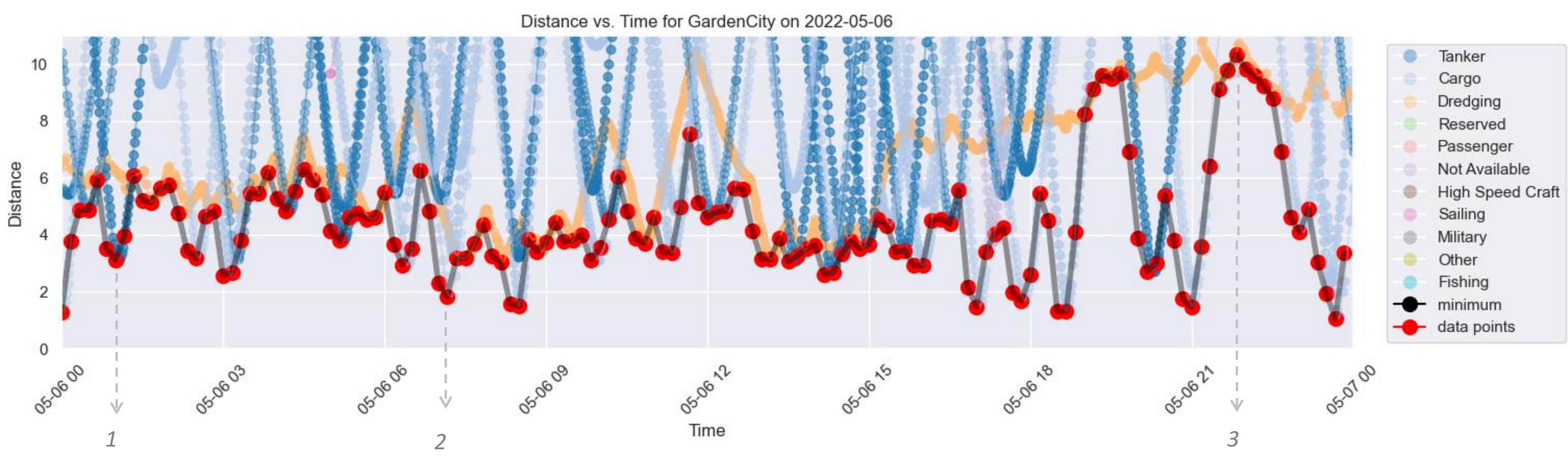
Hydrophone recordings
Coordinates
Timestamp
recording

This provides a database containing labeled acoustic data suitable for training a Convolutional Neural Network (CNN).

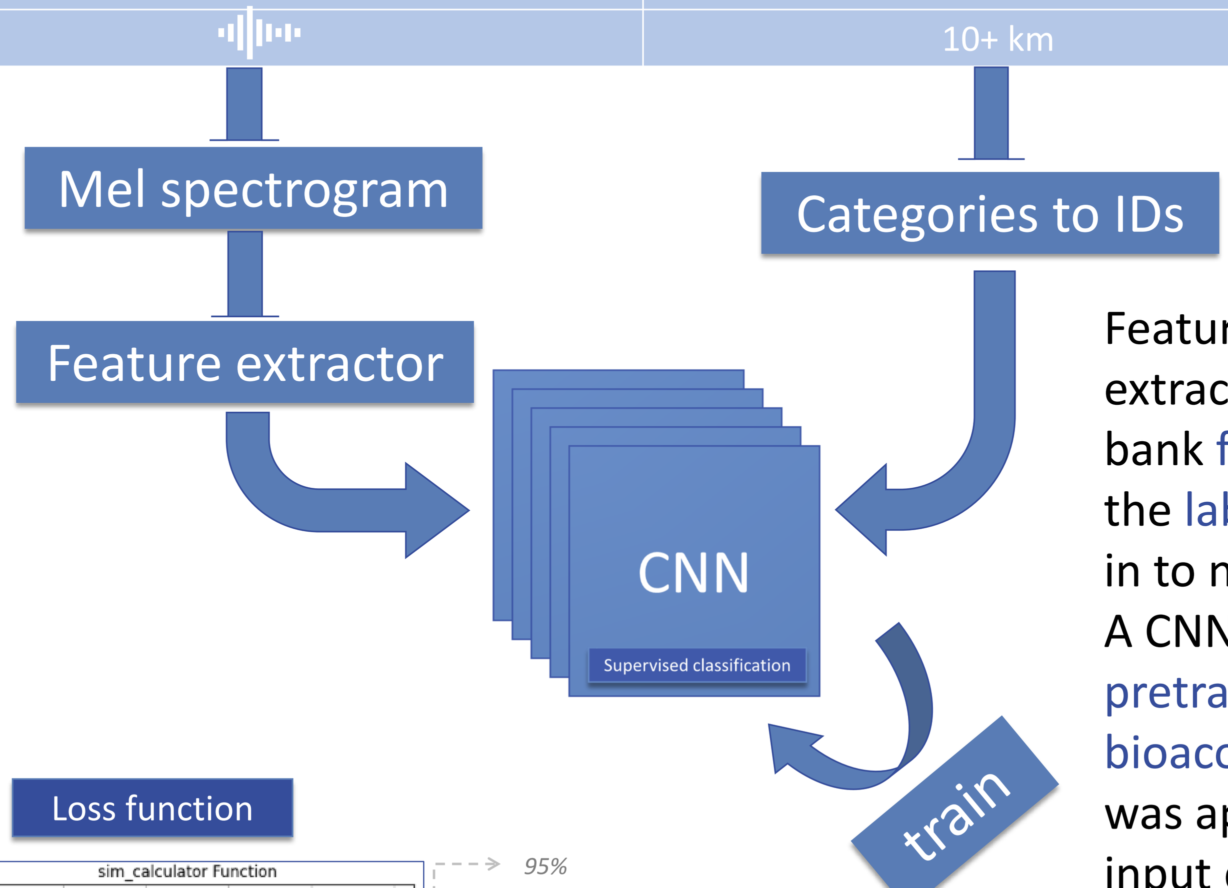
Training the CNN on labeled data

Ten-second WAV files are sampled every 2 minutes, resulting in a total of approximately 39,000 files.



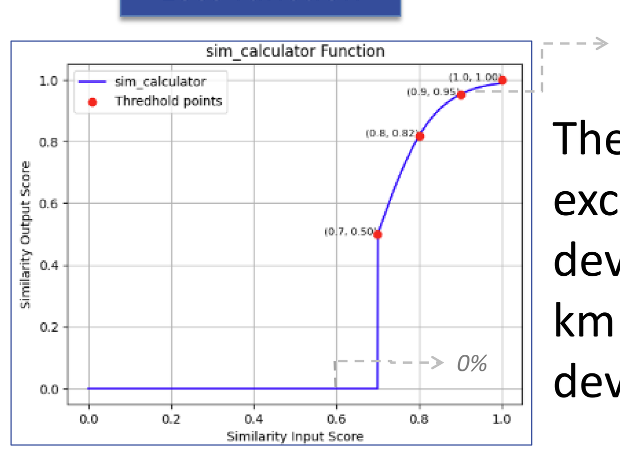


	audio	Labels
1		2-3 km
2		1-2 km
3		10+ km



Feature extractor extracts mel-filter bank features while the labels are turned in to numerical IDs. A CNN clap model, pretrained on bioacoustics data, was applied to the input data

Loss function

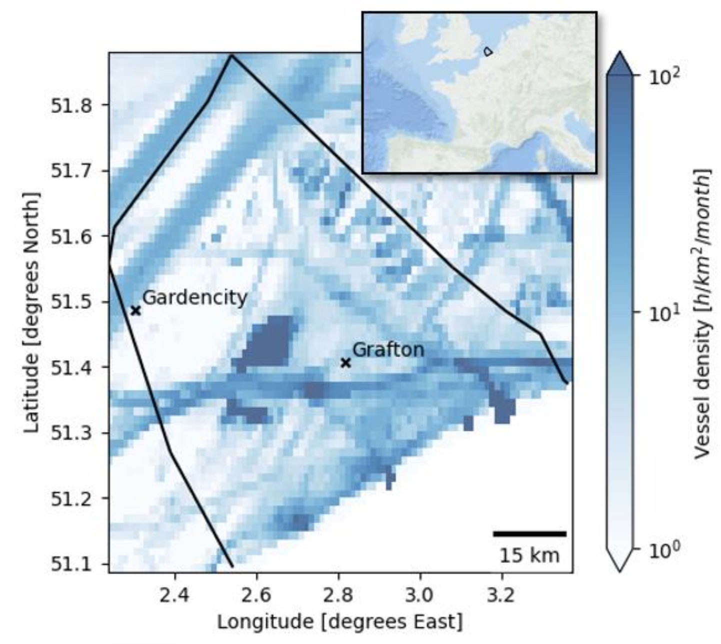


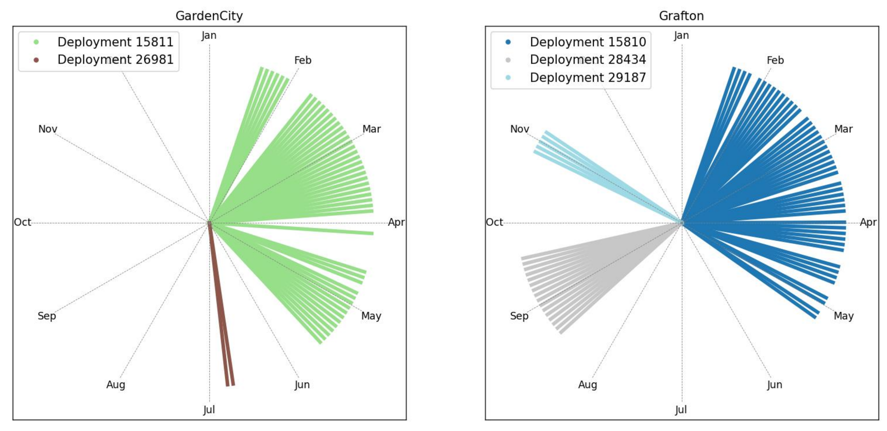
The loss function heavily penalizes errors exceeding 3 km but is more lenient towards deviations within 2 km. For instance, an error of 1 km still achieves 95% correctness, whereas a deviation of 4 km results in 0% correctness.

Spatio-temporal distribution of hydrophones

Where?

Hydrophones recording are from two stations in the Belgium part of the North Sea. The stations are called Gardencity and Grafton. The vessel distribution illustrates that that both are in the proximity of high ways.

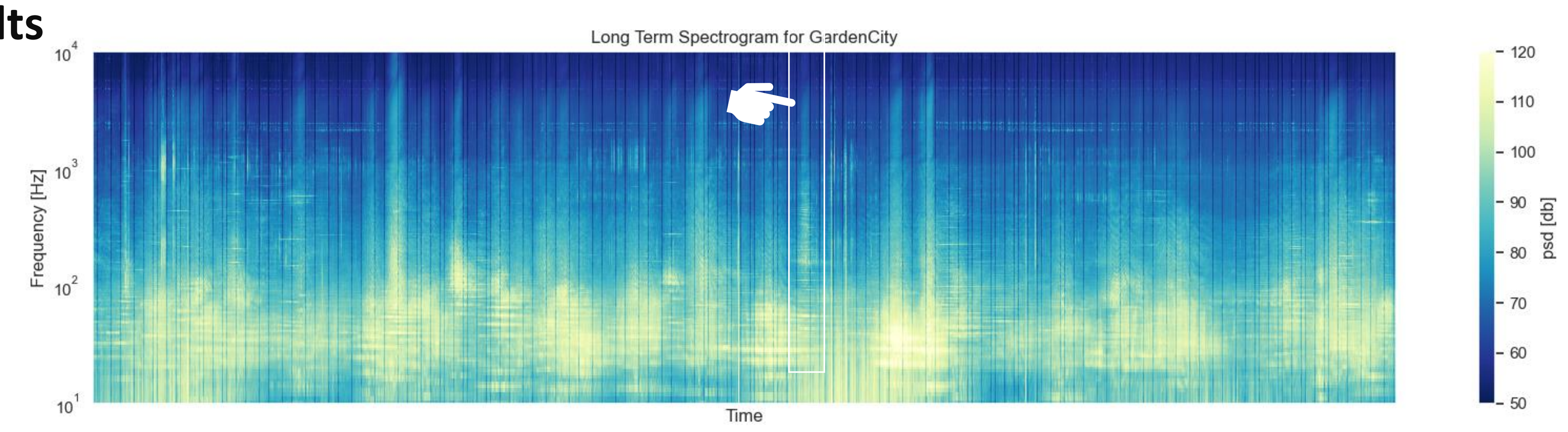


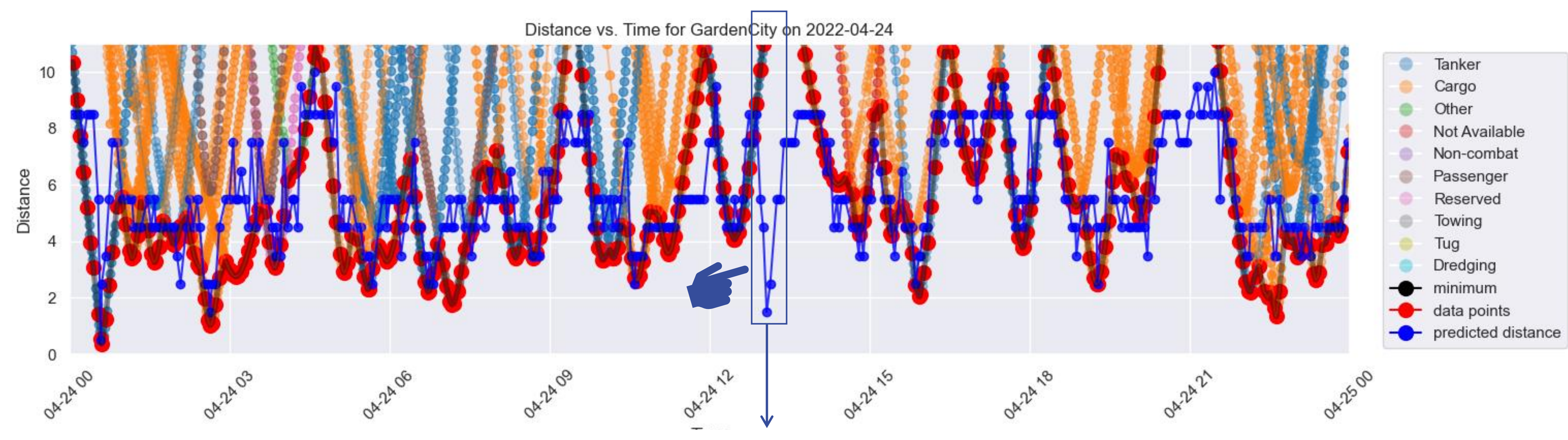


When?

Hydrophone recordings from Gardencity and Grafton in 2022. Each station has multiple deployments, shown in different colors, giving a clear picture of underwater sounds.

3 results: Results from ship detection

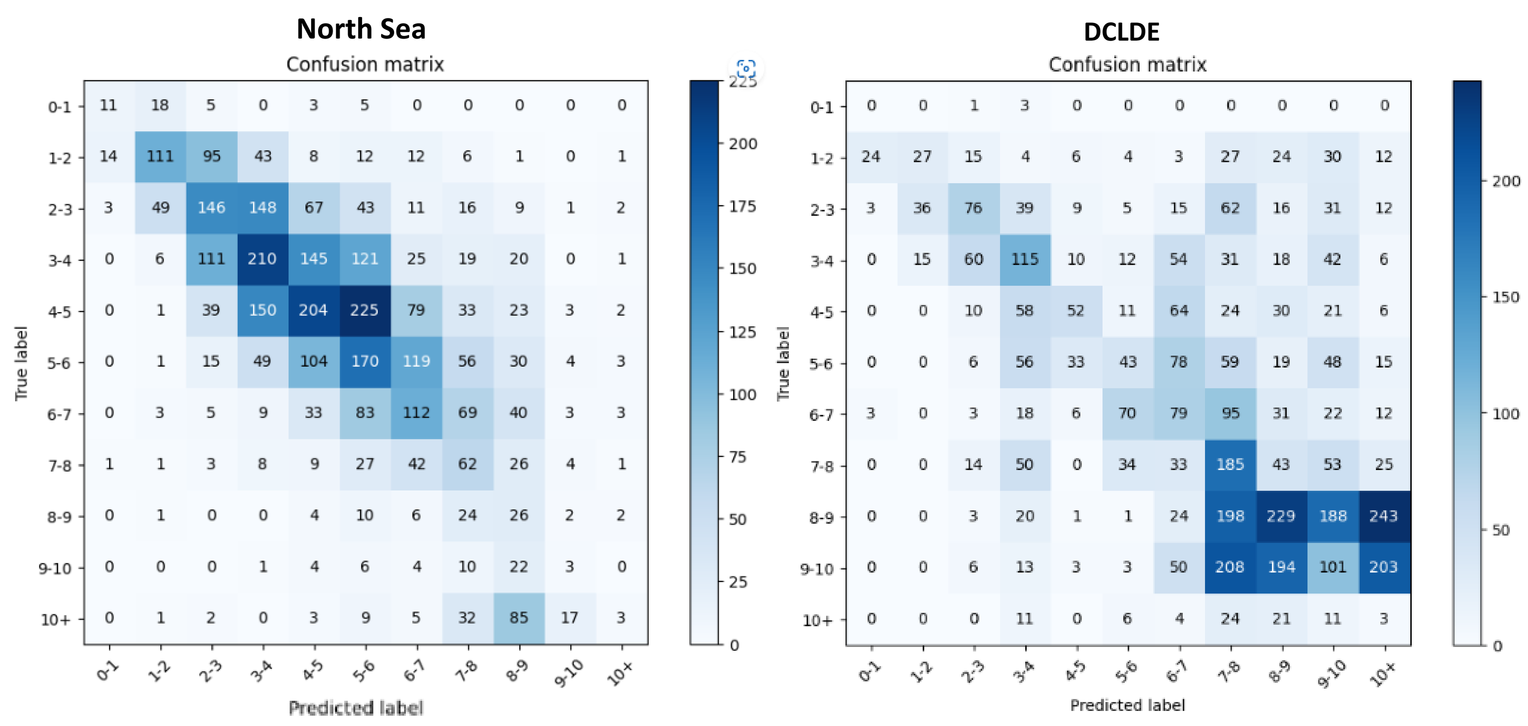




The model effectively identifies false negatives and outperforms the original dataset. Some vessels deactivate their AIS, leading to unlabeled vessels on the left side of the confusion matrix.

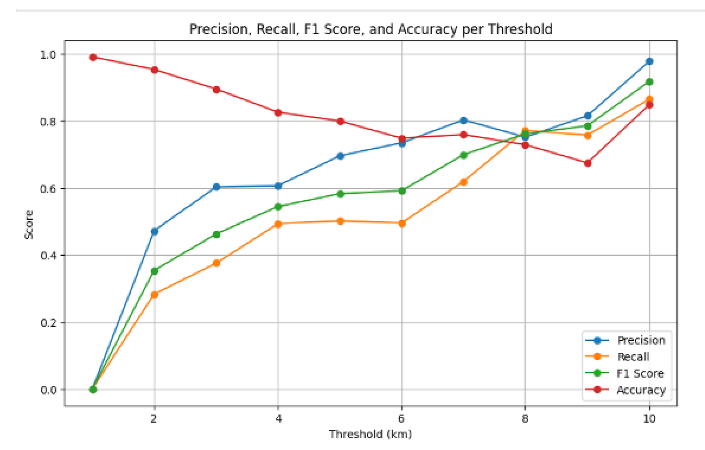
Re-training on DCLDE dataset

The developed model underwent re-training using 2.8k datapoints extracted from vessel tracks within the DCLDE dataset.



	North Sea	DCLDE
MSE	3.46 km	6.1 km
RMSE	1.86 km	2.47 km

The model performs effectively in the North Sea; however, when applied to the DCLDE dataset, it slightly overestimates distances, likely due to differences in environmental conditions.



In terms of detection capability, the DCLDE model demonstrates notable effectiveness in distinguishing the presence or absence of ships, particularly peaking at 10km due to the clearer identification of more distant vessels within the '10+km' category.

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