Data manual – Skulte, Latvia, Gulf of Riga

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Experiment overview

Sensor deployment: 02.08.2022 (Uploaded data start: 03.09.2022 00:00)

Sensor retrieval: 08.09.2022 (Uploaded data end: 05.09.2022 23:59)

Location: Skulte, Skulte Parish, Latvia

Closest address: Skulte Port, Upes iela 41, Zvejniekciems, Saulkrastu lauku teritorija, LV-2161, Latvia

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In this experiment, continuous velocity, direction and pressure measurements were made using a 3x3 sensor grid.

The data is space-time aligned. It consists of continuous measurements between 3. August 2022 and 5. September 2022. The measurements were made using Hydromasts (Egerer et al., 2024; Ristolainen et al., 2016).

This dataset provides all measurements with frequency 2Hz.

Paper providing an overview of the experiments and data can be found (Eelsalu et al., 2025).

Experimental Coordinates, recorded in the middle of the array:

57°19'16.6"N 24°23'33.8"E (57.321290, 24.392710)





Figure 1 A – Sensor array installation. B - Installation location of 3x3 array of current sensors C-Sensor placement

Devices

Hydromast

A water flow and wave measurement device Hydromast provided long-term continuous and resolved data of velocities, direction and wave height. Technical details of the used sensors are given below.

Logger	Adafruit Adalogger M0
Velocity range	0.12 – 1.2m/s (dependent on mast ¹)
Mast sensor	TLV493D
Compass	LIS3MDL
Sampling rate	50 Hz
Capacity	8 GB
Battery	D-cell battery pack, CR1220 for real time clock
Working time	1.5 months
Weight	1.4kg (battery pack 0.85kg)
O rings	NBR70x2 – 2pc, NBR74x2 – 4pc

The details of the Hydromast working principles and validation of the measurements can be found in (Egerer et al., 2024)². The Hydromast components overview and the installed device are shown on Figure 2. The velocity measure is a point measure 0.4m from the bottom.



Figure 2 A – Hydromast overview (B – Hydromast installed on a frame in-situ)

¹ The Hydromast velocity range is dependent on the mast length. In this experiment 300mm mast was used giving the velocity range between 0.12-1.2m/s

² In (Egerer et al., 2024) river measurements gave 0.15m/s as a minimum. In these experiments, 0.12m/s was determined valid. Validation was done with ADV device.

Experimental setup

9 Hydromast were installed in a 3x3 formation onto a 20 x 20 m rigid frame as shown below:



Figure 3 Grid displacement and sensor locations

The total weight of the installation frame was approximately **335kg** (excluding the ADV and diagonal cables). The installation had 9 Hydromast sensors (1,5kg per piece) with total weight of 13,5kg

Device deployment date – 02.08.2022

Sensor offsets were recorded for all 9 and ADV sensors separately during the deployment.

Device retrieval date: 08.09.2022

During retrieval, the distance between sensor points for exact placement of sensors was measured using measuring tape. Measuring dimensions between sensors (1-2-3-6-9-8-7-4-1 and from 5 to 1-2-3-6-9-8-7-4)

Repeat orientation (offsets from North) were taken for all sensors and headings.

Magnetic pulses for time calibration both before and after the experiment.

Dataset overview

The data is saved into NetCDF (Network Common Data Form). The data is organized into datafiles with Dataset name "SkulteYYYYMMDDHHmm.nc", where YYYY is the year, MM is the month, DD is the day, HH is the hour, mm is the minute of the data inside the file. Each file starts at time HH:mm:00:00 and contains data from full hour. The experiment was set up on 02.08.2022, the data is provided from the first full day 03.08.2022 00:00. The experiment ended 08.09.2022, the data is provided until the last day all 9 sensors were working and recording, last file is 05.09.2022 23:00.

Time and coordinates

Hydromasts datetimes were aligned based on the magnetic pulse data (taken before and after the experiment). All 9 Hydromasts datetime was aligned so that Sensor 9 was taken as the reference device and all other Hydromasts datetime was aligned to match Sensor 9.

Each device location is calculated using the known distance measurements and the central sensor (S5) coordinates.

Velocity and Direction Data

The velocity and direction are valid when the water velocity is over 0.12m/s. If the velocity is below 0.12m/s, there is no reading in the Dataset. The velocity and direction data is recorded as NaN.

For example, the data with velocity and direction below the measurement threshold:

Time:1500, Lat: 57.3212571454362, Lon: 24.3928350762083 -> Velocity: --, Dir: --, Depth: 3.824, Raw Pressure: 1334.513

An example of data with velocity and direction over the measurement threshold:

Time:1500, Lat: 57.3212562952731, Lon: 24.3926265766555 -> Velocity: 0.169, Dir: -36.593, Depth: 4.171, Raw Pressure: 1445.064

Note: Direction is more accurate with higher velocities.

Temperature

The temperature sensor has been calibrated at the lab. The bias due to the sensor location has been removed from the temperature measurements.

Depth and Pressure

The raw pressure measurements are uncalibrated raw pressure readings at 2Hz.

The depth measurements given in the data have atmospheric pressure removed. In addition, it has been calibrated so for all the sensors, bias has been removed with respect to Sensor 1. This means, that there may be additional small bias with respect to real water depth that has not been removed, however, with respect to other sensors, we have a very good estimate.

Parameter	Parameter name in dataset	Units	Accuracy
Velocity	'velocity'	m/s	0.1m/s
Direction	'direction'	Degrees (N:0, S: +/-180, E: 90,W: -90)	10 deg
Depth	'depth'	m (given as positive number)	0.05 m*
Temperature	'temperature'	deg C	1 deg C
Raw Pressure	'pressure'	hPa	5 hPa

Data naming, units and accuracy

* 0.05 m ignores error due to bias with respect to real water depth

Data validation

To validate the data, additional measurements were made with Nortek Vector acoustic Doppler velocimeter ADV. Reference atmospheric pressure was measured with HOBO data logger. ADV and HOBO data are available upon request.

Vectrino Vector ADV

In addition to Hydromast measurements, Vectrino Vector ADV was used to make burst measurements every 30 minutes. The length of the burst was 2 minutes.

These measurements were used to validate velocity, direction, and depth measurements.

ADV settings for the installation and placement can be seen in Figure 4. ADV was placed in the center of the grid, next to Sensor 5.

This data is available on request.



Figure 4 A – ADV settings for reference measurements. B – ADV placement on the frame. C – Schematic placement on the frame. D – Schematic side-by-side placement Hydromast and ADV. ADV probe center was 210mm from the base of the Hydromast, 245mm to the left and 30mm top from Hydromast no 5.

HOBO - Reference pressure logger

The background information about atmospheric conditions was recorded using the HOBO Water Level data logger (<u>https://www.onsetcomp.com/products/data-loggers/u20-001-04</u>). It features high accuracy at a great price and ease-of-use. This data is available on request.



Figure 5 Pressure logger for barometry pressure logging

References

- Eelsalu, M., Piho, L., Aigars, J., Kelpšaitė-Rimkienė, L., Kondrat, V., Kruusmaa, M., Parnell, K. E., Ristolainen, A., Šakurova, I., Skudra, M., Viška, M., & Soomere, T. (2025). Exponential distribution of wave-driven near-bed water speeds under short-crested waves: a case study in the eastern Gulf of Riga, the Baltic Sea. *Proceedings of the Estonian Academy of Sciences*, 74(1), 23. https://doi.org/10.3176/proc.2025.1.03
- Egerer, M., Ristolainen, A., Piho, L., Vihman, L., & Kruusmaa, M. (2024). Hall Effect Sensor-Based Low-Cost Flow Monitoring Device: Design and Validation. *IEEE Sensors Journal*, 24(5), 5986– 5997. <u>https://doi.org/10.1109/JSEN.2024.3354194</u>
- Ristolainen, A., Tuhtan, J. A., Kuusik, A., & Kruusmaa, M. (2016). *Hydromast: A Bioinspired Flow* Sensor with Accelerometers. 510–517. https://doi.org/10.1007/978-3-319-42417-0_55