

EOMAP

a **Fugro** company



**WESTBROOK
RACING**



SPACE SOLUTIONS

Delivery Report

Plastic litter detection and Water Quality Monitoring in Dubrovnik, Croatia

Date: June 17, 2026 | **Client:** ESA/Westbrook Racing

Authors: Stefan Mühlbauer, Nick Rotter

EOMAP
a Fugro company

 **WESTBROOK
RACING**

**6 WEEKS
MONITORING
PERIOD** **04 MAY**
16 JUNE



TURBIDITY

CHLOROPHYLL

SECCHI DEPTH

HARMFUL ALGAE BLOOM

ANALYSED SCENES

19

09 JUNE

12 JUNE

09 JUNE 12 JUNE

No clear difference can be observed between turbidity levels before and during the training. Colour difference due to minimal variations.

0 FLOATING PLASTIC LITTER

No floating plastic litter patches larger than 10 sqm were found in the monitoring period.

Slightly higher turbidity and HAB values in estuaries and harbour (enclosed bays) in the week from 29 May to 6 June 2026.

	1	2	3	4	5	6	7
CRITICAL	•	•	•	•	•	•	•
POOR	•	•	•	•	•	•	•
FAIR	•	•	•	•	•	•	•
GOOD	●	●	●	●	●	●	●
WEEK	1	2	3	4	5	6	7

RACE WEEK

CONTENTS

CONTENTS..... 3

1 LOCATION 4

2 DATA AND TIME FRAME 4

3 PLASTIC LITTER DETECTION..... 6

4 WATER QUALITY MONITORING 6

LIST OF FIGURES 14

LIST OF TABLES..... 14

ACRONYMS 14

CONTACT..... 15

1 Location



Figure 1: Coastline at Dubrovnik with marked boxes to indicate the areas for plastic litter detection and water quality monitoring

The race location is at the shore of **Dubrovnik in Croatia**, in the East of the old city centre.

2 Monitoring sites: The white boxes in Figure 1 indicate the primary race area at the shore of Dubrovnik East of the old city centre until Boninovo in the West (1 - Race Location, Figure 1) and the extended monitoring area covering the entire shoreline of Dubrovnik reaching from the Bay of Zaton in the West until the Bay of Župski zaljev in the East (2 - Extended Area, Figure 1). Very high-resolution (VHR) monitoring of plastic litter and water quality was conducted in the Race Location, while water quality monitoring using high-resolution Sentinel-2 and Landsat-8/9 data was conducted in the Extended Area to obtain the big picture.

Coordinates of the race location: 42°38'23.3"N 18°07'03.0"E

2 Data and time frame

Monitoring time frame: 4th May – 16th June 2026

Planet Super Doves: The Planet data have a spatial resolution of 3m (VHR) and a daily repetition rate. The data was used for plastic litter and water quality monitoring in the Race Location of Dubrovnik.

Sentinel-2 and Landsat-8/9: Sentinel-2 data have a spatial resolution of 10 m and a revisit frequency of 3 to 5 days and are distributed through the European Copernicus Service. Landsat-8 and Landsat-9 data, provided by NOAA, have a spatial resolution of 30 m and a combined revisit time of approximately 8 days. These datasets were used for water quality monitoring across the Extended Area.

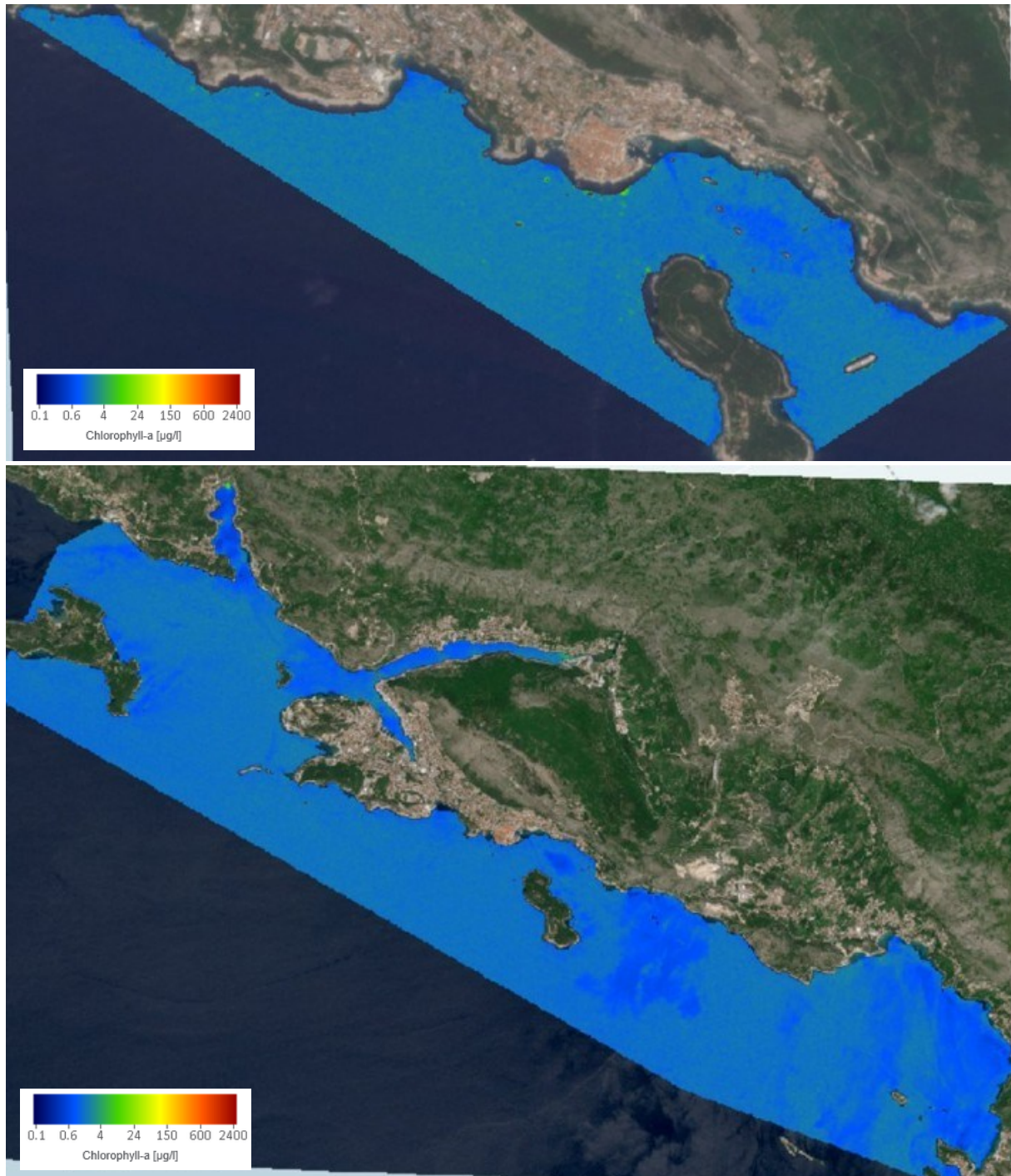


Figure 2: Top - Planet scene from 9th May 2026, 09:38 (UCP) in the core monitoring area for plastic litter and water quality with the Chlorophyll product laid on top of the imagery. Bottom - Sentinel-2 scene from 7th June 2026, 09:48 (UCP) with the Chlorophyll product shown in the extended monitoring region.

Table 1 shows the collected satellite data scenes at Dubrovnik. It indicates that last data collected come from 12th June 2026. The scenes during and after the race weekend could not be used as of high sun glint effects in the source data.

Table 1: Collected scenes for the race location at the race location in Dubrovnik

Sensor	Date, Time (UCP)	Sensor	Date, Time (UCP)
Planet Super Doves	04.05.2026, 09:38	Sentinel-2 Landsat-8/9	18.05.2026, 09:48
	09.05.2026, 09:44		20.05.2026, 09:49
	14.05.2026, 09:39		23.05.2026, 09:48
	18.05.2026, 09:42		30.05.2026, 09:49
	19.05.2026, 09:43		02.06.2026, 09:48
	23.05.2026, 09:38		07.06.2026, 09:48
	24.05.2026, 09:39		09.06.2026, 09:49
	25.05.2026, 10:11		12.06.2026, 09:48
	27.05.2026, 10:15		
	30.05.2026, 10:16		
	04.06.2026, 10:12		

3 Plastic litter detection

Plastic litter detection was conducted within the Race Location (Figure 1 – number 1) and is based on Planet data. Across all the analysed time steps no plastic litter detections were identified - indicated by the blue dots at the 0-axis in

Figure 3: Plastic litter statistic across the monitoring time series.



Figure 3: Plastic litter statistic across the monitoring time series

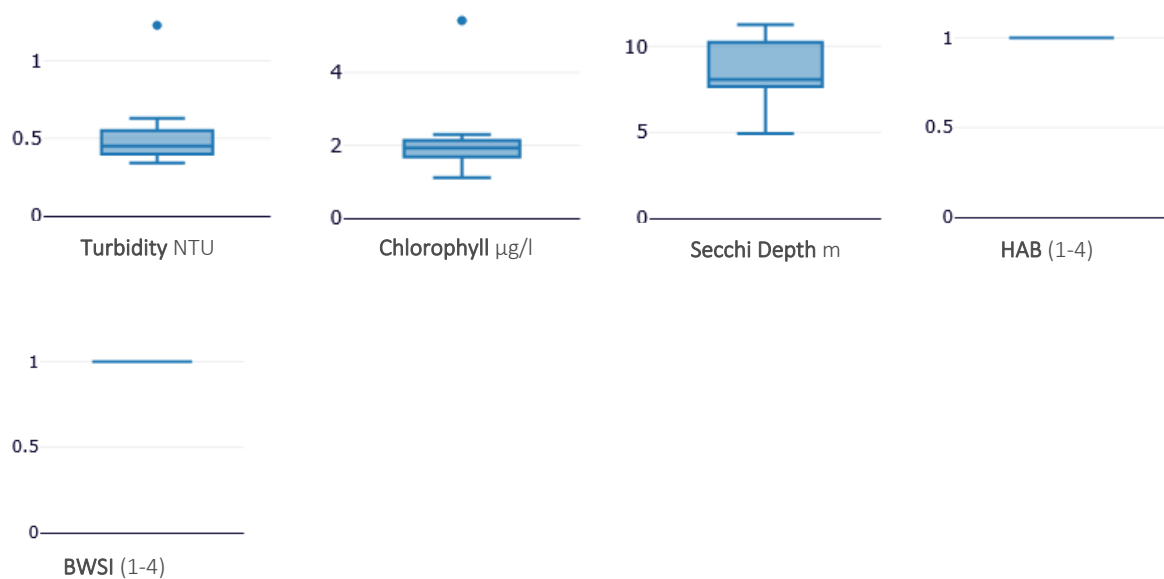
4 Water quality monitoring

Water quality monitoring was conducted in both AOIs in Figure 1. While Planet satellite data are available only for the Race Location, Sentinel-2 and Landsat-8/9 data cover the entire Dubrovnik shoreline. For all time steps, the parameters chlorophyll (algae), turbidity, depth of visibility (Secchi Depth), Bathing Water Safety Index (BWSI) and the Harmful Algal Bloom (HAB) indicator were derived. Latest scenes used come from 12th June 2026, as the imagery afterwards showed high sun glint effects.

RESULTS

Boxplots

Boxplot diagrams for the Race Location (Figure 1 – number 1) indicate a **higher fluctuation for Secchi Depth**, while the one of turbidity and chlorophyll is incrementally lower. For turbidity 50% of the measured values settle around 0.5 NTU corresponding to a very low turbidity level and very clear water conditions. This is also reflected by the Secchi Depth with 50% of the values between 8m and 10m. Both, the HAB and Bathing Water Safety Index (BWSI) are constantly at the best level (1).



Time series plots

The five time series plots below present the temporal evolution of the 5 parameters over the full monitoring period. Each plot shows two different spatial aggregations representing the two monitoring AOIs Race Location and Extended Area (Figure 1). For each aggregation, the median pixel value of all pixels within the corresponding AOI was calculated. In general, the overlap between data points from the Race Location and the Extended Area indicate similar conditions across the expanded monitoring location. A description of the plots is included with the caption of each figure.



Figure 4: Time series plot for Chlorophyll aggregating the measurements for the Race Location and the Extended Area. With exception of the first time step, all other dates show a constant chlorophyll level at approximately 1.8 - 2 µg/l.

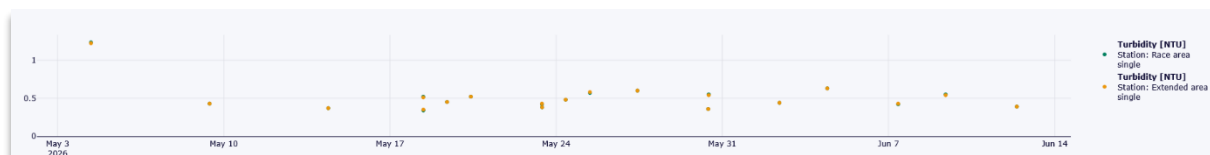


Figure 5: Time series plot for Turbidity aggregating the measurements for the Race Location and the Extended Area. The pattern is similar as for chlorophyll with average values levelling at 0.5 NTU across most time steps.



Figure 6: Time series plot for depth of visibility (Secchi-Depth) aggregating the measurements for the Race Location and the Extended Area. Compared to the other parameters the Secchi Depth experiences larger fluctuation with most values ranging between 8m and 10m depth of visibility. Single areas exhibit a Secchi Depth of 11m and more. The measurements speak for very clear water conditions.

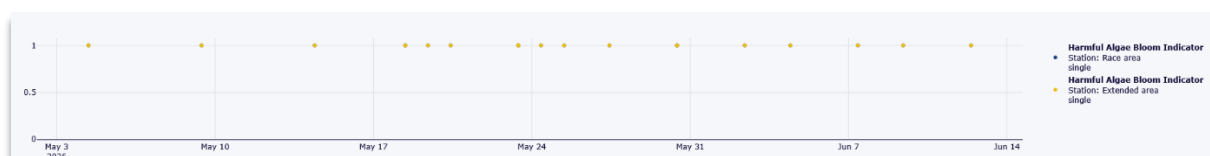


Figure 7: Time series plot for Harmful Algae Bloom Indicator aggregating the measurements for the Race Location and the Extended Area. The average HAB value for the monitoring regions is constantly at the best level.



Figure 8: Time series plot for Bathing Water Safety Index aggregating the measurements for the Race Location and the Extended Area. The average BWSI value for the monitoring regions is constantly at the best level.

MAPS - Single scene examples

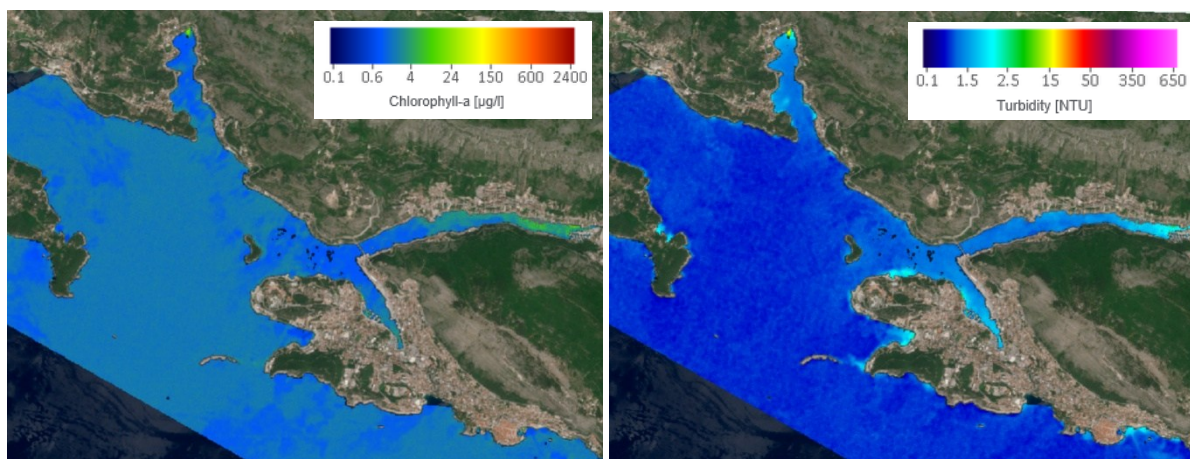


Figure 9: Chlorophyll (left) and turbidity (right) measurements from 23rd May 2026. On that day, slightly elevated values were registered in the port and bay areas in the North of Dubrovnik

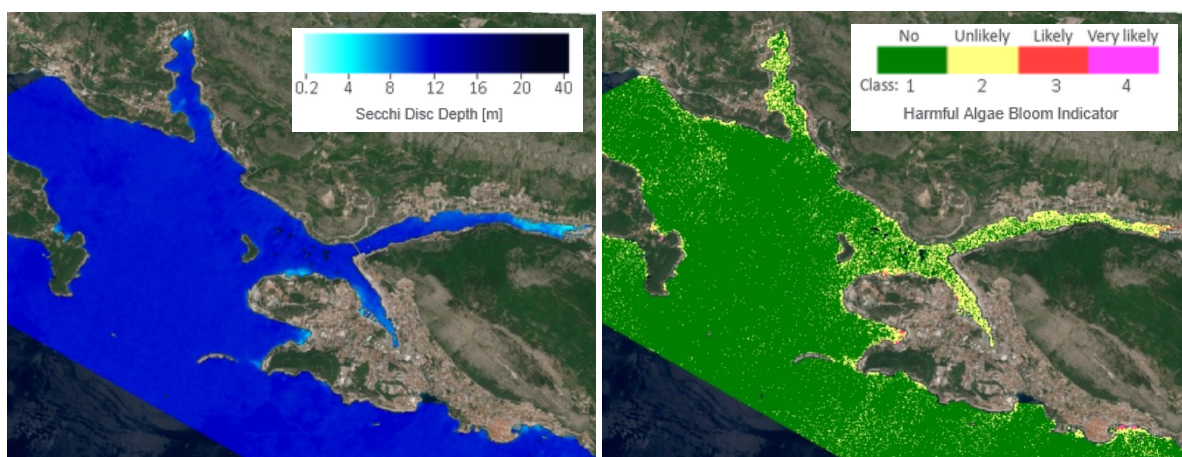


Figure 10: Secchi-depth (left) and HAB (right) from 23rd May 2026



Figure 11: BWSI from 23rd May 2026

MAPS - Turbidity weekly

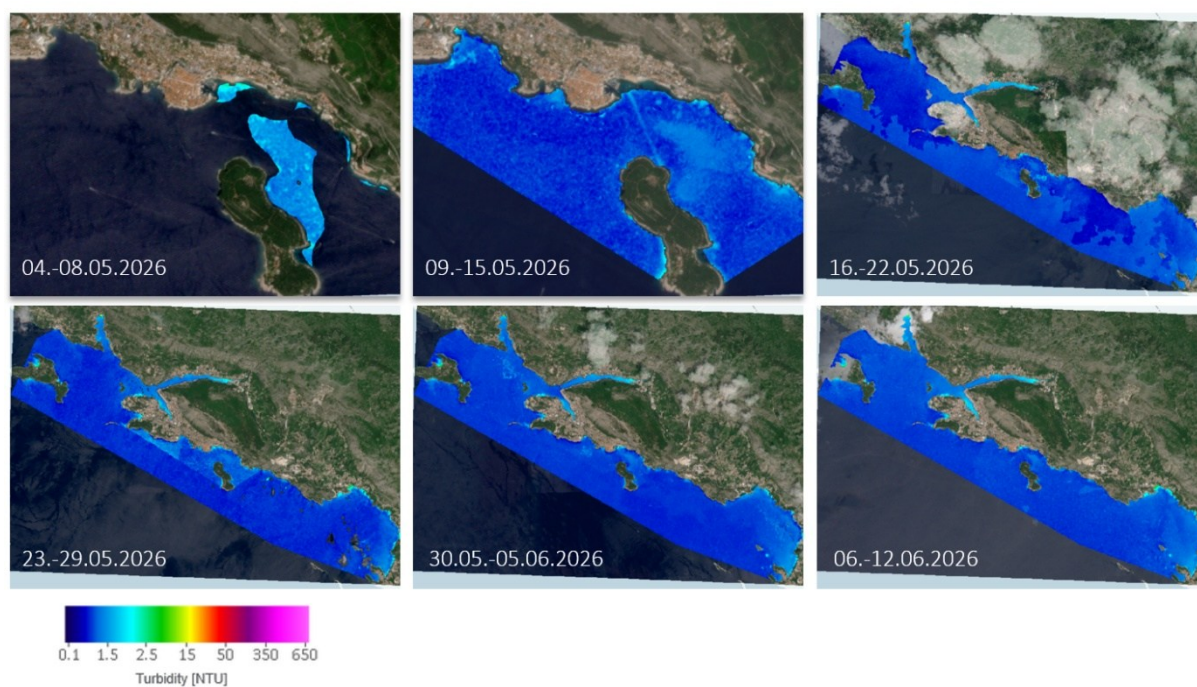


Figure 12: Weekly maps of turbidity

MAPS - Chlorophyll weekly

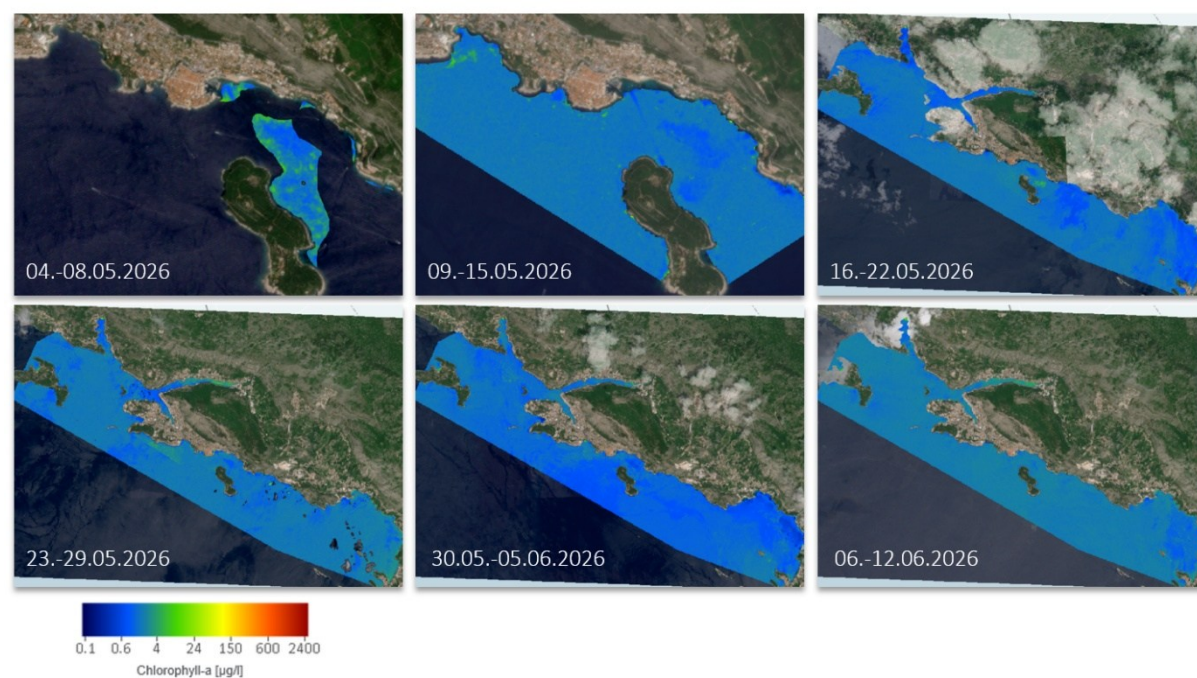


Figure 13: Weekly maps of chlorophyll

DISCUSSION

Chlorophyll

The chlorophyll content for the majority of scenes was around 2µg/l and lower (1,5 – 2 µg/l). On 23rd May and 2nd June slightly higher chlorophyll values were measured for port and bay areas in the North of Dubrovnik with values ranging between 2,5 and 4,5µg/l. Enhanced algae growth can happen after days of bad weather due to nutrient inflow from surrounding areas and has a greater impact in enclosed environments like the mentioned ones.

Turbidity

Turbidity measurements exhibit a pattern similar to that of chlorophyll. The turbidity value for most scenes lies far below 1 NTU (in average 0.3 – 0.6 NTU) and thus corresponds to very clear water conditions. Slightly elevated values for single scenes were recorded for the port and bay areas in the North of Dubrovnik, reaching approximately 1 NTU. This pattern reflects the relationship between turbidity and algal growth, as chlorophyll pigments contribute to increased water turbidity. The scene of 20th May 2026 stands out as on that day higher turbidity values ranging between 1 and 1,5 NTU were measured in the port and bay areas North of Dubrovnik, but chlorophyll does not reveal this pattern. This indicates that the increase of turbidity was not driven by phytoplankton growth but by other factors, most likely sediment inflow from the Ombla river.

Visibility

The average visibility is around 10m with individual areas/dates exhibiting a Secchi Depth of above 11m. This corresponds to very transparent water conditions. In locations of increased turbidity values, the visibility decreases to approximately 8m.

Harmful Algae Indicator (HAB)

The HAB indicator showed a low probability of the presence of toxic algae in the open sea. For the port area and bays in the North of Dubrovnik moderate HAB values were observed at some dates. Nevertheless, these results indicate that the occurrence of toxic algae, such as cyanobacteria, is unlikely, supporting the conclusion of generally good water quality.

Bathing Water Safety Index (BWSI)

The Bathing water index considers chlorophyll (total amount of algae in water), depth of visibility and HAB as input parameters. It classifies pixels into four classes: good – fair – poor – critical. The conditions in the Extended Area are consistently good.

RACE IMPLICATIONS - turbidity

To assess the potential impact of the race on water turbidity, four monitoring stations were established at which turbidity values were evaluated (Figure 14). The results are presented in Figure 15. Across all stations, average turbidity values are around 0.5 NTU, with maximum values reaching approximately 1 NTU. The values on 9th June 2026 seem considerably higher than on 12th June, when race training was already taking place. However, considering the scale of the values, the differences between 0.6 NTU on 9th June and 0.4 NTU on 12th June remain very small and can be neglected. **Consequently, no clear difference can be observed between turbidity levels before the race event and during the training stage.** This finding is consistent with the time series analysis and weekly maps of turbidity. Consequently, the race training in Dubrovnik did not have had a measurable impact on turbidity, Secchi depth, or chlorophyll concentrations.

Due to elevated sun glint effects in the data, no scenes could be gathered and analysed during and immediately after the race event.

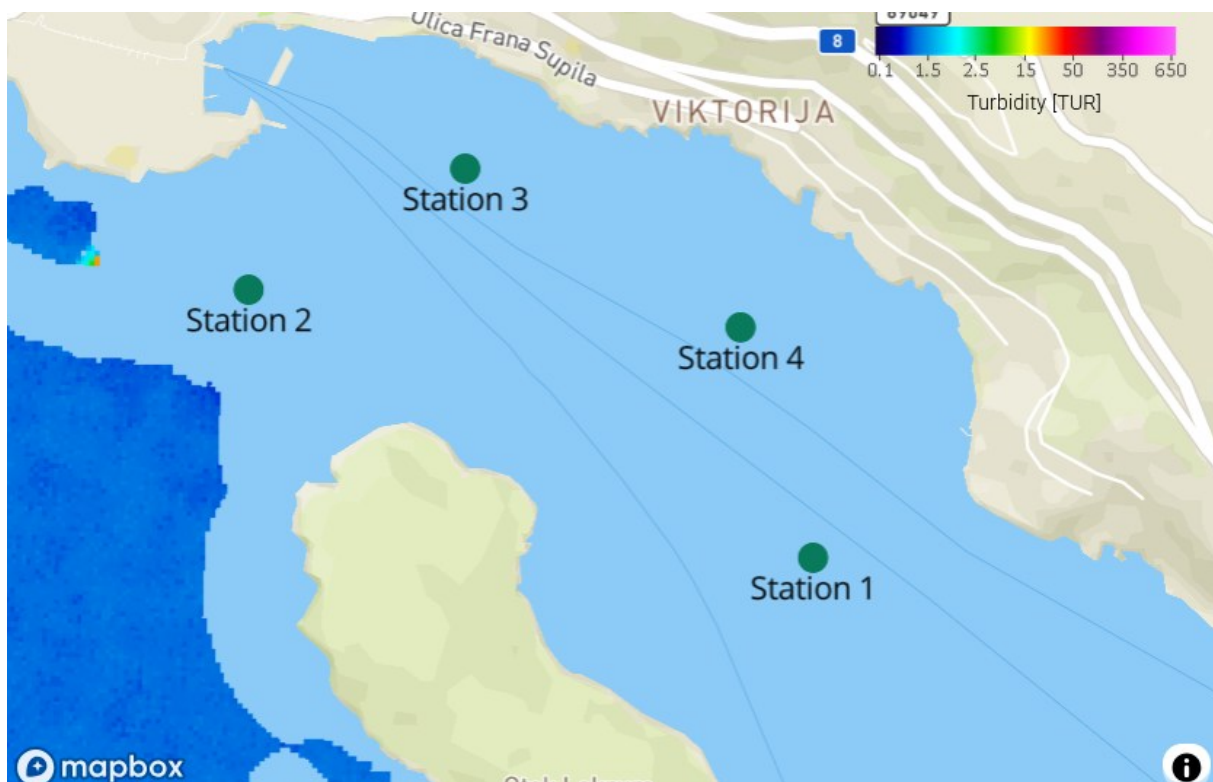


Figure 14: Map indicating the measurement stations for turbidity in the race area

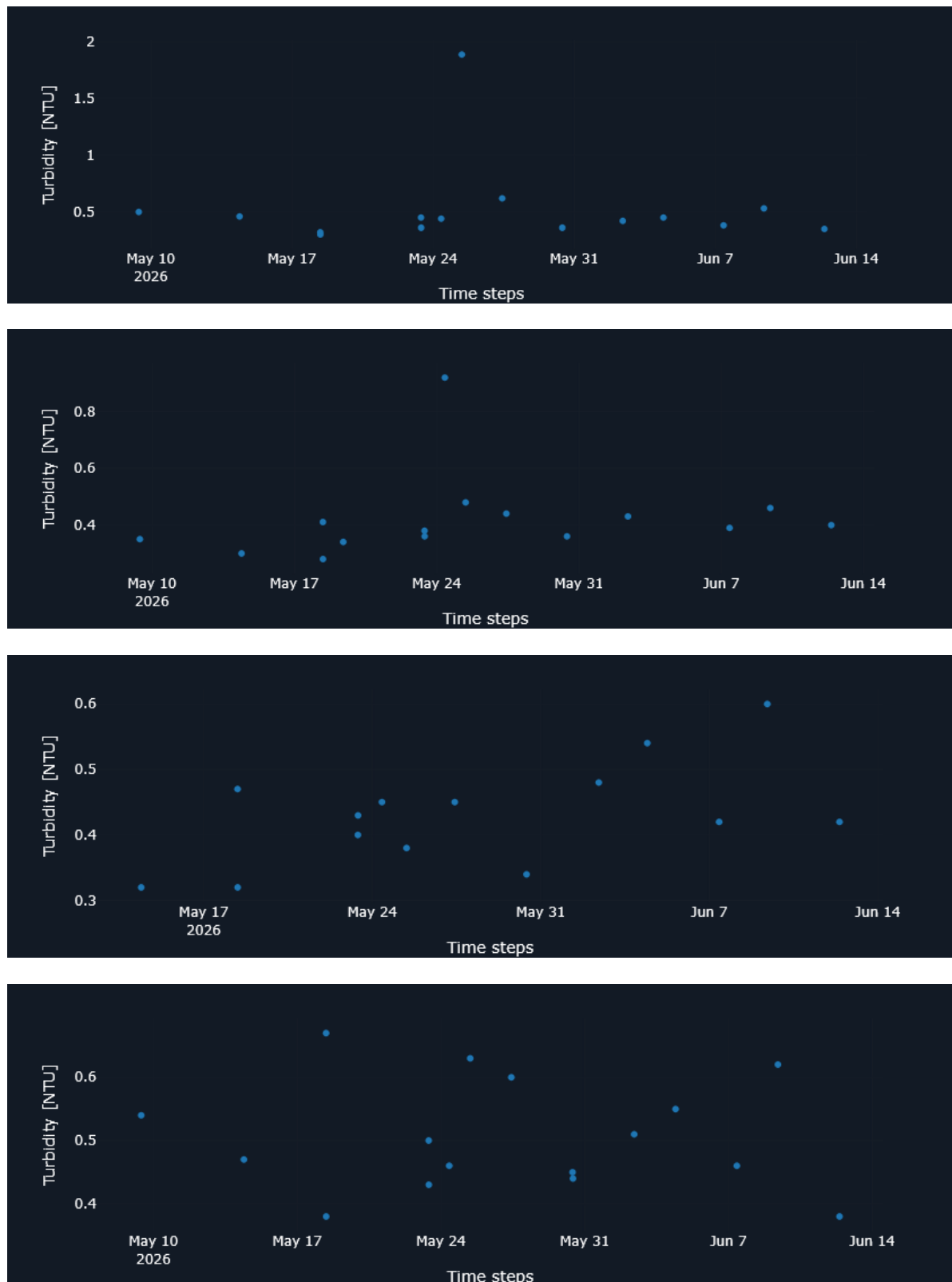


Figure 15: Turbidity measurements at 4 points in the actual race location. The order of panels follows following order from top to bottom: Station 1, Station 2, Station 3, Station 4

List of Figures

Figure 1: Coastline at Dubrovnik.....	4
Figure 2: Top - Planet scene from 9th May 2026, 09:38 (UCP) in the core monitoring area for plastic litter and water quality with the Chlorophyll product laid on top of the imagery. Bottom - Sentinel-2 scene from 7th June 2026, 09:48 (UCP) with the Chlorophyll product shown in the extended monitoring region.	5
Figure 3: Plastic litter statistic across the monitoring time series.....	6
Figure 4: Time series plot for Chlorophyll.....	7
Figure 5: Time series plot for Turbidity.....	8
Figure 6: Time series plot for depth of visibility (Secchi-Depth).	8
Figure 7: Time series plot for Harmful Algae Bloom Indicator.....	8
Figure 8: Time series plot for Bathing Water Safety Index.....	8
Figure 9: Chlorophyll (left) and turbidity (right) measurements from 23 rd May 2026	9
Figure 10: Secchi-depth (left) and HAB (right) from 23 rd May 2026	9
Figure 11: BWSI from 23 rd May 2026.....	9
Figure 12: Weekly maps of turbidity.....	10
Figure 13: Weekly maps of chlorophyll.....	10
Figure 14: Map indicating the measurement stations for turbidity in the race area	12
Figure 15: Turbidity measurements at 4 points in the actual race location.....	13

List of Tables

Table 1: Collected scenes for the race location at the race location in Dubrovnik	6
---	---

Acronyms

Acronym	Description
AOI	Area of Interest
BWSI	Bathing Water Safety Index
HAB	Harmful Algae Bloom

Contact

Please contact the EOMAP Team for any further questions and/or technical support:

Address	EOMAP GmbH & Co. KG, Schlosshof 4, 82229 Seefeld, Germany
Phone	+49 (0)8152 99861 10
Fax	+49 (0)8152 99861 29
Email	info@eomap.com , muehlbauer@eomap.de
Website	www.eomap.com

© EOMAP GmbH & Co. KG, June 17, 2026

Disclaimer: This document contains confidential information that is intended only for the use by EOMAP's Client. It is not for public circulation or publication or to be used by any third party without the express permission of either the Client or EOMAP GmbH & Co. KG. The concepts and information contained in this document are the property of EOMAP GmbH & Co. KG. Use or copying of this document in whole or in part without the written permission of EOMAP GmbH & Co. KG constitutes an infringement of copyright.

While the findings presented in this report are based on information that EOMAP GmbH & Co. KG considers reliable unless stated otherwise, the accuracy and completeness of source information cannot be guaranteed. Furthermore, the information compiled in this report addresses the specific needs of the client, so may not address the needs of third parties using this report for their own purposes. Thus, EOMAP GmbH & Co. KG and its employees accept no liability for any losses or damage for any action taken or not taken on the basis of any part of the contents of this report. Those acting on information provided in this report do so entirely at their own risk.