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a **Fugro** company



SPACE SOLUTIONS

Delivery Report

Plastic litter detection and Water Quality Monitoring in Luanda, Angola

Date: September 18, 2026

Client: ESA/ Westbrook Racing by Visit Angola

Authors: Stefan Mühlbauer, Nick Rotter

MONITORING OVERVIEW

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WESTBROOK
RACING



JEDDA

LAKE COMO

DUBROVNIK

MONACO

LUANDA

MIAMI

7 WEEKS
MONITORING
PERIOD

27 JULY

15 SEPTEMBER



FLOATING PLASTIC LITTER

TURBIDITY

CHLOROPHYLL

SECCHI DEPTH

HARMFUL ALGAE BLOOM

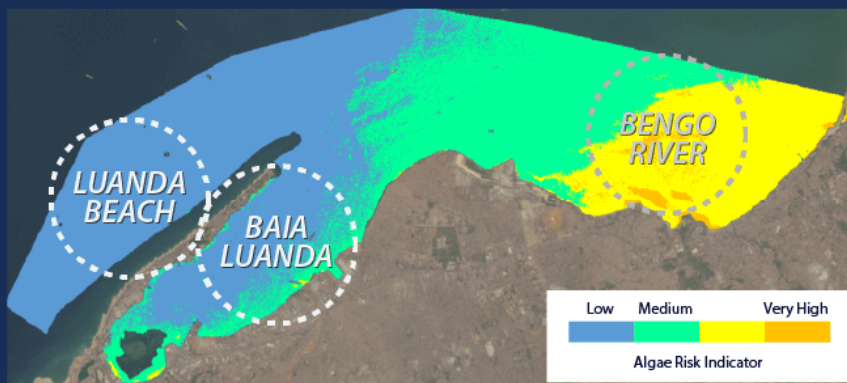
MONITORING RESULTS

ANALYSED
SCENES

21

TURBIDITY AT MONITORING SITE

One can clearly see a difference in turbidity levels between the west and the east part of the monitoring site.



ALGAE RISK INDICATOR JULY 2026

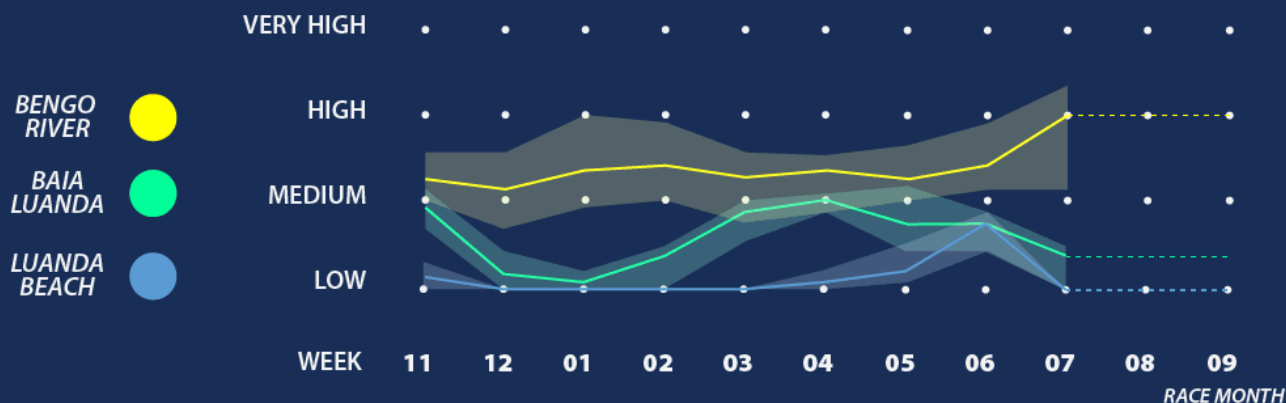
0

FLOATING
PLASTIC
LITTER

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

SPECIFIC OBSERVATION OF ALGAE RISK INDICATOR AT MONITORING SITE

November 2025 to September 2026



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1 Location

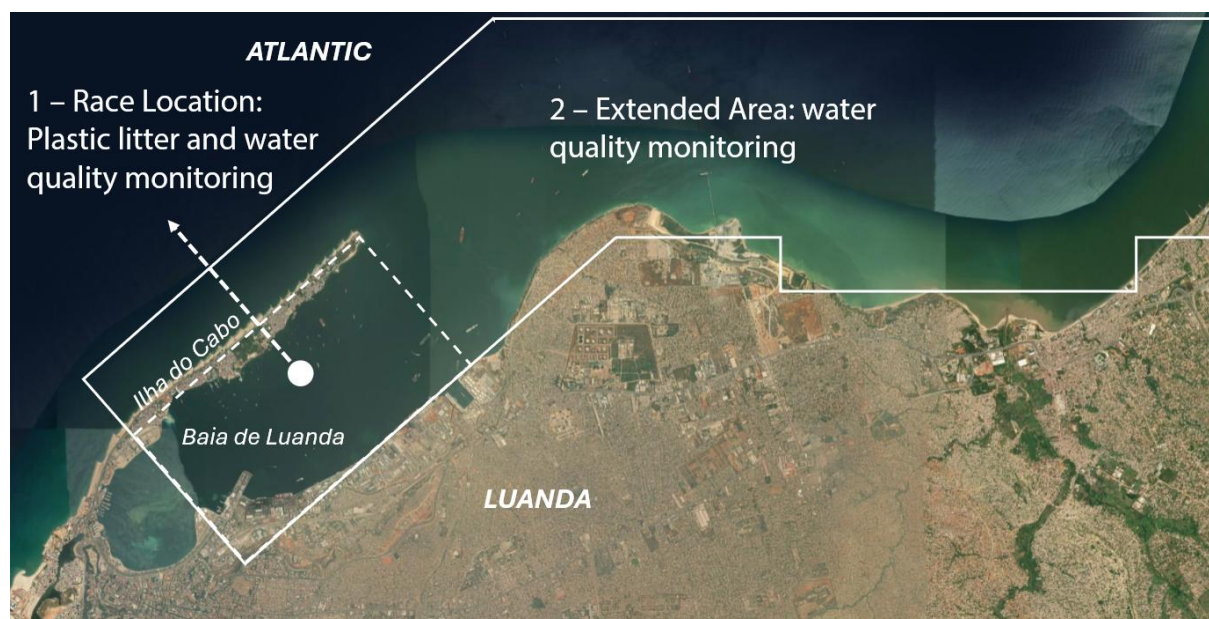


Figure 1: Coastline of Luanda at the Atlantic with the Baia de Luanda in the West and the city centre in the middle of the image. The box with the dashed line indicates the race location, while the box with the continuous line shows the extended area of water quality monitoring.

The race location is in the Baia de Luanda (Luanda Bay) in **Luanda, Angola**.

2 Monitoring sites: The box with the dashed line in Figure 1 indicates the primary race area in the Luanda Bay (**1 – Race location**), while the box with the continuous line indicates the extended monitoring area covering the shoreline from Luanda Bay until the mouth of Bengo River in the East of the city (**2 - Extended Area**). 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 data was conducted in the Extended Area to obtain the big picture.

Coordinates of the race location: 8°47'12.5"S, 13°14'36.7"E

2 Data and time frame

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

The monitoring time frame was 27th July – 15th September 2026.

Sentinel-2: Sentinel-2 data have a spatial resolution of 10 m and a nominal revisit frequency of 3 to 5 days and are distributed through the European Copernicus Service. This data was used for water quality monitoring across the Extended Area.

Due to extended cloud coverage and atmospheric haze in the recent weeks, making the generation of water quality products impossible, the original monitoring window of 27th July – 15th September 2026 was extended back to November 2025.

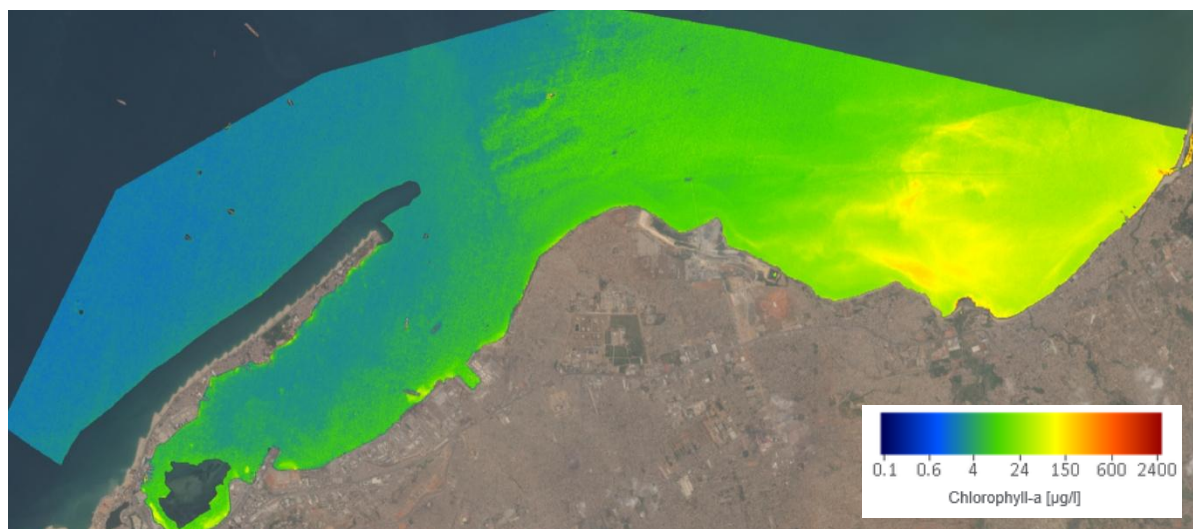


Figure 2: Sentinel-2 scene from 3rd July 2026, 09:32 (UCP) in the Extended Area used for water quality monitoring showing the Chlorophyll product (algae concentration) laid on top of the satellite imagery.

Table 1 shows the collected satellite scenes at the Luanda monitoring sites.

Table 1: Collected scenes for the monitoring sites in Luanda

Sensor	Date, Time (UCP)	Sensor	Date, Time (UCP)
Planet Super Doves	29.07.2026, 10:02	Sentinel-2	11.01.2026, 09:33
	04.08.2026, 13:50		03.02.2026, 09:32
	22.08.2026, 09:26		18.02.2026, 09:33
	26.08.2026, 09:28		02.03.2026, 09:11
Sentinel-2	15.11.2025, 09:32		12.03.2026, 09:33
	18.11.2025, 09:11		02.03.2026, 09:11
	30.11.2025, 09:33		27.04.2026, 09:11
	20.12.2025, 09:11		24.05.2026, 09:32
	28.12.2025, 09:12		03.07.2026, 09:32
	04.01.2026, 09:32		11.09.2026, 09:32
	05.01.2026, 09:11		

3 Plastic litter detection

Plastic litter detection was conducted within the Race Location (Figure 1 – number 1) and is based on Planet data. The results are displayed in the Eyes-on-Plastic platform (Figure 3). Across all analysed time steps, no **plastic litter detections** were identified in the Luanda Bay - indicated by the blue circles that are at the 0-level on the x-axis in Figure 4.

However, in the observation of water quality parameters based on Sentinel-2, a floating formation on the water (see Figure 3) became visible and was therefore added to the Eyes-on-Plastic platform. After having our experts cross-check this sighting, we **do not believe this to be plastics, but rather floating hydrocarbon fluids**. Nonetheless, it was featured in this report to highlight any potential findings. It is

also worth pointing out that this sighting occurred on an image from before the race, i.e., on a Sentinel-2 capture from September 11th. Therefore, it is not featured in the RACE IMPLICATIONS section.

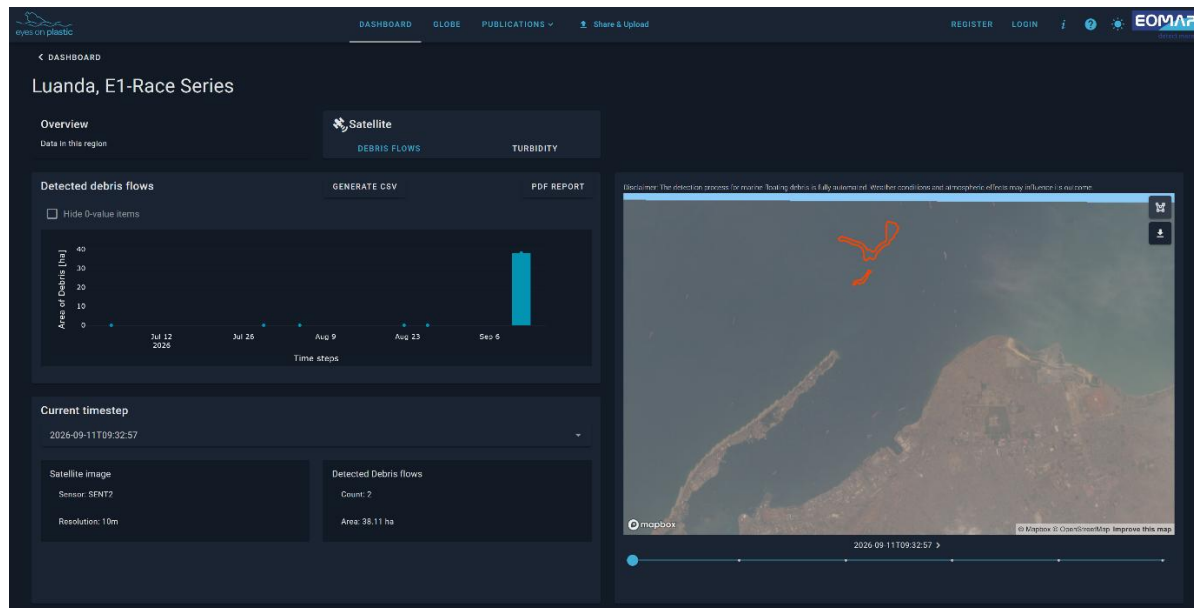


Figure 3: Space component for Luanda in the Eyes-on-Plastic platform showing the detection statistics and metadata on the left side and collected EO imagery on the right-hand side.



Figure 4: Plastic litter statistic across the monitoring time series (featuring the formation detected on September 11th)

4 Water quality monitoring

Water quality monitoring was conducted in the Extended Area (Figure 1) covering the Luanda shoreline from the city centre to the inflow of the Bengo River and is based on Sentinel-2 data. The collected Planet scenes of the Race Location could not be used for water quality processing due to atmospheric haze or extended cloud coverage between 27th July and 15th September 2026. For all time steps, the parameters chlorophyll (algae concentration), Turbidity, Secchi Depth (visibility), Algae Risk Indicator (ARI) and the Harmful Algal Bloom (HAB) indicator were derived.

To analyse water quality information three virtual stations were created across the Extended Area in the eoapp AQUA to provide averaged polygon statistics across these observation spots. These stations, indicated by the white polygons in Figure 5, constitute arbitrary shapes and can be created by any user individually in the eoapp AQUA.



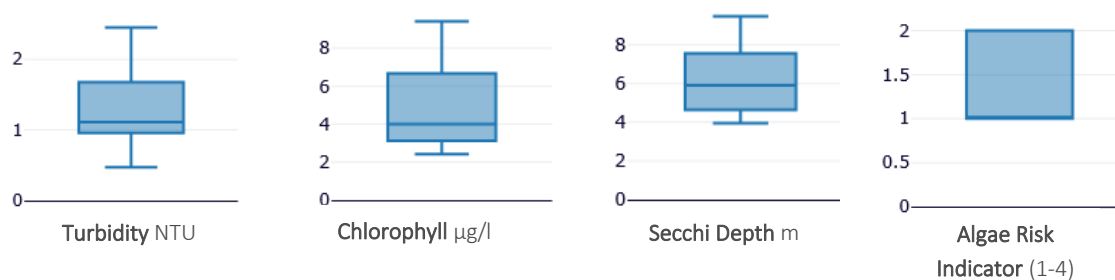
Figure 5: Virtual stations created over the Extended Area for water quality monitoring.

RESULTS

Box plot analysis

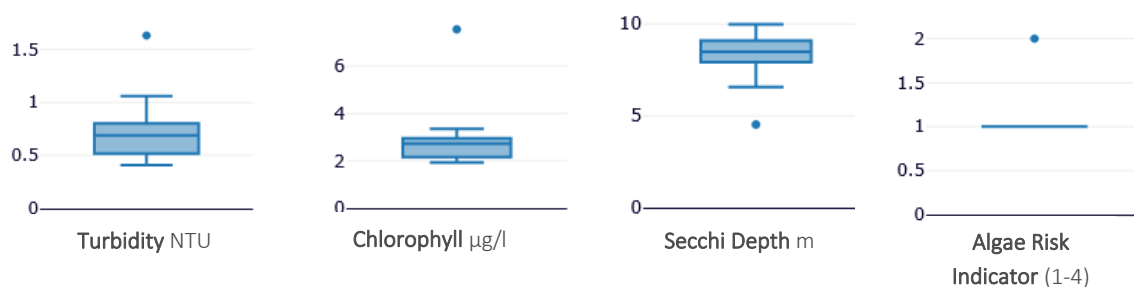
The following assessment includes box plot statistics for the three observed regions Baia de Luanda, Luanda Beach and Eastern Luanda – Rio Bengo (Figure 5). The analysis includes percentile and median analysis, accomplished for the four parameters Turbidity, Chlorophyll, Secchi Depth and Algae Risk Indicator. The analysed time frame covers November 2025 until September 2026.

Baia Luanda (Luanda Bay)



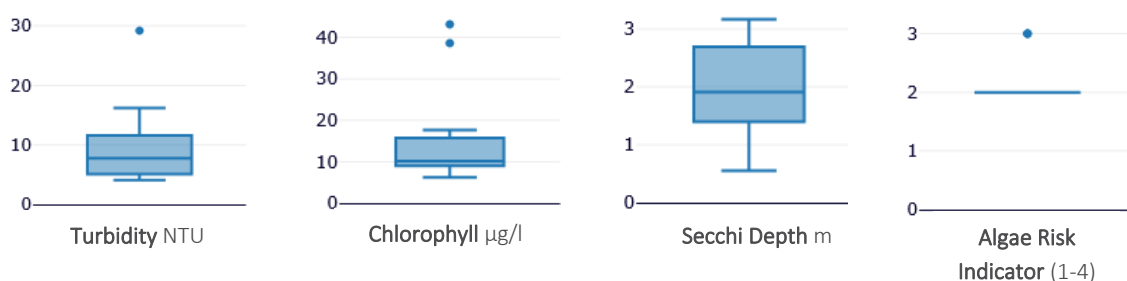
The boxplot diagrams for the Race Location in Luanda Bay show considerable fluctuation across all parameters, reflecting variable conditions within the bay. Turbidity levels are generally balanced, with the 50th percentile just above 1 NTU. Algae concentration ranges from 3.5 µg/l to over 6 µg/l, with an average of approximately 4 µg/l. Visibility, measured as Secchi depth ranges from 5 to 8 metres, with a median value of 6 metres. Based on the Algae Risk Indicator, Baía Luanda shows a low to medium algae risk, while the situation changes frequently between class 1 (low) and 2 (medium).

Luanda Beach



The boxplot diagrams for Luanda Beach generally show more favourable conditions compared to Luanda Bay. Values fluctuate less indicating more stable conditions. Turbidity and chlorophyll levels are roughly half as high as in Luanda Bay, and visibility averages around 9 metres, pointing to high water clarity. Most of the scenes show a low algae risk.

Eastern Luanda – Rio bengo



The boxplot diagrams for Eastern Luanda at the entry of the Bengo River, show significantly less favourable conditions compared to both other locations. This is clear when looking at the value scales of the diagrams reaching considerably higher or lower (visibility) values compared to both other locations. Value fluctuation is high in that area, indicating varying marine conditions. Turbidity values range from 5 NTU to 12 NTU, with 50% of scenes showing turbidity measurements of 7.5 NTU or less. Chlorophyll concentration ranges between 9 µg/l and 16 µg/l, with peaks reaching 40 µg/l for the entire region. On average, visibility in the Eastern Luanda Bay area is low, with a median value of less than 2 metres. This is caused by elevated turbidity values and algae concentrations. The algae risk in this area is mostly medium, with some dates reaching high algae risk conditions across the entire region. It needs to be stressed that the box plot diagram provides polygon statistics considering all pixel values within a region. Since the Eastern Luanda – Bengo River region covers a large area, higher/extremes values may occur locally for all parameters but are buffered in the overall polygon statistic of the box plot diagrams.

Time series analysis

The time series plots below present the temporal evolution of each parameter over the full monitoring period. Each plot shows the values of one parameter for each of the observed regions – Luanda Bay, Luanda Beach and Eastern Luanda – Bengo River. For each region, the median pixel value of all pixels within the respective polygon (Figure 5) was calculated. An overlap of data points indicates similar conditions across the respective monitoring location. A description of the plots is included within the caption of each figure.

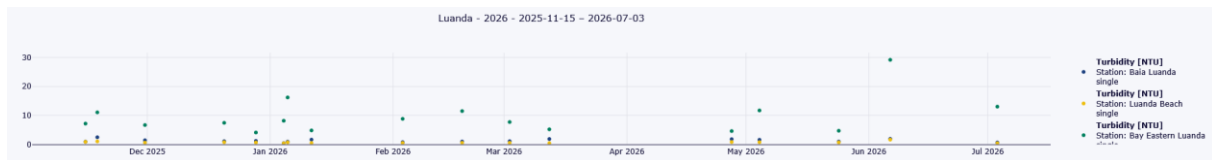


Figure 6: Time series plot for Turbidity aggregating the measurements for the three analysed locations (Luanda Bay - blue, Luanda Beach - yellow and Eastern Luanda – Rio Bengo - green). The Luanda Beach (yellow dots) exhibits lowest turbidity values, while the Eastern part shows significantly higher values (green dots).

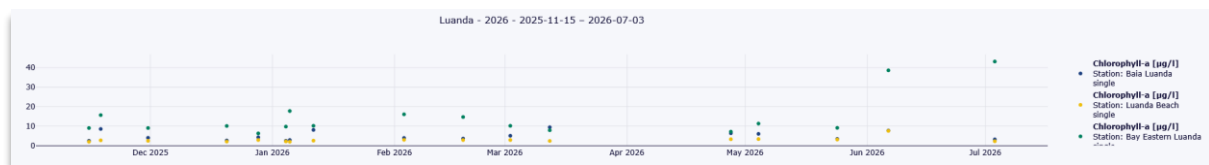


Figure 7: Time series plot for Chlorophyll aggregating the measurements for the three analysed locations (Luanda Bay, Luanda Beach and Eastern Luanda – Rio Bengo). The phytoplankton concentration levels for Luanda Bay and Luanda Beach settle between 2 µg/l and 4 µg/l, while the Eastern part shows higher average values of > 10 µg/l. In the June and July scenes, the values in the East climb up to 40 µg/l.

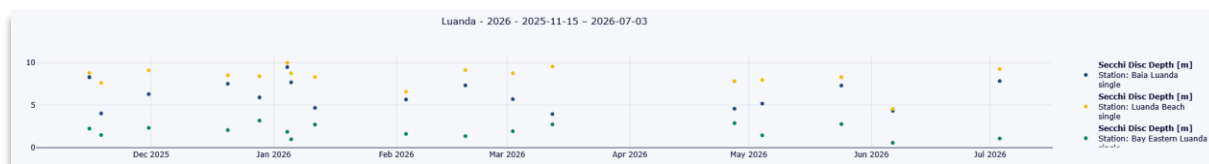


Figure 8: Time series plot for depth of visibility (Secchi-Depth) aggregating the measurements for the three analysed locations (Luanda Bay, Luanda Beach and Eastern Luanda – Rio Bengo). The highest visibility has Luanda Beach (yellow dots) with 6m visibility on average, followed by Luanda Bay (blue dots) with an average visibility of 9 m. The Eastern part of Luanda (green dots) exhibits reduced visibility with < 2m in average.

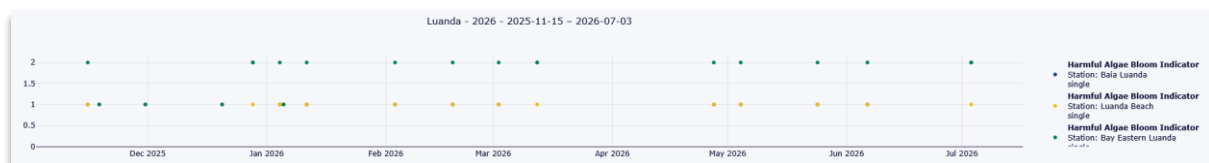


Figure 9: Time series plot for Harmful Algae Bloom Indicator aggregating the measurements for the three analysed locations (Luanda Bay, Luanda Beach and Eastern Luanda – Rio Bengo). The HAB value for Luanda Beach and Luanda Bay shows a mostly low probability of harmful algae occurrence – the yellow and blue dots of the regions mostly overlap. The eastern part shows medium to higher algae bloom probability, with some scenes locally showing a very high probability.

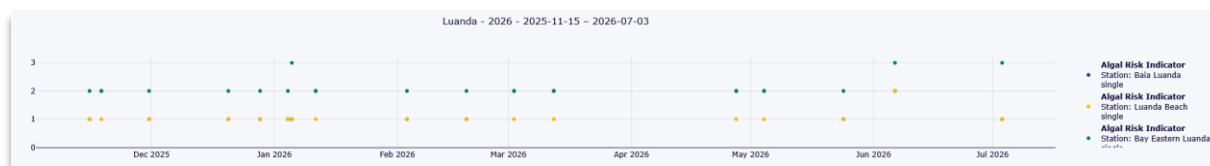


Figure 10: Time series plot for Algae Risk Indicator aggregating the measurements for the three analysed locations (Luanda Bay, Luanda Beach and Eastern Luanda – Rio Bengo). While Luanda Bay (blue dots) and Luanda Beach (yellow dots) exhibit a low to medium algae risk, the situation in the East (green dots) has a medium risk with several scenes reaching an elevated risk.

MAPS - Single scene example from 3rd July 2026 for all parameters

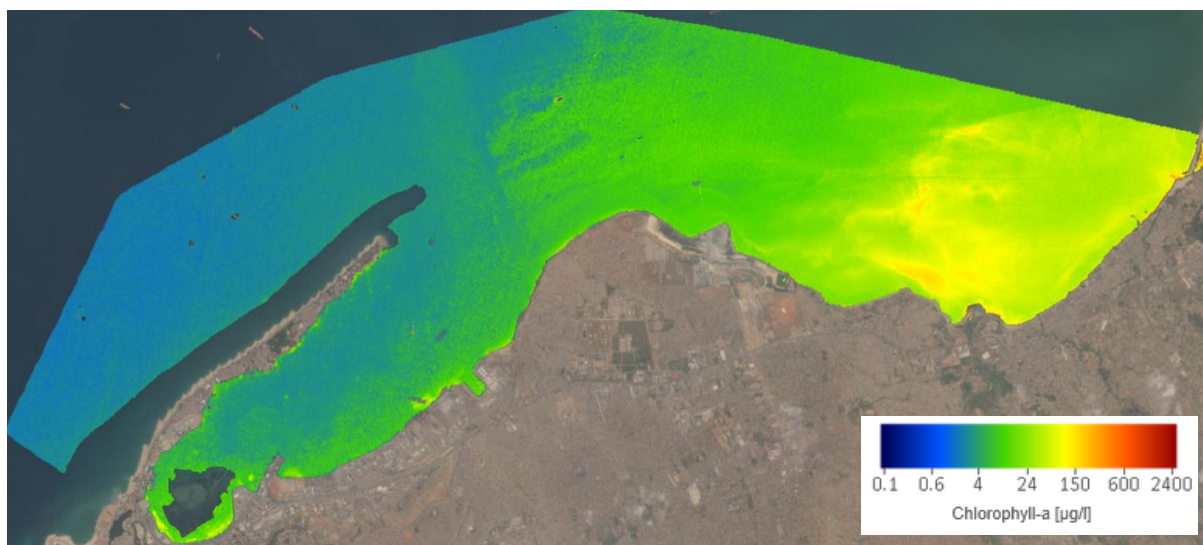


Figure 11: Chlorophyll map from 3rd July 2026 – the scene shows low to medium algae concentrations in the West and higher values in the Eastern part of Luanda.

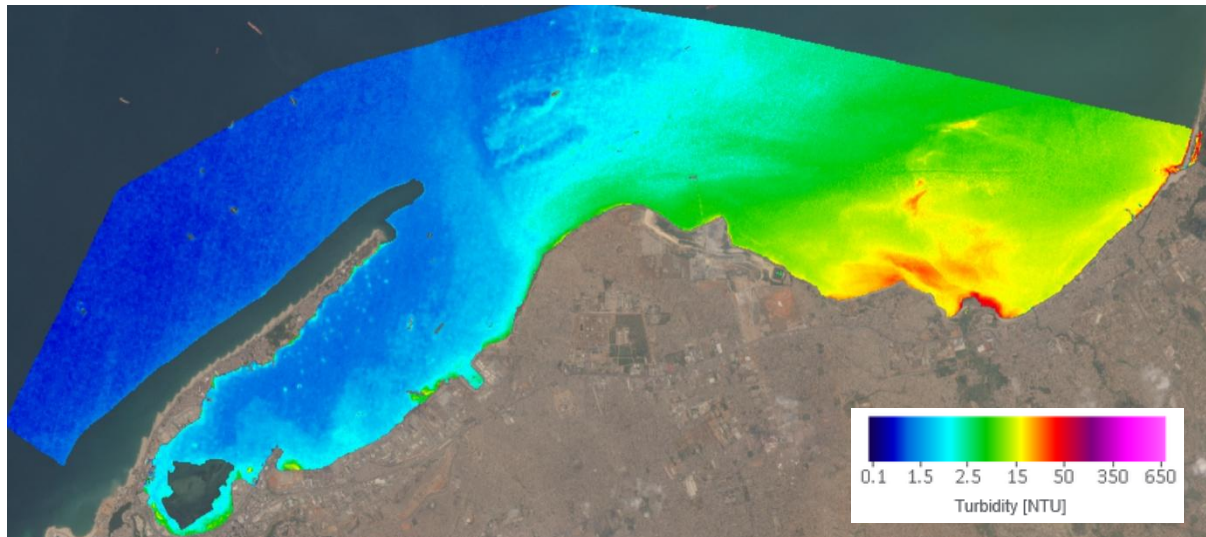


Figure 12: Turbidity map from 3rd July 2026 – the scene shows low to medium turbidity values in the West and higher values in the Eastern part of Luanda.



Figure 13: Secchi Depth map showing the visibility on 3rd July 2026 – the scene shows good visibility at Luanda Beach, medium visibility in the Luanda Bay and low visibility in the Eastern part of Luanda

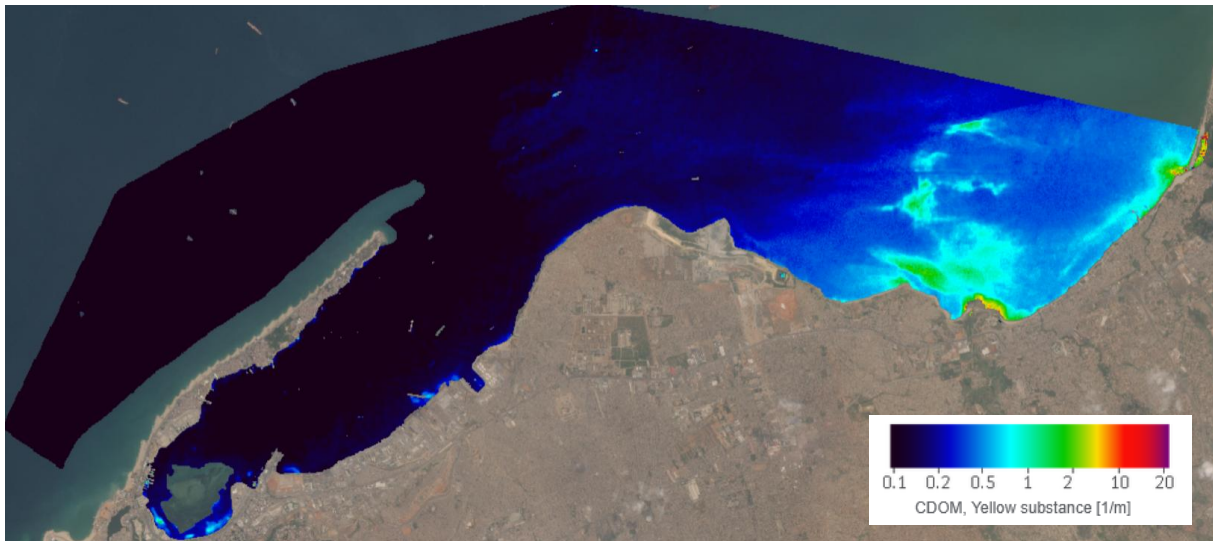


Figure 14: Coloured Dissolved Organic Matter (CDOM) map from 3rd July 2026 showing the presence of organic substances in the water. The scene shows very low presence of organic substances in the Western parts, while the Eastern part shows elevated values of CDOM. This means that the high turbidity values in the East are partly caused by organic substances.

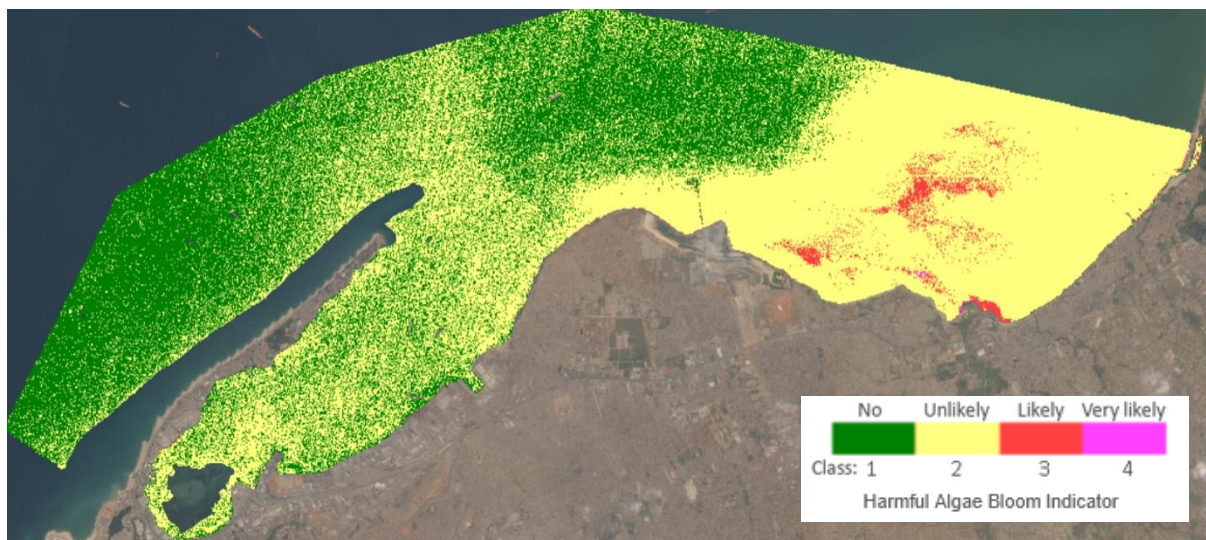


Figure 15: HAB map from 3rd July 2026. While the Western parts show a low risk of harmful algae bloom, the probability raises in the Eastern parts and exhibits a high likelihood of harmful algae.

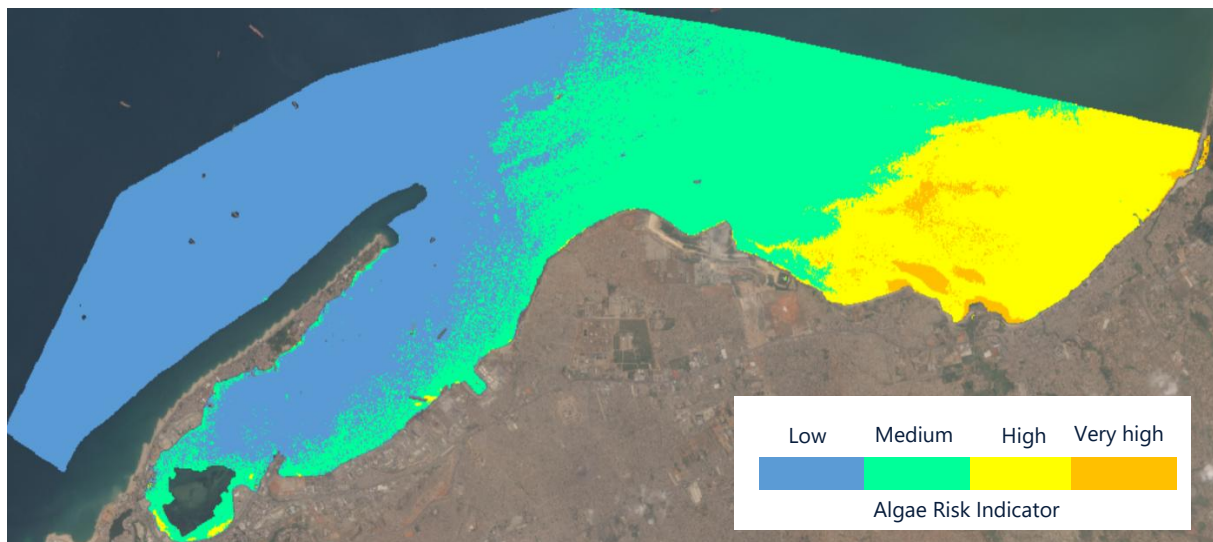


Figure 16: Algae Risk Indicator from 9th July 2026 shows a low algae risk in the West and high to very-high risk in the Eastern part of Luanda.

MAPS – TURBIDITY monthly

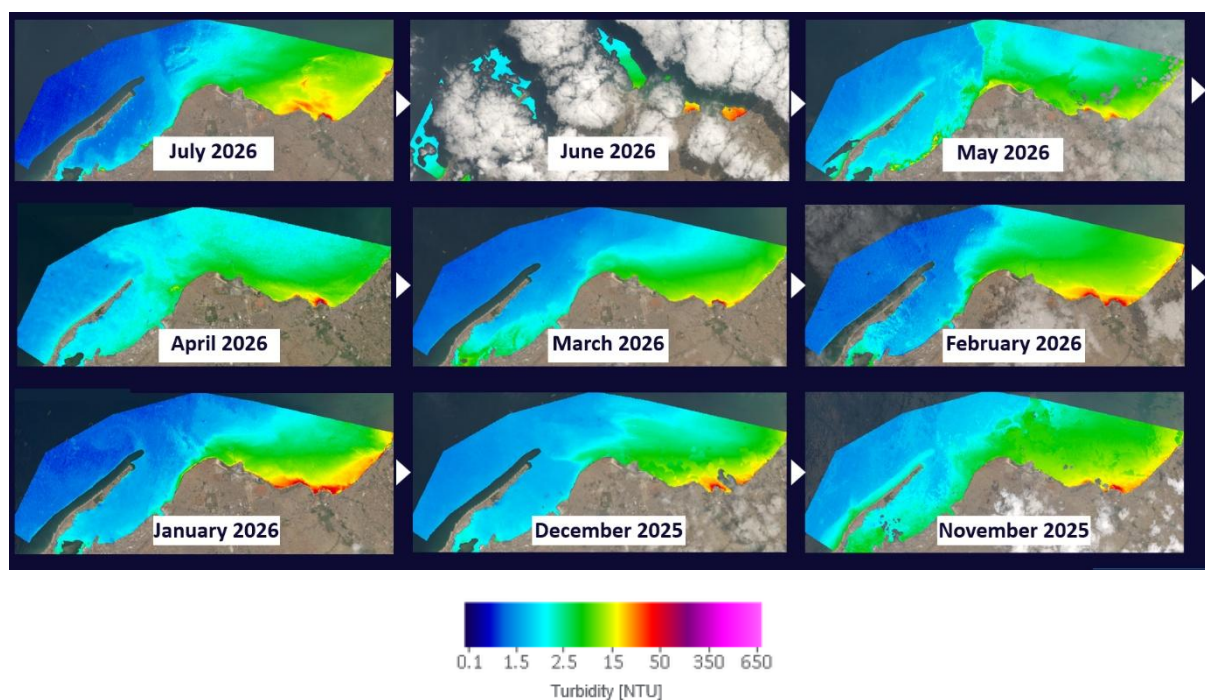


Figure 17: Monthly maps of turbidity

MAPS - Chlorophyll monthly

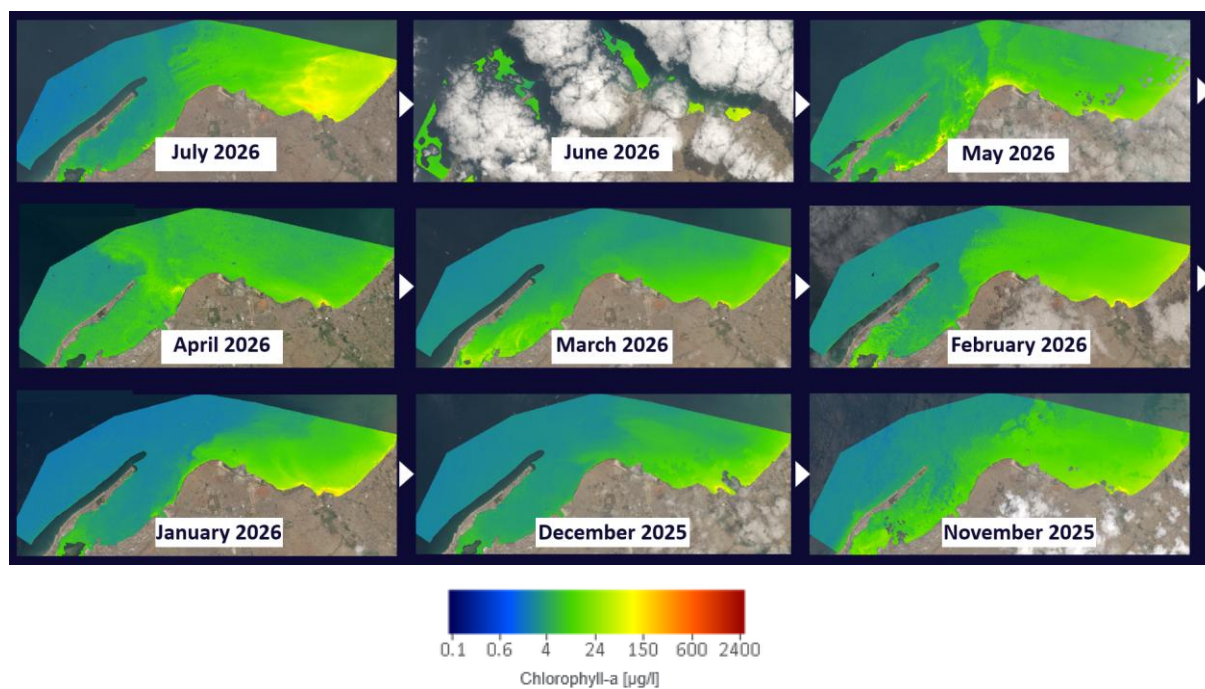


Figure 18: Monthly maps of algae concentrations

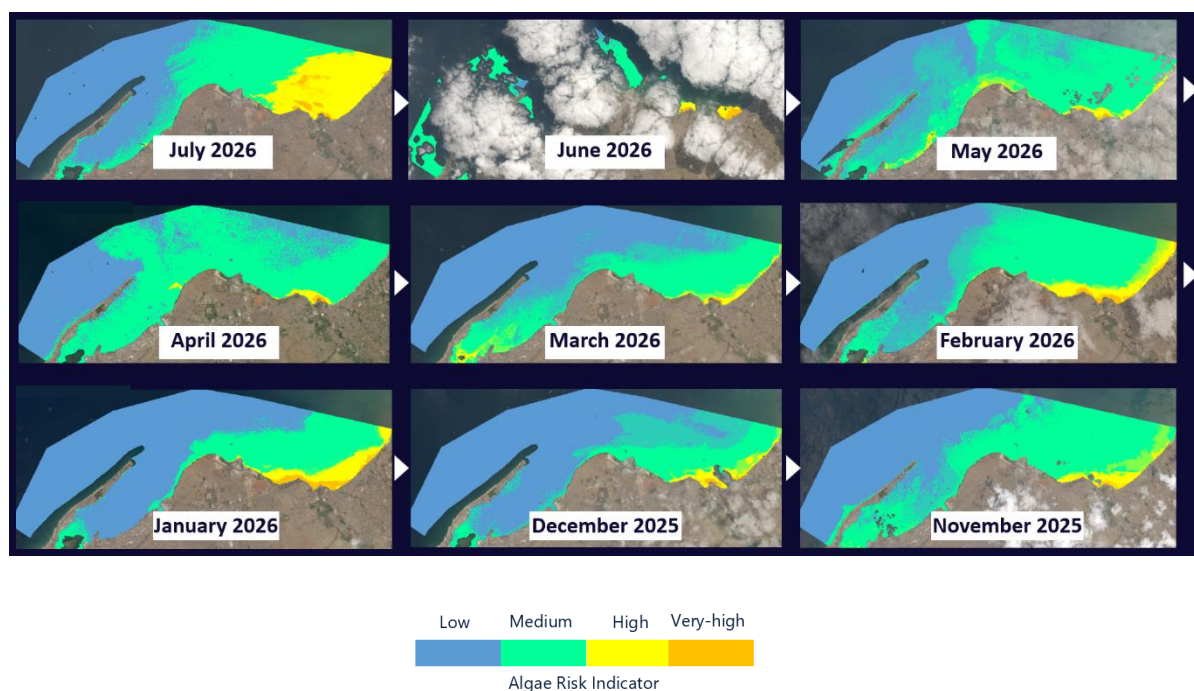


Figure 19: Monthly maps of algae risk

DISCUSSION

Chlorophyll

Chlorophyll content varies across the three analysed locations. The lowest values, on average around 2 $\mu\text{g/l}$, were observed at Luanda Beach, while higher values, averaging between 4 $\mu\text{g/l}$ and 6 $\mu\text{g/l}$, were noted in Luanda Bay. Significantly higher values above 10 $\mu\text{g/l}$ were found in the eastern part of Luanda. Conditions vary considerably throughout the year in Luanda Bay and Eastern Luanda, whereas Luanda Beach shows the most stable conditions. The high phytoplankton concentrations in the eastern part of Luanda may be caused by inflows from the Bengo River and other smaller torrents, which bring nutrients into the marine environment and cause algae growth.

This situation may be explained by inflows from the Bengo River and other smaller torrents,

Turbidity

Turbidity measurements follow a spatial and fluctuation pattern similar to chlorophyll. Values are lowest in the open ocean at Luanda Beach (< 1 NTU) and slightly higher in Luanda Bay (> 1 NTU), while the east shows significantly higher values, around 10 NTU. Individual spots in the east can spike up to 50 NTU, resulting in very turbid conditions. These elevated turbidity levels are found at the inflow rivers, which transport sediments, nutrients, and forms of pollution into the sea, contributing to algae growth and high turbidity values. This is clearly reflected by the monthly turbidity maps, which consistently show high turbidity values at the river mouths. The western areas show seasonal patterns, with January to March exhibiting lower values compared to other months.

Visibility

The visibility pattern is driven by turbidity and phytoplankton concentration, with clearer conditions requiring both low turbidity and low algae content.

Luanda Beach shows the best visibility, with an average Secchi depth of 9 m and little fluctuation. Luanda Bay has lower visibility at approximately 6 metres, while the East shows the lowest visibility with only 2 metres. This spatial pattern and its fluctuation are similar to those seen in the other parameters.

It should be noted that visibility shows a sharp divide around Ponta Lagostas: areas East of this line have on average significantly lower visibility than areas to the West. In the extreme East, visibility drops locally to 1 metre or lower in some scenes.

Harmful Algae Indicator (HAB)

The location differences noted in the parameters above are also reflected in the HAB indicator. Luanda Beach and Luanda Bay consistently show no or unlikely probability of harmful algal blooms, with the "unlikely" class being reached less often than the "no likelihood" class. The situation differs in the east, where the indicator shows, on average, an unlikely probability of harmful algal bloom occurrences across the entire large polygon. It is important to stress that for the identification of HABs the map representation better shows local algae aggregations, which often gets lost in polygon statistics for the monitored regions, where majority logic is applied. That said, some scenes, like the 3rd July 2026 or the January scenes show very high likelihood of harmful algae in some spots in the East.

In terms of seasonality, January, February and July show a high to very high probability of HABs, particularly along the coast where rivers flow into the ocean.

Algae Risk Indicator (ARI)

The Algae Risk Indicator considers the total amount of algae in the water, visibility, and HAB as input parameters. It classifies pixels into four classes: low, medium, high and very high. As an indicator, it points to the probability of encountering risky algae situations, rather than serving as measured proof of them. Luanda Beach consistently has a low algae risk, which raises slightly in Luanda Bay. The eastern bay, again, shows medium to high, locally also very high algae risk, especially during July and from November to February. The risk is most elevated along the coast, coinciding with the inflow of rivers into the ocean. Consequently, in the Eastern part of Luanda, it is not recommended to swim, while the Luanda Beach region shows favourable conditions for bathing.

RACE IMPLICATION - turbidity

Because no usable scenes were available for water quality monitoring across the original monitoring window from 27 July to 15 September, a turbidity comparison between before and after the race cannot be made. However, as explained in previous chapters, the Luanda monitoring focuses on observed long-term trends and associated monthly to seasonal patterns to describe the environmental health of the marine ecosystem.

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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

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