EO SUPPORT SHEET

SDG Indicator 14.1.1a

Index of coastal eutrophication

January 2025

Contributors:

- Paul DiGiacomo, NOAA, USA
- Adria Schwarber, NOAA, USA
- Merrie Beth Neely, GST, USA

Table of Contents

KEY CHANGES IN THE 2025 UPDATE **3**
1. DETAILS OF SDG INDICATOR 14.1.1a **4**
2. SATELLITE OBSERVATIONS **6**
a) Satellite data requirements 6
b) What data is currently available and relevant? 6
c) Where to access EO Data? 7
d) Current EO Gaps (limitations) 7
e) Moving forward: Future EO Missions 7
f) EO-based global products 8
g) Platforms and Tools 8
3. EO-BASED MONITORING METHODOLOGY **8**
4. RECOMMENDATIONS FOR IMPLEMENTATION **8**
a) Use Cases 8
5. TRAININGS **9**
6. REFERENCES **9**
About the SDG Indicator 9
Publications & policy papers 9

KEY CHANGES IN THE 2025 UPDATE

1. Clarified and simplified language on how the indicators are determined.
2. Clarified the language on how the indicator is useful to nations and agencies.
3. Added additional references that have been published since the last revision.

1. DETAILS OF SDG INDICATOR 14.1.1a

INDICATOR	14.1.1a Index of Coastal Eutrophication		
Target	By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution.		
Custodian Agency	United Nations Environment Programme (UNEP)	**TIER**	II
Objectives, approach and challenges	SDG Indicator 14.1.1a aims to measure the contribution to coastal eutrophication from countries and the state of coastal eutrophication. The methodology for SDG Target 14.1.1a Agenda 2030 is a country-led and country-owned process. The methodology encourages the use of globally available environmental data to enhance country-derived data, filling data gaps and enabling countries to more rapidly make progress towards achieving SDG targets. SDG 14.1.1a has a progressive monitoring approach which brings together globally modelled data and national data. This same approach has been adopted for other SDG indicator methodologies. This progressive monitoring approach means that countries can utilize both globally- and nationally- derived data to report on Indicator 14.1.1a. Where countries have the data and capacity to do so, they should aim to report on all aspects of Indicator 14.1.1a. While it is beneficial to capture data on all aspects of the indicator, it is recognised that not all countries may have all required data available to achieve this. Therefore, the progressive monitoring approach presented here encourages different levels of ambition, depending on a country's capacity. The progressive monitoring approach uses 3 Levels. Level 1 data utilizes data which is already globally available and for which UNEP will produce data products. This allows to establish a foundation which can be strengthened by countries as they develop capacity and ability to report on Level 2 data and Level 3 data. Level 2 data is recommended for national data collection in all countries. Level 3 data is a list of supplementary information which is suggested that countries consider monitoring. The Level 1 data utilizes global satellite data. Since this global data is derived from global algorithms, some countries may choose to provide their own data derived from regionally tuned algorithms as part of the Level 2 data.		
Baseline and Reporting	The methodologies for the two remotely-sensed surface chlorophyll a (Chl a) subindicators addressing SDG 14.1.1a are described in the first section of Part 2 in this UNEP published manual and metadata. In this application, satellite-derived Chl a is used as a proxy for estimating surface phytoplankton biomass within the Exclusive Economic Zone. Extracted Chl a biomass (i.e. phytoplankton biomass) is but one recognized indicator of a water body's trophic state, and is typically evaluated alongside field or laboratory analyzed measurements of: temperature, dissolved oxygen, water clarity, and dissolved/particulate nutrients. Of that list, only Chl a, temperature and water clarity can be reliably estimated through remote sensing and used to augment (or in the absence of) in situ monitoring. Yet satellite-derived data products are especially useful in areas where field sampling is not possible (conflict, poor weather conditions or general remoteness), not prioritized or enabled by local or national governments, or fill in temporal and spatial field sampling gaps. Satellite data		

	products also enable transboundary/regional monitoring and post-hoc assessment of nutrient runoff mitigation actions. The first sub-indicator enables national managers and regional seas organizations to assess coastal regions with deviations above baseline Chl a conditions for further investigation via targeted in situ sampling, and to monitor effectiveness of nutrient management policies. Satellite-derived Chl a concentrations are obtained from the global ocean, 4 km spatial resolution per pixel monthly mean product of the OC-CCI project version 6 for each pixel within a country's EEZ. The baseline data for Subindicator 1 is global monthly mean Chl a from the period 2000 to 2004 (the earliest continuous baseline possible from OC-CCI data streams). The second satellite-derived sub-indicator enables regional and country-level managers to evaluate intra-annual changes in Chl a concentration (or anomalies) of surface waters within the EEZ. Recall that Chl a variability in coastal seas include both natural and anthropogenic drivers. Thus, sub indicator 2 is a tool offering country-level or regional temporo-spatial analysis and quantifies the severity of potential coastal eutrophication events in surface waters.This second sub indicator uses the NOAA VIIRS Chl a ratio daily global anomaly product at 2 km spatial resolution, produced from the NOAA Multi-Sensor Level 1 to Level 2 (MSL12) processing of the VIIRS sensor on the Suomi SNPP and NOAA 20/21 satellites. The same time period is covered UNEP as the SDG custodian agency set the EEZ as their desired reporting limit. In cooperation with UNEP and a global panel of experts, the subindicator processing methodology and results reporting was developed and first made possible in 2020 with ESRI and NOAA cooperation. Country level reporting of SDG 14.1.1.a is possible using remotely-sensed Chl a data, but it does not distinguish natural versus manmade high Chl a biomass areas. Also there are bias concerns surrounding "Percentage of pixels in the EEZ"-based reporting for countries with high or low shoreline: EEZ ratios, or areas with complex EEZ boundaries. Thus UNEP and the Regional Seas organization have found the subindicators more useful as a regional monitoring tool and for countries to use in connection with their own in situ monitoring and model results for their national SDG progress reporting.
Limitations	These Chl a subindicator products are only tools to identify *potential* eutrophication areas, and should be used in conjunction with (not as a replacement for) a robust in situ field monitoring and modeling program. Natural reasons exist for elevated satellite-derived Chl a, unrelated to man-made causes, but can be confirmed in conjunction with field monitoring and through evaluation of other supporting data. Many countries lack the in-situ data needed to track eutrophication (nitrogen, phosphorous, Chl a, etc.). Global satellite products provide a course assessment but regionally tuned, higher resolution products are lacking in many regions for Level 2 data due to a lack of validation data and regional capacity.

2. SATELLITE OBSERVATIONS

a) Satellite data requirements

SDG Requirement	Spatial Resolution	Measurement Type	Observation Frequency	Sampling Type	Comments	Mission Classes
SDG 14.1.1a	4km	Satellite	Monthly	Ocean color radiometry	ESA Ocean Colour CCI (OC-CCI) project global merged chlorophyll a product from SeaWiFS, MODIS, MERIS and VIIRS, spanning the years 1997 to 2025 version 6	Environmental Sustainability
SDG 14.1.1a	2km	Satellite	Daily	Ocean color radiometry	NOAA VIIRS daily global chlorophyll a ratio anomaly product from the NOAA Multi-Sensor Level 1 to Level 2 (MSL12) processing of the VIIRS sensor on the Suomi SNPP and NOAA 20/21 satellites, spanning the years 1997 - 2025	Environmental Sustainability

b) What data is currently available and relevant?

There is a range of satellite data sources which could be used within the SDG 14.1.1 indicator monitoring and reporting.

Level 1 Data:

The Chlorophyll a Deviation Modeling Tool (Subindicator 1)

The ESA Ocean Colour CCI (OC-CCI) project, led by Plymouth Marine Laboratory (PML), has produced a consistent, merged Chl a product from SeaWiFS, MODIS, MERIS and VIIRS, spanning the years 1997 to 2025 (Sathyendranath et al., 2018). The merged multi-sensor product will be updated in both time and with data from additional sensors (e.g., OLCI) as part of the Copernicus Climate Change Service (C3S) and the Copernicus Marine Service (CMEMS) that will continue the time series on an operational basis. Future OC-CCI releases will also include algorithmic improvements developed under the CCI+ initiative.

Chl a concentrations for this indicator are obtained from the global ocean, 4 km spatial resolution per pixel monthly mean product of the OC-CCI project product for each pixel within a country's EEZ. For purposes of this sub-indicator, reporting year values are compared to a baseline of years 2000 to 2004. The baseline climatology was calculated as the mean of the 5 years of each month by pixel (e.g., mean of 5 years of January) resulting in a 5 year mean of each calendar month over the period 2000 to 2004.

The Intra-annual EEZ Chlorophyll a Anomalies Tool (Subindicator 2)

The Intra-annual EEZ Chl a anomalies tool was developed to evaluate the intra-annual changes in Chl a concentration anomalies in each Exclusive Economic Zone (EEZ). It utilizes the NOAA VIIRS Chl a ratio anomaly product produced daily for the globe at 2 km spatial resolution. The daily global VIIRS Chl a concentrations are produced from the NOAA Multi-Sensor Level 1 to Level 2 (MSL12) processing of the VIIRS sensor on the Suomi SNPP and NOAA 20/21 satellites. (Wang et al., 2017; Wang et al., 2014) This anomaly product is defined as the daily Chl a concentration after subtracting the rolling 61-day mean baseline with a 15 day lag (based on Stumpf et al., 2003), then normalized to the rolling 61 day mean to create the proportional difference anomaly.

Level 2 Data:

To date, two regions, the Northwest Pacific Region (NOWPAP) and Europe, have produced methodologies for using regionally tuned satellite data for the Level 2 data.

NOWPAP Level 2: Potential eutrophic zones (Chlorophyll a concentration)

This sub-indicator is based on eutrophication based on regionally defined values of Chl a limits and interannual trend. The indicator data will be derived using regionally tuned algorithms for satellite-derived Chl a. For additional information, see de Raús Maúre et al., 2021.

European Level 2

In this method, maps of potential eutrophication and potential oligotrophication areas are produced using CMEMS Ocean Colour regional products. The analysis is based on Padro et al., 2021. The full methodology (Brando et al., 2022) was published in the Journal of Operational Oceanography.

c) Where to access EO Data?

Missions	Main source	Website
CORE MISSIONS		
OC-CCI	Plymouth Marine Lab	https://www.oceancolour.org/portal/
VIIRS	NOAA	https://www.ospo.noaa.gov/products/ocean/color/viirs/snpp/conus_chla_anomaly.html#swap-select

d) Current EO Gaps (limitations)

Many countries lack the in-situ data needed to track eutrophication (nitrogen, phosphorus, chlorophyll, etc.). Application of models is lacking at the country-level, using both satellite data or in situ data. Global satellite products provide a coarse assessment but regionally tuned, higher resolution products are lacking in many regions for Level 2 data due to a lack of validation data and regional capacity.

e) Moving forward: Future EO Missions

Data from current and future ocean color instruments (Sentinel-3 A/B/C/D OLCI, GLIMR HSI, and OceanSat 3a OCM sensors and Hyperspectral sensors, such as onboard the recently launched Plankton - Aerosol - Cloud - ocean Ecosystem (PACE) mission, may refine the resolution and identify phytoplankton functional types responsible for Chl a signatures in satellite data products. This may assist determination of natural vs man-made drivers are responsible for the increased Chl a. Certainly the application of high-resolution ocean data products within 1km of shorelines and incorporating commercial data will improve applicability nearshore and enhance confidence in the subindicator tools. As more regionally-tuned use cases are made available this too should increase the country-level uptake of the product for monitoring eutrophication potential within national EEZs.

f) EO-based global products

Product name	Satellite data used	Method	Website	Comment
Built-up datasets				
SDG 14.1.1a Indicator Maps EEZ	ESA OC-CCI, NOAA VIIRS	As described in this manual	https://chlorophyll-esrioceans.hub.arcgis.com/pages/datasets	ESRI is the website maintainer

g) Platforms and Tools

The primary CEOS satellite data that applies to SDG 14.1.1, plus all relevant partners using or testing the products are linked below.

Primary Tools and Data Services:

- EsriOceans Chlorophyll Hub
- ESA Ocean Color CCI
- NOAA CoastWatch VIIRS single-sensor S-NPP and NOAA-20 Anomaly products
- NOAA's Ocean Color Viewer
- NOWPAP Environmental Watch
- NOWPAP Google Earth Engine Viewer
- Marine Regions
- NASA Ocean Biology Processing Group

3. EO-BASED MONITORING METHODOLOGY

Timeframes (Indicator VS EO considerations):

- Indicator: according to the latest metadata, it is anticipated that countries can report consistently in 5-year intervals, allowing for three reporting points until the year 2030.
- EO timeframe considerations: Technology is mature and EO services already established and in use.

4. RECOMMENDATIONS FOR IMPLEMENTATION

This product was co-developed for UNEP, as the SDG custodian agency for 14.1.1a, in conjunction with ESRI, GEO BluePlanet, NOAA CoastWatch, and Plymouth Marine Laboratory.

a) Use Cases

Any individual or regional user interested in the short or longer term eutrophication status of their EEZ would be suitable Use Cases. Users could be national agency-level staff required to annual report on SDG 14.1.1.a and have no in-situ data, or who wish to include EO data in their local or national eutrophication monitoring and event response strategy. Researchers or individuals also interested in regional or global eutrophication trends will find these products useful.

5. TRAININGS

There is no institutional or online training program associated with this indicator.

6. REFERENCES

About the SDG Indicator

- Indicator 14.1.1a Metadata (March 2021): https://unstats.un.org/sdgs/metadata/files/Metadata-14-01-01.pdf

Publications & policy papers

Brando, V.E., S. Pardo, S. Sathyendranath, B. Howey, P. Land, T. Jackson, R. Santoleri, M. Sammartino, S. Colella, K. von Schuckmann, D.Ghafari, E. Smail, K.VanGraafeiland, S. Ramachandran, V.P. Lance, and M. Wang. 2022. Potential eutrophication of European waters using satellite derived chlorophyll following the UN Sustainable Development Goal 14 framework. *J. Oper. Oceanogr. 15* (Suppl. S1), s83–s91.

Elígio de Raús Maúre, Genki Terauchi, Joji Ishizaka, Nicholas Clinton & Michael DeWitt. 2021. Globally consistent assessment of coastal eutrophication. Nature Communications, 12, Article number: 6142. https://doi.org/10.1038/s41467-021-26391-9.

Pardo, S. Sathyendranath, S., Platt, T. 2021. 2.4 Eutrophic and oligotrophic indicators for the North Atlantic Ocean. Journal of Operational Oceanography, 14, No. S1,1, 1-185. https://doi.org/10.1080/1755876X.2021.194624.

United Nations Environment Programme (2021). Understanding the State of the Ocean:

A Global Manual on Measuring SDG 14.1.1, SDG 14.2.1 and SDG 14.5.1. Nairobi.

Wang, M., X. Liu, L. Jiang and S. Son. 2017. The VIIRS Ocean Color Product Algorithm Theoretical Basis Document, National Oceanic and Atmospheric Administration, National Environmental Satellite and Data Information Service, 68 pp.

Wang, M., X. Liu, L. Jiang, S. Son, J. Sun, W. Shi, L. Tan, P. Naik, K. Mikelsons, X. Wang and V. Lance. 2014. Evaluation of VIIRS Ocean Color Products, Proc. SPIE 9261, 92610E. https://10.1117/12.2069251.