UNITED NATIONS

UNEP

EP

UNEP/MED WG.556/Inf.4/Rev 1

United Nations Environment Programme Mediterranean Action Plan

Distr.: General
17 February 2023

English only

Meeting of the Ecosystem Approach Correspondence Group on Pollution Monitoring

Athens, Greece, 1-2 March 2023

Agenda item 3: 2023 Mediterranean Quality Status Report (QSR) - Pollution Ecological Objectives (EO5, EO9)

The Marine Environment Assessment in the Areas with Insufficient Data: The Assessment Results of IMAP Common Indicators 13&14 in the Aegean - Levantine Sea Sub-region by Applying the Simplified G/M Assessment Methodology

UNEP/MAP
Athens, 2023

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List of Abbreviations / Acronyms

AEL	Aegean-Levantine Sea
AZ	Assesment Zones
CEN	Central Mediterranean Sea
Chl *a*	Chlorophyll *a*
CI	Common Indicator
COP	Conference of the Parties
CORMON	Correspondence Group on Monitoring
CPs	Contracting Parties
DIN	Dissolved Inorganic Nitrogen
EIONET	European Environment Information and Observation Network
EO	Ecological Objective
ESRI	Environmental Systems Research Institute
EU	European Union
GES	Good Environmental Status
nonGES	not Good Environmental Status
IMAP	Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria
MAP	Mediterranean Action Plan
MED POL	Programme for the Assessment and Control of Marine Pollution in the Mediterranean Sea
MED QSR	Mediterranean Quality Status Report
MSFD	Marine Strategy Framework Directive
MSs	Member States
NEAT	Nested Environmental Assessment Tool
SAU	Spatial Assessment Unit
TP	Total Phosphorous
WMS	Western Mediterranean Sea

1. Introduction

1. To implement the recommendations of the Meeting of CorMon on Pollution Monitoring (Teleconference, 26-27 April 2021) and the Meeting of the MEDPOL Focal Points (Resumed Session, 9 July 2021), the methodologies proposed for assessment of eutrophication were tested in the Adriatic Sea Sub-region. Along with the application of the NEAT assessment methodology in the Adriatic Sea Sub-region, and further to data availability, the application of the Ecological quality ratio (EQR); the Simplified EQR methodology, and the Simplified methodology based on G/M comparison was also explored in other three Mediterranean Sub-regions.

2. The application of the EQR methodology was found relevant for assessment of IMAP Common Indicators 13 and 14 where full set assessment criteria for Chl*a*, DIN and TP exist. It is also necessary to perform the typology related assessment. Given the lack of data reported by the CPs, this methodology was impossible to apply for any sub-region/sub-division of the Mediterranean within the preparation of the 2023 MED QSR.

3. The application of the simplified EQR methodology was found relevant where complementary data availability i.e. *in situ* and from remote sensing is found for Chla only and the typology related assessment is not possible to apply. Due to absence of the homogenous quality assured data reported by the CPs even for Chla only, an application of the simplified EQR method was also impossible for any sub-region/sub-division of the Mediterranean within the preparation of the 2023 MED QSR.

4. Given the lack of quality-assured, homogenous data prevented the application of both EQR and simplified EQR assessment methodologies, the assessment of eutrophication within the preparation of the 2023 MED QSR was undertaken in the sub-divisions of the Aegean-Levantine Sea (AEL), the Central Mediterranean Sea (CEN) and the Western Mediterranean Sea (WMS) by evaluating only data for Chla available from the remote sensing sources, whereby the typology-related assessment was impossible to apply.

5. The application of the Simplified methodology based on G/M comparison in the AEL Sub-region relied on the use of COPERNICUS data for Chl*a* obtained by remote sensing.

2. Data availability and elaboration

6. A detailed data analysis was performed in order to decide on applying the assessment methodologies that can be found optimal for specific sub-region/sub-division in the present circumstances related to the lack of data reporting. Table 1 informs on data availability in the AEL by considering data reported by the Contracting Parties by 31st October, the cut-off date for data reporting. Figure 1 shows the locations of sampling stations in the AEL Sub-region.

Table 1. Data availability by country and year for the Aegean Levantine Sea (AEL) Sub-region showing data reported by the CPs for the assessment of EO5 (CI13 and CI14) up to 31st Oct 2022.

Country	Year	Amon	Ntri	Ntra	Phos	Tphs	Slca	Cphl	Temp	Psal	Doxy
Cyprus	2016	182	172	197	89	-	17	180	205	203	186
	2017	38	15	48	14	-	28	141	150	150	131
	2018	39	27	41	41	-	36	56	93	91	109
	2019	45	22	49	49	-	49	37	38	38	62
	2020	84	67	82	82	-	39	86	72	71	72
	2021	-	-	-	-	-	-	136	112	112	107
Greece	2016-2021	No data provided									
Egypt	2016-2021	No data provided									
Israel	2017	15	15	15	15	-	15	15	15	15	15
	2018	14	14	14	14	-	14	14	13	13	13
	2019	14	14	14	14	-	14	14	14	14	14
	2020	14	14	14	14	-	14	14	14	14	14
Lebanon	2017	-	225	225	225	-	-	195	224	224	-
	2018	-	286	286	286	-	-	247	285	285	-
	2019	-	547	547	547	-	40	386	538	538	-
	2020	-	268	268	268	-	-	160	268	268	-

Country	Year	Amon	Ntri	Ntra	Phos	Tphs	Slca	Cphl	Temp	Psal	Doxy
	2021	-	291	291	291	-	-	154	291	291	-
Syria	2016-2021	No data provided									
Türkiye	2016	342	209	341	342	341	342	209	342	342	307
	2019	1460	1055	1479	1138	1545	972	1052	994	17713	1558

Amon - Ammonium; Ntri- Nitrite; Ntra – Nitrate; Phos – Orthophosphate; Tphs—Total phosphorous; Slca – Orthosilicate; Cphl – Chlorophyll *a*; Temp – Temperature; Psal – Salinity; Doxy – Dissolved Oxygen.

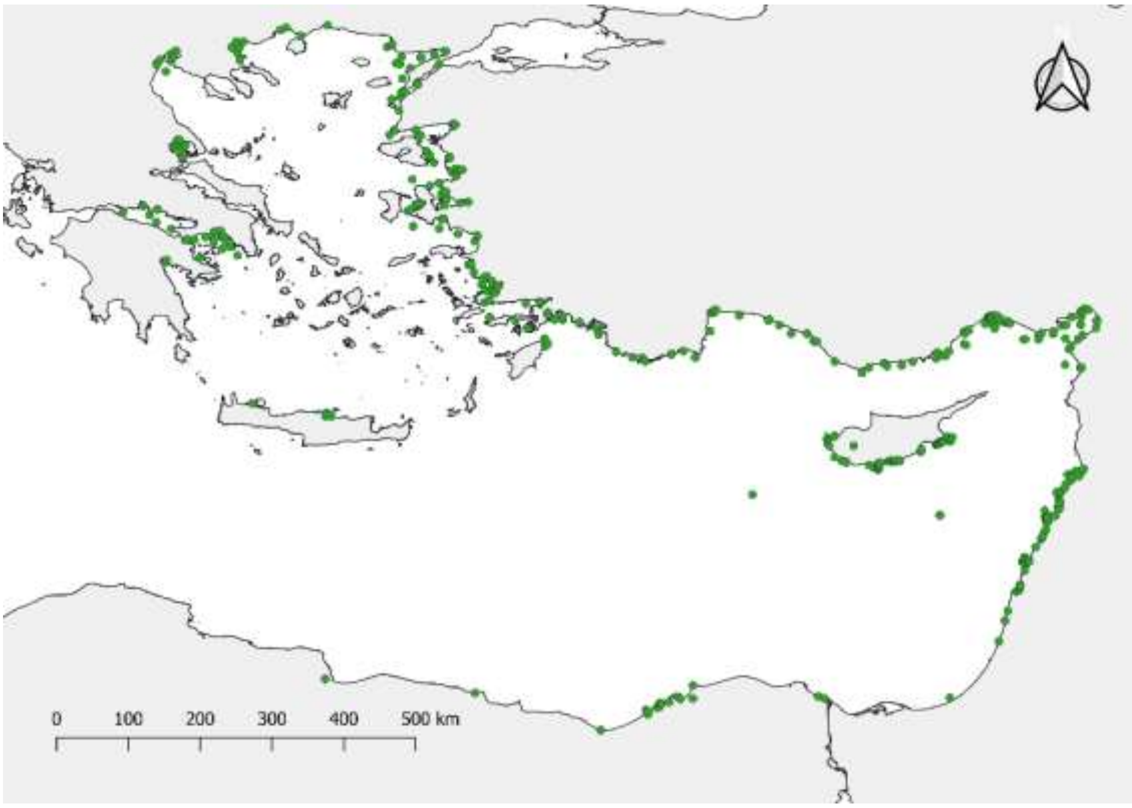

Figure 1. The locations of sampling stations in the AEL Sub-region

7. From Table 1 it can be found that the CPs in the southern Mediterranean rim did not report valid data as required by Decision IG.23/6 of COP 20 related to the 2017 Mediterranean Quality Status Report (MED QSR), and Decision IG.24/4 of COP21 providing the 2023 MED QSR Roadmap implementation.

8. Cyprus provided data for the period 2016-2021 and data for a variable number of stations were provided for different years. From the first screening only data for 10 to 15 stations can be used. Frequency ranged from 2 to 6 times per year and most of the IMAP mandatory parameters were measured. An additional quality check of data is needed in order to understand if a reliable assessment can be performed.

9. Israel provided data only for one sampling per year (summer) for the period 2017-2020. It is not in line with the IMAP requirement, which for example in the best case of oligotrophic waters requires bimonthly frequency in the Coastal Waters (CW) and seasonal frequency in the Offshore Waters (OW).

10. Lebanon provided data for the period 2017-2021, but only data for 2019 are compatible with the IMAP requirements. Other reported data are related to monitoring of beaches, therefore, where local processes (waves, resuspension, etc.,) substantially influence the measurements. For that reason, data cannot be used for IMAP EO 5 assessment.

11. Turkey provided only data for 2019 which need additional quality check given several stations are located in transitional waters which are heavily impacted from land and subject to great variability.

Although data for 2016 should not be considered for the preparation of the 2023 MED QSR, they were analysed given the present scarcity of data reported. However, these data were generated in the course of only one cruise, and therefore they cannot be used for the present IMAP EO 5 assessment.

12. Some of data were reported to IMAP IS very close to the 31st October, the cut-off date for data reporting, and without having a functional data quality control at the level of IMAP IS, at this late stage it was impossible to undertake data quality control and evaluation including through direct consultations with the CPs.

13. Given the above explained status of data reported, in particular lack of homogenous and quality assured data reported in line with IMAP requirements, it was necessary to explore the use of alternative data sources. The COPERNICUS source was found relevant regarding the existence of a systematic repository of remote sensing data for Chl *a*. Using only Chl *a* data, with a good geographical coverage (1 x 1 km) and high sensing frequency (daily), it is possible to tentatively develop a simple assessment method, by applying ecological rules and a comparison of the obtained values to the defined G/M threshold. Due to a huge amount of data for the whole AEL which was impossible to process with an ordinary PC, at the stage of closing preparation of the 2023 MED QSR IMAP Pollution Chapters it was possible to perform only the assessment for the Levantine Sea, one of the two subdivisions of AEL.

14. Chlorophyll *a* data for the Levantine Sea Sub-division were downloaded from the Copernicus site (**https://data.marine.copernicus.eu/product/OCEANCOLOUR_MED_BGC_L4_NRT_009_142/description**).

15. For the Copernicus services the Mediterranean Sea Ocean Satellite Observations, the Italian National Research Council (CNR – Rome, Italy), elaborated the Bio-Geo_Chemical (BGC) regional datasets. Chlorophyll *a* concentration (CHL) were evaluated via region-specific algorithms (Case 1 waters: Volpe et al., 2019[1], with new coefficients; Case 2 waters, Berthon and Zibordi, 2004[2]), and the interpolated gap-free Chl concentration (to provide a "“cloud free”" product) was estimated by means of a modified version of the DINEOF algorithm (Volpe et al., 2018[3]).

16. For the Levantine Sea the Copernicus product with ID: OCEANCOLOUR_MED_BGC_MY_009_78 was downloaded for the period from Apr 2016 to Mar 2021. It consists of Level 4 monthly values of Chlorophyll a concentration (CHL) with a resolution of 1 x 1 km. The file format is NetCDF-4 (.nc).

17. For the Aegean Sea the Copernicus product with ID: OCEANCOLOUR_MED_BGC_MY_009_144 was downloaded for the period from Jan 2016 to Dec 2020. It consists of Level 4 monthly values of Chlorophyll a concentration (CHL) with a resolution of 1 x 1 km. The file format is NetCDF-4 (.nc).

18. Data elaboration was performed by using R, an open-source language widely used for statistical analysis and graphical presentation (R Development Core Team, 2022)[4]. Maps are elaborated using QGIS 3.28, an open-source GIS tool. For the elaboration all relevant R Scripts are given in Annex I.

[1] Volpe, G., Colella, S., Brando, V. E., Forneris, V., Padula, F. L., Cicco, A. D., ... & Santoleri, R. (2019). Mediterranean ocean colour Level 3 operational multi-sensor processing. Ocean Science, 15(1), 127-146

[2] Berthon, J.-F., Zibordi, G. (2004) Bio-optical relationships for the northern Adriatic Sea. Int. J. Remote Sens., 25, 1527-1532.

[3] Volpe, G., Buongiorno Nardelli, B., Colella, S., Pisano, A. and Santoleri, R. (2018). An Operational Interpolated Ocean Colour Product in the Mediterranean Sea, in New Frontiers in Operational Oceanography, edited by E. P. Chassignet, A. Pascual, J. Tintorè, and J. Verron, pp. 227–244

[4] R Development Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0. http://www.R-project.org

19. After download from the Copernicus site, as NetCDF file- .nc, the data were transferred to R data table using the *tidync* package. The transfer and data elaboration were very time demanding as the data set comprise more than **22 million records** for the Levantine Sea Subdivision and around **20 million records** for the Aegean Sea Subdivision.

20. For every point of the grid (Figure 2), a GM annual value was calculated, as required in the COMMISSION DECISION (EU) 2018/229[5]. The parameter values were expressed in µg/l of Chlorophyll *a*, for the geometric mean (GM) calculated over the year in at least a five-year period. These GM annual values were later used as a metric for the development of the assessment criteria and present assessment of CI 14.

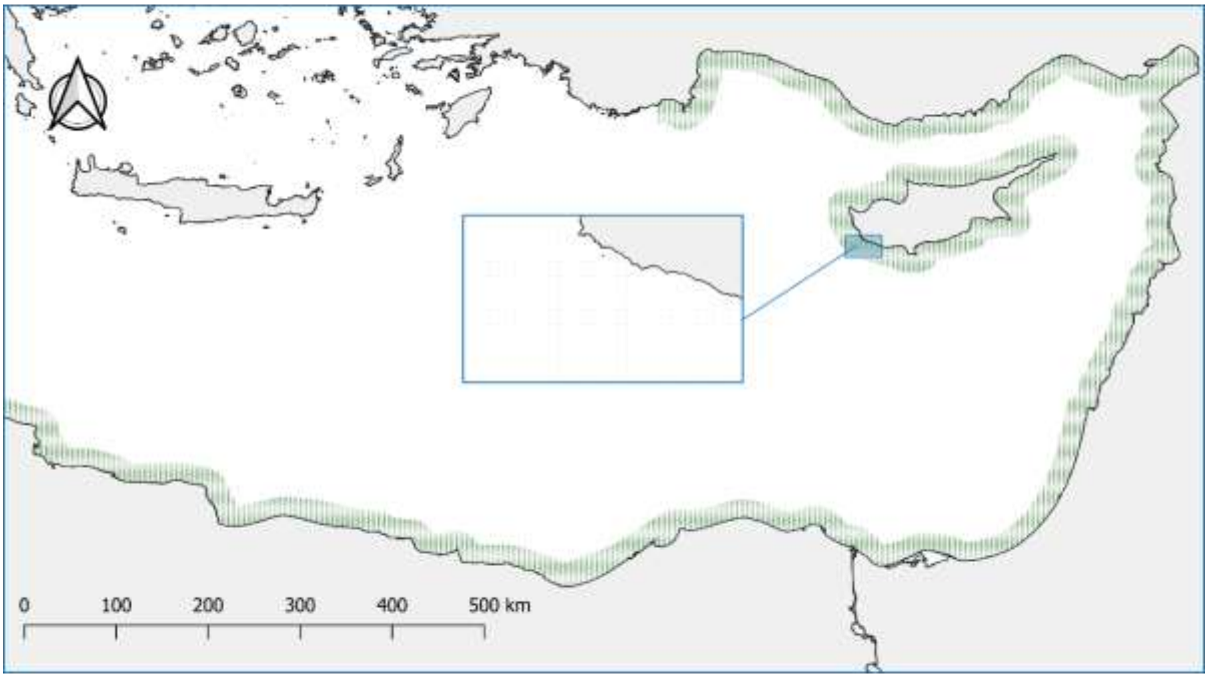

Figure 2. The Levantine Sea Sub-region: The dots in the assessment zones represent the data in the grid (1 x 1 km). In the small rectangle a detailed view of the sensing grid is presented.

[5] Commission Decision (EU) 2018/229 of 12 February 2018 establishing, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, the values of the Member State monitoring system classifications as a result of the intercalibration

Figure 3. The Aegean Sea Sub-division: The dots in the assessment zones represent the data in the grid (1 x 1 km. The blue lines demark the three spatial assessment units set within the Aegean Sea Sub-division for the purpose of data grouping for the present assessment.

3. Setting of the areas of assessment

21. Following the rationale of the IMAP national monitoring programmes related to distribution of the monitoring stations, as well as the rules for integration and aggregation of the assessment products (UNEP/MAP – MED POL 2021), in the Levantine Sea Sub-divisions for the purposes of the present work the two zones of assessment were defined, i.e.,: i) the coastal zone and ii) the offshore zone; and given the lack of information on water typologies present in national waters, for the present assessment in the Aegean Sea Sub-division only the coastal zone was assessed.

22.

23. For purpose the of present work, it should also be recalled that GIS layers collected from different sources (International Hydrographic Organization – IHO Seas subdivisions, European Environment Information and Observation Network – EIONET (WFD delimitation (2018)); VLIZ marine subregions.

24. The principle of the NEAT IMAP assessment methodology applied in the Adriatic Sea Sub-region, as well as in the Western Mediterranean Sea Sub-region regarding CI 17, for setting the spatial

assessment units (SAUs) within the two main assessment zones along the IMAP nesting scheme, was also followed for setting of the coastal (CW) and the offshore monitoring zones (OW) in the Levantine Sea Sub-division. The CW included internal waters and one Nautical Mile outward. The offshore waters in the LEV start at the outward border of CW and extend to 20 km outward given this coverage corresponds to the area where national monitoring programmes are performed as shown in Figure 1.

Levantine Sea

25. The AZ were divided between the five areas Northern, Eastern, Cyprus Island and the two Southern (West and East), which delimitations are shown on Figure 3 (upper map). It resulted in eight SAUs (i.e., CWNO – Northern CW; OWNO – Northern OW; CWEA – Eastern CW; OWEA – Eastern OW; Cyprus Island CW – CWCI; Cyprus Island OW – OWCI; Southern East CW – CWSE; Southern East OW – OWSE; Southern West CW – CWSW; and Southern West OW – OWSW). The finest IMAP subSAUs were further set on the base of nested assessment areas (AZs, five areas) by considering the national areas of monitoring and hydrographic characteristics.

26. The finest IMAP subSAUs set in the Levantine Sea Sub-division for the purpose of the present CI 14 assessment are shown in Table 2. Figure 3 depicts the finest IMAP SAUs nesting in the two main assessment zones i.e. CW and OW of the Levantine Sea Sub-division.

Table 2. The finest IMAP spatial assessment units (SAUs)

AZ	SAU	subSAUs
CW	CI	CWCICYP
CW	EA	CWEAISR
CW	EA	CWEALBN
CW	EA	CWEAPSE
CW	EA	CWEASYR
CW	NO	CWNOTUR
CW	SE	CWSEEGY
CW	SW	CWSWEGY
CW	SW	CWSWLBY
OW	CI	OWCICYP
OW	EA	OWEAISR
OW	EA	OWEALBN
OW	EA	OWEAPSE
OW	EA	OWEASYR
OW	NO	OWNOTUR
OW	SE	OWSEEGY
OW	SW	OWSWEGY
OW	SW	OWSWLBY

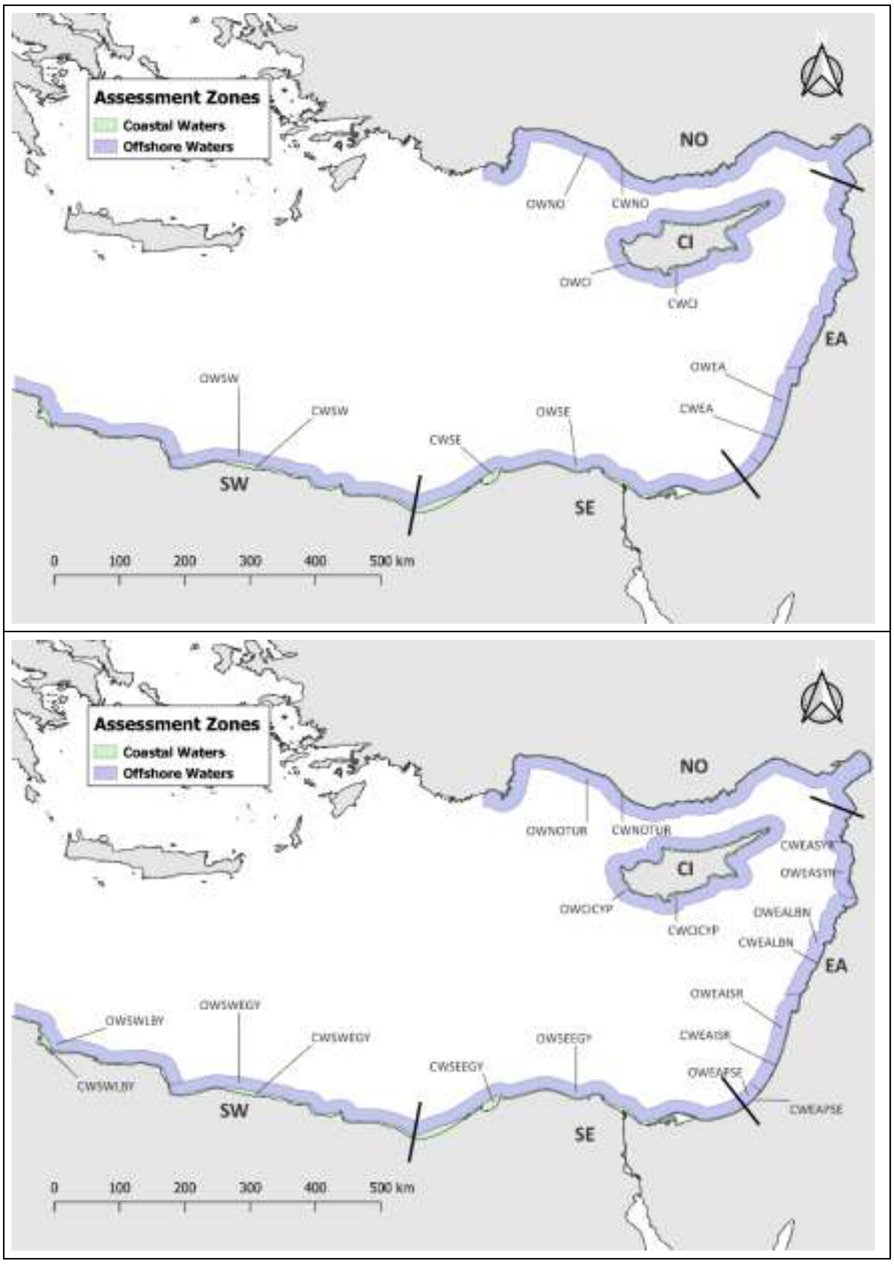

Figure 4. The nesting of IMAP spatial assessment units set in the coastal (CW) and the offshore assessment (OW) zones of the Levantine Sea Sub-division by SAU (upper map); and depiction of the finest IMAP subSAUs (lower map).

Aegean Sea

27. Given the lack of information on water typologies present in national waters, for the present assessment only the Costal Zone was assessed.

28. The Coastal Assessment Zone was divided into three spatial assessment units (SAUs) within the Aegean Sea Subdivision: the North Aegean (NA), the Central Aegean (CA) and the South Aegean (SA) as shown in Figure 3. Then the finest spatial assessment units (sub SAUs) were obtained in the three SAUs by taking account of the definition of the Greek (EIONET) and the Turkish[6] national waterbodies for assessment of eutrophication.

[6] NEAT, BEAST, Lusival Index, Ecological Quality Index Evaluation Report of Turkish Aegean Coast

29. The finest IMAP subSAUs set in the Aegean Sea Sub-division for the purpose of the present CI 14 assessment are shown in Table 3. Figure 5 depicts nesting of the finest IMAP SAUs in the Aegean Sea Sub-division. Namely, the following sub SAUs were set: i) 8 along the coast of Greece: AEG_C_ARG, AEG_C_ISL, AEG_C_SOR, AEG_N_HAL, AEG_N_HAL_O, AEG_N_ISL, AEG_N_THE and AEG_S_KRE; and 7 along the coast of Turkiye EGE_C, EGE_S, EGE04, EGE09, AEG_N, EGE_N and EGE13_2.

Table 3. The finest IMAP spatial assessment units (subSAUs)

Country	SAU	subSAUs
GRE	CA	AEG_C_ARG
GRE	CA	AEG_C_ISL
GRE	CA	AEG_C_SOR
GRE	NA	AEG_N_HAL
GRE	NA	AEG_N_HAL_O
GRE	NA	AEG_N_ISL
GRE	NA	AEG_N_THE
GRE	SA	AEG_S_KRE
TUR	CA	EGE_C
TUR	CA	EGE_S
TUR	CA	EGE04
TUR	CA	EGE09
TUR	NA	AEG_N
TUR	NA	EGE_N
TUR	NA	EGE13_2

Figure 5. The nesting of the finest IMAP spatial assessment units (sub SAUs) in the coastal (CW) zone of the Aegean Sea Sub-division.

4. Setting the good/non-good boundary value/threshold for the Simplified G/M comparison assessment methodology application in the AEL Sub-region

30. The definition of baseline and threshold values for IMAP CIs 13 and 14 in the Mediterranean Sea is an ongoing process. Detail information on their present status is provided in UNEP/MED WG.533/10, Appendix II [7]. The setting of GES-nonGES boundary limits within GES assessment of the Adriatic Sea Sub-region for IMAP CIs 13 and 14 were based on the boundary and reference values defined for TP and DIN, and updated ones for Chl a, as approved in UNEP/MED WG.533/10, Appendix II by the Meeting of CorMon on Pollution Monitoring (17 and 30 May 2022).

31. Within the present work, the attributes were added to all new satellite derived Chl *a* data points in order to allow their use for calculation of the assessment criteria by the CW and OW, and SAUs in Levantine Sea Sub-division, and by the CW and SAUs in the Aegean Sea Sub-division.

32. Namely, the use of a new parameter for assessment i.e. satellite-derived Chl*a* imposes calculation of a new set of assessment criteria given absence of any tested relationship of the satellite derived Chla data with *in situ* measured Chla data based on effects-pressures relationship. Namely, the use of reference and boundary water types related values, as set by the Decision IG.23/6 of COP 20 (MED QSR), was impossible for the present work.

33. In order to calculate the assessment criteria applicable within the present work, the annual GM values for satellite derived Chl*a* data were normalized using the R package *bestNormalize*. Then, the normalization process was tested for usual normalisation transformation, log x, boxcox, yeojohnson and Ordered Quantile normalizing transformation (orderNorm). The best normalisation was obtained with *orderNorm()* as shown in Figure 6, and it was used for calculation of the assessment criteria applied to deliver the present CI 14 assessment.

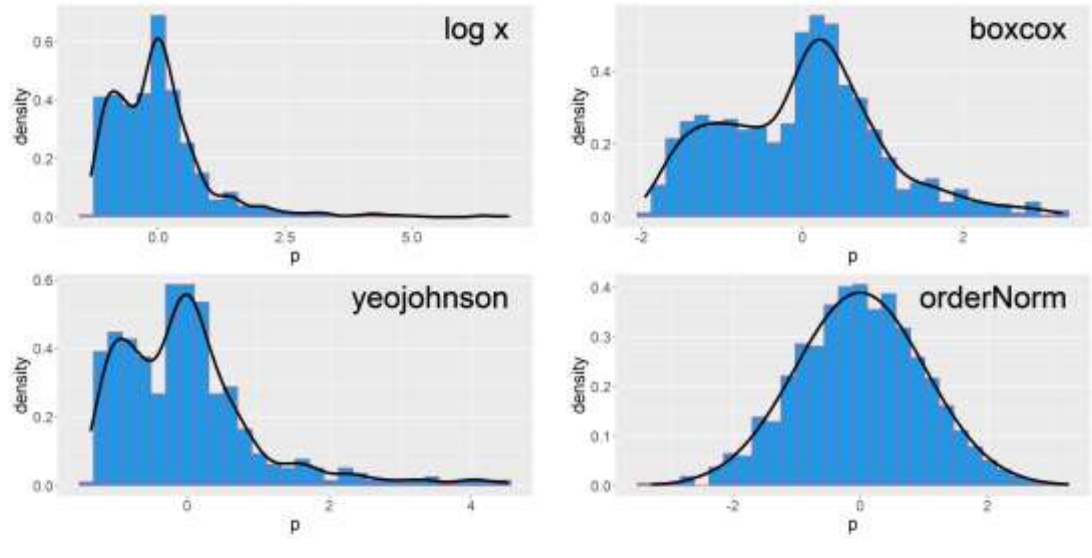

Figure 6. The distribution plot for various normalization transformation.

34. The Ordered Quantile (ORQ) normalization transformation, *orderNorm()*, is a rank-based procedure by which the values of a vector are mapped to their percentile, which is then mapped to the

[7] UNEP/MED WG.533/10, Appendix II: Assessment Criteria. Assessment Criteria Methodologies for IMAP Common Indicator 13: Reference and Boundary Values for DIN and TP in the Adriatic Sea Sub-region, Meeting of the Ecosystem Approach Correspondence Group on Pollution Monitoring, videoconference, 27 and 30 May 2022., pp 59.

same percentile of the normal distribution. Without the presence of links to non-systematic processes, this essentially guarantees that the transformation leads to a uniform distribution.

35. The transformation is:

$$g(x) = \Phi^{-1}((rank(x) - .5)/(length(x)))$$

where Φ refers to the standard normal cdf, rank(x) refers to each observation's rank, and length(x) refers to the number of observations.

36. By itself, this method is certainly not new; the earliest mention of it is in a 1947 paper by Bartlett[8]. This equation was outlined explicitly in Van der Waerden (1952[9]), and expounded upon in Beasley (2009[10]).

37. Using linear interpolation between these percentiles, the ORQ normalization becomes a 1-1 transformation. This transformation can be performed on the satellite derived Chl*a* data and inverted via the *predict* function.

38. The normalization of data is important as it allows generation of the comparable datasets for different assessment zones within the specific Sub-region/Sub-division, and then at upper level between different Sub-regions/subdivision. Further to comparable datasets, it ensures calculation of all aspects relevant to data distribution i.e., z-scores, percentiles, means, etc.

39. The UNEP/MAP Guideline (UNEP(DEC)/MED WG.372/3[11]) defines reference conditions as the state of the marine environment (or a component) in which there is no disturbance or very minor disturbance from the pressures of human activities. Reference conditions (RC) may not necessarily reflect “background” or “historical” conditions, and it is up to the regulator to decide whether GES will represent pristine or slightly impacted but still “good” status (UNEP(DEC)/MED WG.372/3). For the present assessment of CI 14, the RC values were calculated from the normalized values and were represented by the 10^{th} percentile.

40. Thresholds were used to define the boundary limit between the acceptable and the unacceptable environmental status i.e., the Good Environmental Status and non-Good Environmental Statuses. Further to the work undertaken in the Baltic Sea (Andersen et al. 2011[12]; HELCOM 2010[13]), for an indicator showing positive response (i.e., nutrients and Chl *a*), the threshold value has an upper limit of +50 % deviation from reference conditions. Setting the threshold to 50 % implies that low levels of disturbance (defined as less than +50 % deviation) resulting from human activity are considered acceptable, while moderate (i.e., greater than +50 %) deviations are not considered acceptable for the water body in question.

41. A further modification to this rule was applied within the present work in the Aegean - Levantine Sea Subregion given the 50th percentile represents the mean value of the distribution, and the 85th percentile ~ mean +1 SD represents the G/M threshold. It was necessary to use this criterion given expert-based analysis of the satellite derived Chla preliminary indicates that most of the assessed waters are in the high status.

42. The transformation of percentile to z-scores were obtained using the *pnorm()* an *qnorm()* functions in R. The RC values (oN10) and the G/M thresholds (oN85) were calculated from the normalized values through the *predict* function. The results of calculation are presented in Tables 4

[8] Bartlett, M. S. (1947) "The Use of Transformations." Biometrics, vol. 3, no. 1, pp. 39-52. JSTOR www.jstor.org/stable/3001536
[9] Van der Waerden BL. Order tests for the two-sample problem and their power. 1952;55:453-458. Ser A.
[10] Beasley TM, Erickson S, Allison DB (2009) Rank-based inverse normal transformations are increasingly used, but are they merited? Behav. Genet.; 39(5): 580-595. pmid:19526352
[11] UNEP(DEC)/MED WG.372/3 (2012) Approaches for definition of GES and setting targets for the pollution related ecological objectives in the framework of the ecosystem approach. (EO5: eutrophication, EP9: contaminants, EP10: marine litter, EO11: noise). Sarajevo, Bosnia and Herzegovina
[12] Andersen, J. H., Axe, P., Backer, H., Carstensen, J., Claussen, U., Fleming-Lehtinen, V., et al. (2011). Getting the measure of eutrophication in the Baltic Sea: towards improved assessment principles and methods. Biogeochemistry, 106(2), 137–156.
[13] HELCOM. (2010). Ecosystem health of the Baltic Sea 2003-2007: HELCOM Initial Holistic Assessment.

and 5 and are obtained by the AZs and SAUs. In the absence of information on water typologies present in national waters, the assessment criteria were provided only at the level of SAUs in the CW.*Levantine Sea.*

Table 4: Reference conditions (oN10) and G/M threshold (oN85) set by IMAP Assessment zones (AZ) and Spatial Assessment Units (SAU) in the Levantine Sea Sub-division.

AZ	SAU	oN50	oN50+50	oN90	oN10	oN85	oN25
CW	CI	0,047	0,071	0,075	0,034	0,065	0,039
CW	EA	0,462	0,692	1,762	0,125	1,402	0,209
CW	NO	0,152	0,227	2,156	0,066	1,454	0,089
CW	SE	1,769	2,653	5,675	0,059	4,773	0,174
CW	SW	0,038	0,056	0,161	0,025	0,104	0,029
OW	CI	0,039	0,059	0,051	0,029	0,049	0,034
OW	EA	0,061	0,092	0,142	0,042	0,110	0,051
OW	NO	0,064	0,095	0,170	0,044	0,140	0,052
OW	SE	0,227	0,341	1,495	0,042	0,990	0,093
OW	SW	0,031	0,047	0,037	0,023	0,035	0,028
oN50 – Mean, oN50+50 – Mean + 50%, oN90 – 90^{th} percentile, oN10 – 10^{th} percentile, oN85 – 85^{th} percentile, oN25 – 25^{th} percentile							

Aegean Sea

Table 5: Reference conditions (oN10) and G/M threshold (oN85) set by IMAP Assessment zones (AZ) and Spatial Assessment Units (SAU) in the Aegean Sea Sub-division.

AZ	SAU	oN50	oN50+50	oN90	oN10	oN85	oN25
CW	CA	0,074	0,111	0,142	0,053	0,12	0,06
CW	NA	0,126	0,189	0,625	0,085	0,436	0,097
CW	SA	0,056	0,084	0,079	0,046	0,07	0,051

oN50 – Mean, oN50+50 – Mean + 50%, oN90 – 90^{th} percentile, oN10 – 10^{th} percentile, oN85 – 85^{th} percentile, oN25 – 25^{th} percentile

43. Finally, each observation point, or area were classified in GES or non-GES, comparing the concentrations of chl *a* to G/M threshold i.e., the back transformed 85^{th} percentile of normalized distribution.

44. It must be noted that by selecting the 85^{th} percentile of the normalized distribution as G/M boundary limit, therefore as the limit between the acceptable and the unacceptable statuses i.e. good and non-good in the Levantine and Aegean Seas, the compatibility of the present classification was achieved with a five classes GES/non GES scale set in the Adriatic Sea Sub-region. It should also be noted that the two status classes i.e. good and non-good are assigned to the units assessed by applying the simplified G/M assessment methodology since the assessment findings are based on the use of only one parameter and therefore, the integrated consideration of the minimum of parameters needed to assess the good environmental status for IMAP CIs 13 and 14 i.e. the GES was impossible. The harmonization was achieved to the maximum possible extent given the Simplified assessment methodology based on G/M comparison and NEAT GES assessment methodology are different methodologies which application across the Mediterranean Sub-regions/Sub-divisions was conditioned with the statuses of data reported by the CPs. Therefore, the bias assessment of CI 14 within the 2023 MED QSR was avoided as the Simplified G/M method relay on the assessment criteria corresponding to RC and G/M as stated in the Decision 22/7 on Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria (UNEP/MAP, 2016). Based on statistical calculations and related selection of the 85^{th} percentile ~ mean +1 SD represents the G/M threshold, the

synchronization was achieved to the maximal possible extent between the classification statuses assigned in the Levantine Sea Sub-division, and those in the Adriatic Sea Sub-region.

5. Results of the Assessment of CI 14 in the Aegean - Levantine Sea Subregion

45. The results of CI 14 assessment using the satellite derived Chl *a* data are presented in Tables 7 and 9, and Figures 7 and 6. The non-good status (Figure 6) corresponds to the RC conditions, as well as to the values below the 85^{th} percentile of normalized distribution set as good/noon-good boundary (i.e. blue coloured cells in the last column of Tables 7 and 9). The likely non-good corresponds to the class above G/M boundary threshold (i.e., red coloured cells). The assessment results show that all evaluated assessment zones can be considered in good status regarding assessment of the satellite derived Chl *a* data.

	GES			non-GES		
IMAP/NEAT	RC	High	Good	Moderate	Poor	Bad
Boundary limits and normalized NEAT scores	< RC/H limit, not in score scale	1 < score ≤ 0.8	0.8<score≤ 0.6	0.6<score ≤ 0.4	0.4< score ≤0.2	Score<0.2
IMAP/Simplified G/M						
Boundary limits*	≤10^{th} %	>10^{th}% CHL_GM ≤85^{th}%		CHL_GM >85^{th} %		
G/nG threshold			**G/M**			
*** Percentile are calculated from normalized (with Ordered Quantile transformation) annual geometric mean (for at list 5 year)**						

Figure 6: Assessment classification for harmonized IMAP/NEAT and IMAP/Simplified G/M assessment methodologies application in the Mediterannean Sea sub-regions.

Levantine Sea

46. The assessment results show that all evaluated assessment zones can be considered in good status regarding assessment of the satellite derived Chl*a* data. Further to good status assigned to the assessment zones, it can be preliminary found that only 1 out of 18 subSAUs is likely in non-good status. However, it must be noted that the present subSAUs are set at an insufficient level of fineness for a reliable assessment (Tables 7, and Figure 7). This subSAU in non-good status is located in the OW in the southern part of the Eastern Levantine Sea. The local sources of pollution are probably the main driver contributing to the weakened status of this subSAU.

47. In addition, available literature indicates waters in front of Mersin and in the Iskenderun Bay as impacted areas. A slight impact can also be identified along the coast of Israel and in the OW in the southern part of the Eastern Levantine Sea, as well as in front of Port Said and Alexandria. The influence of the Nile River through the river Delta is weak and confirms the changes in the area caused by construction of the Aswan dam. There is also an indication of a coastal impact in the Tobruk area in the waters of Libya.

48. In addition, available literature indicates waters in front of Mersin and in the Iskenderun Bay as impacted areas. A slight impact can also be identified along the coast of Israel and in the OW in the southern part of the Eastern Levantine Sea, as well as in front of Port Said and Alexandria. The influence of the Nile River through the river Delta is weak and confirms the changes in the area caused by construction of the Aswan dam. There is also an indication of a coastal impact in the Tobruk area in the waters of Libya.

Table 6. Results of the assessment (G_NG.oN85 - the good status corresponds to all values below the 85^{th} percentile set as G/M i.e., good/noon-good boundary limit) of the Levantine Sea Sub-division by Assessment Zones (AZ) and Spatial Assessment Units (SAUs). Blue coloured SAUs indicates good status **AZ**	**SAU**	**CHL_N**	**CHL_**	**oN50**	**oN50+**	**oN10**	**oN85**	**G_NG.o**

			GM		**50**			**N85**
CW	CI	677	0,050	0,047	0,071	0,034	0,065	**G**
CW	EA	257	0,458	0,462	0,692	0,125	1,402	**G**
CW	NO	163	0,199	0,152	0,227	0,066	1,454	**G**
CW	SE	853	1,111	1,769	2,653	0,059	4,773	**G**
CW	SW	1281	0,050	0,038	0,056	0,025	0,104	**G**
OW	CI	10383	0,040	0,039	0,059	0,029	0,049	**G**
OW	EA	9178	0,074	0,061	0,092	0,042	0,110	**G**
OW	NO	12598	0,083	0,064	0,095	0,044	0,140	**G**
OW	SE	7568	0,331	0,227	0,341	0,042	0,990	**G**
OW	SW	10458	0,032	0,031	0,047	0,023	0,035	**G**
CHL_N – number of grid point in the SAU; CHL_GM – geometric mean (5-year average); oN50 – mean; oN50+50 – Mean + 50%; oN10 – 10th percentile (Reference conditions)								

Table 7. Result of the assessment (G_NG.oN85- the good status corresponds to all values below the 85th percentile set G/M i.e., good/noon-good boundary limit) of the Levantine Sea Sub-division for the finest Spatial Assessment Units (subSAUs). Blue coloured SAUs indicate good status , Red coloured subSAU indicates non-good status .

AZ	SAU	subSAUs	CHL_N	CHL_GM	oN50+50	oN10	oN85	G_N.G.oN85
CW	CI	CWCICYP	677	0,050	0,071	0,034	0,065	**G**
CW	EA	CWEAISR	95	0,498	0,692	0,125	1,402	**G**
CW	EA	CWEALBN	91	0,360	0,692	0,125	1,402	**G**
CW	EA	CWEAPSE	26	1,362	0,692	0,125	1,402	**G**
CW	EA	CWEASYR	45	0,331	0,692	0,125	1,402	**G**
CW	NO	CWNOTUR	163	0,199	0,227	0,066	1,454	**G**
CW	SE	CWSEEGY	853	1,111	2,653	0,059	4,773	**G**
CW	SW	CWSWEGY	725	0,035	0,056	0,025	0,104	**G**
CW	SW	CWSWLBY	556	0,080	0,056	0,025	0,104	**G**
OW	CI	OWCICYP	10383	0,040	0,059	0,029	0,049	**G**
OW	EA	OWEAISR	2724	0,086	0,092	0,042	0,11	**G**
OW	EA	OWEALBN	3243	0,067	0,092	0,042	0,11	**G**
OW	EA	OWEAPSE	486	0,158	0,092	0,042	0,11	**NG**
OW	EA	OWEASYR	2725	0,062	0,092	0,042	0,11	**G**
OW	NO	OWNOTUR	12598	0,083	0,095	0,044	0,14	**G**
OW	SE	OWSEEGY	7568	0,331	0,341	0,042	0,99	**G**
OW	SW	OWSWEGY	5843	0,030	0,047	0,023	0,035	**G**
OW	SW	OWSWLBY	4615	0,033	0,047	0,023	0,035	**G**
CHL_N – number of grid point in the SAU; CHL_GM – geometric mean (5 year average); oN50 – mean; oN50+50 – Mean + 50%; oN10 – 10th percentile (Reference conditions);								

Aegean Sea

49. The assessment results show that all three evaluated assessment zones can be considered in good status regarding assessment of the satellite derived Chl*a* data. Further to this likely good status assigned to the assessment zones, it can be preliminary found that only 2 out of 16 subSAUs are in noon-good status. However, it must be noted that the present subSAUs are set at an insufficient level of fineness for a reliable assessment (Table9, and Figure 8). The following two non-good status subSAUs are located in the CA SAU in the waters of Turkiye in the Aegean Sea: EGE09 (Izmir Bay) and EGE_C (coast strip south of Izmir Bay). The local sources of pollution are probably the main driver contributing to the weakened status of these two subSAUs.

50. In addition, available literature indicates the presence of drivers and pressures with impacts related to eutrophication in the areas as elaborated here-below.

51. In the Saronikos Gulf and Elfesis Bay, there is evidence of a few following drivers and pressures: i) extensive urbanization in the metropolitan areas of Athens and Piraeus hosting about 1/3 of the Greek population; ii) port activities and maritime traffic (Piraeus port); and iii) industries located in the coastal area of the Elefsis Bay, such as oil refineries, steel and cement industries, and shipyards. Since 2012, the eastern Elefsis Bay receives treated domestic and industrial wastewaters from the Thriasio wastewater treatment plant. The small island of Psyttaleia hosts the wastewater treatment plant of metropolitan Athens, however with pre-treatment, primary and secondary treatment, including biological nitrogen removal, and sludge treatment. Treated wastewaters are discharged into the Inner Saronikos Gulf via a system of three pipelines to the south of the island, at 62m depth (Karageorgis et al., 2020 and references therein)

52. Similarly, the national assessment by applying the NEAT tool to Saronikos Gulf[14] classified this area into good status, with the pelagic habitat components contributing strongly to its overall environmental status. Sediment, benthic fauna and vegetation, mammals and alien species were the most impacted ecological components in Saronikos Gulf. The most affected areas, Elefsis Bay and Psittalia (wastewater submarine outfall), were assessed as in poor and moderate status, respectively.

53. There are also other areas where certain impacts are registered. In the Thessaloniki Bay, these are the Thessaloniki harbor, impacted by industrial, treated or partly treated sewage discharges; the Inner Thermaikos Gulf impacted by agricultural discharges from the heavily polluted Axios River, and fish and shellfish mariculture; as well as the Evoikos Gulf impacted by agriculture, mariculture, and industry. Industrial discharges, port activities, sewage discharges, aquaculture activities, and fishing are the most important pressures affecting the coastal areas of Greece. In fact, mariculture seems to have the highest impacts, and is followed by fishing, other activities and industrial discharges (Pavlidou et al., 2015).

54. A review of the existing pressures and assessment was provided by Turkiye[15]. The analysis was divided by Provinces and drivers and pressures relevant to EO5, as summarized here below.

55. Province of Çanakkale: DPs present in Saros Bay are related to tourism population density and discharge of wastewater from olive oil production. Domestic wastewater discharge occurs in some areas. Bozcaada and Gökçeada are important centers with marine tourism potential.

56. Province of Balıkesir. Urban wastewater treatment plants were put into operation. However, there are some districts without wastewater treatment facilities. Domestic wastewater arising from the increasing population due to tourism in the summer months and olive black water arising from olive oil production in the winter months constitute the most important drivers and pressures in the province. The Havran Stream is the most important stream which ends in the Edremit Gulf, in the Aegean Sea. There are 2 fish farms in Ayvalık Region in Balıkesir as of 2020.

57. Province of İzmir. Urban wastewater treatment plants were put into operation; However, there are some districts without wastewater treatment facilities or are at the project/building stage. Agriculture is of importance in Izmir. Küçük Menderes, Bakırçay and Gediz rivers are the most important rivers of the Aegean Region. The main tributary of the Gediz River ,and the main streams feeding it, are considered to be under pressure in terms of point and diffuse pollution. It should also be noted that İzmir is a natural tourist and port city. Izmir Port is the largest port in Turkey after Mersin Port and it also hosts the only shipbreaking zone. There are 66 fish farms, and 8 mussel farms operating on the coasts of İzmir province

58. Province Aydın There are 38 treatment plants throughout the province of Aydın, but the majority of them are with natural and packaged wastewater treatment systems. In addition, most of them reach the Aegean Sea as a discharge to the Büyük Menderes River or other streams. The 584 km long Büyük Menderes River, the longest river in the Aegean Region, empties into the Aegean Sea from Aydın. Agriculture and animal husbandry activities are very developed in Aydın. Marine, thermal and cultural tourism potential is well developed. The province has a coastline of 150 km with 2 marinas. Kuşadası Port, with an annual acceptance capacity of 2,400 ships, is the most important cruise port of Turkiye in terms of the number of passengers and the number of ships. There are marine fish farming facilities in Didim.

Table 8. Results of the assessment (G_NG.oN85 – the non-good status corresponds to all values below the 85th percentile set as G/M i.e., good/noon-good boundary limit) of the Aegean Sea Sub-division by Assessment Zones (AZ) and Spatial Assessment Units (SAUs). Blue coloured SAUs indicate likely GES.

AZ	SAU	CHL_N	CHL_GM	oN50	oN50+50	oN10	oN85	G_NG.oN85
CW	NA	53613	-	0,126	0,189	0,085	0,436	G

[14] Pavlidou, A., Simboura, N., Pagou, K. et al., (2019) Using a holistic ecosystem-integrated approach to assess the environmental status of Saronikos Gulf, Eastern Mediterranean, Ecological Indicators, 96 (1), 336-350.
[15] Submitted after the Meeting of CORMON Pollution that took place in Athens, 1-2 March 2023

CW	CA	39229	0,093	0,074	0,111	0,053	0,12	G
CW	SA	5091	0,062	0,056	0,084	0,046	0,07	G
CHL_N – number of grid point in the SAU; CHL_GM – geometric mean (5-year average); oN50 – mean; oN50+50 – Mean + 50%; oN10 – 10th percentile (Reference conditions)								

Table 9. Result of the assessment (G_NG.oN85- the non-good status corresponds to all values below the 85th percentile set as G/M i.e., good/noon-good boundary limit) of the Aegean Sea Sub-division for the finest Spatial Assessment Units (subSAUs). Blue coloured subSAUs indicate good status; Red coloured subSAUs indicate non-good status.

Country	**SAU**	**subSAUs**	**CHL_N**	**CHL_GM**	**oN50+50**	**oN10**	**oN85**	**G_NG.oN85**
GRE	CA	AEG_C_ARG	5190	0,095	0,111	0,053	0,12	G
GRE	CA	AEG_C_ISL	19245	0,066	0,111	0,053	0,12	G
GRE	CA	AEG_C_SOR	10338	0,115	0,111	0,053	0,12	G
GRE	NA	AEG_N_HAL	11469	0,315	0,189	0,085	0,436	G
GRE	NA	AEG_N_HAL_O	943	0,156	0,189	0,085	0,436	G
GRE	NA	AEG_N_ISL	15510	-	0,189	0,085	0,436	G
GRE	NA	AEG_N_THE	12128	0,279	0,189	0,085	0,436	G
GRE	SA	AEG_S_KRE	5091	0,062	0,084	0,046	0,07	G
TUR	CA	EGE_C	2032	0,324	0,111	0,053	0,12	NG
TUR	CA	EGE_S	711	0,058	0,111	0,053	0,12	G
TUR	CA	EGE04	748	0,068	0,111	0,053	0,12	G
TUR	CA	EGE09	965	1,057	0,111	0,053	0,12	NG
TUR	NA	AEG_N	11192	0,228	0,189	0,085	0,436	G
TUR	NA	EGE_N	1759	0,405	0,189	0,085	0,436	G
TUR	NA	EGE13_2	612	0,238	0,189	0,085	0,436	G
CHL_N – number of grid point in the SAU; CHL_GM – geometric mean (5-year average); oN50 – mean; oN50+50 – Mean + 50%; oN10 – 10th percentile (Reference conditions);								

6. Conclusions and Key Findings

59. The results of the CI 14 assessment provided by the application of the Simplified assessment methodology based on G/M comparison by using the COPERNICUS satellite - derived Chl*a* data are shown by the respective colours in Figures 7 and 8.

60. The maps depict the acceptable and non-acceptable statuses i.e., good and non-good statusassigned at the level of subSAUs in the Aegean and Levantine Sea Sub-divisions.

61. As explained above, the good status corresponds to the RC conditions class (column oN10 in Tables 7 and 9), as well as to the class between the RC and G/M boundary limit, set as the back-transformed 85th percentile of normalized distribution (i.e., blue coloured cells in the last column of Tables 7 and 9), which is also depicted in blue coloured subSAUs in Figures 7 and 8. The non-good status corresponds to the class above G/M boundary limit (i.e. red coloured cell in the last G_NG.oN85 column of Tables 7 and 9) which is also depicted in red coloured subSAU in Figures 7 and 8.

Levantine Sea

62. Further to good status assigned to the assessment zones, it can be preliminary found that only 1 out of 18 subSAUs is likely in non-good staus. This subSAU in non-good status is located in the OW in

the southern part of the Eastern Levantine Sea, and the local sources of pollution are probably the main driver contributing to the weakened status of this subSAU.

63. In addition, available literature indicates waters in front of Mersin and in the Iskenderun Bay as impacted areas. A slight impact can also be identified along the coast of Israel and in the OW in the southern part of the Eastern Levantine Sea, as well as in front of Port Said and Alexandria. The influence of the Nile River through the river Delta is weak and confirms the changes in the area caused by construction of the Aswan dam. There is also an indication of the impacts present in the Tobruk area in the waters of Libya.

Aegean Sea

64. Further to the good status assigned to the assessment zones, it can be preliminary found that only 2 out of 13 subSAUs are in non-good status. They are EGE09 in Izmir Bay and EGE_C in coastal strip south of Izmir Bay, in CA SAU. Local sources of pollution are probably the main driver contributing to the weakened status of these subSAUs.

65. Based on literature sources there is an evidence of drivers and pressures causing certain impacts related to eutrophication in a few areas. Along the coast of Greece, the literature sources indicate the presence of the impacted areas in the Saronikos Gulf and Elefsis Bay, and the Thessaloniki Bay. In the national assessment of Greece by applying the NEAT tool to Saronikos Gulf , this gulf was classified into good status, with the pelagic habitat components contributing to its overall environmental status. Sediment, benthic fauna and vegetation, mammals, and alien species were the most impacted ecological components in Saronikos Gulf. The most affected areas, Elefsis Bay and Psittalia (wastewater submarine outfall), were assessed as in poor and moderate status, respectively.

66. Along the coast of Turkiye, the literature sources indicate the presence of the impacted areas in the Provinces of Çanakkale; Balıkesir; Aydın and İzmir (as also found in the present GES assessment).

67. The results of the present CI 14 assessment in the Levantine Sea Sub-division represents only an indication of possible good/non-good status at the level of sub SAUs, whereby they are not set at the same level of spatial finesse. Namely, the reliability of the assessment was negatively affected by the lack of data reported by the CPs in IMAP IS, and therefore impossibility to use the IMAP NEAT GES assessment as applied to the Adriatic Sea Sub-region.

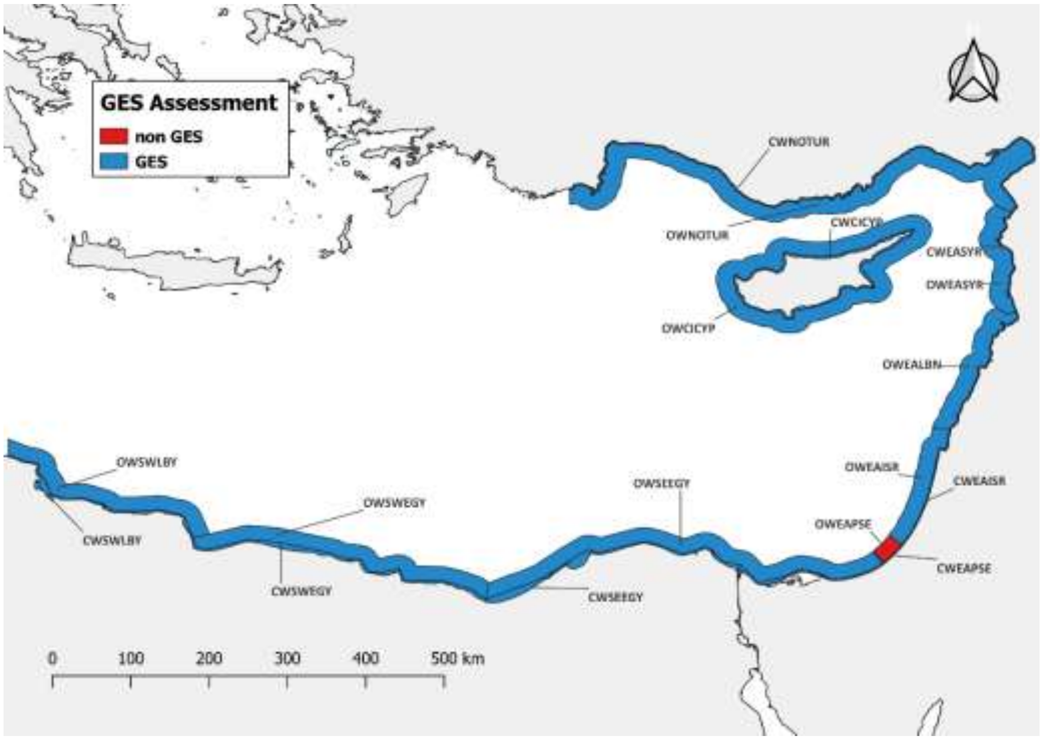

Figure 7: The assessment results for CI 14 in the Levantine Sea Sub-division by applying the simplified G/M method at the level of subSAUs.

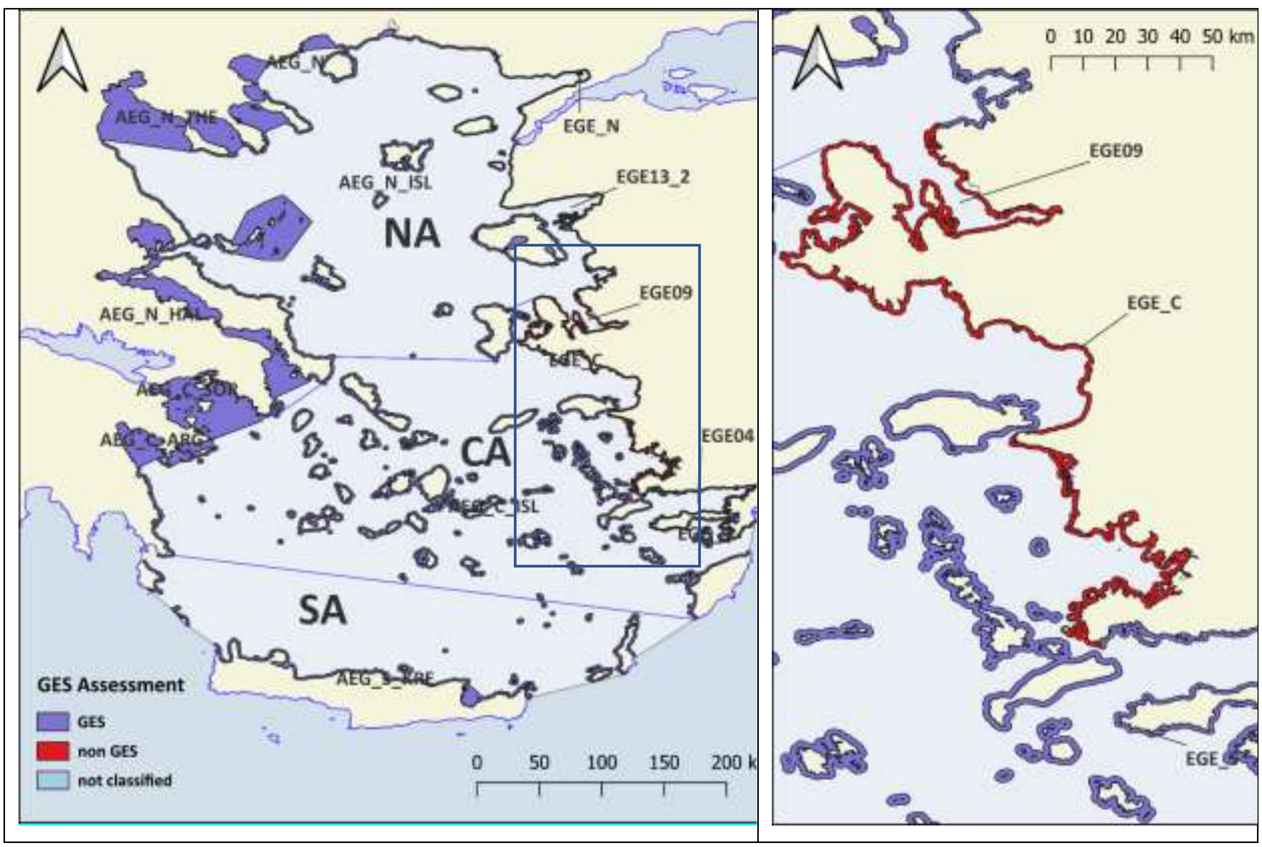

Figure 8: The assessment results for CI 14 in the Aegean Sea Sub-division by applying the simplified G/M method at the level of subSAUs

Annex I
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