UNITED NATIONS

EP

UNEP/MED WG.509/Inf.16

UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

17 May 2021
Original: English

Meeting of the MED POL Focal Points

Videoconference, 27-28 May and 6-7 October 2021

Agenda item 8: Cross-Cutting Issues -The Integration and Aggregation Rules for IMAP Ecological Objectives 5, 9 and 10 and Assessment Criteria for Contaminants and Nutrients

Analysis of the Methodologies Available for Establishment of the Assessment Criteria for IMAP Common Indicator 13

UNEP/MAP
Athens, 2021

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1 Introduction

A significant amount of research has been done in developing and intercalibrating biological indicators to assess impact of eutrophication in coastal waters (Borja et al., 2013). Phytoplankton is the most suitable for assessing eutrophication due to direct response to nutrient conditions (Devlin et al., 2007). However, less attention has been directed to linking ecological status to management actions and establishing meaningful and consistent nutrient criteria to support achievement of GES (Hering et al., 2015).

The European experience is relevant in the field. A comparison of nutrient boundaries set for the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) in transitional, coastal and marine waters across EU Member States (Dworak et al., 2016) revealed a huge variability in nutrient concentrations boundaries, but also in other relevant aspects such as the nutrient parameters and metrics used, the time of year assessed, the reference conditions established.

The possible implications of the wide variations in the nutrient concentration boundaries need to be understood in the context of establishing appropriate nutrient boundaries to achieve GES. A Best Practice Guide (BPG, Phillips et al., 2018) has been elaborated in this context. Its purpose is to help in achieving GES in surface waters. It complements previous guidance on eutrophication assessment (EC, 2009) by providing more targeted advice on how to link nutrient concentrations in surface waters to specific policy objectives.

The statistical approaches proposed in the BPG in coastal and transitional waters focus on the pressure-response relationships found between the nutrients and phytoplankton.

However, in the Mediterranean region there are many differences in the nutrients` parameters assessed, the assessment period (summer, year-round, i.e. annual), and in the statistic used (mean, median or 90th percentile) within assessment of the conditions of saline waters.

The choice of statistical measures used to aggregate nutrients` samples from a chosen assessment period in order to determine the concentrations of monitored parameter/indicator are also important. Most of the Regional Seas Conventions use mean concentrations to ensure cross-comparisons. However, there might be cases where using the median is more robust, since it is less influenced by outliers. The choice of the appropriate statistics depends very much upon sampling size and quality of monitoring.

Since statistical distributions of chlorophyll *a* and nutrients tend towards log-normality, the parameter that better estimates the value around which central clustering occurs, is represented by the geometric mean, i.e. the arithmetic mean of log-data reconverted into numbers. The normalization of the data distributions by means of log transformation stabilizes the variance, with a standard deviation (sd) practically constant in the case of decimal log-transformation (Giovanardi and Tromellini, 1992). These statistical properties indicate that the use of the annual geometric mean of data as the metric for setting the assessment criteria in Mediterranean is the appropriate statistical measure.

Further to above considerations and given limited data availability as presented here-below, present document in detail elaborate the way for calculation of the reference conditions and boundary values for Dissolved Inorganic Nitrogen (DIN) and Total Phosphorous (TP) on the example calculation of their assessment criteria in the Adriatic Sub-region. Short overviews of the Best Practice Guide Toolkit and the experience of Spain in establishment of nutrient boundary values for coastal waters of Catalonia are also presented. Additionally, a detailed overview of the data availability by country in the datasets from IMAP Pilot Info System and MEDPOL Database available for calculation of the assessment criteria for DIN and TP is presented.

2 The calculation of the assessment criteria for DIN and TP in Adriatic Sub-region

The scientific experience related to eutrophication in Adriatic Sea is huge and relay on the problems derived from the eutrophic pressure connected with the Po River watershed where live around 16 000 000 inhabitants. Near the scientific experience, also a huge data set exists that enabled development of TRIX (Volenweider et al., 1998), an index for the assessment of the eutrophication, and a regional approach for development of classification criteria based on Chlorophyll *a* within IMAP (Giovanardi et al., 2018). This ensures further development of a harmonized approach to the definition of reference conditions and boundary values for DIN and TP based on the relationship between pressure and responses.

2.1 Water typology

The Water typology is very important for further development of classification schemes of a certain area. In the Mediterranean a considerable number of eutrophication experts have built a typology scheme for the Mediterranean coastal waters during the first inter-calibration phase for the EU Water Framework Directive implementation, which is still in use after their update according to Commission Decision 2013/480/UE and represents a very simple typology approach that could be easily applied Mediterranean wide for coastal waters (*sensu* WFD, i.e. 1 Nm), since these coastal waters have been intercalibrated. The typology is mainly focused on hydrological parameters, characterizing water bodies' dynamics and circulation, and is based on the introduction of the static stability parameter (derived from temperature and salinity values in the water column). Such a parameter, having a robust numerical basis, can describe the dynamic behaviour of a coastal system. Surface density is adopted as a proxy indicator for static stability as both Temperature and Salinity are relevant in the dynamic behaviour of a coastal marine system: both are involved in circulation and mixing dynamics and all information is then nested in the surface density parameter (Giovanardi *et al.*, 2006).

On the basis of surface density (σ_t) values three major water types with subdivisions have been defined:

Type I	coastal sites highly influenced by freshwater inputs,
Type IIA	coastal sites moderately influenced not directly affected by freshwater inputs (Continent influence),
Type IIIW	continental coast, coastal sites not influenced/affected by freshwater inputs (western Basin),
Type IIIE	not influenced by freshwater input (eastern Basin),
Type Island	coast (western Basin).

The coastal water type III was split in two different sub basins, the western and the Eastern Mediterranean, according to the different trophic conditions and is well documented in literature. Thus, it is recommended to define the major coastal water types in the Mediterranean Sea to assess eutrophication (Table 1). This type subdivision based only on salinity, is perfectly comparable with the previous ones, based on density.

Table 1. Major coastal water types in the Mediterranean

	Type I	**Type IIA, IIA Adriatic**	**Type IIIW**	**Type IIIE**	**Type Island-W**
σ_t (density)	<25	25<d<27	>27	>27	All range
S (salinity)	<34.5	34.5<S<37.5	>37.5	>37.5	All range

In order to better understand the differences between types, the issues presented bellow need to be considered. The Levantine Basin of Eastern Mediterranean is characterized as nutrient-deficient and therefore ultra-oligotrophic in comparison to the Atlantic Ocean (Berman et al., 1984). Furthermore, eastern Mediterranean is more P-limiting to the growth of phytoplankton, in contrast to the general dogma that N is the more limiting nutrient in marine systems (Krom *et al.*, 1991). Recent studies made on phytoplankton biomass in the deeper waters of eastern Mediterranean reveal that prevailing oligotrophic conditions result in low chlorophyll-a concentrations ranging from 0.1 to 0.2 μg/L (Krom *et al.*, 1992). It has also been shown that chlorophyll-a concentrations off the coast of Cyprus are among the lowest in the region and ranged from 10 to 90 ng/L (Bianchi *et al.*, 1996). Recent studies along the coastal waters of Cyprus confirmed its oligotrophic status (Argyrou, 2005, 2006).

Furthermore, it was proposed the subdivision of type II, which includes marine waters with intermediate salinities in two subtypes: type II-A and type II-B. The South of Spain (the main part of Andalusian coast) is clearly affected by the influence of the Atlantic waters, so the natural salinity, nutrients and Chl-a concentrations do not correspond with type III. Moreover, the lower salinities of before defined type II were explained by freshwater inputs, coming mainly from the continent. It should be emphasized that in the vicinities of Gibraltar Strait there are also lower salinities that come from the Atlantic, and that is why this subdivision in Type II-A (the original one) and Type II-B (affected by Atlantic influence) was proposed.

The major coastal water types and related criteria in the Mediterranean were defined following on their inter calibration, that was applicable for phytoplankton only, as provided in Decision IG.22/7 on IMAP (COP 19, 2016).

The first step in setting reference conditions and boundary values for an area i.e. Adriatic Sea sub-region is to identify present Water types and to attribute the data related to the density or salinity boundaries (Table 1). For the Adriatic Sub-region the relevant types are Type I, Type IIA Adriatic and Type IIIW.

2.2 Reference condition

Reference Conditions (RCs) represent “a description of the biological quality elements that exist, or would exist, at high status”. That is, with no, or very minor disturbance from human activities. The objective of setting reference conditions` standards is to enable the assessment of ecological quality against these standards (WFD CIS Guidance Document No. 5 (2003)).

An acceptable approach is to use a comprehensive pressure indicator that is able to address the potential transport of nutrients (natural loads plus anthropogenic loads) from the mainland to the sea, and that also measure, albeit roughly, this transport verifying the eventual absence of pressures of some importance exerted by human activities. For this purpose, use of dilution factor is considered as it was the case when the RCs for the Adriatic and Tyrrhenian Sea were developed (Giovanardi *et al.*, 2018).

The dilution factor is formulated as follows: F_dil=[(S-s)/S]*100, where S = open sea salinity, s = measured salinity at a given coastal sampling point (Giovanardi and Vollenweider, 2004). According to this definition, F_dil does not represent a true pressure indicator; however, it is indisputable that the input of nutrients in a coastal area should be strictly related to the fresh waters of continental origin.

The role of the F_dil factor in assigning the chlorophyll a RCs is depicted in Figure 1. The data points refer to coastal areas belonging to all typologies of water bodies in the Adriatic sea, in order to ensure maximum variation range for the related water quality parameters. As suggested in the RC development a boundary line between the area with data points and the area with no data points are drawn. For each fixed value of the F_dil indicator, corresponding chlorophyll *a* values (as annual G_means) can range from a minimum identified by the separation line to a maximum, which will depend on the weight of the nutrient loads on the coastal systems.

This separation line can be interpreted as the threshold between natural and anthropogenic pressures. It is assumed that the nutrient loads, either natural or generated by minor human activities, determine a response of the coastal systems that is well-represented by concentrations of chlorophyll *a* lying on the curve (Figure 1). Thus, the assessment of RCs does not derive from theoretical considerations or expert judgments, but refers to real situations occurring along the Adriatic coast.

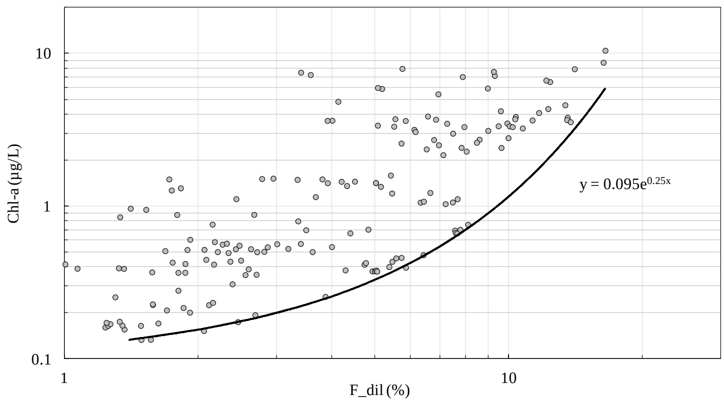


Figure 1. Scatter plot of annual *G_means* of chlorophyll *a* (Chl-a) against the dilution factor (F_dil) for Types I and II A. The curve marks the boundary of the lower limit of chlorophyll *a* reference conditions values (RCs). Original Figure from Giovanardi *et al*, 2018.

The same approach cannot be used for the nutrients, given the dilution factor represents an integrated measure of the nutrient's pressures to the ecosystem. However, defining the reference conditions for chlorophyll *a* for different water types, precedes to setting of the reference conditions for nutrients, whilst the nutrients RCs will be derived from the pressure to effects relationship as presented here-below.

In order to define more accurately chlorophyll *a* RCs for each water type, the data corresponding to individual Adriatic types were considered separately. Then it was possible to plot the curves separately for all types (Figure 2), which represent the RCs for each type.

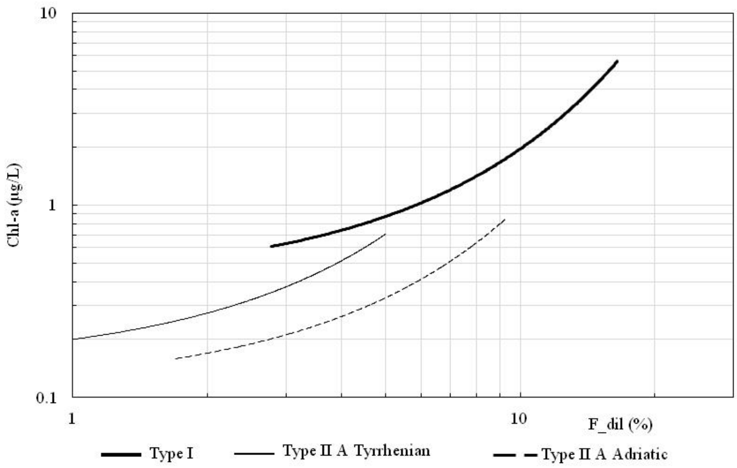


Figure 2. Reference conditions for chlorophyll *a* (Chl a) corresponding to different water types, depending on the gradient of the dilution factor (F_dil). Original Figure from Giovanardi *et al*, 2018.

The best functional relationships between chlorophyll *a* RC and F_dil were always exponential. The equations describing these relationships have been used to derive a unique chlorophyll *a* RCs per water types corresponding to the mean value of F_dil. Table 2 summarizes the results.

Table 2. Summary table for BQE phytoplankton reference conditions (RC) based on chlorophyll *a*.

Type	**Functional relationships**	**F_dil (%) *Mean value***	**RC - Chl-a (µg/L) as *G_Mean***
Type I	$y = 0.388\ e^{0.162x}$	7.9	1.40
Type II A Adriatic	$y = 0.109\ e^{0.221x}$	4.96	0.33

2.3 Pressure to effect relationship

Defining pressure to effect relationship is critical for nutrients RCs setting. Furthermore, a complete understanding of the functional relationship which links pressures to ecological effects result at the end with the programmes and measure as the final goal of the assessment process. To define the pressure to effect relationship, there is a need to apply relevant statistical analyses.

To test the sensitivity of the selected metrics to different pressure indicators, multiple regression analysis with linear models (LMs) has to be performed first of all. By means of this stepwise regression technique, the chlorophyll *a* concentration variations were tested against the pressure indicators provided by the Adriatic and Tyrrhenian data sets (nutrient concentrations, oxygen saturation (as *aD_O*), dilution factor and Secchi depth). Annual geometric means of the parameters were used in the analysis.

Statistical analyses were performed using statistical packages offered by the program R. Data processing involved the use of techniques of regression analysis, provided by the package *stats*. The function *lm* was used to fit linear models and to carry out regressions. The function *predict* allowed to calculate confidence intervals (with confidence levels $P = 0.95$ and $P = 0.99$) for the estimated values of the dependent variable. The command *step* was used to perform stepwise regression analysis. The mode of stepwise search was chosen as *direction* "backward". The following diagnostic tests were used: i) Shapiro-Wilks test (command *shapiro.test(residuals),* from package *stats*), which assures us that the errors (*i.e.* residuals) distribution approaches normality, ii) Breusch-Pagan test (command *bptest* from package *lmtest*) against heteroskedasticity of residuals variances, and iii) Durbin-Watson test (command *dwtest* from package *lmtest*) on absence of serial correlations among the residuals. For more details on these topics consult Ricci (2006). Finally, in the case of stepwise regression, the risk of multicollinearity was controlled using the *vif* (Variance Inflation Factor) function, taken from the package *faraway*.

For Type I among all the possible combinations, the stepwise regression technique provided the following linear model:

lm (formula = Chl-a ~ F_dil + aD_O + TP + DIN, data = Type_I)

The fitted linear model explains 89% of the total chlorophyll *a* variability and the maximum weight in determining this variability accounts to TP. Summary statistic is provided in Table 3.

Table 3. Results of the stepwise regression applied to Type I coastal waters data. For each regression coefficient (Estimate), the value of Student's test (under hypothesis $\beta = 0$), the relative *P*-value and the degree of significance expressed by the number of asterisks, are provided. *Multiple R-squared*: 0.8886, *F-statistic*: 27.93 on 4 and 14 DF, *P-value*: 1.533E-06.

	Estimate (β)	***t* value**	**Pr(>|*t*|)**	**Sign.**
(Intercept)	-2.4536	-4.705	3.380E-04	***
F_dil	0.1598	4.296	7.390E-04	***
aD_O	0.3212	5.241	1.250E-04	***
TP	3.6530	8.021	1.330E-06	***
DIN	-0.1100	-5.646	6.040E-05	***

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

For Type II A coastal water the linear model provided by the stepwise regression technique was:

lm (formula = Chl-a ~ F_dil + TP, data = Type_II A)

The linear model is quite simple, only two regressors were chosen with a largely dominant weight of TP over the weight of F_dil (Table 4). Moreover, *multiple R_squared* shows that the amount of chlorophyll *a* variability explained by this model is 78%.

Table 4. Results of the stepwise regression applied to Type II A data. Multiple R-squared: 0.7758, F-statistic: 36.33 on 2 and 21 DF, P-value: 1.521E-07.

	Estimate (*β*)	***t* value**	**Pr(>|*t*|)**	**Sign.**
(Intercept)	-0.0097	-0.167	0.8692	n.s.
F_dil	0.0414	3.323	3.231E-03	**
TP	1.6219	4.089	5.250E-04	***

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

The linear model is quite simple. Only two regressors were chosen with a largely dominant weight of TP over the weight of F_dil and the amount of chlorophyll *a* variability explained by this model is 78%. As TP accounts for the maximum weight in determining the variability of chlorophyll *a*, for both Type I and Type II A Adriatic, this parameter can be considered as the most eligible indicator of the pressure gradient. In this case the phosphorus pool in the water column (TP) can be considered as an internal measure of external phosphorus enrichment.

The above calculated relationships showed that chlorophyll *a* sensitivity, considered as the response of coastal systems to the availability of nutrients in terms of phytoplankton biomass production, is largely controlled by total phosphorus, which can therefore assume the role of the main pressure indicator.

The important regression equations used subsequently for the construction of the ecological classification criteria are summarized in Table 5.

Table 5. List of functional relationships of interest per water types. For each regression equation, the sample size N and the R-squared values are provided.

Functional link	**Type I**	**Type II A Adriatic**
1.TP vs TRIX	[TP] = exp [(TRIX – 6.064)/1.349] N = 15	[TP] = exp [(TRIX – 6.148)/1.583] N = 52
2. Chl-a *vs* TP	$[\text{Chl-a}] = 10.591\ [\text{TP}]^{1.237}$ N = 15; $R^2 = 0.835$; $P = 4.45\ 10^{-6}$	$[\text{Chl-a}] = 3.978\ [\text{TP}]^{1.347}$ N = 52; $R^2 = 0.896$; $P = 2.2\ 10^{-16}$

The nature of these relationships is almost always *log-log* type, which provides the highest degree of correlation. The equations in row 1 were obtained from the inverse relationship between the TRIX index and its component TP. For Type I and II A Adriatic these equations were prepared separately per water type, using the same data as those used to assess the functional relationships between TP and chlorophyll *a*. Finally, equations in row 2 exploit the relationship between TP and chlorophyll *a*, with the aim of fixing the limits among the ecological quality classes of the classification criterion, both for RCs and boundaries values.

The DIN was not elaborated further as the stepwise regression (i.e. the linear models) showed that it is not explaining the variability of the chlorophyll *a* and precise boundaries for DIN cannot be set.

2.4 Boundaries setting

With the definition of nutrients` RCs for Type I and Type II A coastal waters and the unveiling of their pressure-impact relationships, all the necessary tools are provided for defining the classification criteria for Biological Quality Element (BQE) phytoplankton in Adriatic coastal waters. Given the Trophic Index (TRIX, Vollenveider et al, 1998) was developed first for the northern Adriatic and it ecological use is well known, it was used as an internal scale in setting the boundaries.

The first step was to calculate the RCs for type I and Type II Adriatic from the functional relationship between Chla and TP (Table 5, row 2) and resulting in 0,19 µmol/L and 0,16 µmol/L, respectively.

The next in setting the boundaries was the definition of the most important boundary i.e. the Good/Moderate (G/M) boundary, which delimits the need for taking measures in case of good ecological status failure. Firstly, the boundary was set for TP, as it appeared to be the best pressure indicator for phytoplankton as explained above. The G/M boundary for TP was calculated using the equations in row 1 of Table 5, at the corresponding TRIX boundary between Good and Mediocre

Trophic Status (TRIX = 5; Giovanardi et al, 2018), which matches the transition from mesotrophic to eutrophic conditions in the coastal ecosystem.

This boundary was used for Type II A Adriatic Sea giving the values of 0.48 µmol/L. For Type I, the value of TRIX for deriving the G/M boundary was increased to 5.25, in order to take into account the nutrient loads originating from natural sources carried by the Po River into the Adriatic Sea, presumably in not negligible amounts. In this way, the G/M boundary for TP was set at 0.55 µmol/L for Type I. In the same manner all boundaries` values for Types I and II A Adriatic were calculated (Tables 6 and 7).

The identified P/B boundaries refer to "virtual" conditions, since it was not possible to detect real situations related to ecological class “Bad” in any of the datasets analysed in this work. TP concentrations characterizing “Bad” ecological class have been extrapolated from the functional relationships extended to the area of the diagrams not actually covered by observations. It is impossible to predict how coastal systems would behave with such high concentrations of phosphorus, especially since annual averages need to be determined. Therefore, this class is considered as indicative, but not strictly necessary for proper ecological classification of the BQE phytoplankton based on TP concentration.

Table 6. Reference conditions and boundaries of ecological quality classes for BQE phytoplankton expressed by different parameters for Type I coastal waters.

Boundaries	TRIX	Chl-a annual *G_Mean*	TP annual *G_Mean*
		µg/L	µmol/L
Reference Conditions	-	1.40	0.19
H/G	4.25	2.0	0.26
G/M	5.25	5.0	0.55
M/P	6.25	12.6	1.15
P/B	7	25.0	2.00

Table 7. Reference conditions and boundaries of ecological quality classes for BQE phytoplankton expressed by different parameters for Type II A Adriatic coastal waters.

Boundaries	TRIX	Chl-a annual *G_Mean*	TP annual *G_Mean*
		µg/L	µmol/L
Reference Conditions	-	0.33	0,16
H/G	4	0.64	0.26
G/M	5	1.5	0.48
M/P	6	3.5	0.91
P/B	7	8.2	1.71

Type III W Adriatic

Following the same approach used for Type I and II A waters, overall G_means of nutrients` concentrations were related to the dilution factor for Type III W. No correlation was found for DIN (R2=0.05; P=0.303), while for the TP the relationship was even inverse to the one expected (Giovanardi et al, 2018). Additionally, overall values of G_mean of chlorophyll *a* range from around 0.1 to around 0.4 µg/L. Since the ecological classification scheme consists of 5 ecological quality classes, the discrimination limit between two contiguous chlorophyll *a* annual G_mean values would not be suitable for proper and safe classification (Giovanardi et al, 2018). For that reason, a single threshold value is therefore proposed for Type III W coastal waters that is the H/G value for Type IIA Adriatic of 0,26 µmol/L.

3 The Best Practice Guide (BPG, Nutrient boundaries definition toolkit, JRC)

The document "*Best practice for establishing nutrient concentrations to support good ecological status*" is developed by the Joint Research Centre (JRC), the European Commission's science and knowledge service (Phillips et al, 2018). The purpose of the document is to help EU MSs achieve good ecological status (GES) in surface waters. It complements the Common Implementation Strategy (CIS) Guidance document on eutrophication assessment in the context of European water policies (EC, 2009) by providing advice on how to link nutrient concentrations in surface waters to specific policy objectives. It can be used to check existing boundaries` values or to develop new ones. The guidance is supported by a toolkit in the form of an Excel workbook and a series of scripts which can be run using R, an open-source language widely used for statistical analysis and graphical presentation (R Development Core Team, 2016). The toolkit provides the full R code, together with a series of examples which can be used to explore the methods.

This toolkit includes different statistical approaches to derive nutrients` boundaries, as elaborated here-below.

Univariate linear regression: Assuming a linear relationship between the ecological quality ratio (EQR) and nutrients, three regression types are implemented: two ordinary least squares OLS linear regressions between EQR and log nutrients concentration, where each variable is alternatively treated like the independent variable (because none of our two variables in practice can be considered to be free of error); and a third, type II regression, the ranged major axis (RMA) regression. The predicted range of nutrients` threshold values are then determined from the range of results obtained from these regressions' parameters.

Logistic regression: This approach treats ecological status as a categorical variable where a logistic model is fitted between categorical data using a binary response, "biology moderate or worse" = 1 or "biology good or better" = 0 and log of nutrient. Nutrient concentrations are determined where the probability of being moderate or worse was 0.5. In the case that additional pressures, other than nutrients, are suspected, a nutrient concentration value was determined at a probability of 0.75 instead of 0.5.

Categorical methods: Nutrient concentrations associated with a particular ecological status class could also be expressed as a distribution from which an upper quantile might be chosen to indicate a nutrient concentration above which good status was very unlikely to be achieved, or a lower quantile below which good status was very likely to be achieved (average of upper and lower quartiles of adjacent classes), so long as nutrients are the main driver of status. The average of the median of adjacent classes and the upper 75th percentile distribution are two additional categorical approaches tested.

Minimisation of mismatch of classification: Estimates the nutrient threshold value that minimizes the mismatch between status (good or better and moderate or worse) for the ecological and the supporting element.

Linear quantile regression: Useful alternative when the nutrient-biology interactions are confounded by other stressors, or environmental factors, leading to wedge-shape, or inverted- wedge, type of distributions. In such cases, the quantile regression allows different rates of change in the response variable to be predicted along the upper (in the presence of stressors) or lower (in the presence of mitigating environmental factors) quantiles of the distribution of the data (Cade and Noon, 2003).

Some advantages and disadvantages for some statistical approached used in this guide are presented in Table 8. The table depicts the complexity of the approaches as their possibilities.

Detailed information about the methods included in the toolkit is provided in the Guidance (Phillips et al., 2018).

Table 8. Advantages and disadvantages for some statistical approaches used in the BPG manual.

	Method Advantages/disadvantages
Linear regression	• Less reliant on class width than categorical methods (see below). • Requires linearity, at least in the region around which thresholds are being inferred. • Least sensitive to position of data cloud relative to boundary of interest.
Quantile regression	• Allows lines to be fitted that define the edges of the data cloud, which can be used to allow for the influence of other pressures or environmental factors. • No objective way to determine quantile used as there is currently insufficient understanding of pressure interactions relating to nutrients (guidance is currently being drafted and will be made available at: http://fis.freshwatertools.eu/index.php/guidance.html). • Requires a value judgement as, if an upper quantile is used, the approach risks setting too high a nutrient boundary value by overestimating the influence of other pressures. • Least sensitive to position of data cloud relative to boundary of interest.
Categorical methods 1: using boxplots	• Less dependent upon linearity. • Requires a significant difference between nutrient concentrations in adjacent classes. • Establishes thresholds based on quantiles, so needs ample data points spread throughout the classes around the boundary of interest to ensure robust estimates of parameters. Width of class can also influence position of quantiles. • Sensitive to position of data cloud, relative to the boundary of interest
Categorical methods 2: binomial logistic regression	• Allows estimates of boundary values for different probability of class. • Potentially appropriate for multiple pressures, by use of higher probability of class. • Uncertainty assessment is possible. • Less sensitive to position of data cloud relative to boundary of interest
Categorical methods 3: decision trees	• Simple to interpret. • Less dependent upon linearity and outliers. • Appropriate for multiple pressures • Allows importance of other pressures to be assessed
Categorical methods 4: Mis-match approach	• Simple to understand. • Excel tool is unable to estimate uncertainty of thresholds, however R script using bootstrapping overcomes this. • More sensitive to position of data cloud relative to boundary of interest than logistic regression, but less sensitive than boxplot methods.

4 Experience of Spain in establishment of nutrient boundary values for CW of Catalonia

The FAN (Phosphate-Ammonium-Nitrite) and FLU (FLUviality) indices method assesses the physicochemical state of coastal waters and allows nutrient boundary values to support GES to be established. This method is based on a distinctly different process to establish these values than those described in this document. Rather than using nutrient and BQE data simultaneously, it assesses the physicochemical state of coastal waters and then it relates this to the BQE. Nutrients` boundary values are then established from this relationship. This approach considers several dissolved inorganic nutrients concentrations and their stoichiometry at the same time rather than focusing on a single nutrient, as is the case when applying the toolkit.

The FAN and FLU indices method was developed using the physicochemical database of the Catalan Coastal Water Monitoring Programme. The data are representative of the north-west Mediterranean and comprise 20,102 records from 268 sampling stations collected between 1994 and 2014. A factorial analysis performed with this database revealed that the main pressures impacting coastal waters are *continental influences* (CI), which are related to gradients of dissolved inorganic nutrients, and freshwater content (inverse of salinity).

Equations for the FAN and FLU indexes were developed following Eq. (1):

$$Index_i = [(V_i*(Factor\ score\ coefficient(VT)/Standard\ deviation\ (VT)]-[Mean(VT)*Factor\ score\ coefficient(VT)/Standard\ deviation\ (VT))]+\ldots \quad (1)$$

where V_i is the value of a variable for a concrete entry and VT the value for the same variable calculated with the entire dataset of the factor analysis. Equations (2) and (3) are the final equations of the FAN and FLU indexes, respectively. These indexes are non-dimensional.

$$FAN\ index = -0.19*NO3+2.86*NO2+1.42*NH4+2.91*PO4-0.27*SiO4-0.35*FWC-0.60 \quad (2)$$
$$FLU\ index = 0.86*NO3-0.37*NO2-0.52*NH4-0.89*PO4+1.15*SiO4+0.87*FWC-2.00 \quad (3)$$

The indexes provide continuous and quantitative information on urban and fluvial continental influences.

An assessment of the physicochemical state of coastal waters based on the CI yielded results nearly equivalent (correlation of 0.93) to those obtained with the Trophic Index (TRIX) of Vollenweider et al. (1998). A further rotation applied to the factorial analysis revealed that CI is divided into two distinct gradients: levels of dissolved inorganic ammonium, phosphate, and nitrite define a gradient of urban influences while levels of dissolved inorganic silicate, and nitrate as well as the freshwater content, represent a gradient of freshwater influences or fluviality. The former is considered to reflect urban influences and the latter natural continental pressures on coastal waters (although freshwater influences are partly related to nitrate enrichment from agricultural sources).

These gradients of urban and freshwater influences were the basis for development of the FAN and FLU indices. The FAN index is scaled into five categories of water quality (high, good, moderate, poor and bad) and the FLU index into five categories of fluviality (very low, low, medium, high, and very high). The combined results provide a final assessment of the CI reaching coastal waters (urban, fluvial, mixed, or none) and, therefore, an assessment of their physicochemical state. The indices can be applied using data from inshore (0-200 m from the shore) or offshore (> 200 m from the shore) waters or both. The procedure, equations, and boundaries to apply the FAN and FLU indices together with detailed information on the method are available in Flo (2017).

5 Data availability

The elaboration of data availability for calculation of the assessment criteria for DIN and TP includes the following sources:

1) New data from IMAP Pilot Info System that include national monitoring data reported during its testing phase, and in particular after launching formal call for data reporting in June 2020;
2) All monitoring data from MEDPOL Database (i.e. data reported before 2012 that were uploaded into MEDPOL Database along with data reported to MEDPOL outside MEDPOL Database in the format of old metadata templates in period 2013-2019) that are in the process of their migration into IMAP Pilot Info System;

A summary of both data reported both to IMAP Pilot Info System and MEDPOL Database are presented in Table 9.

Table 9. Datasets from IMAP Pilot Info System and MEDPOL Database available for calculation of the assessment criteria for DIN and TP.

Country	**Data reported to MEDPOL Database**	**Data reported to IMAP Pilot Info system***	
		Validated	**Not validated**
Albania	2005-2006	-	
Algeria	2012	-	
Bosnia and Hercegovina	2006-2008	2013-2020	
Croatia	2009, 2011-2014	-	
Cyprus	1999-2015	-	2016-2019
Egypt	2009-2010; 2012;2015	-	
France	2009-2012;2013; 2016		
Greece	1999-2000, 2004-2006	-	
Israel	2001-2013; 2015	2018-2019	
Italy	-	-	
Lebanon	-		2019
Libya	-	-	
Malta	-	-	
Monaco	-	-	
Montenegro	2008-2012; 2014-2015; 2016-2017	-	2018-2019
Morocco	2006-2008; 2013-2015	-	
Syria	2007	-	
Slovenia	1999-2013, 2015-2016	2017-2019	
Spain	-	2019	
Tunisia	2002-2014	-	
Turkey	2005-2009, 2011, 2013-2015	-	

*Both validated and not validated data have been used for assessing sources for calculation of the assessment criteria for DIN and TP, given temporary not validated status may be assigned to data due to certain technical issues in IMAP Pilot Info System

It can be concluded that data available for calculation of the assessment criteria (i.e. reference conditions (RCs) and boundary values) for both DIN and TP are insufficient. Namely, for calculation of the RCs and boundary values as a minimum the following datasets need to be provided: three continuous years of monitoring with a minimum monthly frequency for Water types I and II and bimonthly to seasonal for Type III. It should also be noted that other supporting parameters (i.e. temperature, salinity and dissolved oxygen) need to be available for defining the water typology.

5.1 Albania

The table below indicates the content (parameters and years) for Albania in the MEDPOL Database. No further datasets were received from Albania.

Count of Concentration	Year		
Parameter	2005	2006	Total
Ammonium	3	3	6
Dissolved oxygen	3	3	6
Nitrate	3	3	6
Nitrate + Nitrite	3	3	6
Nitrite	3	3	6
Orthophosphate	3	3	6
Temperature (water)	3	3	6
Total phosphorus	3	3	6
Total	**24**	**24**	**48**

5.2 Algeria

The table below indicates the content (parameters and years) for Algeria in the MEDPOL Database. No further datasets were received from Algeria.

Count of Concentration	Year		
Parameters	2011	2012	Total
Ammonium	7	8	15
Conductivity	11	5	16
Dissolved oxygen	11	8	19
Nitrate	2	6	8
Orthophosphate	5	7	12
Oxygen saturation	11	8	19
pH	11	8	19
Temperature (water)	11	8	19
Total phosphorus	7	2	9
Total	**76**	**60**	**136**

5.3 Bosnia and Herzegovina

The table below indicates the content (parameters and years) for Bosnia and Herzegovina in the MEDPOL Database. Data for the period 2013-2020 were provided directly to the IMAP Pilot Info System.

Count of Concentration	Years											
Parameter	2006	2007	2008	2013	2014	2015	2016	2017	2018	2019	2020	Total
Ammonium				4	4	4	12	4	4	12	5	49
Chlorophyll a				4	4	4	12	4	4	12	5	49
Conductivity				4	4	4	12	4	4	12	5	49
Dissolved oxygen				4	4	4	12	4	4	12	5	49
Nitrate	24	28	20	4	4	4	12	4	4	12	5	121
Orthophosphate				4	4	4	12	4	4	12	5	49
Oxygen saturation				4	4	4	12	4	4	12	5	49
pH				4	4	4	12	4	4	12	5	49
Temperature (water)	24	28	20	4	4	4	12	4	4	12	5	121
Total nitrogen				4	4	4	12	4	4	12		44
Total phosphorus				4	4	4	12	4	4	12	5	49
Total	**48**	**56**	**40**	**44**	**44**	**44**	**132**	**44**	**44**	**132**	**50**	**678**

5.4 Croatia

Croatia has only the dataset for 2009 in the MED POL Database as shown in the table below. Additionally, four more years of data corresponding to monitoring years 2011, 2012, 2013 and 2014 were submitted. No further datasets were received from Croatia.

Count of Concentration	Column Labels					
Row Labels	2009	2011	2012	2013	2014	Total
Ammonium	674	1466	369	832	364	3705
Chlorophyll a	673	1472	364	794	364	3667
Dissolved oxygen	680	1524	372	842	364	3782
Nitrate	666	1485	368	842	364	3725
Nitrite	650	1499	371	832	364	3716
Orthophosphate	680	1469	336	799	325	3609
Orthosilicate	680	1500	372	842	364	3758
Salinity	680	1460	373	842	364	3719
Temperature (water)	680	1584	373	842	364	3843
Total phosphorus	674	1440	372	842	310	3638
TRIX		642	175	378	151	1346
Total	**6737**	**15541**	**3845**	**8687**	**3698**	**38508**

5.5 Cyprus

Cyprus has a more than a decade of datasets submissions from 1999 up to 2015 loaded in the MED POL Database as shown in the table below. Data for 2011 are provided but were not loaded in the MED POL data base. Data from 2016-2019 were directly provided to the IMAP Pilot Info System but due to technical problems were not evaluated.

Count of Concentration	Years													
Parameters	**1999**	**2001**	**2002**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2012**	**2013**	**2014**	**2015**	**Total**
Ammonium					29	234	109	222	115	86	66	112	114	107	1194
Chlorophyll a				128	107	235	129	132	90	71	88	108	103	90	1281
Conductivity			1												1
Dissolved oxygen					6	88	108				96				298
Nitrate		1	2	27	24	152	46	94	87	54	80	111	98	112	888
Nitrate + Nitrite												114	112	124	350
Nitrite		1	2	28	28	140	53	121	99	69	90	113	106	127	977
Orthophosphate	1	1	1	25	25	129	37	46	114	101	92	113	114	130	929
Salinity						60	107				80	111	77	34	469
Temperature (water)					6	93	108			113	97	114	75	49	655
Total nitrogen					20	211	152								383
Total phosphorus					19	219	124								362
Total	**1**	**3**	**6**	**208**	**264**	**1561**	**973**	**615**	**505**	**494**	**689**	**896**	**799**	**773**	**7787**

5.6 Egypt

Egypt has two years (2009 and 2010) of datasets submissions loaded in the MED POL Database as shown in the table below. There exist data for 2013, 2014 and 2015 but only average data per station were provided.

Count of Concentration	Years					
Parameters	**2009**	**2010**	**2013**	**2014**	**2015**	**Total**
Ammonium	30	30	30	30	30	150
Chlorophyll a	30	30	30	30	30	150
Dissolved oxygen	30	30	30	30	30	150
Nitrate	30	30	30	30	30	150
Nitrate + Nitrite	30	30				60
Nitrite	30	30	30	30	30	150
Orthophosphate	30	30	30	30	30	150
Orthosilicate	30	30	30	30	30	150
Salinity	30	30	30	30	30	150
Temperature (water)	30	30	30	30	30	150
Total nitrogen	30	30	30	30	30	150
Total phosphorus	30	30	30	30	30	150
Total	**360**	**360**	**330**	**330**	**330**	**1710**

5.7 France

For France only the data for 2009 were loaded in the MEDPOL Database. Later only data for Chlrophyll *a* concentration for years from 2012 - 2016 were provided.

Count of Concentration	Years						
Parameters	**2009**	**2012**	**2013**	**2014**	**2015**	**2016**	**Total**
Ammonium	24						24
Chlorophyll a	26	139	151	150	112	130	708
Dissolved oxygen	30	77	73	85	51	74	390
Nitrate + Nitrite	26						26
Orthophosphate	24						24
Orthosilicate	28						28
Salinity	34	134	189	181	151	179	868
Temperature (water)	34	138	190	183	157	179	881
Total	**226**	**488**	**603**	**599**	**471**	**562**	**2949**

5.8 Greece

Greece has only tree years' submissions and were loaded in the MED POL Database (table below). No further data has been submitted.

Count of Concentration	Years			
Row Labels	**2004**	**2005**	**2006**	**Total**
Ammonium	43	213	79	335
Dissolved oxygen	39	211	75	325
Nitrate	43	215	79	337
Nitrate + Nitrite	31	33		64
Nitrite	41	213	79	333
Orthophosphate	43	215	79	337
Orthosilicate	43	215	79	337
Salinity	43	215	79	337
Temperature (water)	43	215	79	337
Total nitrogen	43	196	79	318
Total	**412**	**1941**	**707**	**3060**

5.9 Israel

Israel has the most comprehensive track record in monitoring data (including other categories such as atmospheric, rivers, effluents, etc.) and were loaded in the MED POL Database until 2012. Datasets for 2015 and 2017 are also available to be transferred to IMAP Pilot Info System.

Count of Concentration	Year													
Parameter	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2018**	**2019**	**Total**
Ammonium	17	9	14	17	10	10	16	4	17	17	17	16	14	14	192
Chlorophyll a	17	17	17	17	10	10	16	4	17	17	17	17	14	14	204
Dissolved oxygen	17	17	17	17	10	10	17	17	17	16	17	17	13	14	216
Nitrate		17	17	16	8	8	17	4	2	16	17	13	14	14	163
Nitrate + Nitrite	17	17	17	16	8	8	17	17	17	17	17	17	14	14	213
Nitrite	14	14	13	11	7	3	15	4	17	17	12	17	14	14	172
Orthophosphate	17	17	17	17	10	9	17	17	17	17	17	15	14	14	215
Orthosilicate	17	17	17	17	10	10	17	14	6	17	16	17	14	14	203
Salinity							17	17	17	16	17	17	13	14	128
Temperature (water)	17	17	17	17	10	10	17	17	17	16	17	17	13	14	216
Total nitrogen		17	17	17	10	10	17		4	17	17	17	14	14	171
Total	**133**	**159**	**163**	**162**	**93**	**88**	**183**	**115**	**148**	**183**	**181**	**180**	**151**	**154**	**2093**

5.10 Italy, Libya, Malta, Monaco and Syria

No data related to EO5 from these Contracting Parties has ever been received.

5.11 Lebanon

Lebanon provided the first data set (2019) directly to the IMAP Pilot Info System.

Count of Concentration	Years	
Parameters	**2019**	**Total**
Chlorophyll a	186	186
Nitrate	256	256
Nitrate + Nitrite	256	256
Nitrite	256	256
Orthophosphate	256	256
Orthosilicate	40	40
Salinity	256	256
Temperature (water)	256	256
Total	**1762**	**1762**

5.12 Montenegro

Datasets related to chemical pollution were recorded in the MED POL Database until the year 2011 as shown in the table below. Montenegro submitted later, datasets for 2014, 2016 and 2017. Data are in the phase of migration to the IMAP Pilot Info System. The dataset for 2019 were provided directly to the IMAP Pilot Info System.

Count of Concentration	Years	
Parameters	2018	Total
Ammonium	146	146
Chlorophyll a	206	206
Dissolved oxygen	206	206
Nitrate	199	199
Nitrate + Nitrite	206	206
Nitrite	196	196
Orthophosphate	168	168
Orthosilicate	206	206
Oxygen saturation	206	206
pH	206	206
Salinity	206	206
Secchi disk depth	206	206
Temperature (water)	206	206
Total nitrogen	206	206
Total phosphorus	175	175
TRIX	206	206
Total	**3150**	**3150**

Parameter Code	Parameter Group Code	2008	2009	2010	2011
CHL-A	Ecological Parameters	Y	Y	Y	Y
NH4-N	Nutrients	Y	Y	Y	Y
NO3-N	Nutrients	Y	Y	Y	Y
SIO4	Nutrients	Y	Y	Y	Y
TP	Nutrients	Y	Y	Y	Y
NO2-N	Nutrients	Y	Y	Y	Y
PO4-P	Nutrients	Y	Y	Y	Y

5.13 Morocco

Morocco submitted only data for 2006 and 2007. Later data for the period 2011-2018 were submitted but are related to point sources and can be only partialy be used. Data need a substantial revision.

Count of Concentration	Years		
Parameters	2006	2007	Total
Ammonium	16	16	32
Nitrate	16	14	30
Nitrite	16		16
Orthophosphate	29	15	44
Orthosilicate	31		31
Temperature (water)	31	16	47
Total nitrogen	32	16	48
Total phosphorus	32	16	48
Total	**203**	**93**	**296**

5.14 Slovenia

Slovenian datasets were included until the year 2012 in the MED POL Database as the country submitted regularly and timely. The years from 2013-2019 have been submitted to the Secretariat and were uploaded in the IMAP Pilot Info System. The dataset is the most complete one.

Count of Concentration	Years																			
Parameters	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2015**	**2016**	**2017**	**2018**	**2019**	**Total**
Ammonium	57	48	277	233	204	107	112	7	105	108	216	93	102	202	40	99	160	184	160	2514
Chlorophyll a														101	96	99	216	222	240	974
Dissolved oxygen	57	74	276	230	204	107	124	7	105	108	216	102	102	204	128	99	288	296	240	2967
Nitrate	57	48	277	234	204	107	124	7	102	108	216	101	102	201	40	99	160	184		2371
Nitrate																			160	160
Nitrate + Nitrite						107	124													231
Nitrate + Nitrite																			160	160
Nitrite	57	48	277	234	204	107	124	7	92	108	216	99	102	202	40	99	160	184	160	2520
Orthophosphate	57	48	277	234	204	107	124	7	103	108	192	100	85	202	40	99	160	184	160	2491
Orthosilicate	17	48	265	234	204	107	124	9	106	123	214	102	102	200	40	99	160	184		2338
Oxygen saturation						89	114							102	128	99	288	296	240	1356
pH	57	48																296	240	641
Salinity	17	48						7	104	102	212	102	102	204	128	99	288	296	240	1949
Secchi disk depth																		74	60	134
Temperature (water)	74	122	277	234	204	107	124	7	105	108	216	102	102	204	128	99	288	296	240	3037
Total nitrogen	57	48	276	234	204	107	124	7	105	108	216	102	102	200	40	99	160	184	160	2533
Total phosphorus	57	48	277	234	204	107	124	7	105	108	216	102	102	202	40	99	160	184	160	2536
TRIX	45	168	204			89								100	40	99	160	182	160	1247
Total	**609**	**796**	**2683**	**2101**	**1836**	**1248**	**1342**	**72**	**1032**	**1089**	**2130**	**1005**	**1003**	**2324**	**928**	**1287**	**2648**	**3246**	**2780**	**30159**

5.15 Spain

Spain started providing data in the 2019 and provided only a partial one only for nutrients directly to the IMAP Pilot Info System.

Count of Concentration	Years	
Parameters	**2019**	**Total**
Ammonium	8	8
Nitrate	86	86
Nitrite	95	95
Orthophosphate	95	95
Total	**284**	**284**

5.16 Tunisia

The datasets from Tunisia were loaded in the MED POL Database until 2012. Later on the years 2013 and 2014 have been received and are available for upload into IMAP Pilot Info System despite the format issues and few data available.

Count of Concentration	Years													
Parameters	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**Total**
Chlorophyll a	7	7	7	7	8	8	7		9	5	8	15	7	95
Dissolved oxygen								5	5	8	8	15		41
Salinity					8		8	9	9	8	8	15	8	73
Temperature (water)		7	7	7	8	8	8	9	9	8	8	15	9	103
Total nitrogen	7	7	7	7	8	8	8	9	9	8	8	15	9	110
Total phosphorus	7	7	7	7	8	8	8	9	9	8	8	15	9	110
Total	**21**	**28**	**28**	**28**	**40**	**32**	**39**	**41**	**50**	**45**	**48**	**90**	**42**	**532**

5.17 Turkey

Turkey submitted data from 2005 up to 2010 and for 2011 was loaded in the MED POL Database (see table below). Later on, datasets are available for the years 2013, 2014 and 2015 in an increased monitoring exploratory effort by Turkey.

Count of Concentration	**Years**									
Parameters	**2005**	**2006**	**2007**	**2008**	**2009**	**2011**	**2013**	**2014**	**2015**	**Total**
Ammonium	42	47	92	116	67	254		534	584	1736
Chlorophyll a	41	41	88	112	63	254		366	501	1466
Dissolved oxygen	43	47	92	116	67	254	56	502	853	2030
Nitrate	43	47	92	50	49			199	208	688
Nitrate + Nitrite	43	47	92	116	67	254		534	906	2059
Nitrite	43	47	92	50	49			203	208	692
Orthophosphate	43	47	92	116	67	254		534	918	2071
Orthosilicate	43	47	68	74	49	254		534	900	1969
Oxygen saturation								501	917	1418
pH	43	42	46	46	45	253		533	917	1925
Salinity							56	535	917	1508
Secchi disk depth								388	194	582
Temperature (water)	43	47	92	116	67	254	56	535	917	2127
Total nitrogen						254		312	644	1210
Total phosphorus	43	47	92	116	66	254		512	918	2048
TRIX								244	199	443
Total	**470**	**506**	**938**	**1028**	**656**	**2539**	**168**	**6966**	**10701**	**23972**

Data available in the EU data center (European Marine Observation and Data Network - EMODnet)

Given scarcity of data reported into IMAP Pilot Info System and MEDPOL Database, data availability in EMODnet has also been explored (Tables 9 and 10, Figure 3). In Annex II a summary output is presented regarding a query for Chlorophyll a and nutrients data collected in the Mediterranean Sea in the period 2015-2020 from EMODnet database. However, it must be noted that EMODnet data are limited only to Croatia, France, Greece, Israel, Italy, Montenegro, Spain, Tunisia and Turkey. There is also different format of EMODnet data compared to data reported into IMAP Pilot Info System. Therefore, a significant further work is needed to correlate and aggregate two data sources.

Table 10. Datasets for Chlorophyll a and nutrients by Country available at EMODnet, for period 2015-2020.

Country	Total available data	Unrestricted
Croatia	429	-
France	2344	493
Greece	229	-
Israel	29	29
Italy	2156	1247
Montenegro	146	-
Spain	244	-
Tunisia	29	-
Turkey	726	180

Table 11. Datasets for Chlorophyll a and nutrients by parameter available at EMODnet, for period 2015-2020.

Parameter	Datasets
Chlorophyll pigment concentrations in water bodies	6270
Dissolved oxygen parameters in the water column	4655
Nitrate concentration parameters in the water column	3140
Ammonium and ammonia concentration parameters in water bodies	3079
Silicate concentration parameters in the water column	3020
Nitrite concentration parameters in the water column	2972
Phosphate concentration parameters in the water column	2926
Dissolved total or organic phosphorus concentration in the water column	1749
Dissolved total and organic nitrogen concentrations in the water column	2217
Dissolved inorganic nitrogen concentration in the water column	395
Particulate total and organic phosphorus concentrations in the water column	175

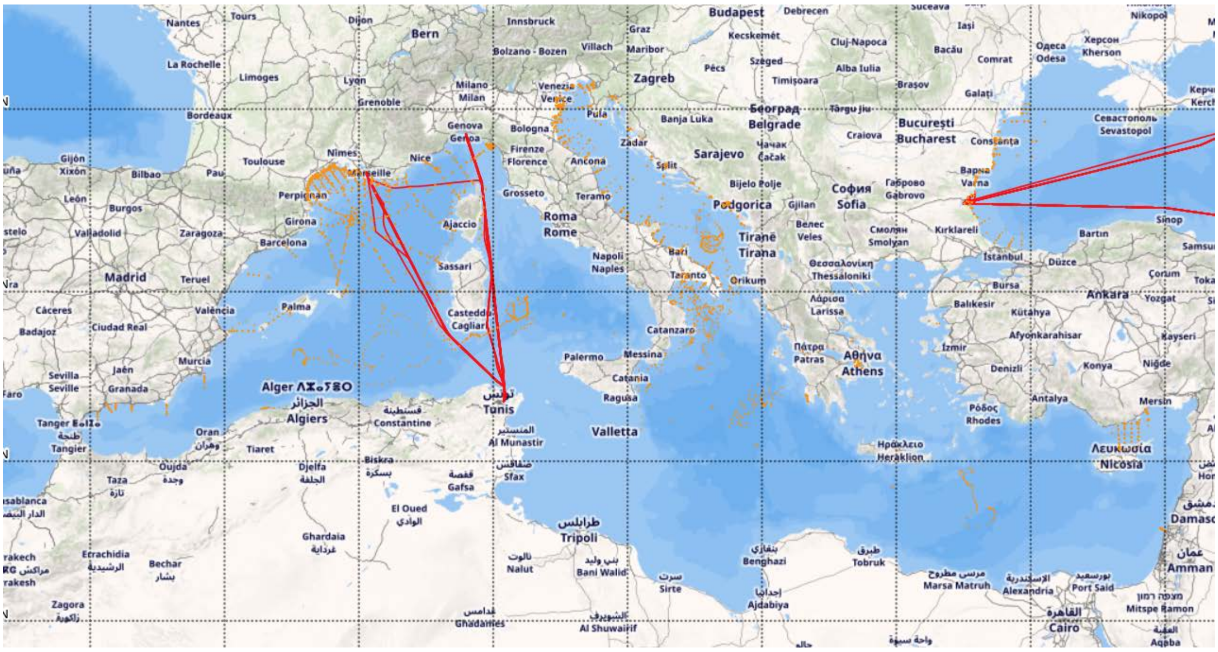


Figure 3. Stations for Chlorophyll a and nutrients available at EMODnet, for period 2015-2020.

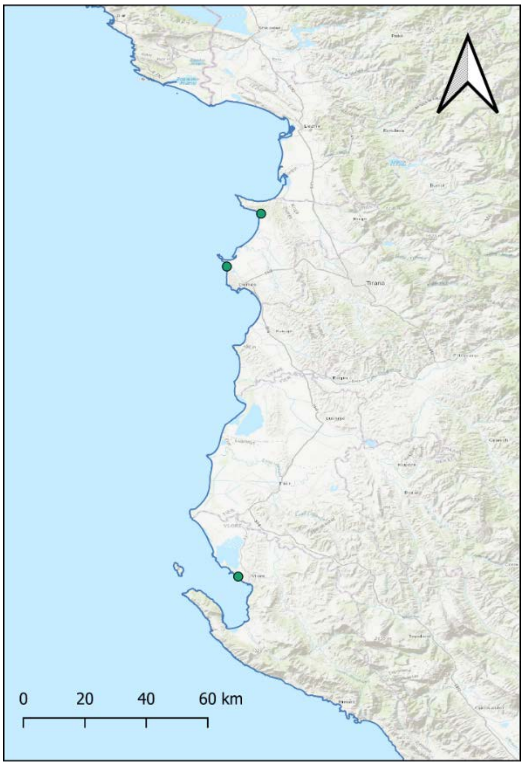
Annex I

Visual presentation of monitoring stations

This Annex provides visual presentation of the geographical positions of the monitoring stations as they can be reported in the IMAP Pilot Info System and MEDPOL Database. The maps are of general quality (ESRI Topo Hybrid), not indicating any official border. As such maps should be used for indicative purpose.

Albania

Albania aims to provide data for tree stations.

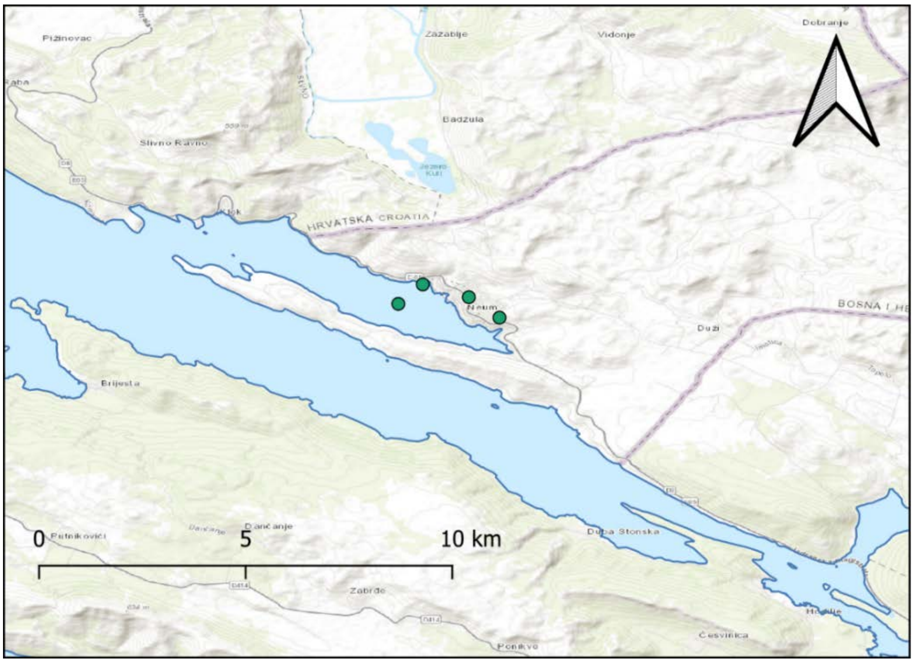


Algeria

Algeria aims to provide data for 10 stations.

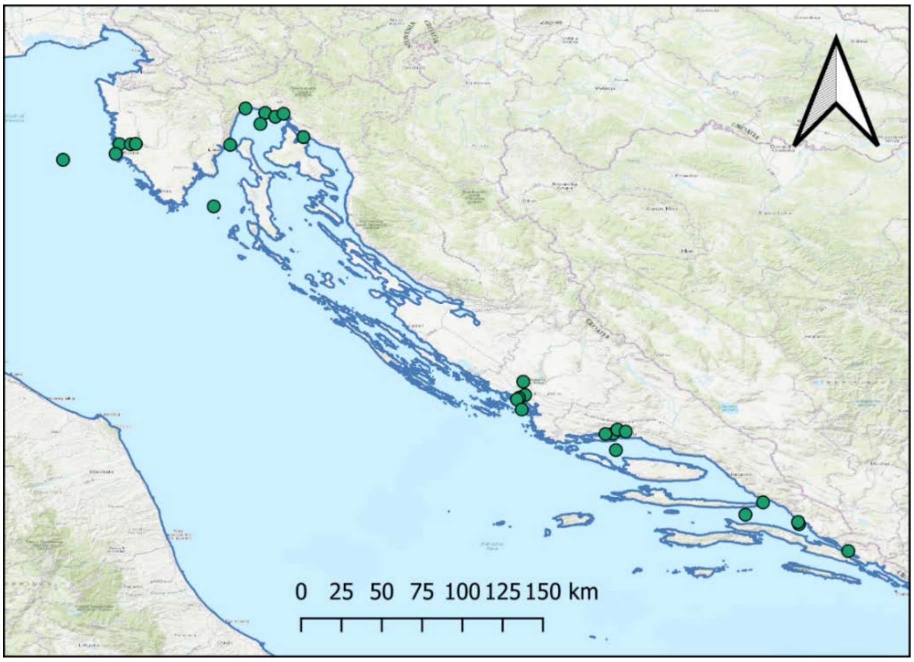
Bosnia and Herzegovina

Bosnia and Herzegovina aims to provide data for four stations.



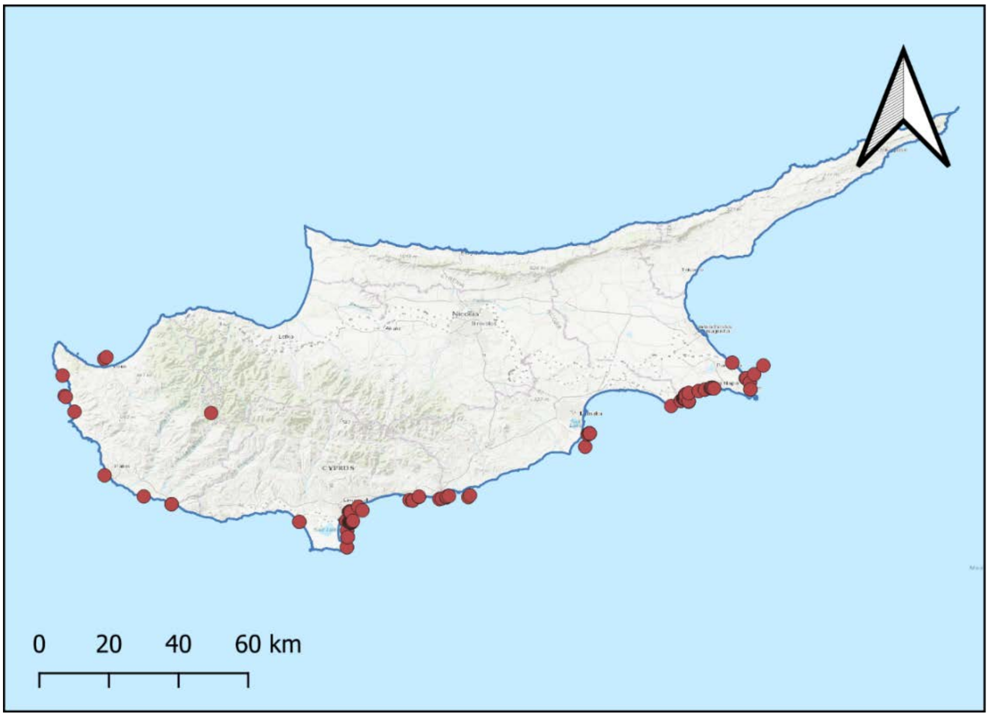
Croatia

Croatia aims to provide data for 28 stations.



Cyprus

Provided aims to provide for 125 stations.

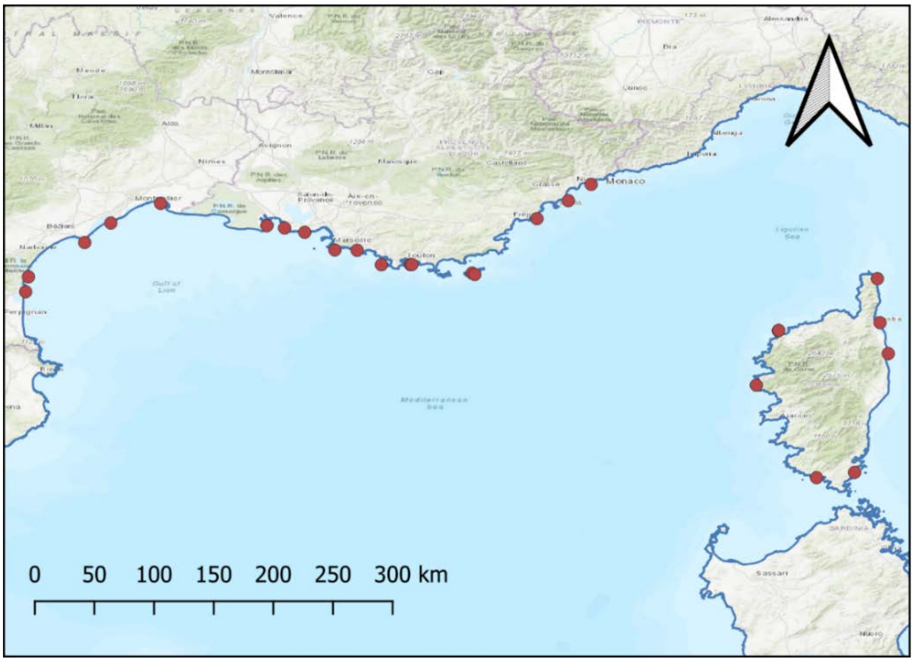


Egypt

Egypt aims to provide data for 31 stations.

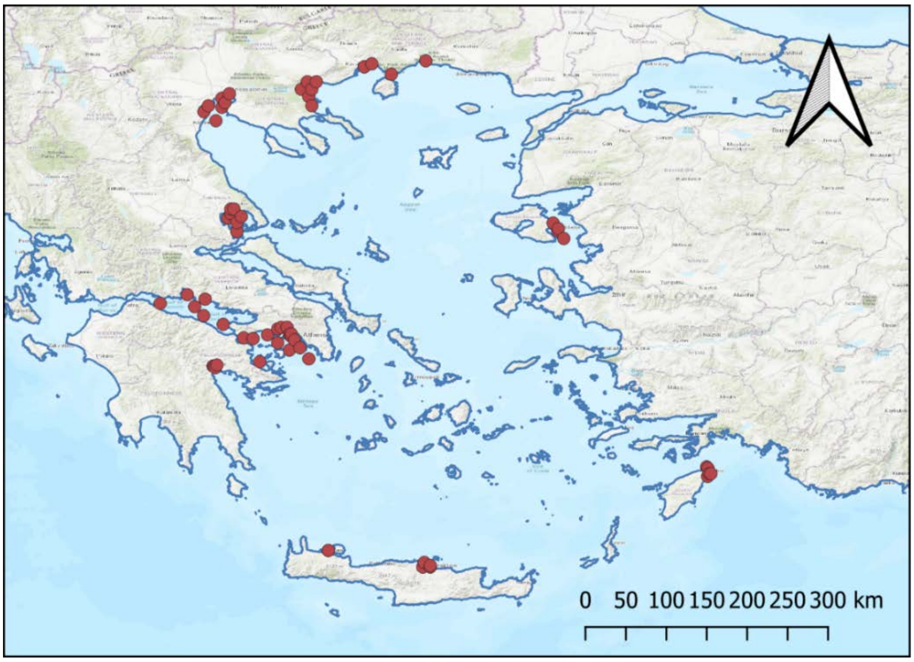
France

France aims to provide data for 26 stations.



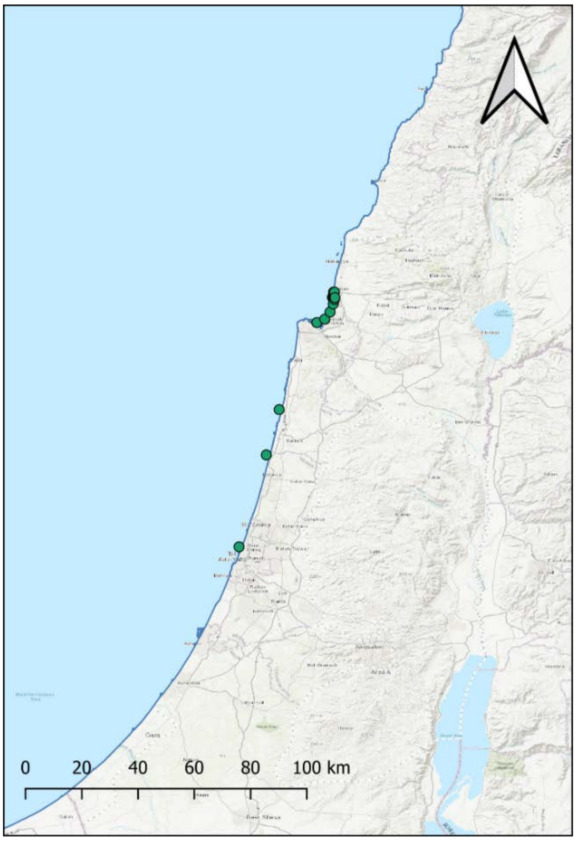
Greece

Greece aims to provide data for 65 stations.



Israel

Israel aims to provide data for 14 stations.

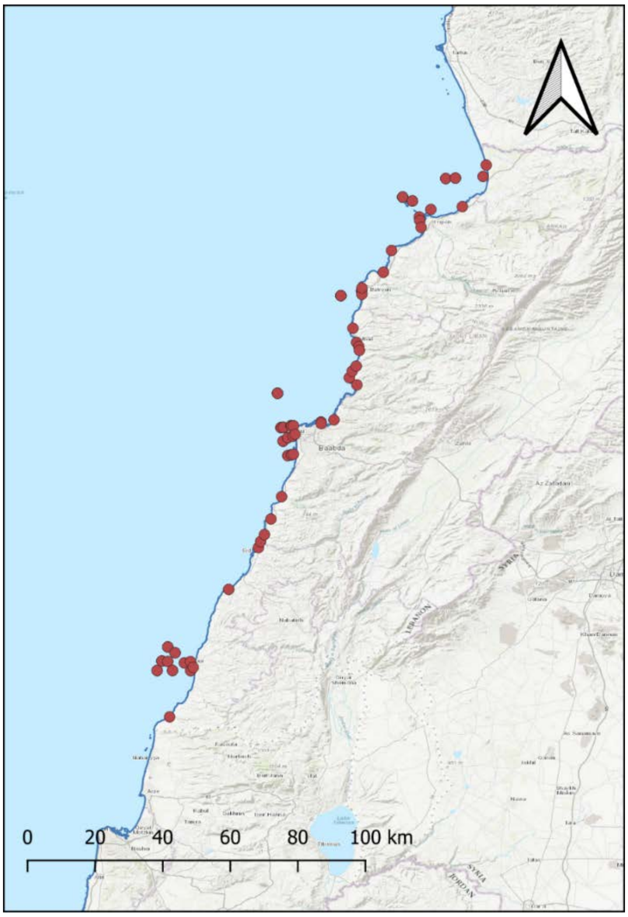


Italy, Libya, Malta, Monaco and Syria

No data related to EO5 from these Contracting Parties has been received.

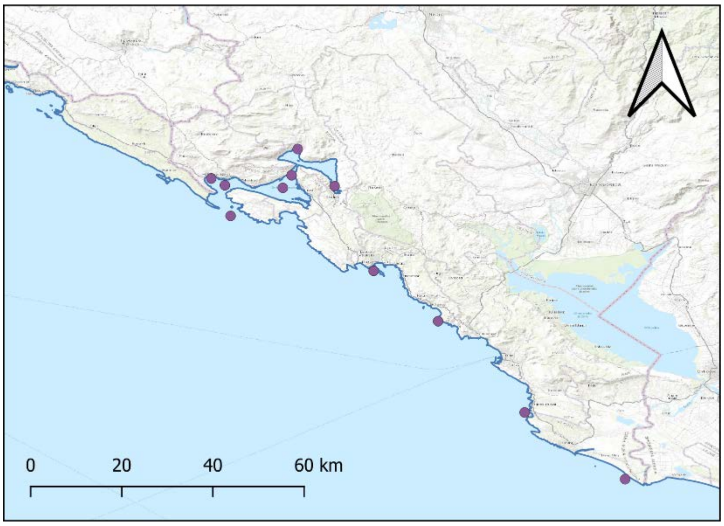
Lebanon

Lebanon provided data for 98 stations.



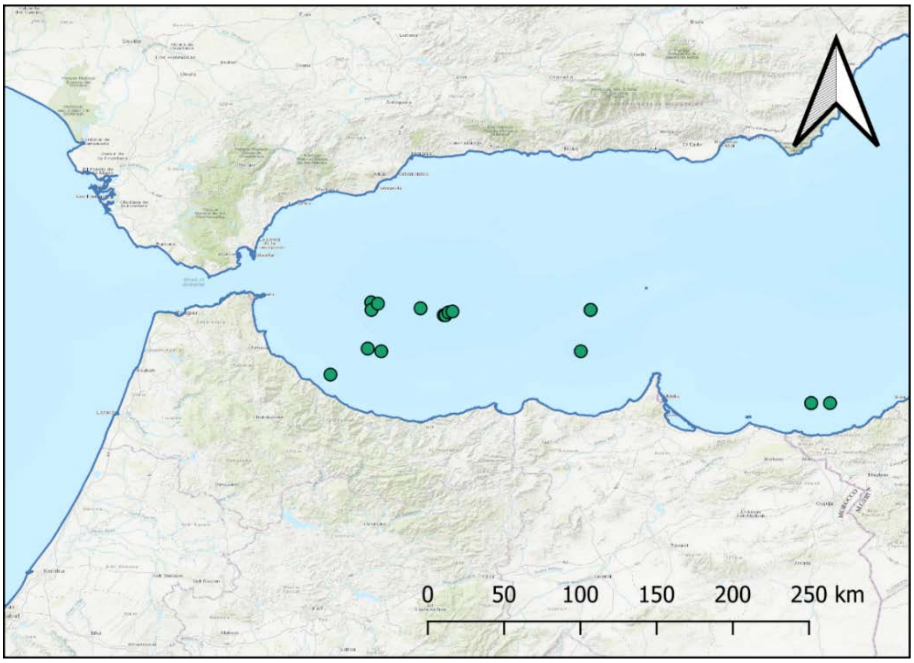
Montenegro

Montenegro aims to provide data for 11 stations.



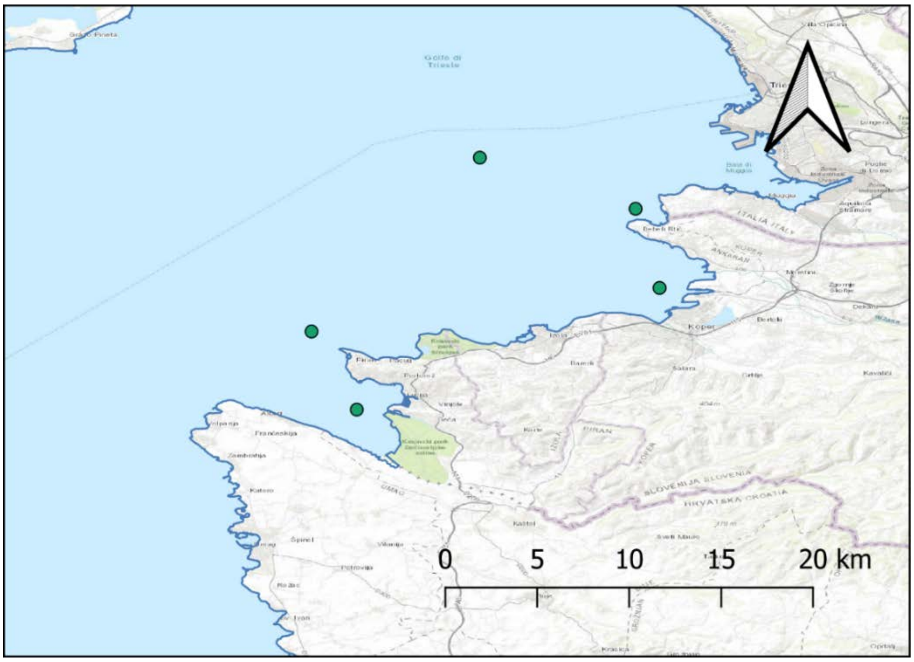
Morocco

Morocco aims to provide data for 20 stations.



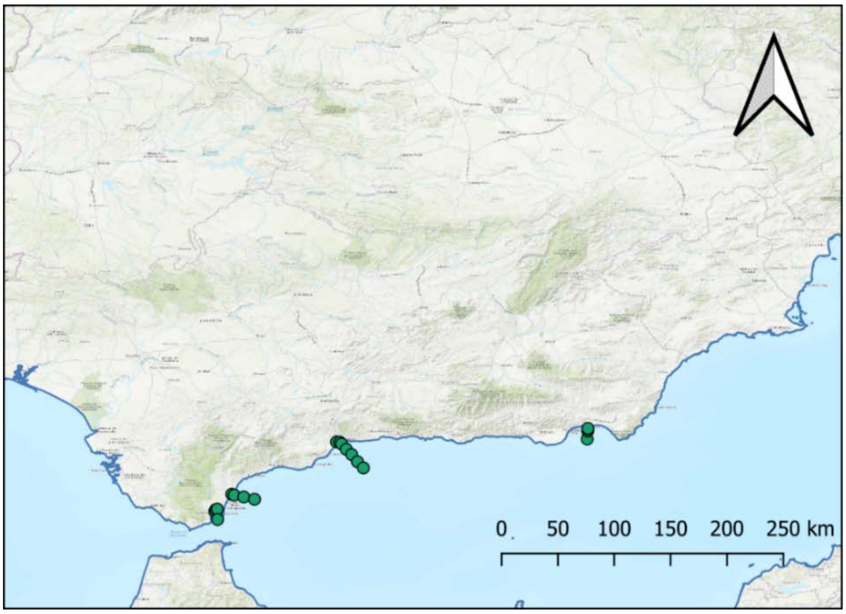
Slovenia

Slovenia aims to provide data for 5 stations.



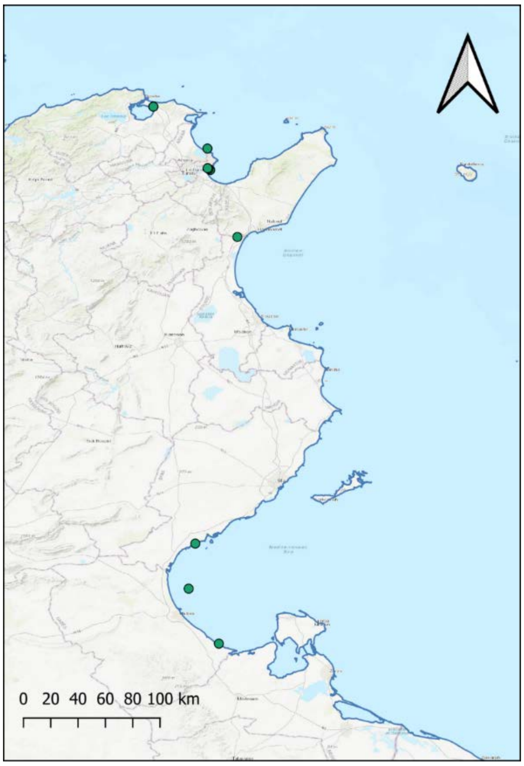
Spain

Spain aims to provide data for 19 stations.



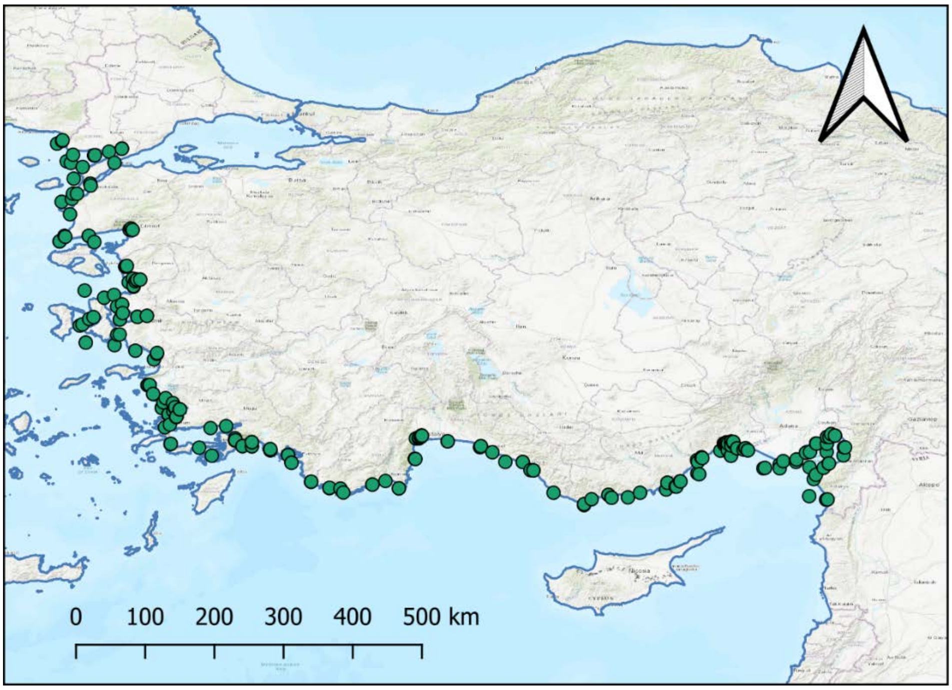
Tunisia

Tunisia aims to provide data for 10 stations.



Turkey

Turkey aims to provide data for 250 stations.



Annex II

Summary output from a query for Chlorophyll a and nutrients data collected in the Mediterranean Sea in the period 2015-2020 from EMODnet database

SUMMARY OF QUERY RESULTS FROM CDI - Marine data access (CDI) V5.
****
"Point of contact"
****
"Per Point of contact","Point of contact code","Country Point of contact","Datasets"
"IFREMER, SISMER, Scientific Information Systems for the SEA","486","France","2132"
"ISPRA-Institute for Environmental Protection and Research","3009","Italy","1247"
"OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale), Division of Oceanography","120","Italy","709"
"Institute of Marine Sciences, Middle East Technical University","696","Turkey","684"
"Institute of Oceanography and Fisheries","700","Croatia","429"
"IEO, Spanish Oceanographic Institute","353","Spain","244"
"Hellenic Centre for Marine Research, Hellenic National Oceanographic Data Centre (HCMR/HNODC)","269","Greece","229"
"National Institute of Biology, Marine Biology Station","1229","Slovenia","192"
"Institute of Marine Biology (IMBK)","2432","Montenegro","146"
"CNR, National Research Council, Institute of Atmospheric Sciences and Climate, Rome","149","Italy","109"
"ENEA Centro Ricerche Ambiente Marino, La Spezia","136","Italy","89"
"Institut National des Sciences et Technologies de la Mer, INSTM","1232","Tunisia","29"
"Israel Oceanographic and Limnological Research ","963","Israel","29"
"Institute for Marine Biological Resources and Biotechnology, Ancona","5060","Italy","2"

****
"Data originator"
****
"Per Data Originator","Data originator code","Country Originator","Datasets"
"ISPRA-Institute for Environmental Protection and Research","3009","Italy","1247"
"Laboratory of Oceanography and Climate: Experiments and numerical Approaches, UMR 7159","494","France","645"
"Institute of Marine Sciences, Middle East Technical University","696","Turkey","504"
"OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale), Division of Oceanography","120","Italy","495"
"IFREMER, STATION DE SETE","721","France","451"
"Laboratory of Oceanography of Villefranche, UMR 7093","490","France","395"
"Villefranche Sea Institute, FR 3761","5041","France","369"
"Institute of Oceanography and Fisheries","700","Croatia","281"
"IEO, Spanish Oceanographic Institute","353","Spain","244"
"Hellenic Centre for Marine Research, Institute of Oceanography (HCMR/IO)","164","Greece","229"
"University of Kyrenia","4748","Turkey","180"
"Oceanological Observatory of Villefranche sur Mer","3928","France","169"
"Center for marine research, Rudjer Boskovic Institute","702","Croatia","152"
"Institute of Marine Biology (IMBK)","2432","Montenegro","146"
"National Institute of Biology, Marine Biology Station","1229","Slovenia","144"
"Adriatic LNG","4997","Italy","139"
"CNR, National Research Council, Institute of Atmospheric Sciences and Climate, Rome","149","Italy","109"
"ENEA Centro Ricerche Ambiente Marino, La Spezia","136","Italy","89"
"OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale), Department of Biological Oceanography","2431","Italy","72"
"Oceanologic Observatory of Banyuls (University of Paris VI), OSU","1015","France","55"
"Environmental Agency of the Republic of Slovenia","1755","Slovenia","48"
"Institut National des Sciences et Technologies de la Mer, INSTM","1232","Tunisia","29"
"Israel Oceanographic and Limnological Research ","963","Israel","29"

"IFREMER, ENVIRONMENT RESOURCES LABORATORY PROVENCE AZUR CORSICA , LA SEYNE-SUR-MER","4606","France","23"

"Ifremer, VIGIES (Information Valuation Service for Integrated Management and Monitoring)","1838","France","20"

"IFREMER, RBE, Biogeochimical end Ecotoxicological Resarch Unit (Brest)","1888","France","9"

"Mediterranean Institute of Oceanography, UMR 7294 UMR IRD 235, MARSEILLE","3078","France","5"

"CNR, National Research Council, Institute of Marine Science, Bologna","145","Italy","2"

"University of Tuscia-Viterbo","1631","Italy","2"

"Joint Research Centre ","642","Italy","1"

****

"Data custodian"

****

"Per Point of contact","Point of contact code","Country Point of contact","Per Custodian","Custodian code","Country Custodian","Datasets"

"IFREMER, SISMER, Scientific Information Systems for the SEA","486","France","IFREMER, SISMER, Scientific Information Systems for the SEA","486","France","2112"

"ISPRA-Institute for Environmental Protection and Research","3009","Italy","ISPRA-Institute for Environmental Protection and Research","3009","Italy","1247"

"OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale), Division of Oceanography","120","Italy","OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale), Division of Oceanography","120","Italy","709"

"Institute of Marine Sciences, Middle East Technical University","696","Turkey","Institute of Marine Sciences, Middle East Technical University","696","Turkey","684"

"Institute of Oceanography and Fisheries","700","Croatia","Institute of Oceanography and Fisheries","700","Croatia","429"

"IEO, Spanish Oceanographic Institute","353","Spain","IEO, Spanish Oceanographic Institute","353","Spain","244"

"Hellenic Centre for Marine Research, Hellenic National Oceanographic Data Centre (HCMR/HNODC)","269","Greece","Hellenic Centre for Marine Research, Hellenic National Oceanographic Data Centre (HCMR/HNODC)","269","Greece","229"

"National Institute of Biology, Marine Biology Station","1229","Slovenia","National Institute of Biology, Marine Biology Station","1229","Slovenia","192"

"Institute of Marine Biology (IMBK)","2432","Montenegro","Institute of Marine Biology (IMBK)","2432","Montenegro","146"

"CNR, National Research Council, Institute of Atmospheric Sciences and Climate, Rome","149","Italy","CNR, National Research Council, Institute of Atmospheric Sciences and Climate, Rome","149","Italy","109"

"ENEA Centro Ricerche Ambiente Marino, La Spezia","136","Italy","ENEA Centro Ricerche Ambiente Marino, La Spezia","136","Italy","89"

"Israel Oceanographic and Limnological Research ","963","Israel","Israel Oceanographic and Limnological Research ","963","Israel","29"

"Institut National des Sciences et Technologies de la Mer, INSTM","1232","Tunisia","Institut National des Sciences et Technologies de la Mer, INSTM","1232","Tunisia","29"

"IFREMER, SISMER, Scientific Information Systems for the SEA","486","France","Ifremer, VIGIES (Information Valuation Service for Integrated Management and Monitoring)","1838","France","20"

"Institute for Marine Biological Resources and Biotechnology, Ancona","5060","Italy","Institute for Marine Biological Resources and Biotechnology, Ancona","5060","Italy","2"

****

"Data distributor"

****

"Per Point of contact","Point of contact code","Country Point of contact","Per Distributor","Distributor code","Country Distributor","Datasets"

"IFREMER, SISMER, Scientific Information Systems for the SEA","486","France","IFREMER, SISMER, Scientific Information Systems for the SEA","486","France","2132"

"ISPRA-Institute for Environmental Protection and Research","3009","Italy","ISPRA-Institute for Environmental Protection and Research","3009","Italy","1247"

"OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale), Division of Oceanography","120","Italy","OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale), Division of Oceanography","120","Italy","709"

"Institute of Marine Sciences, Middle East Technical University","696","Turkey","Institute of Marine Sciences, Middle East Technical University","696","Turkey","684"

"Institute of Oceanography and Fisheries","700","Croatia","Institute of Oceanography and Fisheries","700","Croatia","429"

"IEO, Spanish Oceanographic Institute","353","Spain","IEO, Spanish Oceanographic Institute","353","Spain","244"

"Hellenic Centre for Marine Research, Hellenic National Oceanographic Data Centre (HCMR/HNODC)","269","Greece","Hellenic Centre for Marine Research, Hellenic National Oceanographic Data Centre (HCMR/HNODC)","269","Greece","229"

"National Institute of Biology, Marine Biology Station","1229","Slovenia","National Institute of Biology, Marine Biology Station","1229","Slovenia","192"

"Institute of Marine Biology (IMBK)","2432","Montenegro","Institute of Marine Biology (IMBK)","2432","Montenegro","146"

"CNR, National Research Council, Institute of Atmospheric Sciences and Climate, Rome","149","Italy","CNR, National Research Council, Institute of Atmospheric Sciences and Climate, Rome","149","Italy","109"

"ENEA Centro Ricerche Ambiente Marino, La Spezia","136","Italy","ENEA Centro Ricerche Ambiente Marino, La Spezia","136","Italy","89"

"Israel Oceanographic and Limnological Research ","963","Israel","Israel Oceanographic and Limnological Research ","963","Israel","29"

"Institut National des Sciences et Technologies de la Mer, INSTM","1232","Tunisia","Institut National des Sciences et Technologies de la Mer, INSTM","1232","Tunisia","29"

"Institute for Marine Biological Resources and Biotechnology, Ancona","5060","Italy","Institute for Marine Biological Resources and Biotechnology, Ancona","5060","Italy","2"

****

"Matrix categories"

****

"Per Matrix Categoreis","Datasets"

"water body","6270"

****

"Groups of variables"

****

"Per Parameter group","Datasets"

"Chlorophyll","6270"

"Dissolved gasses","4655"

"Fertilisers","3161"

"Silicates","3020"

"Acidity","1589"

"Organic matter","654"

****

"Discovery Parameter"

****

"Per Discovery parameter","Datasets"

"Chlorophyll pigment concentrations in water bodies","6270"

"Dissolved oxygen parameters in the water column","4655"

"Nitrate concentration parameters in the water column","3140"

"Ammonium and ammonia concentration parameters in water bodies","3079"

"Silicate concentration parameters in the water column","3020"

"Nitrite concentration parameters in the water column","2972"

"Phosphate concentration parameters in the water column","2926"

"Dissolved total or organic phosphorus concentration in the water column","2217"

"Dissolved total and organic nitrogen concentrations in the water column","1749"
"Alkalinity, acidity and pH of the water column","1589"
"Concentration of organic matter in water bodies","488"
"Dissolved inorganic nitrogen concentration in the water column","395"
"Particulate total and organic phosphorus concentrations in the water column","175"
"Particulate total and organic nitrogen concentrations in the water column","173"
"Dissolved organic carbon concentration in the water column","132"
"Particulate total and organic carbon concentrations in the water column","128"
"Total dissolved inorganic carbon (TCO2) concentration in the water column","98"

****
"Instrument Type"
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"Per Instrument type","Datasets","Duration in hours","Duration in days","Duration in years"
"CTD","2109","83.413","3.476","9,52"
"discrete water samplers","2032","923","38","0,11"
"unknown","1426","11.326.331","471.930","1.292,96"
"fluorometers","615","4.540","189","0,52"
"acoustic tracking systems","469","469","20","0,05"
"water temperature sensor","449","4.519","188","0,52"
"salinity sensor","449","4.519","188","0,52"
"titrators","291","5","0","0,00"
"autoanalysers","198","3","0","0,00"
"observers","113","2","0","0,00"
"pH sensors","110","2","0","0,00"
"spectrophotometers","94","131.498","5.479","15,01"
"salinometers","93","2","0","0,00"
"satellite tracking system","19","19","1","0,00"
"continuous water samplers","8","175","7","0,02"
"dissolved gas sensors","3","4.511","188","0,51"
"transmissometers","1","4.511","188","0,51"

****
"Platform type"
****
"Per Platform type","Datasets","Duration in hours","Duration in days","Duration in years"
"research vessel","3580","698.509","29.105","79,74"
"ship","1960","6.964.484","290.187","795,03"
"drifting subsurface profiling float","302","5","0","0,00"
"fishing vessel","213","4","0","0,00"
"vessel of opportunity","167","3","0","0,00"
"unknown","20","3.666.219","152.759","418,52"
"drifting subsurface float","19","19","1","0,00"
"mooring","5","82.092","3.420","9,37"
"moored surface buoy","2","0","0","0,00"
"offshore structure","1","131.496","5.479","15,01"
"subsurface mooring","1","4.511","188","0,51"

****
"Year"
****

"Per Year","Datasets"
"2020","68"
"2019","566"
"2018","754"
"2017","1460"
"2016","1568"
"2015","1938"
"2014","279"
"2013","276"
"2012","116"
"2011","21"
"2010","21"
"2009","21"
"2008","18"
"2007","18"
"2006","18"
"2005","12"
"2004","12"
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"2000","9"
"1999","9"
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"1991","8"
"1990","8"
"1989","8"
"1988","8"
"1987","4"

****
"Data Access restriction"
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"Per Data access restrictions","Datasets"
"SeaDataNet licence","3041"
"unrestricted","1758"
"by negotiation","1450"
"no access","21"

Annex III
References

Argyrou, M. (2005) Report of the National Monitoring Programme of Cyprus for the Year 2004. Programme for the Assessment and Control of Pollution in the Mediterranean Region(MEDPOL /UNEP). Department of Fisheries and Marine Research, pp. 32.

Argyrou, M. (2006) Report of the National Monitoring Programme of Cyprus for the Year 2005. Programme for the Assessment and Control of Pollution in the Mediterranean Region(MEDPOL /UNEP). Depa,rtment of Fisheries and Marine Research, pp. 41.

Berman, T., Townsend, D.W., Elsayed, S.Z., Trees, C.C., Azov, Y. (1984). Optical transparency, chlorophyll and primary productivity in the Eastern Mediterranean near the Israeli coast. Oceanologica Acta 7: 367–372.

Bianchi, T.S., A. Demetropoulos, M. Hadjichristophorou, M. Argyrou, M. Baskaran and C. Lambert. (1996) Plant Pigments as Biomarkers of Organic Matter Sources in Sediments and Coastal Waters of Cyprus (eastern Mediterranean). Estuarine, Coastal and Shelf Science, 42:103-115.

Borja, A., Elliott, M., Henriksen, P., and Marb, N. (2013). Transitional and coastal waters ecological status assessment: advances and challenges resulting from implementing the European water framework directive. Hydrobiologia 704, 213–229. doi: 10.1007/s10750-012-1276-9

Cade, B.S. and Noon, B.R. (2003). A gentle introduction to quantile regression for ecologists. Frontiers in Ecology and the Environment 1: 412-420.

COP 19. (2016). Decision IG.22/7 - Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Sea and Coast and Related Assessment Criteria. COP19, Athens, Greece. United Nations Environment Programme, Mediterranean Action Plan, Athens.

Devlin, M., Best, M., Coates, D., Bresnan, E., O’Boyle, S., Park, R., et al. (2007). Establishing boundary classes for the classification of UK marine waters using phytoplankton communities. Mar. Pollut. Bull. 55, 91–103. doi: 10.1016/j. marpolbul.2006.09.018

Dworak, T., Berglund, M., Haider, S., Leujak, W. and Claussen, U. (2016). A comparison of European nutrient boundaries for transitional, coastal and marine waters. Working Group on ecological Status ECOSTAT.

European Commission [EC] (2009). Guidance Document on Eutrophication Assessment in the Context of European Water Policies. Common Implementation Strategy Guidance Document No. 23. Luxembourg: Office for Official Publications of the European Union.

Flo, E. (2017). Opening the black box of coastal inshore waters in the NW Mediterranean Sea: environmental quality tools and assessment. PhD. 372 pages. https://www.tdx.cat/handle/10803/461378 (date accessed: 26.3.2021)

Giovanardi, F., Finoia, M.G., Russo, S., Amori, M., Di Lorenzo, B., (2006). Coastal watersmonitoring data: frequency distributions of the principal water quality variables. J. Limnology 65, 65–82. doi: 10.4081/jlimnol.2006.65.

Giovanardi, F., Francé, J., Mozetič, P., Precali, R. (2018). Development of ecological classification criteria for the Biological Quality Element phytoplankton for Adriatic and Tyrrhenian coastal waters by means of chlorophyll a (2000/60/EC WFD). Ecological Indicators. 93. 316-332. doi: 10.1016/j.ecolind.2018.05.015.

Giovanardi, F., Tromellini, E., (1992). An empirical dispersion model for total phosphorus in a coastal area: the Po River-Adriatic system. Sci. Total Environ. Supplement 201–210. doi:10.1016/B978-0444-9990-3.50022-5.

Giovanardi, F., Vollenweider, R.A., (2004). Trophic conditions of marine coastal waters: experience in applying the Trophic Index TRIX to two areas of the Adriatic and Tyrrhenian seas. J. Limnology 63, 199–218. doi: 10.4081/jlimnol.2004.199.

Hering, D., Borja, A., Carstensen, J., Carvalho, L., Elliott, M., and Feld, C. K. (2010). The European water framework directive at the age of 10: a critical review of the achievements with recommendations for the future. Sci. Total Environ. 408, 4007–4019.

Krom, M. D., Kress, N., and Benner, S. (1991). Phosphorus limitation of primary productivity in the eastern Mediterranean sea. Limnol. Oceanogr. 36, 424–432. doi: 10.4319/lo.1991.36.3.0424

Krom, M.D., S. Brenner, N. Kress, A. Neori and L.I. Gordon. (1992) Nutrient dynamics and new production in a warm-core eddy from the Eastern Mediterranean Sea. Deep-Sea Research, 39:467-480.

Phillips G, Kelly M, Teixeira H, Salas F, Free G, Leujak W, Pitt Ja, Lyche Solheim A, Varbiro G, Poikane S, (2018) Best practice for establishing nutrient concentrations to support good ecological status, EUR 29329 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-79-92906-9, doi:10.2760/84425, JRC112667.

R Development Core Team (2016). 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

Ricci, V., 2006. Principali tecniche di regressione con R. Versione 0.3. https://cran.rproject.org/doc/contrib/Ricci-regression-it.pdf.

Vollenweider, R.A., F. Giovanardi, G. Montanari, A. Rinaldi, (1998). Characterization of the Trophic Conditions of Marine Coastal Waters. Environmetrics, 9, 329-357.COP

WFD CIS Guidance Document No. 5 (2003) Transitional and Coastal Waters Typology, Reference Conditions and Classification Systems.