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Assessment of environmental status of Malta's Marine Waters

As per Tender for the Implementation and Updating of Marine Monitoring Programmes, Assessment of Environmental Status and Development of a Marine Database System

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1.0 Antecedents

The Environment and Resources Authority (ERA) were entrusted with the technical implementation of the Marine Strategy Framework Directive (2008/56/EC). This directive calls for the achievement of good environmental status in EU marine waters, building upon other EU and regional marine-related policies including the EU Water Framework Directive (2000/60/EC of 23 October 2000), the EU Habitats Directive (92/43/EEC of 21 May 1992) and the Barcelona Convention.

A marine monitoring programme for the assessment of environmental status in marine waters has already been developed for Malta. This project seeks to execute this programme and update it on the basis of the knowledge gained through its implementation. This would lead to the development of a cost-effective monitoring programme which can be sustained in the longer term, hence providing a continuous flow of data and information for effective management of the marine environment.

The main objectives of this project have therefore been defined as follows:

1. Implementation of the marine monitoring programmes and updating of such programmes on the basis of improved knowledge and application of a risk-based approach.
2. Development of a database system supporting and integrating environmental data pertaining to the marine environment as well as other relevant data from marine-related sectors.
3. Assessment of the environmental status of Malta's marine waters on the basis of the monitoring data collected and proposing quantitative environmental thresholds to be achieved through management processes.
4. Communication of the outcome of the monitoring and assessment procedures and the development of the database system with relevant stakeholders.

This report covers the third objective listed above, regarding the assessment of the environmental status in Maltese waters.

Malta Marine Monitoring Consortium (hereafter M3C), composed of AIS Environment Limited (AIS) – the lead partner, and Fundación AZTI, has been awarded tender CT3031/2016 issued by the Environment and Resources Authority (ERA), relating to *the Tender for the Implementation and Updating of Marine Monitoring Programmes, Assessment of Environmental Status and Development of a Marine Database System*.

The scope of works required is set out in some detail in the Tender Document. This tender outlines requirements for the implementation of the monitoring of the waters surrounding the Maltese Islands in accordance with the Marine Strategy Framework Directive. Details on the monitoring strategies to be followed have been outlined in the monitoring factsheets (http://era.org.mt/en/Pages/MSFD.aspx). M3C has revised such documents by consulting with experts and scientific articles. This document serves as the Activity 3 report for

CT3031/16, which assesses the environmental status of Malta's marine waters on the basis of monitoring data collected as part of this project.

This document is sectioned as follows:

- Section 1.0 – Antecedents
- Section 2.0 – Introduction and Objective
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2.0 Introduction and Objective

The ecosystem value of the Maltese marine environment ranges from those characterised by non-monetary worth (i.e. nature experiences, recreational activities), to those with economic value (i.e. tourism, fishing, aquaculture, shipping, etc.). However, the Maltese coastal waters are also recipients of materials and pollution from the coast, as well as of deposition from the atmosphere. These activities impose some anthropogenic pressures (resource depletion, habitat degradation, pollution) on the seas and their services, which may lead to significant degradation of marine ecosystems and threaten their integrity, diversity, structures and functioning and thus may compromise the marine ecosystem's potential to deliver essential services on which Maltese society depends.

The European Union (EU) current approach is to Integrate Marine Policies with the adoption of an Ecosystem-Based Management (EBM) framework for human activities in the marine environment: the Marine Strategy Framework Directive (MSFD; European Commission, 2008), the Marine Spatial Planning Directive (MSPD; European Commission, 2014), and the Common Fisheries Policy (last modified in 2014), are three of the main EU marine policies that adopt EBM. These three directives are combined with others, including the Biodiversity Strategy to 2020 and the Habitats and Birds Directives (Directives 92/43/EEC and 2009/147/EC), in ways capable of handling multiple objectives.

The MSFD aims for clean, healthy and productive marine ecosystems within all EU Member States (MSs), achieving Good Environmental Status (GES) by 2020. Each MS is required to develop a strategy for its marine waters, which must be kept up-to-date and reviewed every six years. Therefore, an EBM of the sea is central to delivery of the MSFD (Art. 1.3) and its overall objective to take the necessary measures to achieve or maintain GES by 2020 (Art. 1.1). It can be expected that achieving GES will primarily be accomplished through reductions in pressures (from human activities) and their impacts on the marine environment.

In addition, the Mediterranean countries, including Malta, have committed themselves to implement the EBM in the framework of UNEP/MAP Barcelona Convention in full synergy with the MSFD implementation.

The MSFD provides in its Article 9(3) for criteria and methodological standards to be laid down in such a way as to ensure consistency and to allow for comparison between marine regions or subregions of the extent to which GES is being achieved. This provision was used to prepare the European Commission (2010) decision, which guided MSs in the first cycle of their implementation of the MSFD, for which Malta completed the initial assessment in 2013 (https://era.org.mt/en/Pages/MSFD-IAs-GES-Targets.aspx).

After the analysis of the results of the initial reports, the European Commission found significant gaps in knowledge and data on marine issues (Palialexis *et al.*, 2014). Hence, while MSs generally applied the 2010 Decision, their determination of GES varied considerably both within regions or sub-regions and across the EU, and the level of detail in the GES definitions was not sufficient. A consistent determination of GES, as required by the

Directive, has thus not been achieved. Part of the problem lies in the fact that the 2010 Decision could not set out the criteria and methodological standards in enough detail for certain descriptors.

Given these shortcomings and to ensure that the next cycle of implementation of the MSFD (2018 and beyond) yields greater benefits, the European Commission (2017) revised the decision and proposed criteria and methodological standards that are "clearer, simpler, more concise, more coherent and comparable".

In this context, as it is included in tender CT3031/16 and the proposal, within month 22 from the award of the tender CT3031/16 (March 2019), the contractor shall provide an environmental assessment of Malta’s Marine Waters, under the MSFD, based upon the monitoring data obtained, and in the proposal of measurable environmental thresholds. In fact, an initial report was delivered in December 2018 for discussion with ERA (Borja *et al.*, 2018), and this is considered the draft that should be delivered in March 2019. After the discussions, the assessment was re-orientated.

Based on the above, **the objective of this Deliverable is to provide an assessment of the environmental status of Maltese waters, based upon the MSFD.**

3.0 Approach followed

The approach used in the analysis of the data obtained in the monitoring has followed that of the European Commission (2017), on the decision laying down criteria and methodological standards on good environmental status of marine waters and specifications and standardised methods for monitoring and assessment for the MSFD. In addition, we have also followed the guidelines from the European Commission (2018b), on the reporting update of Articles 8, 9 and 10 for the MSFD, using the most recent versions of the excel files to report for each Descriptor. These excel files are provided as Annex to this report.

According to Borja *et al.* (2016), in order to evaluate the environmental status of marine ecosystems, a science-based, integrated Ecosystem Approach which incorporates knowledge of ecosystem function and services is needed. This assumes that this can be used to track how management decisions change the health of marine ecosystems. Although many methods have been developed to assess the status of single components of the ecosystem (Birk *et al.*, 2012), few exist for assessing multiple ecosystem components in a holistic way; these have been reviewed by Borja *et al.* (2016).

The most recent method developed to assess the status under the MSFD is the Nested Environmental status Assessment Tool (NEAT) (Borja *et al.*, 2016, Berg *et al.*, 2017). This software, freely available (www.devotes-project.eu/neat), was developed under the umbrella of the EU funded project DEVOTES. This tool was tested in 10 European locations, within all four European regional seas, including the Mediterranean (Uusitalo *et al.*, 2016). This is a flexible tool that allows incorporating multiple indicators, all the MSFD descriptors, all ecosystem components and different spatial-temporal scales. The assessment can be done at different geographical scales (from local to the whole ecoregion), descriptor levels (i.e. integrated assessment versus individual assessment of descriptors, being able to separate pressure descriptors from biological descriptors), and ecosystem component level (i.e. from entire ecosystem to specific ecosystem components). In addition, the tool gives the uncertainty associated to each assessment and the possibility of studying the implications or adding or removing more or less indicators in the final assessment.

The use of this tool was proposed by the M3C Consortium, because it could be adapted to the specificities of Malta, considering the limited availability of data, the different indicators and the descriptors included in the monitoring requirements. We provided a report in December 2018 (Borja *et al.*, 2018) with its application to Malta, but the method was not considered on line with the guidelines from the European Commission (2018b), and as such these guidelines are followed in the present report. The previous report delivered by M3C consortium will be used in some parts of this document for discussions and some comparisons. Also, we have used the monitoring factsheets (https://era.org.mt/en/Pages/MSFD-Monitoring-Programme.aspx), as well as the initial assessment report prepared by Malta (https://era.org.mt/en/Pages/MSFD-IAs-GES-Targets.aspx), as baseline for comparison in this new assessment undertaken.

The steps to assess the status have been the following:

(i) Definition of the Marine Reporting Units for the assessment

In order to assess the status in the Maltese waters (basis for the MSFD Article 8 assessments), Marine Reporting Units (MRUs) must be defined first. In this task, the latest EU guidance on their establishment, and Malta's reported MRUs have been incorporated, fitting with the currently available information on the different official MRUs within Maltese waters.

(ii) Identify and select the descriptors and indicators to use in the assessment

The tender specifications clearly indicate the information to be collected for the different ecosystem components and their specific aim. A list of indicators is provided in accordance with the tender specifications and assigned to the different descriptors, so the monitoring and assessment is in full consonance with the MSFD.

(iii) Setting thresholds for the indicators used at each Descriptor

The approaches implemented in the Mediterranean Members States during the first round of the MSFD implementation or within the framework of the UNEP/MAP "Ecosystem approach" have been reviewed; however, little information is available from these monitoring exercises.

Hence, to undertake the environmental status assessment required by CT3031/16, we have at least eight options to set thresholds (Borja *et al.*, 2012; Borja *et al.*, 2019a), which we have summarised below (in decreasing order of preference).

- **Legally binding thresholds**: For contaminants, there are European and national legislation were these thresholds are set, and we have used them here; as outlined below:
  - for contaminants in seawater and in biota, those within the European Commission (2013);
  - for contaminants in sediments, those derived by Italian Government (Sediment Quality Guidelines, Decreto 56/2009);
  - for contaminants in seafood, those derived by Commission Regulation No 1881/2006 (Maximum levels for fish and mollusc); and
  - for biological elements, such as phytoplankton, macroalgae, seagrasses and macroinvertebrates, those intercalibrated within the Water Framework Directive (WFD; European Commission, 2018).
- **Agreed boundaries accepted by the scientific community, managers or Regional Seas Conventions (especially UNEP)**:
  - For different eutrophication status (eutrophic, mesotrophic, oligotrophic), which can be used in other descriptors and indicators (Ferreira *et al.*, 2011; UNEP-MAP, 2015; UNEP, 2016).
  - Thresholds set by UNEP-MAP (2015) and UNEP (2016) for various descriptors.

- **Information from pristine areas**: such areas can be considered as reference sites, although this does not have been used in Malta.
- **Information from gradients of pressure**: although this does not have been done in Malta.
- **Information from the past:** information originating from before the introduction of anthropogenic pressure, although this does not have been used in Malta.
- **Model a threshold**: in line with the proposal in Rossberg *et al.* (2017), although this does not have been used in Malta.
- **Thresholds from existing literature**: these thresholds are for indicators used in similar habitats, e.g. Sediment Quality Guidelines at regional level.
- **Expert judgment**: from projects such as MEDCIS.

(iv) Assessment of the environmental status

The assessment has been done in accordance with Annex III of MSFD and with the criteria and methodological standards in the European Decision (European Commission, 2017) and the European Commission (2018b) guidelines, using the Excel files that the latter provides, which are included as Annex to this report. Also, we have followed, to some extent, the guidance from UNEP (2016) and UNESCO (2017) on integrated assessment for the Mediterranean.

The assessments are delivered at the different MSFD Descriptor level, with different MRU levels, depending on the abovementioned guidelines. A general overview of the Malta's status is given at the end of this report. However, an integrated assessment for the whole Maltese waters, including all ecosystem components and descriptors, as done by Borja *et al.* (2018) using NEAT, was not possible, since those guidelines do not provide any approach to do it.

4.0 Method

4.1 European Commission Guidelines

After the European Commission (2018b) guidelines, the reporting package comprises:

- **A structured reporting of information, in Excel files:** These files have served to assess the environmental status for different indicators and descriptors, and are provided as annex to this report. These files contain information on how to aggregate indicators, depending on the descriptors and the criteria. These are explained in some cases within each descriptor section;

- **The national indicator assessments:** The indicators selected and used are included below, as well as the thresholds selected. However, as M3C is not responsible of the Maltese national reporting, the final selection should be made by the Maltese competent authorities. The indicators constitute the basis of the assessment, and can be equivalent to the criteria defined by the European Commission (2017). There are some sources to select indicators (Teixeira *et al.*, 2016). For Malta, we have included the indicators measured in the monitoring network, and available in the database developed by M3C project.

- **The supporting assessment datasets**: These are provided as the monitoring database, built by M3C for ERA, and included in the monitoring report (Borja *et al.*, 2019b); and

- **Text-based national reports:** This report can be part of this, but M3C is not responsible of the Maltese national reporting, only on the assessment based on the monitoring programme, as per tender; hence, the final assessment report must be completed by the Maltese competent authorities. Here, we have structured the report by each of the Descriptors for which the monitoring network has information. This should be completed by the competent authorities with information from other sources included in the monitoring network, but not in the tender requirements (e.g. D3 on fishing, D4 on trophic webs, D11 on noise) as well as additional information to complete the assessment for several descriptors (e.g. information on fish, seabirds and mammals for D1 on biodiversity; areas affected by human activities, for D6 seafloor integrity, and D7 hydrography).

4.2 Marine Reporting Units

The monitoring network for Maltese waters is a complex mixture of MRUs, as required by the MSFD, and sampling stations for different environments (water, sediment, biota) and ecosystem components (plankton, macroalgae, seagrasses, macroinvertebrates) as well as other elements (such as litter) (Figure 1).

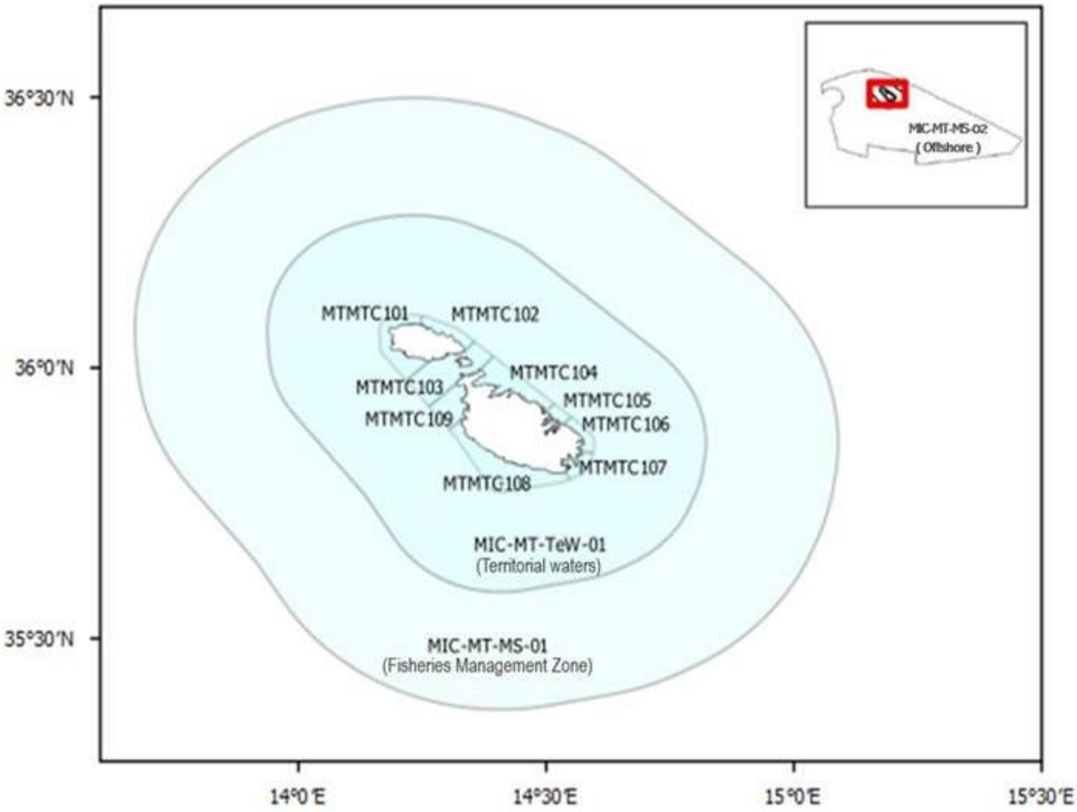

Figure 1: Map showing the Maltese Marine Reporting Units (MRUs) and sampling stations

In total, we have included next MRUs, as agreed with the ERA:

- 9 coastal water bodies within the WFD, with sizes between 13 and 98 km^2, which are aggregated into a unique WFD MRU, covering 399 km^2, as required for some MSFD descriptors (e.g. D5, D8) after the guidelines from 2018,
- Territorial waters, covering approximately 3,830 km^2;
- Fisheries Management Zone; and
- Offshore waters until the outer limit of continental shelf, covering 71,932 km^2.

The Maltese waters cover nearly 76,000 km^2. Some indicators are associated to each of the MRUs, as shown in the monitoring report (Borja *et al.*, 2019b), and then the MRUs are aggregated, by calculating the mean value from the stations in those MRUs, or calculating the percentage of samples not achieving the GES in the whole MRUs, depending on the descriptor and the European Commission (2018b) guidelines.

As a complement to Figure 1, Table 1 summarises the types of sampling stations, the environments and the components sampled at each of them.

On the other hand, to better understand the results from the assessment, it is necessary to know the human pressures which potentially can impact on the different ecosystem components in Maltese MRUs. These have been obtained from a CORINE land cover map (http://geoserver.pa.org.mt/publicgeoserver) included in the Water Catchment Management Plan (ERA, 2015) (Figure 2).

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Table 1: Sampling stations allocated to each of the Marine Reporting Units (MRUs)[1]

MRU	Sampling station	Water										Sediments					Biota			Other
		Phy-chem				Contaminants				Biological		Phy-chem		Cont.	Biological		Contaminants			
		CTD	ADCP	Nut	Ni	BBF	PS	Car	WH	Phyto	Zoo	GS	TOC	PAH	Benthos	Posid	Seafood	Posid	NIS	Litter
MTC101	CBI01-1														X					
MTC101	CBI01-2														X					
MTC101	CN01-1	X	X	X						X	X					X				
MTC101	CN01-1N	X	X	X																
MTC101	CN01-2			X			X		X			X	X		X	X		X		
MTC101	CN01-2Tr101	X		X						X										
MTC101	CN01-2Tr102	X		X						X										
MTC101	CN01-2Tr103	X		X						X										
MTC101	CN01-2Tr201	X		X						X										
MTC101	CN01-2Tr202	X		X						X										
MTC101	CN01-2Tr203	X		X						X										
MTC101	CN01-2Tr301	X		X						X										
MTC101	CN01-2Tr302	X		X						X										
MTC101	CN01-2Tr303	X		X						X										
MTC101	CS01	X	X	X			X		X	X	X	X	X							
MTC102	CBI02-1											X	X		X					
MTC102	CBI02-2											X	X		X					
MTC102	CBI02-3											X	X		X					
MTC102	CML02																			X
MTC102	CN02-1	X	X	X			X		X	X	X	X	X			X				
MTC102	CS02	X	X	X			X		X	X	X	X	X			X		X		
MTC103	MEDITS 5																X			
MTC103	CBA03	X	X		X					X	X									
MTC103	CBI03-1											X	X		X					

[1] Phy-chem: Physicochemical; Cont: contaminants; Nut: nutrients; Ni: nitrates; BBF: Beryllium, Boron, Fluoride; PS: priority substances; Car: Carbamazepine; WH: Water Hardness; Phyto: phytoplankton; Zoo: zooplankton; GS: grain size; TOC: Total Organic Carbon; Posid: Posidonia; NIS: Non-Indigenous Species. Te: territorial waters; Offs: offshore waters

MRU	Sampling station	Water										Sediments					Biota			Other
		Phy-chem				Contaminants				Biological		Phy-chem		Cont.	Biological		Contaminants			
		CTD	ADCP	Nut	Ni	BBF	PS	Car	WH	Phyto	Zoo	GS	TOC	PAH	Benthos	Posid	Seafood	Posid	NIS	Litter
MTC103	CBI03-2											X	X		X					
MTC103	CN03-1	X	X	X			X	X	X	X	X	X	X			X		X		
MTC103	CN03-1N	X	X	X																
MTC103	CN03-2	X	X	X			X		X	X	X	X	X		X					
MTC103	CN03-3	X	X	X			X		X	X	X	X	X		X	X		X		
MTC103	CN03-6	X	X	X							X	X	X		X	X		X		
MTC103	CN03-6N	X	X	X																
MTC103	CN03-7	X	X	X												X			X	
MTC103	CNIS03-2																		X	
MTC103	CNIS03-3																		X	
MTC103	CS03	X	X	X			X		X	X	X	X	X			X		X		
MTC104	CBI04-1											X	X		X					
MTC104	CBI04-2											X	X		X					
MTC104	CBI04-3											X	X		X					
MTC104	CBI04-4											X	X		X					
MTC104	CML04																			X
MTC104	CN04-1	X	X	X			X		X	X	X	X	X			X		X		
MTC104	CN04-3	X	X	X			X			X	X	X	X			X		X		
MTC104	CN04-5	X	X	X					X	X	X	X	X		X	X				
MTC104	CN04-6	X	X	X					X	X	X	X	X		X	X		X		
MTC104	CN04-8Tr101	X		X						X										
MTC104	CN04-8Tr102	X		X						X										
MTC104	CN04-8Tr103	X		X						X										
MTC104	CN04-8Tr201	X		X						X										
MTC104	CN04-8Tr202	X		X						X										
MTC104	CN04-8Tr203	X		X						X										
MTC104	CN04-8Tr301	X		X						X										
MTC104	CN04-8Tr302	X		X						X										
MTC104	CN04-8Tr303	X		X						X										
MTC104	CNIS04-1																		X	
MTC104	CNIS04-2																		X	

MRU	Sampling station	Water										Sediments					Biota			Other
		Phy-chem				Contaminants				Biological		Phy-chem		Cont.	Biological		Contaminants			
		CTD	ADCP	Nut	Ni	BBF	PS	Car	WH	Phyto	Zoo	GS	TOC	PAH	Benthos	Posid	Seafood	Posid	NIS	Litter
MTC104	CP04-1	X	X	X			X		X	X	X	X	X			X		X		
MTC104	CP04-2	X	X	X			X		X	X	X	X	X			X				
MTC104	CP04-2N	X	X	X																
MTC105	CBI05-1											X	X		X					
MTC105	CN05-1	X	X	X			X		X	X	X	X	X							
MTC105	CN05-2			X			X		X			X	X		X					
MTC105	CN05-2Tr101	X		X						X										
MTC105	CN05-2Tr102	X		X						X										
MTC105	CN05-2Tr103	X		X						X										
MTC105	CN05-2Tr201	X		X						X										
MTC105	CN05-2Tr202	X		X						X										
MTC105	CN05-2Tr203	X		X						X										
MTC105	CN05-2Tr301	X		X						X										
MTC105	CN05-2Tr302	X		X						X										
MTC105	CN05-2Tr303	X		X						X										
MTC105	CP05	X	X	X			X		X	X	X	X	X							
MTC105	CP05N	X	X	X																
MTC105	Grand Harbour																		X	
MTC105	Marsamxett																		X	
MTC106	CBA02		X		X					X	X	X	X	X						
MTC106	CN06-1	X	X	X			X		X	X	X	X	X		X	X		X		
MTC106	CP06-1	X	X	X			X	X	X	X	X	X	X			X				
MTC106	CP06-2	X	X	X			X	X	X	X	X	X	X		X					
MTC106	CP06-2N	X	X	X																
MTC107	B'Bugia																		X	
MTC107	CBI07-1											X	X		X					
MTC107	CN07-1	X	X	X			X	X	X	X	X	X	X		X	X		X		
MTC107	CN07-2Tr101	X		X						X										
MTC107	CN07-2Tr102	X		X						X										
MTC107	CN07-2Tr103	X		X						X										
MTC107	CN07-2Tr201	X		X						X										

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MRU	Sampling station	Water										Sediments						Biota			Other
		Phy-chem				Contaminants				Biological		Phy-chem		Cont.	Biological			Contaminants			
		CTD	ADCP	Nut	Ni	BBF	PS	Car	WH	Phyto	Zoo	GS	TOC	PAH	Benthos	Posid		Seafood	Posid	NIS	Litter
MTC107	CN07-2Tr202	X		X						X											
MTC107	CN07-2Tr203	X		X						X											
MTC107	CN07-2Tr301	X		X						X											
MTC107	CN07-2Tr302	X		X						X											
MTC107	CN07-2Tr303	X		X						X											
MTC107	CP07	X	X	X		X	X		X	X	X	X	X			X			X		
MTC107	CP07N	X	X	X																	
MTC107	M'Xlokk																			X	
MTC108	CN08-1	X	X	X			X		X	X	X	X	X		X	X			X		
MTC108	CNIS08-1																			X	
MTC108	CS08	X	X	X			X		X	X	X	X	X								
MTC109	CBA06	X	X		X					X	X										
MTC109	CBI09-1											X	X		X						
MTC109	CBI09-2											X	X		X						
MTC109	CML09-1																				X
MTC109	CML09-2																				X
MTC109	CN09																				
MTC109	CN09-1	X	X	X			X	X		X	X					X					
MTC109	CN09-1N	X	X	X																	
MTC109	CNIS09-1																			X	
MTC109	CS09	X	X	X		X	X		X	X	X	X	X			X			X		
Offs	MEDITS 49																	X			
Offs	MEDITS 54																	X			
Offs	MEDITS 70																	X			
Offs	MEDITS 76																	X			
Offs	COFF01	X	X				X			X	X										X
Offs	COFF02	X	X				X			X	X										X
Offs	COFF03	X	X				X			X	X										X
Offs	COFF04	X	X				X			X	X										X
Te	MEDITS 7																	X			
Te	MEDITS 8																	X			

MRU	Sampling station	Water										Sediments					Biota			Other
		Phy-chem				Contaminants				Biological		Phy-chem		Cont.	Biological		Contaminants			
		CTD	ADCP	Nut	Ni	BBF	PS	Car	WH	Phyto	Zoo	GS	TOC	PAH	Benthos	Posid	Seafood	Posid	NIS	Litter
Te	MEDITS 10																X			
Te	MEDITS 55																X			
Te	MEDITS 74																X			
Te	MEDITS 79																X			
Te	CBA04		X		X					X	X	X	X	X						
Te	CP04-1Te	X			X					X	X									
Te	CP05Te	X			X					X	X									
Te	CP06-1Te	X			X					X	X									
Te	CP07Te	X			X					X	X									
Te	CS01Te	X	X		X					X	X									
Te	CS02Te	X	X		X					X	X									
Te	CS03Te	X	X		X					X	X									
Te	CS04-1Te		X																	
Te	CS05Te		X																	
Te	CS06-1Te		X																	
Te	CS07Te		X																	
Te	CS08Te	X	X		X					X	X									
Te	CS09Te	X	X		X					X	X									
Te	CWA01	X	X		X					X	X	X	X							

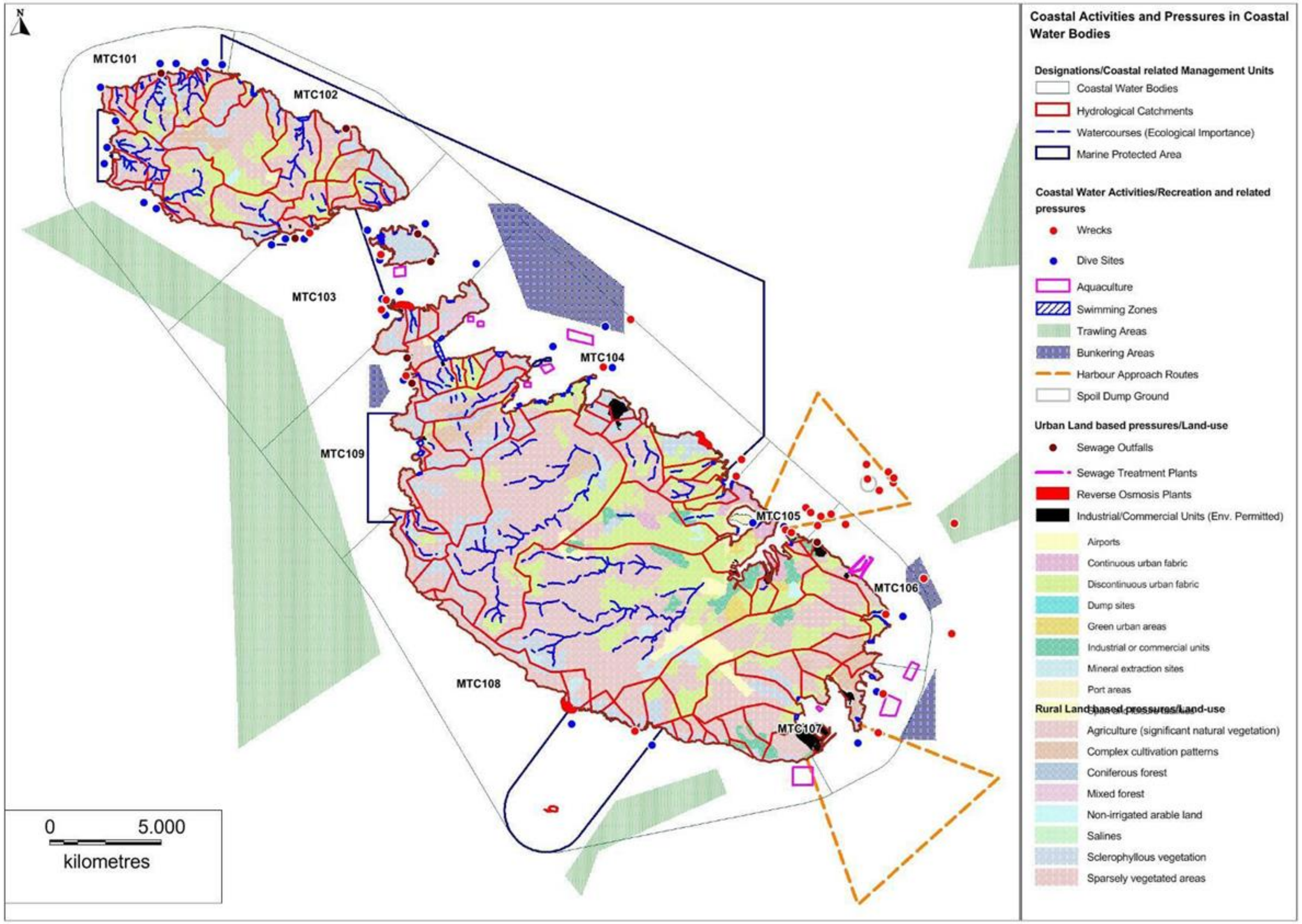

Figure 2: Human pressures in the Maltese waters, together with the coastal water bodies (MTC). (Source: Malta's Second Water Catchment Management Plan)

4.3 Ecosystem components included

Since each indicator describes a specific ecosystem component, we have defined a total of eight ecosystem components:

- water column (associated with nutrients, oxygen, contaminants, floating litter)
- sediment (contaminants, litter)
- phytoplankton (chlorophyll, composition, Non-Indigenous Species (NIS))
- zooplankton (composition, NIS)
- macroalgae (CARLIT, NIS)
- seagrasses (PREI)
- benthic fauna (BENTIX, NIS)
- fish/crustaceans (contaminants).

4.4 Indicators included and associated descriptors

To select the indicators, we have followed as far as possible the criteria of the European Commission (2017) decision, as indicated in Table 2. In that table, primary criteria should be used to ensure consistency across the European Union, and secondary criteria should be decided by Member States, where necessary, to complement a primary criterion or when, for a particular criterion, the marine environment is at risk of not achieving or not maintaining good environmental status.

After this analysis, total of 86 indicators were used (some in two or three descriptors), corresponding to seven descriptors of the MSFD:

- D1-Biodiversity: 5 indicators for benthic habitats and 2 for pelagic habitats
- D2-Non-Indigenous Species: one indicator, in three ecosystem components
- D5-Eutrophication: 11 indicators
- D6-Seafloor integrity: 5 indicators
- D8-contaminants: 26 indicators in water, 16 in sediments and 11 in biota
- D9-Contaminants in seafood: 6 indicators
- D10-Litter: 3 indicators

Each of the indicators has a range of variation (from worst to best values, i.e. reference conditions), and at least a threshold between good/not good status. When these thresholds were not available from directives, intercalibration, UNEP-MAP (2015) or other official sources, we have used scientific papers to set them and, in some cases, by expert judgment (e.g. MEDCIS project), as outlined in Section 3.0.

Table 2: Descriptors and primary (yellow) and secondary (white) criteria to be considered in the assessment, after the European Commission (2017) and the ERA decision, together with the monitoring data available and the indicators associated to them. D: Descriptor, C: criterion, CI: common indicator, NIS: non-indigenous species

Annex III theme	Commission Decision Criteria (primary or mandatory criteria in yellow)	EcAp Common Indicator	Underlying Datasets [to be reported as per Article 19(3)] – Priority criteria/datasets highlighted, indicators used
Descriptor 1: Pelagic Habitats	D1C6: The condition of the habitat type, including its biotic and abiotic structure and its functions is not adversely affected due to anthropogenic pressures	N/A	Phytoplankton: total density of cells; ratio diatoms/dinoflagellates Zooplankton: not used due to the absence of suitable methodology for assessment, absence of thresholds and limited data
Descriptor 1: Benthic habitats	D6C4: The extent of loss of the habitat type, resulting from anthropogenic pressures does not exceed a specified proportion of the natural extent of the habitat type in the assessment area	CI1: Habitat distributional range	Length of coast cover by *Cystoseira* spp.; *Posidonia* and maerl extent Data on pressures however is required in order to enable application of D6C4.
	D6C5: The extent of adverse effects from anthropogenic pressures on the condition of the habitat type, including alteration to its biotic and abiotic structure and its functions does not exceed a specified proportion of the natural extent of the habitat type in the assessment area.	CI2: Condition of the habitat's typical species and communities	CARLIT; PREI; BENTIX; Percentage of *Lithophyllum* alive; maerl data;
Descriptor 2: Input or spread of non-indigenous species	D2C1: The number of non-indigenous species which are newly introduced via human activity into the wild, per assessment period (6 years), measured from the reference year as reported for the initial assessment under Article 8(1) of the Directive 2008/56/EC, is minimised and where possible reduced to zero	CI6: Trends in abundance, temporal occurrence, and spatial distribution of NIS	Data on new NIS arrivals have been included, but it is not possible to calculate trends, because only two datasets exist
	D2C2: Abundance and spatial distribution of established non-indigenous species particularly of invasive species contributing significantly to adverse effects on particular species groups or broad habitat types	Refer to CI6	Not used due to the absence of thresholds
Descriptor 3: Commercial fish	D3C1: The Fishing mortality rate of populations of commercially-exploited species is at or below levels which can produce the maximum sustainable yield (MSY)		Not used, since this information is not included in the monitoring network

Annex III theme	Commission Decision Criteria (primary or mandatory criteria in yellow)	EcAp Common Indicator	Underlying Datasets [to be reported as per Article 19(3)] – Priority criteria/datasets highlighted, indicators used
	D3C2: The Spawning Stock Biomass of populations of commercially-exploited species are above bio-mass levels capable of producing maximum sustainable yield.		Not used, since this information is not included in the monitoring network
	D3C3: The age and size distribution of individuals in the populations of commercially-exploited species is indicative of a healthy population. This shall include a high proportion of old/large individuals and limited adverse effects of exploitation on genetic diversity.		Not used, since this information is not included in the monitoring network
Descriptor 5: Input of nutrient	D5C1: Nutrient concentrations are not at levels that indicate adverse eutrophication effects.	CI13: Concentration of key nutrients in water column	Levels of nutrients in the marine environment
	D5C2: Chlorophyll-a concentrations are not at levels that indicate adverse effects of nutrient enrichment.	CI14: Chlorophyll-a concentration in water column	Levels of chlorophyll-a in the water column (90th percentile)
	D5C3: The number, spatial extent and duration of harmful algal bloom events are not at levels that indicate adverse effects of nutrient enrichment.	N/A	HAB data included
	D5C4: The photic limit (transparency) of the water column is not reduced, due to increases in suspended algae, to a level that indicates adverse effects of nutrient enrichment.	N/A	Secchi disk data used
	D5C5: The concentration of dissolved oxygen is not reduced, due to nutrient enrichment, to levels that indicate adverse effects on benthic habitats (including on associated biota and mobile species) or other eutrophication effects.	N/A	Levels of dissolved oxygen at the bottom in monitoring stations
	D5C6: The abundance of opportunistic macroalgae is not at levels that indicate adverse effects of nutrient enrichment.	N/A	CARLIT
	D5C7: The species composition and relative abundance or depth distribution of macrophyte communities achieve values that indicate there is no adverse effect due to nutrient enrichment including via a decrease in water transparency,	N/A	PREI
	D5C8: The species composition and relative abundance of	N/A	BENTIX

Annex III theme	Commission Decision Criteria (primary or mandatory criteria in yellow)	EcAp Common Indicator	Underlying Datasets [to be reported as per Article 19(3)] – Priority criteria/datasets highlighted, indicators used
	macrofaunal communities, achieve values that indicate that there is no adverse effect due to nutrient and organic enrichment		
Descriptor 6: Physical loss	D6C1: Spatial extent and distribution of physical loss (permanent change) of the natural seabed.	N/A	Not used due to the absence of data and thresholds
Descriptor 6: Physical disturbance to seabed	D6C2: Spatial extent and distribution of physical disturbance pressures on the seabed	N/A	Not used due to the absence of data and thresholds
	D6C3: Spatial extent of each habitat type which is adversely affected through change in its biotic and abiotic structure and its functions by physical disturbance.	N/A	BENTIX; CARLIT and PREI
Descriptor 7: Changes to hydrological conditions	D7C1: Spatial extent and distribution of permanent alteration of hydrographical conditions (e.g. changes in wave action, currents, salinity, temperature) to the seabed and water column, associated in particular with physical loss of the natural seabed.	CI15: Location and extent of the habitats impacted directly by hydrographic alterations	Not used due to the absence of data and thresholds.
	D7C2: Spatial extent of each benthic habitat type adversely affected (physical and hydrographical characteristics and associated biological communities) due to permanent alteration of hydrographical conditions.	CI15: Location and extent of the habitats impacted directly by hydrographic alterations	Not used due to the absence of data and thresholds
Descriptors 8 and 9: Input of substances	D8C1: Within coastal and territorial waters, the concentrations of contaminants do not exceed the following threshold values (refer to Comm Dec 2017/848)	CI17: Concentration of key harmful contaminants measured in the relevant matrix	Concentration of contaminants in the different matrices (water, sediment, biota)
	D8C2: The health of species and the condition of habitats (such as their species composition and relative abundance at locations of chronic pollution) are not adversely affected due to contaminants including cumulative and synergetic effects.	CI18: Level of pollution effects of key contaminants where a cause and effect relationship has been established	Not used due to the absence of data and thresholds
	D8C3: The spatial extent and duration of significant acute pollution events are minimised.	CI19: Occurrence, origin (where possible), extent of acute pollution events (e.g. slicks from oil), and their impact on biota affected by this pollution	Not used due to the absence of data and thresholds
	D8C4: The adverse effects of significant acute pollution events on the	N/A	Not used due to the absence of data and

Annex III theme	Commission Decision Criteria (primary or mandatory criteria in yellow)	EcAp Common Indicator	Underlying Datasets [to be reported as per Article 19(3)] – Priority criteria/datasets highlighted, indicators used
	health of species and on the condition of habitats are minimised and, where possible, eliminated.		thresholds
	D9C1: The level of contaminants in edible seafood does not exceed: (a) for contaminants listed in Regulation (EC) 1881/2006, the maximum levels laid down in that Regulation, (b) for additional contaminants, not listed in that Regulation, threshold values, which Member States shall establish through regional cooperation.	CI20: Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in seafood	Levels of contaminants in commercial fish and crustaceans
Descriptor 10: Input of litter	D10C1: The composition, amount and spatial distribution of litter on the coastline, in the surface layer of the water column, and on the seabed, are at levels that do not cause harm to the coastal and marine environment.	CI22: Trends in the amount of litter washed ashore and/or on coastlines	Marine litter on beaches, seabed, water column in terms of composition and amount.
	D10C2: The composition, amount and spatial distribution of micro-litter on the coastline, in the surface layer of the water column, and in seabed sediment, are at levels that do not cause harm to the coastal and marine environment.	CI23: Trends in the amount of litter in the water column including microplastics and on the seafloor	No data available for microlitter
	D10C3: The amount of litter and micro-litter ingested by marine animals is at a level that does not adversely affect the health of the species concerned.	CI24: Trends in the amount of litter ingested by or entangling marine organisms focusing on selected mammals, marine birds, and marine turtles	Not used due to the absence of data and thresholds
	D10C4: The number of individuals of each species which are adversely affected due to litter, such as by entanglement, other types of injury or mortality, or health effects.	CI24: Trends in the amount of litter ingested by or entangling marine organisms focusing on selected mammals, marine birds, and marine turtles	Not used due to the absence of data and thresholds

4.4.1 Descriptor 1: Biological diversity, and Descriptor 6: seafloor integrity

After the European Commission (2018b) guidelines, the reporting of Descriptor 1 and 6 are merged at some extent. Descriptor 1 for species is done for cephalopods, fish, seabirds, reptiles and mammals. As these species' groups are not included in the monitoring network, they have not been included in the assessment.

On the other hand, the assessment should be done both for pelagic habitats and benthic habitats. In the case of benthic habitats, these include criteria from both Descriptor 1 (biodiversity) and 6 (seafloor integrity). The analysis must be done at the level of subdivision (WFD water bodies and territorial together). It should include different features (e.g. physical loss and disturbance of the seabed) and elements (e.g. EUNIS benthic broad habitat types such as littoral rock and biogenic reef, infralittoral mixed sediments, and infralittoral sand). For each of them, depending on the criteria to be assessed (as shown in Table 2), a series of indicators and thresholds (boundaries of good/not good status) are necessary. The benthic broad habitats are included in the excel file "MSFD2018reporting _ReferenceLists_v5.14", from European Commission (2018b). These broad habitats can be split down into detailed EUNIS habitats. Hence, we have followed a similar approach as done in the initial Malta's assessment (ERA, 2013), to make them comparable. The only exception is that of *Posidonia*, which in the initial assessment was assigned to 'shallow sublittoral sediment', being now 'Infralittoral mixed sediment'. It should be noted however that according to the latest habitat classification as compiled by UNEP/MAP, *Posidonia oceanica* meadows are classified under 'Infralittoral Biogenic Habitat'.

For these benthic habitats, we have used the CARLIT index (Ballesteros *et al.*, 2007), the percentage of live *Lithophyllum* in the organogenic trottoirs (EUNIS: A1, A1.13, A1.14), and percentage of coastal length covered by *Cystoseira,* as macroalgae (EUNIS: A1, A1.13, A1.14) associated to littoral rocks and biogenic reefs habitat. For infralittoral mixed sediment we have used the *Posidonia* Rapid Evaluation Index (PREI) (Gobert *et al.*, 2009) (EUNIS: A5.535). For infralittoral sand we have used BENTIX (Simboura and Zenetos, 2002) to assess the benthic macroinvertebrates (EUNIS: A5.23, A5.24). The boundaries considered are those included in Table 3. We have used those intercalibrated by Malta (European Commission, 2018), such as in CARLIT and PREI. In the case of BENTIX, it has been intercalibrated between Greece and Cyprus, which share the same water type with Malta; hence, we have used the same boundaries. For the surface covered by *Posidonia*, we have used as baseline the surface covered during the initial assessment. Finally, for *Lithophyllum* and *Cystoseira*, we have used the equivalent boundary to that most used in the intercalibration for EQR (0.6), and as the units are percentage, we have taken as boundary 60%.

Once the thresholds for each indicator have been established, we determined the value objective in the MRUs for criterion D6C3 (Spatial extent of each habitat type adversely affected through change in its biotic and abiotic structure). Since habitats have been historically affected by land use, we investigated the percentage distribution of land use in the Maltese islands. After Schembri (2003), the Maltese coast has a length around 180 km, from which (Table 6.2, page 148, in that study) 8.1% is occupied by recreational areas, 8.4% by residential areas, 4.3% dilapidated areas, and 8.1% industrial areas, totalizing 28.9% of the coast. In order to be conservative, instead of using that percentage as the allowed adversely affected habitat, we have used 25%. This value has been extrapolated to apply to marine habitats on the basis of the assumption that disturbance on marine habitats would be linked to the intensity of the activities on the coast or the extent of coastline affected by anthropogenic activities

Table 3: Indicators associated to Descriptor 1 (Biodiversity) and D6 (Seafloor integrity), to the habitat and ecosystem component, used in the assessment, together with the potential range of variation and the boundaries used in the calculations. The boundaries are those from the references included. EQR: Ecological Quality Ratio.

HABITAT	ECOSYSTEM COMPONENT	INDICATOR	Unit	Worst	Good/ Not Good	Best	Reference
Benthic	Benthic Fauna	BENTIX	EQR	0	0.58	1	Greece and Cyprus European Commission 2018
Benthic	Macroalgae	CARLIT	EQR	0	0.60	1	Malta European Commission 2018
Benthic	Macroalgae	*Lithophyllum*	% alive	0	60	100	Expert
Benthic	Macroalgae	*Cystoseira*	% coast	0	60	100	Expert
Benthic	Seagrasses	PREI	EQR	0	0.55	1	Malta European Commission 2018
Pelagic	Phytoplankton	Total density of cells	Cell l^{-1}	2.9 10^4	3.1 10^4	0	Kitsiou and Karydis (2000)
Pelagic	Phytoplankton	Ratio diatoms/dinoflagellates	No unit	0	1	503	Wasmund et al. (2017)

Eventually, for criterion D6C4 ("The extent of loss of the habitat type, resulting from anthropogenic pressures does not exceed a specified proportion of the natural extent of the habitat type in the assessment area") data on *Cystoseira* extent and maerl distribution, from the monitoring report, could be used. However, in both cases the methods used should be similar to those in other studies, to be sure that they are comparable. Otherwise, any increase or decrease could be attributable to human factors and, in fact, be due to methodological differences. Hence, this has prevented its use in the present assessment, but could be used in future assessments if the methodology is the same.

On the other hand, for pelagic habitats data on phytoplankton, communities have been considered. We have not used the data on zooplankton, as no thresholds for this element exist and there is a clear difficulty of using it as an element to assess the effects of human pressures. The few times that zooplankton has been used in assessing the status were in estuaries, and with contrasting results, with little replication (Uriarte and Villate, 2004; Carpenter et al., 2006; Mialet et al., 2011). Most of the studies using zooplankton indicators are to study climate change or the strong relationships of zooplankton abundance and climatic factors (e.g. Sabatés et al., 2007; Molinero et al., 2008), making difficult to disentangle their use to assess the human pressures and impacts from the natural variability.

The analysis for the pelagic habitats has been done for three MRUs: coastal waters (all WFD water bodies together), territorial waters and offshore waters, following the European Commission, 2018b) guidelines. It includes two main features, each one associated with a corresponding indicator: (i) phytoplankton abundance (total number of cells per litre); and (ii) phytoplankton composition, considering the main two groups (ratio diatoms to dinoflagellates).

For the phytoplankton abundance indicator, we have used the mesotrophy level as the boundary between good/not good, which was proposed by Kitsiou and Karydis (2000) to assess the degree of eutrophy of the Aegean Sea (Greece), and used by Balci and Balkis (2017) in the Marmara Sea (Turkey). Regarding the composition of phytoplankton, the ratio diatoms/dinoflagellates has been considered, using the boundary proposed by Wasmund et al. (2017) to establish the good environmental status in the Baltic Sea, for the MSFD.

For integration of the information, when there are two criteria, both of them must achieve thresholds and the extent of habitat loss from D6C4 included in proportion of habitat in poor condition for D6C5 (EU MSFD GES Decision). More details on the elements source, criteria to which the indicators respond, etc., are included in the Excel file provided as Annex to this report, in which all the information related to each descriptor is included in individual sheets.

4.4.2 Descriptor 2: Non-indigenous species

For Descriptor 2 we have used NIS list from different ecosystem components: benthic fauna, macroalgae and phytoplankton. The criteria used in the Commission Decision (European Commission, 2017) include mostly trends and the available information (2017-2018) prevents its use. However, we have compared the present monitoring data with those from the initial assessment done for MSFD, following the threshold shown in Table 4. The criteria used in the assessment are D2C1 and D2C2 (number of newly introduced and abundance and spatial distribution, respectively; see explanations in Table 2).

Table 4: Indicators associated to Descriptor 2 (Non-Indigenous Species), to the habitat and ecosystem component, used in the assessment. The boundary is that from the reference included.

HABITAT	ECOSYSTEM COMPONENT	INDICATOR	Unit	Good/Not Good	Reference
Benthic	Benthic Fauna	Newly introduced non-indigenous species	Nº species	0/1 or more	GES&Thresholds-Descriptor2 https://era.org.mt/en/Pages/MSFD-IAs-GES-Targets.aspx
Benthic	Macroalgae	Newly introduced non-indigenous species	Nº species	0/1 or more	
Pelagic	Phytoplankton	Newly introduced non-indigenous species	Nº species	0/1 or more	

Benthic NIS information (occurrence and distribution) comes from visual underwater surveys undertaken in selected localities (Hotspots in MTC105 and MTC107, and MPA-Marine Protected Areas in MTC103, MTC104, MTC108 and MTC109) and also from soft bottom macroinvertebrates samples (MRU corresponding to the nine WFD water bodies). All these samples belong to sampling stations located in coastal waters (WFD coastal water bodies).

The information for phytoplankton belongs to stations from all the considered MRUs, i.e., Coastal waters (WFD water bodies), Territorial waters and Offshore waters. Thus, assessment for Territorial and Offshore waters is based only on phytoplankton data.

For updated information on NIS species in Europe in general, and in the Mediterranean in particular, we have consulted next repositories and databases:

- European Network on Invasive Alien Species - NOBANIS: http://www.nobanis.org/,
- Regional Euro-Asian Biological Invasions Centre (REABIC): http://www.reabic.net/,
- Global Invasive Species Information Network- GISIN http://www.gisinetwork.org/
- UNEP-MAP-RAC/SPA, 2018. Marine Mediterranean Invasive Alien Species (MAMIAS). http://www.mamias.org/
- AquaNIS. Editorial Board, 2015. Information system on Aquatic Non-Indigenous and Cryptogenic Species. World Wide Web electronic publication. www.corpi.ku.lt/databases/aquanis. Version 2.36+.
- EASIN: European Alien Species Information Network: http://easin.jrc.ec.europa.eu/use-easin/species-search

To determine pathways of identified NIS the following literature has been consulted: Boudouresque *et al.* (2002), ICES (2005), Zenetos *et al.* (2005), Cannicci *et al.* (2008), Gambi *et al.* (2009), CBD (2014), Marchini *et al.* (2015), Evans *et al.* (2015), Schembri *et al.* (2015) and IUCN (2017) which includes both Maltese and Mediterranean waters.

4.4.3 Descriptor 5: Human-Induced Eutrophication

For Descriptor 5, we have included several indicators used across all Member States (e.g. within the WFD): (i) for physico-chemistry, ammonium, nitrates, phosphates, total phosphorous, oxygen at the bottom, and Secchi disk depth, as measure of transparency; (ii) for phytoplankton, 90th percentile of chlorophyll-a and number of events of Harmful Algal Blooms (HABs); (iii) one index for seagrasses (PREI); (iv) one for macroalgae (CARLIT); and (v) one index for benthic fauna (BENTIX). Table 5 shows those thresholds and boundaries considered for these indicators, as commented previously.

Table 5: Indicators associated to Descriptor 5 (eutrophication), to the habitat and ecosystem component, used in the assessment. The boundaries are those from the references included. EQR: Ecological Quality Ratio.

HABITAT	ECOSYSTEM COMPONENT	INDICATOR	Unit	Worst	Good/ Not Good	Best	Reference
Pelagic	Phytoplankton	Chlorophyll-a 90th percentile	µg L^{-1}	5	0.53	0	Greece European Commission 2018
Pelagic	Phytoplankton	Harmful Algal Blooms	Events yr^{-1}	-	2	0	UNEP-MAP (2015)
Pelagic	Water Column	Secchi disk depth	m	0	4.5	50	UNEP-MAP (2015)
Pelagic	Water Column	Nitrates	µmol L^{-1}	10	0.3	0.02	UNEP-MAP (2015)
Pelagic	Water Column	Phosphates	µmol L^{-1}	10	0.06	0.02	
Pelagic	Water Column	Total Phosphorous	µmol L^{-1}	10	0.3	0.02	

HABITAT	ECOSYSTEM COMPONENT	INDICATOR	Unit	Worst	Good/ Not Good	Best	Reference
Pelagic	Water Column	Ammonium	µmol L^{-1}	10	0.3	0.02	
Pelagic	Water Column	Oxygen saturation at the bottom	%	0	80	120	Uriarte and Borja (2009) and 79/923 Shellfish Waters Directive
Benthic	Benthic Fauna	BENTIX	BITS	0	3.48	6	Greece European Commission 2018
Benthic	Macroalgae	CARLIT	EQR	0	0.60	1	Malta European Commission 2018
Benthic	Seagrasses	PREI	EQR	0	0.55	1	

The criteria used in the assessment are D5C1 (nutrients), D5C2 (chlorophyll-a), D5C3 (HABs), D5C4 (transparency), D5C5 (saturation of oxygen), D5C6 (macroalgae), D5C7 (seagrasses), and D5C8 (macroinvertebrates) (see Table 2). A bloom is considered to be present when there are more than 10^5 cells l^{-1} from a harmful alga in a sample, in this oligotrophic area. For the list of harmful algae, see Borja et al. (2019b).

The assessment has been done at the WFD water bodies level and beyond coastal waters, as required by the European Commission (2018) guidelines. Since macroalgae, seagrasses and macroinvertebrates have been assessed only in coastal waters, they do not intervene in the assessment of MRU beyond coastal waters.

The proposed integration of the information, inspired at some extent in proposals from Andersen et al. (2016), has been done as follows:

- 1- Are nutrient concentrations (four indicators) at levels that indicate adverse eutrophication effects?
    - If the response is ‘yes’, and the responses to questions 2, 3, 4 and 5 are ‘yes’, then the status is ‘not good’
    - If the response is ‘yes’, and the responses to questions 2, 3, 4 and 5 are ‘no’, then the status is ‘good’
    - If the response is ‘no’, respond to the next question.
- 2- Are Chlorophyll-a concentration and HABs events at levels that indicate adverse effects because of nutrient enrichment?
    - If the response is ‘yes’, and the responses to questions 3, 4 and 5 are ‘yes’, then the status is ‘not good’
    - If the response is ‘yes’, and the responses to questions 3, 4 and 5 are ‘no’, then the status is ‘good’
    - If the response is ‘no’, respond to the next question.
- 3- Is the transparency of the water column reduced, due to increases in suspended algae, to a level that indicates adverse effects of nutrient enrichment?

  - If the response is 'yes', and the responses to questions 4 and 5 are 'yes', then the status is 'not good'
  - If the response is 'yes', and the responses to questions 4 and 5 are 'no', then the status is 'good'
  - If the response is 'no', respond to the next question.
- 4- Is the oxygen saturation reduced, due to nutrient enrichment, to levels that indicate adverse effects on benthic habitats?
  - If the response is 'yes', and the response to question 5 is 'yes', then the status is 'not good'
  - If the response is 'yes', and the response to question 5 is 'no', then the status is 'good'
  - If the response is 'no', respond to the next question.
- 5- Do macroalgae, seagrass or macroinvertebrates show adverse effects produced by nutrient enrichment?
  - If the response is 'yes', then the status is 'not good'
  - If the response is 'no', then the status is 'good'

The idea behind this integration is that nutrient increase must result in a phytoplankton response (increase in chlorophyll-and HABs), a degradation of the system (reduction of transparency and oxygen), and finally in impacts in the benthic components. If there are no such impacts, or these are due to other causes (e.g. dredging, etc.) and no to nutrient enrichment, then the environmental status for this descriptor would be good.

4.4.4 Descriptor 8: Contaminants

To assess the status of D8, we have followed the European Commission (2017) decision, as well as the guidelines on the methodology (European Commission, 2018b). We have used only one criterion, D8C1, which is the concentration of contaminants in water column, sediments, and biota (benthic fauna and fish). The thresholds used have been those legally set, such as those in the Directive 2013/39/CE of 12 August 2013 and SQG's (Sediment Quality Guidelines) established in Italy (Decreto n.56/2009). The values are detailed in Table 6.

More details on the elements source, criteria to which the indicators respond, etc., are included in the Excel file provided as Annex to this report, in which all the information related to each descriptor is included in individual sheets. When a substance is evaluated using two indicators (e.g. annual average and maximum allowable concentration), following the guidelines, we have used the 'One-out, all-out' (OOAO) principle, and if one fails, the whole substance fails in achieving good status. The whole integration has been done as percentage of achievement.

The assessment has been done at the level of the WFD water bodies (all together, following the guidelines) and at the level of territorial-offshore waters, as required by the European Commission (2018) guidelines.

Table 6: Indicators associated to Descriptor 8 (contaminants), to the habitat and ecosystem component, used in the assessment. AA-EQS: annual average environmental quality standard and MAC-EQS: maximum allowable concentration environmental quality standard. SQG: Sediment Quality Guidelines

HABITAT	ECOSYSTEM COMPONENT	INDICATOR	Unit	Good/Not good		Reference
				AA-EQS	MAC-EQS	
Pelagic	Water Column	1.2-Dichloroethane	µg L^{-1}	10	-	DIRECTIVE 2013/39/EU
Pelagic	Water Column	Aclonifen	µg L-1	0.012	0.012	
Pelagic	Water Column	Benzene	µg L^{-1}	8	50	
Pelagic	Water Column	Benzo(a)pyrene	µg L^{-1}	0.00017	0.0027	
Pelagic	Water Column	Benzo(b)fluoranthene	µg L^{-1}	0.00017	0.017	
Pelagic	Water Column	Benzo(g,h,i)perylene	µg L^{-1}	0.00017	0.00082	
Pelagic	Water Column	Benzo(k)fluoranthene	µg L^{-1}	0.00017	0.017	
Pelagic	Water Column	Indeno(1,2,3-c,d)pyrene	µg L^{-1}	0.00017	-	
Pelagic	Water Column	Fluoranthene	µg L^{-1}	0.0063	0.12	
Pelagic	Water Column	Naphthalene	µg L^{-1}	2	130	
Pelagic	Water Column	Bifenox	µg L^{-1}	0.0012	0.004	
Pelagic	Water Column	Cybutryne	µg L^{-1}	0.0025	0.016	
Pelagic	Water Column	Cypermethrine	µg L^{-1}	0.000008	0.00006	
Pelagic	Water Column	Dichloromethane	µg L^{-1}	20	-	
Pelagic	Water Column	Dichlorvos	µg L^{-1}	0.00006	0.00007	
Pelagic	Water Column	Dicofol	µg L^{-1}	0.000032	-	
Pelagic	Water Column	Heptachlor and heptachlor epoxide	µg L^{-1}	0.00000001	0.00003	
Pelagic	Water Column	Hexabromocyclododecane	µg L^{-1}	0.0008	0.05	
Pelagic	Water Column	Cadmium	µg L^{-1}	0.2	0.45	
Pelagic	Water Column	Lead	µg L^{-1}	1.3	14	
Pelagic	Water Column	Mercury	µg L^{-1}	-	0.07	DIRECTIVE 2013/39/EU
Pelagic	Water Column	Nickel	µg L^{-1}	8.6	34	
Pelagic	Water Column	PFOA and its compounds	µg L^{-1}	0.00013	7.2	
Pelagic	Water Column	Quinoxyfen	µg L^{-1}	0.015	0.54	
Pelagic	Water Column	Terbutryn	µg L^{-1}	0.0065	0.034	
Pelagic	Water Column	Trichloromethane	µg L^{-1}	2.5	-	
Benthic	Sediment	Anthracene	mg kg^{-1}	0.045		SQG from Italy (Decreto 56/2009)

HABITAT	ECOSYSTEM COMPONENT	INDICATOR	Unit	Good/Not good		Reference
				AA-EQS	MAC-EQS	
Benthic	Sediment	Benzo(a)pyrene Sed	mg kg^{-1}	0.03		
Benthic	Sediment	Cadmium	mg kg^{-1}	0.3		
Benthic	Sediment	Chromium	mg kg^{-1}	50		
Benthic	Sediment	Fluoranthene	mg kg^{-1}	0.11		
Benthic	Sediment	Hexachlorobenzene	µg kg^{-1}	0.4		
Benthic	Sediment	Hexachlorocyclohexane	µg kg^{-1}	0.2		
Benthic	Sediment	Lead Sed	mg kg^{-1}	30		
Benthic	Sediment	Mercury Sed	mg kg^{-1}	0.3		
Benthic	Sediment	Naphthalene Sed	mg kg^{-1}	0.035		
Benthic	Sediment	Nickel Sed	mg kg^{-1}	30		
Benthic	Sediment	Polychlorinated biphenyls	mg kg^{-1}	0.008		
Benthic	Sediment	Tributyltin	µg kg^{-1}	5		
Benthic	Sediment	Arsenic	µg kg^{-1}	12		
Benthic	Sediment	Dioxins and dioxin-like PCBs.	µg kg^{-1}	0.002		
Benthic	Sediment	Total PAHs	µg kg^{-1}	800		
Benthic	Fish/Benthic Fauna	Dicofol bio env fish	µg kg^{-1} ww	33		DIRECTIVE 2013/39/EU
Benthic	Fish	Heptachlor and heptachlor epoxide	µg kg^{-1} ww	0.0067		
Benthic	Fish	Hexabromocyclododecane (HBCDD)	µg kg^{-1} ww	167		
Benthic	Fish	Hexachlorobenzene	µg kg^{-1} ww	10		DIRECTIVE 2013/39/EU
Benthic	Fish	Hexachlorobutadiene	µg kg^{-1} ww	55		
Benthic	Fish	Mercury	µg kg^{-1} ww	20		
Benthic	Fish	PFOA and its compounds	µg kg^{-1} ww	9.1		
Benthic	Benthic Fauna	Benzo(a)pyrene bio env	µg kg^{-1} ww	5		
Benthic	Benthic Fauna	Fluoranthene	µg kg^{-1} ww	30		
Benthic	Fish /Crustacean	Dioxin-like polychlorinated biphenyls	µg kg^{-1} ww	0.0065		
Benthic	Fish /Crustacean	Total dioxins and furans (PCDD + PCDF)	µg kg^{-1} ww	0.0035		

4.4.5 Descriptor 9: Contaminants in seafood

In Descriptor 9 (Contaminants in seafood) we have used D9C1, which is the concentration of contaminants in seafood. We have used legal thresholds, described in Regulation 1881/2006 and also in Regulation 1259/2011 amending the Regulation 1881/2006 for dioxin. We have followed the European Commission (2017) decision and the guidelines (European Commission, 2018b). The values are detailed in Table 7. More details on the elements source, criteria to which the indicators respond, etc., are included in the Excel file provided as Annex to this report, in which all the information related to each descriptor is included in individual sheets.

Table 7: Indicators associated to Descriptor 9 (contaminants in seafood), to the habitat and ecosystem component, used in the assessment.

HABITAT	ECOSYSTEM COMPONENT	INDICATOR	Unit	Good/Not Good	Reference
Benthic	Fish	Mercury (*Merluccius*)	µg kg^{-1}	500	Max levels after Regulation 1881/2006
Benthic	Fish	Mercury (*Mullus*)	µg kg^{-1}	1000	
Benthic	Fish	Cadmium	µg kg^{-1}	50	
Benthic	Fish	Lead	µg kg^{-1}	300	
Benthic	Crustacean	Benzo(a)pyrene	µg kg^{-1}	5	
Benthic	Fish /Crustacean	Dioxin-like polychlorinated biphenyls	µg kg^{-1}	0.0065	Max levels after Regulation 1259/2011 that amended the regulation 1881/2006 for dioxin
Benthic	Fish /Crustacean	Total dioxins and furans (PCDD + PCDF)	µg kg^{-1}	0.0035	

The assessment has been done at the level of the territorial-offshore waters, although the guidelines from the European Commission (2018b) require undertaking this at the subregional level. In addition, we have used the OOAO principle, since in the European Commission (2018b) guidance examples (see "GD14_MSFD2018ReportingGuidance_Art8-9-10_AnnexII_WorkedExamples_20180409 (1)") it is said that this principle should be used when several species are included in the analysis.

4.4.6 Descriptor 10: Marine litter

For Descriptor 10 (Marine litter) we have used three indicators, including litter on beach, on the seafloor and in the water column. The boundaries considered are those included in Table 8, and proposed by UNEP-MAP (2015) as baseline for the study and evaluation of litter in the Mediterranean. A baseline is a description of environmental state at a specific point against which subsequent values of state are compared. It may refer to a specified level of an impact or a pressure and act as a reference against which limit can be set or trends for the assessment of GES. Baselines can be derived from reference conditions, initial assessment values, the present state or a potential/predicted state. Taking this into account, and until the experts can determine adequate thresholds, we have use them as the boundary between good and not good.

Table 8: Indicators associated to Descriptor 10 (litter), to the habitat and ecosystem component, used in the assessment, together with the range of variation and the boundaries used in the calculations.

HABITAT	ECOSYSTEM COMPONENT	INDICATOR	Unit	Worst	Good/Not Good	Best	Reference
Benthic	Benthos	Beach Litter	items 100 m^{-1}	3600	1400	11	UNEP-MAP (2015)
Pelagic	Water column	Floating macrolitter	items km^{-2}	195	5	0	
Benthic	Benthos	Seafloor macrolitter	N km^{-2}	7700	230	0	

The assessment has been done at the level of the WFD water bodies (all together, following the guidelines) and at the level of territorial-offshore waters, as required by the European Commission (2018) guidelines.

4.5 Assessment of environmental status

After having decided all the indicators and thresholds to be included in the analyses, as commented previously, the assessment has been done, as far as possible, in accordance with Annex III of MSFD and with the criteria and methodological standards in the European Decision (European Commission, 2017) and the guidelines (European Commission, 2018b).

The database was interrogated for each indicator, obtaining the mean value, the maximum and the minimum, from the stations associated to each MRU included in the assessment, as required by the guidelines (European Commission, 2018b), for the period June 2017 to March 2019. When necessary these values were aggregated at the required MRU level, by calculating the mean value, or the times the threshold value was not achieved, again after the guidelines.

The assessments are delivered at the different MRU and descriptor. Since the European Commission (2018) guidelines does not provide an approach to integrate the information coming from different descriptors (or even at lower level, for different criteria), this was not possible to be undertaken.

5.0 Results of the assessment

5.1 Assessment by Descriptor

The indicators used for this assessment represent the available data for several descriptors of the MSFD (i.e., D1 (biodiversity), D2 (alien species), D5 (eutrophication), D6 (seafloor integrity), D8 (contaminants), D9 (seafood contaminants), and D10 (litter)) carried out in each study area. The details of each of them are given below, and the raw results are shown in the Excel file provided as annex to this report.

5.1.1 Descriptor 1: Biodiversity and Descriptor 6: seafloor integrity

For benthic habitats included in Descriptors 1 and 6, several features have been assessed, including disturbance of the seabed and benthic broad habitats (Table 9), as commented in Section 4.4.1. Five of the criteria shown in Table 2 have been included, being the criteria values those referred to extent of physical loss and disturbance, habitat condition and habitat loss. For Criteria D6C1 and D6C2 (spatial extent of physical loss and physical disturbance), it was not possible to make the assessment, since no data on extent of the pressures in the seafloor exist in the database from the monitoring network. These should include information such as harbour areas, seabed affected by anchoring, dredging, sediment disposal or aquaculture activities.

For criterion D6C3 (Spatial extent of each habitat type adversely affected through change in its biotic and abiotic structure), the value objective in the MRU was 25%, and, depending on the ecosystem component, the values ranged between 4.5 and 20.8% (Table 9). In general, and in consideration of the initial assessment, the changes have been minor, and the situation can be considered as stable. Hence, the objective for this criterion has been achieved and the environmental status of the criterion is good. The pressure explaining the percentage of affected area is the disturbance caused by different human activities. As shown in the monitoring report (Borja et al., 2019b), the most likely explanation of some of these disturbances come from harbour and shipping activities, aquaculture and, in some cases, could be local activities (diving, etc.), as demonstrated in Malta with some recent research (Romeo et al., 2015; Mangion et al., 2017). Romeo et al. (2015), studying the Grand Harbour along a gradient from the inner to the outer part, found the lowest value for Shannon-Wiener benthic biodiversity associated to the station with the highest sediment pollution level. In this way, they determined that MBT and TBT were the factors that most influenced macrozoobenthic abundance and biodiversity in the harbour, with the bivalve *Corbula gibba* and the introduced polychaete *Monticellina dorsobranchialis* being the most abundant species. On the other hand, Mangion et al. (2017), studying three tuna farms in the east and southeast coast of Malta, assessed the impact of this activity, finding lower number and Shannon–Wiener diversity values of polychaete and amphipod taxa close to the farms, compared with the control plots.

In the case of Criteria D6C4 and D6C5 (extent of loss of habitat and extent of adverse effects), the objectives to be achieved ranged between 75 and 95% of the habitat in the MRU must achieve the threshold value, excepting *Cystoseira,* which is 60%. This is because this indicator refers to the percentage of coast covered by this species and part of the coast has not suitable substrata for it (sandy or shingle beaches). In all cases, the criteria are achieved, being the environmental status good (Table 9). The situation is stable in all cases. For these criteria, 100% of the habitats present must achieve good status to have a general good environmental status. As three out of the three habitats are in good status, the GES has been achieved (Figure 3).

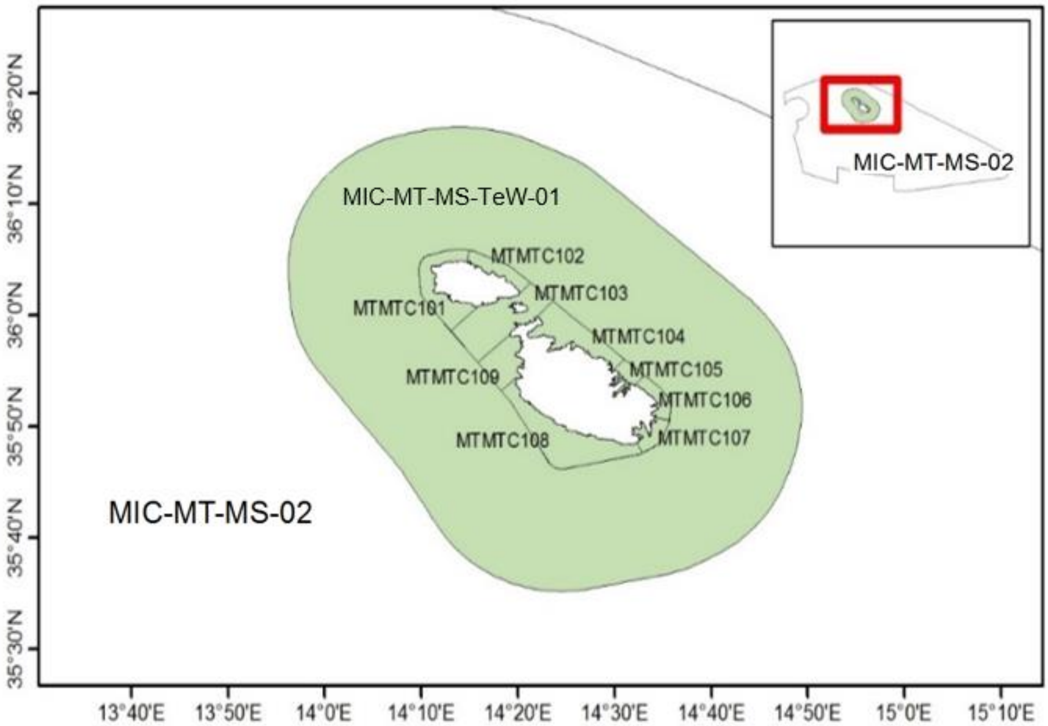

Figure 3: Map showing the environmental status, for Descriptor 1 (Biodiversity) and D6 (seafloor integrity), for benthic habitats, in the Maltese Marine Reporting Units. Green: good status; Pink: Not Good; MT-SS-01-1: offshore waters; MT-Te: territorial waters; MTMTC: coastal waters

The situation of environmental status for the MSFD is stable when compared with the initial assessment (ERA, 2013). There, the habitats and indicators assessed here using quantitative thresholds and reference conditions, achieved good status, as in that initial assessment, in which most of the indicators were assessed using expert judgment. In the particular case of the percentage of coast occupied by *Cystoseira*, in the first assessment the length covered was 66%, whilst now is 66.9%. This small improvement could be attributable to the removal of some disturbances. In fact, in the initial assessment, it is said that "A stretch of coastline along the North-eastern coast of Malta, which until recently was subject to discharge of untreated sewage, is also devoid of *Cystoseira* belts. The sewage outfall has been replaced by treated sewage effluent in 2012, however it is too early to detect any changes in algal communities as a result of such replacement." However, being the difference so small, probably this difference is more linked to the error of measure associated to the methodology.

Table 9: Environmental status results, following the Reporting guidance for Descriptor 1 (Biodiversity) and D6 (seafloor integrity), for benthic habitats in 2017-2018. The considered Marine Reporting Unit (MRU) area is the combination of Coastal waters (WFD water bodies) and Territorial waters. For an explanation of the Criteria, see Table 2. Upper and lower values refer to those found in the database for each variable.

Feature	Element	Criteria	Criteria Values	Threshold	Value (upper)	Value (lower)	Unit	Value objective in MRU (%)	Achieved/ Not achieved	Explanation	Trend	Achieved?	Indicator	Status of criterion	Element status	Overall status threshold	Overall status achieved	Overall ttatus (%)	Overall status projection	Pressures explaining status	Overall status thresholds
Physical loss of the seabed		**D6C1**	Extent of physical loss							Extent in km² of pressure	Unknown	Not assessed		Not assessed	Contributes to D6C4 & D7C1					Physical disturbance to seabed	Art10-D6-2 (physical loss); Art10-D6-1 (physical disturbance)
Physical disturbance to the seabed		**D6C2**	Extent of physical disturbance								Unknown	Not assessed		Not assessed	Contributes to D6C3						
Benthic broad habitats	Littoral rock and biogenic reef	**D6C3**	Habitat condition	60	93	53.6	%	25	20.8	% area of habitat in MRU adversely affected	Stable	Yes	*Lithophyllum* alive	Good	Contributes to D6C5						
	Littoral rock and biogenic reef	**D6C3**	Habitat condition	0.6	1.68	0.08	EQR	25	20.4		Stable	Yes	CARLIT (macroalgae)	Good							
	Infralittoral mixed sediment	**D6C3**	Habitat condition	0.55	0.969	0.413	EQR	25	9.1		Stable	Yes	PREI (*Posidonia*)	Good							
	Infralittoral sand	**D6C3**	Habitat condition	0.58	1	0.555	EQR	25	4.5		Stable	Yes	BENTIX (macroinvertebrates)	Good							
Benthic broad habitats	Littoral rock and biogenic reef	**D6C4**	Habitat extent (loss)	60	93	53.6	%	75	79.2	% area of habitat in MRU achieving threshold value	Stable	Yes	Lithophyllum alive	Good	Good	100	100 (3 of 3 habitats present in area achieving good status)	Proportion (%) of benthic broad habitat types in good status	GES achieved	Physical disturbance; input of nutrients; introduction of NIS, input of contaminants	Art10-D6-1 (physical disturbance); Art10-D5-1 & D5-3 (input of nutrients); Art10-D2-1 (introduction of NIS); Art10-D8-3 (input of contaminants)
		D6C4	Habitat extent (loss)	60			%	60	66.9		Stable	Yes	% coast with Cystoseira	Good							
		D6C5	Habitat condition	0.6	1.68	0.08	EQR	75	79.6		Stable	Yes	CARLIT (macroalgae)	Good							
	Infralittoral mixed sediment	**D6C4**	Habitat extent (loss)	5860	6343		Ha	95	100		increase	Yes	*Posidonia* area	Good	Good						
		D6C5	Habitat condition	0.55	0.916	0.443	EQR	75	77.3		Stable	Yes	PREI (*Posidonia*)	Good							
	Infralittoral sand	**D6C4**	Habitat present, not assessed									Not assessed		Not assessed	Good						
		D6C5	Habitat condition	0.58	1	0.555	EQR	75	95.5		Stable	Yes	BENTIX (macroinvertebrates)	Good							

Table 10: Environmental status results, following the Reporting guidance for Descriptor 1 (Biodiversity), for pelagic habitats in 2017-2019. The considered Marine Reporting Unit (MRU) are Coastal waters (WFD water bodies), Territorial waters and offshore waters. For an explanation of the Criteria, see Table 2.

Element	Criteria	Indicator	Threshold	Value (Upper)	Value (Lower)	Unit	Value objective in MRU (%)	Achieved (%)	Explanation	Trend	Achieved?	Element Status	Overall status achieved	Overall status (%)	Overall status projection
Coastal	**D1C6**	Cell density	3.1E+04	2.9E+04	0	cell l^{-1}	95	100	% samples of MRU achieving threshold value	Stable	Yes	Good	100 (3 of 3 habitats in good status)	Proportion (%) of pelagic broad habitat types in good status	GES expected to be achieved by 2020
		Ratio Diat/Dino	1	503	0.16	Ratio	85	93		Stable	Yes				
Territorial	**D1C6**	Cell density	3.1E+04	6.9E+03	1.0E+02	cell l^{-1}	95	100		Stable	Yes	Good			
		Ratio Diat/Dino	1	94.7	0.14	Ratio	85	93		Stable	Yes				
Offshore	**D1C6**	Cell density	3.1E+04	1.9E+03	8.0E+01	cell l^{-1}	95	100		Stable	Yes	Good			
		Ratio Diat/Dino	1	45	0.49	Ratio	85	85		Stable	Yes				

For pelagic habitats the two indicators (cell density and ratio diatoms/dinoflagellates) refer to Criterion D1C6. This is the condition of the pelagic habitat type, including its biotic and abiotic structure and its functions, which is not adversely affected due to anthropogenic pressures. In fact, the three MRUs achieved the good environmental status (Table 10). Hence, the GES has been achieved by 2020, because anthropogenic pressures do not affect this pelagic habitat. The situation, when compared with the initial assessment for the MSFD could be considered stable, with little changes.

Despite the fact that there are some pressures in the area (physical disturbance, inputs of nutrients, introduction of NIS or some contaminants), these sources of pressure are not relevant enough to produce degradation, preventing the achievement of GES in Malta for this descriptor. Hence, the global environmental status for D1-D6 in Malta is good in benthic habitats (Figure 3) and pelagic habitats (Figure 4). As both are in good status, D1 and D6 can be considered globally in good status.

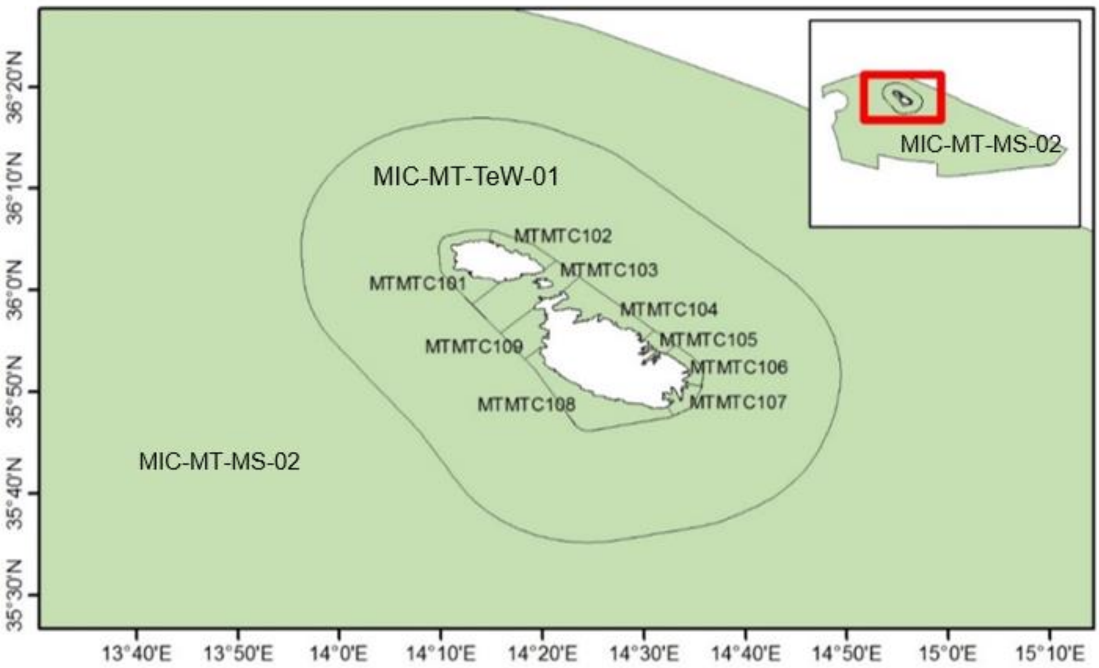

Figure 4: Map showing the environmental status, for Descriptor 1 (Biodiversity), for pelagic habitats, in the Maltese Marine Reporting Units. Green: good status; Pink: Not Good; MT-SS-01-1: offshore waters; MT-Te: territorial waters; MTMTC: coastal waters

This GES in Malta is in agreement with the individual assessment of each of the ecosystem components in benthic habitats, undertaken in the monitoring report, within the WFD (Borja et al., 2019b). Hence, macroalgae are in high status in all coastal water bodies, excepting MTC106 and MTC109, which are in good status; *Posidonia* is in high status in MTC103 and MTC108, and in good in the rest; and macroinvertebrates are in good status in MTC102, MTC108 and MTC109, and in high status in the rest.

This general good status of benthic habitats can be seen also when compared with results from other countries. For example, in macroalgae, a comparison of CARLIT application to different parts of the Mediterranean, such as Spain (Alborán, Catalonia), France, Italy (Liguria, Sardinia), Croatia, Albania and Malta, made by Blanfuné et al. (2017), found that the ecological status in Malta was the best of the countries (with 89% of the samples in high or good status), excepting a Marine Protected Area in Sardinia (Capo Carbonara), in which 100% of the samples achieved high status. In the case of macroinvertebrates, only one sample was in moderate status and, when compared with an index of pressure, such as the Land Uses Simplified Index (LUSI) (Flo et al., 2011, 2019), it has been shown in the monitoring report that the pressure is low enough to explain the high-good status of most macroinvertebrate samples (Borja et al., 2019b). In the case of *Posidonia*, the PREI index indicates a global good status, although in 8 out of the 21 samples the lower depth limit is regressive.

In relation to the pelagic habitats, the assessment is in agreement with the oligotrophic character of the Maltese coast, determined in the monitoring report (Borja et al., 2019b), in which the different indicators which can affect pelagic habitats (i.e. nutrients, transparency, chlorophyll-a, etc.) were in GES. Only few locations, mainly in transects and especially in Valletta harbour, showed occasional moderate status in some indicators, which is in agreement with some previous studies, in which low diversity values in the harbour are associated with the most polluted stations within it (Romeo et al., 2015). However, this does not compromise the whole GES for pelagic habitats in Malta. All of these results are similar to those obtained in the initial assessment for the MSFD.

All the information compiled in the monitoring report (Borja et al., 2019b), and the results from this assessment report, indicate that, despite the human pressures that Maltese coasts support (as seen in Figure 2) the quality of theirs coasts in relation these Descriptors 1 and 6 is good. This said, some attention should be paid to aquaculture activities, since some areas in the southeastern part of Malta could be affected by them (as shown in Mangion et al., 2017), as well as areas with high human density and harbour activities, such as Valletta harbour (as shown in Romeo et al., 2015). On the other hand, assessment of pressures on seabed habitats was beyond the scope of this report and further analysis of relevant pressures is deemed necessary.

5.1.2 Descriptor 2: Non-Indigenous Species.

New NIS species have been found in Coastal waters (benthic fauna, macroalgae and phytoplankton), Territorial waters (phytoplankton) and Offshore waters (phytoplankton). It should be noted that no information on zooplankton composition was included, due to the low taxonomical identification level reached (see Borja et al. (2019b) report on monitoring).

During the specific surveys directed to find NIS (MTC103, 104, 107, 108 and 109), 35 NIS were found (5 solely in MPAs; 23 solely in Hotspots; and 7 in both). This species list was compared to that provided in the "MSFD Initial Assessment Non-Indigenous species" document (https://era.org.mt/en/Pages/MSFD-IAs-GES-Targets.aspx). As a result, 23 out of 35 species were considered as newly introduced species since they are not cited for the Maltese waters in the mentioned reference document.

In all sites but one (CNIS03-2) the number of new NIS is increasing; also, Hotspots are, as expected, more affected than MPAs. Furthermore, some species found in 2012 were not found in 2017-2018: this could show a disappearance of these NIS, or, if they were found in low abundance, that can make difficult to found them with the methodological approach followed, in which the presence is detected, but the abundance is based on the Braun-Blanquet scale.

During the benthic monitoring carried out in October 2018, only two NIS (*Notomastus aberans* and *Prionospio (Prionospio) depauperata*) were identified in eight of the sampled stations and, furthermore, in low abundance (usually 1 ind 0.1 m^{-2}). Furthermore, these two species could be considered as newly introduced since they are not cited in "MSFD Initial Assessment Non-Indigenous species" (https://era.org.mt/en/Pages/MSFD-IAs-GES-Targets.aspx). In addition, the presence of another five macrobenthic NIS was identified. These species were considered as newly introduced because they were not cited in the initial assessment document. These five NIS were Annelida Polychaeta.

With respect to phytoplankton samples, 203 taxa were identified; among them, 16 were NIS (http://easin.jrc.ec.europa.eu). Since phytoplankton species are not mentioned in the "MSFD Initial Assessment Non-Indigenous species" document (https://era.org.mt/en/Pages/MSFD-IAs-GES-Targets.aspx), we have used the work of Streftaris *et al.* (2005) as initial reference. Thus, 14 species could be considered as newly introduced in Maltese waters since 2003. The most likely pathways for their introduction are natural drifting and ballast waters introduction, being impossible to determine the exact pathway for each of them.

Taking into account all of this, the environmental status for Malta, regarding Descriptor 2 is 'not good' (Table 11, Figure 3).

All the data used here, coming from specific sampling (hotspots and MPAs), and routine monitoring (macrobenthos and phytoplankton), show that NIS are increasing in Maltese waters. In this sense, the proposed GES threshold of "The introduction and establishment of new invasive non-indigenous species as a result of human activities, is in so far as practicable prevented" does not have been achieved. Thus, it can be concluded that these sites are deteriorating for this descriptor.

The most probable reason of this worsening is the maritime traffic since the hotspots (port and harbours) show the highest amounts of NIS (in fact, 34 out of the 54 species in Table 11 have been most likely introduced by this pathway) . However, all the MRUs are affected, and it cannot be discarded other colonisation ways. According to Katsanevakis *et al.* (2015), some species are linked to more than one pathway and the most relevant are: Stowaway (introductions due to shipping, as fouling or ballast water), Corridors (through the Suez canal and inland canals), Aquaculture (escapes or contaminants) and Pets-Aquarium (releases or escapes). This is in agreement with Evans *et al.* (2015) who says that, amongst the alien species, 'shipping' is the most common introduction pathway, followed by 'Secondary dispersal' from elsewhere in the Mediterranean Sea.

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According with our data, Evans *et al.* (2015) see an increasing trend in the number of alien marine species for the Maltese Islands. These authors think that the general warming trend of Mediterranean surface waters is facilitating the westward spread of thermophilic alien species from the Eastern to the Central Mediterranean, and the eastward range expansion of tropical and subtropical Eastern Atlantic species.

Table 11: Environmental status results, following the Reporting guidance for Descriptor 2 (Non-indigenous species), in 2017-2019. The Marine Reporting Unit area is the combination of Coastal, Territorial and Offshore waters. Benthic fauna or macroalgae (light brown), phytoplankton (blue). PRE (Presence), ABU (count), Other (coverage). Criterion D2C1: newly introduced; Criterion D2C2: areal extent and distribution. Names after the World Register of Marine Species (WoRMs). Possible Pathway: C-Corridor (interconnected waterways/basins/sea); E- Escape from confinement (aquaria, aquaculture); O-Other (includes secondary, unaided, spread); R-Release in nature; T-Transport (as a stowaway - fouling, ballast); Tr-Transport (as a contaminant - food contaminant); N: Natural shifting.

Element Status	**Criteria Status**		**Criteria Values**		**Overall Status**
Element (species)	**Pathway**	**Criteria**	**Parameter**	**Achieved**	
Chrysiptera hemicyanea (Weber, 1913)	R	D2C1	PRE	No	Not Good
Caprella scaura Templeton, 1836	T	D2C1	PRE	No	
Acrothamnion preissi (Sonder) E.M.Wollaston, 1968	C	D2C1	PRE	No	
Branchiomma bairdi (McIntosh, 1885)	T	D2C1	PRE	No	
Caulerpa taxifolia var. distichophylla (Sonder) Verlaque, Huisman & Procaccini, 2013	C	D2C1	PRE	No	
Paranthura japonica Richardson, 1909	T,Tr	D2C1	PRE	No	
Hydroides elegans (Haswell, 1883)	T	D2C1	PRE	No	
Stenothoe georgiana Bynum & Fox, 1977	T	D2C1	PRE	No	
Amathia verticillata (delle Chiaje, 1822)	C,T	D2C1	PRE	No	
Botryllus schlosseri (Pallas, 1766)	C	D2C1	PRE	No	
Bugula neritina (Linnaeus, 1758)	C	D2C1	PRE	No	
Celleporaria brunnea (Hincks, 1884)	T	D2C1	PRE	No	
Celleporaria vermiformis (Waters, 1909)	T	D2C1	PRE	No	
Codium fragile (Suringar) Hariot, 1889	E,T	D2C1	PRE	No	
Dendostrea folium (Linnaeus, 1758)	T	D2C1	PRE	No	
Didemnum sp. Savigny, 1816	C	D2C1	PRE	No	
Hippopodina sp. A Levinsen, 1909	T	D2C1	PRE	No	
Mesanthura cf. romulea Poore & Lew Ton, 1986	T	D2C1	PRE	No	
Oculina patagonica de Angelis, 1908	C,O	D2C1	PRE	No	
Paraleucilla magna Klautau, Monteiro & Borojevic, 2004	C	D2C1	PRE	No	
Styela plicata (Lesueur, 1823)	T	D2C1	PRE	No	
Notomastus aberans Day, 1957	T	D2C1	PRE	No	
Prionospio depauperata Imajima, 1990	T	D2C1	PRE	No	
Dispio uncinata Hartman, 1951	T	D2C1	PRE	No	
Lumbrinerides neogesae Miura, 1981	T	D2C1	PRE	No	
Kirkegaardia dorsobranchialis (Kirkegaard, 1959)	T	D2C1	PRE	No	
Alexandrium minutum Halim, 1960	T,N	D2C1	PRE	No	
Alexandrium taylori Balech, 1994	T,N	D2C1	PRE	No	
Asterionella glacialis Castracane, 1886	T,N	D2C1	PRE	No	
Chaetoceros diversus Cleve, 1873	T,N	D2C1	PRE	No	
Chaetoceros peruvianus Brightwell, 1856	T,N	D2C1	PRE	No	
Detonula pumila (Castracane) Gran, 1900	T,N	D2C1	PRE	No	
Gyrodinium corallinum Kofoid & Swezy, 1921	T,N	D2C1	PRE	No	

Element Status	Criteria Status		Criteria Values		Overall Status
Element (species)	Pathway	Criteria	Parameter	Achieved	
Octactis octonaria var. pulchra	T,N	D2C1	PRE	No	
Prorocentrum triestinum J.Schiller, 1918	T,N	D2C1	PRE	No	
Pseudo-nitzschia multistriata (Takano) Takano, 1995	T,N	D2C1	PRE	No	
Pseudosolenia calcar-avis (Schultze) B.G.Sundström, 1986	T,N	D2C1	PRE	No	
Rhizosolenia setigera Brightwell, 1858	T,N	D2C1	PRE	No	
Scrippsiella trochoidea (Stein) Loeblich III, 1976	T,N	D2C1	PRE	No	
Spatulodinium pseudonoctiluca (Pouchet) J.Cachon & M.Cachon, 1968	T,N	D2C1	PRE	No	
Bursatella leachii Blainville, 1817	O	D2C2	ABU		
Eucidaris trubuloides (Lamarck, 1816)	C	D2C2	ABU		
Percnon gibbesi (H. Milne Edwards, 1853)	T,C,O	D2C2	ABU		
Siganus luridus (Rüppell, 1829)	C	D2C2	ABU		
Asparagopsis taxiformis (Delile) Trevisan de Saint-Léon, 1845	C	D2C2	Other		
Brachidontes pharaonis (P. Fischer, 1870)	T	D2C2	Other		
Crassostrea gigas (Thunberg, 1793)	E	D2C2	Other		
Fulvia fragilis (Forsskål in Niebuhr, 1775)	C,O	D2C2	Other		
Halophila stipulacea (Forsskål) Ascherson, 1867	C,O	D2C2	Other		
Lophocladia lallemandii (Montagne) F.Schmitz, 1893	C	D2C2	Other		
Pinctada imbricata radiata (Leach, 1814)	E,C,O	D2C2	Other		
Womersleyella setacea (Hollenberg) R.E.Norris, 1992	C	D2C2	Other		
Caulerpa cylindracea Sonder, 1845	C	D2C2	Other		

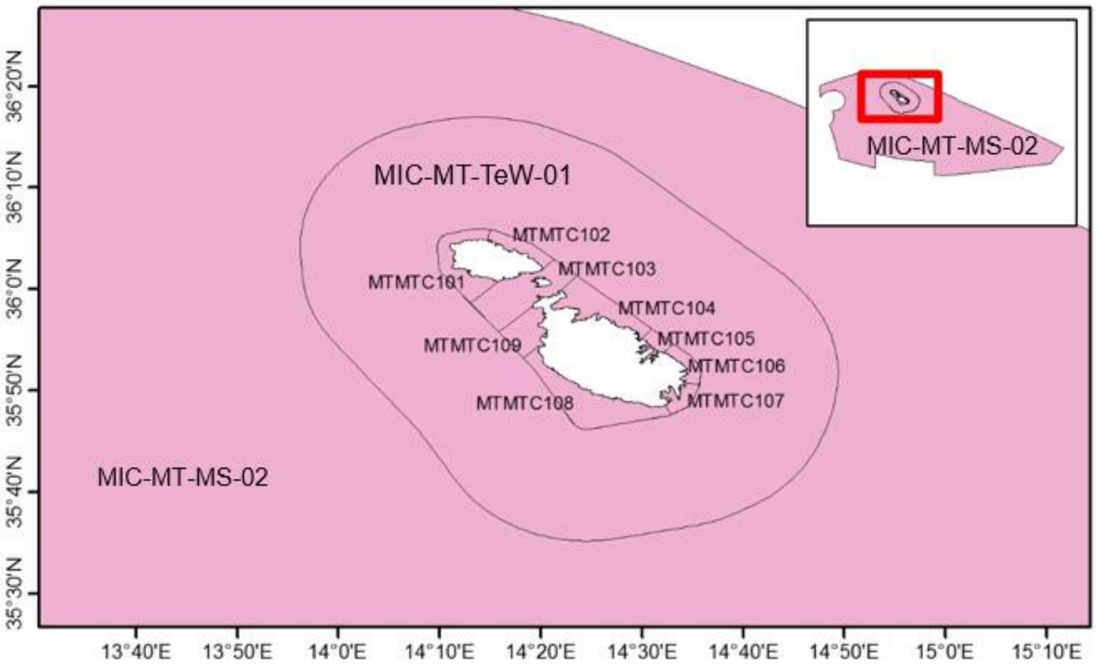

Figure 5: Map showing environmental status, for Descriptor 2 (Non-indigenous species) of the Maltese Marine Reporting Units. Green: good status; Pink: Not Good; MT-SS-01-1: offshore waters; MT-Te: territorial waters; MTMTC: coastal waters.

5.1.3 Descriptor 5: Human-induced eutrophication

Eutrophication (Descriptor 5) does not seem a major problem in Malta, since the environmental status is good in both coastal waters and offshore waters (Table 12, Figure 6). It should be noted that during the first three quarters of the monitoring, nutrients were below the detection limits. Only nitrate in coastal waters presented few values over the threshold (only 5.5% of the samples were over it), and they were mostly in transects, which were placed close to areas which eventually could be affected by discharges, such as run-off and harbours. Nitrate in offshore waters achieve in 100% of the cases the GES.

The other nutrients measured in coastal waters, achieved the GES in 100% of the samples. In fact, all ammonium concentrations, except one, were below the LOQ. For nitrite, more than half of the samples registered concentration below LOQ. All the samples collected in this monitoring program presented phosphate values below LOQ. Low levels of phosphates in this part of the Mediterranean have been observed and confirmed in several studies. For example, models used in Macias *et al*. (2019)[2] indicate phosphate levels of less than 0.02 µmol m^{-3} in the central Mediterranean.

[2] https://doi.org/10.1016/j.pocean.2019.02.005

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Table 12: Environmental status results, following the Reporting guidance for Descriptor 5 (Eutrophication), in 2017-2019. The Marine Reporting Unit areas are the combination of WFD Coastal water bodies, and beyond coastal waters (territorial and Offshore waters). TP: total phosphorous; HAB: Harmful Algae Blooms. For an explanation of the Criteria, see Table 2. Upper and lower values refer to those found in the database for each variable. The 'Value objective in MRU (%)' is based upon the example in European Commission (2018b) and expert judgment.

MRU	Element	Criteria	Criteria values	Threshold	Value (upper)	Value (lower)	Unit	Value objective in MRU (%)	Achieved	Explanation	Trend	Achieved?	Status of criterion	Overall Status threshold	Overall Status achieved	Overall Status explanation	Overall Status projection
Coastal waters	Nitrate	**D5C1**	Concentration in water	0.3	1.27	<0.03	µmol L^{-1}	95	94.5	% samples of MRU achieving threshold value	Stable	No	Not good	95	99.5	Proportion (%) of area in good status (not subject to eutrophication)	**GES achieved**
	Ammonium	**D5C1**		0.3	0.033	<0.03	µmol L^{-1}	95	100		Stable	Yes	Good				
	Phosphate	**D5C1**		0.06	0.01	<0.01	µmol L^{-1}	95	100		Stable	Yes	Good				
	TP	**D5C1**		0.3	0.12	<0.02	µmol L^{-1}	95	100		Stable	Yes	Good				
	Chlorophyll-a	**D5C2**	Concentration in water	0.53	2.64	0.001	µg L^{-1}	95	96.5		Stable	Yes	Good				
	All HAB species	D5C3	Number of HAB events	2	0	0	events y^{-1}	95	100		Stable	Yes	Good				
	Secchi disk depth	D5C4	Water transparency	4.5	45	3	m	95	97.1		Stable	Yes	Good				
	Dissolved oxygen	**D5C5**	Saturation in bottom	80	121.6	74.6	%	95	97.9		Stable	Yes	Good				
	Benthic habitats - macroalgae	D5C6	CARLIT	0.6	1.68	0.08	EQR	75	79.6		Stable	Yes	Good				
	Benthic habitats - seagrass	D5C7	PREI	0.55	0.916	0.443	EQR	75	77.3		Stable	Yes	Good				
	Benthic habitats - macrobenthos	D5C8	BENTIX	0.58	1	0.555	EQR	75	95.5		Stable	Yes	Good				
Beyond coastal waters	Nitrate	**D5C1**	Concentration in water	0.3	0.18	<0.03	µmol L^{-1}	95	100	% samples of MRU achieving threshold value	Stable	Yes	Good	95	100	Proportion (%) of area in good status (not subject to eutrophication)	**GES achieved**
	Chlorophyll-a	**D5C2**	Concentration in water	0.53	0.41	0.003	µg L^{-1}	95	100		Stable	Yes	Good				
	All HAB species	D5C3	Number of HAB events	2	0	0	events y^{-1}	95	100		Stable	Yes	Good				
	Secchi disk depth	D5C4	Water transparency	4.5	50	24	m	95	100		Stable	Yes	Good				
	Dissolved oxygen	**D5C5**	Saturation in bottom	80	116.5	88.1	%	95	100		Stable	Yes	Good				

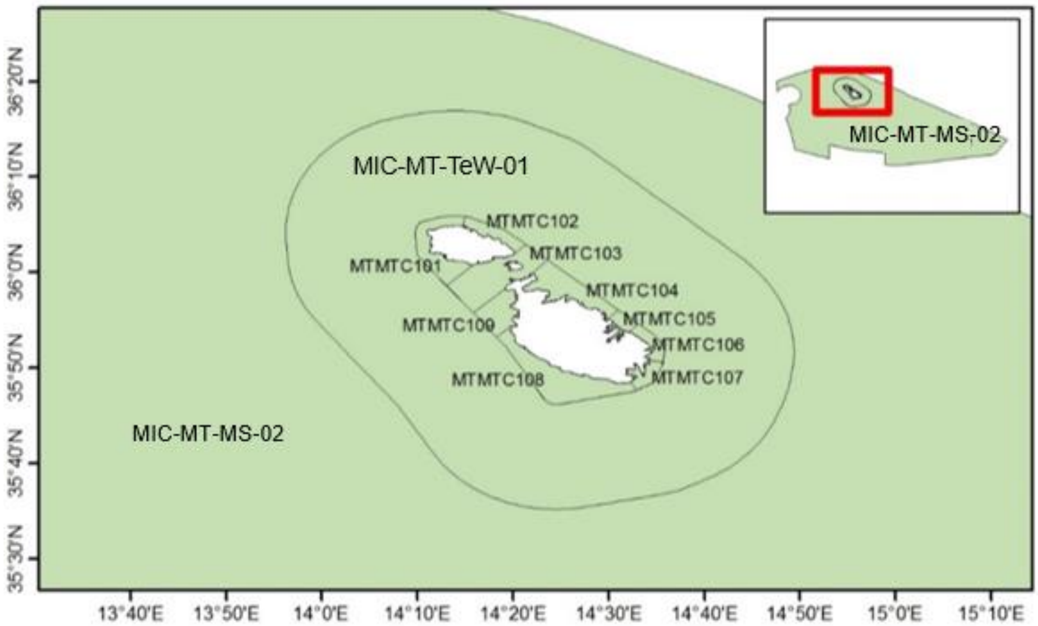

Figure 6: Map showing environmental status, for Descriptor 5 (Eutrophication) of the Maltese Marine Reporting Units. Green: good status; Pink: Not Good; MT-SS-01-1: offshore waters; MT-Te: territorial waters; MTMTC: coastal waters.

In the few samples where nutrients (nitrate) do not achieve GES (almost all of them in inshore and transect stations and very few in nearshore stations), this is not reflected in the phytoplankton component, since chlorophyll-a and HABs do not show higher concentrations or number of events, respectively, with respect to the rest of the samples. Hence, both indicators in coastal and offshore waters achieve GES. Taking into account this oligotrophic situation, the results from transparency and oxygen saturation were expected, since between 97.1 and 100% of the cases achieve GES.

Regarding the HABs, only four taxa from the list considered by Ignatiades and Gotsis-Skretas (2010) for the Greek coastal waters have been registered in this study. The highest abundances of any of these taxa was 2,2 10^3 cell l^{-1} for *Alexandrium*. Hence, no HABs events were registered.

With this background of little nutrient inputs and no impacts in the pelagic habitat (water column), the absence of impact in the benthic habitat (macroalgae, seagrasses and macroinvertebrates) was expected, and between 77.3 and 95.5% of the samples achieve GES. The remainder failing to achieve cannot attributed to eutrophication, but other reasons could be attributed (e.g. dredging, sediment disposal, fishing, etc.).

In fact, when assessing the status for the WFD, both for physico-chemical and chlorophyll a status (Borja et al., 2019b), it can be seen that: (i) for physico-chemical status, all the stations achieved high status, excepting few which were in good status: CN01-2 Tr1 (because oxygen failed), CN05-2 Tr1 (by nitrate and transparency), CN05-2 Tr2 (by nitrate), CN07-2 Tr1 (by transparency), COFF01 (by oxygen), and CN04-6 (by nitrate); whilst water bodies MTMTC101, MTMTC104, MTMTC105, MTMTC107 and MT-SS-01 (offshore) were in good status and the remainder in high status; (ii) for chlorophyll, all the stations achieved high or good status, excepting few which were in moderate status: CN05-2 Tr1, CN05-2 Tr2, CN05-2 Tr3, MTCN05-1 and MTCP05; however, only water body MTMTC105 (Grand Harbour) was in moderate status and the remainder were in high or good status. All of these results are in agreement with the oligotrophy of Maltese waters.

This oligotrophic situation has been highlighted other times in Malta (Lapira, 2017), and especially in the initial assessment for the MSFD, in which the results obtained were quite similar, in terms of oligotrophy, with only few areas (especially Valletta harbour), in a moderate status. This is due to the human density and the activities around the harbour (Romeo et al., 2015). The situation in relation to D1 seems stable, when compared with the mentioned initial assessment.

5.1.4 Descriptor 8: Contaminants

The environmental status results for the Descriptor 8 in WFD coastal water bodies and territorial-offshore MRUs can be seen in Table 13 and Table 14, respectively.

For UPBT (ubiquitous, persistent, bioaccumulative and toxic) substances, mercury is the substance with thresholds which has the highest impairment. Hence, this substance fails the objectives in WFD MRU in water, sediment and biota, whilst in territorial-offshore it fails only in fish and not in water. This could suggest a land-based source, but this should be taken with care, since we have still data from a short period of monitoring and this pattern should be confirmed in future monitoring efforts. In addition, mercury is not a problem only for Malta, but it is a European problem to be addressed together (Kuenen et al., 2018).

Other UPBT substances failing status are Benzo(a)pyrene and total PAHs, in sediments in WFD MRU, and Benzo(a)pyrene in sediments, in territorial-offshore MRU. This could be related with the intense maritime traffic supported by Malta, as well as the bunkering activities. In fact, the sediment is affected by hydrocarbon concentration in costal (MT-CW-01) and territorial and offshore (MT-TeW-01) areas. In addition, sediments have the capacity to capture contaminants, so, the longer they are exposed to pollutants, the greater the concentration they will present.

For non-UPBT substances, Fluoranthene in water; and Anthracene, Fluoranthene, Lead and Naphthalene in sediments from WFD MRU fail to achieve good status. In turn, all substances in territorial-offshore MRU have achieved good status. Again, those substances failing could be linked to maritime traffic and bunkering activities.

Hydrocarbon is formed during incomplete combustion of organic material, but also another primary source is the handling of petroleum, fuel oils and crude oils. Both type of source for hydrocarbons may be significant to the local Maltese context (Axiak, 2004). Because the geographical locations of Malta in Mediterranean Sea may be exposed to intense maritime oil traffic and the bunkering operations importance, and petrol and fuel stations are very close to residential areas (Axiak, 2004; Romeo et al., 2015).

Table 13: Environmental status results, following the Reporting guidance for Descriptor 8 (Contaminants) for pelagic and benthic habitats in 2017-2019. The considered Marine Reporting Unit (MRU) area is the combination of Coastal waters (WFD water bodies; MT-CW-01). AA: annual average, MAC: maximum allowable concentration; UPBT: ubiquitous (present, appearing or found everywhere), persistent, bioaccumulative and toxic. Upper and lower values refer to those found in the database for each variable.

Element	Concentration in/Value	Value (upper)	Value (lower)	Unit	Achieved in MRU (% samples)	Trend	Status of criterion	Element Status	Overall Status achieved	Overall Status (% substances)
UPBT substances										
Benzo(a)pyrene	Water/AA	0.0000255	0.0000255	µg L^{-1}	100	Stable	Good	Good	(5 out of 21 not in good status)	76.2% in good status
Benzo(a)pyrene	Water/MAC	0.0000255	0.0000255	µg L^{-1}	100	Stable	Good			
Benzo(b)fluoranthene	Water/AA	0.0000255	0.0000255	µg L^{-1}	100	Improving	Good	Good		
Benzo(b)fluoranthene	Water/MAC	0.0000255	0.0000255	µg L^{-1}	100	Improving	Good			
Benzo(g.h.i)perylene	Water/AA	0.0000255	0.0000255	µg L^{-1}	100	Improving	Good	Good		
Benzo(g.h.i)perylene	Water/MAC	0.0000255	0.0000255	µg L^{-1}	100	Improving	Good			
Benzo(k)fluoranthene	Water/AA	0.0000255	0.0000255	µg L^{-1}	100	Improving	Good	Good		
Benzo(k)fluoranthene	Water/MAC	0.0000255	0.0000255	µg L^{-1}	100	Improving	Good			
Heptachlor and heptachlor epoxide	Water/AA	1.5E-09	1.5E-09	µg L^{-1}	100	Unknown	Good	Good		
Heptachlor and heptachlor epoxide	Water/MAC	1.5E-09	1.5E-09	µg L^{-1}	100	Unknown	Good			
Hexabromocyclododecane	Water/AA	0.00012	0.00012	µg L^{-1}	100	Unknown	Good	Good		
Hexabromocyclododecane	Water/MAC	0.00012	0.00012	µg L^{-1}	100	Unknown	Good			
Indeno(1.2.3-c.d)pyrene	Water/AA	0.0000255	0.0000255	µg L^{-1}	100	Improving	Good	Good		
Mercury	Water/MAC	0.35	0.01	µg L^{-1}	83.9	Improving	Not good	Not good		
Benzo(a)pyrene	Sediment/AA	7	0.0001	mg kg^{-1}	68.2	Unknown	Not good	Not good		
Mercury	Sediment/AA	4.35	0.005	mg kg^{-1}	90.9	Unknown	Not good	Not good		
Dioxin-like polychlorinated biphenyls	Sediment/AA	0.001	0.001	µg kg^{-1}	100	Unknown	Good	Good		
Total PAHs	Sediment/AA	25.55	0.0002	mg kg^{-1}	91.3	Unknown	Not good	Not good		
Tributyltin	Sediment/AA	0.0001	0.0001	mg kg^{-1}	100	Unknown	Good	Good		
Mercury	Fish/AA	115	115	µg kg^{-1} ww	0	Unknown	Not good	Not good		
Benzo(a)pyrene	Benthic fauna/AA	0.5	0.5	µg kg^{-1} ww	100	Unknown	Good	Good		
non-UPBT substances										
1.2-Dichloroethane	Water/AA	0.01	0.01	µg L^{-1}	100	Unknown	Good	Good	(6 out of 47 not in Good status)	87.2% in good status
Aclonifen	Water/AA	0.0018	0.0018	µg L^{-1}	100	Unknown	Good	Good		
Aclonifen	Water/MAC	0.0018	0.0018	µg L^{-1}	100	Unknown	Good	Good		
Benzene	Water/AA	0.063	0.01	µg L^{-1}	100	Unknown	Good	Good		
Benzene	Water/MAC	0.32	0.01	µg L^{-1}	100	Unknown	Good			
Bifenox	Water/AA	0.00018	0.00018	µg L^{-1}	100	Unknown	Good	Good		
Bifenox	Water/MAC	0.00018	0.00018	µg L^{-1}	100	Unknown	Good			
Cybutryne	Water/AA	0.000375	0.000375	µg L^{-1}	100	Unknown	Good	Good		
Cybutryne	Water/MAC	0.000375	0.000375	µg L^{-1}	100	Unknown	Good			
Cypermethrine	Water/AA	0.0000012	0.0000012	µg L^{-1}	100	Unknown	Good	Good		
Cypermethrine	Water/MAC	0.0000012	0.0000012	µg L^{-1}	100	Unknown	Good			
Dichloromethane	Water/AA	0.01	0.01	µg L^{-1}	100	Unknown	Good	Good		
Dichlorvos	Water/AA	0.000009	0.000009	µg L^{-1}	100	Unknown	Good	Good		
Dichlorvos	Water/MAC	0.000009	0.000009	µg L^{-1}	100	Unknown	Good			
Dicofol	Water/AA	0.0000048	0.0000048	µg L^{-1}	100	Unknown	Good	Good		
Fluoranthene	Water/AA	0.008	0.001	µg L^{-1}	97.1	Unknown	Not good	Not good		
Fluoranthene	Water/MAC	0.13	0.001	µg L^{-1}	97.1	Unknown	Not good			
Cadmium	Water/AA	0.056	0.05	µg L^{-1}	96.9	Unknown	Good	Good		
Cadmium	Water/MAC	0.25	0.05	µg L^{-1}	100	Improving	Good			
Lead	Water/AA	1.51	0.1	µg L^{-1}	100	Improving	Good	Good		
Lead	Water/MAC	10	0.1	µg L^{-1}	100	Unknown	Good			
Naphthalene	Water/AA	0.18	0.002	µg L^{-1}	100	Unknown	Good	Good		
Naphthalene	Water/MAC	0.582	0.002	µg L^{-1}	100	Improving	Good			
Nickel	Water/AA	3.08	0.3	µg L^{-1}	100	Improving	Good	Good		
Nickel	Water/MAC	27	0.3	µg L^{-1}	100	Unknown	Good			
PFOA and its compounds	Water/AA	0.0000195	0.0000195	µg L^{-1}	100	Unknown	Good	Good		

Element	Concentration in/Value	Value (upper)	Value (lower)	Unit	Achieved in MRU (% samples)	Trend	Status of criterion	Element Status	Overall Status achieved	Overall Status (% substances)
PFOA and its compounds	Water/MAC	0.0000195	0.0000195	µg L^{-1}	100	Unknown	Good			
Quinoxyfen	Water/AA	0.0023	0.0023	µg L^{-1}	100	Unknown	Good	Good		
Quinoxyfen	Water/MAC	0.0023	0.0023	µg L^{-1}	100	Unknown	Good			
Terbutryn	Water/AA	0.001	0.001	µg L^{-1}	100	Unknown	Good	Good		
Terbutryn	Water/MAC	0.001	0.001	µg L^{-1}	100	Unknown	Good			
Trichloromethane	Water/AA	0.47	0.01	µg L^{-1}	100	Unknown	Good	Good		
Anthracene	Sediment/AA	2.54	0.0001	mg kg^{-1}	82	Unknown	Not good	Not good		
Arsenic	Sediment/AA	10.25	0.1	mg kg^{-1}	100	Unknown	Good	Good		
Cadmium	Sediment/AA	0.01	0.01	mg kg^{-1}	100	Unknown	Good	Good		
Chromium	Sediment/AA	32.9	0.01	mg kg^{-1}	100	Unknown	Good	Good		
Fluoranthene	Sediment/AA	15.4	0.0001	mg kg^{-1}	75	Unknown	Not good	Not good		
Hexachlorobenzene	Sediment/AA	0.00005	0.00005	mg kg^{-1}	100	Unknown	Good	Good		
Hexachlorocyclohexane	Sediment/AA	0.00003	0.00003	mg kg^{-1}	100	Improving	Good	Good		
Lead	Sediment/AA	117.5	0.01	mg kg^{-1}	92.9	Unknown	Not good	Not good		
Naphthalene	Sediment/AA	0.61	0.0001	mg kg^{-1}	91.3	Unknown	Not good	Not good		
Nickel	Sediment/AA	13.85	0.01	mg kg^{-1}	100	Unknown	Good	Good		
Total dioxins and furans (PCDD + PCDF)	Sediment/AA	0.0000005	0.0000005	mg kg^{-1}	100	Unknown	Good	Good		
Hexachlorobenzene	Fish/AA	1	1	µg kg^{-1} ww	100	Unknown	Good	Good		
Hexachlorobutadiene	Fish/AA	5	5	µg kg^{-1} ww	100	Unknown	Good	Good		
Total dioxins and furans (PCDD + PCDF)	Fish/AA	0.0001	0.0001	µg kg^{-1} ww	100	Unknown	Good	Good		
Fluoranthene	Benthic fauna/AA	5	5	µg kg^{-1} ww	100	Unknown	Good	Good		

Table 14: Environmental status results, following the Reporting guidance for Descriptor 8 (Contaminant) for pelagic, benthic and demersal habitats in 2017-2018. The considered Marine Reporting Unit (MRU) area is the combination of Territorial and offshore waters; MT-TeW-01). For an explanation of the Criteria, see Table 2. AA: annual average, MAC: maximum allowable concentration; UPBT: ubiquitous (present, appearing or found everywhere), persistent, bioaccumulative and toxic. Upper and lower values refer to those found in the database for each variable.

Element	Concentration in/Value	Value (upper)	Value (lower)	Unit	Achieved in MRU (% samples)	Trend	Status of criterion	Element Status	Overall Status achieved	Overall Status (% substances)
UPBT substances										
Benzo(a)pyrene	Water/AA	0.0000255	0.0000255	µg L^{-1}	100	Unknown	Good	Good	(2 out of 16 not in Good status)	87.5% in Good status
Benzo(a)pyrene	Water/MAC	0.0000255	0.0000255	µg L^{-1}	100	Unknown	Good			
Benzo(b)fluoranthene	Water/AA	0.0000255	0.0000255	µg L^{-1}	100	Unknown	Good	Good		
Benzo(b)fluoranthene	Water/MAC	0.0000255	0.0000255	µg L^{-1}	100	Unknown	Good			
Benzo(g,h,i)perylene	Water/AA	0.0000255	0.0000255	µg L^{-1}	100	Unknown	Good	Good		
Benzo(g,h,i)perylene	Water/MAC	0.0000255	0.0000255	µg L^{-1}	100	Unknown	Good			
Benzo(k)fluoranthene	Water/AA	0.0000255	0.0000255	µg L^{-1}	100	Unknown	Good	Good		
Benzo(k)fluoranthene	Water/MAC	0.0000255	0.0000255	µg L^{-1}	100	Unknown	Good			
Indeno(1,2,3-c,d)pyrene	Water/AA	0.0000255	0.0000255	µg L^{-1}	100	Unknown	Good	Good		
Mercury	Water/MAC	0.01	0.01	µg L^{-1}	100	Unknown	Good	Good		
Benzo(a)pyrene	Sediment/AA	0.075	0.0001	mg kg^{-1}	25	Unknown	Not good	Not good		
Total PAHs	Sediment/AA	0.22	0.0002	mg kg^{-1}	100	Unknown	Good	Good		
Heptachlor and heptachlor epoxide	Fish/AA	0.001	0.001	µg kg^{-1} ww	100	Unknown	Good	Good		
Hexabromocyclododecane (HBCDD)	Fish/AA	0.1	0.1	µg kg^{-1} ww	100	Unknown	Good	Good		
Mercury	Fish/AA	2081.5	104.5	µg kg^{-1} ww	0	Unknown	Not good	Not good		
Benzo(a)pyrene	Benthic fauna/AA	0.5	0.5	µg kg^{-1} ww	100	Unknown	Good	Good		
non-UPBT substances										
1,2-Dichloroethane	Water/AA	0.01	0.01	µg L^{-1}	100	Unknown	Good	Good	(0 out of 25 not in Good status)	100% in Good status
Benzene	Water/AA	0.01	0.01	µg L^{-1}	100	Unknown	Good	Good		
Benzene	Water/MAC	0.01	0.01	µg L^{-1}	100	Unknown	Good			
Dichloromethane	Water/AA	0.01	0.01	µg L^{-1}	100	Unknown	Good	Good		
Fluoranthene	Water/AA	0.001	0.001	µg L^{-1}	100	Unknown	Good	Good		
Fluoranthene	Water/MAC	0.001	0.001	µg L^{-1}	100	Unknown	Good			
Cadmium	Water/AA	0.055	0.05	µg L^{-1}	100	Unknown	Good	Good		
Cadmium	Water/MAC	0.055	0.05	µg L^{-1}	100	Unknown	Good			
Lead	Water/AA	0.23	0.1	µg L^{-1}	100	Unknown	Good	Good		
Lead	Water/MAC	0.23	0.1	µg L^{-1}	100	Unknown	Good			
Naphthalene	Water/AA	0.117	0.002	µg L^{-1}	100	Unknown	Good	Good		
Naphthalene	Water/MAC	0.16	0.002	µg L^{-1}	100	Unknown	Good			
Nickel	Water/AA	0.525	0.3	µg L^{-1}	100	Unknown	Good	Good		
Nickel	Water/MAC	0.62	0.3	µg L^{-1}	100	Unknown	Good			
Trichloromethane	Water/AA	0.01	0.01	µg L^{-1}	100	Unknown	Good	Good		
Anthracene	Sediment/AA	0.035	0.0001	mg kg^{-1}	100	Unknown	Good	Good		
Fluoranthene	Sediment/AA	0.11	0.0001	mg kg^{-1}	100	Unknown	Good	Good		
Naphthalene	Sediment/AA	0.0001	0.0001	mg kg^{-1}	100	Unknown	Good	Good		
Dicofol	Fish/AA	0.01	0.01	µg kg^{-1} ww	100	Unknown	Good	Good		
Hexachlorobenzene	Fish/AA	1	1	µg kg^{-1} ww	100	Unknown	Good	Good		
Hexachlorobutadiene	Fish/AA	5	5	µg kg^{-1} ww	100	Unknown	Good	Good		
Total dioxins and furans (PCDD + PCDF)	Fish/AA	0.0001	0.0001	µg kg^{-1} ww	100	Unknown	Good	Good		
PFOA and its compounds	Fish/AA	0.0001	0.0001	µg kg^{-1} ww	100	Unknown	Good	Good		
Dicofol	Benthic fauna/AA	0,01	0,01	µg kg^{-1} ww	100	Unknown	Good	Good		
Fluoranthene	Benthic fauna/AA	5	5	µg kg^{-1} ww	100	Unknown	Good	Good		

In total, for coastal MRU and UPBT substances, 76.2% of the substances achieved the GES (only 5 out of 21 substances monitored do not achieve the good status), whilst for non-UPBT substances, 87.23% of the substances achieved (6 out of 47 substances do not achieve the good status). In territorial-offshore MRU, the percentage increases until 87.5% of the substances for UPBT (2 out of 16 substances do not achieve) and 100% of non-UPBT (all 25 achieved). This indicates again a certain gradient from coast to offshore water. When calculating the whole Maltese waters, 83.8% of the substances in the coastal area and 95% in the territorial-offshore area achieved the good chemical status, for water, sediment and biota. Despite this, globally, and following the OOAO principle, it can be considered that the whole Maltese waters fail to achieve good chemical status, due to mercury and some hydrocarbons linked to bunkering and maritime traffic (Figure 7).

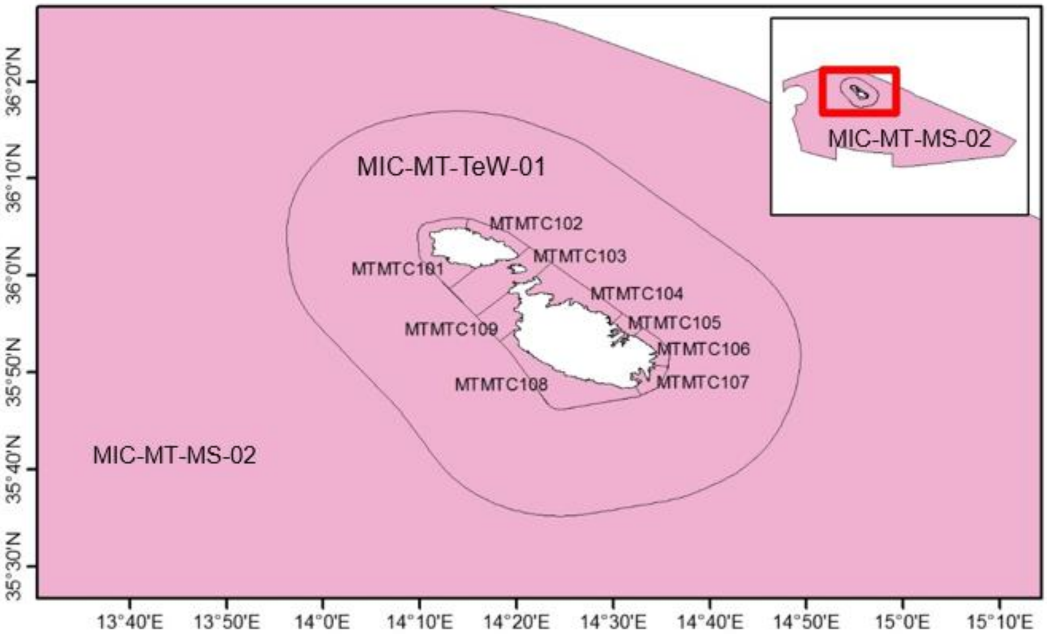

Figure 7: Map showing environmental status, for Descriptor 8 (Contaminants) of the Maltese Marine Reporting Units (MT-CW-01 and MT-TeW-01). Green: good status; Pink: Not Good; MT-SS-01-1: offshore waters; MT-Te: territorial waters; MTMTC: coastal waters.

When assessing the status at the WFD water body level, it can be seen that MTMTC 107, MTMTC 109, territorial and offshore water bodies achieved the good chemical status in waters, whilst the remainder (all coastal) fail to achieve good status (see Borja et al., 2019b). In sediments, only MTMTC 101, MTMTC 102, MTMTC 103, MTMTC 107 and MTMTC 109 water bodies achieved the good chemical status; whilst the rest of the MRUs (including territorial), do not achieve the good chemical status (see Borja et al., 2019b). For biota, none of the studied water bodies achieved good chemical status, because of mercury (see Borja et al., 2019b).

When comparing these data with those in the initial assessment for the MSFD, there are many substances for which the trend is unknown, but in other cases there is an improvement, such as in some organic compounds, in mercury, cadmium, lead and nickel in waters (Table 13). However, more reporting cycles and years of data are needed to determine trends adequately.

5.1.5 Descriptor 9: Contaminants in seafood

This descriptor was evaluated only for the Territorial and offshore water bodies (MT-TeW-01) following the Reporting guidance of the MSFD (European Commission, 2018b). Only mercury in fish (*Mullus barbatus* and *Merluccius merluccius*) failed to achieve good status (Table 15), whilst the remaining 10 substances, either in those fish or in crustaceans (*Aristaeomorpha foliacea* and *Parapenaeus longirostris*) were in good status.

The maximum concentrations of mercury were in MEDITS-54, in offshore MRU (2,211 µg kg^{-1} ww in *Mullus barbatus),* and in MEDITS-74, in territorial MRU (903 µg kg^{-1} ww *Merluccius merluccius)*. Again, the fact that mercury is failing, as in waters, sediments and biota in Descriptor 8, indicates a general problem, similar to that in the whole Europe (Kuenen et al., 2018). Globally, for seafood 83.3% of the substances achieve good status, being the trend, compared with the initial assessment, unknown in all cases (Table 15).

The Cadmium determined in fish meat cannot be used for the assessment, since all the results obtained are below the limit of detection, and the legal threshold for this compound (Table 7) is lower than this LOD. Also, considering the half of the LOD to calculate the mean value, the LOD and the threshold are the same. Hence, as a rough approximation we could estimate a good status for cadmium in seafood.

Hence, following the OOAO integration (required by the European Commission (2018) guidelines), the whole Malta fails to achieve GES, because of mercury in fish, even if 83.3% is in good status (Figure 8).

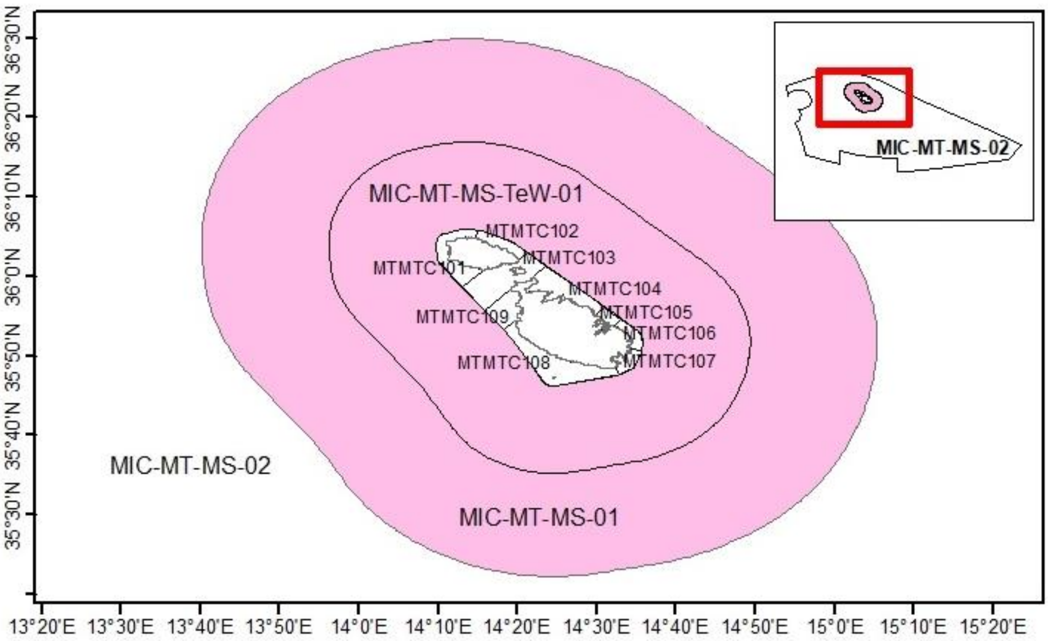

Figure 8: Map showing environmental status, for Descriptor 9 (Contaminants in seafood) of the Maltese Marine Reporting Units. Green: good status; Pink: Not Good; MT-SS-01-1: offshore waters; MT-Te: territorial waters; MTMTC: coastal waters.

Table 15: Environmental status results, following the Reporting guidance for Descriptor 9 (Contaminants in Seafood) for benthic and demersal habitats in 2017-2018. The considered Marine Reporting Unit (MRU) area is the combination of Territorial and offshore water bodies. Upper and lower values refer to those found in the database for each variable.

Element	Parameter	Value (upper)	Value (lower)	Achieved in MRU (% of samples)	Trend	Status of criterion	Element Status	Overall Status achieved	Overall Status (% of substances)
Mercury (*Merluccius*)	Concentration in muscle of fish	823.5	104.5	75	Unknown	Not good	Not good	(2 out of 12 substances not in good status)	83.3% in Good status
Mercury (*Mullus*)	Concentration in muscle of fish	2081.5	115	83.33	Unknown	Not good			
Cadmium	Concentration in muscle of fish	100	100	N/A	Unknown				
Cadmium	Concentration in muscle of fish	100	100	N/A	Unknown				
Lead	Concentration in muscle of fish	100	100	100	Unknown	Good	Good		
Lead	Concentration in muscle of fish	227	100	100	Unknown	Good	Good		
Benzo(a)pyrene	Concentration in crustaceans	0.5	0.5	100	Unknown	Good	Good		
Benzo(a)pyrene	Concentration in crustaceans	0.5	0.5	100	Unknown	Good	Good		
Total dioxins and furans (PCDD + PCDF)	Concentration in crustaceans	0.1	0.1	100	Unknown	Good	Good		
Total dioxins and furans (PCDD + PCDF)	Concentration in crustaceans	0.1	0.1	100	Unknown	Good	Good		
Total dioxins and furans (PCDD + PCDF) *(Merluccius)*	Concentration in muscle of fish	0.1	0.1	100	Unknown	Good	Good		
Dioxin-like polychlorinated biphenyls	Concentration in crustaceans	0.001	0.001	100	Unknown	Good	Good		
Dioxin-like polychlorinated biphenyls *(Mullus)*	Concentration in muscle of fish	0.001	0.001	100	Unknown	Good	Good		
Dioxin-like polychlorinated biphenyls *(Merluccius)*	Concentration in muscle of fish	0.001	0.001	100	Unknown	Good	Good		

5.1.6 Descriptor 10: Marine litter

For Descriptor 10 (Litter), for which only two MRUs were included (Offshore waters and Territorial waters, the latter including the WFD coastal water bodies), Malta is in good status (Table 16, Figure 9). All elements included achieved good status, since the mean values were always lower than the threshold values determined by UNEP-MAP (2015). The maximum presence of litter occurs in beaches, in Territorial MRU (mainly in CML09-02). In turn, the minimum floating items appear in water column from beaches, again in Territorial MRU.

Globally, 100% of the elements for litter achieve good status (Figure 10). After Mifsud et al. (2013), in a study of deep seafloor litter from 2005, Maltese waters seem to have more litter than other adjacent areas (i.e. Sicily, Greece). Although the environments studied are different, in our study, it seems that Malta, for the period 2017-2019, does not have a huge problem. However, it is true that, after the monitoring report (Borja et al., 2019b), some urban beaches have a problem with litter, especially in summer, probably due to the presence of more tourists. Also, the maritime traffic and fishing could be other sources of litter that must be taken into account to develop measures that can minimize the entry of litter into the waters adjacent to Malta. Finally, in this assessment microplastics have not been analyzed, since they are not surveyed in the monitoring network.

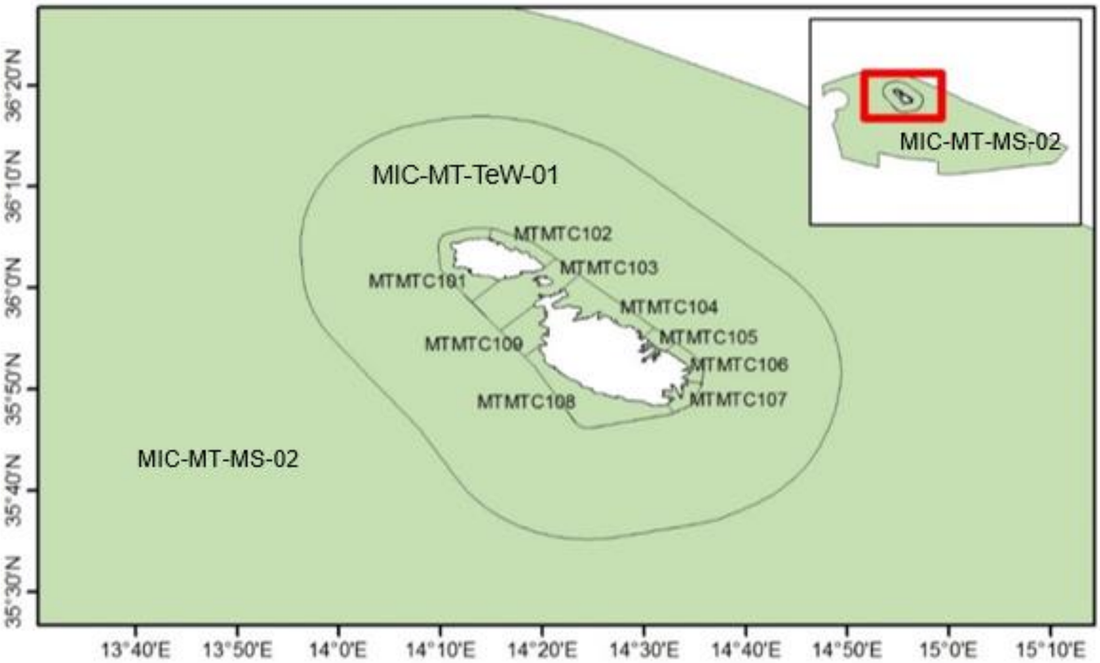

Figure 9: Map showing environmental status, for Descriptor 10 (Marine litter) of the Maltese Marine Reporting Units. Green: good status; Pink: Not Good; MT-SS-01-1: offshore waters; MT-Te: territorial waters; MTMTC: coastal waters.

Table 16: Environmental status results, following the Reporting guidance for Descriptor 10 (Litter), in 2017-2019. The considered Marine Reporting Unit (MRU) areas are offshore water bodies and the combination of Territorial waters bodies

MRU	Element	Parameter	Threshold Value	Achieved in MRU (%)	Trend	Status of criterion	Element Status	Overall Status achieved	Overall Status (%)
MT-CW-01	Artificial polymer materials	Seafloor	230	100	Unknown	Good	Good	(0 out of 10 elements not in good status)	100% in Good status
	Rubber	Seafloor		100	Unknown	Good			
	Cloth/ textile	Seafloor		100	Unknown	Good			
	Paper/ cardboard	Seafloor		100	Unknown	Good			
	Processed/ worked wood	Seafloor		100	Unknown	Good			
	Metal	Seafloor		100	Unknown	Good			
	Glass/ ceramics	Seafloor		100	Unknown	Good			
	Chemicals	Seafloor		100	Unknown	Good			
	Food waste	Seafloor		100	Unknown	Good			
	Undefined	Seafloor		100	Unknown	Good			
	Artificial polymer materials	Beaches	1400	100	Unknown	Good	Good	0 out of 10 elements not in good status)	
	Rubber	Beaches		100	Unknown	Good			
	Cloth/ textile	Beaches		100	Unknown	Good			
	Paper/ cardboard	Beaches		100	Unknown	Good			
	Processed/ worked wood	Beaches		100	Unknown	Good			
	Metal	Beaches		100	Unknown	Good			
	Glass/ ceramics	Beaches		100	Unknown	Good			
	Chemicals	Beaches		100	Unknown	Good			
	Food waste	Beaches		100	Unknown	Good			
	Undefined	Beaches		100	Unknown	Good			
	Artificial polymer materials	Floating litter	5	100	Unknown	Good	Good	0 out of 10 elements not in good status)	
	Rubber	Floating litter		100	Unknown	Good			
	Cloth/ textile	Floating litter		100	Unknown	Good			
	Paper/ cardboard	Floating litter		100	Unknown	Good			
	Processed/ worked wood	Floating litter		100	Unknown	Good			
	Metal	Floating litter		100	Unknown	Good			
	Glass/ ceramics	Floating litter		100	Unknown	Good			
	Chemicals	Floating litter		100	Unknown	Good			
	Food waste	Floating litter		100	Unknown	Good			
	Undefined	Floating litter		100	Unknown	Good			
MT-TeW-01	Artificial polymer materials	Floating litter	5	100	Unknown	Good	Good	(0 out of 10 litter categories not in good status)	100% in Good status
	Rubber	Floating litter		100	Unknown	Good			
	Cloth/ textile	Floating litter		100	Unknown	Good			
	Paper/ cardboard	Floating litter		100	Unknown	Good			
	Processed/ worked wood	Floating litter		100	Unknown	Good			
	Metal	Floating litter		100	Unknown	Good			
	Glass/ ceramics	Floating litter		100	Unknown	Good			
	Chemicals	Floating litter		100	Unknown	Good			
	Food waste	Floating litter		100	Unknown	Good			
	Undefined	Floating litter		100	Unknown	Good			

5.2 Global overview of the assessment

During the monitoring period (2017-2019), the assessment for the Water Framework Directive has been done in the nine coastal water bodies (Borja et al., 2019b). In the Table 17 it is shown the global status for each water body, as well as the status for each of the elements (physico-chemical, chemical and biological). Following the OOAO principle, the ecological status is good in Malta, excepting water body MTC105, which is in moderate, due to the presence of urban and industrial infrastructures (harbours, cities, etc.). In turn, the whole Maltese coastal water bodies, except MTC107 and MTC109, fail to achieve good chemical status. Hence, as the global status is the worst of the two (chemical and ecological), the Maltese coastal waters fail in achieving good status, excepting MTC107 and MTC109.

Table 17: Physico-chemical, chemical and ecological status of the Water Framework Directive coastal water bodies, within the period 2017-2019. Blue: high status, Green: good status, Yellow: moderate status, Red: bad status, White: not assessed.

Status	MTC 101	MTC 102	MTC 103	MTC 104	MTC 105	MTC 106	MTC 107	MTC 108	MTC 109
Chemistry (waters)	Red	Red	Red	Red	Red	Red	Blue	Red	Blue
Chemistry (sediments)	Blue	Blue	Blue	Red	Red	Red	Blue	Red	Blue
Chemistry (biota)	White	White	Red	White	White	White	White	White	White
Total Chemical status	Red	Red	Red	Red	Red	Red	Blue	Red	Blue
Physico-chemistry	Green	Blue	Blue	Green	Blue	Blue	Green	Blue	Blue
Phytoplankton	Blue	Blue	Green	Green	Yellow	Green	Green	Blue	Blue
Macroalgae	Blue	Blue	Blue	Blue	Blue	Blue	Green	Blue	Blue
Posidonia	Green	Green	Blue	Green	White	Green	Green	Blue	Green
Macroinvertebrates	White	Green	Blue	Blue	Blue	Blue	Blue	Green	Green
Total Ecological status	Green	Green	Green	Green	Yellow	Green	Green	Green	Green
Final status	Red	Red	Red	Red	Red	Red	Blue	Red	Blue

On the other hand, the indicators used for this assessment represent the available data for 7 out of the 11 the descriptors of the MSFD (i.e., D1 (biodiversity), D2 (NIS), D5 (eutrophication), D6 (seafloor integrity), D8 (contaminants), D9 (seafood contaminants), and D10 (litter)) carried out in each MRU. The European Commission (2018) guidelines do not provide an approach to integrate the different descriptors into a unique assessment of the whole Maltese waters. From the seven descriptors four achieved GES (D1, D5, D6, D10) and three failed to achieve GES (D2, D8 and D9) (Table 18).

Within each descriptor there are no differences in the environmental status between the MRUs. In general, trends are stable when compared with the initial assessment done in Malta for the MSFD. However, in D2 (NIS) these trends seem to deteriorate, with an increase in the number of new arrivals. In the case of contaminants (D8, D9) and litter (D10), trends are unknown, although for individual contaminants in water it has been seen some improvements.

Table 18: Environmental status results and trends, following the Reporting guidance, for each descriptor of the Marine Strategy Framework Directive, within the period 2017-2019. Green: good status; Pink: Not Good; Cont: contaminants; Sed: sediment

Descriptor	Habitat/matrix	Marine Reporting Units		
		Coastal	Territorial	Offshore
D1 Biodiversity	Benthic habitats	Stable	Stable	
	Pelagic habitats	Stable	Stable	Stable
D2 NIS		Deteriorating	Deteriorating	Deteriorating
D5 Eutrophication		Stable	Stable	Stable
D6 Seafloor integrity		Stable	Stable	
D8 Contaminants	Water, Sed., Biota	Mostly Unk.	Mostly Unk.	Mostly Unk.
D9 Cont. in seafood			Unknown	Unknown
D10 Litter		Unknown	Unknown	Unknown

6.0 Discussion

Despite the progress made in assessing marine health in an integrative way (Borja *et al.*, 2016; Inniss *et al.*, 2016), some authors (Borja *et al.*, 2019a) have identified six barriers that managers and policy-makers confront when undertaking MSFD assessments, namely the:

- lack of indicators;
- absence of suitable reference conditions or thresholds;
- difficulty of aggregating indicators;
- absence of criteria on the number of indicators to be used;
- use of the 'OOAO' principle; and
- lack of traceability of the problems when integrating.

Hence, in a previous report (Borja et al., 2018), following as much as possible the guidelines from the European Commission (2017), we tried to undertake a real MSFD assessment of Malta's waters. In that report, our objective was to show ERA managers and Maltese policy-makers that these barriers can be overcome when using integrating methods, such as NEAT.

In that research we used well-known indicators, together with legally binding thresholds whenever possible, based upon international decisions, e.g. intercalibration exercises within the WFD (European Commission, 2018) and Environmental Quality Standards (European Commission, 2013), etc. In the absence of suitable reference conditions (best and worst values, as defined in NEAT) and thresholds values, it is not possible to undertake quantitative environmental assessments. When those binding thresholds were not available, we used agreed boundaries, accepted by the scientific community or managers, e.g. for fish and shellfish stocks (Froese *et al.*, 2018). In some cases, it was necessary to use other national thresholds (e.g. from Greece or Italy) and, in few ones, expert judgment from MEDCIS partners (e.g. in marine litter).

Taking into account the scientific knowledge in the Mediterranean applying NEAT (Pavlidou *et al.*, 2019; Borja *et al.*, 2019a), and the availability of indicators data and thresholds, as mentioned above, we considered that it was feasible to undertake the MSFD assessment for Malta, with a high confidence in the final result using data from the monitoring network started in June 2017. Hence, using NEAT, we determined that the global status for all of Malta was good (Borja et al., 2018). Despite this global environmental status, we determined that the status of the MRU MTC 105, in which Valetta is included, had a lower NEAT value (still good), but with some ecosystem components in moderate status (i.e. phytoplankton) and others close to the threshold between good and moderate (i.e. contaminants in sediments and benthic fauna). In addition, this MRU did not have *Posidonia oceanica*. All these observations indicate that the urban and harbour activities (e.g. discharges, shipping, dredging, etc.) are downgrading the quality of the MRU and it therefore needs specific management measures. Other small MRUs also had ecosystem components either in moderate or near the boundary between moderate and good (e.g. MTC 102, MTC 103, MTC 106 and MTC 109), needing a reflection on the potential pressures causing this lower status in specific ecosystem components and, eventually, a specific program of measures to improve their status, even if globally they are in high environmental status.

Despite this proposal, ERA preferred to assess the status of Maltese waters using exclusively the European Commission (2017) decision and the guidelines for reporting (European Commission, 2018b). In this study, following these guidelines, we have been able to assess the status of some of the descriptors (e.g. D1, D2, D5, D6, D8, D9 and D10), but it is not possible to offer a global integrated assessment for Malta, since the guidelines only provide the assessment approach at descriptor level (and even in this case, for some descriptors, it is difficult to present an integrated result).

From those descriptors, D2, D8 and D9 failed to achieve GES, mainly because of the need of using the OOAO principle, despite the fact that in D8 between 76.2 and 100% of the areas achieved GES (depending on the substances) and in D9 they were 83.3% achieving GES. The use of the OOAO principle has been repeatedly criticised (Moss et al., 2003; Moss, 2008; Caroni et al., 2013; Langhans et al., 2014), because it tends to downgrade the quality assessed locations unjustifiably, depending on the number of indicators included in the assessment, as demonstrated elsewhere (Borja and Rodríguez, 2010; Borja et al., 2019a). Although this principle is consistent with the precautionary principle, at the same time, tends to inflate Type I errors (concluding that the assessed area is below good status, even if the real status is good). In fact, it has been demonstrated that integrative assessments show better the improvement of marine areas after applying management measures, whilst using the OOAO there is no trend in the improvement because of the probabilities of having individual indicators below the good status (Borja and Rodríguez, 2010). This means that there is a risk of implementing additional management measures to revert the situation where they are not really needed (Borja and Rodríguez, 2010). Hence, the OOAO principle increases the likelihood of misclassifying to a lower status class by sheer randomness (Hering et al., 2010). Borja et al. (2019a) demonstrated that, increasing the number of indicators, ecosystem components or descriptors for the MSFD, the possibility of downgrading the quality status in the assessment increases exponentially.

In fact, the problems in Malta for descriptors D8 and D9 are very clear. For D8, the indicators in waters that are over the boundaries were fluoranthene and mercury in some MRUs, whilst anthracene, benzo(a)pyrene, fluoranthene, lead, mercury and naphthalene exceeded the thresholds in sediments in a few MRUs. In biota (fish) several indicators were observed to be above the thresholds. In turn, in seafood (D9), mercury is also the responsible of concentrations above the thresholds in fish. As commented in the monitoring report (Borja et al., 2019b), mercury is a substance of concern in the whole Europe (Višnjevec *et al.*, 2014; Kuenen *et al.*, 2018) in water, sediment, biota, as well as in seafood. There is a chronic contamination by this metal in many European locations and it seems that the solution, if existing, probably is not national but at European level (Kuenen *et al.*, 2018). For the remaining contaminants, some of them could be related to the bunkering activities, but this should be proven with additional sampling in future applications of the monitoring network.

Another problem in Malta, mostly linked to the intense maritime traffic, is the presence of NIS. It is well-known that this is a problem in the Mediterranean (Katsanevakis *et al.*, 2016), and probably this has contributed to the observed status in Malta. However, it is true that the monitoring undertaken in 2017-2019 has included an intensive assessment of NIS, which was not previously undertaken at a national scale, in different biological components and habitats, at such systematic way. Therefore, the increase in the number of species could also be attributed to the high research effort, and would serve in coming cycles of the MSFD reporting to have a better comparison baseline.

Despite the clear human activities and pressures in Malta (e.g. high population density, massive tourism in summer, shipping, bunkering, aquaculture, etc.), only small areas can be considered as severely affected, as identified in the monitoring report for this project (Borja et al., 2019b). These areas would require management measures to revert the situation (e.g. Valletta harbour, which has some evident pressures (Romeo et al., 2015)). In turn, the situation of the Maltese waters is in general in good environmental status, with some areas which can be considered near pristine and with most of the marine surface as highly oligotrophic. Although a gradient can be observed from the coastal areas to offshore waters (decrease in nutrients, transparency, etc.), in most of the cases, even those areas can still be considered oligotrophic.

All of these features were identified also when using NEAT, which results in the achievement of a global GES for Malta (Borja et al., 2019b). In that study, we demonstrated that, even it could be difficult to aggregate indicators from different spatial and temporal frameworks, different descriptors and ecosystem components, as debated elsewhere (Borja *et al.*, 2014; Langhans *et al.*, 2014; Link and Browman, 2014; Probst and Lynam, 2016), it could be done effectively. Using NEAT, the flexibility and customization possibilities are ensured, as shown by Uusitalo *et al.* (2016), Nemati *et al.* (2017), Pavlidou *et al.* (2019), Borja *et al.* (2019a) and, specifically, in Borja et al. (2018).

Authorities often find difficulty in tracing the origin of problems when assessing status through aggregated data, preventing the adoption of management measures to address the impacts detected. However, Pavlidou *et al.* (2019) demonstrated that the use of NEAT, spatially and temporally, allows linking the assessment with the human pressures and the measures taken to reverse a degraded situation. Borja et al. (2018) showed the ecosystem components, descriptors or habitats, which need some management measures to achieve the GES. In the case of NEAT, we were able to track the problems linked to contaminants in different habitats (water column, seafloor, biota), whilst using the European Commission (2018) guidelines this was not possible, since the evaluation must be done under different premises.

Using the European Commission (2018) guidelines we have shown that still the assessment for the MSFD can be done, but the integration is much more difficult and impossible at global level, since four descriptors are in good status and three do not achieve good status.

7.0 References

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8.0 Annex 1

Original datasets in Excel, used to assess the status, after the European Commission Guidelines, are provided as Annex to this Deliverable.

9.0 Annex 2

Signatures of the experts who have participated in the coordination of the main aspects of this report.

Malta Marine Monitoring Consortium
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Reg No: P1730

Expert Declaration: Prof Deidun

RE: CT3031/16 for the Implementation and Updating of Marine Monitoring Programmes, Assessment of Environmental Status and Development of a Marine Database System

I, the undersigned, have been designated as a subcontracted expert to M3C (comprised of AIS Environment and AZTI Tecnalia) for the abovementioned project. I was responsible for carrying out the sampling and/or analysis for the studies listed below. I hereby confirm that the data presented in this report has been collected on the basis of the necessary expertise.

Expert name	Prof Alan Deidun
Qualifications	PhD in marine biology
Responsibilities (sampling and/or analysis)	SCUBA studies and coordination of the maerl bed survey
Relevant study	» *Posidonia oceanica* studies » *Pinna nobilis* survey » Non-indigenous species » Marine litter on the seabed » Maerl bed survey

Signature: ______________________ Date: 13/5/19

Maritime and Fisheries Operational Programme 2014-2020
Part-financed by the European Union
European Maritime Fisheries Fund
Co-financing rate: 75% European Union Funds; 25% National Funds

Investing in sustainable fisheries and aquaculture

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Expert Declaration: Dr Gauci

RE: CT3031/16 for the Implementation and Updating of Marine Monitoring Programmes, Assessment of Environmental Status and Development of a Marine Database System

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Expert name	Dr Adam Gauci
Qualifications	PhD in artificial intelligence
Responsibilities (sampling and/or analysis)	Coordinate survey and subsequent analysis of footage to determine sediment:live maerl ratio
Relevant study	Maerl bed survey

Signature: ______________ Date: 9th May 2019

Maritime and Fisheries Operational Programme 2014-2020
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Expert Declaration: Dr Nicastro

RE: CT3031/16 for the Implementation and Updating of Marine Monitoring Programmes, Assessment of Environmental Status and Development of a Marine Database System

I, the undersigned, have been designated as a subcontracted expert to M3C (comprised of AIS Environment and AZTI Tecnalia) for the abovementioned project. I was responsible for carrying out the sampling and/or analysis for the studies listed below. I hereby confirm that the data presented in this report has been collected on the basis of the necessary expertise.

Expert name	Dr Andrea Nicastro
Qualifications	
Responsibilities (sampling and/or analysis)	In situ field surveys and subsequent analysis of data to determine relevant indices
Relevant study	» CARLIT study » *Lithophyllum* spp. study

Signature: ______________ Date: 14/05/2019

Maritime and Fisheries Operational Programme 2014-2020
Part-financed by the European Union
European Maritime Fisheries Fund
Co-financing rate: 75% European Union Funds; 25% National Funds

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Expert Declaration: Dr Borja

RE: CT3031/16 for the Implementation and Updating of Marine Monitoring Programmes, Assessment of Environmental Status and Development of a Marine Database System

I, the undersigned, have been designated as an internal expert, forming part of the M3C team (comprised of AIS Environment and AZTI Tecnalia) for the abovementioned project. I was responsible for carrying out the sampling and/or analysis for the studies listed below. I hereby confirm that the data presented in this report has been collected on the basis of the necessary expertise.

Expert name	Dr Ángel Borja
Qualifications	PhD in marine biology
Responsibilities (sampling and/or analysis)	Expert guidance on the biological aspect of the surveys and preparation of deliverables
Relevant study	N/A

Signature: Angel Borja

Date: 10/5/2019

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Expert Declaration: Ms Sagarminaga

RE: CT3031/16 for the Implementation and Updating of Marine Monitoring Programmes, Assessment of Environmental Status and Development of a Marine Database System

I, the undersigned, have been designated as an internal expert, forming part of the M3C team (comprised of AIS Environment and AZTI Tecnalia) for the abovementioned project. I was responsible for carrying out the sampling and/or analysis for the studies listed below. I hereby confirm that the data presented in this report has been collected on the basis of the necessary expertise.

Expert name	Ms Yolanda Sagarminaga
Qualifications	MSc in integrated management of territories
Responsibilities (sampling and/or analysis)	Creation and population of marine database
Relevant study	N/A

Signature: Yolanda Sagarminaga   Date: 10/5/2019

Maritime and Fisheries Operational Programme 2014-2020
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Co-financing rate: 75% European Union Funds; 25% National Funds

Investing in sustainable fisheries and aquaculture

Expert Declaration: Dr Joana Larreta

RE: CT3031/16 for the Implementation and Updating of Marine Monitoring Programmes, Assessment of Environmental Status and Development of a Marine Database System

I, the undersigned, have been designated as an internal expert, forming part of the M3C team (comprised of AIS Environment and AZTI Tecnalia) for the abovementioned project. I was therefore responsible for carrying out the sampling and/or analysis for the studies listed below. I hereby confirm that the data presented in this report has been collected on the basis of the necessary expertise.

Expert name	Dr Joana Larreta
Qualifications	PhD in analytical chemistry
Responsibilities (sampling and/or analysis)	Expert guidance on the chemical aspect of the surveys and preparation of deliverables
Relevant study	N/A

Signature: ______________________ Date: 10/5/2019

Expert Declaration: Dr Giglio

RE: CT3031/16 for the Implementation and Updating of Marine Monitoring Programmes, Assessment of Environmental Status and Development of a Marine Database System

I, the undersigned, have been designated as a subcontracted expert to M3C (comprised of AIS Environment and AZTI Tecnalia) for the abovementioned project. I was responsible for carrying out the analysis for the studies listed below. I hereby confirm that the data presented in this report has been did on the basis of the necessary expertise.

Expert name	Dr Elettra Giglio
Qualifications	Msc Biologist
Responsibilities (analysis)	Laboratory analysis of water, sediment and biota samples
Relevant study	» Contaminants (water, sediment, fish and crustacea, *P. oceanica*) » Nutrients (water) » Phytoplankton » Zooplankton » Organic matter in sediments » Granulometric analysis

Signature: ....

Date: 10/05/19

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Expert Declaration: Dr Rocchia

RE: CT3031/16 for the Implementation and Updating of Marine Monitoring Programmes, Assessment of Environmental Status and Development of a Marine Database System

I, the undersigned, have been designated as a subcontracted expert to M3C (comprised of AIS Environment and AZTI Tecnalia) for the abovementioned project. I was responsible for carrying out the analysis for the studies listed below. I hereby confirm that the data presented in this report has been did on the basis of the necessary expertise.

Expert name	Dr Giorgio Rocchia
Qualifications	Msc Chemist
Responsibilities (analysis)	Laboratory analysis of water, sediment and biota samples
Relevant study	» Contaminants (water, sediment, fish and crustacea, *P. oceanica*) » Nutrients (water) » Phytoplankton » Zooplankton » Organic matter in sediments » Granulometric analysis

Signature:

Date: 10/05/19

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Reg No: P1730

Expert Declaration: Dr D'Alessandro

RE: CT3031/16 for the Implementation and Updating of Marine Monitoring Programmes, Assessment of Environmental Status and Development of a Marine Database System

I, the undersigned, have been designated as a subcontracted expert to M3C (comprised of AIS Environment and AZTI Tecnalia) for the abovementioned project. I was responsible for carrying out the sampling and/or analysis for the studies listed below. I hereby confirm that the data presented in this report has been collected on the basis of the necessary expertise.

Expert name	Dr Michela D'Alessandro
Qualifications	PhD in marine biology
Responsibilities (sampling and/or analysis)	Laboratory identification of benthic invertebrates samples and calculation of BENTIX
Relevant study	» Shallow sublittoral sediment » Benthic invertebrates

Signature: Michela D'Alessandro Date: 13 May 2019

Maritime and Fisheries Operational Programme 2014-2020
Part-financed by the European Union
European Maritime Fisheries Fund
Co-financing rate: 75% European Union Funds; 25% National Funds

Investing in sustainable fisheries and aquaculture

Malta Marine Monitoring Consortium
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Reg No P1730

Expert Declaration: Dr Anton

RE: CT3031/16 for the Implementation and Updating of Marine Monitoring Programmes, Assessment of Environmental Status and Development of a Marine Database System

I, the undersigned, have been designated as an internal expert, forming part of the M3C team (comprised of AIS Environment and AZTI Tecnalia) for the abovementioned project. I was responsible for carrying out the sampling and/or analysis for the studies listed below. I hereby confirm that the data presented in this report has been collected on the basis of the necessary expertise.

Expert name	Dr Rocio Anton
Qualifications	PhD in marine science
Responsibilities (sampling and/or analysis)	Water sample collection, in situ analyses using multiparametric probe and sediment sample collection (Van Veen grab)
Relevant study	Water sampling & in situ analyses » Contaminants » Nutrients (water) » Physical and chemical characteristics » Hydrographical characteristics » Litter washed ashore » Litter in water column » Phytoplankton » Zooplankton Sediment sampling » Contaminants » Benthic invertebrates » Organic matter in sediments

Signature: [signature] Date: 09/05/2019

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Reg No P1730

Expert Declaration: Ms Gonzalez

RE: CT3031/16 for the Implementation and Updating of Marine Monitoring Programmes, Assessment of Environmental Status and Development of a Marine Database System

I, the undersigned, have been designated as an internal expert, forming part of the M3C team (comprised of AIS Environment and AZTI Tecnalia) for the abovementioned project. I was responsible for carrying out the sampling and/or analysis for the studies listed below. I hereby confirm that the data presented in this report has been collected on the basis of the necessary expertise.

Expert name	Ms Rocio Gonzalez
Qualifications	MSc in marine science
Responsibilities (sampling and/or analysis)	Water sample collection, in situ analyses using multiparametric probe and sediment sample collection (Van Veen grab)
Relevant study	Water sampling & in situ analyses » Contaminants » Nutrients (water) » Physical and chemical characteristics » Hydrographical characteristics » Litter washed ashore » Litter in water column » Phytoplankton » Zooplankton Sediment sampling » Contaminants » Benthic invertebrates » Organic matter in sediments

Signature: ____________ Date: 09/05/2019

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Expert Declaration: Ms Schembri

RE: CT3031/16 for the Implementation and Updating of Marine Monitoring Programmes, Assessment of Environmental Status and Development of a Marine Database System

I, the undersigned, have been designated as an internal expert, forming part of the M3C team (comprised of AIS Environment and AZTI Tecnalia) for the abovementioned project. I was responsible for carrying out the sampling and/or analysis for the studies listed below. I hereby confirm that the data presented in this report has been collected on the basis of the necessary expertise.

Expert name	Ms Yasmin Schembri
Qualifications	BSc biology and chemistry (Hons)
Responsibilities (sampling and/or analysis)	Water sample collection, in situ analyses using multiparametric probe and sediment sample collection (Van Veen grab)
Relevant study	Water sampling & in situ analyses » Contaminants » Nutrients (water) » Physical and chemical characteristics » Hydrographical characteristics » Litter washed ashore » Litter in water column » Phytoplankton » Zooplankton Sediment sampling » Contaminants » Benthic invertebrates » Organic matter in sediments

Signature: ____________ Date: 06/05/19

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