Monitoring Factsheet: Water Column Habitats

October 2015

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1. Subject: Water Column Habitats

Water column habitats are generally referred to as 'pelagic' habitats which include the water column and all the organisms that inhabit it. In accordance with UNEP/RAC/SPA (2013)[1], two zones of pelagic habitats are identified:

- the neritic zone – also known as coastal zone - which is the portion of the ocean lying above the continental shelf (i.e., extending from the low tide mark to the location corresponding to the continental shelf break - around a depth of 200 m); and
- the oceanic zone – also termed the open ocean or open sea - which extends away from the coast beyond the shelf break.

Water column habitats are largely dependent on movements of the water masses and the complex interactions between biological and physical processes[2]. For this reason, water column habitats can be classified differently at different times of the year. In the case of Malta such classification would depend on the hydrodynamics in the area, which are mainly dictated by the general flow in the Sicilian Channel, and thermal stratification of the water column that characterises the Mediterranean basin.

Characterisation of pelagic habitats in the Mediterranean is necessary for the implementation of the Ecosystem Approach (EcAp) roadmap[3]. However, a reference list of pelagic habitat types in the Mediterranean still needs to be compiled. UNEP/RAC/SPA (2013)[4] recommends that efforts are undertaken at compiling a reference list of pelagic habitat types through in-depth multidisciplinary expert consultations. An initial draft reference list for the epipelagic layer (0-200m) is provided in UNEP/RAC/SPA (2013)[5] as extracted in Figure 1.

Figure 1: Initial draft reference list proposed by RAC/SPA as extracted from UNEP/RAC/SPA (2013)[6]

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1 UNEP(DEPI)/MED WG.382/11: Towards the identification and Reference List of Pelagic Habitat Types in the Mediterranean Sea.

2 UNEP(DEPI)/MED WG.382/11: Towards the identification and Reference List of Pelagic Habitat Types in the Mediterranean Sea.

3 within the framework of the Barcelona Convention

4 UNEP(DEPI)/MED WG.382/11: Towards the identification and Reference List of Pelagic Habitat Types in the Mediterranean Sea.

5 UNEP(DEPI)/MED WG.382/11: Towards the identification and Reference List of Pelagic Habitat Types in the Mediterranean Sea.

6 UNEP(DEPI)/MED WG.382/11: Towards the identification and Reference List of Pelagic Habitat Types in the Mediterranean Sea.

A. Epipelagic layer (0 – 200 m):

A.1.	Reduced salinity water	coastal lagoons
A.2.	Variable salinity water - high surface CHL (>3 mg/m³)	estuaries, river plumes
A.3.	Marine water: neritic - medium surface CHL (0.5-3 mg/m³)	upwellings, re-suspension in shallow waters and outskirts of river plumes
A.4.	Marine water: oceanic - medium surface CHL (0.5-3 mg/m³)	upwellings
A.5.	Marine water: oceanic - low surface CHL (~0.1-0.5 mg/m³)	chlorophyll-a fronts (whatever type of horizontal gradient of CHL, thus including e.g. gyres)
A.6a.	Marine water: oceanic - very low surface CHL (<0.1 mg/m³) with subsurface CHL maximum	euphotic depth > mixed layer depth
A.6b.	Marine water: oceanic - very low surface CHL (<0.1 mg/m³) without subsurface CHL maximum	euphotic depth < mixed layer depth

The Marine Strategy Framework Directive's (MSFD) Commission Staff Working Paper[7] includes the category 'water column habitats' with divisions representing a simplified version of the EUNIS classification of pelagic water column (A7). The following MSFD categories are deemed relevant to Malta:

- Marine: Coastal Water
- Marine: Shelf Water
- Marine: Oceanic Water

2. Monitoring Requirements

2.1. Marine Strategy Framework Directive – MSFD (2008/56/EC)

2.1.1. Annex III characteristics/pressures/impacts

The MSFD calls for an assessment of the environmental status based on a list of characteristics listed in Table 1 of Annex III to the Directive, and pressures and impacts listed in Table 2 of the same Annex.

Implementation of this monitoring factsheet will enable a description of the following elements listed in Table 1:

- the water column habitat type(s) with a description of the characteristic physical and chemical features;
- biological communities associated with the water column habitats. This would include information on the phytoplankton and zooplankton communities, including the species and seasonal and geographical variability.

[7] Commission Staff Working Paper: Relationship between the initial assessment of marine waters and the criteria for good environmental status. SEC(2011)1255 final

2.1.2. Annex I Good Environmental Status Descriptors

MSFD Annex I descriptors of Good Environmental Status and the associated criteria and indicators established by MSFD Commission Decision 2010/477/EU for assessment of progress towards the achievement of GES in terms of water column habitats and which will be addressed by this monitoring factsheet are listed hereunder:

Descriptor 1: *Biological Diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions*

- 1.6 Habitat Condition
  - Condition of the typical species and communities (1.6.1)
  - Relative abundance and/or biomass, as appropriate (1.6.2)
  - Physical, hydrological and chemical conditions (1.6.3)

2.2. Water Framework Directive – WFD (2000/60/EC)

The EU Water Framework Directive (WFD) 2000/60/EC calls for the protection of all water resources, including coastal waters. The main objective of the WFD for coastal water bodies is the achievement, by 2015, of 'good ecological status' up to one nautical mile from the coast; 'good chemical status' for all territorial waters (12 nautical miles) and 'good ecological potential'[8] for heavily modified water bodies[9]. 'Good ecological status' is defined by the ecological status of biological elements, including phytoplankton, which needs to be monitored with a view to assess status. For this purpose, the composition, abundance and biomass of phytoplankton need to be monitored for the purpose of the WFD.

2.3. Barcelona Convention

The Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention) was adopted in 1976 and came into force in 1978. The principal aim of the Barcelona Convention and its protocols is to reduce pollution in the Mediterranean Sea and to protect and improve the marine environment in the area, thereby contributing to its sustainable development. The Barcelona Convention/MAP are working towards an Integrated Monitoring Programme and an Integrated Policy of Assessments to be established by 2015. The Integrated Monitoring Programme should be able to provide all the data needed to

[8] 'Good Ecological Potential' is less stringent objective than good ecological status, making allowances for ecological impacts resulting from alterations to the physical environment that are necessary to either support a specific use, or must be maintained in order to avoid effects on the wider environment.

[9] Heavily Modified Water Bodies are substantially changed in character as a result of physical alterations by human activity, and cannot therefore, meet 'good ecological status'

assess whether 'Good Environmental Status' defined through the EcAp process[10] has been achieved or maintained.

The list of habitats which would be subject to EcAp biodiversity monitoring through the Integrated Monitoring Programme is under discussion at the time of compiling this monitoring factsheet. The draft list includes[11]:

- Pelagic oceanic:
  - upwelling areas
  - fronts
  - gyres
- Pelagic Neritic

[10] Ecosystem-based approach undertaken as part of the Barcelona Convention.

[11] UNEP/MAP 2014. Draft Monitoring and Assessment Methodological Guidance, 4th meeting of the EcAp Coordination Group UNEP(DEPI)/MED WG.401/3

3. Targets

This section includes targets set by policies in relation to phytoplankton and zooplankton.

Implementation of this monitoring factsheet will facilitate achievement of the targets adopted by Malta as part of the EU Marine Strategy Framework Directive and will enable assessment of progress towards achievement of Water Framework Directive targets. Such monitoring may also apply in assessing progress towards targets articulated through other processes.

Policy	Status to be achieved	Targets
Marine Strategy Framework Directive	No GES defined for water column habitat types.	To strengthen knowledge via updated data on key characteristics of the water column, including plankton communities that would enable Malta to further develop the definition of this habitat type in line with the requirements of the Marine Strategy Framework Directive.
Water Framework Directive	Achievement, by 2015, of 'good ecological status' up to one nautical mile from the coast and 'good ecological potential'[12] for heavily modified water bodies. 'Good ecological status' is defined by the ecological status of biological elements, including composition, abundance and biomass of phytoplankton.	No quantitative thresholds have been set to date for Malta.
Barcelona Convention: EcAp Process	Operational Objective: Key coastal and marine habitats are not being lost *Common Indicator[13]:* ▪ *Habitat Distributional Range* Good Environmental Status defined as 'The habitat is present in all its natural distributional range'	State Target: The ratio Natural/observed distributional range tends to 1 Pressure Target: Decrease in the main human causes of the habitat decline
	Operational Objective:	State Target:

[12] 'Good Ecological Potential' is less stringent objective than good ecological status, making allowances for ecological impacts resulting from alterations to the physical environment that are necessary to either support a specific use, or must be maintained in order to avoid effects on the wider environment.

[13] UNEP/MAP 2014.Working document on Common Indicators for the Mediterranean. Integrated Correspondence Groups of GES and Targets Meeting, Athens (Greece), 17-19 February 2014 , UNEP(DEPI)/MED WG.390/3

	Key coastal and marine habitats are not being lost *Indicator:* ▪ *Distributional pattern of certain coastal and marine habitats listed under SPA protocol* Good Environmental Status defined as 'The distributional extent is in line with prevailing physiographic, hydrographic, geographic and climatic conditions'	Decline in habitat extension is reversed and the extension of recovering habitats shows a positive trend.
	Operational Objective: Key coastal and marine habitats are not being lost *Common Indicator*[14]*:* ▪ *Condition of the habitat's typical species and communities* Good Environmental Status defined as: The population size and density of the habitat-defining species, and species composition of the community, are within reference conditions ensuring the long term maintenance of the Habitat	State Targets: No human induced significant deviation of population abundance and density from reference conditions The species composition shows a positive trend towards reference condition over an increasing proportion of the habitat (for recovering habitats)

4. Competent Authorities

Policy	Competent Authority
MSFD	Office of the Prime Minister (delegation of technical implementation to the Malta Environment and Planning Authority)
WFD (Coastal waters)	Malta Environment and Planning Authority
Barcelona Convention – SPA/BD Protocol	Malta Environment and Planning Authority

[14] UNEP/MAP 2014.Working document on Common Indicators for the Mediterranean. Integrated Correspondence Groups of GES and Targets Meeting, Athens (Greece), 17-19 February 2014 , UNEP(DEPI)/MED WG.390/3

5. Spatial Extent of monitoring requirements

Policy	Extent of marine waters
MSFD	Extent of waters to be monitored depends on relevance and established GES and targets.
WFD (Coastal waters)	1 nautical mile
Barcelona Convention – SPA/BD Protocol	Regional

6. Monitoring Approach

This monitoring factsheet includes two monitoring subprogrammes listed hereunder:

Monitoring sub-programme	Title	Monitoring Purpose
1	Water Column habitats – phytoplankton	State
2	Water Column habitats – zooplankton	State

The monitoring sub-programmes focus on state monitoring noting that the main pressures on water column habitats will be monitored through other monitoring programmes. Within this context, monitoring will focus on the assessment of phytoplankton and zooplankton composition, abundance and biomass.

7. Assessment of status

Assessment of status is detailed for the monitoring sub-programmes as relevant.

8. Monitoring sub-programme 1: *Water Column Habitats – Phytoplankton*

8.1. Monitoring Parameters

8.1.1. Phytoplankton[15]

Table 1: List of parameters to be monitored

Parameter	Unit	WFD	MSFD	MEDPOL[16]
Phytoplankton abundance	cells per litre	×	×	×
Phytoplankton biomass (chlorophyll-a)	µg/L	×	×	×
Phytoplankton composition including:		×	×	×
- Percentage abundance of known opportunistic/blooming/non-indigenous species[17]			×[18]	×
- Species shifts: Diatom to flagellate ratio			×[19]	

8.2. Supporting Parameters

Parameter	Unit	Related Monitoring Factsheet
Nutrients		Eutrophication
Dissolved Oxygen	% saturation	
Water Transparency/Turbidity	Secchi depths, NTU	
Temperature	°C	
Salinity	psu	
pH		
Hydrodynamics Data		Hydrographical Changes

8.3. Monitoring methodologies

This section briefly outlines methodologies for monitoring phytoplankton. Adherence to methodological standards as listed in Section 11 of this factsheet

[15] Monitoring processes for phytoplankton reflect those adopted by 'Eutrophication' monitoring factsheet

[16] The list of parameters is in line with the 'Eutrophication Monitoring Strategy for MED POL' UNEP(DEPI)/MED WG.321/Inf.5 listing the mandatory parameters to be monitored by each country, which parameters support the adoption of the TRIX index.

[17] Ferreria *et al.* (2010) distinguish three types of harmful blooms: (i) those due to toxic algae (e.g. *Alexandrium*, *Dinophysis* and *Pseudonitzschia*) which can poison fish and shellfish even at low algal abundance; (ii) potentially toxic algae (e.g. *Pseudonitzschia*); and (iii) high-biomass blooms that cause problems mainly because of the high biomass itself. High-biomass blooms are sometimes called "red tides" but may in fact be brown, green or white discolourations of the sea. Some organisms (e.g. *Alexandrium*) occur in more than one category. Links between HABs and nutrient enrichment have been much debated. HABs should be treated as part of the undesirable consequences of eutrophication only if their frequency or amplitude increases in correspondence with increased nutrient input.

[18] Mainly required for MSFD Descriptors 2 and 5 but included here for harmonisation purposes

[19] Mainly required for MSFD Descriptor 5 but included here for harmonisation purposes

should be ensured at all times. Methodologies should primarily be in line with those stipulated in UNEP/MAP/MED POL (2005)[20].

8.3.1. Sampling

- Water sampling will take place at the monitoring stations at surface and sub-surface depth (between 1m and 5m from surface[21]) and along specified transects (as per Section 8.4.5) at three depths: surface, medium depth and bottom, as per methodology proposed by the 'eutrophication' monitoring factsheet and in line with the 'Eutrophication Monitoring Strategy of MEDPOL'[22].

- Replicate samples are collected using Van-Dorn vertical all-plastic sampler or Niskin bottles[23]. The volume collected is normally about 5L, which will sufficiently provide sub-samples for the different parameters that would need to be analysed from each location. For chlorophyll-a analysis, samples are collected in dark glass containers and filtered either immediately on board the vessel, or else in the laboratory within 8 hours from collection.

- Samples are appropriately preserved: those intended for identification of major phytoplankton groups are preserved in Lugol's Iodine, while samples intended for detailed species identification are preserved using both Lugol's Iodine and formalin (2 aliquots).

8.3.2. Sample Analysis

The following analysis will be carried out with respect to phytoplankton[24]:

- *Full species composition and abundance*: involving concentration of samples followed by enumeration and identification to genus or species level on an inverted optical microscope. The cells being randomly distributed, would be viewed along transects within the field of view or else, if a significant amount of cells are present, they would be viewed in random fields. The cells on the transect or in a field are identified to species level and counted in a tally chart. The number of cells recorded in a subsample is then calculated as a function of the volume of sample and the magnification used, to arrive at the estimate of

[20] UNEP/MAP/MED POL (2005). Sampling and Analysis Techniques for the Eutrophication Monitoring Strategy of MED POL. MAP Technical Reports Series No. 163. UNEP/MAP, Athens, 2005.

[21] When vertical distribution of phytoplankton populations is to be studied, samples from deeper waters and at a number of depths would need to be collected. During the first cycle of monitoring the samples are taken at surface and sub-surface depth, e.g. between 1 and 5 m from surface pending further knowledge on the vertical distribution patterns of phytoplankton and their relationship with environmental status.

[22] UNEP(DEC)/MED WG. 231/14

[23] Phytoplankton nets, which are useful in collecting samples over a relatively large area to assess the different species of phytoplankton that are present, may be used in offshore stations (only) to collect semi-quantitative data to be combined with quantitative data from samples collected in Niskin bottles. A conical net of diameter 20 – 30 cm, having a mesh size of 100µm or smaller (30 – 80 µm), is deployed at a specific depth between 1 and 5m from surface. The towing speed should be relatively constant between 1 and 2 knots and horizontal tows should be of 5-10 minutes duration. The net is rinsed thoroughly between hauls so as to remove any species that might have adhered to its sides.

[24] Monitoring processes for phytoplankton reflect those adopted by 'Eutrophication' monitoring factsheet

'number of cells per litre'. This value would be used to calculate percentage abundances for other parameters.

- *Total Abundance of major groups*: identification of individuals down to the major groups: diatoms, dinoflagellates, and other phytoplankton[25]. Diatom to flagellate ratios to be determined.
- *Percentage abundance of known opportunistic/blooming/non-indigenous species*: Species that are known to be opportunistic or have a tendency to bloom or that are known to be non-indigenous, are specifically counted and their percentage abundance is calculated from the total abundance.
- *Biomass (Chlorophyll a)*: chemical determination of chlorophyll *a* concentration through spectrophotometry (SPFT)

8.4. Monitoring area

Monitoring stations and transects indicated in below sections are subject to revisions following the initial monitoring years.

8.4.1. Monitoring Stations: inshore

Inshore stations are listed in Table 2.

Table 2: Inshore Monitoring Stations

Mon. Site Ref. Code	Monitoring Network	Coordinates (Full UTM ED50)	
		Longitude	Latitude
Operational Monitoring Stations			
CP04-1[26]	Operational	453769,71	3977836,62
CP04-2	Operational	449013,07	3979914,24
CP05	Operational - Harbour	457169,68	3973252,05
CP06-1[27]	Operational	461078,41	3971492,15
CP06-2	Operational	460522,84	3970960,01
CP07	Operational - Harbour	459771,77	3964111,98
Surveillance Monitoring Stations			
CS01[28]	Surveillance	425781,39	3992303,97
CS02[29]	Sur + Reference Site	435571,14	3992063,13
CS03[30]	Sur + Reference Site	442502,54	3984741,51
CS08[31]	Surveillance	453654,59	3962794,34

[25] Due to their small size and lack of protruding structures that aid identification, phytoplankton other than diatoms and dinoflagellates often require more strenuous and sophisticated methods for their identification and enumeration, with preliminary filtration of samples, specialised concentration techniques and the combination of light and electron microscopical observations for satisfactory identification. Focus will thus be on the processing of samples for diatom and dinoflagellate identification, with the remaining specimens being categorised under 'other flagellates'

[26] Station located beyond 500m therefore can be considered to be nearshore.

[27] Station located beyond 500m therefore can be considered to be nearshore.

[28] Station located beyond 500m therefore can be considered to be nearshore.

[29] Station located beyond 500m therefore can be considered to be nearshore.

[30] Station located beyond 500m therefore can be considered to be nearshore.

[31] Station located beyond 500m therefore can be considered to be nearshore.

Mon. Site Ref. Code	Monitoring Network	Coordinates (Full UTM ED50)	
		Longitude	Latitude
CS09[32]	Sur + Protected area	439697,26	3976129,46
National Monitoring Stations			
CN01-1	Protected Area	426700,89	3990134,58
CN02-1	Op – Diffuse sources	433397,15	3992518,78
CN03-1	Op – Sewage Outfall	435420,03	3986084,12
CN03-2	Op - Harbour	437057,14	3987236,76
CN03-3	Op-Harbour	440130,02	3983083,45
CN03-6	Op-Minor Sewage Outfall	441540,34	3985079,15
CN04-1[33]	Op - diffuse sources	442596,44	3981355,59
CN04-3[34]	Op - bunkering site	445500,41	3984462,78
CN04-5	Nitrates Directive	454162,08	3976206,21
CN04-6	Nitrates Directive	454528,54	3975162,74
CN05-1	Op - Harbour	455167,45	3973034,62
CN06-1	Op - diffuse sources	460815,92	3969206,43
CN07-1	Op - Thermal effluent	460712,08	3966044,50
CN07-3	Op – Harbour	458110,28	3965070,20
CN08-1	Op – Desalination Plant	447163,40	3965389,58
CN09-1	Op – Sewage Outfall	440099,89	3979621,63

8.4.2. Monitoring stations: nearshore (500m-1500m) [chlorophyll-a only]

Sampling of chlorophyll-a from additional nearshore stations shall be carried out for one monitoring year to enable WFD intercalibration of chlorophyll-a. Additional inshore stations to be sampled at a distance of >500m - <1500m perpendicular to the shoreline for measurement of chlorophyll-a are listed in Table 3.

Table 3: Additional nearshore stations for monitoring of chlorophyll-a.

Mon. Site Ref. Code	Monitoring Network	Coordinates (Full UTM ED50)	
		Longitude	Latitude
CP04-2	Operational	449013,07	3979914,24
CP05	Operational - Harbour	457169,68	3973252,05
CP06-2	Operational	460522,84	3970960,01
CP07	Operational - Harbour	459771,77	3964111,98
CN01-1	Protected Area	426700,89	3990134,58
CN03-1	Op – Sewage Outfall	435420,03	3986084,12
CN03-6	Op-Minor Sewage Outfall	441540,34	3985079,15
CN09-1	Op – Sewage Outfall	440099,89	3979621,63

[32] Station located beyond 500m therefore can be considered to be nearshore.
[33] Station located beyond 500m therefore can be considered to be nearshore.
[34] Nutrients were not assessed within this station during the first WFD monitoring surveys. Station retained for monitoring to be representative of bunkering sites. Station located beyond 500m therefore can be considered to be nearshore.

8.4.3. Monitoring stations: territorial waters

Nine of the inshore stations will be sampled at a distance of 6 nautical miles from the baselines where the breadth of the territorial waters is measured with a view to provide data between the 1nm and the 12nm extent of Malta's territorial waters. These stations are listed in Table 4 together with additional stations in bunkering areas.

Table 4: Monitoring Stations to **be sampled at a distance of 6 nautical miles from the baselines where the breadth of the territorial waters is measured and additional monitoring stations in bunkering areas, for monitoring of phytoplankton parameters**[35]

Mon. Site Ref. Code	Monitoring Network	Coordinates (Full UTM ED50)	
		Longitude	Latitude
CS01	Surveillance	425781,39	3992303,97
CS02	Sur + Reference Site	435571,14	3992063,13
CS03	Sur + Reference Site	442502,54	3984741,51
CP04-1	Operational	453769,71	3977836,62
CP05	Operational - Harbour	457169,68	3973252,05
CP06-1	Operational	461078,41	3971492,15
CP07	Operational - Harbour	459771,77	3964111,98
CS08	Surveillance	453654,59	3962794,34
CS09	Sur + Protected area	439697,26	3976129,46
Bunkering Area 2		463215,69	3970468,46
Bunkering Area 3		480042,40	3971974,31
Bunkering Area 4		463310,71	3964577,20
Bunkering Area 6		439080,51	3978830,25
Waiting Area		470247,20	3967047,73

[35] Bunkering Area 1 is covered by monitoring station CN04-3 hence not included in this table

8.4.4. Monitoring Stations: Offshore

Offshore monitoring stations are listed in Table 5 and shown in Figure 2.

Table 5: Offshore monitoring stations

Offshore Monitoring stations	**Coordinates (Full UTM ED50)**	
	Longitude	**Longitude**
Malta North	378799.33 4	4028101.37
Malta East	530961.17 3	3976110.62
Malta South	473775.46 3	3904926.63
Malta West	375854.66 3	3951016.29

Figure 2: Offshore Monitoring Stations

8.4.5. Transects

Sampling along a transect perpendicular to the coastline will be carried out for monitoring stations listed in Table 6. Monitoring of phytoplankton in line with the methodologies identified by this monitoring factsheet will be undertaken along these transects with a view to assess the horizontal and vertical distribution of phytoplankton.

Table 6: Monitoring stations to be supplemented by monitoring stations along a transect.

Mon. Site Ref. Code	Monitoring Network	Coordinates (Full UTM ED50)	
		Longitude	Latitude
CN01-2	Op – Diffuse Sources	429492,88	3987775,43
CN05-2	Op - Harbour	456279,18	3972594,26
CN07-2	Op – Harbour	459413,96	3965607,40
	Innermost part of Salini	448260,79	3978712,49

8.5. Monitoring frequency

Monitoring frequency for the first monitoring year is indicated below. The monitoring frequency is subject to revisions following the first monitoring episodes.

Parameters	Monitoring Stations	Monitoring Frequency
Chlorophyll-a	Inshore monitoring Stations	monthly
	Additional nearshore stations	Monthly
	Stations at 6 nautical miles; bunkering areas	6-monthly
	Offshore stations	6-monthly
	Transects	3-monthly
Phytoplankton composition and abundance	Inshore monitoring stations	3-Monthly
	Stations at 6 nautical miles; bunkering areas	6-monthly
	Offshore stations	6-monthly
	Transects	3-monthly

8.6. Assessment of Status

8.6.1. Phytoplankton composition and abundance

For the purpose of the EU Water Framework Directive, data on phytoplankton composition and abundance should be used to set 'ecological quality ratios' (EQR) to establish the boundary levels for the High-Good and Good-Moderate status boundaries. Establishment of these boundaries or thresholds for Malta is pending the intercalibration exercise for phytoplankton.

Broad definitions of high, good and moderate status as qualitatively defined by the WFD for phytoplankton are included in Table 7.

Within this context and pending completion of the WFD intercalibration exercise for phytoplankton, assessment of status of water column habitats will be based on an analysis of trends in phytoplankton composition and abundance.

Table 7: High, Good and Moderate Status definitions for phytoplankton.

High Status	Good Status	Moderate Status
The composition and abundance of phytoplanktonic taxa are consistent with undisturbed conditions. The average phytoplankton biomass is consistent with the type-specific physico-chemical conditions and is not such as to significantly alter the type-specific transparency conditions. Planktonic blooms occur at a frequency and intensity which is consistent with the type specific physico-chemical conditions.	The composition and abundance of phytoplanktonic taxa show slight signs of disturbance. There are slight changes in biomass compared to type-specific conditions. Such changes do not indicate any accelerated growth of algae resulting in undesirable disturbance to the balance of organisms present in the water body or to the quality of the water. A slight increase in the frequency and intensity of the type-specific planktonic blooms may occur.	The composition and abundance of planktonic taxa show signs of moderate disturbance. Algal biomass is substantially outside the range associated with type-specific conditions, and is such as to impact upon other biological quality elements. A moderate increase in the frequency and intensity of planktonic blooms may occur. Persistent blooms may occur during summer months.

8.6.2. Phytoplankton: Chlorophyll-a

In line with the monitoring factsheet for eutrophication, this factsheet is adopting on an interim basis the Ecological Quality Ratios for High-Good and Good-Moderate ecological status in terms of chlorophyll-a concentrations for Type IIIE waters in Greece and Cyprus (as per Commission Decision 2013/480/EU). This is based on the assumption that Maltese waters constitute Type IIIE coastal waters as defined by Commission Decision 2013/480/EU and the eutrophication scale provided in

Simboura *et al*. (2005)[36] is used for this purpose. Parameter values are expressed in µg/l of Chlorophyll-a, for the 90th percentile calculated over the year in at least a five year period.

The boundaries proposed need to be updated once the typology of Maltese coastal waters is defined and the WFD intercalibration exercise is completed.

[36] Simboura, N., Panayotidis, P. & Papathanassiuo, E. (2005) A synthesis of the biological quality elements for the implementation of the European Water Framework Directive in the Mediterranean ecoregion: the case of Saronikos Gulf. *Ecological Indicators* **5**: 253-266

9. Monitoring sub-programme 2: *Water Column Habitats – zooplankton*

9.1. Monitoring Parameters

Table 8: List of parameters to be monitored

Parameter	Unit	WFD	MSFD	MEDPOL[37]
Zooplankton abundance	number of individuals per litre		×	
Zooplankton biomass	To be determined		×	
Zooplankton composition			×	
Percentage abundance of known opportunistic/non-indigenous species			×	

9.2. Supporting Parameters

Parameter	Unit	Related Monitoring Factsheet
Nutrients		Eutrophication
Dissolved Oxygen	% saturation	
Water Transparency/Turbidity	Secchi depths, NTU	
Temperature	°C	
Salinity	psu	
pH		
Hydrodynamics Data		Hydrographical Changes

9.3. Monitoring methodologies

This section briefly outlines methodologies for monitoring zooplankton. Consideration should also be given to methodological standards listed in Section 11.

9.3.1. Sampling

- Water sampling will take place at the monitoring stations at surface and sub-surface depth (between 1m and 5m from surface[38]). Replicate samples are collected using Van-Dorn vertical all-plastic sampler or Niskin bottles[39].

- Additional sampling by nets may be undertaken in offshore stations. For the smaller zooplankton, nets with diameter of 0.5m and mesh size of 0.1-0.2mm are

[37] The list of parameters is in line with the 'Eutrophication Monitoring Strategy for MED POL' UNEP(DEPI)/MED WG.321/Inf.5 listing the mandatory parameters to be monitored by each country, which parameters support the adoption of the TRIX index.

[38] When vertical distribution of phytoplankton populations is to be studied, samples from deeper waters and at a number of depths would need to be collected. During the first cycle of monitoring the samples are taken at a single depth, e.g. between 1 and 5 m from surface pending further knowledge on the vertical distribution patterns of phytoplankton and their relationship with environmental status.

[39] Use of sample bottles is more suitable for collecting the smaller forms of zooplankton.

used, whilst for larger zooplankton nets of 1-2m diameter with mesh size of 1-2mm are used. The towing speed should be relatively constant between 1 and 2 knots and horizontal tows should be of 5-10 minutes duration. Horizontal surface hauls should be done before dawn, after dusk or at night. After each haul, the net is rinsed well. Samples will be appropriately preserved in 4% formaldehyde (or 10% formalin made with 1 part of the 40% commercial stock formaldehyde and 9 parts filtered seawater) buffered with borax.

9.3.2. Sample Analysis

The following analysis is carried out with respect to zooplankton:

- *Species composition and abundance:* zooplankton is sorted through the use of a low-power stereomicroscope into major groups as follows:
  - Crustacean zooplankton: copeopods, krill, cladocera, and other crustaceans;
  - Gelatinous zooplankton: coelenterates, comb jellies, salps, and larvacea;
  - Other zooplankton: arrow worms, pteropods, and planktonic polychaetes;
  - Protistan plankton: ciliates, foraminiferans and radiolarians.

  The number of individuals recorded for a particular group in a subsample is calculated as a function of the volume of sample to estimate 'number of individuals per litre'.
- *Percentage abundance of non-indigenous invasive species*: species that are known to be non-indigenous, are specifically counted and their percentage abundance is calculated from the total abundance
- *Biomass*: zooplankton biomass is determined using one of the following methods[40]:
  - the volumetric method involving the measurement of the total zooplankton volume by displacement: sample is filtered through a mesh of size equal or smaller than that used for collection, interstitial water is blotted away and the zooplankton remaining on the mesh is collected using a spatula and transferred to a measuring cylinder containing a volume of preservative. The displacement volume is then measured.
  - the gravimetric method involving the measurement of the wet weight of the filtered zooplankton (after blotting away the interstitial water as in the volumetric method). The dry weight can be obtained by drying the filtered zooplankton in an oven at constant temperature (60^{o}C), kept in a desiccator until weighing to constant weight.

[40] Most feasible method to be determined at a later stage

9.4. Monitoring area

9.4.1. Monitoring Stations

Monitoring stations for zooplankton are equivalent to those for phytoplankton as described in Sections 8.4.1, 8.4.3 and 8.4.4. Additional nearshore stations as described in Section 8.4.2 and transects as described in Section 8.4.5 will not be used for the purpose of zooplankton.

These monitoring stations are subject to revision following the initial monitoring episodes.

9.5. Monitoring frequency

Monitoring frequency for the first monitoring year is indicated below. The monitoring frequency is subject to revisions following the first monitoring episodes.

Parameters	Monitoring Stations	Monitoring Frequency
Zooplankton composition, abundance, biomass	Inshore monitoring Stations	3-monthly
	Stations at 6 nautical miles; bunkering areas	6-monthly
	Offshore stations	6-monthly

9.6. Assessment of status

Assessment of status will be based on an analysis of trends in zooplankton composition and abundance.

10. Links to monitoring processes

Monitoring in terms of this factsheet is linked with monitoring for other marine elements as follows:

- Monitoring stations are shared with those proposed for 'contaminants', 'eutrophication' and 'hydrographical changes'.
- Inshore monitoring stations are shared with monitoring of 'benthic habitats' specifically monitoring of *Posidonia oceanica*.
- Transects to be sampled as per Section 8.4.5 are used for monitoring of 'eutrophication'
- Monitoring parameters for phytoplankton are used for monitoring 'eutrophication'
- Monitoring for phytoplankton and zooplankton will contribute to monitoring of non-indigenous species through the identification of non-indigenous invasive species and estimation of their percentage abundance.

11. Quality Assurance & Quality Control

Sampling methodologies and analysis of samples shall be carried out in line with standards and other published documents listed in this section.

Standards for sampling:

- EN ISO 5667-3: 2012 including guideline procedures for sampling programmes and techniques, preservation and handling of different types of water and sediments, bio-testing of samples and other general techniques.

Standards for phytoplankton:

- EN 15204:2006: Water Quality – Guidance standard on the enumeration of phytoplankton using inverted microscopy (Utermöhl Technique)
- EN 15972:2011: Water Quality – Guidance on quantitative and qualitative investigations of marine phytoplankton
- ISO 10260:1992: Water Quality – Measurement of biochemical parameters – Spectrometric determination of the chlorophyll-a concentration

Methodologies to be considered for zooplankton:

- Methodologies outlined in Tranter and Fraser (1968)[41]; Steedman (1976)[42] and Goswami (2004)[43]
- ASTM International, formerly known as the American Society for Testing and Materials (ASTM)[44] standards including:

41 Tranter & Fraser (eds.) 1968. Zooplankton Sampling. Monographs on Oceanographic Methodology 2. Paris: UNESCO Publishing. 337 pp.

42 Steedman, H. F. (ed) 1976) Zooplankton fixation and preservation. Monographs on Oceanographic Methodology 4. Paris: UNESCO Publishing. 336 pp.

43 Goswami, S.C. 2004. Zooplankton Methodology, Collection & Identification – a field Manual. National Institute of Oceanography, India. 26 pp.

- ASTM E1201 - 87(2012): Standard Practice for Sampling Zooplankton with Conical Tow Nets;
- ASTM E1200 - 87(2012) Standard Practice for Preserving Zooplankton Samples.

12. Data collection, storage and dissemination

All data should be collected and stored in accordance with the INSPIRE Technical Specifications listed in this section and/or any other relevant INSPIRE standard as identified through the Marine Pilot Project[45]. Processed data to be uploaded in a geoportal.

- 'D2.8.II/III.7 INSPIRE Data Specification on Environmental Monitoring Facilities – Technical Guidelines'[46].
- 'D2.8.III.15 Data Specification on Oceanographic geographical features – Technical Guidelines'[47]

13. Responsible organisations

Monitoring sub-programme	Monitoring stations	Responsible authorities
Phytoplankton	Stations & Transects	MEPA
Zooplankton	Stations	MEPA

[44] http://www.astm.org/Standards
[45] https://circabc.europa.eu/w/browse/bc33dff1-0f8c-467a-8382-7724c5f79d45
[46] http://inspire.ec.europa.eu/index.cfm/pageid/2
[47] http://inspire.ec.europa.eu/index.cfm/pageid/2;

14. Gaps and Research Needs

Gaps	Plans to address gaps
Water column habitat types have not been characterised as yet.	Data generated through the implementation of this monitoring factsheet to be analysed for the purposes of characterising water column habitat types for Malta and for contributing to assessment of food webs in terms of abundance indices for groups/species with fast turnover rates.
Knowledge on the vertical distribution of plankton is limited.	Research studies to be encouraged to study the vertical distribution patterns of plankton and their relationship with environmental status

15. Main Sources

- AAE Consortium (ADI Associates Ltd, Ecoserv Ltd and E Cubed Consultants). 2014. Long Term Monitoring Strategy for the Marine Environment of the Maltese Islands under the Marine Strategy Framework Directive. Service Contract for the development of a long-term monitoring strategy for the marine environment, a social and economic analysis of the use of marine waters and costs of degradation, and baseline sediment survey in inland waters (MEPA tender ref: CT3048/2012). ERDF156 - Developing national environmental monitoring infrastructure and capacity. Malta, unpublished report, 252 pp.

- AAE Consortium (ADI Associates Ltd, Ecoserv Ltd and E Cubed Consultants). 2014. Long Term Monitoring Programme for the Marine Environment of the Maltese Islands under the Marine Strategy Framework Directive. Service Contract for the development of a long-term monitoring strategy for the marine environment, a social and economic analysis of the use of marine waters and costs of degradation, and baseline sediment survey in inland waters (MEPA tender ref: CT3048/2012). ERDF156 - Developing national environmental monitoring infrastructure and capacity. Malta, unpublished report, 346 pp.

- CIBM & Ambiente SC. 2013. Development of Environmental Monitoring Strategy and Environmental Monitoring Baseline Surveys – Water Lot 1 – Long-term monitoring – September 2013. ERDF156 - Developing national environmental monitoring infrastructure and capacity