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NOTES ON THE DEVELOPMENT OF WATER FRAMEWORK DIRECTIVE COASTAL AND TRANSITIONAL WATERBODY TYPOLOGIES

GUIDANCE ON MONITORING OF SUCH WATERBODIES TO CONFORM WITH EC ENVIRONMENTAL LEGISLATION

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Sampling MUST be done most precisely and properly – to obtain the highest certainty, precision and most reliable data – as the basis for the ecological status assessment of surface water bodies. Good field practice provides the basis for laboratory sample processing and result interpretation.

1. INTRODUCTION

1.1 Relevant legislation

Within the EU, environmental monitoring of coastal waters falls under two main pieces of legislation: the Water Framework Directive (2000/60/EC), WFD, and the Marine Strategy Framework Directive (2008/56/EC), MSFD. Both are complex legislative texts, with the overall objective of achieving 'good status.' However, while the former requires Member States to achieve similar environmental status as each other in their fresh, transitional and coastal waters through intercalibration exercises, the latter allows Member States to offer their own interpretation of good status (albeit defined in terms of the same descriptors and criteria). Thus, the MSFD allows different levels of ambition and greater flexibility. The geographical scope of the WFD covers terrestrial surface and groundwaters to a distance of 1 nautical mile from the coast, while the MSFD covers all marine sovereign waters. The two therefore overlap only in terms coastal waters, to a distance of 1 nautical mile from shore.

The WFD recognises three main types of monitoring (excluding Special Areas and Groundwater Level monitoring). These are: (i) surveillance; (ii) operational; and (iii) investigative monitoring. This document deals primarily with surveillance and operational monitoring. According to the WFD, the objectives of these are to:

Surveillance monitoring

- Supplement and validate the assessment of the likelihood that transitional or coastal waters are failing to meet the environmental quality objectives.
- Enable the efficient and effective design of future monitoring programmes.
- Assess long-term changes in natural conditions in order to distinguish between non-natural and natural alterations in the ecosystem.
- Assess long-term changes resulting from widespread anthropogenic activity.

Operational monitoring

- Establish the status of those bodies identified as being at risk of failing to meet their environmental objectives (i.e. at risk of not achieving good status).
- Assess any changes in the status of such bodies resulting from the programmes of measures.

Surveillance monitoring should encompass all quality elements, whereas operational monitoring usually includes only parameters indicative of the major pressure(s). However, operational monitoring may be more frequent. Monitoring sites used for pollution load estimation (notably the transition from inland waters to marine environment) should, where possible, include representative water quantity as well as quality monitoring.

1.2 Subjects and areas covered by this document

This document offers guidance on environmental monitoring of transitional and coastal waters. It is written primarily for use in Georgian transitional/coastal waters, placing the Georgian situation in context with work already undertaken by the two Black Sea EU Member States (Bulgaria and Romania). However, the majority of information is also applicable to Ukraine and to Azerbaijani Caspian waters.

It does not contain guidance on the designation of coastal and transitional waters as Heavily Modified waterbodies, and neither does it contain any guidance on monitoring of fish populations as a biological quality element. This is required under the WFD (species composition, abundance and community age structure) for transitional waters, but not for coastal waters. However, fish populations require monitoring in all sovereign marine waters under the MSFD (see Section 4, Descriptors 4 and 5). Fish population monitoring in coastal waters is being dealt with under a sister project (EMBLAS[1]) to this one.

1.2.1 The Caspian question

The Caspian is the largest enclosed inland body of water on Earth by area, classed either as a lake or a sea. It has no outflows, but is connected to the Sea of Azov, and therefore to the Black Sea proper by a canal. It has an average salinity of 12 ‰, lower than that of the Black Sea (17.5-18 ‰), and only about one-third that of fully marine seas (approx. 35 ‰).

The issue is therefore whether to consider the Caspian as a sea or as a lake (in this project at least), since one of the beneficiaries (Azerbaijan) has a Caspian coast.

The EC has 4 ‘regional seas’, a sea in which at least one of its Member States has a coast and sovereign waters (Baltic, Black Sea, Mediterranean and North East Atlantic). None of these are naturally fully enclosed like the Caspian, but the Black Sea has limited transfer of water through the Bosphorus and Dardanelles straits with the World’s oceans. Like the Black Sea, the Baltic has a lower sanity than fully marine waters due to freshwater inflow from its catchment, having a salinity of 5-8 ‰ in the surface waters of the central basin, and only 1-2 ‰ in the far north and east. In the Kattegat, the salinity increases to about 20 ‰, getting closer to the fully marine North Sea (North East Atlantic). Thus, the ‘average’ salinity of the Baltic (surface waters) is probably lower than that of the Caspian, and the Baltic is essentially a very large *transitional* body of water, rather than a sea. However, it is managed as a sea for various purposes (historical, cultural, political, etc.) including the over-riding issues of scale and the large number of bordering countries: 9 (compared to the Caspian’s 5). From a pragmatic perspective, therefore, it appears more sensible for Azerbaijan to characterise and monitor the Caspian as a Sea, rather than as a huge saline *lake*.

[1] http://emblasproject.org/

2. COASTAL AND TRANSITIONAL WATERBODY TYPOLOGIES

Annex II of the WFD gives directions on how waters should be divided into types for WFD monitoring, assessment and classification purposes. The aim is to produce as simple a physical typology as possible that is both ecologically relevant and practical to implement[2]. The Directive gives two options for differentiating transitional waterbodies according to type, systems A and B:

- System A - transitional waters water type is described according to mean annual salinity and mean tidal range. Coastal water type is described by mean annual salinity and mean depth.

- System B - uses a series of obligatory (latitude, longitude, tidal range and salinity) and optional factors (depth, current velocity, wave exposure, residence time, mean water temperature, mixing characteristics, turbidity, mean substratum composition, shape and water temperature range) to classify transitional waters into types. For coastal waters, the same obligatory factors are used, but the optional factors are slightly different: current velocity, wave exposure, mean water temperature, mixing characteristics, turbidity, retention time (of enclosed bays), mean substratum composition and water temperature range. At least the same degree of differentiation must be achieved as using system A.

Because the Black Sea is essentially tide-less – tidal range at most is less than 10 cm, System B has to be chosen. Even though larger short-term changes in water level can be produced due to strong winds, such fluctuations are still minor[3], even in relation to microtidal coasts. A salinity value of 0.5 ‰ is used to define the boundary between rivers and transitional waters, but estuarine outer limits are usually determined physically - an artificial line is drawn to represent a continuing coastline across the mouth of transitional waterbodies.

Limans are formed at the widening mouth of a river, where flow is blocked by a bar of sediments. The sediment can be marine (the bar being created by the rim current in the Black Sea) or fluvial in origin. Water in limans is brackish with variable salinity; during periods of low freshwater input they may become more saline as a result of evaporation and inflow of sea water. Saline lagoons need to be treated in as a separate group of their own because of their physical separation from the sea.

So, which of the optional factors (below) could be used to provide typologies?

- Depth
- Current velocity
- Wave exposure
- Residence time
- Mean water temperature
- Mixing characteristics
- Turbidity

[2]CIS Guidance Document № 5. Transitional and Coastal Waters – typology, reference conditions and classification systems (http://www.eutro.org/documents/wfd%20cis2.4%20%28coast%29%20guidance%20on%20tcw.pdf).
[3]Black Sea geography, oceanography, ecology, history - general information. (http://blacksea-education.ru/e2.shtml).

- Mean substratum composition
- Shape
- Water temperature range

Water circulation in the Black Sea is dominated by the anti-clockwise rim current, driven by the Coriolis force which, in turn, is due to the Earth's rotation. The current is both spatially and temporally variable (due to winds), with water movement ranging from barely discernible to 100 cm s^{-1}. The combined role of morphology, meteorology, rim currents and anthropogenic impacts on coastal erosion/deposition have long been studied in the Black Sea (as in other seas) (e.g. Shuisky and Schwartz, 1988), with decisions on beach nourishment vs. construction of physical coastal defences being made to cost-effectively minimise erosion from longshore (rim) currents.

Shape can clearly be used to distinguish between adjacent coastal waterbodies, e.g. in the case of embayments, but whether such embayments are ecologically distinct from adjacent coastal waters is not clear.

Average depth can also be used to distinguish between different waterbodies, but only where there is a sudden change in depth, can this be used to set the boundary between adjacent waterbodies.

Wave exposure is also ecologically relevant, but it is not clear whether such data exists. This could, however, be determined using wind direction and strength (wind roses) obtained from coastal meteorological stations.

Residence time is only really an issue for saline lagoons, but could be considered relevant to some Georgian waters, e.g. Paliastomi lagoon.

Mean water temperature is not considered relevant over such a short distance as the Georgian coastline (310 km; similar to the 300 km of Bulgaria[4]) – shallow and surface waters will increase in temperature, during summer, with thermoclines/haloclines known to form in the sea, but this is not relevant to designating coastal waterbodies.

Mixing characteristics are certainly relevant in tidal estuaries, but much less so in non-tidal estuaries. Turbidity is also related to mixing characteristics, so the two can effectively be considered a single factor.

Mean substratum composition. This is definitely relevant, with substrate composition (sand and/or mud and/or rocky shores) having a major influence on what lives there.

Based on the above, average depth, wave exposure and substrate type should be used to define coastal and transitional waters, with coastal lagoons being designated in a separate category. Residence time could be used to further divide coastal lagoons into different types.

For comparison, Bulgaria has designated 13 coastal and 15 transitional waterbodies, while Romania has 4 coastal and 2 transitional waterbodies.[5]

[4] 2008 Black Sea Transboundary Diagnostic Analysis (http://www.blacksea-commission.org/_tda2008.asp)
[5] http://discomap.eea.europa.eu/report/wfd/SWB_SIZE_AVERAGE

3 MONITORING REQUIREMENTS OF THE WATER FRAMEWORK DIRECTIVE

The *status* of water bodies is the most important driving force for monitoring under the WFD. The status can be affected by anthropogenic pressures. A low level of Impacts is implied in the 'good status' objective and iterated in the no deterioration provision. Monitoring requirements can, therefore, change with ongoing assessments and changes in anthropogenic pressures and impacts. Thus, while general guidance can be produced for the design of monitoring programmes which fits within the requirements of the WFD, this may need to be adapted for individual waterbodies based initially on known pressures and as a better understanding of status is obtained, on impacts identified through biological monitoring. While WFD monitoring of chemical parameters is based on measuring concentrations, the combined use of this data with hydromorphological (flow) data to determine chemical loads to the marine environment is essential. Measures and environmental targets to control chemical pollution to the marine environment tend to be based on load reduction, rather than concentration reduction, although both options can be (and are) applied.

General guidance on monitoring water quality elements can be found in CIS guidance document No. 7.[6]

3.1 Biological quality elements

The WFD stipulates that EU Member States must establish monitoring plans in order to assess the Ecological Status of their water bodies. This is done through the assessment of a range of Biological Quality Elements (BQE) and Supporting Quality Elements (SQE), that together lead to a classification into one of five Ecological Status classes, ranging from high status to bad status. The WFD requires a definition of type-specific reference conditions, which can be determined in one of three ways:

- Monitoring of quasi-pristine type-specific conditions
- Modelling
- Expert opinion

The following biological quality elements need to be monitored in coastal waters:

3.1.1 Phytoplankton: composition, abundance and biomass

The first Black Sea phytoplankton manual was produced in 2005[7], with a subsequent update by the Black Sea Scene Project (2010). A Black Sea phytoplankton checklist has been produced[8] [updating of which is not frequent enough to account for changes in taxonomy, so the list may contain some errors, but still represents the best single source of Back Sea data], along with a spreadsheet/table of cell volumes.[9] Moncheva (2010) also produced guidelines for QA/QC of phytoplank-

[6] Common Implementation Strategy Guidance document № 7. Monitoring under the Water Framework Directive (https://circabc.europa.eu/sd/a/63f7715f-0f45-4955-b7cb-58ca305e42a8/Guidance%20No%207%20-%20Monitoring%20%28WG%202.7%29.pdf)

[7] Manual for Phytoplankton Sampling and Analysis in the Black Sea, GEF/UNDP Black Sea Ecosystem Recovery Project (BSERP) RER/01/G33/A/1G/31, 67pp.

[8] http://phyto.bss.ibss.org.ua/wiki/Category:Species

[9] (http://phyto.bss.ibss.org.ua/wiki/Cell_volumes

ton data and in 2013 tested the use of a synthetic integrated phytoplankton index (IBI-PH) in the Black Sea for ecological/environmental quality assessment.[10] This appeared to hold some advantages for the assessment of coastal water quality as compared to the application of single metrics, but the functional relationships didn't hold in every case. Thus, more simplistic indicators, such as diatom: dinoflagelllate ratios[11], chlorophyll-a levels and total phytoplankton biomass remain as important now as they have done over previous decades.

Many, if not the majority, of EU countries appear to have opted for summer average chlorophyll-a level and/or phytoplankton biomass (mean or total) as either a WFD or MSFD indicator of the phytoplankton quality element in coastal waters. A major problem with chlorophyll, phytoplankton biomass and composition, however, is its great variability – typically maximum chlorophyll and phytoplankton biomass levels are about three times average annual levels, with concentrations/biomass capable of doubling or, under ideal growth conditions, increasing 4-fold within a week. Upon bloom collapse, levels can drop even faster than they can increase. Thus phytoplankton monitoring (chlorophyll-a concentrations, community composition and biomass) should be undertaken (as a minimum) monthly during the growing season (nominally March –October).

This requires considerable effort and is expensive, but without continuous monitoring, either from satellite-based remote sensing (e.g. as undertaken by all Baltic States, Spain, etc.) or moored (and appropriately serviced) fluorimetry-based monitoring equipment (so-called smart buoys), the sensitivity for being able to detect trends is likely to be insufficient. OSPAR requires its contracting parties to be able to detect only a 50% change in chlorophyll levels over a 10 year period[12], with ICES concluding that further development is needed before satellite observations can reliably be included in the OSPAR JAMP Eutrophication guidelines. This timescale is outside the 6-year planning cycle of both the WFD and MSFD, so cannot be considered sensitive enough for our purposes.

3.1.2 Macrophytes and phytobenthos: composition and abundance

Species composition and abundance/biomass/cover of benthic hydrobionts are the most widespread monitoring parameters for aquatic macrophytes, as they are for most biological monitoring – flora and fauna. However, the adoption of 'depth of colonisation'-type monitoring (dependant on light blocking by phytoplankton, thereby reduce euphotic depth), used by most HELCOM countries as a component of trophic status monitoring, is gaining wider support for MSFD purposes. This type of monitoring complies with indicators 5.2.2 and 5.3.1of the MSFD, but when combined with '*r*' and '*K*' growth strategy monitoring of macrophyte communities, also ties in neatly with indicators 5.2.3 and5.2.4 (see Section 4). Depth of colonisation monitoring may be used for individual macrophyte species, genera or groups (angiosperms and macroalgae).

Bulgaria is currently investigating the use of *Cystoseria* depth of colonisation monitoring (analogous to the HELCOM methodology adopted by most Baltic countries), and recently set itself a tar-

[10] http://mares2020.io-bas.bg/downloads/mares2020/MARES2020/Moncheva_SINTEGRATED%20PHYTOPLANKTON%20INDEX.pdf
[11] ICES suggests that this as a general indicator of environmental status, rather than an indicator of nutrient status as the WFD [but not the MSFD] requires - OSPAR request on review of draft OSPAR JAMP eutrophication guidelines on phytoplankton species composition. (http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2015/Special_Requests/OSPAR_JAMP_advice.pdf)
[12] JAMP Eutrophication Monitoring Guidelines: Chlorophyll a in Water (OSPAR Agreement 2012-1)

get under the MSFD of achieving a threshold value for the abundance of opportunistic macroalgae as expressed by the ecological evaluation index - continuous formula (EEI-c) (see Orfanidis *et al*, 2011 and http://www.eei.gr/index.html). This method was originally developed and employed in Greece, but is now used by several Mediterranean states. It is based on '*r*-' and '*K*'-selection strategies, where '*r*'-strategies typically involve a high growth rate, with species exploiting less-crowded ecological niches. '*K*'-selected taxa are usually slower growing, but live at high density/abundance where they are strong competitors in crowded niches.

In EEI-c, slightly different approaches are used for coastal and transitional waters: shallow submerged vegetation is divided into five Ecological Status Groups in coastal waters, and six groups in transitional waters, as follows:

Table 3.1 Key functional traits of coastal water benthic macrophyte ecological status groups. (The taxa in each group are shown in Annex A.)

Functional traits	Group IA	Group IB	Group IC	Group IIA	Group IIB
Thallus morphology	Thick	Thick	Calcareous upright, and calcareous and non-calcarious crusts	Fleshy	Filamentous and leaf-like
Growth rate	Slow	Slow	Slow	Fast	Fast
Light adaptation	Sun-adapted	Sun-adapted	Shade-adapted	Sun-adapted	Sun-adapted
Phenotypic plasticity	No	Yes	Yes	Yes	Yes
Thallus longevity	Perennial	Perennial thallus base or stipe	Perennial thallus base	Annual	Annual
Succession	Late successional	Late successional	Late successional	Opportunistic	Opportunistic
Selection strategy	'*K*'	'*K*'	'*K*'	'*r*'	'*r*'

Table 3.2 Key functional traits of transitional water benthic macrophyte ecological status groups. (The taxa in each group are shown in Annex B.)

Functional traits	Group IA	Group IB	Group IC	Group IIA	Group IIB	Group IIC
Thallus morphology	Angiosperm	Thick	Calcareous and non-calcarious crusts	Fleshy	Filamentous and leaf-like	Angiosperm freshwater
Growth rate	Slow	Slow	Slow	Fast	Fast	Fast
Light adaptation	Sun-adapted	Sun-adapted	Shade - adapted	Sun-adapted	Sun-adapted	Sun-adapted
Phenotypic	Yes	Yes	Yes	Yes	Yes	Yes

plasticity						
Thallus longevity	Annual to perennial	Annual to perennial	Annual	Annual	Annual	Annual to perennial
Succession	Late successional	Late successional	Late successional	Opportunistic	Opportunistic	Opportunistic
Selection strategy	*'K'*	*'K'*	*'K'*	*'r'*	*'r'*	*'r'*

From the tables above, it is clear to see why 'late successional' and 'perennial' macrophytes are often grouped together, and in some cases (uses) the terms are Interchangeable; likewise with the terms 'annual' and 'opportunistic.'

Factors such as nutrient supply, turbidity, bed stability, hydrography, area and type of substratum suitable for growth are important limiting factors where macroalgal blooms are concerned. Inter-annual variation in spatial coverage and biomass, often attributed to variability in meteorological conditions is to be expected and can be pronounced, so monitoring should be undertaken annually at the same time of year where resources permit, or as a minimum, once every two years. Nevertheless, blooms of the two EEI-c 'r' strategist groups are used by a number of EC member states (e.g. the UK) as an indicator of either trophic status (for MSFD purposes) or in WFD terms as the 'macrophytes' biological quality element of Ecological status

A draft manual on macrophytobenthos monitoring has been produced by the EMBLAS project[13]. This includes a checklist of 445 macroalgae and higher plants (complied by MISIS and EMBLAS Project experts), although unfortunately with no Georgian input. However, the manual includes the following table of some indicators, which can be used for marine macrophytes community monitoring purposes:

Table 3.3 [Some] **Macrophytobenthos indicators for Black Sea monitoring** (Minicheva *et al.*, 2014)

Number	Indicator name	Index, Unit
Qualitative (State Indicators)		
1	Community diversity	Number of species, Number of taxonomic group
2	Status of key species	Systematic, saprobic status, Red Data Book status, life cycle (annual, perennial)
3	Threatened species	Number, status
4	Disappeared species	Number, status
5	Invasive species	Abundance, Cover, Biomass, Distribution map
6	Recovered species	Cover, Biomass, Distribution map
7	Returning species	Cover, Biomass, Distribution map
Quantitative (Response Indicators)		
8	Changes of lower depth distribution limit of macrophytes	m (for last specimen with min. 10% coverage)
9	Changes of bottom coverage by macrophytes	% coverage of bottom

13 Minicheva, G., Afanasyev, D. And Kurakin, A. (2014) Black Sea Monitoring Guidelines. Macrophytobenthos. (http://emblasproject.org/wp-content/uploads/2013/12/Manual_macrophytes_EMBLAS_ann.pdf)

10	Biomass of community (on meadow, average)	$kg.m^{-2}$
11	Trends of Phytocoenoses Surface Index (SI_{ph})	units
12	Biomass and abundance of dominant species	$kg.m^{-2}$
13	Age and size structure of dominant species	Distribution diagrams of classes
14	Trend of ecological activity (S/W_p) of replaced dominants	$m^2.kg^{-1}$
15	Biomass and abundance of key species	$kg.m^{-2}$, №.m^{-2}
16	Production and stock of commercial macroalgae and seagrasses	$kg.m^{-2}.year^{-1}$, tonne per area investigated ?
17	Opportunistic (annual) macroalgal biomass as a proportion of total (annual and perennial) macroalgal biomass	%
18	Proportion of total seagrass biomass above sediment surface	%
Ecological Evaluation Index		
19	Three dominants activity (S/W_{3Dp})	$m^2.kg^{-1}$, classification scheme for 5 Ecological Status Classes corresponds to the WFD
20	Community activity (S/W_{xcom})	$m^2.kg^{-1}$, classification scheme for 5 Ecological Status Classes corresponds to the WFD
21	Phytocoenoses Surface Index (SI_{ph})	Units, classification scheme for 5 ecological status classes corresponds to the WFD
22	Ecological Status Groups (ESG): ESG I, (*K*-selected species), (IC, IB, IA); ESG II, (*r*-selected species), (IIB, IIA).	% - ratio between species of ESGI and ESGII, classification scheme for 5 Ecological Status Classes corresponds to the WFD

However, the emphasis on MSFD monitoring is more associated with maintaining/improving biodiversity, so indicators such as disappeared, recovered or returning species which are applicable for some MSFD purposes (notably biodiversity monitoring) are not necessarily suited to WFD monitoring. The emphasis of the WFD is more concerned with assessing current status – in terms of biology, what taxa live where, and at what density/abundance/coverage - rather than what once lived there.

Although the last four indicators in Table 3.1 are entitled EEI indicators, it is important not to confuse the first three of these (19-21) with the EEI and EEI-c phytobenthos indices (Orfanidis *et al.*, 2001, 2003, 2011 and Panayotidis *et al.*, 2004) discussed earlier.

The EEI classification scheme for use in Ukrainian waters (see Table 3.2) is based on morpho-functional and morpho-structural indicators, earlier discussed and developed by the principal author (e.g. Minicheva, 1998, 2000), so the ideas/methodology have been developed over quite some time. The choice of indicator selection depends on the purpose of monitoring – whether temporal or spatial assessment (Minicheva, 2013[14]), but since future uses of the data are not known, all three of the indicators need to be calculated.

[14] http://emblasproject.org/wp-content/uploads/2013/12/Minicheva_WFD.pdf

Table 3.4 Ecological Evaluation Indices (EEI) classification scheme for macrophyte morpho-functional indices in Black Sea coastal waters of 10-12 m depth with a salinity of 9-17‰

(NB. The values shown were derived for Ukrainian waters. These are likely to require adjusting in an intercalibration exercise if they are to be used for other national coasts of the Black Sea)

Ecological status	EEI range					
	S/W_{3Dp} ($m^2.kg^{-1}$)	EQR	S/W_{xcom} ($m^2.kg^{-1}$)	EQR	SI_{ph} (units)	EQR
High	$S/W_{3Dp} < 15$	≥ 0.82	$S/W_{xcom} < 60$	≥0.98	$SI_{ph} \geq 25$	≥ 0.95
Good	$15 \leq S/W_{3Dp} < 30$	0.54	$60 \leq S/W_{xcom} < 80$	0.79	$25 \leq SI_{ph} \geq 40$	0.84
Moderate	$31 \leq S/W_{3Dp} < 45$	0.37	$81 \leq S/W_{xcom} < 120$	0.58	$41 \leq SI_{ph} \geq 65$	0.55
Poor	$46 \leq S/W_{3Dp} < 60$	0.25	$121 \leq S/W_{xcom} < 200$	0.17	$66 \leq SI_{ph} \geq 90$	0.15
Bad	$S/W_{3Dp} > 60$	≥ 0	$S/W_{xcom} > 200$	≥ 0	$SI_{ph} > 90$	≥ 0

The adoption of the EEI-c classification sytem(s) by Cyprus, Greece and Slovenia for WFD and/or MSFD monitoring/reporting purposes indicates that the approach is pragmatic, but modifications have been made to the method by Bulgarian Scientists for use in the Black Sea. This is not surprising because of two main reasons:

1. The salinity in the Black Sea is about half the level of the Mediterranean.
2. The Black Sea is essentially tide-less, so lacks intertidal vegetation.

The newly developed Ukrainian Black Sea EEI (BS EEI) applies to plants growing at a depth of 10-12 m, but the EEI-c is applicable in shallow (<1 m depth) waters, so is easier and safer to monitor. The Bulgarian target (using the EEI-c) is based on the ratio between species of ecological status groups (ESGI and ESGII – indicator 22 in Table 3.1), rather than the three morpho-functional indicators used in the BS EEI classification scheme (indicators 19-21 in Table 3.1; see Table 3.2). However, because nutrient enrichment tends to shift the balance from perennial angiosperms/seagrasses [*K*-strategists] to dominance by opportunistic macroalgae [*r*-strategists] (Orfandis *et al* 2008), in Ukrainian waters it was felt such a change may be better indicated by functional metrics - morpho-functional and structural-functional indices - than the simpler grouping approach employed in the EEI-c. The reasons behind the Ukrainian choice are not fully explained, and neither are the advantages of the BS EEI over the EEI-c, as such it recommended that for Georgian waters the EEI-c is used for now, together with shore-based monitoring of vegetated (% coverage>10%) mature climax communities, shallow water sites (typically 0.5 m depth) of >10‰ salinity. On each monitoring occasion, three replicate datasets of the taxa present and percentage coverage of each taxon should be collected using a 25 x 25 cm quadrat.

As part of their marine monitoring programmes, both Romania and Bulgaria monitor their marine waters along transects perpendicular to the shoreline. This pattern of monitoring is commonly used when investigating terrestrial impacts on the marine environment, and it should be further used in Georgian coastal waters.

3.1.3 Benthic macroinvertebrates: composition and abundance

A large number of benthic invertebrate indices have been developed, with a relatively large number employed for WFD status assessment purposes, perhaps amongst the most popular of which have been the AMBI, based on species sensitivity/tolerance (Borja *et al*., 2000), M-AMBI (integrating AMBI results with diversity and richness), and BQI (Rosenberg *et al*., 2004) indices. There does not appear to be any absolute winner amongst the methods to choose from, of which there are many (e.g. see HELCOM 2013), so it is not possible to recommend any particular one for use in the marine waters of any new country. However, an initial assessment of soft-bottom macrozoobenthos status by Todorova and Konsulova (2006) (see Fig. 3.1) suggests that the AMBI is a suitable index for Black Sea ecological status assessment, particularly with regard to organic enrichment/ eutrophication, although probably less so with regard to toxic pollution. (Albeit further work needs to be undertaken on EQR boundaries to distinguish between the status different waterbodies.) AMBI results appear to be less sensitive to salinity than BQI results (Zettler *et al*, 2007), so the former index should also be a better zoobenthos index to use in transitional waters.

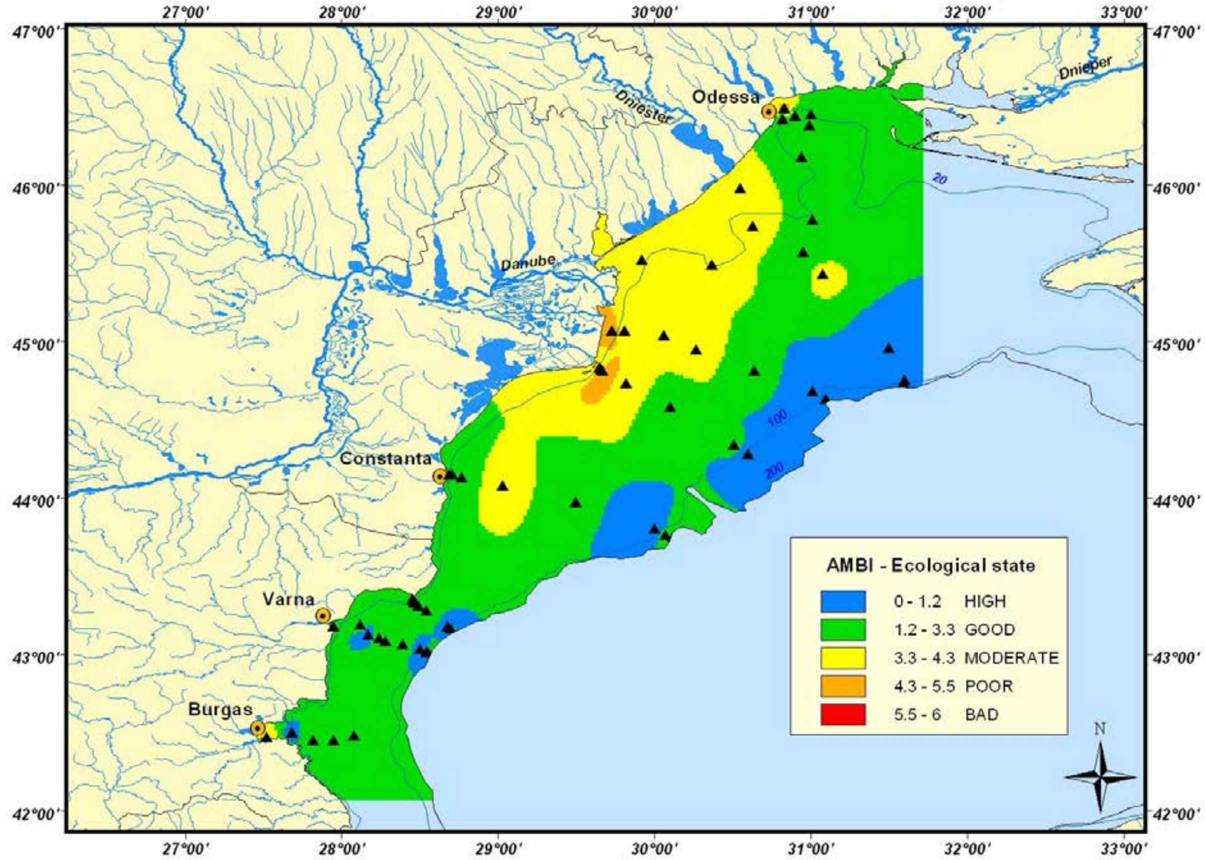

Figure 3.1. AMBI results showing soft-bottom macroinvertebrate community status (autumn 2003) for the North West Shelf of the Black Sea (Todorova and Konsulova, 2006)

Soft-bottom macroinvertebrate sampling, sorting and identification of taxa should follow the procedures laid down in the Black Sea manual[15].

3.2 Physico-chemical quality elements

Chemical monitoring of surface waters is dealt with, to some extent, in CIS Guidance Document № 19[16], although this document is largely concerned with micropollutants, having a strong focus on

[15] Manual for quantitative sampling and sample treatment of marine soft-bottom macrozoobenthos. http://www.blacksea-commission.org/_publications.asp

priority substances. The same environmental quality standards (EQSs) as applied in inland waters often apply to transitional and coastal waters, but not always[17]. For example, the annual average (AA)-EQS for benzene is 10 µg/l in inland surface waters, but only 8 µg/l in other surface waters, and the maximum allowable concentration (MAC)-EQS for brominated diphenylethers is 0.14 µg/l in inland surface waters, but reduced by an order of magnitude to 0.014 µg/l in other surface waters. Other instances where EQSs change in different waterbody types (rivers and lakes versus transitional and coastal waters) are:

- Aclonifen (AA-EQS, MAC-EQS)
- Benzo(a)pyrene (MAC-EQS)
- Benzo(g,h,i)- perylene (MAC-EQS)
- Bifenox (AA-EQS, MAC-EQS)
- Cadmium (AA-EQS),
- Cyclodiene pesticides (AA-EQS),
- Cypermethrin (AA-EQS, MAC-EQS)
- Dichlorvos (AA-EQS, MAC-EQS)
- Dicofol (AA-EQS)
- Endosulfan (AA-EQS, MAC-EQS),
- Heptachlor and heptachlor epoxide (AA-EQS, MAC-EQS)
- Hexabromocyclododecane (AA-EQS, MAC-EQS)
- Hexachlocyclohexane (MAC-EQS),
- Lead (AA-EQS)
- Nickel (AA-EQS)
- Octylphenols (AA-EQS)
- Pentachlorobenzene (AA-EQS)
- Perfluorooctane sulfonic acid (AA-EQS, MAC-EQS)
- Quinoxyfen (AA-EQS, MAC-EQS)
- Terbutryn (AA-EQS, MAC-EQS).

Monitoring of physico-chemical quality elements is part of the assessment of both the *chemical* status as well as the *ecological* status.

3.2.1 Physico-chemical quality elements under Chemical status

In case of monitoring the chemical status, the physico-chemical quality elements concern the group of so-called 'Priority substances'. The most recent list with Priority substances (PSs) and their environmental quality standards has been published in the Directive 2013/39/EU of the Eu-

[16] Guidance Document No. 19. Guidance on surface water chemical monitoring under the Water Framework Directive (https://circabc.europa.eu/sd/a/e54e8583-faf5-478f-9b11-41fda9e9c564/Guidance%20No%2019%20-%20Surface%20water%20chemical%20monitoring.pdf)

[17] Directive 2013/39/EU of the European Parliament and of The Council of 12 August 2013 amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:226:0001:0017:EN:PDF)

ropean Parliament and of The Council of 12 August 2013 amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy.[18]

Laboratory analysis of the Priority substances requires sophisticated analytical equipment and methods. Their environmental quality standards furthermore challenge the concentration levels that can be analysed with existing techniques. For several Priority substances it is known that the environmental quality standards defined in the Directive 2013/39/EU are too low concentrations for reliable analysis with existing methods. A useful document regarding monitoring the chemical status is Guidance Document № 19: Guidance on surface water chemical monitoring under the Water Framework Directive.[19]

From WFD Annex V.1 one can infer that the chemical status applies to "*Pollution by all priority substances identified as being discharged into the body of water*". It is, however, not easy to determine which PSs are indeed discharged into surface water bodies. Complicating factors include:

- The Priority substances are a heterogeneous group of substances, comprising non-synthetic and synthetic substances.[20]
- As a group, they cannot be linked to specific anthropogenic pressures; each Priority substance has its own characteristics. Individual substances can originate from different sources and can arrive in surface water bodies via multiple pathways.

Worth reading is the CIS Guidance Document № 28: *Technical Guidance on the Preparation of an Inventory of Emissions, Discharges and Losses of Priority and Priority Hazardous Substances*.[21]

3.2.2 Physico-chemical quality elements under Ecological status

Two groups of physico-chemical quality elements can be distinguished here:

a) General conditions, supporting the biological quality elements.
b) Other specific substances/pollutants.

The General conditions, supporting the biological quality elements, are basic physico-chemical parameters. In the case of transitional and coastal waters, they encompass:

- Nutrient conditions
- Oxygenation conditions
- Salinity
- Thermal conditions
- Transparency.

[18] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:226:0001:0017:EN:PDF
[19] https://circabc.europa.eu/sd/a/e54e8583-faf5-478f-9b11-41fda9e9c564/Guidance%20No%2019%20-%20Surface%20water%20chemical%20monitoring.pdf
[20] Non-synthetic substances can be present due to natural conditions, e.g. metals and polyaromatic hydrocarbons. Many trace/heavy metals are actually essential for proper functioning of many organisms, although only up to certain levels; at higher concentrations, such metals can have toxic effects. Anthropogenic activities (pressures) can lead to concentrations in surface waters beyond natural background levels. Synthetic substances, such as 'biocides' (pesticides, herbicides, insecticides, fungicides, etc.) are solely man-made.
[21] https://circabc.europa.eu/sd/a/6a3fb5a0-4dec-4fde-a69d-5ac93dfbbadd/Guidance%20document%20n28.pdf

There is no detailed list specifying the 'other specific substances', although Annex VIII of the WFD gives some indications about which pollutants might be concerned. While noting that several WFD Annex VIII pollutants are already included as 'priority substances', several groups of less harmful substances are included which fall within the 'general conditions' category:

- Materials in suspension
- Substances which contribute to eutrophication (in particular, nitrates and phosphates)
- Substances which have an unfavourable influence on the oxygen balance (and can be measured using parameters such as BOD, COD, etc.).

3.2.3 Monitoring frequencies

WFD Annex V.1.3.4 includes monitoring frequencies for the various quality elements. Those given for physico-chemical quality elements are shown below.

Table 3.5 Monitoring frequencies for physico-chemical quality elements according to the WFD

	Rivers	**Lakes**	**Transitional**	**Coastal**
Thermal conditions	3 monthly	3 monthly	3 monthly	3 monthly
Oxygenation	3 months	3 monthly	3 monthly	3 monthly
Salinity	3 monthly	3 monthly	3 monthly	
Nutrient status	3 monthly	3 monthly	3 monthly	3 monthly
Acidification status	3 monthly	3 monthly		
Other pollutants	3 monthly	3 monthly	3 monthly	3 monthly
Priority substances	Monthly	Monthly	Monthly	Monthly

Monthly sampling and analysis of Priority substances implies considerable efforts. Nevertheless, this frequency is to be endeavoured at least during the one year of surveillance monitoring, if possible. A frequency of once per two months (six samples per year) would be a reasonable comprise when resources are limiting. Sampling and analysis of Priority substances once per 3 months should be considered a bare minimum.

On the other hand, a monitoring frequency for General conditions of once per 3 months might be too low to capture seasonal variations in water temperature, dissolved oxygen and nutrient concentrations. Higher frequencies would prevail, for example once per two months, or even better: monthly.

Generally, more frequent sampling may be required to determine long-term trends or estimate pollution loads with acceptable levels of confidence and precision.

3.3 Hydromorphology

With reference to Section 2, the list of morphological attributes for coastal and transitional waters is shown below:

- Depth variation
- Bed quantity (area) structure and substrate
- Intertidal zone structure

Drivers (human activities) with the potential for causing morphological change(s) in transitional and coastal waters include: (i) coastal/flood defences; (ii) infrastructure construction and maintenance (e.g. of ports/harbours); (iii) manipulation of river flows, e.g. by dam construction (thereby affecting sediment budgets); (iv) changes in riparian land use/management (affecting sediment and contaminant budgets); (v) navigation - (e.g. dredging of channels); and (vi) port and harbour operations.

Much of the coastal hydromorphological monitoring can effectively be done from desk, using data gathered by other organisations, e.g. dredging activities that affect bathymetry. However, as part of their Bucharest Convention/Black Sea Commission obligations, the six countries with Black Sea coastlines have to monitor river flows and pollutant loads to the Sea from a total of 30 rivers, including 6 Georgian rivers: the Riona, Supsa, Chorakhi, Natanebi, Khobi and Kubastskali. Monitoring of flows within these rivers, rather than relying on historical values recorded when flow gauging stations worked, should be regarded as a priority. However, a re-calculation of flows for the Georgian rivers from catchment precipitation - river flow relationships should improve the information available. Data recorded when river flows gauging stations were operational and precipitation was monitored need to be collated. Data from meteorological stations which were operational at that time and which are still operational today can be used to model river flows during the period since the gauging stations became inoperable.

Options for measuring the rim current (or indicators of it) and patterns of water flow around the coast need to be considered, e.g. sediment particle size analysis. Not only to assess how pollutants may move round the coast, but also a component of investigative monitoring – to assess how river regulation may impact on the coastal zone.

4 MONITORING REQUIREMENTS OF THE MARINE FRAMEWORK STRATEGY DIRECTIVE

For the MSFD, environmental status has to be defined in terms of 11 Descriptors:

- 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 climate conditions.
- Descriptor 2: Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem.
- Descriptor 3: Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.
- Descriptor 4: All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.
- Descriptor 5: Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters.
- Descriptor 6: Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.
- Descriptor 7: Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.
- Descriptor 8: Concentrations of contaminants are at levels not giving rise to pollution effects.
- Descriptor 9: Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.
- Descriptor 10: Properties and quantities of marine litter do not cause harm to the coastal and marine environment.
- Descriptor 11: Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

Commission Decision 2010/477/EU[22] then stipulates more precisely what has to be monitored for each of those descriptors, in two levels of importance. The higher level are called criteria, and the lower level are called characteristics or indicators, e.g. for D5 (Eutrophication) the characteristics and indicators are:

- 5.1: Nutrients levels.
  - 5.1.1: Nutrients concentration in the water column. Nutrients levels are monitored in terms of total and dissolved ('bioavailable') nutrient fractions
  - 5.1.2: Nutrient ratios.

- 5.2: Direct effects of nutrient enrichment.
  - 5.2.1: Chlorophyll concentration in the water column.
  - 5.2.2: Water transparency related to increase in suspended algae.

[22] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:232:0014:0024:EN:PDF

- 5.2.3: Abundance of opportunistic macroalgae.
- 5.2.4: Species shift in floristic composition such as diatom to flagellate ratio.

- 5.3: Indirect effects of nutrient enrichment.
    - 5.3.1: Abundance of perennial seaweeds and seagrasses adversely impacted by decrease in water transparency.
    - 5.3.2: Dissolved oxygen concentrations.

Thus, from a monitoring perspective, The Decision is a more informative document than the Directive itself. The greatest cross-over between WFD and MSFD monitoring programmes, probably occurs with regard to Descriptors 5- 8, although Descriptor 1 exhibits great synergy with the Habitats and Birds Directives, and therefore also with the WFD. While the WFD only requires monitoring of pollutant levels in the water column, Decision 2010/477/EU requires concentrations of relevant contaminants to be measured in a relevant matrix (biota, sediment and water) in a way that ensures comparability with assessments under the WFD. CIS document №s 32[23] and 33[24] provide guidance on the use of biotic EQSs in environmental monitoring, which exist for 11 of the 45 priority substances and pollutants in Directive 2013/39/EU[25] In urban estuaries with a history of polluting activities but which have undergone a clean-up programme in recent decades, it is not uncommon for chemical water quality to be assessed as good, even though sediment remains in a contaminated state with heavy metals and persistent organic pollutants.

Use of the EEI-c index (Section 3.1.2) would therefore cover both WFD requirements and MSFD requirements for indicators 5.2.3, 5.3.1 and possibly 5.2.4. Monitoring should be undertaken at suitable shallow rocky and sediment-bottomed littoral sites once a year at the same time of year, preferably summer or, since variations in vegetation frond/thallus length and percentage cover follow a seasonal pattern. The EEI-c index is recommended over the Black Sea-developed EEI index because of the lower costs, improved ease and safety of monitoring, as well as its suitability for both coastal and transitional waters.

Of all EC Member States, Bulgaria has opted for probably the most complex array of plankton-based indicators (not only phytoplankton, but also zooplankton) as part of its MSFD monitoring programme and GES definition. This includes:

- The proportion of microflagellates, euglenophyceae and cyanophyceae (MEC %) in the total number of phytoplankton
- The ratio of diatoms: dinoflagellates (Bac: Din)
- Biomass of *Noctiluca scintillans* and total mesozooplankton
- Chlorophyll-a concentrations

[23] CIS Guidance Document No. 32 on biota monitoring (the implementation of EQS_{biota}) under the Water Framework Directive (https://circabc.europa.eu/sd/a/62343f10-5759-4e7c-ae2b-12677aa57605/Guidance%20No%2032%20-%20Biota%20Monitoring.pdf)

[24] Guidance Document No. 33 on analytical methods for biota monitoring under the Water Framework Directive (https://circabc.europa.eu/sd/a/9cf535ba-14f2-4f0f-b75e-e334ad506caf/Guidance%20No%2033%20-%20Analytical%20Methods%20for%20Biota%20Monitoring.pdf)

[25] Directive 2013/39/EU of the European Parliament and of The Council of 12 August 2013 amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy (http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32013L0039)

Of these, only the first three are used in its GES definition, as indicators, but chlorophyll-a is used in its MSFD environmental targets. In contrast, Romania has opted to define MSFD GES in terms of chlorophyll-a as its only phytoplankton indicator, but as a target, the MS cites that a stable ratio between diatoms and dinoflagellates (at sites close to land-derived nutrient inputs) should be achieved. Thus indicators 5.2.1 and 5.2.4 are covered, in addition to contributing to indicator 5.2.2. However, of these (bearing in mind Romania and other EC Member States' MSFD monitoring programmes), it is considered that average summer chlorophyll-a concentration, average summer total phytoplankton biomass and annual Bac: Din ratios are the most important, so monitoring should focus on these. As discussed in Section 3.1.1, fortnightly sampling is recommended for phytoplankton and to ensure the spring diatom bloom is 'captured' within the monitoring programme, sampling should be undertaken from March to October, unless continuous remote sensing of chlorophyll-like substances can be arranged to cover the Black Sea.

Descriptor 6 (sea floor integrity) requires monitoring of physical damage to the sea floor, as well as the condition of the benthic community, including:

- The presence of particularly sensitive and/or tolerant species (indicator 6.2.1)
- Multi-metric indexes assessing benthic community condition and functionality, such as species diversity and richness, proportion of opportunistic to sensitive species (indicator 6.2.2)

The AMBI index therefore covers indicator 6.2.1, since it divides species into 5 groups, depending on their sensitivity to environment disturbance (physico-chemical, physical, etc.):

- **Group I** (initial state). Species very sensitive to disturbance, present under unpolluted conditions specialist carnivores, some deposit-feeding tubicolous polychaetes.
- **Group II** (from initial state, to slight unbalance). Species indifferent to disturbance, present in low densities, non-significant variations with time. Suspension feeders, less selective carnivores and scavengers.
- **Group III** (slightly unbalanced situations). Species tolerant to excess organic matter enrichment. They occur under normal conditions, but are stimulated by organic enrichment. Surface deposit-feeding species, such as tubicolous spionids.
- **Group IV** (slight to pronounced unbalanced situations). Second-order opportunistic species. Mainly small sized polychaetes: subsurface deposit-feeders, such as cirratulids.
- **Group V** (pronounced unbalanced situations). First-order opportunistic species. Deposit-feeders, which proliferate in reduced sediments.

However, while the AMBI is a univariate method of analysis, the M-AMBI is multivariate (i.e. involves observation and analysis of more than one statistical outcome variable at a time), and thus satisfies indicator 6.2.2. Use of M-AMBI needs clear sampling protocols, since diversity and richness depend on sample size. Both AMBI and M-AMBI have been verified in a very large number of geographical areas and both are easy to use, with freely available software, and an updated species list with 6,500 taxa[26] (Borja, 2013).

Descriptor 7 (Permanent alteration of hydrographical conditions) requires monitoring of:

- Size of area and habitats affected by permanent alterations

[26] http://ambi.azti.es

- Changes in habitats, in particular the functions provided (e.g. spawning, breeding and feeding areas and migration routes of fish, birds and mammals),

Descriptor 8 (Contaminants) requires monitoring of the concentrations (in the relevant matrix (water, sediment and/or biota) and effects of the same contaminants (e.g. imposex in gastropod molluscs as a result of TBT contamination) as required for the WFD. This is largely the same for transitional and marine waters as it is for freshwaters. Thus the table of physico-chemical monitoring requirements given in Section 5 is copied (with modification) from the guidance presented for the freshwater Joint Field Surveys (Hulla & Co. Human Dynamics KG, 2013).

5 PROPOSED MONITORING PROGRAMME

One site/station within each transitional and coastal waterbody should be selected and monitoring undertaken for each of the biological, physico-chemical and hydromorphological quality elements.

5.1 Biological quality elements

5.1.1 Phytoplankton: composition, abundance and biomass

Surface water samples should be collected and monitored for chlorophyll-a concentration, total phytoplankton biomass and community composition to determine diatom:dinoflagellate ratios.

5.1.2 Macrophytes: composition and abundance of aquatic flora

Monitoring should be undertaken in shallow water (<1 m depth) and >10‰ salinity and analysed using the EEI-c index at the same time each year, preferably at a single site in each designated waterbody.

5.1.3 Benthic invertebrates: composition and abundance

Macrozoobenthos samples should be collected from soft-bottom transitional water (>10‰ salinity) and coastal water sites, 3 replicates per sampling station, using a boat and a grab. Because seasonality may affect the results of some zoobenthic indices, samples should be collected at the same time each year. Sample results should be analysed using a range of indices, including at least BQI, AMBI and M-AMBI.

5.2 Physico-chemical quality elements

All samples are to be collected from the surface of both transitional and coastal water sites, unless stated otherwise. Depth profile sampling is to be undertaken at a reduced number of specified coastal sites.

Table 5.1 Physico-chemical quality elements – monitoring requirements

Quality Element	Indicative parameters	Sampling Comments	Suggested Sampling Bottle
CTD depth profiles	Temperature Electrical conductivity Depth	Monitor *in-situ* using a CTD sonde. Monitor 1 m sub-surface, every 10 m subsequently, and 1 m above the sea floor. Note depth of themocline/halocline	None
Oxygenation conditions	Dissolved oxygen, oxygen saturation	If equipment is available, measure *in situ* using an oxygen sensor attached to the depth profiling sonde at the same depths as above. Otherwise, collect discrete samples from the specified depths and ensure there is	If analysed in Laboratory analysis fill 250-300ml glass bottle to top. [No air bubbles.] Store at 1-5ºC

		no splashing of the sample as water is filled to the top of the bottle with no air gaps. At all sites, samples must be collected from 1 m above the seabed. Measure the DO ASAP after the sample has been taken	
Oxygen demand	COD (dichromate)	Ensure there is no splashing of the sample and the water is filled to the top of the bottle with no air gaps. Transport & Store at 1-5ºC	2000- 25000ml glass bottle Analyse within 24 hours
Nutrients	NO_2 NO_3 NH_4 N_{total} (including organic nitrogen) PO_4 (orthophosphates) P_{total}	Transport & Store at 1-5ºC On-site semi-quantitative tests can be undertaken. However, accurate analysis must be undertaken in Laboratory	2000- 25000ml glass bottle Analyse within 24 hours
Water transparency	Secchi depth	Measure *in situ*. Use the mean depth value of the disc disappearing and reappearing from sight as it is lowered and raised from the boat	None
	Total suspended solids	Analyse within 2 days	2000- 25000ml glass bottle
Phytoplankton biomass/density	Chlorophyll-a	Can be measured by fluorimetry *in situ* (e.g. sensor on sonde), or sample collected and analysed spectrophotometrically in laboratory Keep sample in the dark Transport & Store at 1-5ºC	2000- 25000ml glass or plastic bottle Analyse within 24 hours
Acidification status	pH	measure pH on–site immediately after the sample has been taken	None
Heavy metals	Total As, Cd, Pb, Ni, Cu, Zn	Avoid sampling solid residues	100ml polypropylene bottle with 1ml 50% Nitric acid
	Dissolved As, Cd, Pb, Ni, Cu, Zn	Avoid sampling solid residues	Filter the sample with 0.45 µm filter into 100ml polypropylene bottle, then acidify with 1ml 50% Nitric acid.
Organo-chlorine pesticides	Aldrin, Hexachloro-benzene, Endrin and pp DDT	The bottle should be filled to the top and not be rinsed by the sample. The bottle should not be filled to the top and should be rinsed by the sample. 2000-25000ml Amber Glass Bottle	2000- 25000ml amber glass bottle

5.3 Hydromorphology

Since no work has been done on hydromorphological assessment of transitional and coastal waters, this needs to cover the following pressures:

- Land claim
- Bank/Shoreline reinforcement
- Dredging/deposition of dredged material
- Intensive grazing of saltmarshes
- Modifications to flow and sediment regime, including changes to forestry and agricultural management practices
- Construction/shoreline development, e.g Batumi landfill
- Fishing (proportion of underwater bed affected)
- Impounding

Once the Pressures have been identified and assessed, there will be a need to continue monitoring of sediment budgets, transport and substrate type(s) in coastal and transitional waters, which should include monitoring of longshore (rim) currents in the sea itself.

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Annex A – Taxa belonging to each Ecological Status Group in the coastal water EEI-c macrophyte index

Group IA	Group IB	Group IC	Group IIA	Group IIB
Chondrus	*Aglaozonia*	*Acetabularia*	*Acrodiscus*	*Acinetospora*
Cystoseira [except *C. barbata and C. compressa*]	*Asperococcus*	*Amphirhoa*	*Acrosorium*	*Acrochaetium*
Posidonia	*Culteria*	*Anadyomene*	*Ahnfeltiopsis*	*Acrothamnion*
	Cymodocea	*Choreonema*	*Alsidium*	*Aglaothamnion*
	Cystoseira barbata	*Corallina*	*Asparagopsis*	*Anotrichium*
	Cystoseira compressa	*Dermatolithon*	*Boergeseniella*	*Antithamnion*
	Digenea	*Flabellia*	*Botryocladia*	*Antithamnionella*
	Erythroglossum	*Fosliela*	*Caulacanthus*	*Auduniella*
	Halopitys	*Ganonema*	*Caulerpa*	*Bangia*
	Nanozostera	*Halimeda*	*Champia*	*Blastophysa*
	Padina	*Haliptilon*	*Chondracanthus*	*Blidingia*
	Pedobesia	*Hydrolithon*	*Chondria*	*Bryopsis*
	Penicillus	*Jania*	*Chondrophycus*	*Callithamnion*
	Petalonia	*Liagora*	*Chondrophycus*	*Centroceras*
	Plocamium	*Lithophyllum*	*Chrysymenia*	*Ceramimum*
	Rhodophyllis	*Melobesia*	*Chylocladia*	*Chaetomorpha*
	Ruppia	*Mesophyllum*	*Cladostephus*	*Chroodactylon*
	Rytiphlaea	*Peyssonnelia*	*Colpomenia*	*Cladophora*
	Sargassum	*Pneophyllum*	*Dasycladus*	*Codium*
	Taonia	*Ralfsia*	*Dictyopteris*	*Corallophila*
	Zostera	*Spongites*	*Dictyota*	*Corynophlaea*
		Titanoderma	*Dilophus*	*Cottoniella*
		Tricleocarpa	*Drachiella*	*Crouania*
			Gastroclonium	Cyanobacteria [Predominantly planktonic, but some attached colonial species, e.g. *Rivularia atra*]
			Gelidiella	*Dasya*
			Gelidium	*Derbesia*
			Gigartina	*Dipterosiphonia*
			Gracilaria	*Dudresnaya*
			Gracilariopsis	*Ectocarpus*
			Grateloupia	*Entocladia*
			Halopteris	*Erythrocladia*
			Halymenia	*Erythropeltis*
			Hydroclathrus	*Erythrotrichia*
			Hypnea	*Falkenbergia*

			Hypoglossum	*Feldmannia*
Group IA	**Group IB**	**Group IC**	**Group IIA**	**Group IIB**
			Kallymenia	*Giffordia*
			Laurencia	*Goniotrichum*
			Lobophora	*Griffithsia*
			Lomentaria	*Gulsonia*
			Mesogloia	*Halodictyon*
			Nemastoma	*Halurus*
			Neurocaulon	*Herposiphonia*
			Nitophyllum	*Heterosiphonia*
			Osmundaria	*Hincksia*
			Osmundea	*Kuckuckia*
			Phyllophora	*Kuetzingiella*
			Pterocladia	*Lejolisia*
			Pterocladiella	*Liebmannia*
			Radicilingua	*Lophosiphonia*
			Rhodymenia	*Monosporus*
			Sarconema	*Monostroma*
			Schizymenia	*Myriactula*
			Schottera	*Myrionema*
			Scinaia	*Neosiphonia*
			Sphacelaria	*Phaeophila*
			Stypocaulon	*Pleonosporium*
			Zanardinia	*Polysiphonia*
			Zonaria	*Porphyra*
				Porphyrostromium
				Pringsheimiella
				Pseudobryopsis
				Pseudochlorodesmis
				Pseudocrouania
				Pterosiphonia
				Pterothamnion
				Rhizoclonium
				Rhodothamnionella
				Sahlingia
				Scytosiphon
				Spermothanmion
				Sphaerotrichia
				Sphondylothamnion
				Spyridia
				Stictyosiphon
				Stilophora
				Stylonema
				Taenioma
				Ulotrix/Ulothrix

				Ulva
				Ulvella
Group IA	**Group IB**	**Group IC**	**Group IIA**	**Group IIB**
				Valonia
				Vaucheria
				Womersleyella
				Wrangelia

Annex B – Taxa belonging to each Ecological Status Group in the transitional water EEI-c macrophyte index

Group IA	Group IB	Group IC	Group IIA	Group IIB	Group IIC
Cymodocea	*Cystoseira*	*Lithophyllum*	*Acanthophora*	*Acrothamnion*	*Acetabularia*
Nanozostera	*Fucus*	*Pneophyllum*	*Agardhiella*	*Anotrichium*	*Hydrolithon*
Ruppia	*Lamprothamnion*		*Alsidium*	*Antithamnion*	
Zostera	*Rytiphlea*		*Boergeseniella*	*Bangia*	
	Sargassum		*Chondria*	*Blidingia*	
	Undaria		*Chondrophycus*	*Callithamnion*	
			Dichtyota	*Ceramium*	
			Gastroclonium	*Chaetomorpha*	
			Gracilaria	*Cladophora*	
			Gracilariopsis	Cyanobacteria [Predominantly planktonic, but some attached colonial species.]	
			Halopitys	*Dasya*	
			Hypnea	*Entocladia*	
			Laurencia	*Erythropeltis*	
			Nitophyllum	*Erythrotrichia*	
			Rhodophylis	*Griffitsia*	
			Solieria	*Herposiphonia*	
			Sphacelaria	*Hincksia*	
			Spyridia	*Lophosiphonia*	
				Monostroma	
				Phaeophyla	
				Polysiphonia	
				Porphyra	
				Pterothamnion	
				Rhizoclonium	
				Stylonema	
				Ulotrix	
				Ulva	
				Ulvella	
				Valonia	
				Vaucheria	