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Marine management – towards an integrated implementation of the European Marine Strategy Framework and the Water Framework Directives

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Abstract

Through implementing environmental Directives, Europe has moved towards coordinated and integrated catchment-to-coast management, following the most novel legislation on ecosystem-based approaches worldwide. This novel joint synthesis of this direction allows us to regard the Water Framework Directive (WFD) as a '*deconstructing structural approach*' whereas the Marine Strategy Framework Directive (MSFD) is a '*holistic functional approach*', i.e. the WFD has split the ecosystem into several biological quality elements, then it compares the structure of these (such as species complement) individually before combining them and attempting to determine the overall condition. In contrast the MSFD concentrates on the set of 11 descriptors which together summarize the way in which the whole system functions. In addition, the WFD implementation has been left to the Member States, and hence we then need a detailed intercalibration exercise to compare the outputs. In contrast, MSFD is a more top-down approach in which the European Commission has created a task group approach for a cross-Europe agreement before implementation. We emphasize that both Directives are frameworks on which many other directives are linked but that they need to be fully and seamlessly integrated to give a land to open sea system of assessment and management. Hence, by taking account of the experience gained in the WFD implementation, together with that from regional sea conventions, such as OSPAR (North East Atlantic) or HELCOM (Baltic Sea), we propose in this contribution an integrative approach for the environmental status assessment, within the MSFD.

Key Words: marine management; ecosystem-based approach; Water Framework Directive; Marine Strategy Framework Directive; monitoring and assessment; reference conditions.

1.- Introduction

Recent marine legislation worldwide (e.g. Oceans Act in USA, Australia or Canada; Water Framework Directive (WFD, 2000/60/EC) and Marine Strategy Framework Directive (MSFD, 2008/56/EC) in Europe, and National Water Act in South Africa) has been developed in order to protect and restore ecological quality or integrity, within estuarine, coastal and offshore systems (Ricketts and Harrison, 2007; Barnes and McFadden, 2008, Borja *et al*., 2008a). The main objective of these legislative measures and policies is to maintain a good status for marine waters, habitats and resources, delivering an integrated ecosystem-based approach (EBA).

Both MSFD and the WFD rely on our ability to determine what is 'good status', a subjective term, which then has be supported by a scientific justification (see Mee *et al*., 2008). The concept of environmental status takes into account the structure and functioning (where the latter by definition includes processes) of the marine ecosystems together with natural physiographic, geographic and climatic factors, as well as physical and chemical conditions including those resulting from human activities in the area concerned.

Taking into account the experience gained through the implementation of the WFD, over the past decade (Hering *et al.,* 2010), we discuss here how that experience could benefit the implementation of the MSFD; in particular, in the context of setting the good environmental status (GEnS) criteria and ensuring the comparability of these objectives across the regional seas. In this context the data and assessments carried out by the Regional Seas Conventions (OSPAR, in the Atlantic; HELCOM, in the Baltic; Barcelona, in the Mediterranean; and Bucharest, in the Black Sea) provide regionally consistent approaches (OSPAR Commission, 2009; Topcu *et al.,* 2009; Backer *et al.,* 2010; HELCOM, 2010), but the consistency and comparability across the European seas remains to be ensured as a part of the MSFD implementation. Although the marine areas have different and unique characteristics, it is necessary to have coherent approaches and consistent principles in setting the GEnS criteria and targets, in order to ensure equivalent levels of protection and restoration throughout European seas. Because of this, we contend that the lessons in Europe are relevant to the management of marine areas worldwide. While some efforts towards rectifying contrasting policies have also been made elsewhere (Cruz and McLaughlin, 2008), the objective of this contribution is to provide an overview of the lessons learnt from the WFD, which can be used in the implementation of the MSFD, by contrasting both directives.

2.- Comparison of WFD and MSFD

The EU environmental policies during the last three decades have focused on determining adverse and undesirable changes to the natural system as the result of human activities and then, if such a change is detected, initiate management responses to alleviate those adverse changes. The WFD and MSFD have to be seen as components of a suite of environmental controls as shown by links to the Directives for Environmental Impact Assessment, Strategic Environmental Assessment, Nitrates control and the Habitats and Species and Wild Birds Directives – all of which can be summed up as '*what is an area like, what should it be like with minimal interference, and if these differ (or are predicted to differ with a future development) then either do something about it (mitigation and/or compensation) or make a socio-economic case for accepting the change*' (McLusky and Elliott, 2004). The overall objectives, i.e. '*what should an area be like*' may be termed the reference condition against which all assessments of change are measured.

The MSFD establishes a framework for the development of marine strategies designed to achieve GEnS in the marine environment, by the year 2020, using 11 qualitative descriptors (Table 1). Accordingly, the WFD aims in achieving 'good ecological status' (GEcS), for all waters, by 2015 or, failing that, by 2021 (Table 1). In the WFD the assessment of ecological status is based upon five biological quality elements

(BQE), together with hydromorphological and physico-chemical quality elements, with the BQE being especially important (Table 1). These directives spatially overlap in the coastal area as the WFD extends to 1 nm from the coastline, which could be extensive in states with archipelagos, whereas the MSFD covers all marine waters from the baseline of territorial waters until the 200 nm Exclusive Economic Zone (EEZ). However, as yet it remains to be seen how Member States (MS) achieve the spatial consistency of the two directives.

The main issues of the potential mismatches concerning the WFD and the MSFD are given in Table 1. The main difference is how the final assessment of the aquatic ecosystem status is required to be carried out. In essence, we consider that the WFD takes a '*deconstructing, structural approach*' whereas the MSFD takes a '*holistic, functional approach*'. The former can be summed up as taking the ecosystem, separating it (deconstructing it) into its constituent parts, or at least those parts considered important, the so-called BQE, *then* assessing the individual quality of each BQE, *then* using a combining rule to put these back together and *then* assume that the outcome summarizes and protects the whole ecosystem (Figure 1). The BQE are assessed according to their structure, i.e. their qualities at one time – the number of species, their abundance or cover. Hence, in combining these BQE, although the WFD assesses several BQE independently, the final status is based upon the principle of '*one out, all out*' (OOAO). This principle is based upon the assumption that the status of the worst element, used in the assessment, determines the final status. This may be regarded as a precautionary approach if properly addressed by taking into account confidence and uncertainty of each metric or parameter (e.g. number of species, biomass, etc.) and how those are combined in the final BQE level assessment (Heiskanen *et al.*, 2004; Borja, 2005). However, this approach entails the risk of imposing recovery costs not proportionate to the achievable environmental improvement, possibly increasing the risk of misclassification (see Hering *et al.*, 2010). Therefore an area may fail GEcS based on the failure of a single BQE even if there are problems assessing that particular BQE in an area; for example an area may fail for the phytoplankton even if an area is naturally turbid and hence has naturally poor phytoplankton. Hence, some authors have proposed avoidance of this simplistic approach (Crane, 2003; Borja *et al.*, 2004a, Tueros *et al.*, 2009), although it may provide a useful starting point in the assessment (Moss, 2008; Borja *et al.*, 2009a). Borja and Rodríguez (2010) demonstrated that, when a BQE is not reliable or even relevant to a particular stressor, the final status result using this principle will be jeopardised because of this unsuitable element.

In contrast, we consider that the MSFD aims to provide a *holistic, functional approach* as it *takes* the ecosystem and separates it into a set of process-related (functional) objectives and *then* recombines these to give a holistic approach, ensuring the integrity of the ecosystem (see Figure 1). Further it relies on rate processes and responses to changes in physical-chemical processes (e.g. Gray and Elliott, 2009). The assessment of the GEnS criteria can be carried out selecting a suite of the quality elements (both biological, hydrodynamical and chemical) from comprehensive lists of parameters that are provided in the annexes of the directive. Thus, it allows choosing a set of quality elements that are relevant for each particular regional sea and ecosystem type in question. The MSFD is the first of EU directives that aims to be based upon an EBA that has a holistic view on the management and protection of marine ecosystems (Browman *et al.*, 2004; Nicholson and Jennings, 2004; Jennings, 2005; Apitz *et al.*, 2006; Borja *et al.*, 2008a), focusing on ensuring sustainable use of the seas, and providing safe, clean, healthy and productive marine waters.

While the EBA is not mentioned in the text of WFD, this does not prevent the programme of measures from following the ecosystem approach requiring planning process that ensures sustainable use of aquatic resources. Both directives also require an economic and social assessment of the costs and benefits, and allow for exemptions for not reaching targets if economically and socially unjustified.

The MSFD stipulates: … *that "good environmental status" means … marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential for uses and activities by current and future generations*... The WFD defines the GEcS as an expression of the quality of the structure and functioning of aquatic ecosystems associated with surface waters. Hence, although both directives require that the ecosystem integrity should be maintained, and where appropriate restored, the challenge for the future is not only to integrate indicators for single ecosystem elements (as the WFD does), but also to include measures of ecosystem structure, function and process (as demanded by the MSFD) (Borja *et al.,* 2009a). The ecological integrity of an aquatic system should be evaluated using all information available, including as many biological ecosystem elements as is reasonable, and using an EBA (Borja *et al.,* 2008a, 2009a, 2009b). However, the reliability of the methods used in the assessment, for each of the elements, should be taken into account, and removed if the reliability is too low (Borja and Rodríguez, 2010). As yet, the method of recombining the 11 MSFD qualitative descriptors has not been defined but we see that there is a fundamental and far-reaching conundrum in deciding how these descriptors are to be combined. If the descriptors all represent different facets of the marine environment affected by human activities and they have been agreed as in total covering all aspects of marine health then logically it follows that all of the descriptors have to be fulfilled in order to produce a healthy environment and the converse that if one descriptor is not met then a healthy marine environment is not achieved, hence *de facto* a OOAO approach. However, as the GEnS descriptors combine both ecological objectives and requirements for the reduction of various pressures, which all may have a different degree of impact on ecosystems in question, then it is not possible to implement an evaluation such as OOAO, as the descriptors do not have an equal weighting. Therefore we conclude that this calls for a risk-based assessment of the potential of pressures to cause ecological damage or restrict the possibility to reach ecological objective as stated in the MSFD. This would require combining various tools such as deterministic modeling, Bayesian Belief networks and GIS-modelling in order to first describe and quantify the causalities between ecological functioning and pressures, and subsequently to quantify the probability of reaching ecological targets as response to decreasing or eliminating different pressures (Stelzenmüller *et al.*, 2010).

We take the view that anthropogenic change in the marine system comes from two main sources: '*endogenic managed pressures*' and '*exogenic unmanaged pressures*'. The former relates to those anthropogenic pressures created inside a system (e.g. waterbody, catchment, sea-area) and over which environmental management has control, i.e. the causes of change are controlled. The anthropogenic endogenic managed pressures on the marine system can easily be divided into those which put physical, chemical and biological materials into the system (e.g. sediments, structures, chemicals and alien species) and those which take materials out of the system (e.g. substratum, space, fisheries). Superimposed on this is the physical control on the ecological nature of the area, i.e. the protection of hydrographic regime and the resultant substratum. As shown by Figure 2, these 3 features link to the 11 qualitative descriptors of the MSFD; however, although in the Directive each of the 11 is given equal weighting, we suggest here that descriptors 1 and 4, which relate to the protection of biodiversity and ecological functioning, should be given a greater weighting.

In contrast, the term '*exogenic unmanaged pressures*' relates to causes of change from outside a system and over which internally we are not affecting or managing the causes of change but only responding to the consequences of change. For example sea-level rise caused by isostatic rebound or global climate change require local management of their consequences such as erosion protection or other flood defence mechanisms.

In interrogating the causes, consequences and societal response to the above changes, we advocate the use of the DPSIR (Drivers-Pressures-State change-Impacts-

Response) philosophy (OECD, 1993; EEA, 1999; Turner *et al.,* 1998; Elliott, 2002; Aubry and Elliott, 2006; Borja and Dauer, 2008); this also gives us a means to explaining and communicating the process of marine and coastal management (Elliott *et al.*, 2006). To undertake such an assessment, both directives require an analysis of anthropogenic pressures and impacts on the human system caused in the ecosystems, in order to link changes in the natural state of the environment to drivers and pressures, and implement a management response. That response can include governance mechanisms, economic controls or demands to insert adaptation, mitigation or compensation measures to reduce the stressors causing the states change (on the natural environment) and impacts (on the human environment). The DPSIR cycle as presented will be for each main Driver but it should be remembered that any set of Responses to one Driver may affect other Drivers, for example, the Response to overfishing through restrictions on fishing quotas may influence the demand for aquaculture, in itself likely to cause problems in the system and so need other Responses. Both directives require a definition of restoration targets defined as the good environmental/ecological status, and a comparison of these targets across the MS, sub-regions and regional seas in order to ensure consistency of environmental objectives and approaches across Europe. As the objectives of the Directives are parallel and they also may spatially overlap in the coastal waters, the consideration of the experience from the implementation of the WFD (see, as an example, Borja *et al.* (2006)) will be a useful exercise, which may facilitate the implementation process of the MSFD.

3.- Steps in the implementation of both directives

The implementation of the WFD involves several steps which can now be compared to those in the MSFD (Table 2).

3.1.- Determining water categories

One of the first preparatory steps in the WFD is delimiting water categories (i.e. transitional and coastal waters in the case of marine systems). Only coastal waters overlap with the MSFD, in which this step does not exist. However, a comparable division (also existing in the WFD) is related to the European marine ecoregions, which include: (i) the Baltic Sea; (ii) the North East Atlantic Ocean (including several sub-regions); (iii) the Mediterranean (including several sub-regions); and (iv) the Black Sea. The openness and interlinked nature of the marine system dictates that the separation into smaller marine water bodies for management is not productive while the challenge for marine and coastal managers is to carry out appropriate and coordinated measures at all scales, from local coastal areas and communities to the European level (Escaravage *et al.,* 2006). The assessment of the status and GEnS needs to be carried out on sub-regional (or even water body-level), as the natural characteristics of different sub-regions result in different level of impacts, depending on pressures. For example, a particular input of nutrients results in a different level of biomass increase between the NE Atlantic, Baltic Sea and Mediterranean, as a result of the resilience of the planktonic ecosystem to external perturbation (Olsen *et al.,* 2006). Similarly, the sensitivity of various marine sub-regions for organic loading varies depending on the hydrodynamic characteristics and the physical vulnerability of each region (Druon *et al.,* 2004).

3.2- Establishing types

The second step in the WFD implementation is the characterization of coastal waters in different types (European Commission, 2008). A somewhat similar characterization is also required as part of the initial assessment of the MSFD (*an analysis of the essential features and characteristics, and current environmental status of marine waters,* Art. 8, Annex 3). The purpose of identifying specific coastal water body types in the WFD was to identify areas which could have similar ecologically-relevant functional types and thus share common reference conditions and thus would allow comparison of like-with-like when classification of the water bodies was to be carried out. The MSFD includes also an initial assessment of chemical and biological features of marine waters as a part of the characterization (including the 11 qualitative descriptors), while in the WFD those are included as quality elements supporting the classification of the ecological status, and the biological features were not used as criteria for identification of the water body types.

The WFD process for identifying coastal and transitional water body types required the development of new approaches and the need to agree on a common set of typology factors (i.e. salinity, tidal range, exposure, etc.), and their categories for comparable and consistent typology categorization across the coastal areas of the regional seas (CIS, 2003a). It was also acknowledged that the estuarine and coastal types are not distinct categories that can be easily identified by a set of factors, but rather a continuum. Therefore the borderline between two separate types has often been difficult to define. We also question whether estuaries and other transitional waters should be excluded from the MSFD if they have a large marine influence, e.g. tidal systems or where salinity incursion occurs as these by definition are part of marine systems.

Several common coastal types were defined for the WFD intercalibration (European Commission, 2008; Borja *et al.*, 2009c). The common intercalibration types were based on the differences in the physical (exposure, tidal regime, etc.), salinity and freshwater discharge regime in the regional seas (Carletti *et al.*, 2009). We emphasize the need to check that those are in line with the marine regions and sub-regions identified for the MSFD, in order to achieve a more comprehensive and defendable comparison of the different environmental status assessments.

Each WFD water body type may comprise several habitats that consist of specific physical and chemical factors, and are characterized by specific biological assemblages. In turn, the MSFD requires an assessment of the marine habitat types, which was not directly required by the WFD. However, all biological monitoring methods and all defined indices of change are generally habitat specific. In practice, the assessment of quality element specific status in the WFD is carried out at the habitat level, and then combined with metrics for other quality elements that apply for different organism groups and habitats, and up-scaled to apply for the whole water body (or parts of it) (Borja *et al.,* 2009b). Therefore there is the danger in both directives that an assessment carried out on one habitat may indicate the whole water body is in one quality status when in fact the major part of the water body, composed of other habitats, may be in an opposing quality status.

3.3.- Reference conditions and targets for environmental status

Identifying type specific reference conditions for BQE is the first step in the process of the setting environmental targets in the WFD (as Ecological Quality Ratio – EQR, the value between 0 and 1 obtained by monitoring with a reference). The actual WFD restoration target is the 'good status' that is defined as a 'slight' deviation from the reference conditions. In general, the concept of reference conditions, and determining the slight, minor, or small deviations from them, have caused a debate and analysis because the WFD suggests 4 ways of determining reference conditions (Vincent *et al.*, 2002): minimally impacted conditions, hindcasting (historical data), predictive models and, if all else fails, 'expert judgment'. This is difficult especially as (a) there are few unimpacted areas in Europe, (b) hindcasting is difficult because of (i) which year to be go back to and (ii) even if we wanted to return to some earlier status of few pressures caused by fewer people then this is not an achievable goal, and (c) in dynamic and highly variable marine environments our modeling capabilities are not yet sufficient for defining reference conditions (Hering *et al.*, 2010). At the same time, the hindcasting tools to search for historical changes in coastal water quality have been developed (e.g. Kauppila *et al.,* 2005; Clarke *et al.,* 2006; Billen and Garnier, 2007) and long-term data sets have shown their value for searching for causal links between changes in biological community structures and environmental change (Devlin *et al.*, 2009; Henriksen 2009). Such tools, used in combination with 'expert judgment', in many cases have been used for defining and determining reference conditions (e.g. Carletti *et al.,* 2009).

One of the problems in this approach is that it is difficult to find coastal areas that are minimally impacted, as the major pressures such as nutrient loading, eutrophication and habitat loss result in large scale impacts and changes in the coastal ecosystems. Therefore modeling or hind-casting using long-term monitoring data from restoration (see Borja *et al.,* submitted) or extrapolation has had to be used, resulting in uncertainty in the reference status. This also led to the discussion, still ongoing after a decade of WFD implementation, of whether to define reference conditions according to an *absence* of pressures (i.e. where human interference is minimal) or a *presence* of 'good ecology' (i.e. the ecology of the area reflects what we imagine to be unimpacted) (Hering *et al.,* 2010).

In the MSFD the concept 'reference conditions' does not exist. However, the Art. 10 stipulates that MS have to set a comprehensive set of environmental targets …*to guide progress towards achieving good environmental status*…, and to …*take into account the continuing application of relevant existing environmental targets laid down at national, Community or international level in respect of the same waters*…. We consider that the 11 qualitative descriptors implicitly indicate conditions where the aspect in question is not adversely affected (Table 3), i.e. a *de facto* reference condition. This suggests that at least for those indicators/BQE that are common with WFD classification (such as phytoplankton status), the MSFD targets should be compatible with the GEcS set as a part of the WFD implementation. Hence, despite not using the term reference conditions, this approach still requires us to know whether activities are sustainable and, if not, can this be achieved by the removal of pressures (Mee *et al.,* 2008). Naturally when the 'type' (*sensu* WFD) is changing to be 'more oceanic', new targets reflecting the characteristics of open sea (and its habitats) need to be set. For example, a comprehensive assessment system for eutrophication would be required in order to incorporate the nutrient loading impacts both in the shallow coastal and in the open marine waters and so determining nutrient problems across the 11 descriptors is required (see Table 3). However, such a system should be also compatible with the WFD classification boundaries in the coastal fringe. The regional seas conventions (OSPAR, HELCOM) are working towards assessment systems that link with WFD classifications (see Topcu *et al.,* 2009; Backer *et al.,* 2010, and HELCOM, 2010). Hence we show, in Table 3, the way in which the whole system needs to be considered for the MSFD rather than a separation into BQE *a la* the WFD.

3.4- Classification and normative definitions for good ecological status

The WFD ecological status classification is based on biological and physico-chemical monitoring results (Table 1). The normative definitions of the WFD (Annex 5) set the descriptive definitions for the high, good, and moderate status for different water categories and quality elements. The guidance (CIS, 2003b) on GEcS classification described a common understanding of how the biological and physico-chemical quality elements should be used in the classification of surface water bodies. The normative definitions provide a general description of how the critical biological components (such as species composition, diversity, abundance, biomass, etc.), change in response to environmental degradation and pressures, and thus provide a generic description of what is a GEcS. Taking this idea into the MSFD, we recommend that the descriptors need to be translated into specific quantitative metrics (e.g. various diversity indices or biomass metrics, or metrics describing numbers of sensitive *vs.* non-sensitive species in the marine environment) (see European Commission, 2008) otherwise it will not be possible to monitor for their compliance (see Gray and Elliott, 2009).

Similar normative definitions describing the desirable status of biological quality elements as in WFD are not included in the MSFD. Instead the MSFD 11 qualitative descriptors to determine the GEnS, at some extent, can be related to some of the elements within the WFD (Table 3). Similarly, the table illustrates the fact that the BQE are now distributed across the objectives, again we consider that this indicates a degree of learning from the WFD to the MSFD.

The WFD normative definitions provide a uniform approach to interpret changes in the biological descriptors for the purpose of setting the boundaries in the classification, particularly in order to set the critical boundary between the good and moderate environmental status, which sets the targets for restoration. It is proposed in the MSFD that the GEnS will only have a met/not-met classification and so the boundary between these will become as important as the good/moderate boundary, i.e. falling below the boundary will require action to bring the status above the boundary.

3.5- Monitoring and assessment

The WFD prescribes three different types of monitoring: surveillance, operational, and investigative, which all have different purposes, and also may have a (partially) different set of parameters and spatial coverage and frequency. The CIS (2003c) and Gray and Elliott (2009) detail these different types of monitoring and the strategies to achieve them. We emphasize that operational monitoring, similar to compliance monitoring, is where pre-defined targets are set and which act as thresholds for action. In comparison investigative or diagnostic monitoring is where the cause of an effect is being sought (Borja *et al.*, 2008b). The minimum monitoring frequencies for the BQE in the WFD were also given, while the number of stations per water body is not defined. The critical issue concerning monitoring programmes is that those should have such a spatial and temporal coverage that would allow sufficient confidence in the classification (De Jonge *et al.*, 2006; Ferreira *et al.*, 2007), although the degree of sufficiency is not defined. This should differ with BQE as the frequency of monitoring should be related to the seasonal dynamics of the organism group in question and also to cover the natural variability within the habitat where these organisms occur. Therefore it is evident that it is very difficult to give generic guidance on minimum number of samples, but rather there should be an agreement on the minimum level of confidence and uncertainty that would allow us to identify whether the target (i.e. GEcS) has been achieved (Carstensen, 2007). The WFD gives the possibility not to use a BQE where the natural variability is so high that it is not possible to identify reference conditions with sufficient confidence. This, however, requires a network of reference sites where long term biological monitoring data should be available, although in many cases and particularly for coastal waters there is no longer any such network of reference sites/areas. Hence, the marine implementation of the WFD and the implementation of the MSFD face the central difficulty, not experienced by the freshwater elements of the WFD, in coping with a highly dynamic and variable system in which the signal of change due to human actions is difficult to detect against background variability (the signal-to-noise ratio) (McLusky and Elliott, 2004). We emphasize that all MSFD descriptors have to allow for an inherently highly variable marine system and hence a highly numerical approach may not be achievable where a statistically significant signal against background noise may not be possible to detect. Because of this, we contend that the emphasis will have to be more on 'expert judgment', which has been demonstrated as suitable in some cases across wide geographies (Teixeira *et al.*, 2010). We also emphasize that the nature of the monitoring will be easy to define only once the final outcomes have been determined.

Some of the parameters and assessment tools used in the WFD most probably are also applicable in the MSFD. For instance those tools that are designed to assess status of eutrophication (i.e. indices for phytoplankton, chlorophyll *a*, and some indices for soft sediment macroinvertebrates) are potentially applicable for larger oceanic regions. However, it is necessary to evaluate to what extent the current intercalibrated WFD classification tools can be also used for the MSFD monitoring and assessment and the targets may differ for offshore regions compared to the near shore waters. It will also be necessary to revisit the type and water body concept in such a way that natural marine hydro-morphological 'types' (or sub-regions) could be identified in order to have equal targets for those areas, where the natural habitat is continuing further. However, we repeat that in order to have a fully-functioning marine system then all components of the system are required, e.g. a sustainable herring population requires not only a good water column but also a good gravel spawning area.

Unlike the WFD, all MSFD elements are interrelated and the co-relationships make it difficult to separate them according to specific pressures. For example as a well-defined pressure, the exploration for oil and gas and the construction and operation of oil and gas rigs in the open sea will affect all of the 11 descriptors.

3.6.- Harmonisation/ Intercalibration of approaches

The WFD lists several methodological standards and opens the possibility to amend and complete that list when methodological improvements are developed and when new standards become available. Similarly, the MSFD requires methodological standards to ensure consistency and to allow comparison between MS and sub-regions with respect to the criteria used to determine the GEnS. Such methodological standards are necessary to ensure quality control in the sampling and analysis of the chemical and biological quality elements. Eventually such standards, or commonly accepted harmonized tools, will also allow harmonized monitoring and assessment of environmental status, and enable comparison of the environmental status across the marine sub-regions (understanding that the targets or reference conditions are different in different sub-regions).

As we indicate earlier, because of the ‘bottom-up approach’ of implementing the WFD (see below), it required a process for the intercalibration of the GEcS (i.e. the target for restoration of surface water) between the MS that shared similar types of waters in order to ensure that there will be similar understanding of ' what is good' and to have a same level of ambition in the protection and restoration of surface water quality and ecological integrity of aquatic ecosystems (see Mee *et al.*, 2008). We emphasize that in moving towards a more functional approach, we will need indicators of overall health of the system rather than just indicators of single aspects of the biota (see Mee *et al.* (2008) for a discussion of ‘health’ in relation to the concept of what is ‘good’). At present, because of a more 'top-down approach' for the MSFD, the WFD intercalibation is not required for MSFD on the level of monitoring and analysis of BQE. Also as the MS is free to develop a diverse set of ecological assessment tools, which in many cases are based on local tradition of sampling and assessment, our experience has shown that the resulting diversity of assessment tools and methods made the intercalibration process both necessary and in many cases very difficult (see European Commission, 2008).

During the WFD intercalibration process, it appeared to be quite difficult to compare GEcS targets if very different methods are to be compared (European Commission, 2008). For instance, in the case of benthic macroinvertebrate methods, many countries choose to develop tools that are dependent on the Pearson-Rosenberg's paradigm (Pearson and Rosenberg, 1978; Gray and Elliott, 2009) and are modified from the AMBI-index (Borja *et al.*, 2000, 2007, 2009c) and applied for local conditions. In general such methods were highly comparable as those targeting the same habitat (soft sediments) and pressure (organic loading) type and used the common understanding of the sensitivity of benthic species to external disturbance. Other methods that applied different approach in sampling and were targeted to combine monitoring data from several habitats (mud, sandy, and rocky habitats) could not be compared with others.

The WFD intercalibration process showed that there should be an agreement on what kind of assessment tools can be actually compared against each others in order to avoid comparing 'apples with oranges'. Also it was recommended that there should be development towards 'regional' assessment tools that actually use harmonized sampling and analytical methods, and where the metrics are calculated following common procedures. However, even that could not guarantee a complete 'comparability' (i.e. equal EQR ratios for same quality elements and types) between MS that used same methods for assessment. This was concluded to be due to local variability in reference conditions and data sets that were used for intercalibration. Therefore it was agreed that EQR was considered sufficiently comparable if those were within a 10% band that marked the boundary between 'good and moderate' and good and high (i.e. the classification boundaries intercalibrated for the WFD). Again, each of these aspects requires to be addressed for the MSFD without overly complicating the implementation process.

We accordingly emphasize here a further apparent difference between the directives – that the WFD, under the concept of subsidiarity, was left to each MS to implement in its own way and then expensive and detailed intercomparison exercises were required to ensure the different methods gave the same outcome, i.e. this is a bottom-up approach. In comparison, the MSFD appears to be a more top-down approach in that MS will be told how to implement it based on common methods – it is argued here that the former method is much more time-consuming and thus expensive but it does have the advantage of letting MS control the process. We take the view that the bottom-up process for the WFD has both delayed its implementation and led to a more expensive and confusing set of methods and that the MSFD has to learn from this. Furthermore, we recommend that the MSFD, through the top-down approach, should not need the intercalibration process and should be based more upon expert judgment and a lower level of analysis. Given the extent of the sea areas involved, we consider that there is unlikely to be the degree of funding available for an intensive surveillance monitoring approach.

4.- A proposal for assessing the Environmental Status within the MSFD

Taking into account the experience gained in the last decade, from the WFD, and OSPAR and HELCOM conventions, together with the comments in the previous sections, we suggest for discussion an approach for combining the 11 descriptors of the MSFD into a unique and integrative environmental status assessment (Table 4).

The marine ecosystem components can be grouped into four distinct but interlinked systems: (i) water and sediment physico-chemical quality (including general conditions and contaminants); (ii) planktonic system (phyto- and zooplankton); (iii) mobile species system (fishes, sea mammals, seabirds, etc.) and (iv) benthic system (including species and habitats) (Table 4). Changes in the composition of these biological components can be related to the changes of pressure parameters (Table 4) and those changes can be linked to normative definitions to further help with decisions to set critical boundaries or targets for desired ecosystem status (e.g. Heiskanen and Solimini, 2005; Chainho *et al.*, 2008; Borja *et al*., 2009d; Josefson *et al.*, 2009; Uriarte and Borja, 2009). The ecosystem components, affected by different pressures, can be related to the 11 qualitative descriptors and, as such, to different indicators able to provide information on the quality of all these elements.

Hence, as some WFD methods to assess the status already exist for many of these descriptors (see some lists in Borja *et al*., 2009c; Borja and Rodríguez, 2010), they can be used, together with new ones developed for the MSFD, in this assessment. This also illustrates how the normative descriptors in the WFD can be linked to the practical management of environmental status, as the targets (i.e. reference conditions, Environmental Quality Standards (Table 4)) are set based on observed true changes in BQE and which can be linked to pressure proxies, that allow linking to drivers. Although there are no normative definitions in the MSFD, we recommend that targets for GEnS should be operational such that the critical descriptors of the ecosystem integrity can be linked to pressures, and that there is a common understanding across regional seas what is 'good' and what is 'undesirable' status for the 11 descriptors (see also Mee *et al.*, 2008). We also emphasize the need to ensure that the descriptors lead to SMART indicators (i.e. that they are Specific, Measurable, Achievable, Realistic and Time-bounded) otherwise they cannot be linked to efficient and effective monitoring (e.g. see Gray and Elliott, 2009).

This implies that the WFD ecological status assessment and the BQE used in that could be incorporated into the MSFD initial assessment and approaches need to be harmonized across the spatial boundaries in marine and coastal areas. Indeed, the recently completed eutrophication assessment of the Baltic Sea (HELCOM, 2009) tested the applicability of the 'deconstructing' WFD approach and eutrophication assessment tools across the entire Baltic Sea from coastal monitoring sites within the 1 nm as well as other monitoring sites in off-shore waters. The developed HELCOM Eutrophication Assessment Tool (HEAT) was applied using available monitoring data, taking reference levels determined in the course of the national WFD implementation, and calculating ecological quality ratios for each BQE separately. Finally, a simple confidence rating of the each regional/local assessment was also carried out (Andersen *et al.*, 2010). The combination rules for different BQE was agreed and a harmonized and comparable assessment of eutrophication status of the Baltic Sea was developed (HELCOM, 2009). In the assessment of the biodiversity status of the Baltic Sea a similar type of approach was used (HELCOM, 2010).

A similar approach is proposed in Table 4, in which the reliability of the methods used to assess each indicator needs to be take into account, as recommended also in Borja and Rodríguez (2010) for the WFD. Some kind of weighting will also be required (Table 4). For example, in this proposal, weighing for nutrients is 70% and for priority substances is 30%. If we know that the area to be assessed does not show contaminants, this weighting can be reduced or eliminated. The same can apply to the habitats, which can be weighted using habitat mapping, geomorphological tools and habitat suitability modeling (see Brown and Collier, 2008; Degraer *et al.*, 2008; Galparsoro *et al.*, 2010). Hence, dividing the weight by 100, and multiplying by the EQR of each indicator, an environmental status value can be derived, and adding all the values for each system a global value can be obtained. The approach is similar to that proposed for the WFD by Borja *et al.* (2004b, 2009b) in integrating different EQR. From the 5 environmental status values, obtained in this example, an OOOA approach could be applied; however, from the previous discussions, we consider that a decision-tree such as that proposed by Borja *et al.* (2004b, 2009b), for the WFD, could be more useful. In this particular example, in which the only system not reaching the GEnS is the mobile species system, and taking into account that the confidence ratio is high and the recent trend for all indicators is to decrease quality, a precautionary approach could be applied and the global status of the area could be classified as ‘not Good’.

Conclusions

Although there exist two directives overlapping in European marine waters which gives the potential for some confusion in the quality status assessment, we think that there is now the opportunity for simplifying the governance system and moving from a deconstructing structural approach (BQE: WFD) to a holistic functional (descriptors) and integrative assessment (MSFD). Of course, we know the limitations of the current European science in undertaking such task. However, taking into account that the marine system is a continuum, from coast to open waters, the experience gained in the WFD implementation, together with the steps initiated by OSPAR and HELCOM conventions, we emphasize that we need a completely merged approach and a harmonized, seamless transition from catchment through transitional waters and coast to an open marine system.

In this way, most of the methods, tools, indicators and targets implemented in the WFD could be used within the MSFD, although we know that some WFD metrics may be relevant to only certain habitats, e.g. macrophytes only relate to macrophyte beds, macroalgae only on rocky shores, macrobenthos only on soft sediments, whereas the MSFD descriptors will have to cut across all habitats simultaneously.

The MSFD will be more heavily based on the regional seas approaches, and the regional seas conventions will be the tool for implementing the MSFD, so we may need tools that are specific to biogeographic regions, e.g. a tool needed for tidal systems in the OSPAR area my not be suitable for the non-tidal Mediterranean, Black Sea and Baltic areas.

However, even with these difficulties, we consider that most of the ideas that are currently being debated, in relation to the integrative assessment of marine waters, can be used in a way quite similar to that proposed in this contribution, which needs to be tested with real data at large scale.

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Table 1. Main concepts and potential conflicts within the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD).

Main issues	**Water Framework Directive**	**Marine Strategy Directive**	**Potential Conflicts**
Spatial application	Estuaries & coasts (baseline + 1 nm)	From baseline to 200 nm	Spatial overlap (1 nm from baseline)
Main definitions	Ecological status	Environmental status	Meaning of terms
Levels of status	High, Good, Mod, Poor, Bad	Good, Not Good	Simplification of levels
Good status achieved by	2015	2020	Resilience of marine ecosystems after restoration (long time to recovery)
Elements (WFD) or qualitative descriptors (MSFD) to be used in assessing the ecological or environmental status	Chemical Physico-chemical Hydromorphological Phytoplankton Macroalgae Phanerogams Macroinvertebrates Fishes (only in transitional waters)	1- Biodiversity 2- Non-indigenous species 3- Exploited fish and shellfish 4- Food webs 5- Human-induced eutrophication 6- Sea-floor integrity 7- Hydrographical conditions 8- Contaminants 9- Contaminants in fish 10- Marine litter 11- Introduction of energy/noise	- Fish in the WFD only in estuaries, but in the MSFD they play and important economic and ecological role. - Biodiversity in the MSFD includes from phyto- and zooplankton (latter absent from the WFD) to marine mammals, reptiles and sea-birds (also absent) - Sea-floor integrity includes not only invertebrates and macroalgae, but also habitats
Ecological differences	Integration of each element 'One out, all out' principle Bottom-up approach	Ecological integrity Ecosystem-based approach Top-down approach	Deconstruction (WFD) versus integrity of the ecosystem (MSFD)

Table 2. Steps in the implementation of the Water Framework Directive (WFD), compared to the Marine Strategy Framework Directive (MSFD)

STEPS	WFD	MSFD
Determine water categories	Coastal Water Bodies	Marine Ecoregions
Establish types	Yes	Partially
Determine reference conditions	Yes	No
Analyze pressures	Yes	Yes
Undertake monitoring programmes	Yes	Yes
Calculate Ecological Quality Ratios	Yes	No
Assess the Ecological/Environmental Status	Yes	Yes
Intercalibrate methods	Yes	No

Table 3. Qualitative descriptors for determining good environmental status, within the Marine Strategy Framework Directive, compared with similar issues within the Water Framework Directive (WFD), and cross links related to a pressure (using nutrients and eutrophication as an example). BQE-Biological Quality Elements.

Marine Strategy Framework Directive	Relation to nutrients/eutrophication	Links to Water Framework Directive	Links to other Directives/Legislation
(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	Avoid deterioration along organic loading gradient (Pearson-Rosenberg model on degradation along pressure gradients: see Gray and Elliott, 2009), minimize secondary eutrophication effects (i.e. impacts on submerged macrophyte and angiosperms and sublittoral benthic communities)	Included within all normative definitions on ecological quality status for BQE that includes composition and abundance of species.	Habitats Directive 92/43/EEC Birds Directive 79/409/EEC and 2009/147/EC Convention on Biological Diversity (United Nations, 1993)
(2) Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems	Avoid influx of non-native Harmful Algal Blooms (HAB) species	Not mentioned in the WFD, but constitutes a pressure and should be included in the analysis of pressures and impacts. Assessing methods including alien species and their impacts on the ecosystems need to be developed Included in some metrics e.g. fish in Transitional Waters. Changes to all BQE	EU Strategy on Invasive Species (3 December 2008)
(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	Avoid anoxic zones, fish kills and water quality barriers	As such, not taken into account within the WFD but included in some metrics, in transitional waters e.g. fish guilds. Changes to epibenthos and fishes	Common Fisheries Policy and the new reform COM(2010)241 final
(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	As (1) and (3)	As such, not taken into account within the WFD. However, at some extent, it is included implicitly within each of the BQE, as expression of the quality of structure and functioning of ecosystems. Requires all BQE to be merged	
(5) Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters	Avoid eutrophication	This pressure is related to physico-chemical and phytoplankton and other macroalgae, macrophytes elements, within the WFD, and then linked to benthos and fishes	Urban wastewater treatment directive (91/271/EEC; 98/15/EC), Nitrates Directive (91/676/EEC), Bathing Water Directive (76/160/EEC; 2006/7/EC)
(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	Avoid biogeochemical changes due to excess organic inputs	This qualitative descriptor can be related explicitly to macroalgae, angiosperms and macroinvertebrates quality elements within the WFD. Relate also to hydromorphological status	Habitats Directive 92/43/EEC Recommendation on Integrated Coastal Zone Management (2002/413/EC); also Environmental Impact Assessment and Strategic Environmental Assessment Directives

(7) Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems	Avoid WQ barriers	This qualitative descriptor can be related explicitly to hydromorphological elements within the WFD	
(8) Concentrations of contaminants are at levels not giving rise to pollution effects	Treat nutrients as all other contaminants and avoid inputs with respect to assimilative capacity	Related explicitly to chemical status within the WFD	Priority Substances Directive (2008/105/EC) and the new Environmental Standards Directive (2008/105/EC)
(9) Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards	Avoid levels of toxins resulting from ingestion of HABs	As such, not taken into account within the WFD. However, at some extent, it can be related implicitly to the chemical status within the WFD	Shellfish Harvesting Directive (2006/113/EC) Regulation 2007/333/EC (quality) and the new Environmental Standards Directive (2008/105/EC) and IPPC Directive
(10) Properties and quantities of marine litter do not cause harm to the coastal and marine environment	Not relevant	Not specifically mentioned in the WFD, but should be considered in the analysis of pressures and impacts at WFD	
(11) Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment	Not relevant	Not specifically mentioned in the WFD, but it is considered as a part of the analysis of pressures and impacts	Renewable Energy Directive (2009/28/EC), EU's Energy-Related Strategy

Table 4. Proposal for an assessment of the Good Environmental Status, within the Marine Strategy Framework Directive (MSFD), taking into account, the ecosystem components, the main pressures, the 11 qualitative descriptors (see Table 1 for the list) and some indicators (adapted from the WFD or developed for the MSFD). The values are based upon the recent trends in the indicator values, the reliability of the indicators/methods used in the assessment, the weight of the indicator (e.g. importance in the zone, area occupied in the case of habitats, etc.). WFD-Water Framework Directive; EQS- Environmental Quality Standards; EQR-Ecological Quality Ratio. Note: data are not real.

	Ecosystem component	**Main pressures**	**Relation to Qualitative Descriptors**	**Indicators**	**Reference conditions/EQS**	**Recent trend**	**Reliability (%)**	**Weight (%)**	**EQR**	**Final Environmental Status**	**Final Confidence ratio**
Water & sediment chemical quality	Nutrient & oxygen levels	Discharges, eutrophication	(5)	WFD methods	Adapted from the WFD	▲	100	70	0.7	0.49	70
	Priority substances	Discharges	(8), (9)	WFD methods	Adapted from the WFD	▼	100	30	0.8	0.24	30
	TOTAL							100		0.73 (Good)	100 (High)
Planktonic system	Phytoplankton	Discharges, eutrophication	(5), (1), (2), (7)	WFD methods	Adapted from the WFD	▲	100	50	0.6	0.30	50
	Zooplankton		(1), (2), (4)	abundance, composition	To be determined	►	50	50	0.7	0.35	25
	TOTAL							100		0.65 (Good)	75 (High)
Mobile species system	Fish	Removal of target species	(1), (2), (3), (4), (5), (6), (7), (9), (11)	abundance, composition, guilds	To be determined	▼	100	70	0.4	0.28	70
	Sea mammals	Pollutants, Plastics & Debris	(1), (4), (8), (10), (11)	abundance, composition	To be determined	▼	50	10	0.7	0.07	5
	Seabirds	Pollutants, Plastics & Debris	(1), (4), (8), (10), (11)	abundance, composition	To be determined	▼	30	20	0.9	0.18	6
	TOTAL							100		0.53 (not Good)	81 (High)
Benthic system	Benthic species										
	Invertebrates	Discharges, habitat loss	(1), (2), (3), (4), (5), (6), (7), (8), (9), (10), (11)	WFD methods	Adapted from the WFD	►	100	40	0.8	0.32	40
	Macroalgae	Discharges, removal of target species	(1), (2), (4), (5), (6), (7), (8), (9), (11)	WFD methods	Adapted from the WFD	▼	100	20	0.7	0.14	20

Angiosperms	Discharges, habitat loss	(1), (2), (5), (6), (7), (8), (11)	WFD methods	Adapted from the WFD	▼	100	40	0.6	0.24	40
TOTAL							100		0.70 (Good)	100 (High)
Habitats										
Rock & biogenic reefs	Habitat damage	(6), (7)	Percentage of alteration	5%	►	50	10	0.9	0.09	5
Coastal sediments (0-50 m)	Habitat loss	(6), (7), (8)	Percentage of alteration	20%	►	100	20	0.95	0.19	20
Shelf sediments (50-200 m)	Habitat damage, Removal of target species	(6), (7), (8)	Percentage of alteration	5%	►	50	20	0.97	0.19	10
Deep-sea (>200 m)	Habitat damage	(6), (7), (8)	Percentage of alteration	5%	►	30	50	1	0.50	15
TOTAL							100		0.97 (Good)	50 (Moderate)

Figure captions

Figure 1. Comparison of the status assessment in the Water Framework Directive (WFD) and in the Marine Strategy Framework Directive (MSFD). Notes: BQE- Biological Quality Elements; WB-Water Body; GEcS-Good Ecological Status; GEnS-Good Environmental Status.

Figure 2. Marine Strategy Framework Directive interlinking pressures and the 11 qualitative descriptors.

Fig. 1

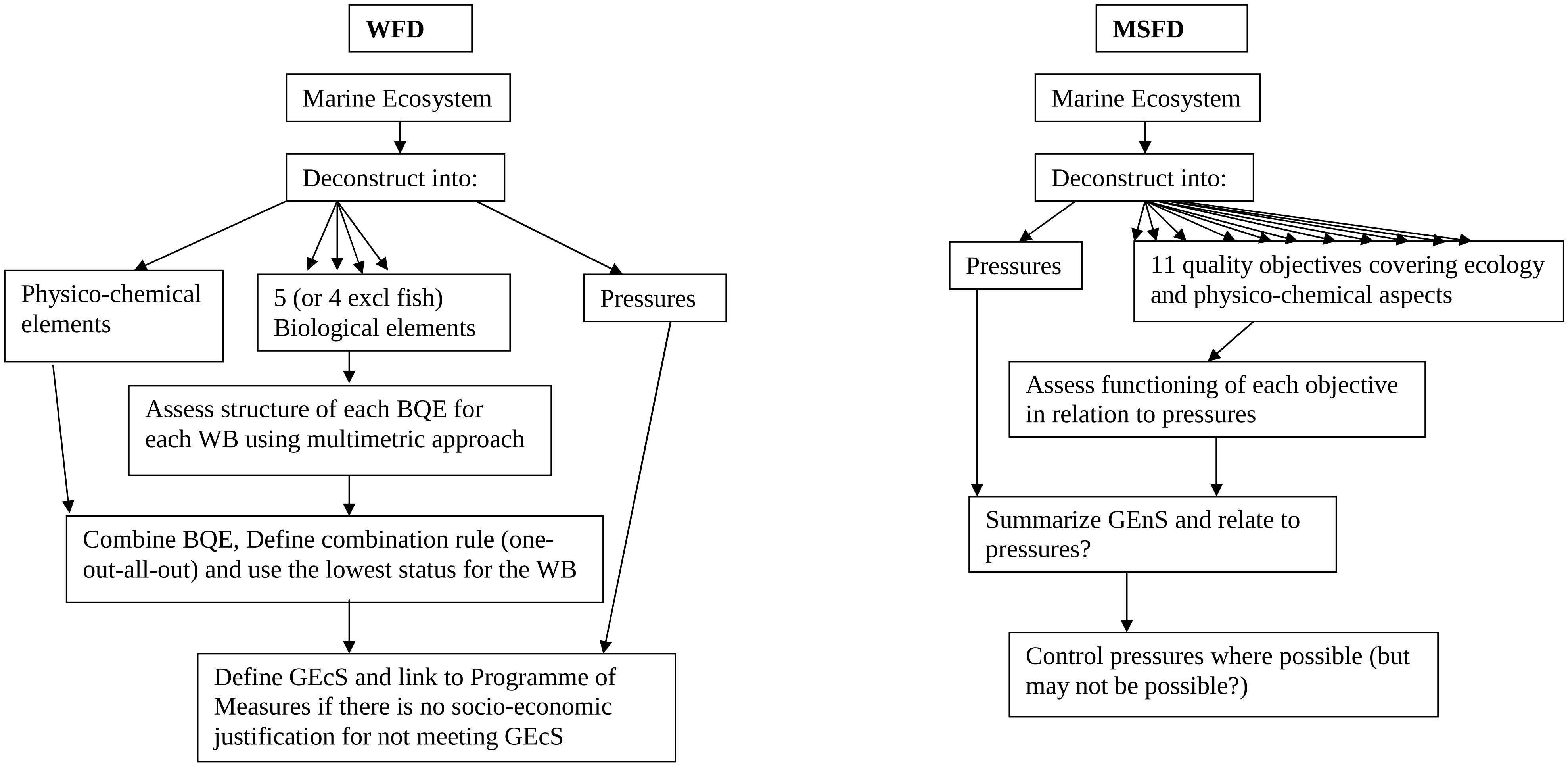
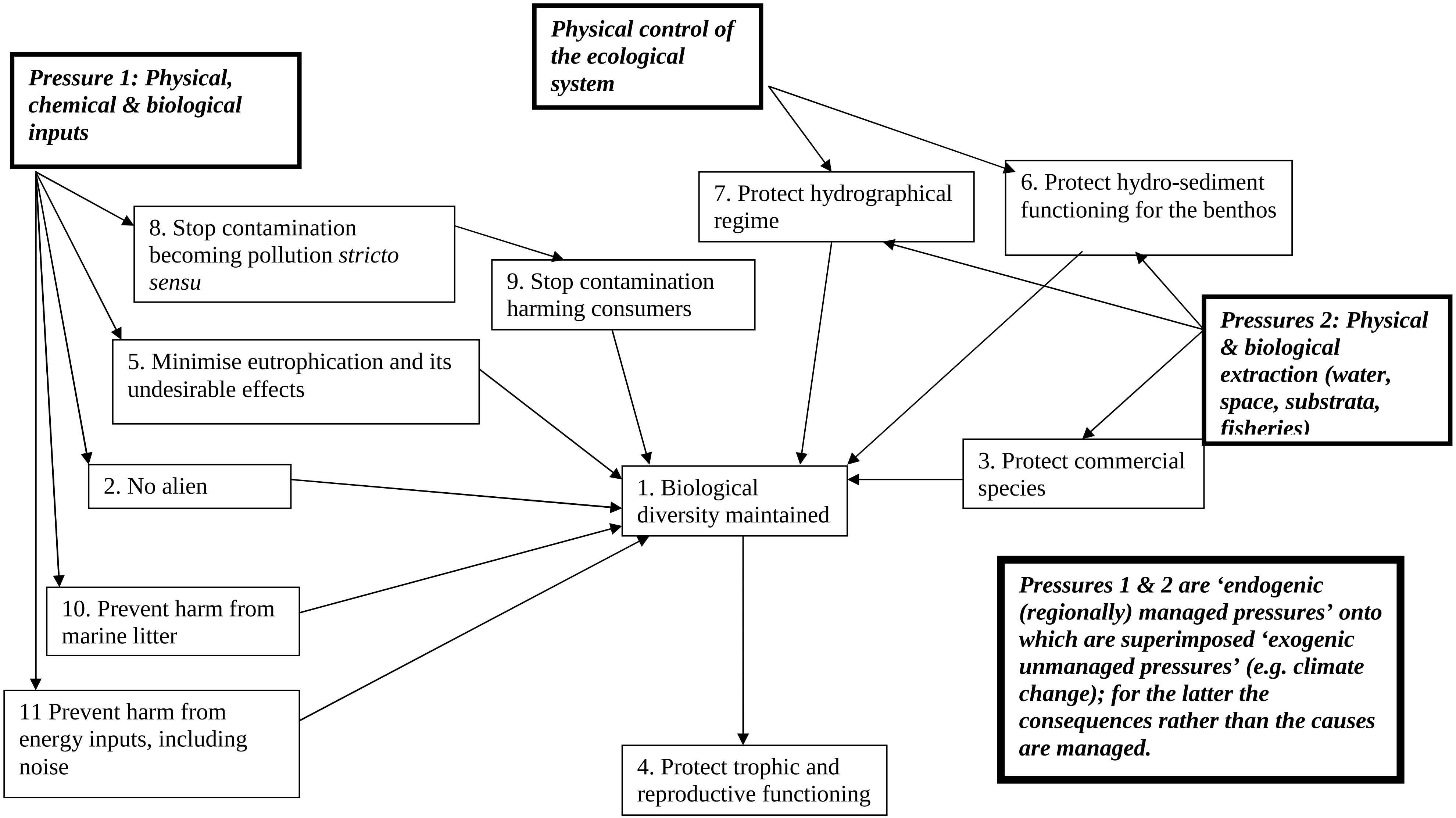

WFD
Marine Ecosystem
Deconstruct into:
Physico-chemical elements
5 (or 4 excl fish) Biological elements
Pressures
Assess structure of each BQE for each WB using multimetric approach
Combine BQE, Define combination rule (one-out-all-out) and use the lowest status for the WB
Define GEcS and link to Programme of Measures if there is no socio-economic justification for not meeting GEcS
MSFD
Marine Ecosystem
Deconstruct into:
Pressures
11 quality objectives covering ecology and physico-chemical aspects
Assess functioning of each objective in relation to pressures
Summarize GEnS and relate to pressures?
Control pressures where possible (but may not be possible?)

Fig 2


Pressure 1: Physical, chemical & biological inputs
Physical control of the ecological system
8. Stop contamination becoming pollution stricto sensu
9. Stop contamination harming consumers
7. Protect hydrographical regime
6. Protect hydro-sediment functioning for the benthos
Pressures 2: Physical & biological extraction (water, space, substrata, fisheries)
5. Minimise eutrophication and its undesirable effects
2. No alien
1. Biological diversity maintained
3. Protect commercial species
10. Prevent harm from marine litter
11 Prevent harm from energy inputs, including noise
4. Protect trophic and reproductive functioning
Pressures 1 & 2 are ‘endogenic (regionally) managed pressures’ onto which are superimposed ‘exogenic unmanaged pressures’ (e.g. climate change); for the latter the consequences rather than the causes are managed.