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Viewpoint

Implementation of the European water framework directive from the Basque country (northern Spain): a methodological approach

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Abstract

The European Water Framework Directive provides a challenge in the development of new and accurate methodologies. It addresses assessment of Ecological Quality Status within European rivers, lakes, groundwaters, estuaries and coasts. Although this directive is simple and flexible in its concept, it is necessary to develop an approach based upon scientific knowledge; however, at the same time it should be as simple as possible, in order to achieve both requirements and comparability of results throughout European waters.

This contribution presents the first methodological approach to the problem, as used for estuaries and coasts of the Basque Country (northern Spain), in: selecting typologies and reference conditions; determining biological quality and ecological status; and identifying some problems in implementing the WFD. As such, the present paper could serve as the basis for a discussion document for other regions and countries, throughout Europe.

Keywords: Water framework directive; Ecological status; Methodological approach; Implementation; Quality assessment

1. Introduction

The European *Water Framework Directive* (WFD; 2000/60/EC) establishes a framework for the protection of all waters (including inland surface waters, transitional (= estuarine) waters, coastal waters and groundwater) which: (i) prevents further deterioration, protects and enhances the status of water resources; (ii) promotes sustainable water use; (iii) aims at enhancing protection and improvement of the aquatic environment through specific measures for the progressive reduction of discharges; (iv) ensures the progressive reduction of pollution of groundwater and prevents its further pollution; and (v) contributes to mitigating effects of floods and droughts. Overall, the directive aims at achieving 'good water status' for all waters, by 2015. The WFD requires member states to assess the ecological quality status (EcoQ) of water bodies. The EcoQ will be based upon the status of the biological, hydromorphological and physico-chemical quality elements, with the biological elements being especially important. In coastal and transitional waters, the biological elements to be considered are phytoplankton, macroalgae, benthos and fishes (the latter only in transitional waters).

In order to assist the WFD implementation, a "common implementation strategy" (CIS) was agreed in May 2001. The CIS includes four key activities, including: (i) the development of guidance on technical issues; and (ii) the application, testing and validation of the guidance provided. Several working groups were created to deal with these issues. The COAST working group dealed specifically with transitional and coastal waters, with their guidance document being published in November 2002 (Vincent et al., 2002). Other methodological approaches in implementing the WFD have been undertaken over the past few years (Henocque and Andral, 2003).

In the Basque Country (northern Spain), work has been undertaken over several years in developing new tools addressed at this Directive and other problems

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associated with the different biological elements (Borja et al., 2000, 2003a,b,c). This contribution presents the initial approach suggested from the Basque Country, as a basis for discussion, comparison and assistance to other researchers throughout Europe. Hence, the stepwise progression of this contribution includes: (i) the presentation of the Basque Monitoring Network; (ii) the selection of typologies and reference conditions; (iii) the specific methodologies applied in determining the biological quality and the EcoQ; and (iv) some problems identified in implementing the WFD.

2. The Basque monitoring network

The Department of Land Action and Environment of the Basque Government, by means of the *Littoral Water Quality Monitoring and Control Network* (hereafter, LQM), has monitored the Basque coastal and estuarine water quality since 1994 (Borja et al., 1996, 2003c). This network comprises the analyses of both physico-chemical (in water, sediment and biota) and biological elements (phytoplankton, macroalgae, benthos and fishes) (see Table 1, for details). The LQM series data includes 32 coastal and estuarine stations sampled, from 1995 to 2002, and 19 more since 2002 (Fig. 1).

From 1994 to 2001, the LQM has been used in assessing the evolution of the marine waters quality under the development of various sewerage schemes (Franco et al., 2004; Gorostiaga et al., 2004), contributing to the knowledge of pollutant ranges and backgrounds in different matrices, such as: (i) waters (Belzunce et al., 2004a; Bald et al., 2004); (ii) sediments (Belzunce et al., 2004b); and (iii) biota (Borja et al., 2004a; Marigómez et al., 2004). Likewise, since 2001, the LQM has been used for the implementation of the WFD, using the database as a useful tool in the development of new methods in assessing the EcoQ (Borja et al., 2003c).

3. The development of typologies

The WFD requires surface waters within the River Basin District to be split into water bodies, representing the classification and management unit of the Directive. The suggested hierarchical approach to the identification of surface water bodies includes: (i) the definition of the River Basin District; (ii) the division of surface waters into one of six surface water categories (i.e. rivers, lakes, transitional waters, coastal waters, artificial and heavily modified water bodies); (iii) the sub-division of surface water categories into types, then assigning the surface waters to one type; and (iv) the sub-division of a water body of one type into smaller water bodies according to pressures and resulting impacts (for details, see Vincent et al., 2002).

The purpose of typology is to enable type specific reference conditions to be established. Such conditions

Table 1
Elements and parameters monitored in estuaries and along the coast, within the *Littoral Water Quality Monitoring and Control Network* of the Basque Country, together with the corresponding sampling periodicity (for additional details, see Borja et al., 2003c)

Element	Parameter Type	Parameters	Quarterly	6-monthly	Annually	Tri-annually
Water	Physico-chemical	General: transparency, salinity, temperature, dissolved oxygen, nutrients, suspended solids, TOC, etc.	■			
		11 Heavy metals		■		
		Organic compounds: PAH, PCB, DDT, HCH, HCB, detergents, etc.		■		
Sediment	Physico-chemical	General: organic matter, grain size, redox potential, C/N			■	
		10 Heavy metals			■	
		Organic compounds: PAH, PCB, DDT, HCH, HCB, etc.			■	
Biota	Biological	Microbiology			■	
	Physico-chemical	10 Heavy metals			■	
		Organic compounds: PAH, PCB, DDT, HCH, HCB, etc.			■	
Benthos	Biological	Density, richness, biomass, diversity, AMBI			■	
Fishes (*)	Biological	Composition and abundance				■
Phytoplankton	Biological	Biomass (chlorophyll)	■			
		Composition and abundance		■		
Macroalgae	Biological	Composition and coverage				■
Hydromorphology	Physical	Bathymetry, tides, substrate conditions			■	

*Monitored only in estuaries; AMBI = AZTI marine biotic index (see Borja et al., 2000).

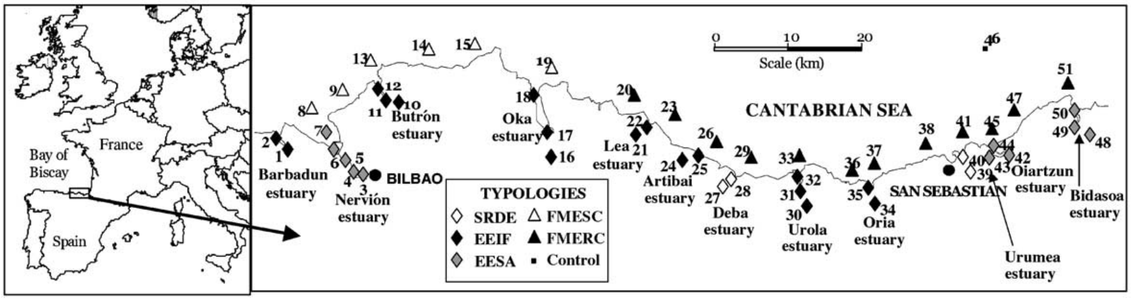

Fig. 1. Sampling stations within the *Littoral Water Quality Monitoring and Control Network* of the Basque Country, at present (for typologies, see Table 2).

then become the basis for the classification schemes, with consequences for all subsequent operational aspects of the implementation of the WFD (including monitoring, assessment and reporting). Water bodies within each surface water category are differentiated according to type using a system of typology as defined in the WFD. On the basis of the latitude, longitude, tidal range and salinity (known as 'obligatory factors'), it is possible to divide the maritime area into three basic eco-regions: (i) the Atlantic/North Sea Eco-region Complex, comprising the North Atlantic Ocean, North Sea, Norwegian Sea and the Barents Sea Eco-regions; (ii) the Baltic Sea Eco-region; and (iii) the Mediterranean Sea Eco-region.

However, the WFD establishes the use of other 'optional factors', if the ecological separation used to define the 'type specific' reference conditions, according to types, cannot be achieved by only using the obligatory factors. In transitional waters, the optional factors may be used in the following order: (i) mixing; (ii) intertidal area (as an integrator of depth, tidal range and shape); (iii) residence time; and (iv) other factors, until an ecologically-relevant type of water body is achieved. In coastal waters, the optional factors are: (i) wave exposure; (ii) depth; and (iii) other factors, until an ecologically relevant type of water body is achieved (Vincent et al., 2002).

The Basque Country is contained within the Atlantic/North Sea Eco-region Complex. In these waters, the optional factors that have been used in the classification of water masses typologies include salinity, tidal range, depth, current velocity, wave exposure, water mixing, residence time, substrata texture, and intertidal area (Table 2) (Borja et al., 2003c). The sampling stations have been assigned to each of the defined typologies, having 4 sampling stations located within the SRDE water type, 17 in EEIF, 12 in EESA, 6 in FMESC and 12 in FMERC, with a station, offshore and undisturbed, used as a control (Table 2, Fig. 1). This typology pattern is now under study and discussion, with some problems

Table 2
Water mass typologies determined for the Basque Country, using the optional factors of the WFD in the classification (Borja et al., 2003c)

Variables	Typologies				
	SRDE	EEIF	EESA	FMESC	FMERC
Definition	Small river-dominated estuaries	Estuaries with extensive intertidal flats	Estuaries with extensive subtidal areas	Full marine exposed, sandy coast	Full marine exposed, rocky coast
Locations	Estuaries of Deba and Urumea	Estuaries of Barbadún, Butrón, Oka, Lea, Artibai, Urola, Oria	Estuaries of Nervión, Oiartzun, Bidasoa	Coast of Nervión, Butrón, Oka	Rest of the coast
Salinity	5–30 PSU	18 –> 30 PSU	18 –> 30 PSU	>30 PSU	>30 PSU
Tidal range	1–3 m	1–3 m	1–3 m	1–3 m	1–3 m
Depth	<30 m	<30 m	<30 m	<30 m	<30 m
Current velocity	50–150 cm s^{-1}	50–150 cm s^{-1}	50–150 cm s^{-1}	50–150 cm s^{-1}	50–150 cm s^{-1}
Wave exposure	Sheltered	Sheltered	Sheltered, very sheltered	Exposed, very exposed	Exposed, very exposed
Mixing	Permanent stratification	Permanent stratification	Permanent stratification	Seasonal stratification	Seasonal stratification
Residence time	Days	Days	Weeks, months	Days	Days
Substrata	Mixed sediments	Mixed sediments	Mixed sediments	Sand, Gravel	Hard substrata
Intertidal area	<50%	>50%	<50%	<50%	<50%

associated with the assignation of several of the locations.

4. The development of reference conditions

The difficulty in establishing the environmental quality of an ecosystem in the absence of a reference value, or knowledge of the state of the system, against which comparisons can be made and put into perspective in relation to assessments like "good ecological status" (similar than those included in Directive 2000/60/EC), has been identified previously (Maksimov, 1991).

The reference condition, for a water mass type, is a description of the biological quality elements that exist, or would exist, at an high biological status, i.e. with no, or only very minor disturbance, from human activities. The objective of setting reference condition standards is to enable the assessment of EcoQ, against these standards. The reference condition is a description of the biological quality elements only. High ecological status incorporates the biological, physico-chemical and hydromorphological elements (Vincent et al., 2002).

The WFD identifies four options for deriving reference conditions: (i) an existing undisturbed site or a site with only very minor disturbance; (ii) historical data and information; (iii) models; or (iv) expert judgement (Annex II, 1.3(iii), in the WFD, see Vincent et al., 2002). One of the problems in deriving reference conditions, in some European regions, arises from the absence of unimpacted areas. This is the case of the Basque Country, in which all of the estuaries have been historically impacted upon by human activities (Cearreta et al., 2004). Moreover, this region has no pre-industrial historical data; hence, the use of 'virtual' reference locations should be considered (Borja et al., 2003c). (Virtual locations do not exist in reality, but are based upon experience gained of the area and conceived as the 'potential' components—biological parameters, chemical concentrations, etc.—that should be present). The reference values from these locations have been based upon the LQM database (including low or background levels) and legal quality values (Borja et al., 2003c).

Because reference conditions must incorporate natural variability, in most instances they will be expressed as ranges. Reference conditions should be derived with a view to distinguishing between very minor, slight, and moderate disturbance. 'Very minor' disturbance could be defined as just detectable in the sense that the disturbance is more likely to be anthropogenic, than not. 'Slight' disturbance could be defined as anthropogenic, at a prescribed level of confidence.

'Type specific' reference conditions are to be established for the biological quality elements for that type of surface water at an high status. Reference conditions are a description of the biological quality elements at an high status: "the results of the (classification) systems… shall be expressed as ecological quality ratios for the purposes of classification of ecological status. These ratios shall represent the relationship between the values of the biological parameters observed for a given body of surface water and the values for these parameters in the reference conditions applicable to that body. The ratio shall be expressed as a numerical value between zero and one, with high ecological status represented by values close to one and bad ecological status by values close to zero" (Annex V 1.4.1.(ii), of the WFD, in Vincent et al., 2002).

The description of the biological reference conditions must permit the comparison of monitoring results with the reference conditions, in order to derive an Ecological Quality Ratio (EQR). The values of the EQR set for each status class must mean that the water body meets the normative definition, for that status class given in the WFD. The EQR is not necessarily a simple ratio of two numbers but 'represents the relationship between the values of the biological parameters', within a given water body. The EQR expresses the relationship between observed values and reference condition values; its numerical value lies between 0 and 1. At high status, the reference condition may be regarded as an optimum where the EQR is close to, and including one unity.

In the cases of physico-chemical conditions and the benthos, Principal Component Analysis (PCA) has been used, as a useful tool in determining the EQR, according to the methodology established by Bald et al. (1999, 2001). Similar methodologies have been used elsewhere by Algarra and Niell (1985) and Belan (2003). This multivariante analysis uses the Euclidean metric distance between each of the locations, together with the distance between the 'High Status' and 'Bad Status' virtual locations. Logically, the greatest Euclidean distance corresponds to that between both references (this distance being equal to 1), as they represent the two extreme conditions of the system. The remainder of the locations are situated between them, in the new space defined by the PCA (therefore, each station has an EQR ranging from 0 to 1). This methodology has been applied also in assessing environmental impacts (Bald et al., 2001).

5. Physico-chemical conditions

The physico-chemical indicators, used in the assessment of the ecological status, are those referred to by the WFD: transparency (measured as Secchi disc depth of disappearance); percentage of oxygen saturation and nutrients (ammonium, nitrate and phosphate). Salinity and temperature were not included in the analysis, because most of the system variability is explained by these variables. As such, they are not directly related to the anthropogenic impact on the ecological status.

Table 3
Physico-chemical reference conditions of 'high' and 'bad' quality, defined on the basis of salinity, for each of the typologies, proposed in Borja et al. (2003c)

Parameters	Typologies			
	SRDE (75% FW–25% MW)	EEIF (50% FW–50% MW)	EESA (25% FW–75% MW)	FMESC–FMERC (100% MW)
High quality				
O_2(%)	85	90	95	100
SD (m)	2	2	2	12
NH_4 (μmol L^{-1})	5	4	3	2
NO_3 (μmol L^{-1})	65	45	25	5
PO_4 (μmol L^{-1})	1.12	0.88	0.74	0.4
Bad quality				
O_2(%)	45	50	55	60
SD (m)	0.5	0.5	0.5	4
NH_4 (μmol L^{-1})	55	40	30	15
NO_3 (μmol L^{-1})	180	125	70	12
PO_4 (μmol L^{-1})	12	8	4	1.5

FW—freshwater; MW—marine water; SD—secchi disc (for typology acronyms, see Table 2).

Salinity has a weighted influence upon the characteristics of 'high' and 'bad' physico-chemical quality. Such a control is because salinity is an index of the fraction of continental and marine waters; it is the main variable regulating the concentrations of dissolved materials, in both the horizontal and vertical (Valencia et al., 2004). Hence, those estuaries dominated by rivers in terms of their hydro-morphology will naturally have highest values of nutrients, and vice-versa. Taking into account the reference values for the Basque rivers (Borja et al., 2003c), a dilution pattern can be established for each of the typologies (Table 3), with different reference values for nutrients.

A PCA was undertaken, as described above, including all the studied sampling stations in the LQM, together with the 'virtual' reference locations with 'high' and 'bad' quality. In order to achieve a normal distribution with these data, they were previously $\log(1 + X)$-transformed, as recommended by Bock et al. (1999); further, they were standardised by subtracting the mean and dividing by the standard deviation. The factor analysis solution was rotated (using the Varimax rotation method), in order to facilitate the interpretation of the results of the analysis.

Hence, the analysis showed that the 3 first axes explained 86% of the variability within the system. Likewise, the first axis explains 47% of the variability, being related to the anthropogenical impacts; the second is related to transparency (20% of the explained variability) and the third with oxygen conditions (19% of the variability). The vectorial distances from each of the locations, to the 'high' quality location, were calculated using the methodology proposed by Bald et al. (1999). In this approach the equivalences used were: 'High Quality': vectorial distances between 0.91 and 1; 'good quality': 0.71–0.9; 'moderate quality': 0.51–0.7; 'poor quality': 0.26–0.5; 'bad quality': 0–0.25. Thus, all of these values lie between 0 and 1, as required by the WFD.

6. Methodologies applied in determining the biological quality

6.1. Phytoplankton

The composition and abundance of phytoplankton is based upon sampling every 6-months, in spring and summer (10 samples, over 5 years). However, the chlorophyll concentrations are analysed quarterly (40 samples in estuaries and 20 samples from the coast, over 5 years). The tentative classification tool used for phytoplankton is based upon that of Ifremer (Vincent et al., 2002), for France, modified and adapted for the Basque Country (Table 4). From the 5-year running period sampling, the number of cases above the quality levels for chlorophyll *a* and blooms of toxic phytoplankton are computed. The final classification is based upon the worst data set of the 4 indicators used for estuaries and the coast, respectively (Table 4).

6.2. Macroalgae

The proposal is based upon: (i) the richness of macroalgae and phanerogams in the estuaries and the adjacent coastal area; (ii) the presence of pollution-indicator species; (iii) the mean coverage of the species; and (iv) the ratio between green algae and the remainder of the species (Table 5). The sampling is undertaken every 3 years. Each of the indicators has an associated score (1, 3 or 5), and the addition of all the scores has provided the final quality classification for the macroalgae, as follows: high quality: 26–30 scores; good quality: 21–25; moderate quality: 16–20; poor quality:

Table 4
Indicators and proposed levels used in establishing the phytoplankton biological quality in the Basque Country (Borja et al., 2003c)

Indicator	Level	Classes and number of events				
		High	Good	Moderate	Poor	Bad
Chlorophyll *a* (1)	$8\ \mu g\,l^{-1}$	<2	2–5	6–10	11–15	>15
Chlorophyll *a* (2)	$16\ \mu g\,l^{-1}$	<4	4–10	11–20	21–30	>30
Blooms (3)	$>10^6$ cel l^{-1}	0	1–2	3–5	6–8	>8
Blooms (4)	$>10^6$ cel l^{-1}	0	1–2	3–5	6–8	>8
Blooms (5)	$>10^5$ cel l^{-1}	<2	2–4	5–7	7–9	>9

The values are the number of events based upon quarterly (chlorophyll) and 6-monthly (phytoplankton) sampling data, for 5-year running periods: (1) chlorophyll in coastal waters; (2) chlorophyll in transitional waters; (3) human health toxic phytoplanktonic species (producing DSP, PSP and ASP toxins, such as *Dinophysis* spp., *Alexandrium minutum*, *Gymnodinium catenatum*, *G. breve*, *Prorocentrum minimum* and the Diatom genus *Pseudo-Nitzchia*); (4) flora and fauna toxic phytoplanktonic species (*Gymnodinium cf. nagasakiense* (= *G. nagasakiense*, *G. aureolus*, *G. mikimotoi*), *G. splendens* (= *G. sanguineum*), *G. breve* (= *Ptychodiscus brevis*), *Gyrodinium spirale*, *Prorocentrum micans* (= *P. arcuatum* = *P. gibbosum*)(main species) + *P. minimum* (= *P. balticum* = *P. cordatum*) (high proportion of species),*P. gracile*, *P. lima* (= *P. marinum*), *P. triestum* (= *P. redfieldii*) (low proportion of species) + *P. compressum*, *P. mexicanum* (sporadic species), *Dictyocha* sp., *Heterosigma carterae*, *Fibrocapsa japonica*, *Chrysochromulina* spp.), *Dinophysis* spp., *Phaeocystis* spp., *Distephanus* spp., *Dictyocha* spp. and *Pfiesteria piscicida*; and (5) eutrophication indicator species (all).

Table 5
Macroalgae indicators in the Basque Country, with their assigned ratings, used in the assessment of the biological quality of this element

Indicator	Score		
	1	3	5
1. Richness (macroalgae and phanerogams)	<3	4–10	>10
2. Pollution indicator species	Presence		Absence
3. Pollution indicator species (mean coverage in %)	>50	5–50	<5
4. Mean phanerogams coverage (%)	<2	2–10	>10
6. Mean macroalgae coverage (without pollution indicator sp.)	<10	10–60	>60
7. Ratio (coverage) green algae/ remainder of the macroalgae and phanerogams	>1	0.3–1	<0.3

11–15; and bad quality: 6–10. These values are equivalent to an EQR lying between 0 and 1, with five thresholds every 0.2, i.e. 6 scores are equivalent to 0, 30 scores are equivalent to 1, and each level is approximately equivalent to 0.2.

6.3. Benthos

The benthic communities are sampled in the Basque Country once a year. Following the WFD, the 'High Status' for benthic invertebrate fauna is the level of diversity and abundance of invertebrate taxa within the range normally associated with undisturbed conditions. All the disturbance-sensitive taxa associated with undisturbed conditions are present. The LQM provides information about density, biomass, richness, Shannon-Wiener diversity (for density and biomass) and AMBI. The AMBI, as defined by Borja et al. (2000, 2003a), is a biotic index which provides a 'pollution classification' of a particular site, representing the benthic community 'health' (*sensu* Grall and Glémarec, 1997). It is based upon the distribution of the abundance of each species, to one of five ecological groups (sensitive to pollution, indifferent, tolerant, and second and first-order opportunistic species); these are related closely with the definitions of the WFD, for detecting disturbed and undisturbed locations (see Borja et al. (2003a), for different case-studies, and Borja et al. (2003b,d), for equivalences with the WFD).

The EQR is calculated on the basis of a PCA analysis, including the distance of a location to a 'virtual' 'high quality' status location, using the maximum population structure parameter values (Borja et al., 2004b) for each of the defined typologies (Table 6), using the communities characteristic of each of the types. The values used for the 'virtual''bad quality' status location were 0, for each of the parameters, except for AMBI, which was 7.

6.4. Estuarine fishes

The proposal for the Basque Country is based upon two different models: those of the UK (Whitfield and Elliott, 2002) and those of Belgium (Goethals et al., 2002). One of the problems in adapting these models is the small size of the Basque estuaries, containing only a small number of estuarine resident fish species. In order of improve this classification, the crustaceans, as characteristic demersal component of the estuaries, have been included. The method incorporates: (i) the richness; (ii) indicator and introduced species; (iii) fish health; (iv) trophic composition; and (v) resident estuarine species. The sampling, using trawling, is undertaken every 3 years. Each of the nine indicators has an associated score (1, 3 or 5). The addition of all the scores has provided the final quality classification for this element (Table 7), as follows: High Quality: 39 to 45 scores;

Table 6
Benthic reference conditions used as 'high quality' status location, for each of the typologies (data from Borja et al., 2004b)

Parameter	Units	Typology			
		SRDE	EEIF	EESA	FMESC
Density	ind m^{-2}	900	200	2500	500
Biomass	g m^{-2}	30	6	15	10
Richness	n	13	32	40	42
Diversity (density)	bit ind^{-1}	2.5	3.8	3.5	4
Diversity (biomass)	bit g^{-1}	1.5	1.6	2.8	2.3
AMBI		0	0	0	0

Table 7
Estuarine demersal indicators in the Basque Country, with the assigned scores, proposed by Borja et al. (2003c)

Indicator	Scores		
	1	3	5
1. Richness (F and C)	<3	4–9	>9
2. Pollution indicator species (F and C)	Presence		Absence
3. Introduced species (F and C)	Presence		Absence
4. Fish health (damage, diseases...)(% affection)	>50	5–49	<5
5. Flat fish presence (%)	<5	5–10 or >60	10–60
6. Trophic composition (% omnivorous)	<1 or >80	1–2.5 or 20–80	2.5–20
7. Trophic composition (% piscivorous)	<5 or >80	5–10 or 50–80	10–50
8. Estuarine resident species number (F and C)	<2	2–5	>5
9. Resident species (%) (F and C)	<5 or >50	5–10 or 40–50	10–40

F—fishes; C—crustaceans.

good quality: 31–38; moderate quality: 24–30; poor quality: 17–23; bad quality: 9–16. These values are equivalent to an EQR lying between 0 and 1, with five thresholds every 0.2, i.e. 9 scores are equivalent to 0, 45 scores are equivalent to 1, and each level is approximately equivalent to 0.2.

7. The classification of the ecological status, within transitional and coastal waters

The classification of the Ecological Status in the WFD is based upon the worst of the values in the biological elements. Hence, if the phytoplankton has a *moderate* value and the remainder of the elements have a *high status*, the global classification should be *moderate ecological status*. In the Basque Country, taking into account that there is much more data available from benthos, than fishes or phytoplankton, the possibility of weighting the results of the benthos has been considered, in order to derive a more accurate global classification (Fig. 2). This approach was adopted previously by Franco et al. (2004), for the area, because there is general agreement that benthic communities are good indicators of the ecosystem health (Grall and Glémarec, 1997).

The first step consists in assessing the Biological Quality, from the previous classification made for each of the four biological elements (phytoplankton, macroalgae, benthos and fishes). When the biological quality is 'moderate', 'poor' or 'bad', the corresponding ecological status is 'moderate', 'poor' or 'bad', respectively. As the WFD has stated (Vincent et al., 2002), when the biological quality is 'high' or 'good', a series of steps, involving the physico-chemical and hydro-morphological conditions, must be undertaken (Fig. 2).

In the Basque Country the physico-chemical status has been determined by means of a PCA. When the conditions meet the 'high status' and all the specific contaminant concentrations are under the detection limits, the hydro-morphological conditions are analysed. When the PCA shows a 'good status' for the physico-chemical conditions and/or some of the contaminant concentrations are over the detection limits, the normative values are examined (for details in these limits and values, see Borja et al., 2003c). This approach permits the global ecological status to be assessed easily.

8. The ecological status in the Basque country

Using the LQM database, and using the methodology outlined previously, the accomplishment of the WFD in the Basque Country is listed in Table 8. The Ecological Status worsens significantly in relation with the biological conditions (25.5% of the locations have 'good' or 'high' biological quality, but only 7.8% have 'good' ecological status). Undoubtedly, this pattern is related to the poor or moderate physico-chemical conditions at some of the locations.

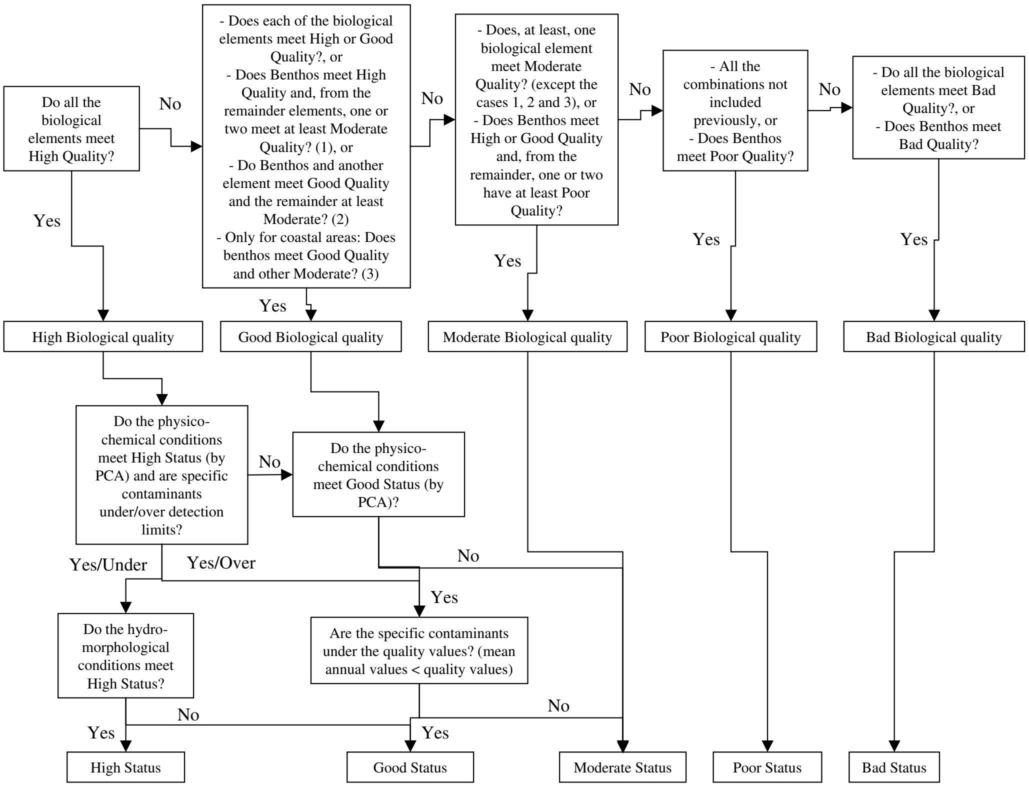

Fig. 2. Proposed criteria to be used in establishing the global biological quality (based upon the biological elements of the system) and the ecological status (based upon biological, physico-chemical and hydro-morphological conditions), in the Basque Country (adapted from Borja et al., 2003c). Key: PCA—principal component analysis.

In comparison, none of the estuarine water masses (SRDE, EEIF and EESA types) accomplished the good ecological status of the WFD, even though 9.1% have good biological conditions (Table 8). Probably, this is produced by the exigent thresholds proposed in our methodology e.g. 'Good Status' is reached when the vectorial distance is 70% of the reference conditions. When reducing the threshold to 60%, the results improve significantly (Borja et al., unpublished data).

Only the coastal locations have high levels of accomplishment with the proposed thresholds, i.e. more than 58% of 'good' ecological status (Table 8), with no 'bad' or only very few 'poor' levels.

9. Some problems in implementing the WFD

Kallis and Butler (2001) have discussed that the financial costs involved in achieving the objective of 'good status', for all European waters, will be high. The costs are divided into three categories: administrative, monitoring and intervention-related. The Commission has estimated that the annual administrative cost for a unique River Basin Authority will be 0.5 M€ (1997 values); the monitoring as 730 M€ (1993 values), for the whole of the EU (at this moment, the Basque Government will spend 2.4 M€, in 2004–2005, in monitoring a territory of 7235 km^2 and 20 hydrographical

Table 8
Percentage of locations assigned to each of the categories, in terms of biological conditions and ecological status, for each of the typologies and for the whole of the Basque Country

Typologies	Biological conditions					Ecological status				
	B	P	M	G	H	B	P	M	G	H
SRDE	25.0	50.0	25.0	0.0	0.0	25.0	50.0	25.0	0.0	0.0
EEIF	17.6	58.8	23.5	0.0	0.0	17.6	58.8	23.5	0.0	0.0
EESA	9.1	54.5	27.3	9.1	0.0	9.1	54.5	36.4	0.0	0.0
FMESC	0.0	0.0	33.3	66.7	0.0	0.0	0.0	50.0	50.0	0.0
FMERC	0.0	15.4	23.1	53.8	7.7	0.0	15.4	76.9	7.7	0.0
TOTAL	9.8	39.2	25.5	23.5	2.0	9.8	39.2	43.1	7.8	0.0

B—bad; P—poor; M—moderate; G—good; H—high. For typologies, see Table 2.

units); and, finally, only the UK has estimated its cost of complying with the WFD to be within a range of £3.2 and 11.2 billion (Kallis and Butler, 2001). Such costs emphasise the importance in developing an approach based upon scientific knowledge, but being maintained as simple as possible. This is in order that all countries (developed and less developed) around Europe can achieve all the requirements of the WFD, with the methodologies and results being comparable throughout Europe. Hence, some of the problems which have arisen in the Basque Country, together with the solutions proposed, could serve others (scientists and individuals working on the implementation of the WFD), as the basis for discussion and improvement in the future (see below).

- The number of water mass types should be as few as possible, i.e. not more than 15–20 for the EU Atlantic coasts; this is in order to avoid an unmanageable situation, in relation to the further application of the WFD (achievement of the 'good status').
- The reference conditions should be defined in a pragmatic and realistic way, taking into account previous data and expert judgement. This would avoid any complicated approach which could lead to the impossibility of accomplishing 'good status'.
- In addition to the selected methodologies, many of the problems arise from the selected thresholds for each of the ecological status levels. After many iterations and studies (Borja et al., unpublished data), it is suggested that the EQR should utilise the following thresholds: 'high status': 0.81–1; 'good status': 0.61–0.8; 'moderate status': 0.41–0.6; 'poor status': 0.21–0.4; and 'bad status': 0–0.2.
- In some cases, the PCA analysis presents problems of interpretation, when a particular location has vectorial values above the 'High' or under the 'Bad' reference conditions. In such cases, the locations should be assigned to 'High' or 'Bad' situation, respectively.
- It is considered that the WFD principle 'one out, all out', in determining the ecological status, should be considered for discussion. Due to different sampling frequencies, the high spatial and temporal variability of some of the biological elements and the role of some of the elements as good indicators, i.e. benthos and fishes, any form of weighting in the data should be investigated (as outlined here).
- The use of different methodologies, adapted to the requirements of any of the EU countries, should be considered, but only if they can be intercalibrated. Some of the methodologies could include multimetric and multivariant analyses (see above, or others) addressed to the pragmatic assessment of the ecological status.
- Finally, this contribution is an initial approach to implementing the WFD in the Basque Country; as such, it is now under refinement, discussion and improvement, being these results provisional.

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