Joint Research Centre

Ecological status in a changing climate

An ECOSTAT workshop discussion paper

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Contents

Abstract

Ecological assessment under the Water Framework Directive has been ongoing for over 20 years. Climate change poses a threat to aquatic systems in Europe but also to the established approaches and methods used to assess them. This report arose from a workshop to review the current impact of climate change on status assessments, with a focus on use cases in Member States. The principle objective was to explore potential approaches to dealing with climate change in ecological assessment. Climate change was found to be influencing the ecological assessment of many aquatic systems. However, at the workshop, Member States adopted a cautious approach focused on a critical dichotomy: whether observed changes are temporary and avoidable through additional measures, or permanent and unavoidable, potentially necessitating a reassignment of water body typology or updated reference conditions. There was agreement that sufficient evidence and certainty should be a pre-requisite to implementing changes to maintain the integrity of assessment time-series and stakeholder confidence. Key recommendations include monitoring climate-relevant parameters, expanding the reference site networks to track long-term trends, and ensuring that measures to tackle other pressures (e.g., nutrients, abstraction) are exhausted before adjusting classification systems. Recording the degree of ecosystem change driven by climate change should be part of future frameworks to track changing sensitivity, resilience and ecosystem service loss in Europe.

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Executive summary

Climate change and ecological assessment

Climate change is increasingly impacting aquatic ecosystems through temperature rise, changes in precipitation, altered hydrology, geochemical shifts, sea-level rise and the increasing frequency of extreme events. These changes affect Biological Quality Elements (BQEs) and supporting elements, complicating ecological status assessments. Current assessment frameworks struggle to isolate climate impacts from other pressures like nutrient pollution or hydromorphological changes. How to approach the influence of climate change on WFD systems for assessing ecological status was ranked as a top priority by members of the working group ECOSTAT in the work programme for 2025-2027.

Potential approaches

As well as examining the role of derogations, this report explored four potential approaches to incorporating climate change into ecological assessment:

1. Maintain existing assessment system unaltered: Continue to manage within constraints of the existing system.

2. Reassignment of waterbody type: Update typology and reference conditions to reflect new climate-driven baselines. This approach has been previously recommended in WFD guidance document 24.

3. Partitioning EQR influence: Quantify the portion of Ecological Quality Ratio (EQR) decline attributable to climate change.

4. Climate as a supporting parameter: Integrate climate metrics into the assessment framework alongside existing supporting elements.

Workshop synopsis

The workshop was held in presence in Copenhagen and online on the 31st of September 2025. The above approaches were introduced along with presentations on the formal guidance document and guest presentations on the influence of climate change on aquatic ecosystems. This was followed by breakout sessions on rivers, lakes and Transitional and Coastal Waters (TRAC). The focus of discussion was on a sub-set of 11 case studies from Member States dealing with their experience of climate change influencing ecological status assessments. The main finding was that many Member States, across all water categories, have examples where **climate change is currently affecting ecological status**. These included altered mixing patterns of lakes, flood induced eutrophication of littoral zones, intermittent streams, flooding events disrupting ecological assessment, degraded systems tipped by climate change into poor status, shifting species composition and reference conditions. While climate change wasn't explicitly included in the original text of the directive, 25 years later the influence of climate change is clearly emerging as a complicating factor in ecological status assessment.

A lot of countries and case studies reported from the breakout session indicated that while the influence of climate change was apparent, **permanent change had not occurred and that measures were possible** to counteract the influence of climate change and reach environmental objectives. However, some systems had undergone **permanent change and type reassignment was considered appropriate**. Type reassignment was considered to be only appropriate in situations where an unavoidable impact on status is permanent and technically irreversible.

During the discussions that followed each case study, there was a **strong focus on evidence that climate change was altering status** and whether such change was permanent and unavoidable. There was agreement that **sufficient evidence and certainty should be a pre-requisite to implementing changes** in ecological assessment. Many Member States were cautious about changing the assessment systems prematurely for several reasons such as introducing a discontinuity in the assessment time-series, or the danger that it is perceived as lowering objectives.

Another common theme in the discussion was the contrasting opinions on the **purpose of ecological assessment** under the WFD brought into focus by the influence of climate change. Many attendees felt ecological assessment should strongly focus on its role in the WFD **management cycle** where assessment systems and environmental objectives must be orientated towards achievable goals anchored in appropriate typology and reference conditions. The review of these is required to be carried out under article 5(2) of the WFD every 6 years. In contrast, there were those who held that **Ecological assessment should track degradation from all pressures** (including climate change) and report it. Fundamental changes to ecosystems driven by climate change should probably not go unnoted. One attendee commented that if data were reported at smaller granularity then calculations for assessments could be redone or shifts in species distribution could be examined.

Conclusions and recommendations

It was clear that climate change is having an influence on the assessment of ecological status across water categories in Member States. However, Member States felt that the majority of their water bodies where either not affected significantly or at an early stage of being affected by climate change. There was also difficulty in separating the climate signal from other pressures. Therefore, clear **evidence** should be presented on the influence of climate change and whether the change is permanent and unmitigable by feasible measures before deciding to alter classification approaches. In order to do this, Member States should start to purposively **include parameters and metrics indicative of climate change** relevant for their water categories and types into their data gathering framework to complement existing formal monitoring programmes. This will increase understanding of changes in status influenced by climate change alongside other pressures. ECOSTAT should support further work by this expert group to **define a set of key parameters to monitor** climate change. Many Member States **monitor reference sites** with the purpose of detecting long term variation and this practice should be expanded where possible. The current approach recommended in the **guidance of reassigning types** was found to be useful in some of the use cases examined. ECOSTAT should consider supporting the expert group to provide more detailed examples and procedures for its application. This report and its use cases examined the current situation, it is recommended that this be taken forward by some Member States as **projections under different climate change scenarios**.

1. Introduction

1.1. Background

During consultation with Member States on the 2025-2027 ECOSTAT work programme the classification of ecological status in a changing climate was ranked as the top priority to address (see Figure 1 in Annex 1). This was not surprising as climate change was frequently raised in biannual meetings of ECOSTAT as an important factor influencing ecological assessment directly or hampering achievement of environmental objectives through programmes of measures. Frequently this was in the context of unprecedented droughts or disastrous floods rendering WFD implementation extremely difficult (CIRCABC). There already exists a recently revised official guidance document: "River basin management in a changing climate" that deals with projections, adaptation of management and other WFD thematic priorities (pressures, status, monitoring, exemptions, flood and drought management and measures including nature based solutions (European Commission: Directorate-General for Environment, 2024). However, there was limited space to appropriately cover issues relating to ecological status assessment in the guidance and the planned workshop and follow on work seeks to address this.

1.2. Purpose of workshop

The purposes of the workshop and this supporting document are:

- Examine current and future impacts from climate change on aquatic ecosystems
- Review current impact of climate change on status assessments
- Explore potential approaches to dealing with climate change in ecological assessment
- Present case studies from European waterbodies where the pros and cons of the different approaches can be explored by workshop participants
- Outline the potential role of derogations
- Conclusions and recommendations (recorded from the workshop)

Climate change and its influence on aquatic systems is incredibly complex, the workshop therefore aims to explore and gather opinions from a wide spectrum of practitioners and experts. The aim is not to hastily arrive at decisions but to promote discussion, reflection and to carefully document the outcome. The key challenge is to adapt the framework to manage aquatic systems in the context of climate change, while maintaining focus on implementing measures to tackle key pressures such as nutrients and hydromorphological alteration (including water abstraction) to achieve environmental objectives. Key things to avoid are blaming climate change when other pressures in WFD assessment need to be addressed. The focus should be on implementing measures to counteract negative effects of climate change in combination with other pressures. The widespread use of derogations for climate change by every MS would also not be a solution. The question the workshop addresses is what to do when there is a permanent change to the waterbody caused by climate change.

1.3. Current and future impacts from climate change on aquatic ecosystems

The main avenues through which climate change will influence aquatic ecosystems and water resources are through temperature, hydrology and sea level rise. There is now high confidence that the global water cycle has intensified since at least 1980 with amplified precipitation and evaporation cycles (Arias et al., 2021). Changes are predicted to differ spatially in Europe, with for example stronger hydrological droughts in the Mediterranean while the Boreal region will have fewer drought traits (Cammalleri et al., 2020). Anthropogenic efforts to respond to climate change, such as increased abstraction and hydromorphological alterations are likely to add additional pressure on water resources. The resulting impact of climate change needs to be considered in a holistic way at catchment level to understand the broad implications for structural and functional health of aquatic ecosystems. The impact is likely to be also dependent on a water body's typological factors as well as its position on pressure gradients.

The obligation for Member States to include biological quality elements (BQE) in assessment was a novel introduction for European legislation in 2000 and stemmed from the aim to preserve the "structure and functioning of aquatic ecosystems". This aim also acknowledged the ability of bio-indicators to capture the effects of a growing list of human pressures, including nutrients, organic pollution, acidification as well as other pollutants and their interactions as well as continued physical habitat alteration (Karr and Chu, 2006). This system may now start to provide additional value in detecting the integrated effects of climate change driven ecosystem degradation across the water resource. However, the difficulty is in the partitioning and managing the influence of the various pressures, including climate change.

The recent update of the guidance document on climate change was needed as the previous version primarily presented the impacts as uncertain. This position has now changed over a short term as the impacts have started to become apparent. The IPCC have defined the term 'emergence' for this phenomenon to refer "to the experience or appearance of novel conditions of a particular climate variable in a given region". This concept is often expressed as the ratio of the change in a climate variable relative to the amplitude of natural variations of that variable (often termed a 'signal-to-noise' ratio, with emergence occurring as a defined threshold of this ratio)" (Arias et al., 2021). This section deals with aquatic ecosystems focusing on implications for the natural environment in the context of physical, chemical and biological change.

The key objective of the WFD is to achieve both good chemical and ecological status, the latter an expression of the quality of the structure and functioning of aquatic ecosystems that includes biological, physicochemical parameters and hydromorphology. Climate change can affect status in multiple ways thereby threatening the continued provision of key ecosystem services such as clean water for drinking, irrigation and wastewater disposal amongst others.

1.3.1. Temperature

River temperatures face increases in median values between 1.3 °C and 3.8 °C by 2090–2099 (van Vliet et al., 2011). Similarly, lakes globally have been estimated to warm by a median value of 2.5 °C with extremes of 5.5 °C possible and about a quarter of lakes will lose seasonal ice cover by 2080-2100 (Woolway and Merchant, 2019). In addition, annual mean evaporation rates are projected to rise by 16% by 2100, impacting lake levels and surface water extent (Woolway et al., 2020). Increasing water temperature can have a direct physiological response in biota increasing respiration, while the increasingly frequent pattern of heatwaves followed by colder low-pressure systems can cause metabolic disruption potentially inducing fish kills (Jeppesen et al., 2021). Warmer temperatures can lead to altered stratification regimes in lakes and TRAC waters altering nutrient cycling and isolating lower layers from the atmosphere reducing oxygen (van Vliet et al., 2011; Ferrarin et al., 2024). Responses can be habitat and region specific and vary by BQE (Johnson et al., 2025). In addition, seasonal mismatch with alteration to the traditional start, length and end of seasons is already altering species phenology resulting in a mismatch between prey and predators, with implications across ecosystems (Winder and Sommer, 2012; Moe et al., 2022). There is also evidence that intense, summer marine heatwaves play a significant role globally in the decline of coastal foundation species, such as macroalgae and seagrasses (Smith et al., 2024). High frequency, duration and intensity of marine heatwaves correspond to high frequency of Chl-*a* peaks and/or increased intensity and duration of low Chl-*a* anomalies, suggesting pronounced fluctuations with intense phytoplankton blooms alternating to extremely low production events in shallow coastal areas, as in the Adriatic Sea for example (Motta et al., 2025).

1.3.2. Hydromorphology

The hydromorphological character of waterbodies will also be altered by climate change. Changing rainfall patterns including less snowfall and retention will reshape the annual hydrograph with more extreme floods and droughts (predicted to be more severe in northern and southern Europe respectively) which will degrade biological communities through scouring or desiccation, reducing biodiversity and lowering ecological status. Alteration of river flow will have serious consequences on processes such as sediment provision and transport, which, together with flow, shape waterbody morphology and create physical habitats (Poff et al., 1997). Smaller water bodies can hold a considerable portion of landscape scale biodiversity but are at risk from drought and falling groundwater levels (Zacharias and Zamparas, 2010; Biggs et al., 2017). A large number of estuaries are also vulnerable to the reductions in river flow and anthropogenic channel modification (Hoagland et al., 2020). Coastal erosion is a natural process, but the rate of coastal erosion is now increasing due to the combined effect of sea level rise and intensified storms (Pang et al., 2023). Coastal flooding and property loss, biodiversity loss and degradation of vital ecosystems, economic consequences and loss of ecosystem services are among the detrimental impacts of coastal erosion. In boreal coastal ecosystems, riverine discharge and sediment transport will increase, reducing surface salinity and enriching further the coastal waters with suspended particulate material, which leads to what is reported as ‘coastal darkening’ of waters (Frigstad et al., 2023). As a consequence, the lower growth depth limit of several macroalgae species is reduced and a structural shift in the community composition from macroalgae towards increased abundance of animals is related to coastal darkening.

1.3.3. Geochemistry

Geochemical parameters and processes will also be increasingly affected by climate change. Warmer temperatures and increased soil moisture deficit has been predicted to lead to an increase in the mineralisation of nitrogen by over 30% following rewetting (Rustad et al., 2001; McAleer et al., 2022) and together with changes in land use and hydrology has already been blamed for increasing N export to the Baltic (Räike et al., 2020). Climate change in combination with less acid rain and land-use change have caused brownification of lakes in Europe, in particular in the Northern region (Finstad et al., 2016; Kritzberg, 2017). Increased evaporation and reduced flow lead to less dilution of nutrients, especially in rivers receiving urban wastewater and diffuse pollution from agricultural areas. Flooding or more frequent summer storms can deliver heavy nutrient loads during short time intervals (Kurz, 2000) and can cause more storm-overflows in urban wastewater systems, estimated to increase by 37% in volume for a high emissions scenario (Abdellatif et al., 2015). Increasing temperature and heatwaves may also interact with pesticides to increase the threat to aquatic ecosystems (Hermann et al., 2023). Reduced rainfall and increased evaporation and abstraction during droughts is already leading to increased salinization of lakes such as Trasimeno in Italy (Ludovisi and Gaino, 2010). Coastal sediments are important sinks of trace elements and contaminants. Coastal erosion and hydraulic perturbation can disrupt the sediments, leading to the remobilization and transport of toxic metals and contaminants(Eggleton and Thomas, 2004). While linked to global ocean acidification from atmospheric CO_2, coastal acidification is also driven by processes specific to coastal areas, as land-based runoffs, nutrient inputs, coastal upwelling and algal blooms (Rosenau et al., 2021). Low pH prevents some animals (oysters, clams, corals) and plankton to build and maintain their shells and skeletons, as carbonate ions become less available in acidic waters. Other threats to marine life by the coastal acidification include food web disruption and behavioural changes. Increased CO_2 concentrations in freshwater can also have implications such as enhancing phytoplankton blooms in low to moderate alkalinity lakes with high nutrients (Verspagen et al., 2014)

1.3.4. Impact of sea-level rise

Global sea levels are predicted to rise between 0.63 and 1.01 meters by 2100 under the highest greenhouse gas scenario (IPCC, 2021). Sea level rise will have the most direct impact on transitional and coastal ecosystems by increasing the flood risk, exacerbating erosion, as well as leading to salinization inland. For example, higher sea levels have already started to lead to a receding in the deep edge of seagrass colonisation in the Mediterranean (Pergent et al., 2015). For tidal marshes, their ability to cope with sea level rise depends on a sufficient sediment load to allow accretion and the tidal range, but many are likely to become sub-tidal by the end of the century. Migration of zones landward is possible if this is not blocked by natural or anthropogenic barriers (Short et al., 2016; Schuerch et al., 2025). As sea levels rise and river flows reduce, saltwater will move further inland causing a ‘saline intrusion’ (Prandle and Lane, 2015). The increasing ‘saline intrusion’ will be most detrimental for upper estuarine, low salinity and tidal freshwater zones, which might progressively become ‘squeezed out’ against artificial barriers. This ‘estuarine squeeze’ increases vulnerability and ecosystem degradation (Little et al., 2022).

1.3.5. Complex environmental responses

Aquatic systems respond in a holistic way to climate change with different pressures having additive, synergistic or antagonistic interactions. Timing is also crucial, for example compounded events like the two successive rainfall events in May 2023 that led to the disastrous flooding in Emilia-Romagna (Italy) caused 12 categories of environmental impact (Arrighi and Domeneghetti, 2023). Warmer temperatures and increasing nutrient loads are a major reason why cyanobacterial blooms are appearing in more lakes (Paerl and Huisman, 2009). Extreme rain events can also cause cyanobacterial blooms in many lakes, including near-shore waters of very large lakes (Sterner et al., 2020). The major disaster in the river Oder in 2022 was a multifactorial event with the climatic factors of high solar irradiance, drought and low flows concentrating more substantial existing pressures such as industrial saline discharges and nutrients to promote rapid growth of an invasive brackish algae (*Prymnesium parvum*) the toxins of which killed fish over 100s of kilometres (Kolada et al., 2022; Schulte et al., 2022; Free et al., 2023).

1.3.6. Current and projected impact on EQRs

Long-time series of reference sites are particularly useful in understanding climate change and extracting its influence from other complex drivers. A ‘reference’ dataset identified a negative trend over the decade 2013-2023 for the French fish-based index particularly for upstream headwater sites. A potential solution proposed was to update index calculation to integrate new climate conditions allowing for separation of climate change effects from other anthropogenic pressures (Irz et al., 2024). Future climate impacts on a fish EQR for two Danish catchments were estimated for three scenarios as: wet (EQR: +0.01 & -0.06), medium (EQR: +0.04 & -0.03) and dry (EQR: -0.03 & -0.02) (all median catchment values) but results varied considerably locally underlining response complexity (Henriksen et al., 2021).

An extended suite of 25 WFD relevant indicators were used to examine historical and projected climate driven changes in lake Annecy in France including temperature, water column stability, thermocline depth and stratification start/end date. Projections estimated continued high or good conditions for nutrients and chlorophyll-a but with a substantial loss of suitable habitat for salmonids (Soares et al., 2025). Recent climate modelling of hundreds of lakes In Northern and Central-European countries indicate a small deterioration in EQRs for phytoplankton for all the stratified lake types included in the dataset after correcting for the impacts of phosphorus and geographic location (Thrane et al., 2026). This suggests that additional management effort may be required to maintain status under a changing climate.

The focus of the workshop is on the classification of ecological status in the context of climate change and so specific focus is needed on understanding how status is currently changing and may change in the future. The following sections compile MS experience on climate driven status change from three sources: 1) the 7th implementation reports of RBMPs, 2) WISE reporting (data on derogations and KTMs), and 3) Member State assessments collected through last year's survey.

1.4. Review of current impact of climate change on status according to Member States

1.4.1. RBMP reviews (7th implementation reports)

A review of Member States 3rd River Basin Management Plans (RBMPs) is available in the 7th implementation report (European Commission, 2025). These were reviewed to examine approaches to climate change across 22 EU Member States and revealed significant variation in implementation approaches and integration levels. Whilst the reviewed Member State RBMPs do not directly address the impact of climate change on WFD ecological assessment, across all assessed countries there is a shared acknowledgment of the impacts of climate change on water management, particularly concerning increasing flood risks and shifting precipitation patterns with a focus on adaptation.

From the perspective of addressing WFD ecological assessment in a changing climate, ECOSTAT will need to consider adaptation measures as a developing and significant influence on water bodies. Most nations have integrated climate considerations into flood risk assessments, in alignment with the EU Floods Directive, and many refer to national climate adaptation strategies within their RBMPs. However, notable differences emerge in the depth and progress of this integration. Some countries demonstrate a high level of comprehensive climate integration, while others exhibit more limited implementation. Drought management approaches also vary significantly, with some countries developing specific drought plans and others lacking formal drought management frameworks. Approaches to climate modelling further highlight disparities: for example, while the Netherlands and France incorporate detailed IPCC scenarios and long-term projections into planning, others cite uncertainty as a barrier to detailed modelling. Furthermore, even in countries with advanced planning systems, implementation gaps persist, particularly in translating climate projections into concrete, actionable measures.

Advanced approaches are evident in countries such as Belgium, which explicitly prioritises climate adaptation in RBMPs across Wallonia and Flanders, combining detailed flood hazard mapping with climate projections. Similarly, France integrates climate scenarios across its Flood Risk Management Plans (FRMPs), with the Adour-Garonne plan identifying climate adaptation as its primary objective. The Netherlands employs comprehensive climate modelling through the Delta Programme, using Dutch (Royal Netherlands Meteorological Institute/KNMI) scenarios based on IPCC projections for 2065 and 2115. Conversely, several countries show lower levels of integration. The Czech Republic's second-cycle FRMPs notably exclude climate change implications in flood modelling due to conflicting national climate impact studies, while Estonia concludes that climate change impacts on flood risk remain minimal. Similarly, Lithuania's planning documents lack explicit links between measures and climate adaptation rationale.

An analysis of drought management across Member States shows starker disparities. Hungary's 2019 Drought Management Plan includes defined indicators and mitigation measures, while Slovakia and Italy have region-specific plans. However, Austria, Estonia, Finland, and Latvia lack national frameworks despite recurrent droughts. France adopts a decentralised, voluntary approach, and Germany addresses drought within broader water strategies without standalone plans. In Greece the drought management plans are an integral part of the RBMPs.

Geographic and sectoral factors significantly influence adaptation approaches. Coastal countries prioritise sea-level rise and storm surge protection, with Croatia focusing on Adriatic coastal vulnerabilities and Denmark addressing both fluvial and coastal flooding threats. Continental countries emphasise changing precipitation patterns and seasonal shifts, with Finland noting transitions from spring snowmelt floods to year-round precipitation-driven events. Agricultural adaptation emerges as a critical concern across multiple countries, particularly regarding irrigation demands and groundwater depletion. Austria projects up to 80% increased irrigation demand in eastern regions, while Poland faces tensions between drought infrastructure improvements and broader adaptive management strategies.

The developing nature of climate change modelling and adoption of adaptation measures evidenced in the RBMPs raises questions regarding the potential use of derogations under the WFD. Those questions are considered in Section 3 below, Role of Derogations. Member States also report on RBMPs at a more granular level through WISE and more nuanced information on approaches to climate change are captured. Those data are described below.

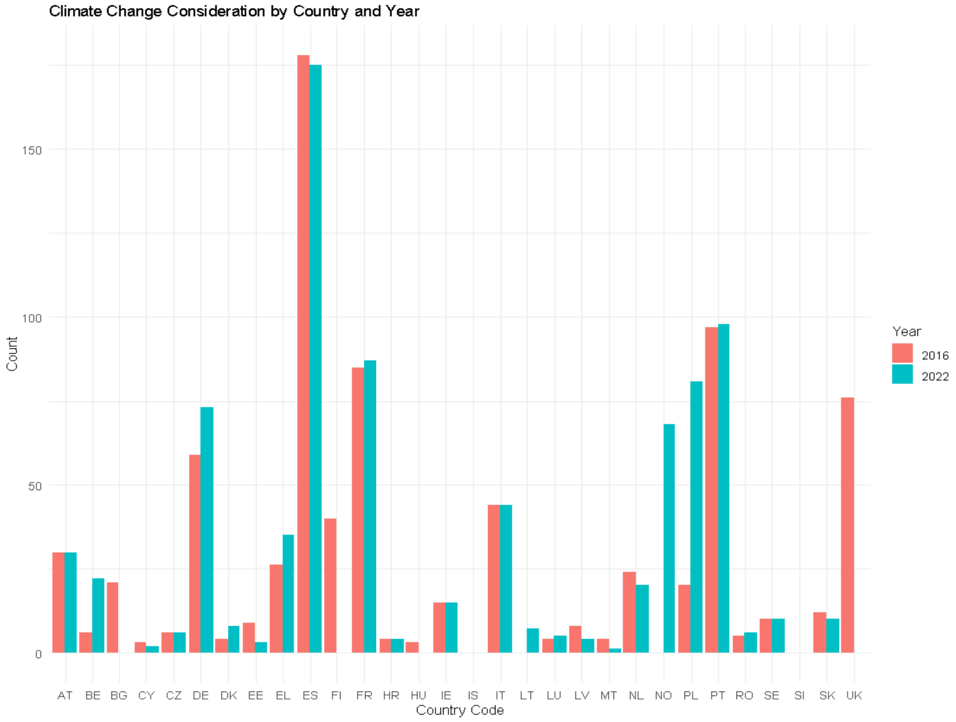
1.4.2. Data reported to WISE

Member states report data originating from their river basin management plans that is accessible on the EEA's discodata platform (https://discodata.eea.europa.eu/). This data has the benefit of being the official record from MS with reported granularity ranging from national to river basin district to waterbody level. Four components were examined:

1) Targeted questions on RBMP POMs regarding climate change
2) Exemption use
3) Significant impact types
4) Key types of measures used

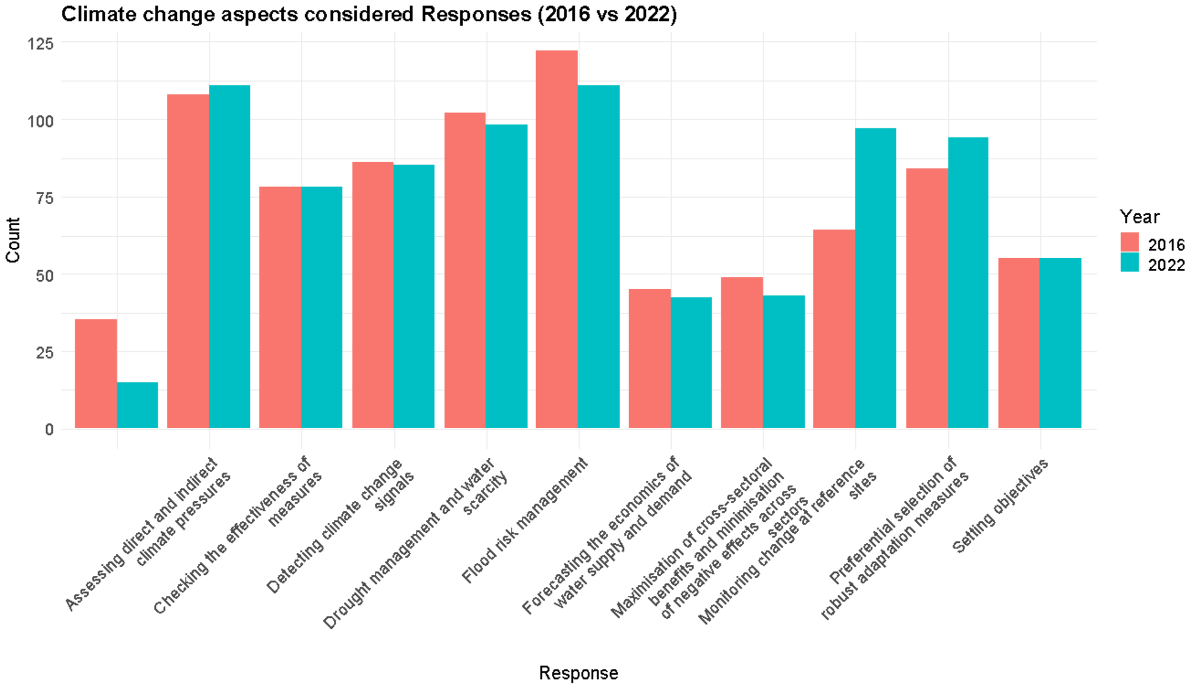
In the targeted questions, the majority of MS reported that climate change was considered in their POMS (Figure 1), although a lower number had used the official climate change guidance document (Annex 1, Figure 2). The specific aspects of climate change considered were most frequently flood risk management, direct and indirect pressures followed by drought management / water scarcity (Figure 2). Of specific interest to this work was the use of reference sites to monitor change carried out by 14 countries (Figure 3).

Figure 1. Count of RBDs where climate change has been considered by country in RBMP and POMs (Source WISE_WFD targeted questions on climate change; Table reference: RBMPPoM_TargetedQ_climateChangeAspectsConsidered).



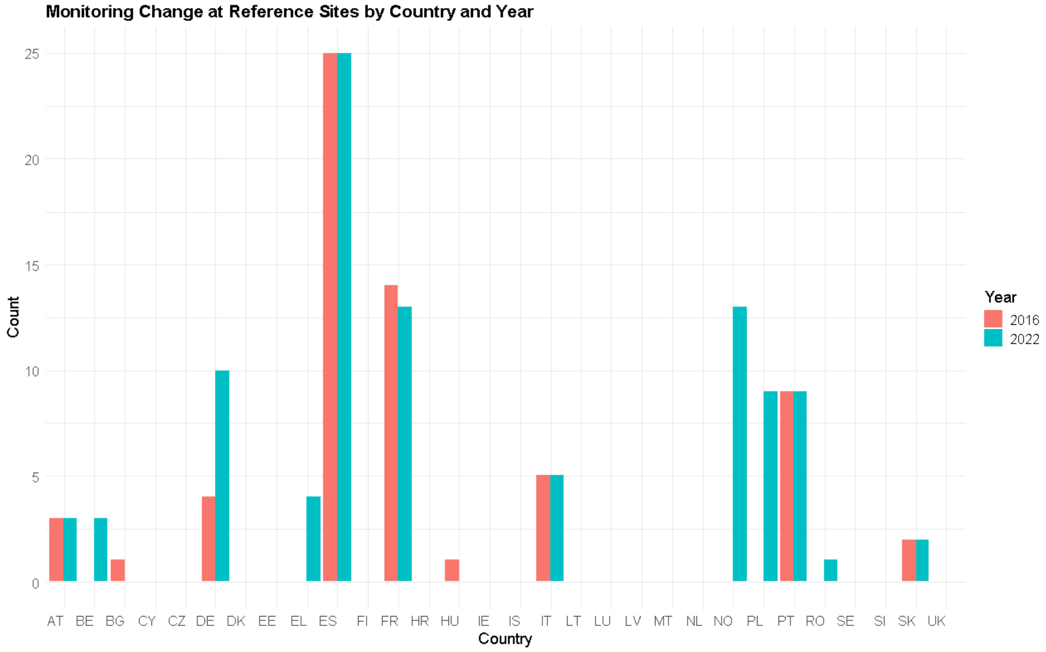
Source: Own elaboration

Figure 2. Count of RBDs where climate change aspects have been considered by reporting year (Source WISE_WFD targeted questions on climate change; Table reference: RBMPPoM_TargetedQ_climateChangeAspectsConsidered).



Source: Own elaboration

Figure 3. Count of RBDs where climate change aspect: “Monitoring change at reference sites” has been considered by reporting year (Source WISE_WFD targeted questions on climate change; Table reference: RBMPPoM_TargetedQ_climateChangeAspectsConsidered).

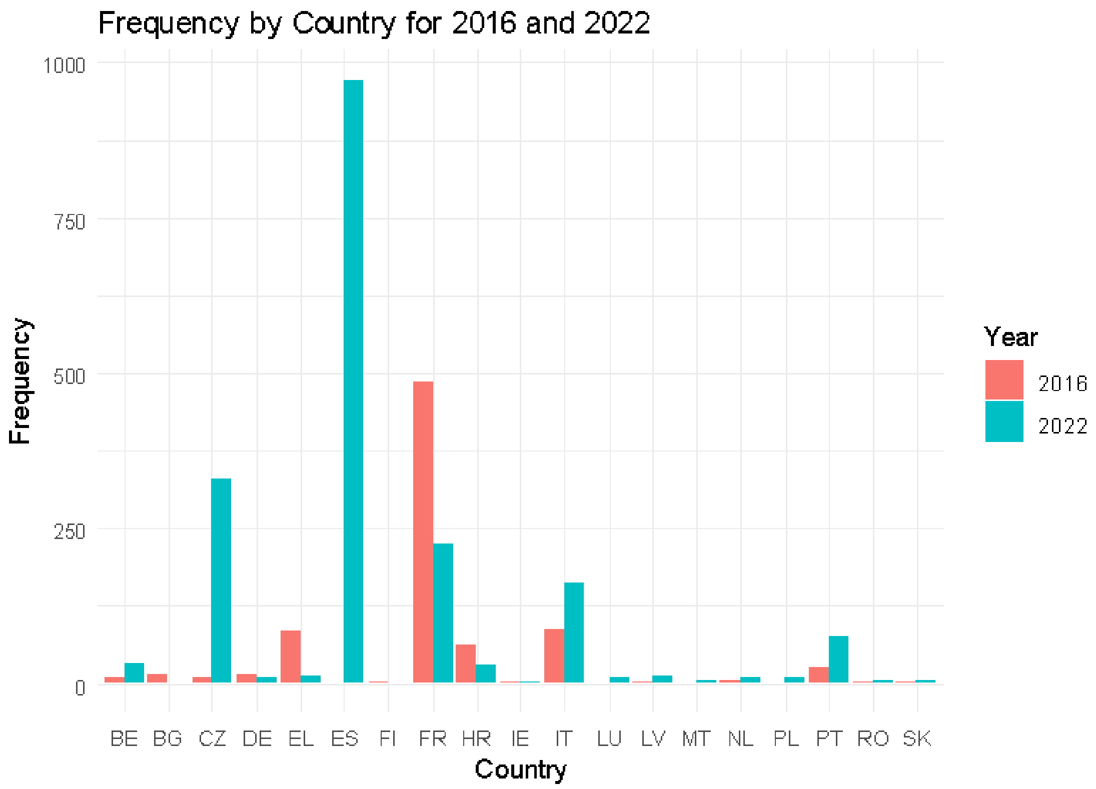


Source: Own elaboration

In WFD reporting the reasons for exemptions are recorded at RBD level, therefore there can be several exemption types per RBD. Only CZ, FR, IT applied for exemptions under article 4.5 (less stringent), while 12 countries applied for exemptions under Article 4.4 (extension) (Annex 1, Figure 3).

The surface water impact types identified in WFD reporting are: Chemical pollution, Altered habitats due to hydrological changes, Altered habitats due to morphological changes, Nutrient pollution, Organic pollution, Other, Saline or other intrusion, Acidification, Unknown, Elevated temperatures, Water balance / Lowering water table, Microbiological pollution, Inapplicable, Litter, Dependent terrestrial ecosystems, Associated surface waters. Those that are likely to be the most, but not exclusively, climate relevant, are Elevated temperatures (Annex 1, Figure 4) and Altered habitats due to hydrological changes (Annex 1, Figure 5). A total of 19 countries employed key type of measure 24 (Climate change) (Figure 4).

Figure 4. Frequency of KTM24 by country and year, Spain has a lot but often listed many measure names under this per RBD. Source table: KTM_basicmeasuretype.



Source: Own elaboration

1.4.3. MS assessments from 2024 ECOSTAT survey

In autumn 2024 ECOSTAT members completed a structured questionnaire regarding climate change impacts on ecological assessment (Bissett and O'Hare, 2025). Given the emerging nature of climate change, responses were subjective but the nature of the respondents as national experts in ecological assessment validated this approach in identifying emerging trends. Respondents considered that, at some level, climate change is already influencing Biological Quality Elements, Supporting Elements and Typology factors (Table 1). Several Member States were also able to provide detailed case studies.

Concerns previously raised by ECOSTAT members regarding climate change and its impact on WFD assessment were confirmed by the survey. In the expert opinion of respondents, the impact of climate change on WFD assessment will become more significant in the future (Figure 5). The survey results also indicate that current impacts from traditionally dominant pressures on water quality remain more significant than climate change, with nutrient status and hydromorphology identified as primary challenges. This is consistent with the very detailed European Environment Agency (EEA) collation of national reports on RBMP pressures and status (European Environment Agency, 2024).

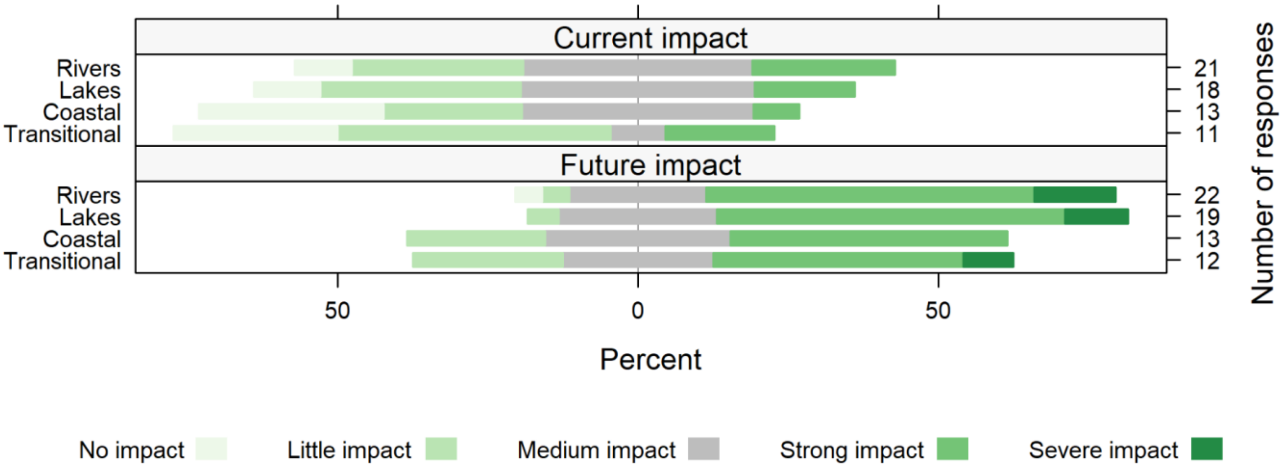
According to respondents, climate change impacts are beginning to be observed in site typology factors across all major water body types for a wide range of parameters. Respondents consider that, at some level, climate change is already influencing both Biological Quality Elements and Supporting Elements. Several climate impact factors are implicated, with particular concern that droughts, floods, heatwaves, changes to ice cover, seasonality and temperature can impact ecological assessment strongly or severely (Figure 6).

Approaches to addressing climate change impacts on ecological assessment appear to be at an early stage of development within Member States, with respondents identifying modelling, the use of historical data and expert opinion as potentially important methods for defining changes to reference condition attributable to climate change.

There was strong consensus among respondents that the topic requires deeper and better-informed understanding to support remedial action. The ECOSTAT respondents advocated new research, sharing information and the development of informative case studies.

Case studies were provided by many of the survey respondents, as well as additional case studies sourced during the preparation of this report (see Section 4), with the intention that this material will provide a focus for further discussions during the workshop on the practical measures required to tackle climate change impacts on ecological assessment.

Figure 5. Respondents' opinions on how significantly climate change is impacting current and future WFD assessment per water category.



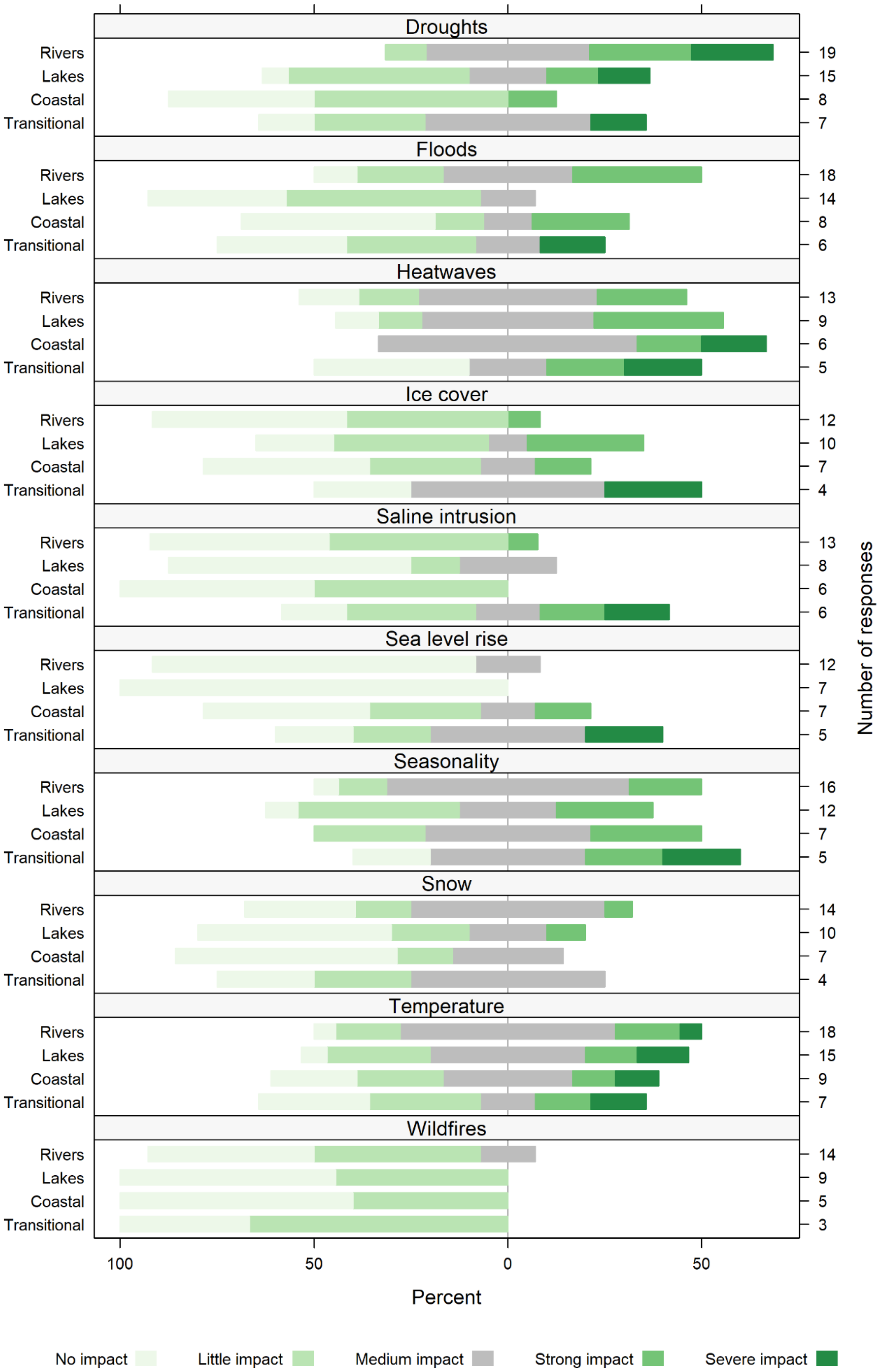
Source: Own elaboration

Table 1. WFD typology parameters with green bars and numbers representing survey based estimates of the importance of climate change.

	Lakes	Rivers	Transitional	Coastal
Altitude	0.6	0.8	0.0	0.1
Background nutrient status	1.5	1.7	0.3	0.3
Precipitation	2.5	2.8	0.5	0.3
Flow	0.4	3.3	0.7	0.1
Salinity/chloride/conductivity	1.6	1.7	0.8	1.1
Mean depth	1.6	1.5	0.4	0.6
Mixing/stratification	2.3	0.7	0.5	0.9
Morphology/shape	1.1	1.6	1.0	0.4
Region	0.8	1.2	0.2	0.4
Residence time	1.9	0.6	0.6	0.1
River width		1.7		
Size	1.6	1.7	0.5	0.4
Solids/turbidity (natural)	1.5	1.9	0.9	0.7
Substrate composition	1.1	1.4	0.5	0.7
Temperature	2.4	2.7	1.1	1.6
Tidal range	0.2	0.1	0.7	0.7
Water level fluctuation	2.4	0.8	0.3	0.3
Wave exposure	0.7	0.0	0.6	1.1
Geology: alkalinity	0.9	1.1	0.3	0.3
Geology: humic substances (colour)	1.1	1.3	0.1	0.1

Source: Own elaboration

Figure 6. Intensity of impact on ecological assessment from climate change factors identified by MS per water category.



Source: Own elaboration

2. Introduction to potential approaches

Given the significant current and future impacts identified above, the challenge is therefore in ensuring the framework can manage aquatic systems in the context of climate change, while maintaining focus on implementing measures to tackle key pressures such as nutrients and hydromorphological modification to achieve the environmental objectives of good or high status and to prevent deterioration. The fundamental approach to ecological assessment of the WFD will remain valid but it is clear it could benefit from being optimised to protect aquatic ecosystems for the coming decades alongside pervasive climatic change. According to the guidance the current approach is to reassign type but only when absolutely necessary. Where climate change is leading to a deterioration in status, before reassigning type a MS should first ascertain:

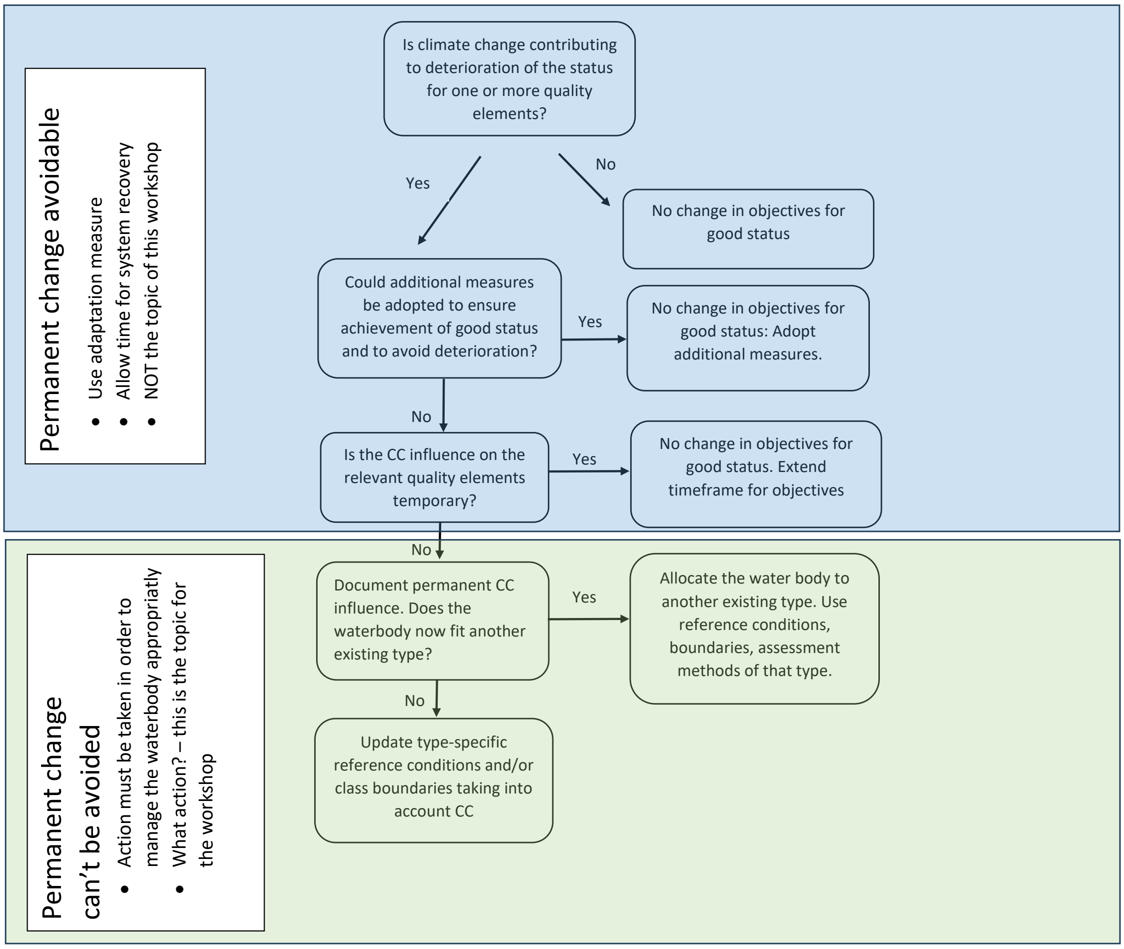
1. If additional measures could be adopted to ensure achievement of good status.
2. Whether the change caused by climate change is likely to be permanent (see Figure 7)

For the workshop we will examine the advantages and disadvantages of four potential approaches:

1. Maintain existing assessment system unaltered;
2. Reassignment of waterbody type (Nõges et al., 2007);
3. Identifying the portion of a response metric representing a sensitive biological quality element (e.g. macroinvertebrates, phytoplankton) as attributable to climate change and
4. Insertion of a new assessment module based on climate pressure and ecological response.

The overall purpose of the workshop is to stimulate, orientate and launch discussion, rather than prematurely forward an approach. Care should be taken in addressing the extremely challenging issue of how to manage Europe's waters over the coming decades. Can the assessment and management framework be adjusted or is a radical redesign needed?

Figure 7. Current approach recommended by guidance to ensure that climate change is having an unavoidable and permanent impact on status before considering a typology change.



Source: Own elaboration

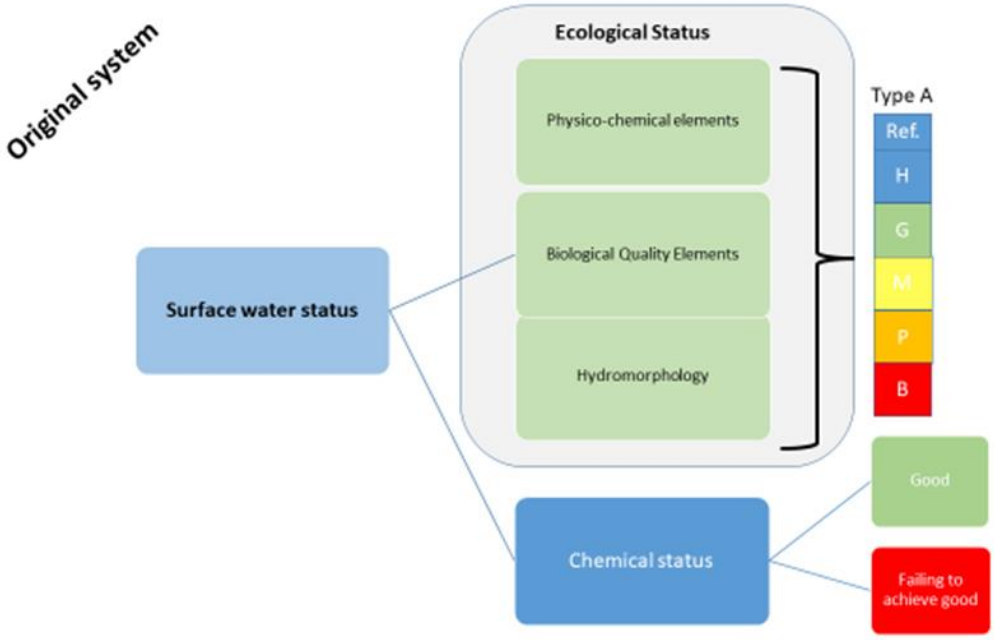
2.1. Maintain existing assessment system unaltered

The default approach is to continue with the established assessment system and approaches at national level (Figure 8). This is certainly preferable when permanent changes are avoidable as in the above diagram. Retention of the existing system also has the benefit of providing stakeholders and the public with a consistent measure of change over a timeseries. This also ensures that environmental objectives don't change although climate change may make achieving them more challenging or impossible. In addition, there would be no need to adjust national or international legislation. Many biological quality elements integrate the effect of several pressures such as nutrients, hydromorphology and would also integrate the effects of climate change reflecting the influence of anthropogenic impact in a broad sense. This may be welcomed by some stakeholders and the public seeking to understand the degree of total environmental change.

The disadvantage of maintaining the existing system is that it would not represent an adaptive management approach, although additional measures would remain possible. With increasing climate change the reference conditions may be outdated and consequently the environmental objectives will be no longer obtainable through management. In such cases this would conflict with the approach required under WFD Article 5(2) (update characteristics every 6 years) and current guidance to revise type when necessary. It may also present further challenges to management as it may be difficult to establish programmes of measures where climate change is confounding the response to other pressures.

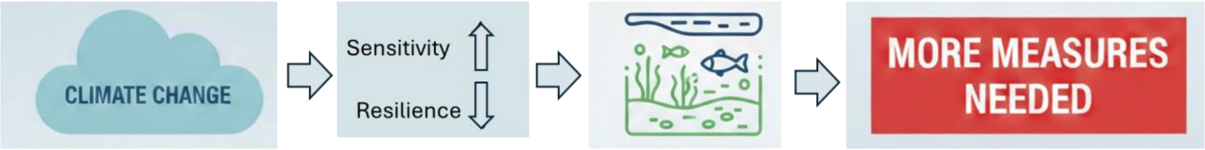
As part of this approach the boundaries of the relevant supporting QEs may need to be adjusted (tightened) to achieve good ecological status for the BQEs. More measures will be needed to achieve these boundaries. This is because the resilience of BQEs to nutrients, organic pollution and some hymo-pressures is likely to be reduced (Figure 9). The underlying reasons for this loss of resilience are related to the temperature increase in surface water bodies reducing oxygen solubility in water, as well as longer seasons, respiration and growth of the BQEs (Paerl and Huisman, 2009; Woolway et al., 2022). Moreover, droughts and floods will change the loads and concentrations of nutrients and organic pollution as well as changing the river flows and water level of lakes, thereby causing physical habitat alterations for many BQEs. Therefore, the boundaries of the relevant supporting QEs may need to be adjusted (tightened) to achieve good ecological status for the BQEs.

Figure 8. Original assessment components of the WFD classification system for surface water status.



Source: (Free et al., 2024) (CC BY 4.0).

Figure 9. Climate change is likely to increase sensitivity and reduce resilience to other human pressures in aquatic systems, thereby requiring more measures to be implemented to achieve good ecological status and provision of ecosystem services.



Source: Own elaboration

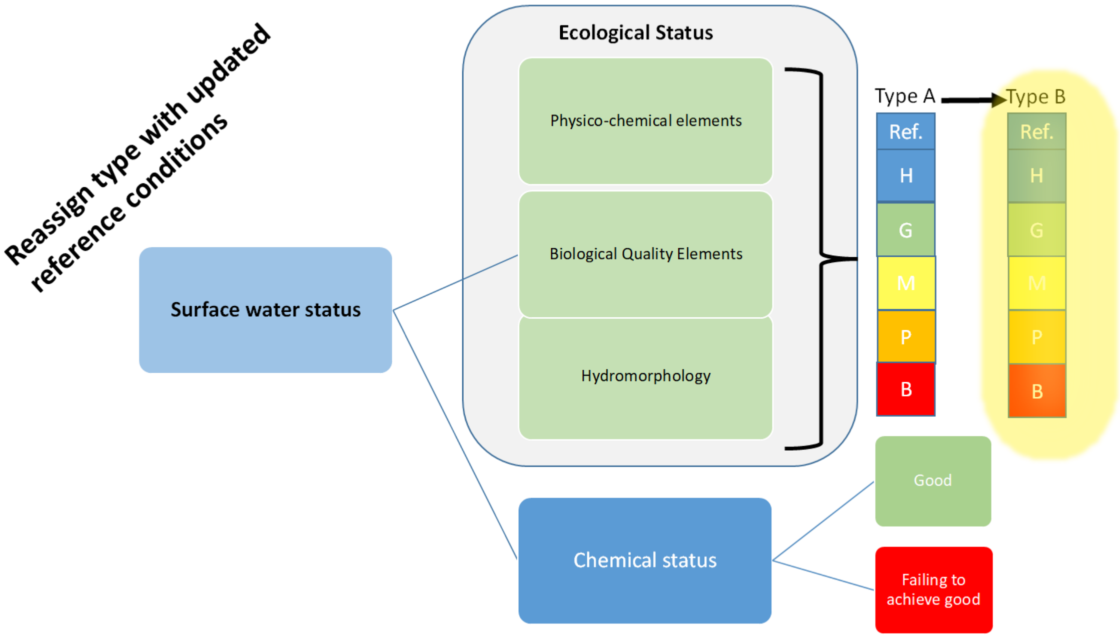
2.2. Reassignment of waterbody type

Surface water bodies are characterised into water body types defined by a set of obligatory (e.g. physical, geological, hydrological) and optional natural descriptors (e.g., water depth, mixing characteristic, background nutrient status) (Council of the European Communities, 2000). A number of these descriptors are climate-sensitive and could therefore result in waterbodies changing from one type to another over time or as a result of extreme events. For example, climate change could lead to reduced flow, which in extreme circumstances could mean a river switches to an intermittent stream type. See Table 1 for a list of typology parameters used (Lyche Solheim et al., 2019) along with estimated sensitivity to climate change from a MS survey - modified from the revised guidance document No. 24 “River basin management in a changing climate” (European Commission: Directorate-General for Environment, 2024).

The approach of reassignment of type together with its associated reference conditions is currently recommended by guidance document 24 (European Commission: Directorate-General for Environment, 2024). The core idea is that the new type and associated reference conditions will better describe the new climate-driven ‘background’ conditions, allowing the waterbodies to be managed towards achievable (realigned) environmental objectives such as high or good ecological status (Figure 8 and Figure 10 for current and proposed system). In practical terms a new type could be assigned by either i) moving the water body to an already existing type and simply applying its reference conditions or ii) in the absence of an existing type, a new one could be created necessitating definition of reference conditions and class boundaries (European Commission: Directorate-General for Environment, 2024). Guidance document 10 suggests methods for establishing reference conditions such as using spatial networks of existing reference sites, historical data, palaeoenvironmental approaches, modelling or expert judgement as a last resort (REFCOND, 2003). Monitoring and updating the conditions from a representative series of reference sites would allow for adaptive management (Nõges et al., 2007). The concept of reference conditions not being static in time and space is supported by studies of reference sites showing natural variability (Bouleau and Pont, 2015; White and Walker, 1997). The characterisation of waterbodies in a river basin district is required to be carried out every 6 years (WFD, Article 5(2)) and would allow a typology reassignment.

There are several drawbacks to this approach including the disruption to the time series for a waterbody with an EQR switching reference conditions and type thereby making assessment less transparent to stakeholders. It also represents an additional complexity for scientists already struggling to understand environmental change across multiple combinations of types, methods and classification rules applied in the 27 EU countries (Birk et al., 2012). There is also concern that adjusting type and reference condition may have to be done more than once. While an initial breaching of a resilience threshold due to climate change may result in a new community that could be used as a reference point, the reduction in resilience means that subsequent changes are more likely, with each change being accompanied by a successive reduction in the communities original species (O’Briain, 2019). In addition, the approach may be less useful for countries that have only broad types or generic assessment metrics.

Figure 10. Reassignment of type and associated reference conditions (yellow oval highlighted) to update assessment components of the WFD system of classification of surface water status in response to climate change.



Source: (Free et al., 2024) modified (CC BY 4.0).

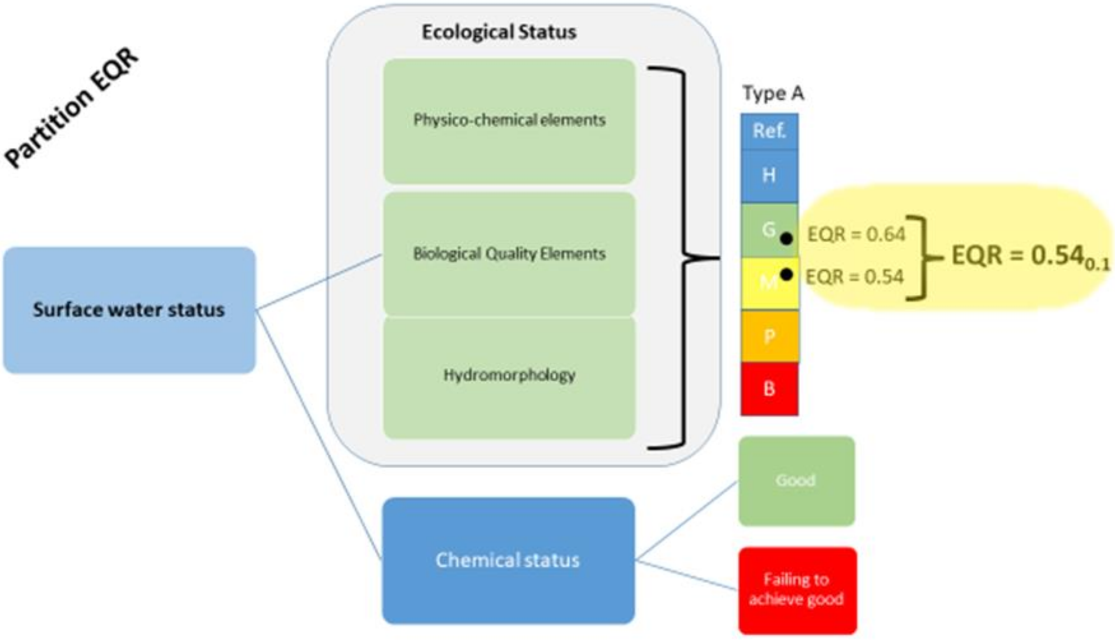
2.3. Quantify the portion of EQR driven by climate change

WFD monitoring and assessment systems are designed to incorporate the impact from multiple stressors. The key challenge is to maintain the integrity of these systems in a changing climate. One approach may be to attempt to separate the effects of climate change from other pressures. In particular, the BQEs may be uniquely useful in integrating the net influence of climate change alongside other pressures such as nutrients and hydromorphology. One possibility is to quantify the decrease in EQR estimated as attributable to climate change and notify this by adding a subscript value to an EQR. For example, a reported EQR of $0.54_{0.10}$ would indicate that established assessment systems have assigned an EQR of 0.54 (moderate status) but the subscript of 0.10 indicates that climate change is responsible for a decline of 0.10 EQR units (from 0.64 to 0.54) resulting in a change from good to moderate status. Essentially this would be conceptually similar to temperature anomaly maps where deviation from the established normal conditions are reported (Figure 11).

A key benefit of biological monitoring is that it integrates the effect of multiple pressures and their interactions and allows a results-based assessment of the effectiveness of management in the form of preservation or restoration of ecological quality. Apportioning a part of the EQR to the impact of climate change allows focus on the most important part of the assessment system – the ecological response to a complex mix of pressures such as altered hydrology, chemistry and interactions.

Some of the benefits of this approach are that it maintains the original EQR while adding additional information as to the climate driven component of it. The approach also makes transparent a member state’s estimate of how climate change is influencing a waterbody. It would allow a regional and European analysis of how climate change is affecting aquatic ecology. However, a key drawback is that reference conditions and environmental objectives may no longer be appropriate or achievable under climate change conditions. However, the proportion of EQR attributed to climate change could be useful to inform on the need to increase measures that could counteract the impact of climate change combined with other pressures to achieve good status and maintain ecosystem services. It could also inform on the application of exemptions.

Figure 11. Partitioning of EQR to quantify the part driven by climate change (yellow oval highlighted) to update assessment components of the WFD classification system for surface water status in response to climate change. The EQR value of 0.54 is the value determined by assessment of the biological quality element and the subscript indicates that climate change has caused a 0.1 decline – in the absence of climate change the EQR would have been 0.64.



Source: (Free et al., 2024) (CC BY 4.0).

2.4. Create assessment module of climatic pressures and ecological responses (Climate as a supporting parameter)

Currently the WFD requires the assessment of supporting parameters to ensure good ecological status or higher. These include nutrients, salinity, acidification, thermal conditions, oxygen, transparency and hydromorphology. The classification of ecological status is required to be carried out using these supporting elements as well as BQEs. Therefore, for example if phosphorus concentrations were deemed not to be supporting good ecological status or higher a waterbody could be classified as below good ecological status and in need of restoration. A similar approach could be applied to climatic factors if they are considered as a dynamic supporting parameter or pressure (Figure 12). For example, rainfall or drought indicators could be linked to aspects of macroinvertebrate community health in rivers or lakes. Such metrics could be considered in an overall assessment of ecological status. While gradual climatic change, such as warming, may impact ecological quality, so too can sudden climatic events such as floods.

The WFD six-year management cycle focuses on restoring status through established programmes of measures to reduce pressures such as nutrients and hydro-morphological modifications, while the exclusion of climate change as an anthropogenic pressure was due to the absence of mitigation options within this framework (Quevauviller, 2011). However, its exclusion as a pressure from assessment of water quality is generating an increasing gap in the understanding of ecological status decline when climate change is strongly interacting with other pressures (Birk et al., 2020; Spears et al., 2022). Countries that are particularly sensitive to climate change such as Spain with increasing droughts, low flows, higher temperatures and water quality issues that threaten sustainable development have pointed to gaps in policy and implementation suggesting that climate change should be mentioned as an anthropogenic pressure in WFD revision (Escribano Francés et al., 2017).

Current recommendations for incorporating supporting parameters include a stepwise process of establishing a significant relationship with ecological quality, defining thresholds that correspond to class change, emphasizing the transition point from good to moderate using either linear methods (ranged major axis) or categorical methods (binary logistic regression) (Phillips et al., 2024; Phillips et al., 2019). While this approach works for dominant drivers such as total phosphorus for phytoplankton in lakes, it is more likely that climate change parameters mostly act as secondary pressures with important interactions. Adopting a multi-stressor approach to setting boundaries or altering combination classification rules among supporting parameters may be needed rather than the one-out-all-out univariate system currently in use (Caroni et al., 2013). Classification outcomes could be assessed using a confusion matrix approach to manage false negatives and positives appropriately (Phillips et al., 2024). In addition, most existing BQE metrics have been developed to detect traditional pressures such as nutrients or general degradation and effort would have to be directed to establishing new climate orientated BQE metrics able to detect climate driven shifts in structure and function of ecosystems. An approach to this could include revisiting current metric components to allow greater specificity in response to specified pressures or climate. For example many river macroinvertebrate community based metrics decrease in response to both impacts and drying, while metrics specifically developed using groups of taxa with drought resistant and resilient traits have been found to be better placed to detect specific impacts in rivers susceptible to drying (Stubbington et al., 2022).

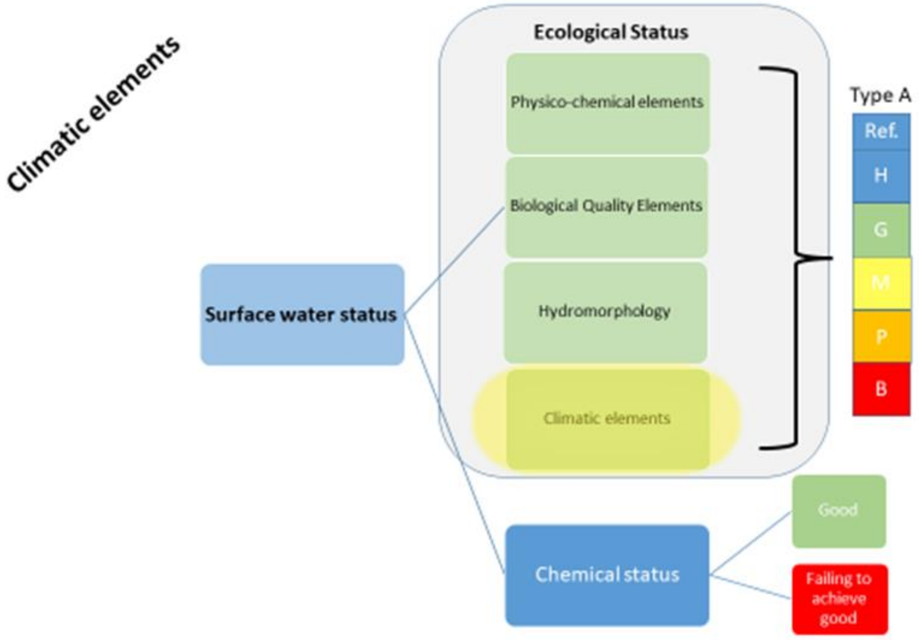
One of the key benefits of this approach is that inclusion of climate change as an increasingly important stressor provides essential context as to why some waterbodies may fail to improve their ecological status even if measures to reduce nutrients or hydromorphological pressures have been taken. Other water-bodies may even decline in status due to a combination of climate change and other pressures.

Grouping climate change alongside other pressures may be one of the most intuitive approaches. It also ensures the collection of appropriate data for developing a multi-stressor model of impact on status or on EQR values. Supporting information regarding the climate pressure experienced by a site could be collected as part of the WFD programme but detailed information can also be taken from annual European State of the Climate reports (https://climate.copernicus.eu/ESOTC) or reanalysis datasets (https://climate.copernicus.eu/climate-reanalysis). These provide data and maps on temperature anomaly, soil moisture deficit, river discharge etc. as well as associated documents on heatwaves and floods.

A pressure that signals a failure to provide supporting conditions for good status – such as climate driven low flows would prompt the exploration of targeted measures for mitigation or adaptation at local level. While the success of measures may not be guaranteed with the accelerating progression of climate change, a combination of several measures can still be effective to at least partly counteract the negative impacts. Such solutions include better governance, smart metering, pricing, green infrastructure, natural water retention, enhancing water-efficiency in agriculture and riparian zone management (Costa and Lopes, 2024; Escribano Francés et al., 2017; Kritzberg et al., 2020). However, one of the main reasons for the original exclusion of climate from the WFD was the difficulty in managing it in the context of reaching environmental objectives and some unmanageable impacts and events will require exemptions. Table 2 summarises some of the potential pros and cons of the different approaches.

It is one of the main objectives of the workshop to look at examples of waterbodies currently suffering from the effects of climate change and to voice solutions along with an objective evaluation of their use in management and fidelity to ecological assessment approaches and principles of the WFD.

Figure 12. Incorporation of a climate elements component (yellow oval highlighted) as a new group of supporting parameters to update assessment components of the WFD classification system for surface water status in response to climate change.



Source: (Free et al., 2024) (CC BY 4.0).

Table 2. Summary of four approaches to incorporate climate change into WFD assessment together with advantages and disadvantages. CC = climate change, POMs = programmes of measures. ooao = One out all out.

	Maintain existing system	Type reassignment	Partition influence of CC	Climate as a 'supporting parameter'
Summary of approach	**Current assessment system remains unaltered.**	**Move to another existing type or define new type.**	**EQR is reported using standard approach together with the proportion attributed to CC.**	**Climate is defined as a supporting parameter. Sites can then fail for climate when it fails to support GES.**
Advantages	***Provides stakeholders and public a stable measure of change over time.** ***No revision of legislation needed.** ***BQE will integrate influence of all anthropogenic pressures including climate change**	***Allows a framework where realistic management objectives can be achieved in the context of a changed climate. *Recognises that reference conditions are not static over time.**	***Allows a continued focus on pressures such as nutrients apart from CC. *Maintains integrity of timeseries. *Allows additional adaption measures to be included to counteract the negative impact of CC on EQR values. *Assessment of the fraction of change driven by CC could provide evidence for exemptions under the WFD. *Allows for transparency in effect of CC and subsequent decision making. *Allows an estimation at European level how CC is affecting aquatic ecology.**	***Provides increasingly essential context as to why some waterbodies may fail or decline in status. *Provides accessible and appropriate data for developing a multi-stressor model of status. *Understanding the driver of status failure allows for better planning of POMs including CC adaptation strategies. *A demonstrated failure driven solely by climate on the ooao principle could provide evidence for exemptions under the WFD in cases where additional adaptation measures to counteract CC impacts would not be sufficient to achieve good status. *Many metrics of climatic and weather related stress already exist and are available at appropriate spatial level. Allows for transparency in effect of CC and subsequent decision making.**
Disadvantages	***Not responsive to evolving conditions caused by climate change.** ***Climate change may shift baselines, making objectives unattainable.** ***May contradict WFD Article 5 requirements to update assessments every 6 years** ***Climate change can obscure the effects of other pressures, complicating action plans.**	***Climate change may continually occur rather than fitting a stage or type reassignment framework. *Difficult to maintain a timeseries on how quality has changed. *Could be interpreted as a de facto lowering of environmental objectives. *May not help countries who use few or one type for assessment. *Masks reality of the impact of CC on ecological status. *Reduces transparency in status and objectives assignment.**	***Technically difficult to precisely define.*Original reference conditions may no longer be appropriate. *Environmental objectives may no longer be achievable. *CC may influence nutrient loading or hydromorphology - impacts on a BQE may be indirect and not straightforward.**	***Introduces a supporting element that can cause status decline for which remediation may not be feasible. *Confounds typology and supporting parameters. *Interacts with other supporting elements, which makes it difficult to know whether the impact on BQEs are direct (e.g. warming) or indirect through impacts on other supporting QEs (e.g. increasing nutrient loads and concentrations). *Difficult to maintain a timeseries on how quality has changed if a new supporting element is included. * If CC is not considered as a pressure, the PoMs may not be able to include measures to counteract its negative impacts on BQEs and on other supporting elements.**

Source: (Free et al., 2024) modified (CC BY 4.0).

3. The role of derogations

Under Article 4 the WFD allows derogations/exemptions, under specific circumstances, where Member States will not be in breach of the Directive where good status is not achieved or deterioration is not prevented (Table 3). Climate change has not been explicitly used as a justification for an exemption submitted under the third RBMPs but many of the pressures causing exemptions are influenced by climate change (Common Implementation Strategy (CIS) Exemptions Task Group, 2025). However, examining the WISE database, exemptions stating climate change were detected (see Annex 1, Figure 3).

Could Article 4 derogations be invoked in relation to climate change to reduce or relax Ecological Assessment Targets?

The simple theoretical scenarios outlined below in Table 3 suggest that it is possible to imagine Article 4 derogations being invoked for water bodies subject to climate change impacts as well as where climate change adaptation measures may reduce WFD status. The official Common Implementation Strategy (CIS) guidance on WFD exemptions (latest CIS Guidance No. 36, updating the earlier Guidance No. 20) explicitly covers some of the project scenarios and clearly defines their regulatory constraints (European Commission, 2017; European Commission, 2009).

For example:

Review current impact of climate change on status assessments document are:

- *New Infrastructure for Adaptation*: Guidance No. 36 cites flood protection and reservoirs as examples of heavy modifications that can be allowed under Article 4.7's conditions but emphasises that ecological impacts must be limited to the minimum necessary and that any project granted a derogation should undergo climate-proofing to avoid maladaptation.
- *Abstraction Changes and Drought Measures:* Specific examples exist of Member States already interpreting Article 4.7 in a climate-changing context. In Finland, a city proposed a new groundwater abstraction scheme to address climate-influenced water scarcity risk. During the Article 4.7 process, the project underwent a full alternatives analysis, reduction in scope, and incorporation of nature-based mitigation to satisfy Article 4.7 – closely mirroring the kind of rigorous test the summary envisions while still responding to climate-driven pressures

A decision tree has been considered for evaluating whether or not climate change impacts can be derogated under the different sections of Article 4 but it has not been adopted (Figure 13).

Some key points for consideration are as follows:

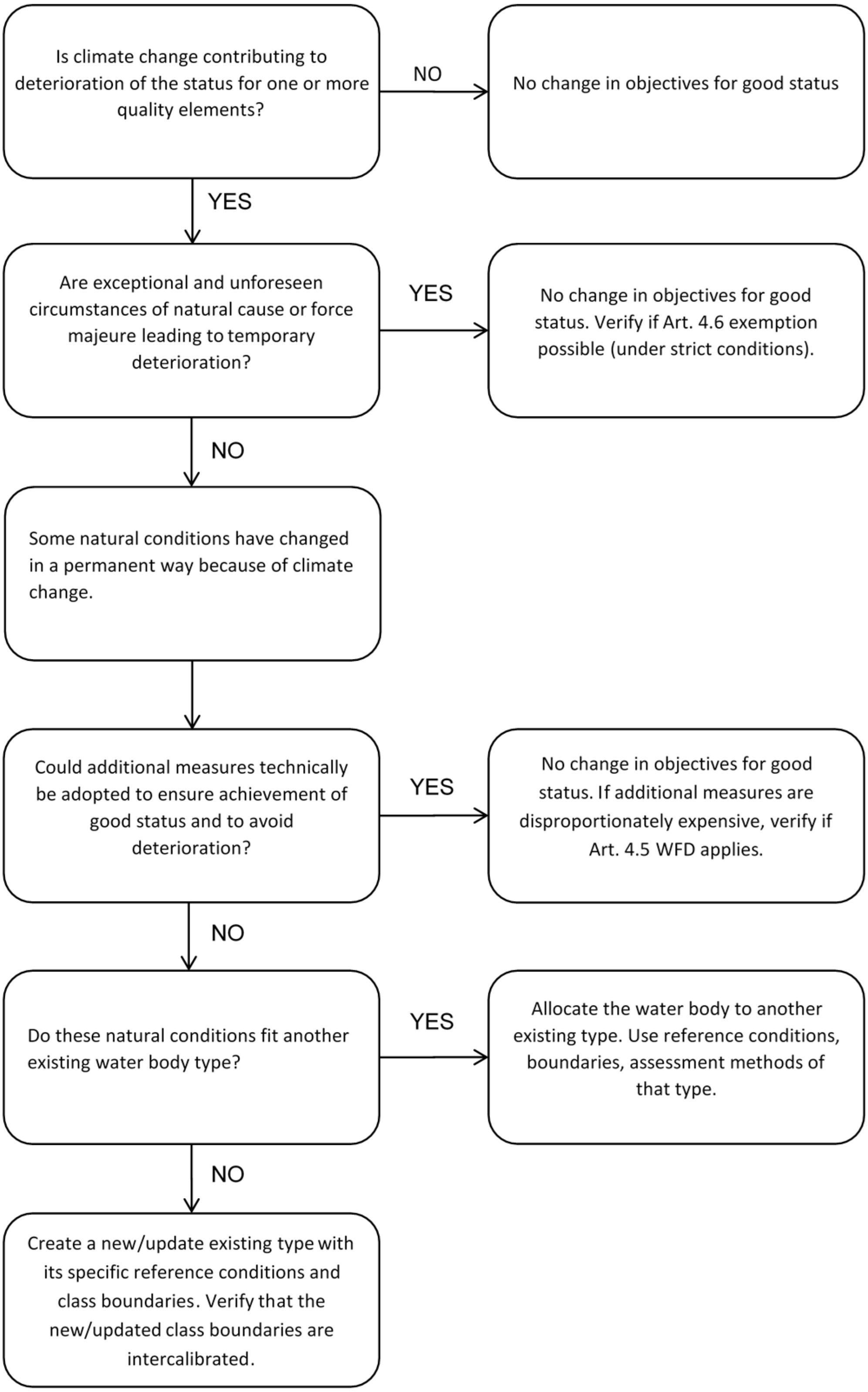
- Derogations under Article 4.5 are dependent on an interpretation of what constitutes an infeasible or disproportionately costly degree of mitigation. These are terms which are open to interpretation and would require careful definition in the context of climate change adaptation.
- Temporary derogations under Article 4.7 are reliant on how predictable an event is and interpretation of the concept of *force majeure*. The term does not have fixed or quantitative definitions in terms of the magnitude of a flood event or the duration of a drought. To avoid misuse, arguably, the term would need to equate to quantified thresholds
- Article 4 requires that the potential for derogations are outlined in advance under the RBMPs. This would require significant forward planning.
- A strong line would be required during the planning and assessment phases of adaptation measures to make sure mitigation was thoroughly addressed and implemented in a consistent fashion across Member States.

Table 3. Water Framework Directive Article 4 derogations. Each derogation type has specific qualifying conditions but commonly they require the RBMP to consider the derogation type in advance and all mitigation to have been reasonably considered. Both surface and groundwaters are considered.

Article	**Derogation**	**Context**	**Theoretical climate change scenario**
4.4	Deadline extension	To facilitate phased achievement of objectives Due to: i) technical feasibility, ii) disproportionate expense iii) natural conditions	A phased achievement of objectives is required following the creation of a flood alleviation scheme. It has river restoration components incorporated into the design which mitigate impact but it will take time for fluvial geomorphic processes to adjust to field conditions and improve status.
4.5	Less stringent objectives	So affected by humans or natural conditions it is infeasible or disproportionately expensive to achieve higher status	Abstraction in climate-induced drought years results in damaging drawdown where littoral macrophytes are damaged causing lower status. The Water Company abstracting the water has tried to mitigate impact by looking at alternative water sources and has encouraged reduced water usage by end users. There is no cost-effective alternative.
4.6	Temporary reduction in status	Resulting from a *force majeure* or exceptional natural causes, which could not have been reasonably foreseen, in particular, extreme floods and prolonged droughts	*Force majeure* is declared for a prolonged drought where climate change models predict an intensification of droughts, but an individual drought event cannot be attributed to climate change specifically.
4.7	Failure to achieve good status or GEP	Resulting from new modifications to physical character or new sustainable human development activities, where mitigation is undertaken and the new activity is of overriding public interest/benefit to society or the environment	A new flood alleviation scheme is required to mitigate climate change impacts. Natural Flood Management has been considered in the design as mitigation but hard engineering is still required, resulting in a failure to achieve good status.

Source: Own elaboration

Figure 13. Draft of a decision tree for evaluating whether or not climate change impacts can be derogated under the different sections of Article 4. This is for illustration purposes and has not been formally adopted.

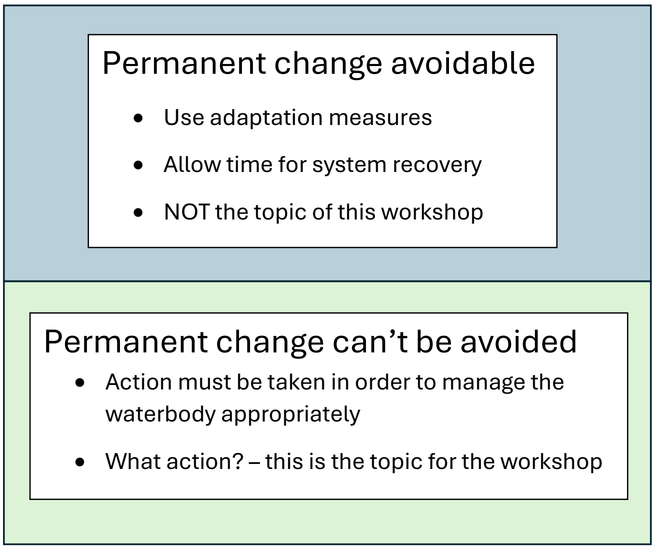


Source: Own elaboration

4. Case studies

Example case studies are provided to illustrate some core aspects or applications of the approaches but an analysis that is comprehensive of the diverse climatic impacts on the various water categories, types and biological, physical, chemical and hydromorphological components is not possible here. A selection of these case studies will be used for discussion during the breakout sessions at the workshop. Although they use real case studies, our discussion is meant to be open without any prejudice to the countries who supplied them and who are best placed to decide management options. Most importantly we should be careful to focus our discussion of what to do when permanent changes have occurred in a waterbody. The workshop should focus on the mechanics of status assessment in the context of climate change in such situations. The issue of adaptation measures to prevent change and temporary alterations to waterbodies could be considered separate as they don't require a permanent change to the assessment system (Figure 14).

Figure 14. Deciding when change is permanent is key to decision making.



Source: Own elaboration

4.1. Workshop tasks

The participants will be separated into three breakout sessions on rivers, lakes and TRAC. A series of case studies, largely supplied by Member States, will be examined (Table 4). The questions to be addressed can be specific to the case study but could follow the format:

1. If the case study represents a change that is not permanent what measures could be taken to reach the environmental objectives?
2. Could the system be managed using the original WFD classification system? (advantages/disadvantages)
3. If you reassigned the type what advantages and disadvantages would this have?
4. Could you use a set of 'climatic elements' to track change and could it be used as part of a classification system? What parameters would you select? (advantages/disadvantages)
5. Do you think that it would be possible to quantify the changes to the EQR caused by climate change, and if so what are the advantages and disadvantages?

Table 4. Overview of case studies

#	Title	Country	Waterbody Cat.	Climatic Change Trend
1	The Italian deep subalpine lakes	Italy	Lake	Warming trend, reduced mixing, altered nutrient dynamics.
2	Brownification of lakes	Northern Europe	Lake	Brownification due to climate change, reduced acid rain, and land-use change.
3	Norway – Lake Mjøsa	Norway	Lake	Increased temperature and flash floods causing phosphorus influx.
4	Norway – Lake Vansjø	Norway	Lake	Browning from humic substances due to climate change.
5	Slovakia – reassignment of WBs	Slovakia	River	Typology change and water bodies subdivision due to reduced flow and stream size change.
6	Slovakia – flooding impacts	Slovakia	River	Observed changes in BQEs following torrential rains and flooding.
7	Czech Republic – intermittent rivers	Czech Republic	River	Increasing irregular precipitation causing intermittent flow.
8	Hungary – intermittent rivers	Hungary	River	Typology change due to drift in intermittency patterns.
9	Norway – Sognefjord	Norway	Transitional	Warming and increased nutrient input causing oxygen depletion.
10	Denmark – coastal waters	Denmark	Coastal	Warming, increased freshwater discharge, and reduced wind speed.
11	Estuarine fish communities	Multiple (EU)	Transitional	Warming and reduced river discharge causing tropicalization of fish communities.

Case study 01: The Italian deep subalpine lakes - cascading effects from increased winter temperatures, reduced mixing and altered nutrient dynamics.

Water Category: Subalpine Lakes

BQE methods: Italian Phytoplankton Assessment Method (IPAM), BQIES (Benthic Quality Index Expected Species number)

Background

The deep subalpine lakes are of key economic importance in northern Italy and their size and depth make them a key regional water resource requiring priority management (Premazzi et al., 2003; Regione del Veneto, 2018).

Climate change trend

A warming trend has been detected in the lakes with annual average surface temperatures increasing by 0.017 °C yr^{-1} and 0.032 °C yr^{-1} in summer (Pareeth et al., 2017).

Impact on waterbody

This has led to more stable stratification and increasing isolation of the hypolimnion from the epilimnion, altering nutrient dynamics, with no complete mixing since 2006. This has led to a gradual decrease in oxygen concentrations in the hypolimnion with the result that climate now exerts more control on oxygen than trophic status (Figure 15) (Rogora et al., 2018). This, in turn, has also reduced nutrient transfer from the hypolimnion to the epilimnion resulting in alterations to phytoplankton composition (Salmaso et al., 2018).

Figure 15. Hypolimnetic oxygen depletion in a deep oligomictic lake under climate change.

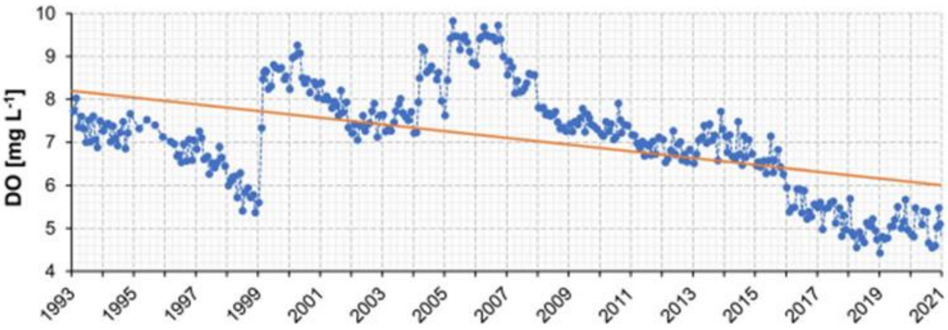


Fig. 6 Observed volume-weighted DO concentrations in the 200–370 m deep hypolimnion of Lake Maggiore for 1993–2020 (full turnovers occurred at the end of winters 1999, 2004, 2005; the solid line displays the linear trend, calculated on daily interpolated data)

Source: (Dresti et al., 2022) (CC BY 4.0).

Impact on BQEs

While in some cases, chlorophyll-a may decline with continued stratification, superficially indicating an improvement, the composition of the phytoplankton community may change or other biological quality elements such as macroinvertebrates in the sub-littoral and profundal zones may deteriorate given the lower oxygen concentrations below the thermocline (Rossaro et al., 2007).

Future risks

An issue of future concern is a possible mixing event that may deliver to the surface layer water with low oxygen and high nutrients (Dresti et al., 2023).

Workshop tasks

1. Imagine you reassigned the type for this lake to meromictic (rarely or never mixes) what advantages and disadvantages would this have?
2. What parameters would you monitor to track the influence of CC on this lake and if you included them in classification as ‘climatic elements’ what advantages and disadvantages would this have?
3. Do you think that it would be possible to quantify the changes to the EQR caused by climate change, and if so what are the advantages and disadvantages?
4. Could measures be taken to still reach the environmental objectives for all BQEs?
5. Could the system be managed using the original WFD classification system?

Case study 02: Brownification of lakes and a potential reduction in abundance of isoetid macrophytes

Water Category: Low and Mid altitude siliceous lakes

BQE methods: Macrophyte indices

Background

Climate change in combination with less acid rain and land-use change have caused brownification of lakes in Europe, in particular in northern regions (Finstad et al., 2016; Kritzberg, 2017).

Climate change trend

An increasing trend has been detected in many lakes in Europe although this may now be levelling off (Eklöf et al., 2021). However, for high acid deposition sites the brownification may represent a return to pre-industrial levels of dissolved organic carbon. In contrast, for lakes without high deposition, climate change is leading to increasing colour with ecological consequences (Meyer-Jacob et al., 2019).

Impact on waterbody

Increased colour can lower ecosystem services related to water provision through increased treatment costs and risk of chlorination by-products. In addition, humic substances interact with phosphorus and metals as well as lowering oxygen and increasing light attenuation in lakes. A loss of isoetids in lakes may represent the loss of a keystone species that provides structural habitat as well as acting to keep sediments oxygenated thereby maintaining oligotrophic conditions through retaining phosphorus (Free et al., 2009; Smolders et al., 2002).

Impact on BQEs

Considering status assessment, its impacts can be positive or negative for phytoplankton and alter fish foraging (Horppila et al., 2024). The reduction in light with increasing colour could alter macrophyte community types.

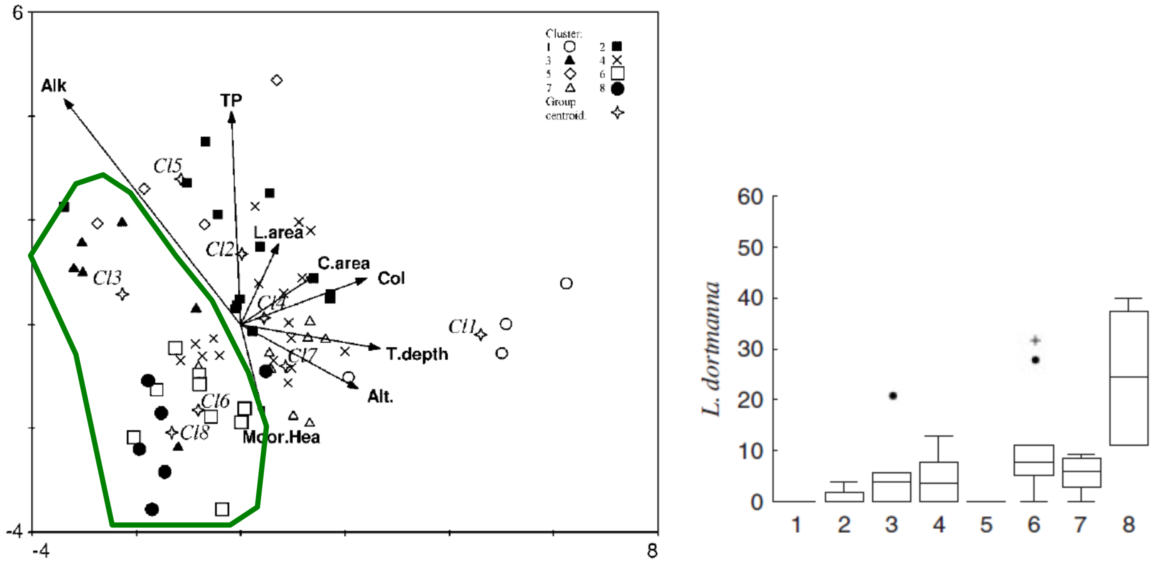
Future risks

Macrophyte indices are mostly designed to detect eutrophication pressure. A decline in the abundance of isoetid species will be recorded as a decline in EQR but caused by brownification rather than eutrophication (Figure 16). See horizontal ordination axis below that indicates that highly coloured lakes are less isoetid rich (Figure 17).

Figure 16. A lake in Ireland with an isoetid macrophyte community.

Source: Gary Free

Figure 17. Ordination of soft-water lake groups (In green Isoetid rich lakes) with environmental variables overlain. TP and alkalinity dominate the vertical axis and depth and colour dominate the horizontal axis. Boxplot of abundance of *Lobelia* by lake group.



Source: Modified from Free et al., 2009, © *2008 John Wiley & Sons, Ltd (reproduction under licence 6212400597558)*

Workshop tasks

Imagine you reassigned the type for these lakes to a humic type what advantages and disadvantages would this have?

What parameters would you monitor to track the influence of CC on this lake and if you included them in classification as 'climatic elements' what advantages and disadvantages would this have?

Do you think that it would be possible to quantify the changes to the EQR caused by climate change, and if so what are the advantages and disadvantages?

Could measures be taken to still reach the environmental objectives for all BQEs?

Could the system be managed using the original WFD classification system?

Case study 03: Norway - In Lake Mjøsa, Norway's largest lake, near-shore cyanobacterial blooms have become more frequent, likely due to warmer water and more frequent flash floods

Jan-Erik Thrane, Anne Lyche Solheim

Water Category*:* Lake

BQE methods*:* phytoplankton, macrophytes, invertebrates, fish

- Phytoplankton is classified by an intercalibrated method based on four indices/parameters; chlorophyll a, Phytoplankton Trophic Index (PTI), total biovolume of phytoplankton and annual maximum biomass of cyanobacteria. The classification system for macrophytes includes three indices related to changes in species composition due to different pressures: eutrophication, acidification and water level fluctuations (relevant in regulated lakes). The macrophytes eutrophication index (TIc) is intercalibrated. Invertebrates are classified based on littoral crustacean species composition and their responses to eutrophication (CIT) and acidification (LACI). Fish classification uses several methods ranging from a pelagic fish index for eutrophication, which is based on echo sounding, another index using gillnet fishing, and an index based on expert judgement where different types of data and observations can be used. In Lake Mjøsa, the pelagic fish index for eutrophication (WS-FBI), which is based on echo sounding, is used.
- Physico-chemical elements classified in lakes affected by runoff from agriculture and wastewater include parameters like nutrients (TP and TN), oxygen-profile and transparency (Secchi depth).
- At present, the national classification system does not consider effects from climate change, but the effects are to some degree mentioned in monitoring reports and surveys. We have observed effects of climate change on typology, for instance from increased concentrations of humic substances, as well as effects on status.

Background

Many water bodies suffer effects from other pressures in addition to effects from climate change, and the contribution from each pressure is difficult to distinguish. Climate change may, for instance, increase eutrophication as well as alter typology factors. How should water bodies that are affected by eutrophication be assessed in a changing climate?

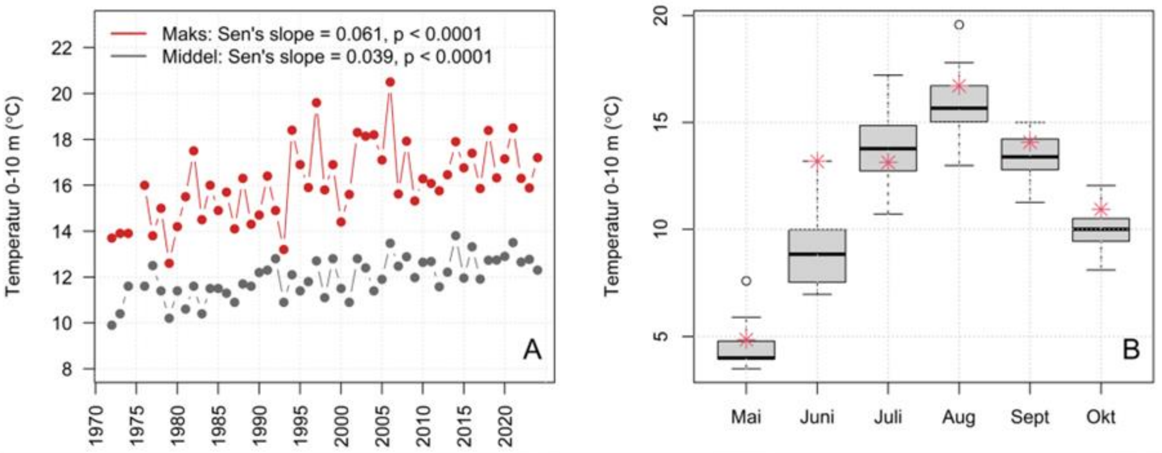
Lake Mjøsa is the largest lake in Norway and is included in the national surveillance monitoring programme for large lakes. The lake suffered from eutrophication with harmful algal blooms (cyanobacteria) in the 1970s, but a comprehensive programme of measures was implemented in the late 1970s, strongly reducing nutrient loads to the lake from wastewater and agriculture. During the period from 1980-2010, the lake was restored to good status and the algal blooms disappeared.

Climate change trend

Annual monitoring at the main pelagic station in Lake Mjøsa has shown a ~2 °C increase in epilimnion temperature since 1975 and a ~3.5 °C increase in maximum surface temperature from

14 to 17.5 °C (Figure 18). Flash floods during summer are also becoming more frequent in Norway during recent years (Sorteberg et al., 2018), likely bringing more nutrients to Lake Mjøsa (and to other lakes and rivers) due to the erosion of agricultural soils and overflow of urban wastewater.

Figure 18. A) Timeseries and trends in mean and max temperature in the 0-10 m surface layer in Lake Mjøsa, June-October 1972 to 2024. B) Monthly mean temperature in surface layer 1990-2024 (grey boxes; black horizontal line shows mean value; box showing 20- and 75 percentile). Monthly means for 2024 shown with red stars.



Figur 3. A) Tidsutvikling i middeltemperatur i overflatelaget (0–10 m) ved Skreia i perioden juni–oktober fra 1972 til 2024. B) Månedsvis fordeling av middeltemperatur i overflatelaget for årene 1990–2024 (grå bokser; svart horisontal linje viser medianverdi; nedre og øvre del av boks viser hhv. 20- og 75-persentil). Månedsmidler for 2024 er vist med røde stjerner.

Source: (Thrane et al., 2025) © Norsk institutt for vannforskning STI

Impact on waterbody

In recent years, potentially toxic algal blooms (the cyanobacterium a *Dolichospermum lemmermannii*) have reappeared in near-shore areas all around the lake, causing a ban on swimming in July 2019 and 2021 (Lyche Solheim et al., 2020, Thrane et al., 2022). These blooms were the first ones since the 1970s and appeared a couple of weeks after flash floods in early summer, likely causing substantial runoff of phosphorus from the agricultural fields around the lakes and additional nutrient loads from overflows of urban wastewater. The combined effects of warmer water and increased frequency of flash floods in early summer are hypothesized to increase the risk for harmful algal blooms in near-shore areas, while the off-shore pelagic areas are less affected due to the large size of the lake. Another massive flood in late summer 2023 caused high nutrient loads and very turbid water in the northern part of the lake. This flood did not cause any major algal blooms, probably due to light limitation of phytoplankton caused by the turbid waters. In July 2025 however, the blooms reappeared in near-shore waters.

Impact on BQEs

In addition to the recent cyanobacterial blooms seen in the near-shore waters of Lake Mjøsa, there are also other changes in the phenology of the BQEs. Analyses of data from the last 40 years have shown changes in the seasonal dynamics of phytoplankton and zooplankton (Moe et al., 2022). In the long run, climate-related changes in both phytoplankton and zooplankton phenology may also have implications for the fish communities. Such changes in seasonal dynamics will not necessarily be detected by our classification system in the short term.

In the pelagic areas of Lake Mjøsa, the BQEs are currently classified as good ecological status. Status for phytoplankton is close to the good-moderate boundary (nEQR = 0.62 in 2024). Physico-chemical supporting elements are classified as good (phosphorus) or high (transparency). Status in the off-shore waters has been somewhat stable over the last years, but moderate to large blooms of cyanobacteria have been observed in the near-shore areas. These blooms have not been detected at the monitoring stations of the national surveillance programme as they do not cover near-shore areas. This could be solved by including more stations in the near shore-areas in the monitoring design. We are also exploring how to include data from satellite observations in an ongoing project.

Climate change with combination of warmer water and flash floods increasing the runoff of phosphorus from agriculture and wastewater, are probably the causes of this reappearance of potentially toxic cyanobacteria blooms in near-shore areas, leading to a ban on swimming. However, near-shore cyanobacterial blooms have not appeared in all warm summers, e.g. not during the record warm summers of 2018, but this was an extremely dry summer with low nutrient loads. In one instance, a massive flood in late summer 2023 caused more turbid water and no algal blooms, probably due to light limitation, showing a complex interplay of factors. Climate change is therefore directly affecting the BQEs in Lake Mjøsa in several ways.

Future risks

The most significant future risk is the increasing risk for harmful algal blooms in near-shore areas of lakes like Mjøsa. This is due to the combined effects of warmer water and flash floods in early summer, which lead to a massive runoff of phosphorus. This risk is particularly acute in near-shore areas, while the larger, off-shore pelagic areas may be less affected. In the long run, changes in plankton phenology could have cascading effects on the entire fish community, potentially disrupting the food web and ecosystem balance.

Increased temperatures and changes in precipitation and water levels alters ice coverage in lakes, affecting stratification and light conditions. The ice cover of Lake Mjøsa has been reduced and complete absence of ice cover is becoming more and more common in the main lake. As glaciers withdraw due to climate change, rivers and lakes downstream, such as Lake Mjøsa and its main tributary, will eventually receive less of the cold and turbid waters from the glaciers. This will further aggravate the impacts of climate change as warmer and clearer waters, where more light penetrates, combined with prolonged summer stratification and less dilution of local pollution by oligotrophic melting water, are likely to increase algal growth even further, adding to the already existing problems with near-shore algal blooms.

Workshop tasks:

1. What parameters would you monitor to track the influence of CC on this lake and if you included them in classification as ‘climatic elements’ what advantages and disadvantages would this have?
2. Do you think that it would be possible to quantify the changes to the EQR caused by climate change, and if so what are the advantages and disadvantages?

Case study 04: Norway, Lake Vansjø, Increased nutrients and browning from humic substances due to climate change.

Jan-Erik Thrane, Anne Lyche Solheim

BQE-methods:

- Phytoplankton is classified by an intercalibrated method based on four indices/parameters; chlorophyll a, Phytoplankton Trophic Index (PTI), total biovolume of phytoplankton and annual maximum biomass of cyanobacteria. The classification system for macrophytes includes three indices related to changes in species composition due to different pressures: eutrophication, acidification and water level fluctuations (relevant in regulated lakes). The macrophytes eutrophication index (TIc) is intercalibrated. Fish classification uses several methods ranging from a pelagic fish index for eutrophication, which is based on echo sounding, another index using net fishing, and an index based on expert judgement for which different types of data and observations can be used. In Lake Vansjø, the pelagic fish index for eutrophication (WS-FBI), which is based on echo sounding, is used.
- Physico-chemical elements classified in lakes affected by runoff from agriculture and wastewater include parameters like nutrients (TP and TN), oxygen-profile and transparency (Secchi depth).
- At present, the national classification system does not consider effects from climate change, but the effects are to some degree mentioned in monitoring reports and surveys. We have observed effects of climate change on typology, for instance from increased humic substances, as well as effects on status.

Background:

Nutrients from agriculture have caused massive eutrophication in this lake since the 1970-ies.

Lake Vansjø in South-Eastern Norway is in moderate ecological status, mainly due to runoff from agriculture and waste waters. Monitoring has shown an impact on the biological quality element phytoplankton and supporting elements phosphorus, transparency and oxygen. Phytoplankton is in moderate status, whereas levels of phosphorus and transparency also indicate moderate status. Oxygen level is classified as moderate or poor (varying in different parts of the lake). In addition, both macrophytes and fish are assessed as being in moderate status based on surveys in the lake.

The major problem in the lake has been massive blooms of toxic cyanobacteria for many years, causing a ban on swimming in the most eutrophic lake basin. The lake also serves as raw water for > 60.000 people A huge programme of measures has been implemented to improve the ecological status and reduce the algal blooms, including agricultural nutrient reduction measures as well as better control of wastewater from scattered dwellings. This has resulted in a gradual and moderate reduction of nutrients and chlorophyll.

Climate change trend:

The impact of climate change with increased amount of rain and flooding was expected to increase runoff from agriculture and wastewater, hence increasing the amount of nutrients in the lake.

Higher temperatures combined with runoff of nutrients was expected to enhance eutrophication and frequency of algal blooms. However, Lake Vansjø has experienced browning after 2000, a phenomenon where humic substances from the surrounding catchment increase the brown colour of the water. This browning is a result of less acid rain combined with climate change (de Wit et al., 2016).

Impact on waterbody:

The browning, measured as water colour (mg Pt L^{-1}), started around the year 2000 but was fluctuating a lot during the period 1999-2006 causing the lake to switch back-and forth between oligohumic and mesohumic conditions. Since then, the lake has mostly been in the mesohumic range (> 40 mg Pt L^{-1}) and has been classified as a humic lake. As Norway only implemented the WFD in 2007, it has not been necessary to change the type from a clearwater to a humic lake.

Impact on BQEs:

Recent studies have shown that the browning has drastically reduced the harmful algal blooms due to light limitation (Lyche Solheim et al., 2024). Thus, climate change can also improve ecological status in lakes experiencing browning, in particular concerning phytoplankton.

For macrophytes, invertebrates and fish, however, the browning may potentially have negative effects due to reduced underwater light for isoetids and less oxygen for invertebrates and fish. There are no particular studies on that in the lake, so far.

Future risks:

If the browning is reduced, in particular in dry years with low inputs of humic substances from the catchment, there is a risk that the harmful cyanobacterial blooms can return to the most eutrophied lake basin. However, the risk is considered to be small-medium due to all the implemented nutrient reduction measures that have brought the phosphorus concentration down towards good status. However, continued warming, flash floods bringing in more nutrients and/or less focus on measures could potentially lead to new blooms of another harmful algae (*Gonyostomum semen*) which is known to create blooms in meso-eutrophic humic lakes.

Workshop tasks

See section 4.1

Case study 05: Slovakia – reassignment of water bodies as a result of climate change

Emília Elexová

Water Category: River

BQE methods: Biological Macrophyte Index for Rivers, Slovak assessment of benthic invertebrates in rivers, ecological status assessment system for rivers using phytobenthos, (fish typology is specific and phytoplankton assessment is relevant only in large lowland rivers, hence they were not included in reassignment).

Background

In some water bodies located within hilly areas (200-500 m a.s.l.) with small-sized streams, where the lowland lower section is impacted by climate change (increasing temperature, reduced flow etc.), a gradual decrease in ecological status has been recorded. To better reflect the changed conditions of the related stream, the longer water body (with stringent/"highly-ambitious targets") is divided into two water bodies representing different typological sections: upper (within the original type) and lower (more affected, assigned to the new type), representing the changed conditions.

Climate change trend

This case study was submitted to the 2024 ECOSTAT survey and the respondent categorised the changes described above as "typology change" (from a choice of drought-related / flood-related / typology change / biological change – timing / biological change – spatial distribution / other) with the characteristics of the changes deemed as drift (as opposed to "abrupt change").

Impact on waterbody

A single water body is being re-categorized into two separate water bodies. This change is in response to the different effects observed in different sections of the stream. Specifically, the lower, lowland section is more significantly impacted by climate change, experiencing increased temperatures and reduced flow.

Impact on BQEs

A gradual decrease in ecological status has been recorded in these waterbodies. This is a direct impact on the BQEs, as the ecological status is an overall assessment based on various BQEs. While information has not been submitted on which BQEs are affected, the recorded decline in ecological status is a clear indicator that the biological health of the waterbody is deteriorating, particularly in the lower, more impacted section.

Future risks

The main risk highlighted is the continued decline of ecological status in these waterbodies, particularly in the lower sections that are more vulnerable to climate change. The proactive measure of dividing the waterbody and assigning it a new type is an attempt to mitigate this risk by setting more realistic and appropriate targets.

Workshop tasks

See section 4.1

Case study 06: Slovakia – flooding impacts: observed changes in BQEs following torrential rains and flooding

Emília Elexová

Water Category: River

BQE methods: Fish Index of Slovakia - FIS, Biological Macrophyte Index for Rivers, Slovak assessment of benthic invertebrates in rivers, ecological status assessment system for rivers using phytobenthos, assessment method for rivers using phytoplankton.

Background

After long-lasting torrential and frequent rains, floods cause a decrease in diversity and the related metrics values and thus also a deterioration of status (phytoplankton+chlorophyll a, benthic invertebrates), by increasing flow, velocity, solids/turbidity, nutrient content, sediment movement, physico-chemical parameter changes, etc. After the initial elimination, changes in functional diversity are observed in phytobenthos community. Fish community and functional diversity of macrophytes are also affected, depending on the duration of the flood period.

Climate change trend

This case study was submitted to the 2024 ECOSTAT survey and the respondent categorised the changes described above as "flood-related" (from a choice of drought-related / flood-related / typology change / biological change – timing / biological change – spatial distribution / other) with the characteristics of the changes deemed as "abrupt" (as opposed to "drift").

Impact on waterbody

Floods caused by long and frequent rains lead to a number of physical and chemical changes in a waterbody. Specifically, floods cause an increase in flow, velocity, solids/turbidity, and nutrient content. They also lead to sediment movement and changes in various physico-chemical parameters.

Impact on BQEs

- **Fish:** After torrential rains at least 1 month is needed for stabilization and recolonization by original communities. Flushing can cause a decrease in abundance and diversity, and an absence of typical species, which is reflected in assessment metrics potentially leading to deterioration of ecological status based on fish quality element.
- **Macrophytes:** Torrential rains and floods destroy both the riparian zone and the riverbed substrate and create unstable conditions for the development of macrophytes. Therefore, mainly helophytes (but also tolerant species) are flushed away and fewer species are found as well. Lower diversity can also be found. But both situations can happen so status based on macrophytes can be over or underestimated.
- **Benthic invertebrates:** Sediment/substratum movement, increasing flow velocity and physico-chemical changes cause major changes in benthic invertebrate community structure. Mostly lower diversity is evident, which has the consequence of underestimating. But the resulting status based on macrozoobenthos is influenced also by the resistance of more stable species.

- **Phytobenthos:** After torrential rains and floods, status based on phytobenthos can be over or underestimated, both situations can happen. It depends on which species are eliminated. When species tolerant to pollution are eliminated and/or pioneer species occur (reflecting better conditions) improvement can also be found.
- **Phytoplankton:** In the case of phytoplankton-based assessment, torrential rains cause decrease in status level as indicative metrics of abundance (number of cells), number of species, chlorophyll-a concentration decline and proportion of abioseston (inorganic particles) decrease and negatively affects phytoplankton.

Future risks

Case study details the immediate impacts of a flood event. The main risk implied is the recurrent deterioration of a waterbody's ecological status following prolonged and frequent rainfall events. The changes in functional diversity of multiple communities (phytobenthos, fish, macrophytes) could lead to long-term instability in the ecosystem if these flood events become more frequent.

Workshop tasks

See section 4.1

Case study 07*:* Czech Republic – rivers have become intermittent, and a new typology and new BQE assessment methods are required

Michal Straka

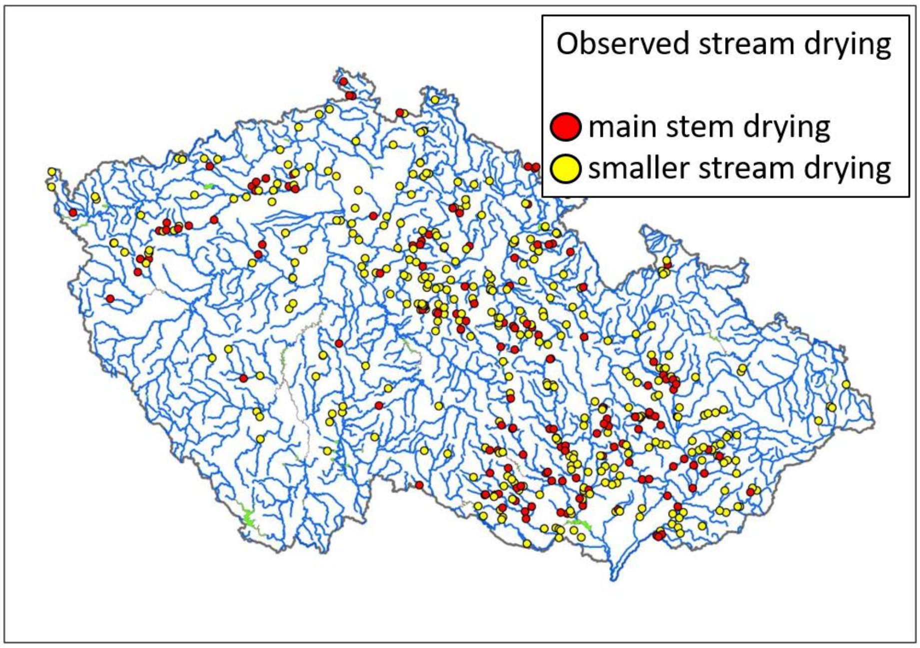
Water Category: River

BQE methods: To assess the ecological status of water bodies that lose surface flow during the summer season, the methods developed for perennial streams are used. Spring and autumn sampling during the flowing phase are taken for benthic invertebrates and phytobenthos, and processed and evaluated in the same way as from perennial streams. Fish and macrophytes occur only marginally in the intermittent streams. Phytoplankton is not a relevant BQE for small streams (methodology is used only for rivers with Strahler order 7-9).

Background

All water bodies in the Czech Republic were defined as perennial with permanent discharge, however, due to the increasing irregularity of precipitation, some water bodies have started to dry up periodically and should be viewed as temporary (Figure 19). The phenomenon of some water bodies completely losing surface flow has recently become increasingly frequent and we can assume that the problem is likely to escalate. The loss of surface runoff has an impact on the BQEs, which are then affected by drought, even if all other natural conditions remain good. The current assessment system in the Czech Republic is only set up for perennial flows and therefore it is not possible to achieve good ecological status in these water bodies. Adaptive measures in this case have only limited usefulness. For this reason, a research project has been initiated to identify intermittent water bodies in the Czech Republic and to adjust the ecological status assessment methodology so that these streams can also be evaluated.

Figure 19. Map of the Czech Republic with streams where complete flow cessation and stream drying was observed during 2000-2023.



Source: Michal Straka

Climate change trend

The climate change trend is increasingly irregular precipitation. This case study was submitted to the 2024 ECOSTAT survey and the respondent categorised the changes described above as drought related (from a choice of drought-related / flood-related / typology change / biological change – timing / biological change – spatial distribution / other) with the characteristics of the changes deemed as "drift" (as opposed to "abrupt").

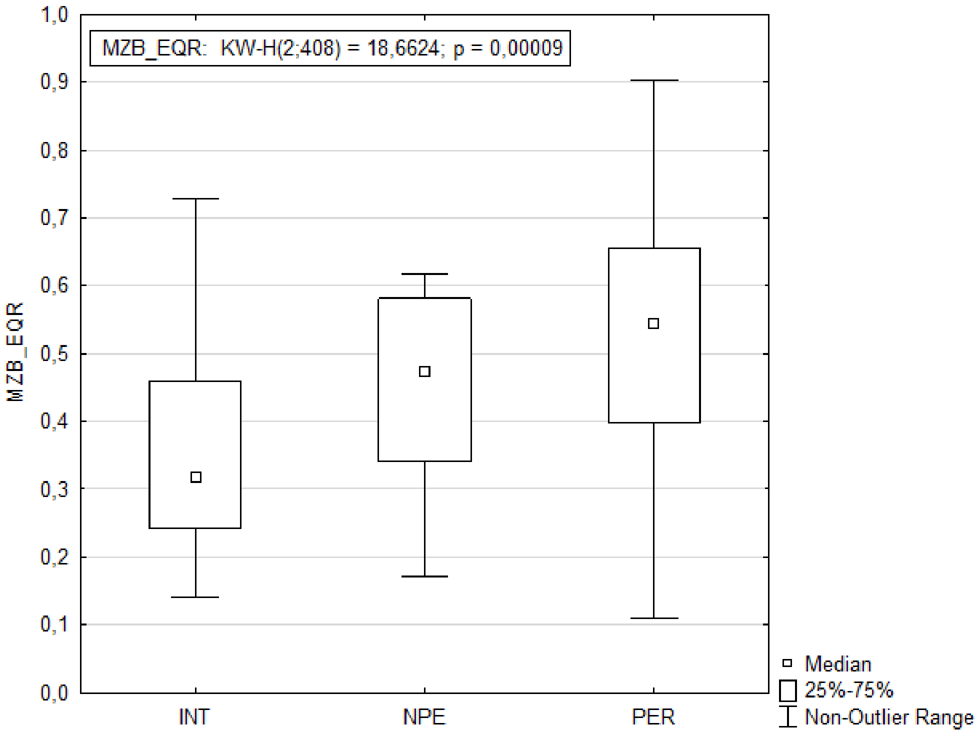
Impact on waterbody

Waterbodies have become intermittent and temporary.

Impact on BQEs

The loss of surface runoff directly impacts BQEs by exposing them to drought conditions, even when other environmental factors are favourable. This phenomenon complicates the assessment of ecological status, as the current system in the Czech Republic is exclusively designed for perennial flows. As a result, it is not possible to accurately determine whether affected water bodies have achieved a good ecological status. In streams where drying was observed, the ecological status based on benthic macroinvertebrates was, on average, one class lower compared to the ecological status of streams of the same type but without drying (Figure 20). Phytobenthos status did not change in relation to stream drying, and other BQEs (fish, macrophytes) cannot be reliably evaluated and used for waterbody assessment.

Figure 20. Differences in EQRs of benthic invertebrate communities in intermittent (INT), near-perennial (NPE), perennial (PER) water bodies. Only water bodies with good chemical status and type where intermittent streams were present are included.



Source: Michal Straka

Future risks

The case study highlights a growing risk associated with increasing precipitation irregularity, which has led to some water bodies becoming temporary rather than perennial. This problem is expected to escalate, resulting in more frequent and widespread loss of surface flow. The current assessment methodology is ill-equipped to handle this growing issue, necessitating the development of a new framework to properly evaluate the ecological status of these intermittent water bodies.

Workshop tasks

1. Are there grounds here to establish a new water body type? Advantages vs. disadvantages.
2. How to recognize intermittent stream (high space and time variability) and what kind of data are needed? For example: gauging stations vs. modelling vs. use of dataloggers vs. personal observation.
3. Are communities in intermittent streams consistent and stable enough to define reference conditions?

Case study 08: Hungary –rivers becoming intermittent requiring a revision in typology

Pál Boda, Tamás Bozóki, Zoltán Csabai and Gábor Várbíró

Water Category: River

BQE methods: Macroinvertebrates

Background

Hungary developed guidance during 2020-2024 on the intermittent character of water bodies which contain categories of empirical intermittence (what can be seen in the river) and categories of water management (the cause of the empirical intermittence/permanency, e.g. water abstraction). Based on this the whole length of water bodies was analysed and a map produced based on route calculation in GIS. It was the first time that water bodies could be analysed based on their different intermittency, and not only as a whole water body but section by section. It will be the basis of reach delineation/revision based on CEN 14614:2020 and of monitoring planning and water body review. Intermittent types are also intended to be revised. The first observations show that there are water bodies where intermittency changes along the water body based on geological, geomorphological characteristics and human interventions, and it is not obvious that drier sections are upstream sections. Monitoring planning based on intermittent character is ongoing; the new knowledge will be first be taken into account in nitrate and hydromorphological monitoring. Also, the review of water bodies is ongoing. Hungary uses grouped water bodies (based on same type and very similar pressures, small water bodies in the same catchment were grouped into one water body). Assessments of intermittent character show that within grouped water bodies different intermittency can be detected. To allow status assessment these grouped water bodies will be analysed along with the revision of their typology.

Climate change trend

The observed climate trend is through rivers becoming intermittent. This case study was submitted to the 2024 ECOSTAT survey and the respondent categorised the changes described above as typology change-related (from a choice of drought-related / flood-related / typology change / biological change – timing / biological change – spatial distribution / other) with the characteristics of the changes deemed as “drift” (as opposed to “abrupt”).

Impact on waterbody

Intermittency of waterbodies can change along their length, rather than being uniform.

Impact on BQEs

This case study focuses on the effects of flow intermittency on macroinvertebrate communities both at taxonomic and functional levels, rather than solely presenting a methodology for identifying and categorizing intermittency. Intermittency were shown to alter community composition, functional diversity and ecosystem functions. To capture the hydrological dynamics underpinning these changes, detailed flow investigations were carried out using high-frequency dataloggers and retrospective modelling. This combined approach enabled a robust characterization of intermittency patterns and their ecological consequences. The improved understanding of intermittent regimes not only informs monitoring design for supporting elements such as nitrate and hydro-morphology, but more importantly provides the basis for assessing the biological consequences of flow intermittency under the WFD, ensuring more reliable assessment of ecological status.

Future risks

The case study describes a proactive solution to a current problem. The ongoing work to identify and map intermittent waterbodies, revise their typology, and adapt monitoring plans is intended to mitigate the risks associated with an inaccurate or outdated assessment system. The new methodology will provide a more precise way to manage water resources by considering the varied intermittent nature of different sections of a waterbody.

Workshop tasks

See section 4.1

Case study 9: Norway – Oxygen trends in Norwegian waters, Sognefjord

André Staalstrøm, Evgeniy Yakushev, Anfisa Berezina, Shamil Iakubov, Lars Golmen

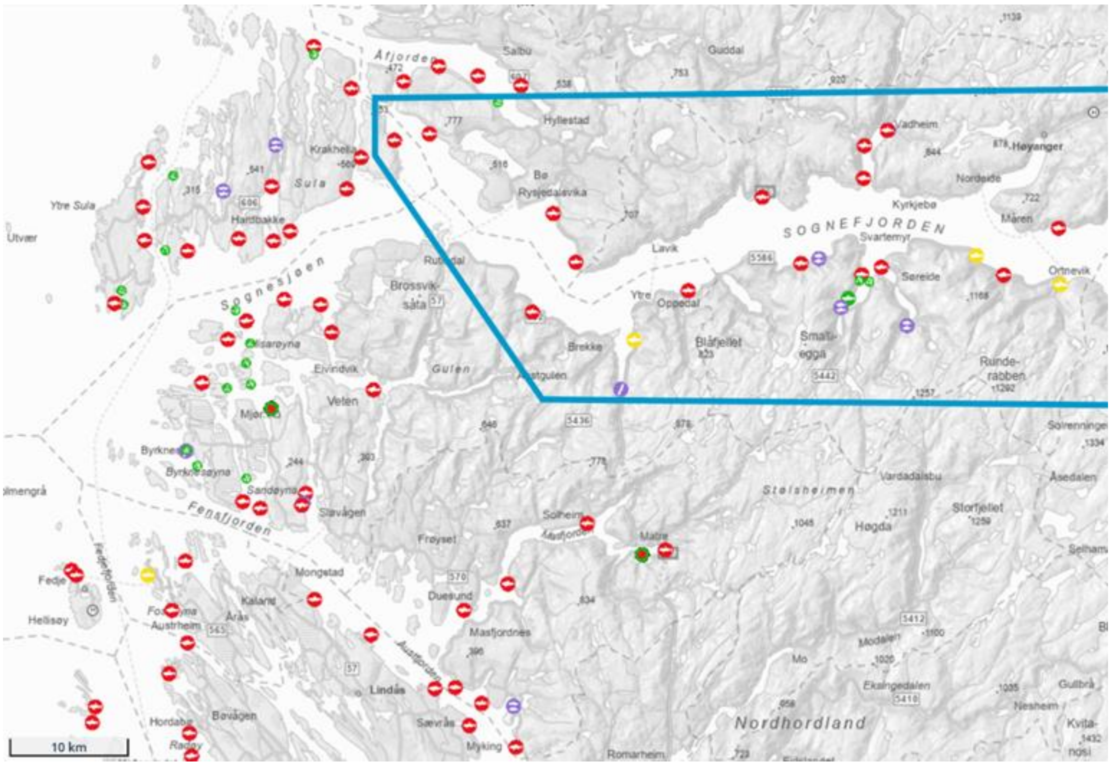
Water Category: Coastal and transitional waters (fjords)

Background

Data from Norwegian fjords south of Trondheim show that oxygen concentrations have decreased in many places (Staalstrøm et al., 2025). In the inner parts of Storfjorden within Ålesund, oxygen concentrations have decreased by 0.5-1.0 ml/L in the period 1991-2023 (Figure 21). The same decline can be found at a depth of 1,000 metres in the Sognefjord between 1970 and 2020. Decreases in oxygen concentrations have also been reported in many other threshold fjords in Western Norway. In the open water masses off the Norwegian coast, we found no significant changes in oxygen concentration, but the data here is limited. Decreases in oxygen concentration may be due to increased temperature, increased input of organic matter and nutrient salts, or a combination of these. In both open and coastal water masses along the Norwegian coast, there has been a clear warming of the water, and water at a depth of 150 meters has become 0.6-0.7 degrees Celsius warmer over the past 35-40 years. This is consistent with global trends in ocean temperature.

To quantify the effect of inputs vs. temperature rise, the Sognefjord was used as an example. Inputs to the Sognefjord within the Losna sill (area inside blue polygon in the map below) have increased by a factor of 1.5 for nitrogen and 3.4 for phosphorus. Red dots on the map are aquaculture sites.

Figure 21. Map of Sognefjord showing area within the Losna sill (blue polygon). Red dots are aquaculture sites.



Source: kystinfo.no modified by (Staalstrøm et al., 2025).

When modelling the oxygen conditions in the Sognefjord, approximately two thirds of the decrease in oxygen concentration can be attributed to increased input and the last third to increased sea temperature. The increase in sea temperature that we see along the entire Norwegian coast, which also coincides with global trends, means that the fjords are more vulnerable for discharge of nutrients and organic matter.

Climate change trend

- **Water Temperature Increase**: Water at a depth of 150 meters has become 0.6-0.7 degrees Celsius warmer over the past 35-40 years.
- **Effect on Fjords**: This warming trend, along with increased inputs of organic matter and nutrients, has led to a decrease in oxygen concentrations in Norwegian fjords.
- **Attribution of Oxygen Decrease**: A model for the Sognefjord attributed approximately two-thirds of the oxygen decrease to increased nutrient and organic matter input and one-third to the increased sea temperature.

Impact on waterbody

Data from Norwegian fjords, specifically in Storfjorden and Sognefjord, shows a significant decrease in oxygen concentrations. In Storfjorden, the decrease was 0.5-1.0 ml/L between 1991 and 2023, while in Sognefjord, the decline was observed at a depth of 1,000 meters between 1970 and 2020. This decrease is attributed to a combination of factors, including warming of the water and an increase in the input of organic matter and nutrient salts. Specifically, water at a depth of 150 meters has become 0.6-0.7 degrees Celsius warmer over the past 35-40 years. In the Sognefjord example, increased input of nitrogen and phosphorus was a major contributing factor to the drop in oxygen.

Impact on BQEs

No direct mention of the impact on specific BQEs like fish or invertebrates. However, it is well known that in aquatic ecology decreased oxygen concentrations (hypoxia) can severely stress or kill most aquatic organisms, especially fish.

Future risks

The most significant future risk is that fjords are becoming more vulnerable to discharges of nutrients and organic matter. This is due to the increase in sea temperature, which is consistent with global trends. The text's modelling of the Sognefjord shows that roughly two-thirds of the oxygen decrease can be attributed to increased inputs, while one-third is due to rising temperatures. As temperatures continue to rise, the fjords' ability to cope with nutrient loads from sources like agriculture and aquaculture will diminish, exacerbating the problem of declining oxygen levels and threatening the overall health of these ecosystems.

Workshop tasks

See section 4.1

Case study 10: Climate change is counteracting efforts to improve ecological status in Danish coastal waters

Jacob Carstensen

Water Category: Coastal and transitional waters

BQE methods: Phytoplankton (summer chlorophyll biomass), benthic vegetation (macroalgae cumulative cover, eelgrass depth limit), oxygen depletion (SQE)

Background

Nutrient inputs to coastal waters have been reduced drastically through the course of several management plans, but recovery from these reductions has not been fully realized. This is mainly because of other stressors and climate change (Riemann et al. 2016).

Climate change trend

Since the 1970s, temperature has risen by around 2 °C, and four out of the five warmest years have occurred in the last five years. Freshwater discharge has also increased by around 10% over the same period, and the last two years had record-high discharges. Average wind speed has also decreased over the last 50 years, creating more stratification and reducing oxygen supply to bottom waters.

Impact on waterbody

Nutrient management plans have resulted in declining nutrient concentrations in coastal waters, although this has only had a modest effect on Secchi depth. Light conditions have not improved to the same extent as nutrient concentrations. The last two years were among the worst for light conditions and the spread of hypoxia, even though nutrient levels were much lower than in the 1980s and 1990s. This renders Danish coastal ecosystems vulnerable to extreme events such as wet years with high freshwater discharge. Finally, warming has a negative effect on oxygen conditions by lowering oxygen saturation and increasing respiration.

Impact on BQEs

Despite declining nutrient concentrations chlorophyll levels remain high, with chlorophyll concentrations achieving a record high in the last two years. Warming has led to an increase in the chla:TN ratio over time, suggesting that phytoplankton have become more effective in utilizing nutrients, i.e. warming is enhancing nutrient turnover which increases the production of organic matter. Cumulative cover of macroalgae has improved slightly, although not everywhere. Eelgrass depth limits are much lower than 100 years ago and have not changed in the last 30–40 years. Physical disturbance from fishing activities contributes to the lack of deeper eelgrass populations. However, there is no evidence of large eelgrass populations dying off because of marine heatwaves.

Future risks

Continued warming will enhance nutrient turnover with bloom developing earlier and later in the season. This prolonged productive season will increase annual production and the export of organic matter to the seafloor. This, in addition to warming effects, will enhance oxygen depletion, promoting nutrient release from sediments. This could lead to a downward spiralling effect, counteracting efforts to restore coastal ecosystem functioning and status.

Workshop tasks

See section 4.1

Case study 11: Effects of increase in temperature and reduction in river discharge over three decades on fish in estuaries

Water Category: Transitional waters

BQE methods*:* Fish index in northeastern Atlantic Europe

Climate change trend

Over the past decade, from 2015 to 2024, each year has been the warmest on record since 1850. There is increasing evidence that global warming is significantly altering biodiversity at various ecological levels. At the community level, climate change is causing local extinctions, species invasions, and shifts in the relative abundances of species, often leading to communities dominated by species that thrive in warmer conditions. This trend has long been linked to the expansion of tropical and subtropical species towards the poles.

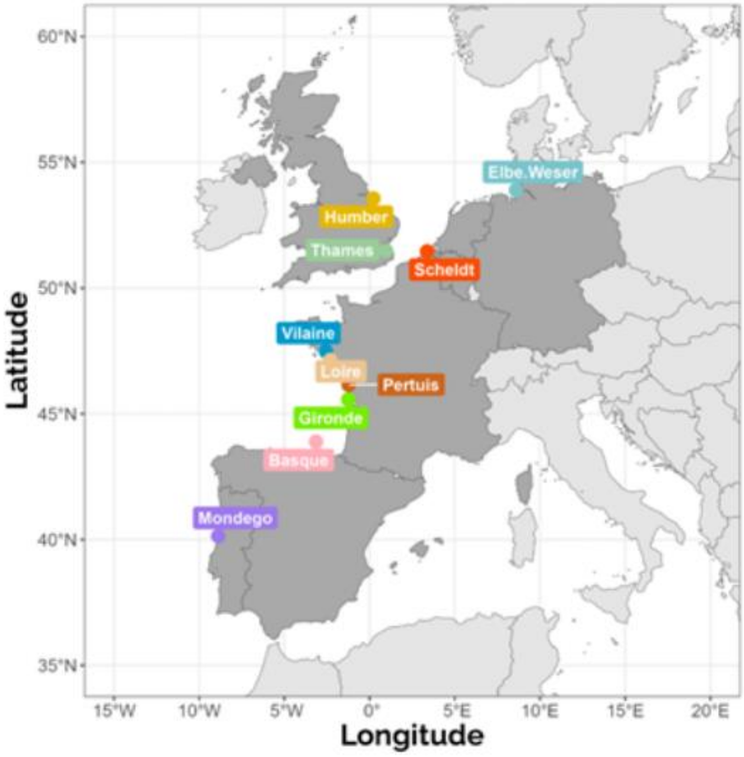
Impact on environmental conditions

The rise in air temperature also triggers several other abiotic changes in aquatic environments, such as increased water temperature, reduced dissolved oxygen, decreased water discharge, and more frequent extreme events. For the purposes of the Water Framework Directive (WFD), these effects of climate change will also impact what are known as reference conditions for several taxonomic groups. Fish in estuaries are one of these groups under surveillance for the WFD that is being affected by climate change.

Impact on BQEs

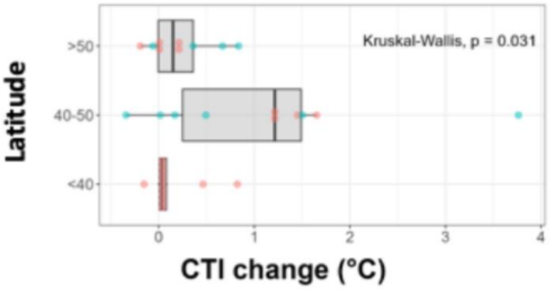
Fish abundance time series from 10 estuarine systems across northeastern Atlantic Europe, from Portugal to the UK, were analysed using a Community Temperature Index (CTI) (Figure 22). Our findings reveal a broad reorganization of estuarine fish communities, with a growing predominance of warm-affinity species. This trend is more intense at mid-latitudes (Figure 23). Overall, tropicalization is the dominant trend, but this trajectory appears to unfold in distinct phases that vary with latitude and ecoregion. Communities in Portuguese estuaries remain relatively stable, suggesting that the Bay of Biscay could be a transition zone. Conversely, northern estuaries show signs of deborealization, which may represent an early stage of climate-driven community reshaping (Lobry et al., 2026).

Figure 22. *Estuaries used for the CTI exercise*.



Source: (Lobry et al., 2026) submitted.

Figure 23. Relationship between the value of the Community Temperature Index (CTI) change (between late and early years) and the latitude (in °N) of the estuary mouth.



Source: (Lobry et al., 2026) submitted.

Additionally, as river discharge is affected by climate change, we observed in a long-term series on the Gironde estuary where mean annual discharge decreased by 330 m^3/s between 1975 and 2020, from 1160 m^3/s to about 830 m^3/s. This reduction has had several effects on other parameters, such as salinity, which has extended nearly 20 km upstream compared to conditions in the 1970s, potentially leading to mismatch in suitable habitats for fish species. This shift has led to an increase in marine species abundance and a decrease in freshwater and diadromous species in the estuary, altering the fish assemblage and the proportion of guild representativity.

Workshop discussion

Climate change has brought about nearly definitive changes in fish assemblages in European estuaries and these changes are still ongoing. These findings raise two questions about the reference conditions used in assessment tools:

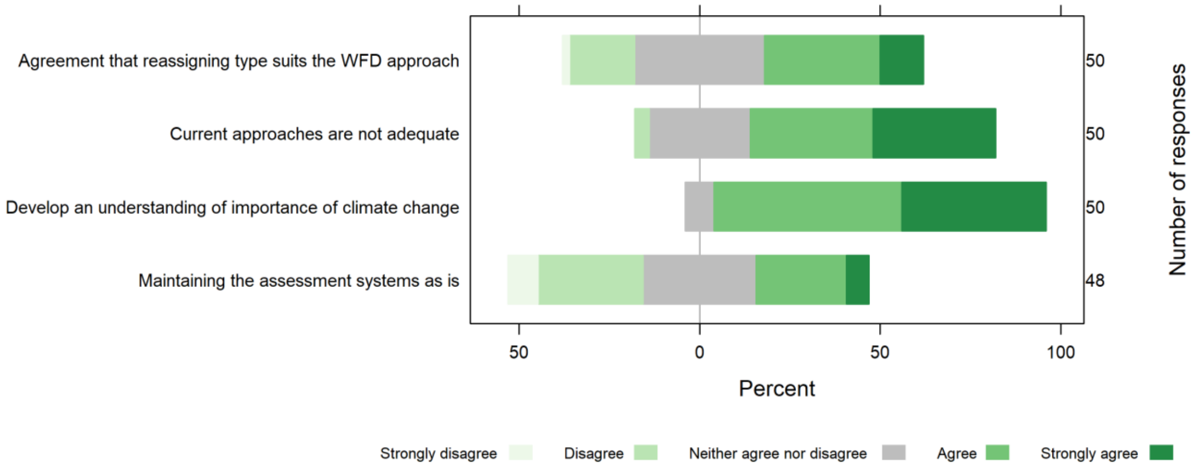
- -How accurate and achievable are reference conditions established with historical data?
- -When and how frequently should reference conditions be revised?

Example derived from: Lobry J., Dambrine C., Pierre M., Lepage M., Villarino E., Chust G., Borja A., Uriarte A., Arevalo E., Breine J., Van den Bergh E., Martinho F., Pardal M., Brind'Amour A., Scholle J., Maire A. & Cabral H. (submitted) Is tropicalization of European estuarine fish communities a matter of latitude?

5. Workshop Synopsis

The workshop was held in presence in Copenhagen and online on the 31st of September 2025. All presentations, including case studies, are available online in the CIRCA ECOSTAT folder: https://circabc.europa.eu/ui/group/9ab5926d-bed4-4322-9aa7-9964bbe8312d/library/3d49ddef-aa30-4d66-acd4-82f86c68e392?p=1&n=10&sort=modified_DESC. Prior to the meeting, a first draft of this report (Chapters 1 to 4) and a survey were circulated to attendees. Attendees were asked what would be the best outcome of the workshop? The most positive options selected were: “develop an understanding of importance of climate change” and an acknowledgement that “current approaches are not adequate”, while opinion was more neutral on the need to maintain existing assessment systems as they are (Figure 24).

Figure 24. Responses to the question: In your opinion what would be the best outcomes from attending the workshop?



Source: own elaboration

5.1 Plenary session

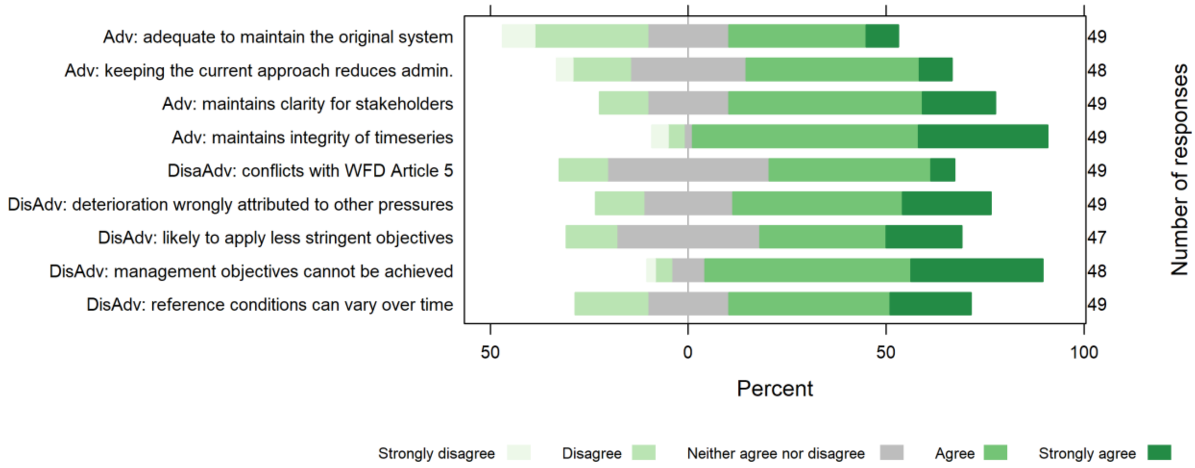
Introductory talks outlined the objectives of the workshop, principally exploring potential approaches to ecological assessment in the context of current and future impacts of climate change (see Chapter 1). Information on the existing guidance document 24 on climate change and the WFD was also presented to participants (https://data.europa.eu/doi/10.2779/126657). A guest presentation from Nikolai Friberg explored many direct and indirect effects of climate change in freshwater systems and concluded “Climate change should be included in assessments as a long-term stressor on aquatic biota that will influence baselines, and sensitivity to other stressors, in a relatively predictable manner”. The second guest presentation by Jacob Carstensen examined how climate change is hampering efforts to improve status in Danish coastal waters. It was concluded that all BQEs were negatively impacted by climate change. Evidence was presented of increasing hypoxia driven by warmer temperatures and lower wind speeds. This had implications for nutrient turnover, stratification, increasing phytoplankton biomass, reduced light, more organic matter deposition and food web decoupling.

Following this, Matthew O'Hare gave a presentation on member state's approaches to climate change derived from the RBMP reviews (7th implementation reports) and also on the possible use of exemptions. Although many Member States were using reference site networks to track climate induced change, no evidence was found that they were directly assessing the impact of climate change on ecological assessment but see Chapters 1 and 3 of this report for full details. Gary Free presented, on behalf of the ECOSTAT expert group, four possible approaches that could be used to include climate change into WFD ecological assessment:

1. Maintain existing assessment system unaltered
2. Reassign type
3. Tag the EQR with the proportion of change ascribed to climate change
4. Represent climate change in a supporting parameter module

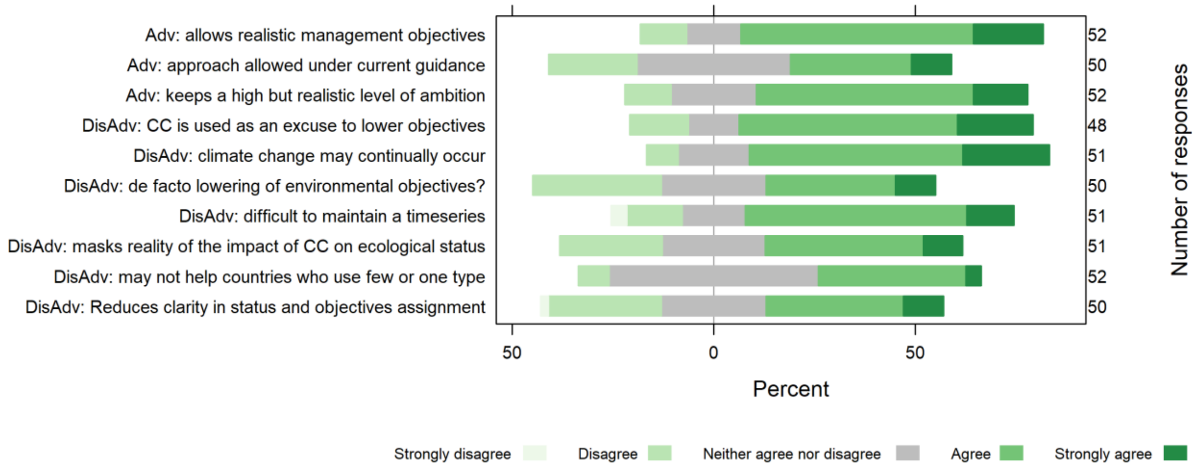
These approaches have been presented in detail in Chapter 2 of this report along with their advantages and disadvantages (Table 2), see also (Free et al., 2024). Some of these advantages and disadvantages were posed via survey to attendees of the workshop: for maintaining the current system unchanged and also for reassigning type - the approach recommended by revised guidance document 24. The main advantage of keeping the system unaltered was that it maintains the integrity of the timeseries while the main disadvantage was that objectives may become unachievable (Figure 25). In contrast, the main perceived advantage of reassigning type is that it allows realistic management objectives but with the disadvantage that change may continually occur (Figure 26). All questions and responses are available in Annex 2 – as well as a set filtered only for official MS representatives. This separate analysis was carried out to avoid any bias in the survey results that attendees that were not official MS representatives might introduce.

Figure 25. Responses to the question: How would you rate your agreement with these advantages and disadvantages of maintaining the current assessment system unchanged?



Source: own elaboration

Figure 26. Responses to the question: How would you rate your agreement with these advantages and disadvantages of reassigning type?



Source: own elaboration

Following discussion, incorporated below, three breakout sessions (rivers, lakes and TRAC) were established to look at a selection of case studies (see Chapter 4). The rational of this was to shift perspective from theoretical or academic studies to focus on issues that Member States were experiencing currently.

5.2 Rivers break-out

Michal Straka presented a case study on rivers have become intermittent in the Czech Republic which is having a significant effect on EQR values. Discussion focused on the need to establish if the change is permanent, to ensure that no measure can reverse the change and to present evidence such as historical hydrometric data before shifting type. Emília Elexová presented on the complex influence of floods on EQRs for several BQEs in Slovakia. The main issue was an increased variability in EQRs and how to deal with this. The discussion focused around the need for evidence to show it is clearly climate induced and permanent and whether changes in methods could suffice. Slovakia has tested shifting the sampling season to control variation. Wouter van de Bund presented the example of the river Oder and the influence of climate change alongside many other pressures in causing the disaster. DE and PL confirmed fish recovery in the river but the invertebrates appear to be more affected. The extraction of the influence of climate change in such a complex case with many pressures was seen as difficult. It was concluded that the main issue was management of the river rather than climate change.

5.3 Lakes break-out

Gary Free presented a summary of results from literature on lake Maggiore in Italy (especially (Rogora et al., 2018) where climate change has made stratification more stable leading to less nutrients in the epilimnion and lower chlorophyll-a as well as lower oxygen concentration in the hypolimnion. The national perspective was that the assessment system is unlikely to be changed in the short term but a change in reference condition within the type is preferred, an approach made easier by the availability of several decades of data. Anne Lyche Solheim and Jan-Erik Thrane presented on Lake Mjøsa in Norway where higher temperatures and increased frequency of mid-year flash floods are leading to localized blooms in near shore areas. The solution was to increase measures in the catchment to reduce nutrient loads rather than reassigning type, as none of the type-descriptors have changed. In contrast, in Lake Vansjø, the lake changed from clear-water to humic thereby reducing Cyanobacterial blooms. This lake was changed to a humic type (a permanent unavoidable change) prior to the WFD implementation thereby avoiding a discontinuity in classification approaches and timeseries.

5.4 TRAC break-out

Ioanna Varkitzi presented on Regional Sea Conventions (RSCs) and existing thematic assessments on climate change impacts. A list of parameters considered important by RSCs expert networks on climate change fell into seven categories: energy cycle, water cycle, carbon and nutrient cycles, sea level and wind, biota and ecosystems, human activities and services. Mario Lepage presented time-series on the thermal affinity of fish communities from 10 estuaries across north-western Europe. Subtropical fish species are increasing in northern latitudes (tropicalization) while boreal species decrease (deborealization). During discussion, the changes observed in this case study were characterised as permanent and irreversible. The case study proposed that reference conditions should be updated based on a network of reference sites that allow consideration of climate change. André Staalstrøm presented a case study on the Norwegian Sognefjord where a negative trend in oxygen conditions was estimated to be one-third caused by climate change and two-thirds by increased nutrients. Discussion and input from Norway indicated that this may be a permanent change but more study is needed to understand the main drivers and an approach to classification. Jan Brooke, NAVI, presented examples of changes in transitional and coastal waters. For example, saltmarshes where sea level rise results in unavoidable and irreversible change because the natural topography prevents habitat migration inland (so a new type should be assigned) vs. a situation where a flood defence embankment could be moved to landward, enabling the saltmarsh to migrate naturally towards the low-lying land behind the existing flood defence embankment. Another example are lagoons that are flooded with seawater more frequently due to sea level rise thereby necessitating a reassignment of type from a brackish or transitional to saline or coastal lagoon to allow a realistic target of good status/potential to be achieved. The last case study was presented by Jenni Attila, showing how satellite observations can follow long-term changes and current practices in Finland.

5.5 Common themes

The main finding is that many Member States, across all water categories, have examples where **climate change is currently affecting ecological status**. These included altered mixing patterns of lakes, flood induced eutrophication of littoral zones, intermittent streams, flooding events disrupting ecological assessment, degraded systems tipped by climate change into poor status, shifting species composition and reference conditions due to warming and changes in river discharges. While climate change wasn't explicitly included in the original text of the directive, 25 years later the influence of climate change is clearly emerging as a complicating factor in ecological status assessment. A lot of countries and case studies reported from the breakout session indicated that while the influence of climate change was apparent, **permanent change had not occurred and that measures were possible** to counteract the influence of climate change and reach environmental objectives. However, some systems had undergone **permanent change and type reassignment was considered appropriate** (e.g. brownification of lakes, or tidal marshes).

During the discussions that followed each case study, there was a **strong focus on evidence that climate change was altering status** and whether such change was permanent and unavoidable.

The climate parameters used to understand and quantify the influence of climate change were often detailed and specific to the use case. For example, increasing hypoxia in Danish coastal waters was linked to time-series showing warmer temperatures and lower wind speeds. In contrast, increased localised blooms in the littoral of lakes in Norway was linked to data on nearby river discharge showing increased frequency of mid-year flash floods leading to pulsed P loading. In this case, despite changes in temperature and flow patterns likely being permanent it was considered that further measures were possible to achieve environmental objectives.

Therefore, a lot of the discussion fell naturally around the approach outlined in Figure 7 that essentially outlines a dichotomy:

1. **Permanent changes avoidable** – either through additional measures or because the change is temporary.

2. **Permanent changes unavoidable** – Clear evidence from climatic parameters that change is permanent. Action should be taken in adjusting the assessment approach to manage the water body appropriately. Consider type reassignment / updated reference conditions.

There was agreement that sufficient evidence and certainty should be a pre-requisite to implementing changes. Many Member States were cautious about changing the assessment systems prematurely for several reasons such as introducing a discontinuity in the assessment time-series, or the danger that it is perceived as lowering objectives (Figure 26). Type reassignment was considered to be only appropriate in situations where an unavoidable impact on status is permanent and technically irreversible. An instant poll of 71 participants during the workshop asked: how often do you think it will be necessary to make any changes to the classification procedure? The responses were in some cases (66%), in most cases (14%), impossible to answer (13%), never (4%) and in all cases (3%).

Another common theme in the discussion revolved around the **purpose of ecological assessment** under the WFD brought into focus by the influence of climate change. There were two main schools of thought that emerged from discussions:

1. The WFD is a **management cycle** and ecological assessment systems and environmental objectives must be orientated towards achievable goals anchored in appropriate typology and reference conditions. The review of these is supported under article 5(2) of the WFD every 6 years.

2. **Ecological assessment should track degradation from all pressures** (including climate change) and report it. Fundamental changes to ecosystems driven by climate change should probably not go unnoted. Some examples include the loss of the isoetid environment with brownification, increased blooms or tropicalization of fish communities.

Ideally some balance could be achieved between maintaining a management cycle and also documenting and tracking change from all pressures including climate change. One attendee commented that If data were reported at smaller granularity then calculations for assessments could be redone or shifts in species distribution could be examined.

6. Conclusions

The overall objective of the meeting was to examine the influence of climate change on ecological status using examples from Member States and explore pathways to a workable solution. Naturally the current document represents a state in time and the wider ECOSTAT group are clearly aware that future impacts will be of greater magnitude (Figure 5). It was **clear that climate change is having an influence** on the assessment of ecological status across water categories in Member States. However, a lot of the discussion centred on ensuring that clear **evidence** was presented on the influence of climate change and if the change was permanent rather than natural variation. Furthermore, discussion focused on determining if objectives could be achieved by **additional measures** such as reducing nutrients. It appeared that Member States felt that the **majority of their water bodies where either not affected or at an early stage** of being affected by climate change (Figure 5). That said, there were also examples where the group agreed that permanent climate driven changes such as brownification justified a reassignment of typology. The principal conclusion is to **proceed cautiously** and ensure that there is **clear scientific evidence** that climate change, as separate from other pressures, is influencing status. Current recommendations in the guidance are for **reassignment of type where justified** and this may allow some flexibility and be preferable to more specific approaches (detailed in this report). However, there are some parallels to the weight placed by the workshop participants on demanding clear evidence of climate change to the candidate approach to include climatic elements as a supporting parameter. In any case, it is vital to maintain stakeholders' confidence in ecological assessment at European level and transparency in assessment and communication of environmental change will play a vital role in this. Currently **40% of waterbodies in Europe are in good or high ecological status** (EEA, 2025), which is the same as it was after the 1st and 2nd RBMPs (EEA, 2012; EEA, 2018). However, **measures continue to have success** for many water bodies in poor status although more time is needed for them to achieve good status.

7. Recommendations

As many Member States had use cases where there was evidence that climate change was affecting ecological status it is recommended that ECOSTAT actively **consider this influence** in WFD assessments.

Member States should start to purposively **include parameters and metrics indicative of climate change** relevant for their water categories and types into their data gathering framework to complement existing formal monitoring programmes. This will increase understanding of changes in status influenced by climate change alongside other pressures. Future work could apply the IPCC concept of emergence to estimate signal to noise ratios for key parameters.

ECOSTAT should support further work by this expert group to **define a set of key parameters to monitor** climate change. These should be tailored to be relevant to different water categories and types. As change is already occurring, preference should be given to existing datasets or utilizing the Copernicus reanalysis datasets. The susceptibly of typological parameters to climate change defined in this document may serve as a starting point for selection (Table 1).

Many Member States **monitor reference sites,** this practice should be expanded where possible in line with the formal WFD requirement (Annex 5, 1.3.1) that specify that surveillance monitoring programmes should include

— the assessment of long-term changes in natural conditions,

— the assessment of long-term changes resulting from widespread anthropogenic activity.

It is recommended to follow the **cautious approach** practiced at the workshop in identifying and documenting the evidence that climate change is altering status as separate from other pressures. It should be ascertained if change is unavoidable and permanent. Pressures from other sources must be clearly tackled by feasible measures before altering classification approaches (e.g. abstraction/nutrient loading). Figure 7 could serve as a future basis for deciding whether to alter classification approaches.

The current approach recommended in the **guidance of reassigning types** was found to be useful in some of the use cases examined. ECOSTAT should consider supporting the expert group to provide more detailed examples and procedures for its application.

The current report and use cases examined the current situation, it is recommended that this be taken forward by some Member States as **projections under different climate change scenarios**. This should include future looking assessment of efficacy of measures. Reporting back on results should inform ECOSTAT and the wider WFD community.

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List of abbreviations and definitions

Abbreviations	**Definitions**
BQE	Biological Quality Element
Chl-a	Chlorophyll-a
CIRCABC	Communication & Information Resource Centre for Administrations, Businesses & Citizens
EQR	Ecological Quality Ratio
IPCC	Intergovernmental Panel on Climate Change
KTM	Key Type of Measure
MS	Member State
RBMP	River Basin Management Plan
OOAO	One Out All Out
TRAC	Transitional and Coastal Waters
POMs	Programmes Of Measures
WFD	Water Framework Directive
WISE	Water Information System for Europe
ECOSTAT	Working Group on Ecological Status

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Annexes

Annex 1. Additional graphs

Figure 1. ECOSTAT work programme (2025-2027) ranked priorities from a survey (27 replies from 4 stakeholders and 23 MS).

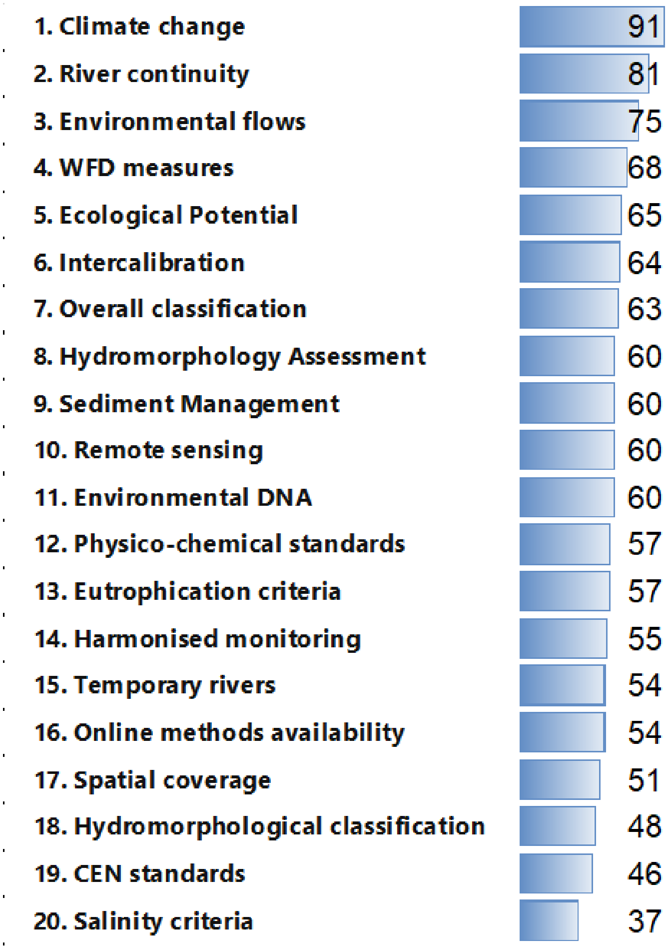


Figure 2. Count of RBDs where climate change guidance has been considered by country (Source WISE_WFD targeted questions on climate change; Table reference: RBMPPoM_TargetedQ_climateChangeAspectsConsidered).

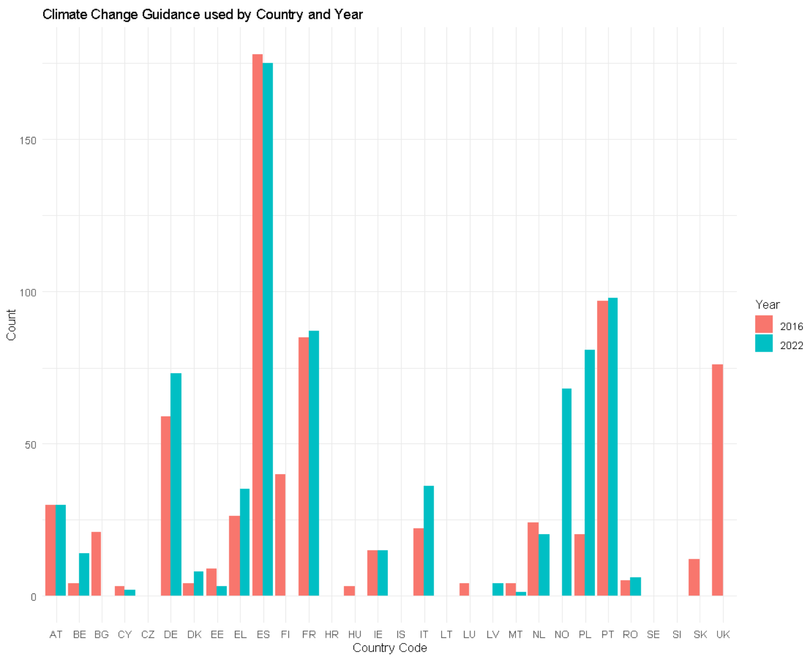


Figure 3. Frequency of RBDs by country that had a surface water exemption (4.4) driver as "Climate change". Data source WISE WFD: swmet_swexemptions_swexemption44driver (https://discodata.eea.europa.eu/).

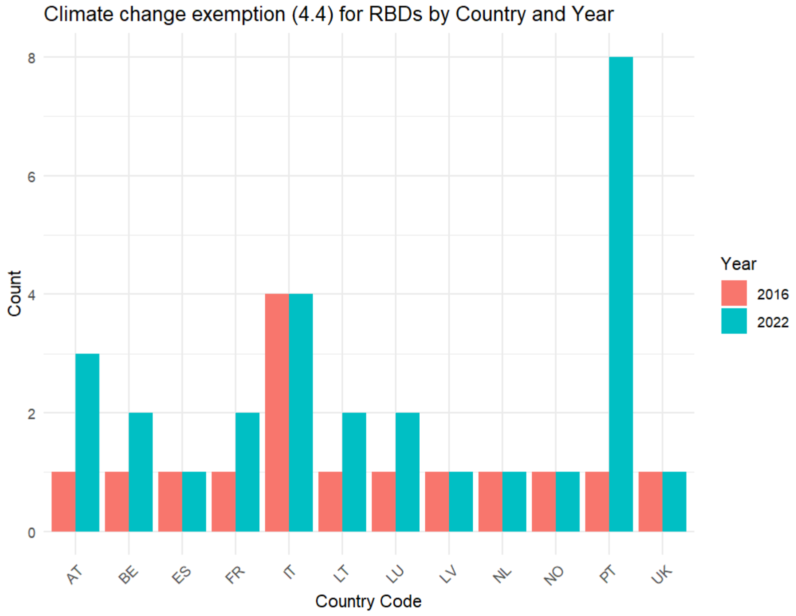


Figure 4. Frequency of water bodies identified with a surface water impact type as "Elevated temperatures". Data source WISE WFD: swb_surfacewaterbody_swsignificantimpacttype (https://discodata.eea.europa.eu/).

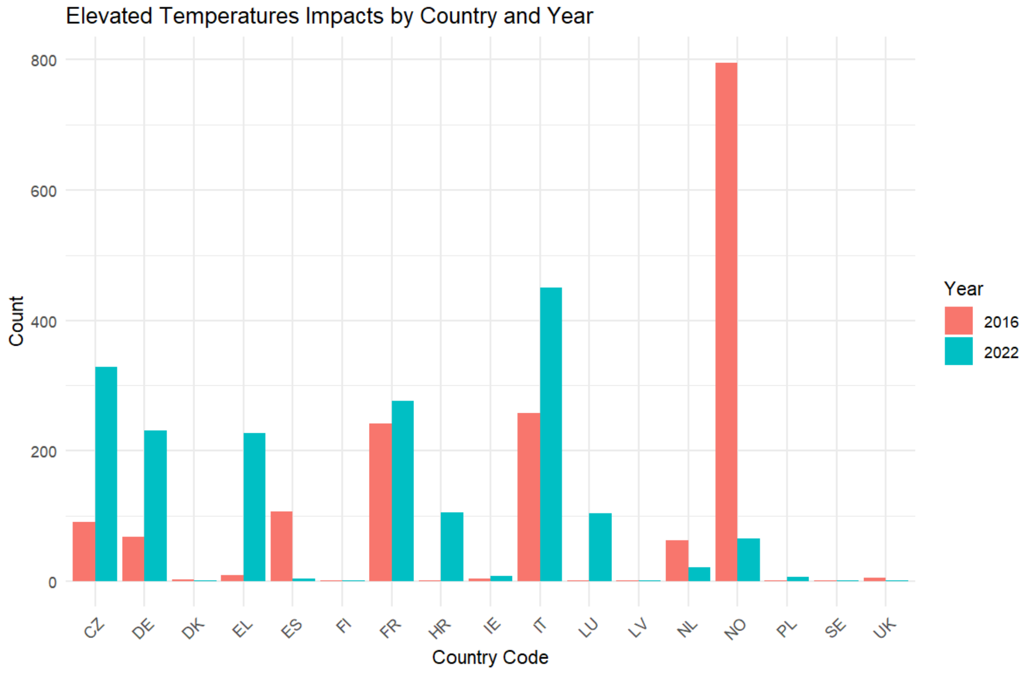
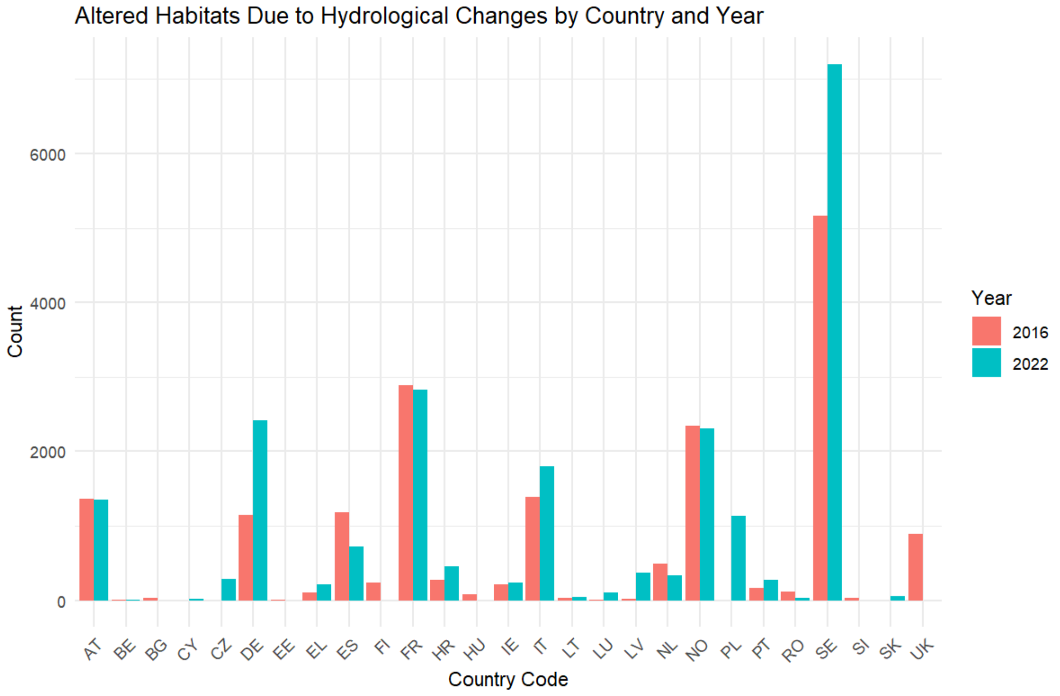


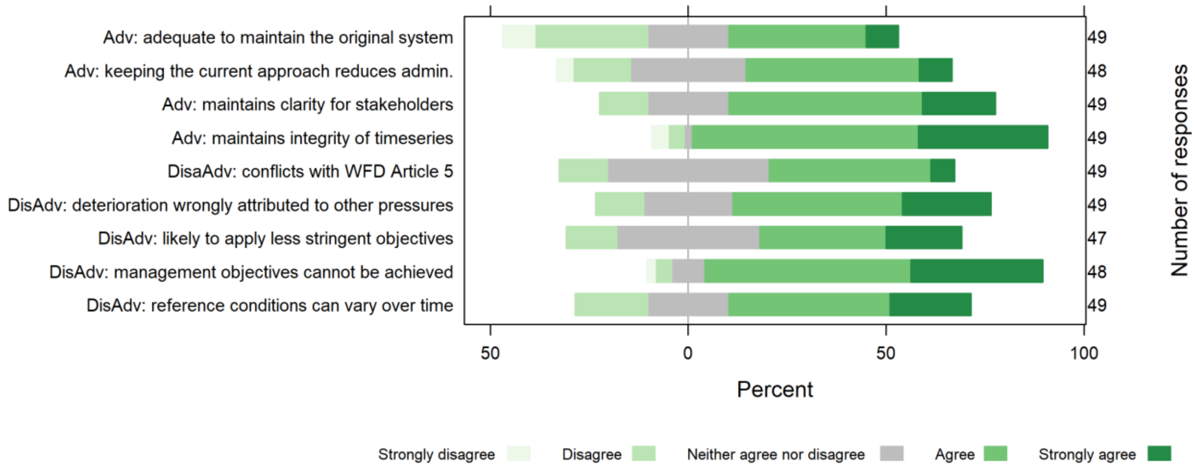
Figure 5. Frequency of water bodies identified with a surface water impact type as "Altered habitats due to hydrological changes". Data source WISE WFD: swb_surfacewaterbody_swsignificantimpacttype (https://discodata.eea.europa.eu/).



Annex 2. Pre-workshop survey results

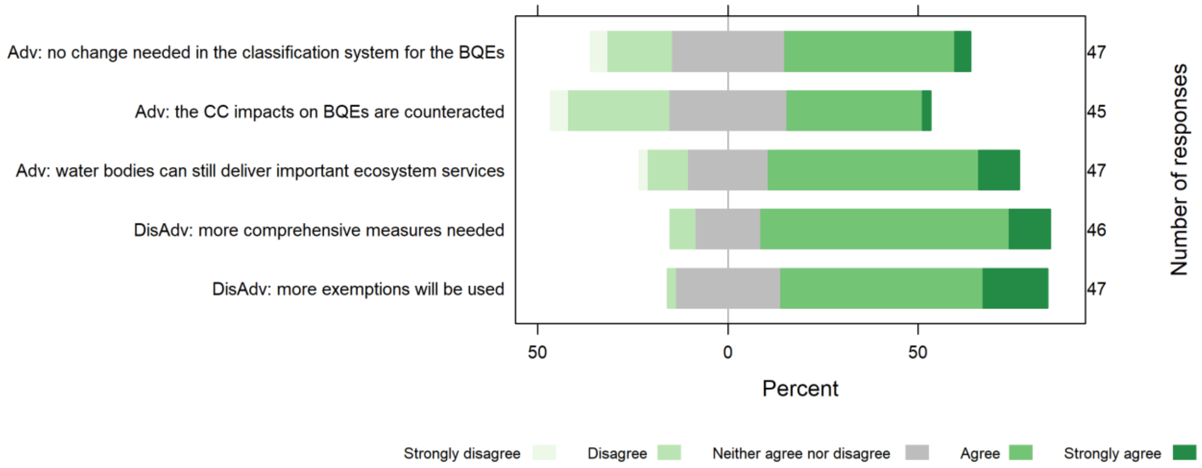
Questions and replies from all participants to a pre-workshop survey.

Q1 How would you rate your agreement with these advantages and disadvantages of maintaining the current assessment system unchanged?



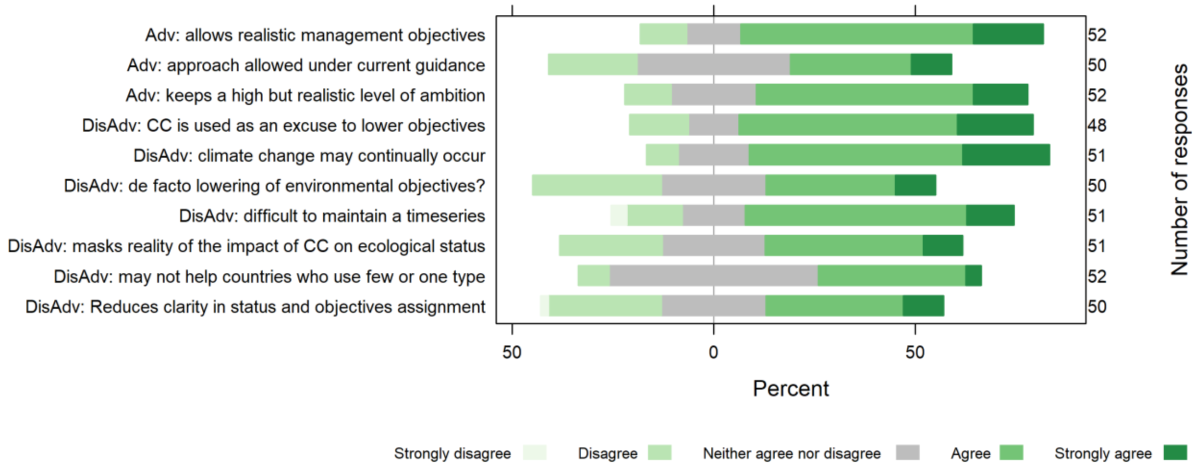
Source: Own elaboration

Q2 How would you agree with various advantages and disadvantages of tightening the GM boundaries for the most relevant supporting QEs?



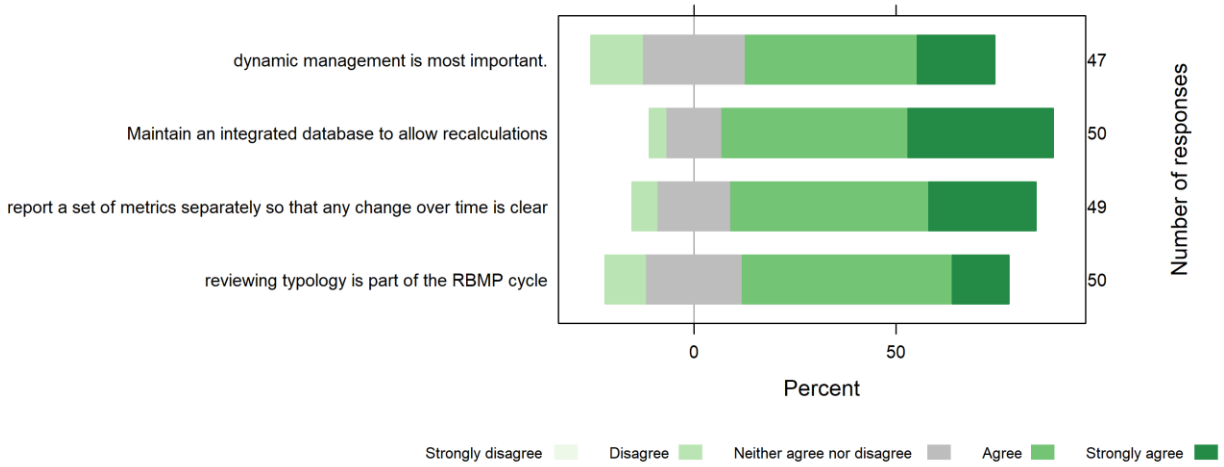
Source: Own elaboration

Q3 How would you rate your agreement with these advantages and disadvantages of reassigning type?



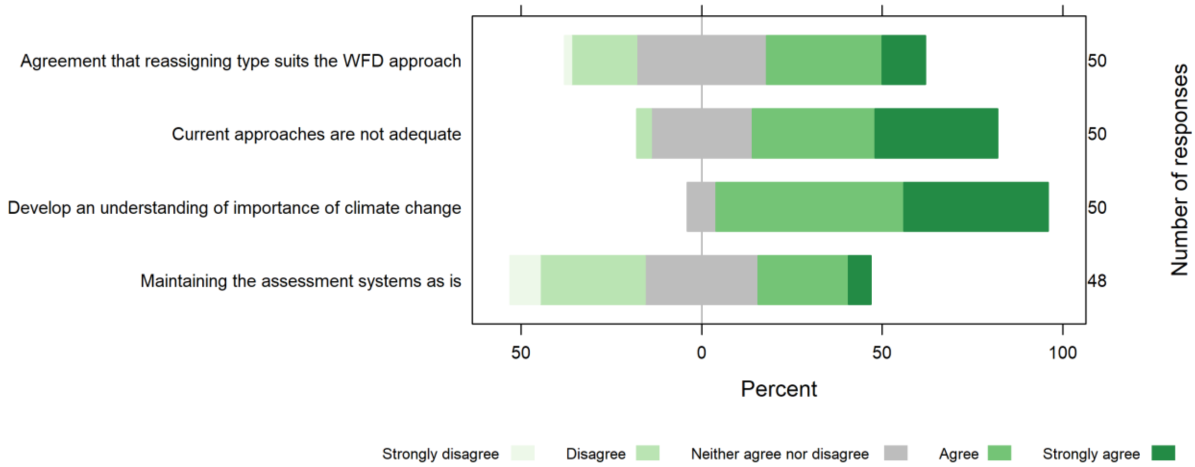
Source: Own elaboration

Q4 Many MS are reluctant to reassign types as this will change the assessment framework and make comparisons with results from previous cycles difficult. How well do you agree with the solutions below to overcome this barrier?



Source: Own elaboration

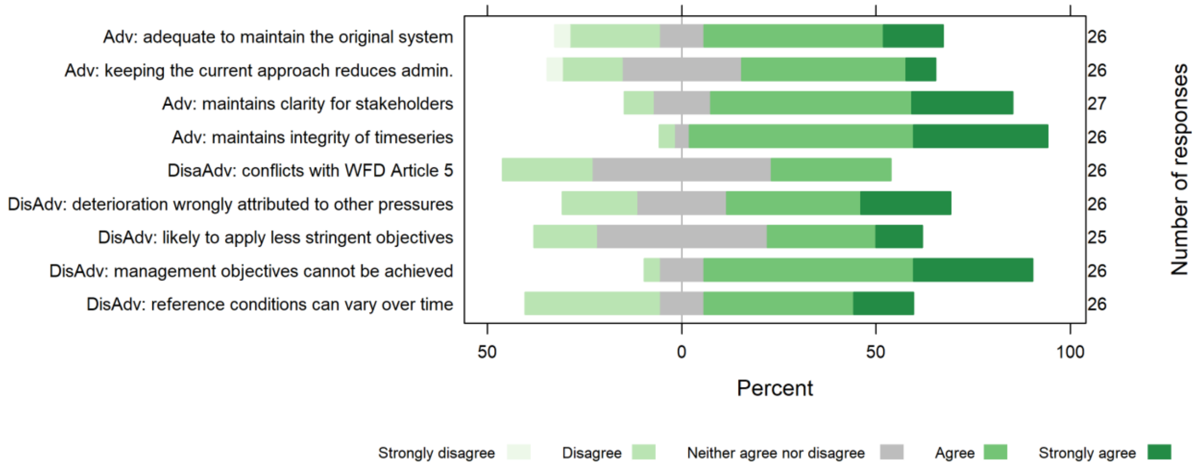
Q5 In your opinion what would be the best outcomes from attending the workshop?



Source: Own elaboration

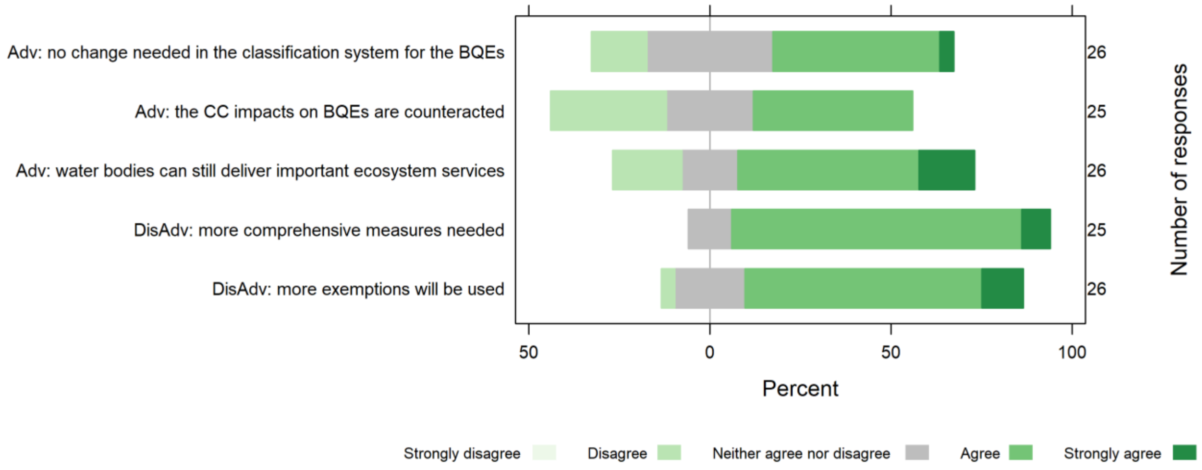
Questions and replies from only official MS representatives to the survey.

Q1 How would you rate your agreement with these advantages and disadvantages of maintaining the current assessment system unchanged?



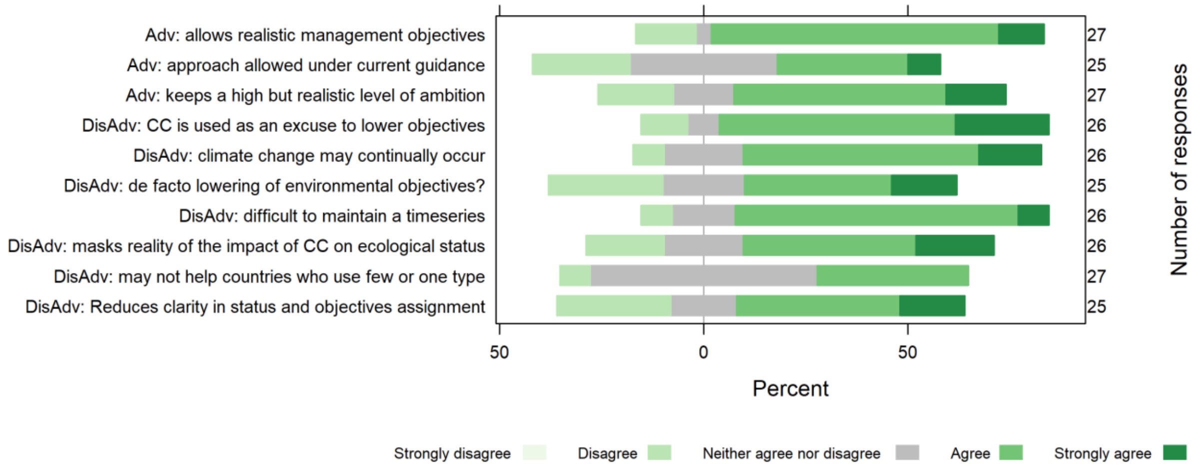
Source: Own elaboration

Q2 How would you agree with various advantages and disadvantages of tightening the GM boundaries for the most relevant supporting QEs?



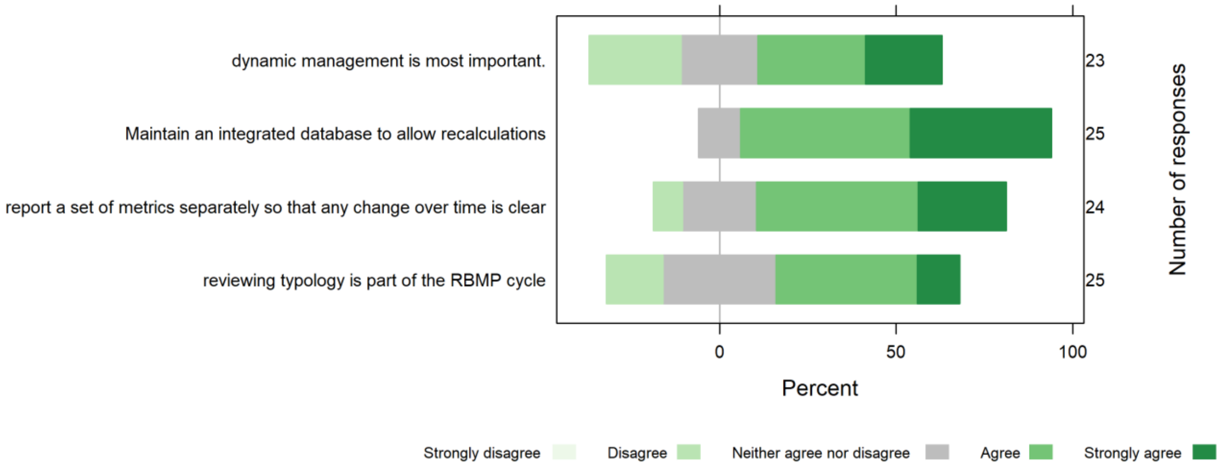
Source: Own elaboration

Q3 How would you rate your agreement with these advantages and disadvantages of reassigning type?



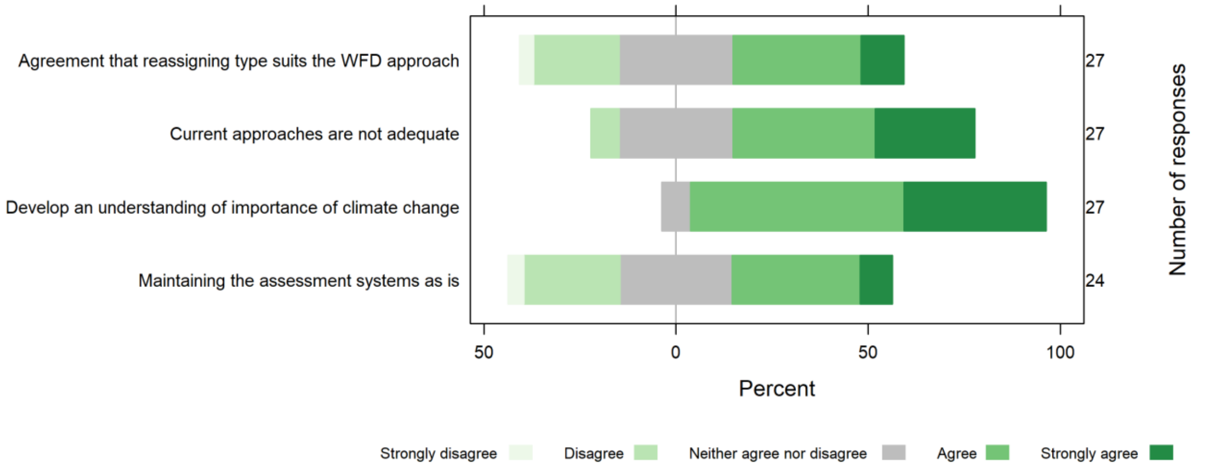
Source: Own elaboration

Q4 Many MS are reluctant to reassign types as this will change the assessment framework and make comparisons with results from previous cycles difficult. How well do you agree with the solutions below to overcome this barrier?



Source: Own elaboration

Q5 In your opinion what would be the best outcomes from attending the workshop?



Source: Own elaboration

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