OA ALLIANCE
INTERNATIONAL ALLIANCE TO COMBAT OCEAN ACIDIFICATION

UNITED NATIONS FOUNDATION

OA ACTION PLAN

LEADERSHIP CIRCLE

ADDRESSING OCEAN AND COASTAL ACIDIFICATION ACROSS THE MARINE STRATEGY FRAMEWORK DIRECTIVE IN EUROPE

SUMMARY

Recommendations for incorporating OA information to strengthen descriptors and support governments in achieving Good Environmental Status:

The OA Alliance—and relevant regional practitioners—have reviewed the MSFD and suggested the strongest pathways for ensuring OA is incorporated into the MSFD. This includes an assessment of which Descriptors are most apt for integrating, increasing or utilizing OA data and information.

Key recommendations:

Measures to limit coastal acidification should be taken under Descriptor 5.

To ensure a better assessment of the land-based local drivers of coastal acidification, OA parameters (**pH and TA**) should be incorporated into Descriptor 5. This will make it possible to consider the relationship between coastal acidification and local inputs of nutrients/organic matter. This should incentivize that nutrients/organic matter inputs are additionally controlled to minimize coastal acidification. Further, incorporating OA parameters (pH and TA) to Descriptor 5 would strengthen linkages between MSFD and the Water Framework Directive.

Ocean acidification should be monitored and assessed in marine waters under Descriptor 7.

The scope of Descriptor 7 should be broadened to include the ocean's chemical conditions including OA parameters (**pCO_2 and DIC**) alongside the existing hydrographical conditions. Such an inclusion will ensure that the diverse ocean pressures, including atmospheric CO_2 driven OA, can be monitored and addressed in a more holistic manner in the context of climate change.

OA information should be reported to the Regional Seas Conventions.

To create greater harmony between the OA actions taken by the EU Member States and any other concerned States, OA monitoring should be reported and commiunicated to the Regional Seas Conventions. This will allow for increased harmonisation of OA indicators/best practices and monitoring parameters. It will also facilitate more informed and coordinated regional research to support Member States in the most effective OA response actions.

OCEAN ACIDIFICATION AND ITS IMPACT ON EUROPEAN WATERS

Climate-ocean change is happening now with negative consequences in European waters including the NE Atlantic Ocean, Baltic Sea, Black Sea, and Mediterranean Sea. We are already seeing the negative impacts of climate-ocean change, including ocean acidification (OA), on habitat and biodiversity, fisheries and aquaculture, economies, cultural practices, and livelihoods. Recent studies further indicate that OA has negative consequences for commercial species such as Atlantic cod, and important habitats, such as cold-water corals. In the Mediterranean, effects are also being observed, and additional impacts are projected for species such as calcifying algae, temperate and deep-water corals, and sea urchins.

There are global and local drivers of ocean and coastal acidifcation.

The ocean absorbs not only 90% of excess heat caused by the burning of fossil fuels, but also 25% of the carbon dioxide (CO_2) emissions released into the atmosphere. This addition of CO_2 to the ocean is making seawater more acidified; we call this process "ocean acidification" or OA.

The chemical reactions that occur in the ocean because of OA include an increase in proton ions [H+], which lead to a lowering of the seawater's pH, and a decrease in the availability of carbonate ions, which many species like shellfish, finfish, plankton, and corals, need to grow and thrive.

OA combines with other climate-ocean impacts like ocean warming and reduced oxygen levels, increasing the overall stress marine species and ecosystems are experiencing from climate and non-climate related pressures . In nearshore and coastal environments, local sources of land-based nutrient pollution (including nitrates) enter the ocean through wastewater, stormwater, and agriculture run-off, additionally contributing to eutrophication, which can accelerate coastal acidification in the water column and amplify negative conditions for marine organisms.

Actions to reduce global and local drivers of OA can reduce impacts on species and promote healthy ecosystem functioning. Additionally, local actions to improve resilience across marine ecosystems—through blue carbon, nature-based solutions, planning or conservation measures—can have multiple beneficial outcomes.

The European Union's Marine Strategy Framework Directive (MSFD Dir 2008/56/EC) requires its Member States to achieve or maintain Good Environmental Status of marine waters. This policy document explores how efforts to measure, address and minimize ocean and coastal acidification can be incorporated into the MSFD and related directives.

MSFD AND OCEAN ACIDIFICATION

The MSFD is a European legislation, which aims to protect the marine environment with a particular focus on marine ecosystems and biodiversity. To achieve this goal, the MSFD introduced the concept of "Good Environmental Status" (GES), which Member States must aim to achieve. GES requires that the marine waters of the European Union are not only dynamic, ecologically diverse, clean, healthy and productive, but also that the marine environment can support sustainable use and activities by humans. To achieve GES, Member States must apply an ecosystem-based approach and adaptive management. In order to implement the Directive, each Member State is required to:

- conduct an initial assessment of their marine waters.
- determine the characteristics of GES within their marine (sub)regions.
- monitor and assess the environmental status of their marine waters.
- establish environmental targets and other indicators to achieve GES.
- establish programmes of measures for marine (sub)regions to achieve and maintain GES.

Although, GES does not explicitly address climate change or climate-ocean impacts such as OA, the preamble of the MSFD recognises that the determination of GES may be adapted over time to address human induced environmental concerns.

MSFD and Ocean Acidification Parameters

Ocean acidification can be quantified by measuring two of the four interlinked carbonate system parameters. These four parameters include partial pressure of carbon dioxide (pCO_2), total dissolved inorganic carbon (DIC), potential of hydrogen (pH), and total alkalinity (TA).

***p*CO_2** describes the carbon dioxide (CO_2) that has absorbed into a liquid, in this case seawater. As CO_2 in our atmosphere increases, due to fossil fuel combustion, so does pCO_2 in our seawater.

DIC is the sum of four dissolved substances (carbon dioxide, carbonic acid, bicarbonate ions and carbonate ions) that are in a chemical equilibrium within the ocean. The equilibrium can go out of balance if one substance is added to quickly, for example when an increase of CO_2 occurs in the ocean.

pH measures the hydrogen ion concentration in seawater. As the hydrogen ion concentration increases (as a result of chemical reactions between seawater and CO_2), the seawater's pH decreases.

Total Alkalinity measures the concentration of negatively charged ions and molecules available in seawater to bond to the positively charged hydrogen ions and thus buffer the effects of OA.

The MSFD framework has already recognized the importance of two of the four OA parameters. This is made clear in Annex III, which provides an indicative list of characteristics, pressures and impacts that can be considered as part of the initial assessment and monitoring programmes to determine good environmental status of the EU's marine waters. Annex III lists pH and pCO_2 as parameters open for Member States to consider.

The next step for Member States' is to proactively incorporate all four of these parameters into the most relevant assessment, monitoring, and evaluation efforts of MSFD.

Of particular importance is identifying and leveraging the link between each OA parameter and the most approppraite MSFD Descriptors.

Marine Strategy Framework Directive & Descriptors:

The MSFD has established 11 qualitative descriptors used to determine the characteristics of good environmental status in a marine region or sub-region.

11 Qualitative Descriptors Established under the MSFD:

Descriptor 1: Biodiversity is maintained.
Descriptor 2: Non-indigenous species do not adversely alter the ecosystem.
Descriptor 3: The population of commercial fish species is healthy.
Descriptor 4: Elements of food webs ensure long-term abundance and reproduction.
Descriptor 5: Eutrophication is minimized.
Descriptor 6: The sea floor integrity ensures functioning of the ecosystem.
Descriptor 7: Permanent alteration of hydrographical conditions does not adversely affect the ecosystem.
Descriptor 8: Concentrations of contaminants give no effects.
Descriptor 9: Contaminants in seafood are within safe levels.
Descriptor 10: Marine litter does not cause harm.
Descriptor 11: Introduction of energy (including underwater noise) does not adversely affect the ecosystem.

Relationship between GES and Descriptors:

The Commission Decision (EU) 2017/848 defined criteria, criteria elements and called for the development of threshold values that are to be employed by the Member States when using the descriptors. The threshold values are meant to contribute to Member States' determination of a set of characteristics for GES and enable their assessment of the extent to which GES is being achieved. The criteria, criteria elements and threshold values are based on Annex III of the MSFD, which lays down an "Indicative lists of ecosystem elements, anthropogenic pressures and human activities relevant to the marine waters".

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Key recommendations:

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UTILIZING REGIONAL SEAS CONVENTIONS:

The MSFD emphasises regional cooperation between Member States and, if possible, also third countries especially within the same marine (sub)regions. The MSFD highlights where appropriate regional institutional cooperation, such as those established under Regional Seas Conventions (e.g. OSPAR, HELCOM, UNEP MAP, Bucharest Convention), shall be utilised.

Regional cooperation is particularly important for the coherent implementation of EU-wide marine strategies within marine (sub)regions, including the monitoring programmes and the programmes of measures of the Member States. Additionally, regional cooperation can enhance the data collection and comparability between the different states or advance shared research priorities.

OSPAR recently published the OSPAR's Quality Status report 2023, which included a first OSPAR Ocean Acidification assessment for the North-East Atlantic. This assessment is a valuable source of OA data and trends in North-East Atlantic waters. The report found that OA is observed in all OSPAR regions, but that the rate of change varies between regions as well as locally. The report includes monitoring, forecasting, biological impacts case studies and policy recommendations, though it acknowledges that the understanding of trends, variability, drivers, and ecological impacts of OA needs to improve. OSPAR also recently decided to install WG COCOA (Working Group on Changing Ocean Climate and Ocean Acidification), which is a merger of the existing groups working on climate change and on ocean acidification. It has a broader remit and is tasked to collaborate with all relevant OSPAR groups and committees on climate and acidification, which form one of the main pillars in OSPAR's North-East Atlantic Environment Strategy (NEAES). This includes interaction with the Intersessional Correspondence Group on the MSFD (ICG-MSFD).

The HELCOM Convention itself does not include a direct reference to OA. However, parties to the Convention are required to tackle nutrient inputs from both atmospheric and land-based sources. Moreover, as part of the Baltic Sea Action Plan (BSAP) revision in 2021, climate change has now been added as a Horizontal Topic thereby acknowledging its crosscutting nature and its role as an umbrella term encompassing an extensive number of other topics. One of the actions agreed in the Action Plan is that HELCOM will develop a strategic approach to ocean acidification. Currently this work includes taking stock of the current information, identifying data gaps and making plans to fill them (see BSAP action Horizontal Topic 5). OA has also been included in the HELCOM indicators, which are intended to facilitate the achievement of the nutrient input reduction scheme and the overall vision of the HELCOM Action Plan. Baltic Sea acidification is highlighted as a supporting element indicator with no threshold values applied but trends provided (last report published in 2023). Finally, OA has also been addressed in the Baltic Sea Climate Change Fact Sheet.

Similar to HELCOM, UNEP MAP (Barcelona Convention) also focuses on the prevention of pollution from different sources e.g. land-based pollution. This again allows for a link between the prevention of pollution, eutrophication and OA. In the UNEP/MAP Medium-Term Strategy 2022-2027, the contracting Parties to the Convention also highlight the importance of addressing 'ongoing climate drivers of environmental change, including OA'. The Strategy also acknowledges the need for further research on the impacts of climate change, in particular OA, on Mediterranean ecosystems. The issue of OA has also been acknowledged in the First Mediterranean Assessment Report, which identified a high level of CO2 absorbtion by the Mediteranien Sea compared to the global oceans. Moreover, the Report noted the potentially negative effect of OA on marine food resources. Lastly, as part of their [2023 Mediterranean Quality Status Report], the Contracting Parties to the Barcelona Convention also highlighted the negative impact of sea water acidification on the Mediterranean Sea in general.

Finally, the Bucharest Convention also includes an obligation for their contracting parties to adopt laws and regulations to address and prevent atmospheric pollution of the marine environment. This obligation thus provides the possible ground for more OA action under the Convention.

Overall, national OA monitoring and reporting to these regional seas conventions could ensure more robust OA information is made available regionally for decision-making and better evaluation of descriptors across individual governments. Moreover, the involvement of these regional seas conventions can also facilitate the development of more coherent strategies, methodologies, and biological research needs for evaluating GES across descriptors.

OPPORTUNITIES TO INCORPORATE OA INTO MSFD DESCRIPTORS

The MSFD provides existing opportunities to incorporate OA into its relevant Descriptors.

Descriptor 5 "that Eutrophication is minimized and **Descriptor 7**, "that permanent alteration of hydrographical conditions does not adversely affect the ecosystem" offer the most immediate opportunities for expanding OA information and applying measures to limit ocean and coastal acidification.

Descriptors 1 "that biodiversity is maintained", 4 "that elements of food webs ensure long-term abundance and reproduction" and 6 "that the sea floor integrity ensures functioning of the ecosystem," are not concerned with a particular pressure, but instead with the ecosystem or specific ecosystem elements.

Importantly, OA information collected by Descriptor 5 and Descriptor 7 could be applied, over time, to better understand OA's impact on marine ecosystems and species, and manage effective responses accordingly.

The knowledge collected under Descriptor 5 and 7, and further coordinated through the Regional Seas Conventions, will help to inform relevant ecosystem and species responses, tolerances, or vulnerabilities to OA, thus furthering the indicator assessments and resilience building efforts to be advanced under Descriptors 1, 4, and 6.

DESCRIPTOR 5

Human-induced eutrophication is minimized, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.

Relevant pressures: Input of nutrients, Input of organic matter

Nutrients (as well as harmful algal blooms) in the water column within and beyond coastal waters – Nutrient concentrations are not at levels that indicate adverse nutrient enrichment/eutrophication effects.

Relevant specifications and standardized methods for monitoring and assessment

For example: Information on the pathways (atmospheric, land- or sea-based) for nutrients entering the marine environment shall be collected, where feasible.

Relevance for OA: in particular coastal and regional acidification hot spots

In the vicinity of a coastline, nutrient pollution can cause detrimental acidification effects. More specifically, when nutrients enter the marine water, they cause growth of phytoplankton and enhance primary production. This enhanced production becomes an issue when phytoplankton eventually die and start to sink to the sea floor as organic matter. This organic matter is then decomposed by bacteria, whereby, bacteria convert the organic matter into inorganic substances, including CO_2. It is this CO_2 that then causes coastal acidification. In addition to nutrient-induced eutrophication and coastal acidification, any high input of organic matter from land could also result in high rates of CO_2 production in coastal waters. Measuring the exact negative impacts from nutrients and organic matter in coastal waters is challenging. The reason for this challenge is the greater natural variability because of daily and seasonal geochemical, biological and physical processes in the vicinity of the coastline. The coastal waters that are affected by nutrient pollution are called 'hot spots'. According to Kelly (2011), these hot spots can be defined as "(...) patches of ocean water with significantly depressed pH levels relative to historical baselines occurring at spatial scales of tens to hundreds of square kilometres." Coastal activities are an important cause of coastal acidification at the local and regional level.

Suggested incorporation

To understand and limit the impacts of coastal acidification caused by local land-based nutrients and organic matter, the inherent connection between nutrients, organic matter and coastal acidification must be acknowledged in Descriptor 5. This consideration should further incentivize that pressures are controlled to an extent that these actions can also minimize coastal acidification. To ensure that coastal acidification inducing levels of nutrient input are not exceeded, it will be necessary to incorporate especially two of the before mentioned OA parameters, namely pH and Total Alkalinity into Descriptor 5. This will lay the groundwork for more coordinated OA monitoring and awareness across all relevant spatial and time scales. Only by integrating OA attuned monitoring will it be possible to collect the necessary information to measure, assess, and minimize the effects of coastal acidification on the EU marine waters.

Such considerations can be facilitated by the existing monitoring and reporting obligations under the Water Framework Directive (WFD) and the Nitrates Directive. While the WFD requires the monitoring of the oxygen and nutrient conditions of coastal waters, the Nitrates Directive focuses on the eutrophic state of the water. The obligations under both Directives offer valuable monitoring information that can help address coastal acidification and eutrophication under the MSFD. The Nitrates Directive also offers a pathway for OA mitigation through the reduction of nutrient input from agricultural sources.

In summary, Descriptor 5 should incorporate the OA parameters, pH, and Total Alkalinity, in order to address nutrient enrichment/eutrophication, minimize coastal acidification, and limit local/ regional OA hotspots.

DESCRIPTOR 7

Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.

Relevant pressures: Physical loss (due to permanent change of seabed substrate or morphology or to extraction of seabed substrate); Changes to hydrological conditions

Nutrients (as well as harmful algal blooms) in the water column within and beyond coastal waters – Nutrient concentrations Hydrographical changes to the seabed and water column. In particular, spatial extent and distribution of permanent alteration of hydrographical conditions (e.g. changes in wave action, currents, salinity, temperature) to the seabed and water column, associated in particular with physical loss of the natural seabed.

Relevant specifications and standardized methods for monitoring and assessment

For example: Environmental impact assessment hydrodynamic models, where required, which are validated with ground-truth measurements, or other suitable sources of information, shall be used to assess the extent of effects from each infrastructure development.

Relevance for OA

Under the current definition of D7, OA does not technically fall under hydrographical conditions.

In the context of ongoing climate-ocean change, a lack of accounting for increased chemical changes (like OA) caused by CO2 emissions, poses an existiential gap in knowledge as to the impacts of climate change on EU Marine Waters. This impacts Member States' ability to assess GES, especially as climate-ocean change creates a moving baseline.

Although, GES does not explicitly address climate change or climate-ocean impacts such as OA, the preamble of the MSFD recognises that the determination of GES may be adapted over time to address human induced environmental concerns. Accounting for atmospheric CO2-driven OA in EU Marine Waters.

Furthermore, alterations to any of the hydrographical conditions currently accounted for in D7 (wave action, currents, salinity and temperature) will impact the chemistry of the seawater.

Temperature and salinity are key drivers in determining rates of chemical change. For instance, temperature and pH have a tight relationship such that as temperature increases (ocean warming), pH decreases (OA).

Wave action is important for gas exchange and uptake of CO2 into the ocean. Changes in currents will impact the distribution of carbon and nutrients around the coastal regions, which in turn can impact the short-term variability in pH through driving processes such as biological photosynthesis, respiration, or physical removal of CO2 from surface waters to deeper waters or even off the shelf to the deep ocean.

Suggested Integration

Although Descriptor 7 in its current form focuses only on hydrographical conditions, in the context of climate change, diverse ocean pressures including chemical changes like atmospheric CO2-driven OA, should be monitored, assessed and minimized in a more holistic manner under D7.

To capture the interconnectivity between multiple sources of ocean change, it is necessary to broaden the scope of this descriptor to include both chemical and hydrographical conditions. The chemistry of coastal regions is complex, and the hydrographical changes need to be considered in relation to chemical changes to understand trends of OA in a specific region. Therefore, it will become necessary to incorporate especially two of the OA parameters, namely pCO2 and DIC into a new category of chemical conditions to be included into descriptor 7.

Only if both hydographic and chemical conditions are considered together, will it be possible to establish a holistic assessment of the state of the EU waters in the context of climate change. This in turn will allow for improved management, forecasting and preventing of changes in disturbance which could result in accelerated ocean or coastal acidification.

CONCLUSION

The ocean—and its ecosystems and species—are currently battling many different changes related to anthropogenic GHG emissions that create ocean and coastal stress at the same time. In particular, temperature, oxygen loss, changing currents, ocean and coastal acidification stand to negatively affect marine ecosystems and species.

Climate-ocean change is happening now with negative consequences in European waters including the NE Atlantic Ocean, Baltic Sea, Black Sea, and Mediterranean Sea. We are already seeing the negative impacts of climate-ocean change, including ocean acidification (OA), on habitat and biodiversity, fisheries and aquaculture, economies, cultural practices, and livelihoods

In addition to urgently and drastically reducing atmospheric carbon dioxide emissions, the number one cause of OA, governments can take action by utilizing regional information to design local strategies.

The European Union's MSFD requires its Member States to achieve or maintain Good Environmental Status of marine waters. In support of this outcome, Member States can take actions now to integrate OA relevant information and responses across the Marine Strategy Framework Directive.

These actions include:

- **Measures to limit coastal acidification should be taken under Descriptor 5.**
- **Monitoring and assessing ocean acidification in marine waters under Descriptor 7.**
- **Reporting OA information to Regional Seas Conventions.**