PML | Plymouth Marine Laboratory

Research excellence supporting a sustainable ocean

The importance of understanding OA trends and impacts in NE Atlantic and Mediterranean

OA ALLIANCE | INTERNATIONAL ALLIANCE TO COMBAT OCEAN ACIDIFICATION

OSPAR COMMISSION

NEA Hub GOA-ON | Global Ocean Acidification Observing Network

Ocean Acidification

CO_2

↓ Natural uptake by oceans

Reacts with water as part of **marine carbonate system**

***But* too much, too quickly** =

↓ **pH** = more “acidic”

↓ **Carbonate ion** = more “corrosive” to calcium carbonate
(especially *Aragonite*; when aragonite saturation state < 1)

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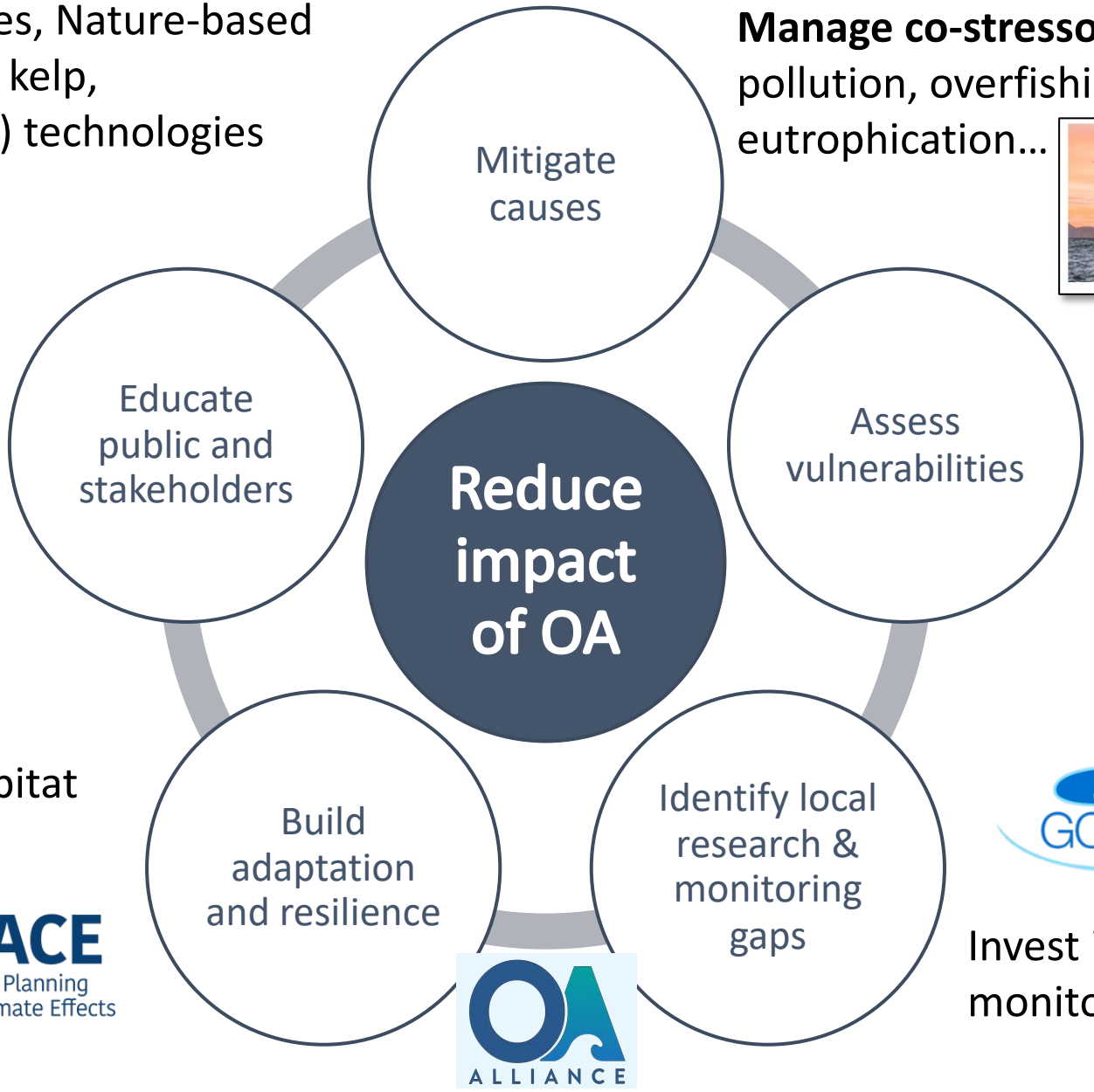
Why is it important to monitor OA locally?

Reduce emissions, Use renewables, Nature-based solutions, Blue carbon (sea-grass, kelp, shellfisheries), CO_2 Removal (CDR) technologies

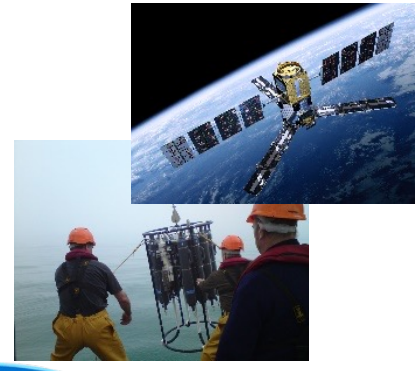
Invest in **adaptative planning**, habitat protection & restoration

Future MARES

MSPACE
Marine Spatial Planning Addressing Climate Effects



Manage co-stressors: Land run-off, pollution, overfishing, agricultural, eutrophication…



GOA-ON Global Ocean Acidification Observing Network

Invest in science, networks, monitoring, **capacity building**

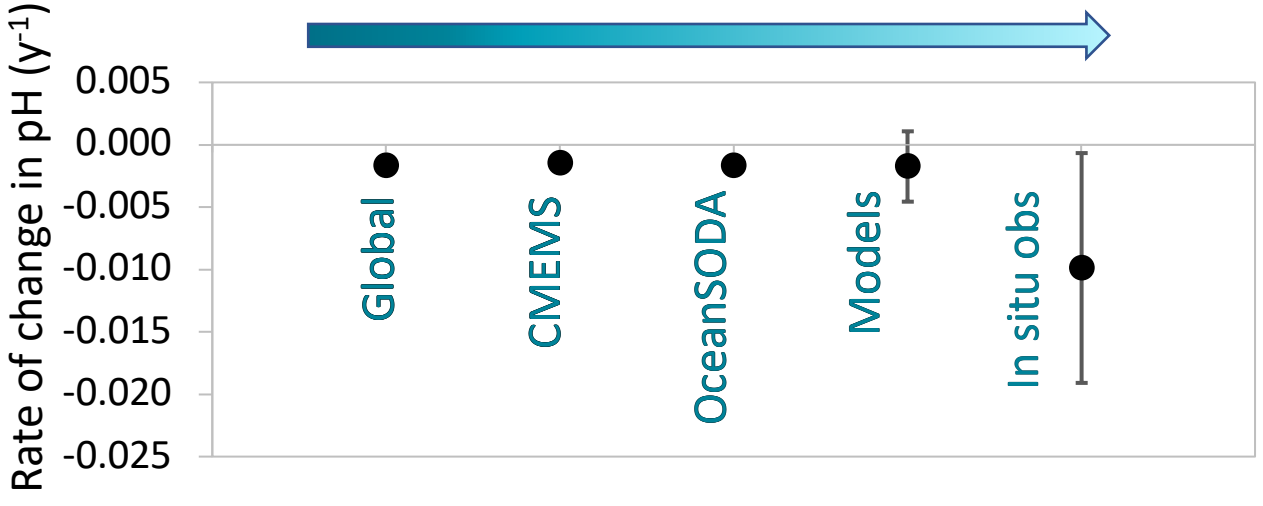
Why is it important to monitor OA locally?

(Global: average = -0.0017 y^{-1}) Regional Local

OSPAR QSR2023, OA Assessment

Region	Synthesis products		Regional models (hindcast)	*In situ* observations	
	CMEMS	OceanSODA		GLODAP	Time-series stations
Arctic Seas (OSPAR I)	-0.0011 y^{-1}	-0.0019 y^{-1}	Not available		-0.0021 to -0.0033 y^{-1}
Greater North Sea (OSPAR II)	-0.0015 y^{-1}	-0.0017 y^{-1}	-0.0020 y^{-1}		-0.0044 to -0.0197 y^{-1}
Celtic Seas (OSPAR III)	-0.0016 y^{-1}	-0.0016 y^{-1}	-0.0019 y^{-1}		-0.0120 to -0.0219 y^{-1}
Bay of Biscay & Iberian coast (OSPAR IV)	-0.0017 y^{-1}	-0.0016 y^{-1}	-0.0014 y^{-1}		-0.0089 to -0.0195 y^{-1}
Wider Atlantic (OSPAR V)	-0.0016 y^{-1}	-0.0016 y^{-1}	Not available	-0.001 to -0.002 y^{-1}	Not available
Mediterranean			-0.005 to -0.06 y^{-1}		-0.001 to -0.0026 y^{-1}

Palmieri et al. (2015) Hassoun et al. 2022



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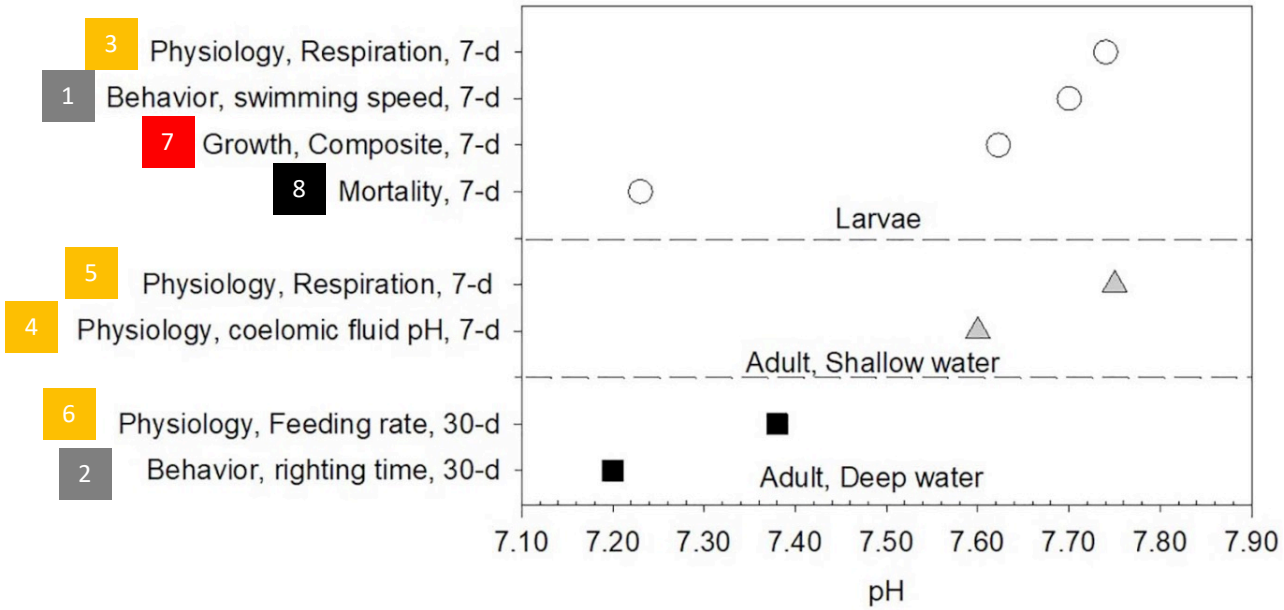
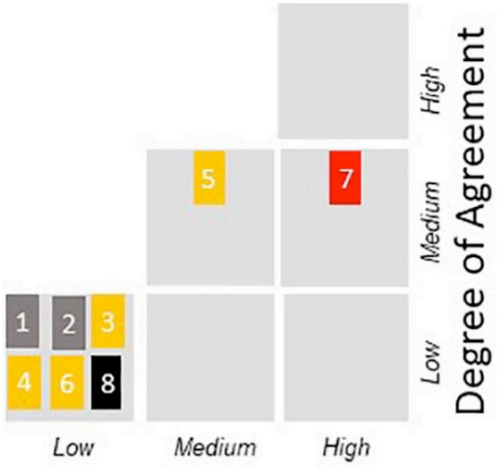
Why is it important to monitor OA locally?

Coupling chemical and biological information

(For example) Echinoderm threshold assessment

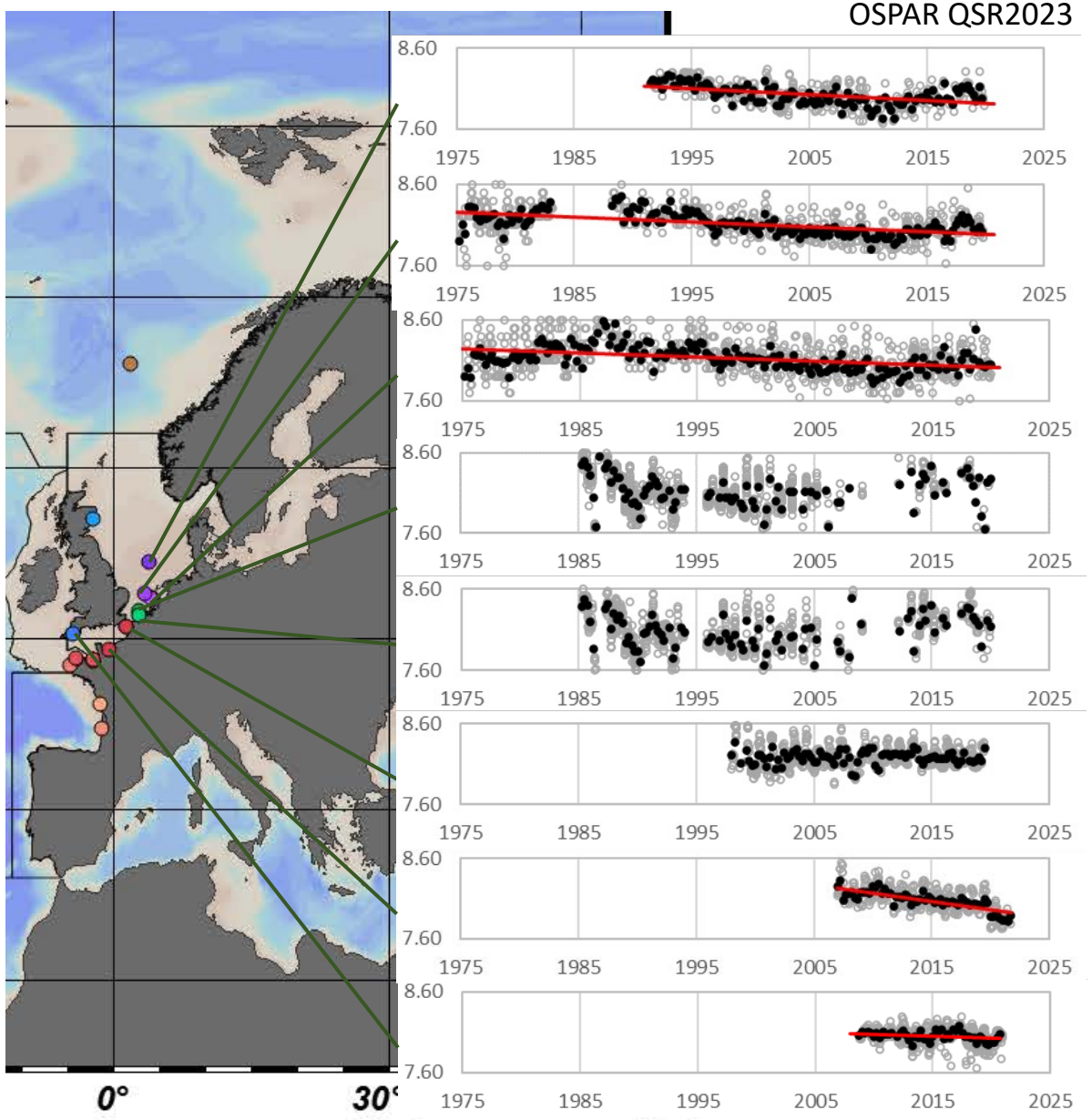
Bednarsek et al. 2021





1 Behavior, swimming speed, larval
2 Behavior, righting time, adult deep water
3 Physiology, respiration, larval
4 Physiology, coelomic fluid pH, adult shallow water
5 Physiology, respiration, adult shallow water
6 Physiology, feeding rate, adult deep water
7 Growth and development, larval
8 Mortality, larval

OSPAR QSR2023



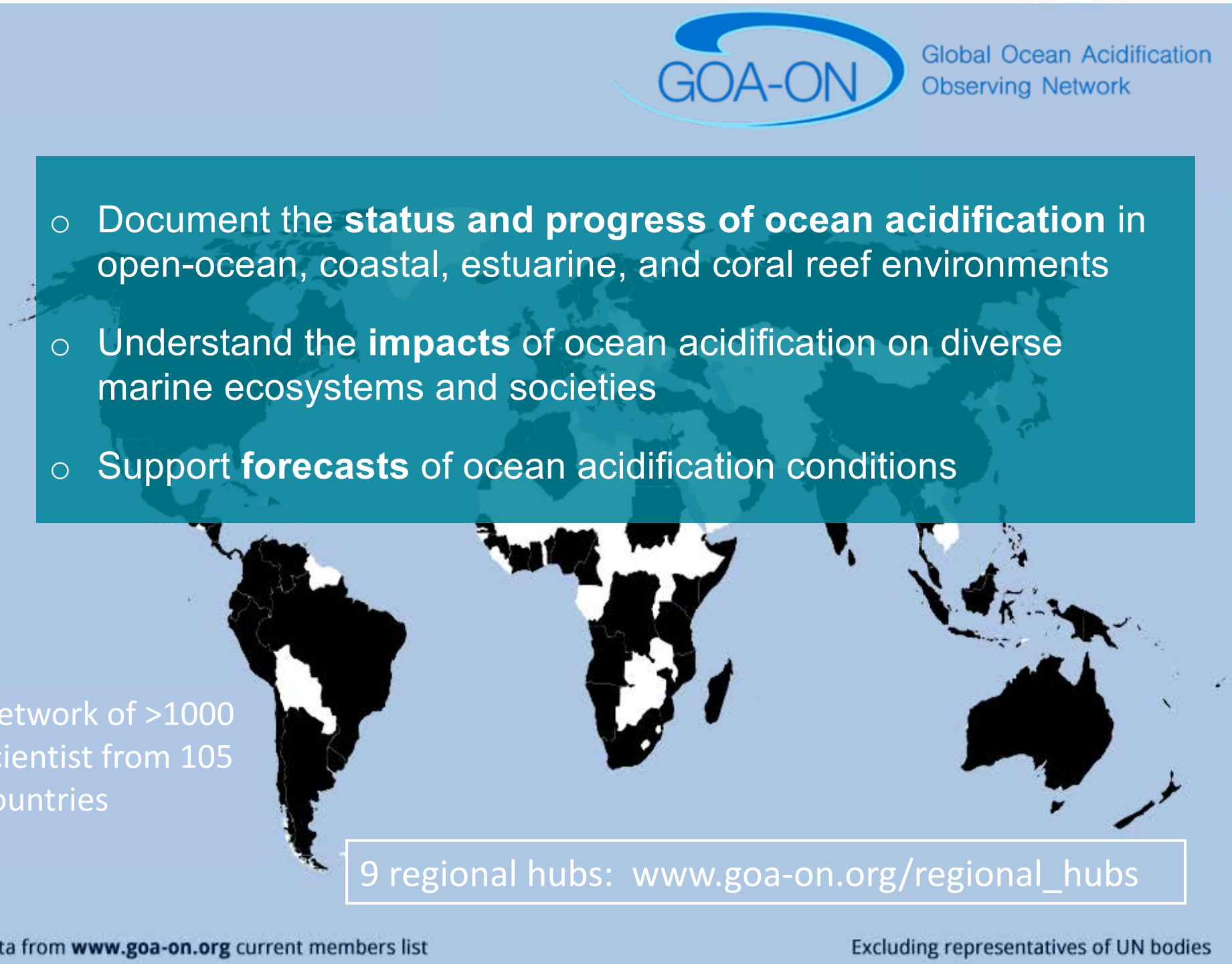
A successful integrated ocean acidification (OA) observing network must include:

- **Scientists and technicians** from a range of disciplines;
- Government, private, and intergovernmental **support**;
- **Regional cohorts** working together on regionally specific issues;
- **Publicly accessible data** from the open ocean to coastal to estuarine systems;
- **Close integration** with other networks focusing on related measurements or issues;
- Observation-based **informational products useful for decision making** such as management of fisheries and aquaculture.

Tilbrook et al., 2019

GOA-ON Global Ocean Acidification Observing Network

- Document the **status and progress of ocean acidification** in open-ocean, coastal, estuarine, and coral reef environments
- Understand the **impacts** of ocean acidification on diverse marine ecosystems and societies
- Support **forecasts** of ocean acidification conditions



Network of >1000 scientist from 105 countries

9 regional hubs: www.goa-on.org/regional_hubs

Data from **www.goa-on.org** current members list

Excluding representatives of UN bodies

The Ocean Acidification Mediterranean Hub

GOA-ON
Global Ocean Acidification Observing Network

OA Med Hub

OAMedHub
@oa_medhub
@oa_medhub

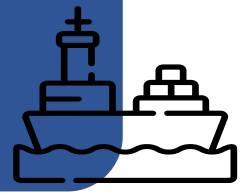
ACIDIFICATION

Mediterranean waters have been invaded by **anthropogenic CO_2** from the **surface to its deepest waters**. Rates are **faster** than global average

ANTHROPOGENIC PRESSURES

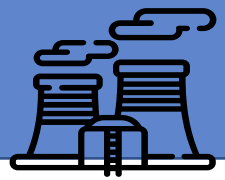
The Mediterranean Sea is:

- Surrounded by **23** countries
- A hot-spot for climate change
- Intense maritime traffic
- Very diverse geopolitically



MULTIPLE STRESSORS

- Faster warming than the average global ocean,
- Increasing frequency, duration, and intensity of marine heatwaves
- Semi-enclosed
- Eutrophication



BIOLOGICAL IMPACTS

Acidification is having negative effects on marine species and ecosystem services. Without adaptation, **shellfish aquaculture** and iconic ecosystems will **decline** due to ocean acidification combined with other stressors.

OA MED HUB

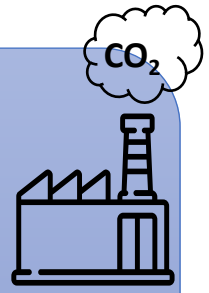
~**100** members from **14** countries

- ➢ Capacity building and training
- ➢ Improve communication
- ➢ Promote GOA-ON Best Practices
- ➢ Collaborate with solid science:

doi.org/10.3389/fmars.2022.892670

POLICY MAKERS NEED TO

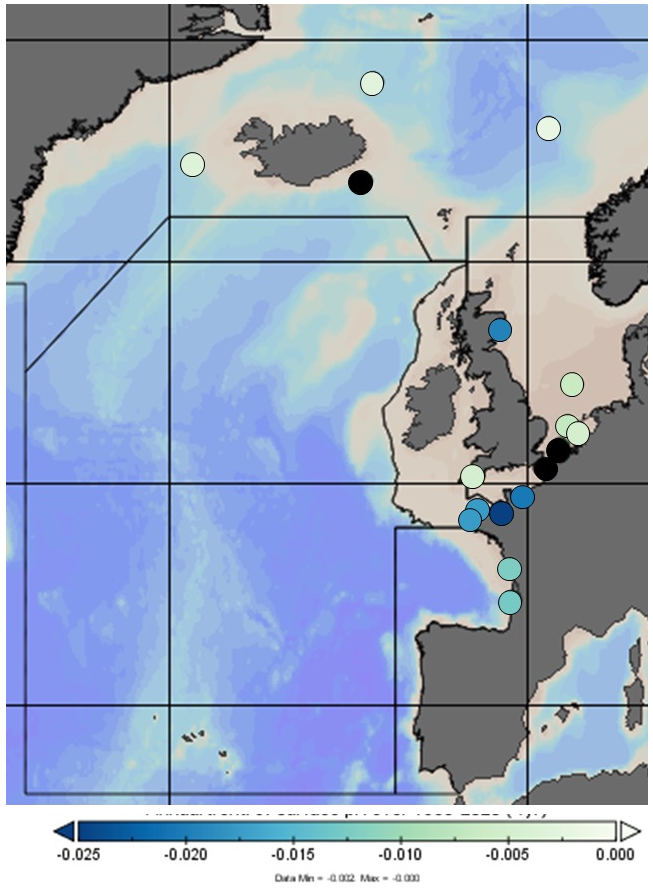
- Make consistent OA policies at Mediterranean level
- Promote regulatory Med-wide tools to combat OA
- Improve N-S and E-W connections
- Promote mCDR solutions
- Optimize strategies for protection and restoration
- Support solutions to decrease biological impacts in a multi stressor environment



The North East Atlantic Ocean Acidification Hub

NEA Hub

GOA-ON Global Ocean Acidification Observing Network



Currently **108 members** from **15 countries**

- Share information on OA monitoring (and experimental and modelling) activities
- Facilitate data submission to the GOA-ON data portal
- Promote community "best practices" consistent with GOA-ON
- Facilitate capacity building & training activities
- Provide integration across the region

Contributed to the OSPAR QSR2023 OA Assessment

Assessing current status of monitoring

Facilitating dialogue between stakeholder groups

Facilitating data sharing and submission to SDG14.3.1

Thank you

@goa-ne

www.nea-oa.org

goaon.atlantic@pml.ac.uk

NEA Hub GOA-ON

Global Ocean Acidification Observing Network

OSPAR
QUALITY STATUS REPORT 2023

OSPAR
COMMISSION

The OSPAR Ocean Acidification Assessment (Quality Status Report 2023)

Exploring Marine Management and Policy Response to Ocean Acidification Workshop

24 May 2023

Jos Schilder, OSPAR ICG-OA, Rijkswaterstaat (NL)

Jos.schilder@rws.nl

What I will (not) be presenting

- **OSPAR and the OA assessment process**
- **A taste of the content of the OSPAR OA assessment**
  - No detail on the science output (too much)
- **Key messages**
- **Recommendations**

OSPAR CONVENTION (1992) FOR THE PROTECTION OF THE MARINE ENVIRONMENT OF THE NORTH-EAST ATLANTIC

15 Governments and the **EU**

OSPAR Vision

A **clean, healthy and biologically diverse** North-East Atlantic Ocean, which is **productive, used sustainably** and **resilient to climate change and ocean acidification**.

OSPAR is a platform where scientists, policy advisors and policy makers interact.

OSPAR produces Quality Status reports (2000, 2010, 2023) that

- Assess status (130 assessments)
- Inform policy
- Evaluate measures
- (Inform MSFD reporting)

OA assessment took 4 years and 30 contributors to complete

ICGOA Jan 2019	ICGOA Sept 2019	ICGOA Sept 2020	ICGOA Sept 2021	Various to Q1 2023
GOA-ON; CMEMS	*Planning*	3 Sub-groups 6 Champions *-Key messages* *-Work plan* *-Content*	*-Progress review SGs* *-Messages* *-Gaps*	*-Integration* *-Consistency* *-Review* *-Production* *-Publication*

Summary, Key Messages, Recommendations

1 Introduction
2 Trends and variability
3 Future projections
4 Impacts & Case Studies
5 Adaptation and Mitigation

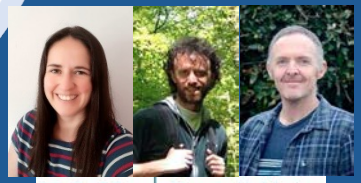
GOA-ON Global Ocean Acidification Observing Network

NEA Hub

Copernicus Marine Service

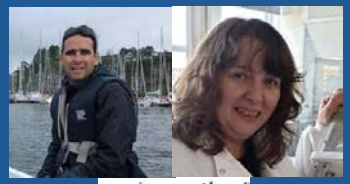
OSPAR COMMISSION







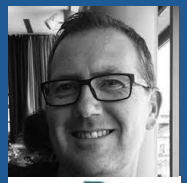
Marine Institute Foras na Mara | Rijkswaterstaat | PML Plymouth Marine Laboratory | Cefas | University of Gothenburg | NORCE | Institute of Marine Research

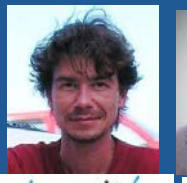



Instituto Español de Oceanografía | marinescotland science | NINA Norwegian Institute for Nature Research | MERCATOR OCEAN INTERNATIONAL | National Oceanography Centre | NUI Galway OÉ Gaillimh | Aarhus Universitet | Bundesamt für Seeschiffahrt und Hydrographie








ETH zürich | Royal Netherlands Institute for Sea Research | museum Royal Belgian Institute of Natural Sciences | Umwelt Bundesamt | IPMA Instituto Português do Mar e da Atmosfera | MARINE & FRESHWATER RESEARCH INSTITUTE | OKEANOS | université de BORDEAUX | OSPAR COMMISSION

OSPAR Intersessional Correspondence Group on Ocean Acidification

Evin McGovern, Jos Schilder, Helen Findlay, Yuri Artioli, Silvana Birchenough, Sam Dupont, Ingunn Skjelvan, Morten D. Skogen, Marta Álvarez, Melissa Chierici, Pablo Leon Diaz, Johanna Järnegren, Karina von Schuckmann, Martina Stiasny, Janina Büsher, Jesper Philip Aagaard Christensen, Annika Grage, Luke Gregor, Matthew Humphreys, Marc Knockaert, Manuela Krakau, Marta Nogueira, Solveig Rosa Olafsdottir, Nicolas Savoye, Marina Carreiro-Silva, Pam Walsham, Steve Widdicombe, Alejandro Iglesias Campos, Carole Durussel

Approach and methods used

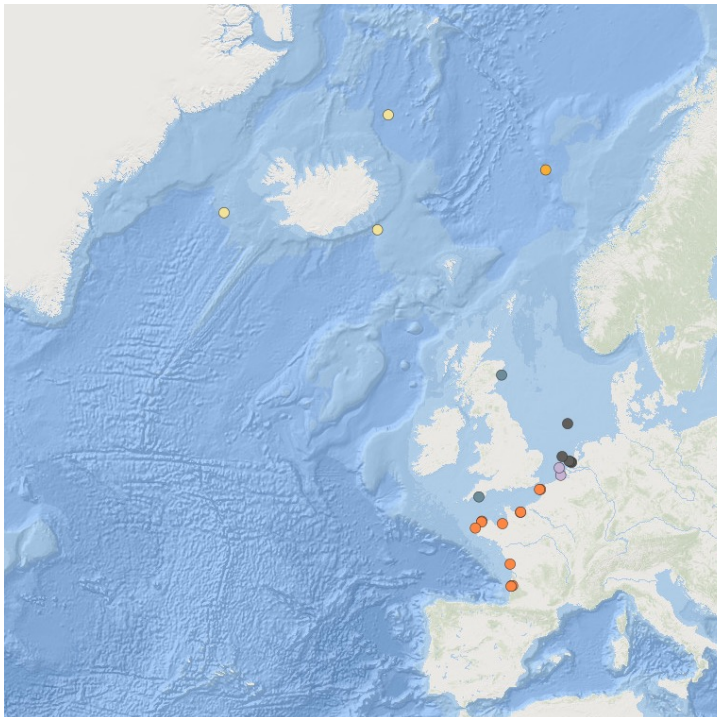
Key Messages, Recommendations

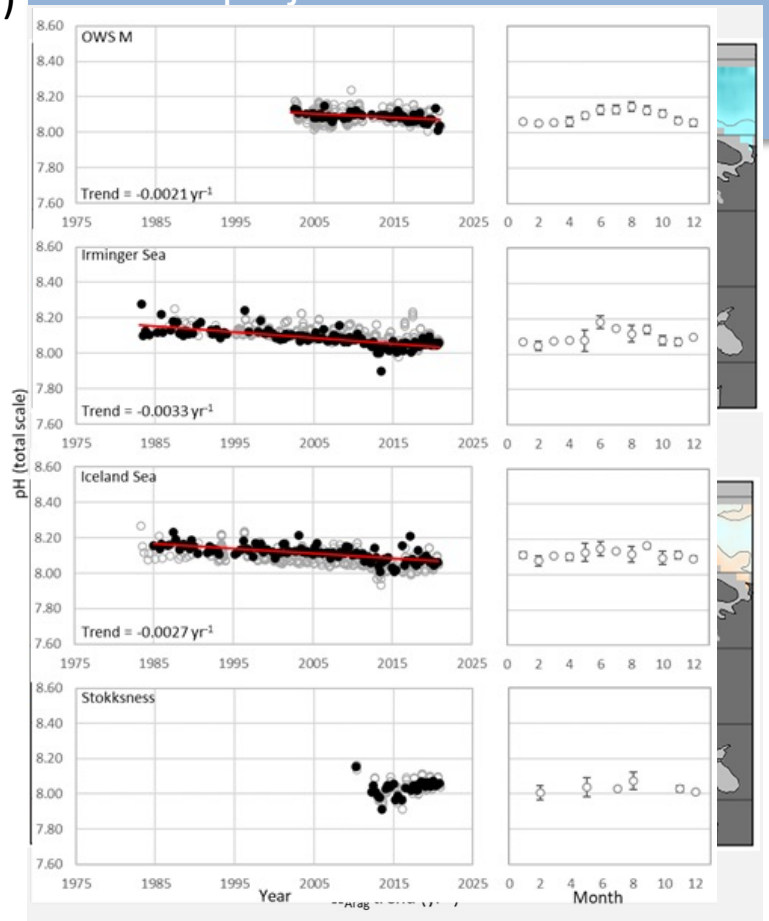
1 Introduction

2 Trends and variability

3 Future projections

- *In situ*-time series
- Reconstruction synthesis products (*in situ* and satellite)
- Model hindcasts
- Synthesis of open ocean deep water database

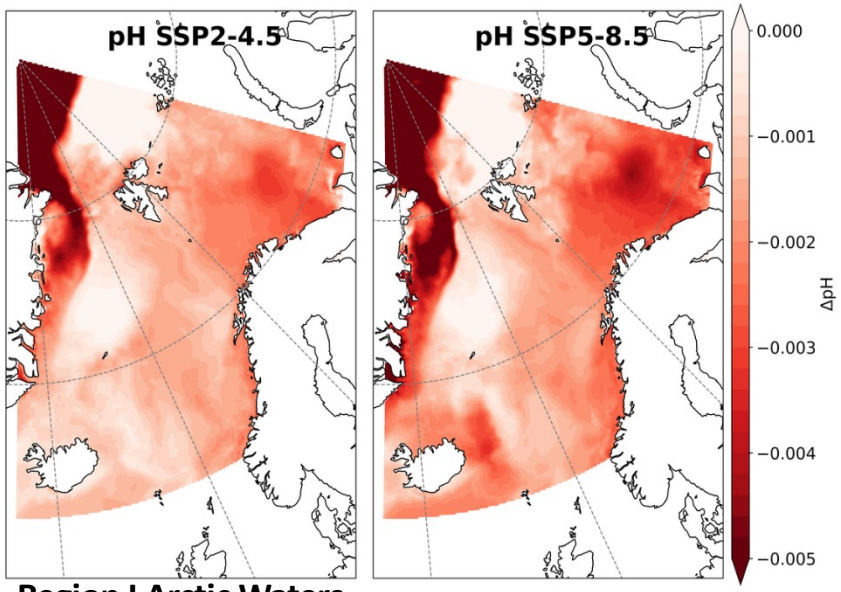




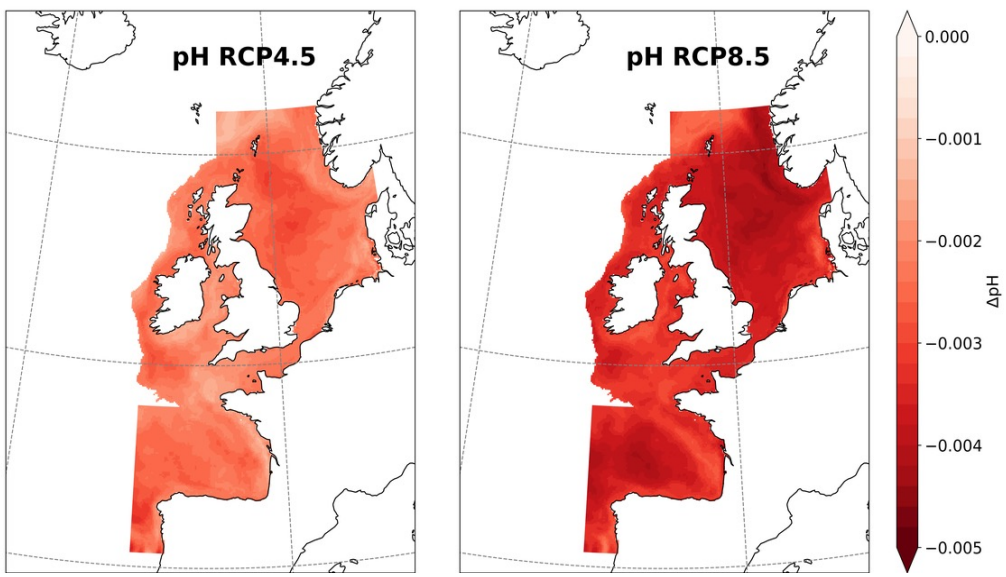
Approach and methods used

- 2 regional process-based models
- High and mid emission scenarios (2050)
- High emission scenario (2100)

pH trend (yr^{-1}) between 2015 and 2049



Region I Arctic Waters
NORWECOM.E2E (IMR NO)

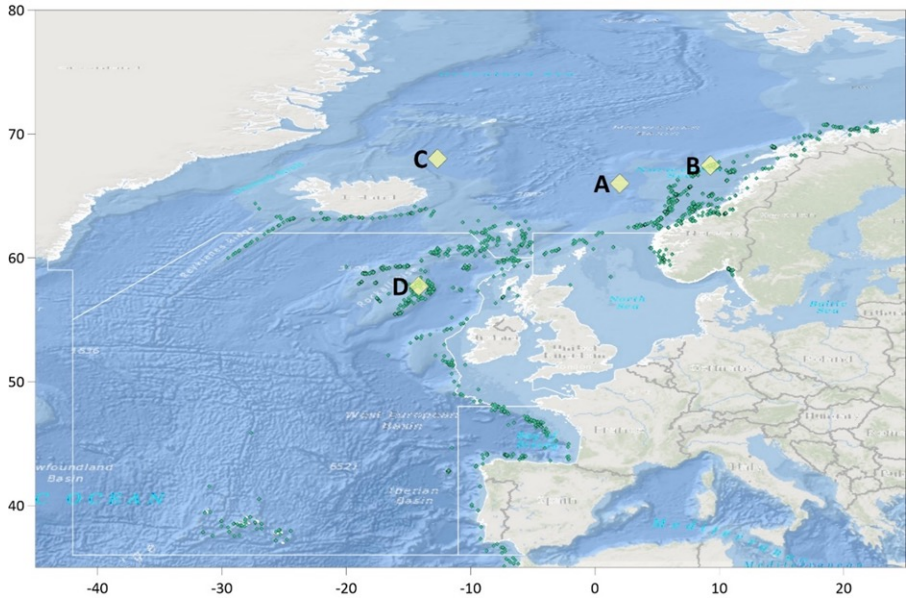


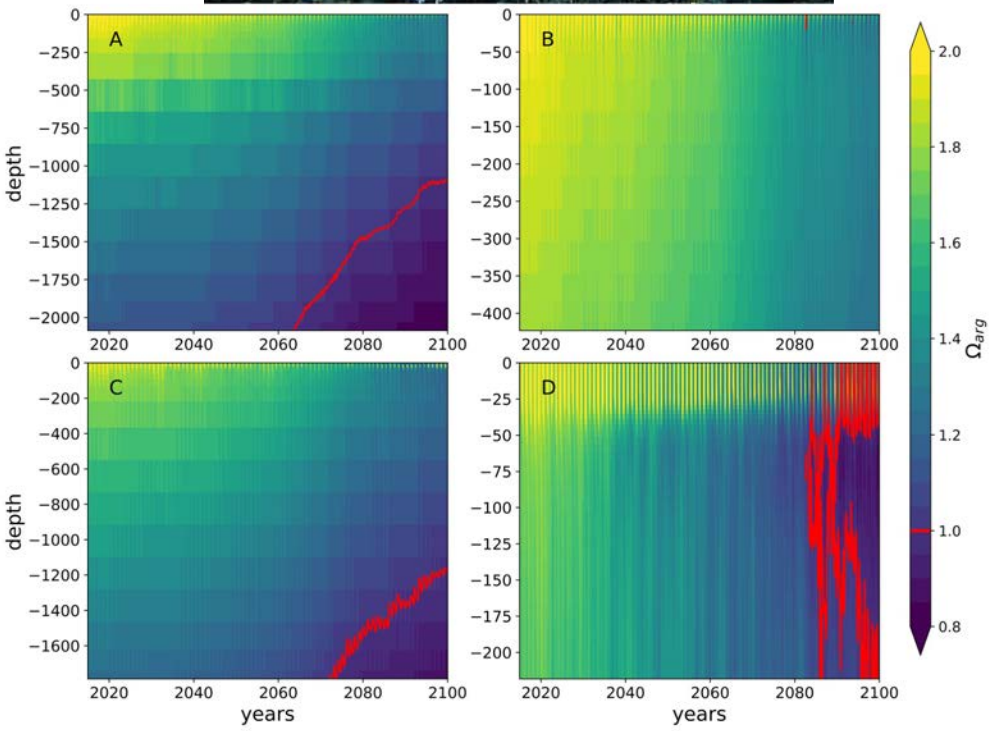
Regions II North Sea, III Celtic Seas, IV Bay of Biscay
AMM7 NEMO-ERSEM (PML UK)

Approach and methods used

CASE STUDIES relevant to NE Atlantic:

- *Lophelia pertusa* reefs
- Atlantic Cod (interactions with T & fishing pressure)
- Bivalve Larvae Shell integrity and Ω
- Literature on projected revenue loss (fisheries)





Approach and methods used

Key Messages, Recommendations

1 Introduction

2 Trends and variability

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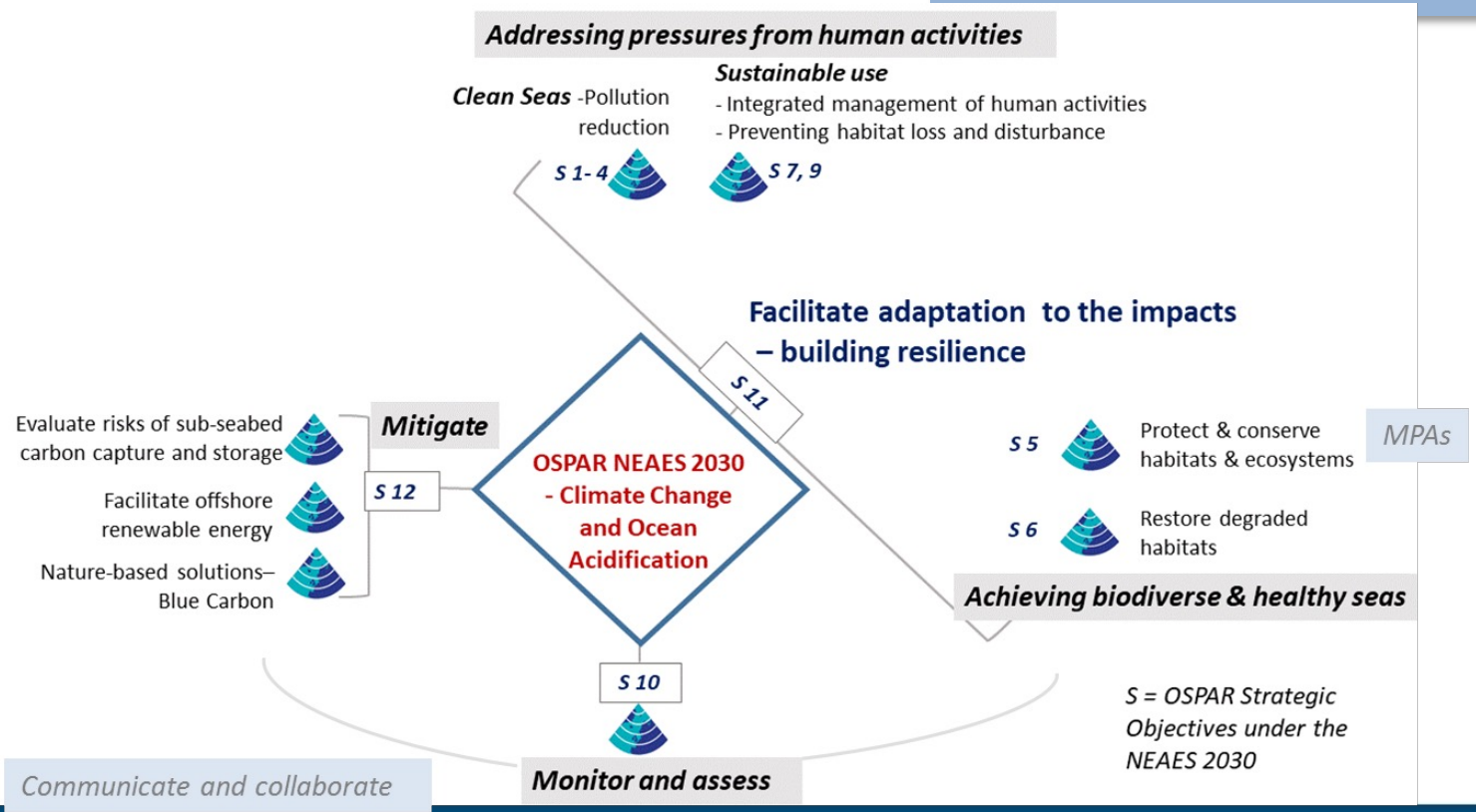
5 Adaptation and Mitigation

Mitigation, Adaptation &
the OSPAR NE-Atlantic Environment Strategy (NEAES)



Key messages

Ocean acidification is observed in all regions of the OSPAR Maritime Area

- The rate of change varies per region (-0,0011 to -0,033 pH units per year)
- Local processes (such as nutrient input and productivity) have strong influence

Ocean acidification is projected to continue under the studied emmission scenarios

- An acceleration is projected for the high emission scenario
- The sea floor area of deep waters corrosive to calcareous structures is projected to increase significantly

Ocean acidification puts marine life (further) under pressure

- OA pressure typically coincides with other pressures (multi-stressor)
- Threatened and/or declining species and habitats are particularly vulnerable
- Significant economical consequences expected (loss of revenue commercial species)

OA needs to be taken into account when considering climate change adaptation and mitigation

- Such measures may alleviate or exacarbate ocean acidification and its impacts
- Removing other pressures (pollution, habitat destruction) can increase ecosystem resilience to OA impacts

Recommendations (research)

More and continued support is needed for monitoring

- Multiple components of the carbonate system
- At appropriate spatial and temporal resolution (especially in coastal areas)
- Optimised for investigating biological impacts
- Optimised for informing measures

Support is needed to further constrain future projections of OA using model ensembles

Future work to resolve the biological impact should

- Consider realistic (and not just worst-case) scenarios
- Account for the modulating role of multiple ocean stressors, ecological interactions, and evolutionary processes

Further work is needed on potential 'bioindicator' candidates

- Robust
- Sensitive
- Ocean acidification-specific is needed
- Wide biogeographical range

Recommendations (policy)

Measures that reduce CO_2 emissions

Measures that remove CO_2 from the atmosphere or the ocean

- Notably with the latter: consider potential OA and other environmental impacts of measure

Measures that enhance resilience (by reducing other pressure), e.g.

- Nutrient input
- Pollution
- Habitat degradation and destruction

Measures that enhance resilience (by increasing biodiversity and community structure), e.g.

- MPA's
- OECM's
- (Over)exploitation

Find the OA assessment on our Assessment Portal

https://oap.ospar.org/en/ospar-assessments/quality-status-reports/qsr-2023/other-assessments/ocean-acidification/

OSPAR
QUALITY STATUS REPORT 2023

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jos.schilder@rws.nl

EXPLORING MARINE MANAGEMENT AND POLICY RESPONSE TO OCEAN ACIDIFICATION

Brest, France | 24th May 2023

OA ALLIANCE | INTERNATIONAL ALLIANCE TO COMBAT OCEAN ACIDIFICATION

OSPAR COMMISSION

NEA Hub


OA
ALLIANCE
INTERNATIONAL ALLIANCE TO
COMBAT OCEAN ACIDIFICATION

OA ACTION PLANS INTEGRATE & INCLUDE:

ADVANCING SCIENTIFIC UNDERSTANDING:
Improving understanding within the region, including support for monitoring, research and OA observations.

REDUCING ATMOSPHERIC EMISSIONS OF CO_2,
the number one cause of ocean acidification

REDUCING LAND-BASED POLLUTIONS
(e.g. wastewater, stormwater, agriculture runoff, nutrients) that can exacerbate coastal conditions.

BUILDING ADAPTATION AND RESILIENCY:
Actions that assist ocean-dependent communities, industries, and marine ecosystems in adapting to increasing acidity in marine waters.

EXPANDING PUBLIC AWARENESS:
Engaging policy makers, scientists, local communities/ villages and the public about the growing threat posed by OA, as well as local actions that may be taken to address OA.

BUILDING SUSTAINED INTERNATIONAL SUPPORT:
Advocating for sustained funding, nationally and regionally, for coordinated research and OA observation systems, to continue to inform governments and others about the increasing impacts of OA.

EXISTING EUROPEAN LANDSCAPE

CONVENTIONS WITH RELEVANT RESPONSIBILITIES

- OSPAR Convention
  - Intersessional Correspondence Group on Ocean Acidification (ICG-OA) OA Assessment
- Helsinki Convention (HELCOM)
- Barcelona Convention
- Arctic Council
  - Working groups including AMAP; CAAF; PAME
- Bucharest Convention

CONVENTIONS WITH RELEVANT MANDATES

OSPAR Commission	
Existing Efforts	Relevance for OA
OSPAR COMMISSION	Monitor Report Set research priorities Reduction of CO2 (introduced through atmosphere & land) Reduction of other stressors (esp. pollution) Build ecosystem resilience
Helcom	
Existing Efforts	Relevance for OA
HELCOM	Monitor Report Set research priorities Reduction of CO2 (introduced through atmosphere & land) Reduction of other stressors (esp. pollution_ Build ecosystem resilience
Arctic Council – Working Groups: AMAP, CAFF, PAME	
Existing Efforts	Relevance for OA
ARCTIC COUNCIL	Monitor Report Set research priorities Reduction of CO2 (introduced through atmosphere & land) Reduction of other stressors (esp. pollution) Build ecosystem resilience

DIRECTIVES WITH RELEVANT GOALS OR MANDATES

- Marine Strategy Framework Directive
- Marine Spatial Planning Directive
- Water Framework Directive
- Nitrates Directive
- Habitats Directive
- Birds Directive

DIRECTIVES WITH RELEVANT GOALS OR MANDATES

Monitoring; Reporting; Research; Mitigation & Remediation; Adaptation & Resilience Building.

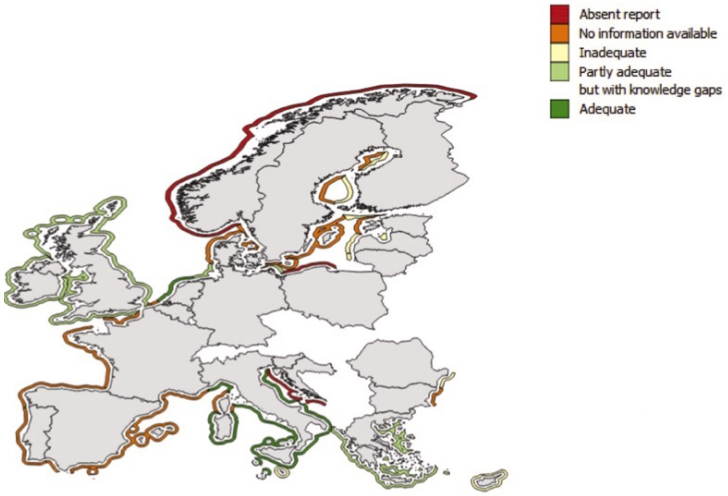
Directives	**Legal and Management Responses to Ocean Acidification—European Frameworks**				
	OA Monitoring Measure, Evaluate/Assessment	OA Reporting Document and Share OA information	OA Research Set OA Research Priorities	Mitigation/Remediation CO_2 and Pollution	Adaptation and Resilience Building
MSFD					
MSPD					
WFD					
Nitrates Directive					
Habitats Directive					
Birds Directive					

MARINE STRATEGY FRAMEWORK DIRECTIVE

L-Università ta' Malta

Assessing Frameworks for Implementing OA Action

European policies and legislation targeting ocean acidification in European waters



OceanGov
EUROPEAN COST ACTION

cost
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

Funded by the Horizon 2020 Framework Programme of the European Union

Galdies, et al. 2020

CONCLUSIONS & RECOMMENDATIONS

- Need to ensure a **coordinated governance** effort to directly address OA (global & regional).

- At the European level, national policies and legislation addressing OA remains **scarce** and **uncoordinated**.

- Need European-wide coordinated governance and to **improve national GES and MSFD reporting on OA**.

Galdies et al., 2020.

WE CAN ACCOMPLISH THIS BY…

- Identify **gaps/ opportunities** in current **policies and management** strategies (*information, mitigation and adaptation/resilience*).

- Strengthen the **MSFD** by making it **more comprehensive** towards OA abatement, **synergised** with other **EU Directives**.

- **Raise awareness** among policy-makers of the unique **threat**, **management** actions, and **governance** solutions needed to mitigate OA.

Galdies et al., 2020.

RELEVANCE OF OA INFORMATION TO MSFD

- **Aim and Objectives:** *To achieve GES using eco- based approach*
- **What Does it Measure:** *GES* (*bio, physio, geo, climate, physical, chemical, acoustic*).
- **Thresholds**: *Across 11 descriptors*.

  - Relevance for: OA monitoring, reporting, setting research priorities…
    Also: remediation, adaptation and resilience strategies??

OA Information can be used for:

- Increasing monitoring, modelling and determining shared research priorities (biological/ indicators).
- Make the case for increased pollution controls (nutrients/ eutrophication).
- Help inform decisions about conservation (MPA).
- Help inform decisions about sustainable marine use/ activities (MSP).

INTERVENTIONS & DISCUSSION

How is the European Commission approaching updates to the Marine Strategic Framework Directive and the Marine Spatial Planning Directive in the context of climate change?

ALLIANCE

OSPAR COMMISSION

NEA Hub

Are countries including OA within annual reports?

From your perspective, how does OA information support evaluations of Good Environmental Status or taking an ecosystem – based approach to marine management?

OA ALLIANCE

OSPAR COMMISSION

NEA Hub

Is OA information adequately represented across the MSFD?

What are the opportunities for incorporating OA monitoring and information more uniformly across MSFD? What are the challenges?

What other Conventions or Directives should be examined or utilized to accelerate OA information and reduce impacts?

OA ALLIANCE

OSPAR COMMISSION

NEA Hub

IS IT USEFUL TO CONTINUE MAPPING RESPONSIBILITIES AND OPPORTUNITIES?

OSPAR Commission – organized by Work Areas	
Existing Efforts	Relevance for OA
Biological Diversity and Ecosystems – Including through: MPAs, Biodiversity Monitoring & Assessment, (Monitoring: CEMP)	Monitor Adaptation, Report
Hazardous Substances and Eutrophication - Including through: HASEC (MIME, INPUT, ICG Eut, ICG EMO) (Monitoring: CAMP, RID, CEMP, JAMP, HARPNUT, EMEP)	CO2 Reduction, Stressor Reduction, Monitor, Report
Human Activities – Including through: EIHA with Marine Litter (ICG ML including ML RAP for plastic), Cumulative Effects (ICG EcoC), Shipping & Ballast Water, Dredging & Dumping, Fisheries & Mariculture	Stressor Reduction, Monitor, CO2 Reduction
Cross-cutting issues – Including through: OA - OSPAR's Intersessional Correspondence Group on Ocean Acidification (ICG-OA) OA Assessment, Work on OA with partners from: IOC and ICES (SGOA), Climate Change both OA and CC added to North-East Atlantic Environment Strategy 2030, (Monitoring: CEMP, JAMP)	Monitor, Research, Report, CO2 Reduction, Stressor Reduction, Adaptation
Helcom – organized by Working Groups	
Existing Efforts	Relevance for OA
State & Conservation – Including through: EN Clime, EG Benthic, EG Eutro, EG Haz	Monitor, Research, Report, CO2 Reduction, Stressor Reduction, Adaptation
Maritime – Including through: JTG Ballast & Biofouling	Monitor, Research, Report, CO2 Reduction, Stressor Reduction
Pressure – Including through: EG DreDS, EG Marine Litter, EG RedCore	Monitor, Report, CO2 Reduction, Stressor Reduction
Agri	CO2 Reduction, Stressor Reduction
Fish – Including through: Fish M	Report, Monitor, Adaptation, Stressor Reduction
HELCOM-VASAB MSP	Monitor, Research, Report, Adaptation
Arctic Council – organized by Working Groups	
Existing Efforts	Relevance for OA
AMAP – Including through: Assessment on Arctic OA 2013, 2018; Scoping outline for AMAP-CAFF joint-work on Climate change impacts on Arctic ecosystems and associated climate feedbacks	Monitor, Report, Research, CO2 Reduction
CAFF – Including through: Circumpolar Biodiversity Monitoring Programme (CBMP); Arctic Biodiversity Assessment (ABA): Report for Policy Makers 2013; Arctic Biodiversity Assessment (ABA): Report for Policy Makers 2013 (policy recommendations); Actions for Arctic Biodiversity 2013-2021: implementing the recommendations of the Arctic Biodiversity Assessment (ABA)	Monitor, Report, Research, CO2 Reduction, Stressor Reduction, Adaptation,
PAME – Including through: Arctic Marine Shipping Assessment (AMSA) 2009; Survey' of wastewater discharges; Arctic Offshore Oil and Gas Guidelines 2009, 2017; Framework for a Pan-Arctic Network of Marine Protected Areas 2015 & 2021-2023 update assessment	CO2 Reduction, Stressor Reduction, Adaptation,

IS IT USEFUL TO CONTINUE MAPPING RESPONSIBILITIES AND OPPORTUNITIES?

Directives	**Legal and Management Responses to Ocean Acidification – European Frameworks**				
	OA Monitoring Measure, Evaluate/Assessment	OA Reporting Document and Share OA information	OA Research Set OA Research Priorities	Mitigation & Remediation CO_2 and Pollution	Adaptation and Resilience Building
MSFD	pH and equivalent OA indicators, oxygen and nutrients.	Reporting after reviews and updates of marine strategies including on monitoring programs, and the determination of GES (especially descriptor 5 and 7). Interim report on the implementation of programs of measures.			Marine Protected Areas (networks)
MSPD		Reporting of the Maritime Spatial Plans and explanatory materials by each Member State.			Marine Protected Areas as part of MSP
WFD	Especially: Oxygen and nutrient conditions.	Reporting on: Monitoring programs, the human impacts on surface water status and the implementation of the programs of measures.			Marine protected Areas (facilitative)
Nitrates Directive	Eutrophic state.	Reporting on: water (possibly) affected by pollution, monitoring results and the action programs implemented by Member States.		Reduction of nutrient input	Reduction of nutrient input
Habitats Directive	Conservation status of natural habitats and species → all parts **influencing** the long-term natural distribution, structure, and functions of habitats as well as the long-term survival of its typical species and the long-term distribution and abundance of species.	Reporting on: Conservation measures for protected areas, their effect on the conservation status of the natural habitats and species and the results of the monitoring.	Research facilitates the monitoring process and the achievement of favorable conservation status		Framework for Marine Protected Areas (Natura 2000)
Birds Directive		Reporting on the national implementation of the obligations under this directive (e.g., the establishment of MPAs).	Particular attention on the role of species as pollution indicators and the effects of chemical pollution on bird populations.		Framework for Marine Protected Areas (Natura 2000)

THANK YOU!

Brest, France | 24th May 2023

OA ALLIANCE | INTERNATIONAL ALLIANCE TO COMBAT OCEAN ACIDIFICATION

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