FutureMARES Science for Policy




ISABEL SOUSA PINTO

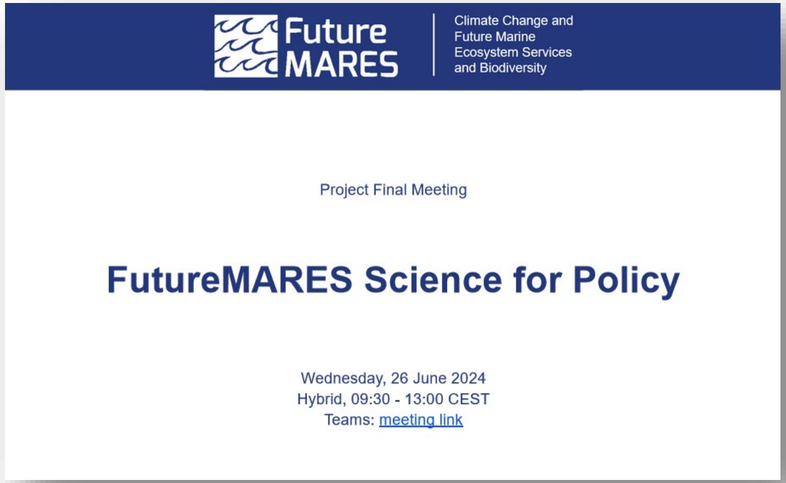
CIIMAR

TEXEL, 26 JUNE 2024

European Commission

Objectives

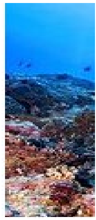
- Present **policy relevant results** to policy makers, and **receive their feedback**.
- Coordinator presents FutureMARES
- Project experts
    - present 1-2 key results/tools produced by FuMa
    - explain how these results/tools can inform policymaking;
    - identify expectations or requests for support from policy makers for the uptake of these key results/tools.
- Presentations will be followed by interactive discussions with policymakers to collect feedback on the work presented

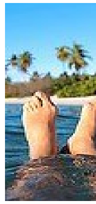

Future MARES | Climate Change and Future Marine Ecosystem Services and Biodiversity

Project Final Meeting

FutureMARES Science for Policy

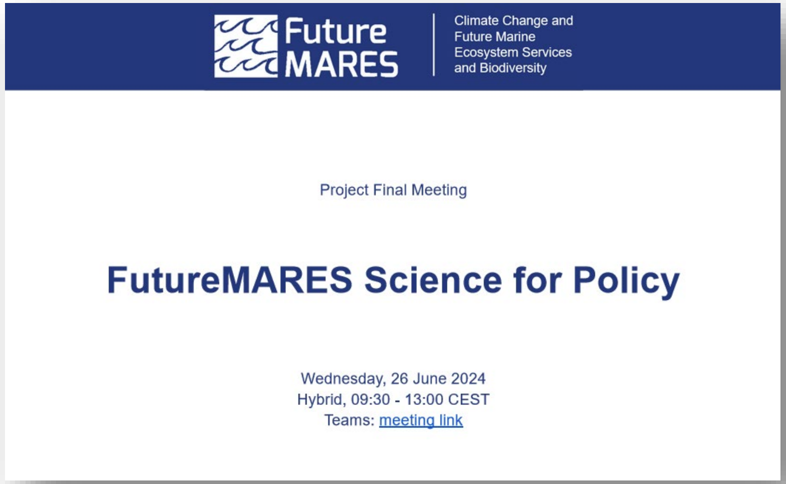
Wednesday, 26 June 2024
Hybrid, 09:30 - 13:00 CEST
Teams: meeting link



Expected Outcomes

1. Results and tools are **linked to specific EU policies**, enhancing their relevance and application
2. Expectations and requests for support from policymakers for the **uptake of FuMA results** and tools are identified and addressed
3. Opportunities to **embed the knowledge** produced by FuMA in the policy landscape are seized
4. Specific **contributions made by FuMA are known and recognised** by policymakers


Future MARES
Climate Change and Future Marine Ecosystem Services and Biodiversity

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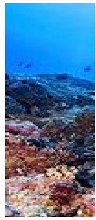
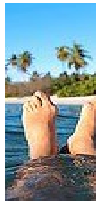
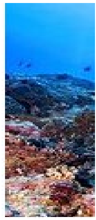
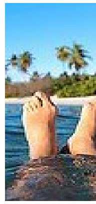




Session 1 – Climate Sensitivity and Resilience of Marine Biodiversity

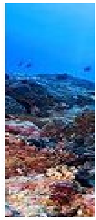
Moderator: Myron Peck		
9:40 - 9:50	**Climate Exposure of European Marine Areas: Hotspots and refugia**	**Momme Butenschön,** CMCC
9:50 - 10:00	**Building Blocks of Marine Biodiversity: Climate sensitivity and resilience**	**Gil Rilov,** IOLR
10:00 - 10:30	**Interactive discussion with policymakers and policy-related stakeholders**	**In the panel:** Momme Butenschön, Gil Rilov, Katharina Alter, and policymakers

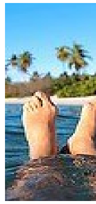





Session 2 – Effective Restoration and Conservation Strategies for Marine Species and Habitats

Moderator: Isabel Sousa Pinto		
11:00 - 11:10	**Climate-smart Nature-based Solutions**	**Ana Queirós,** PML
11:10 - 11:20	**Big data and ecosystem indicators**	**Jose Fernandes,** AZTI
11:20 - 11:30	**Marine Restoration**	**Dorte Krause-Jensen,** Aahrus University
11:30 - 12:00	**Interactive discussion with policymakers and policy-related stakeholders**	**In the panel:** Jose Fernandes, Dorte Krause-Jensen, Ana Queirós, and policymakers

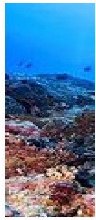



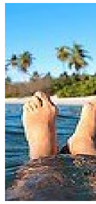


Session 3 – Marine Ecosystem Services and Sustainable Harvesting in a Future Climate

Future MARES

Moderator: Chris Lynam		
12:00 - 12:10	**Digital marine labs as experiments to investigate the effects of socio-political scenarios with combined Nature-based Solutions and Nature-inclusive Harvesting**	**Marta Coll,** ICM-CSIC
12:10 - 12:20	**Evaluating the effectiveness of Nature-based Solutions using Climate Risk Assessments**	**Juan Bueno,** UVigo (online)
12:20 - 12:30	**Ecosystem Services valuation for Nature-based Solutions assessments**	**Sarah Simons**, Thünen Institute
12:30 - 12:55	**Interactive discussion with policymakers and policy-related stakeholders**	**In the panel:** Marta Coll, Juan Bueno, Sarah Simons, and policymakers



FutureMARES Science for Policy

Introduction to the FutureMARES Program

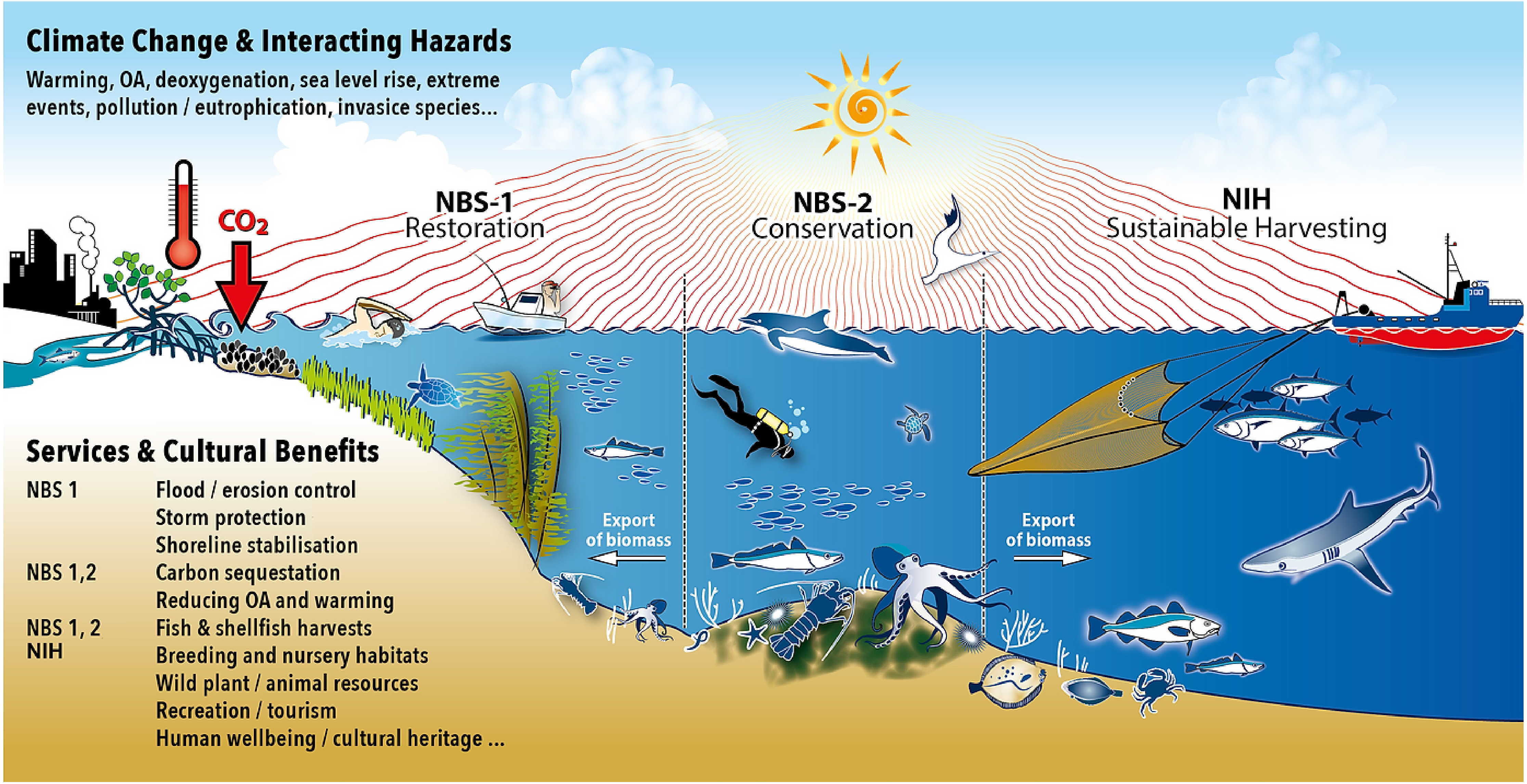
(Climate Change and Future Marine Ecosystem Services and Biodiversity)

Myron A. Peck and whole FutureMARES team

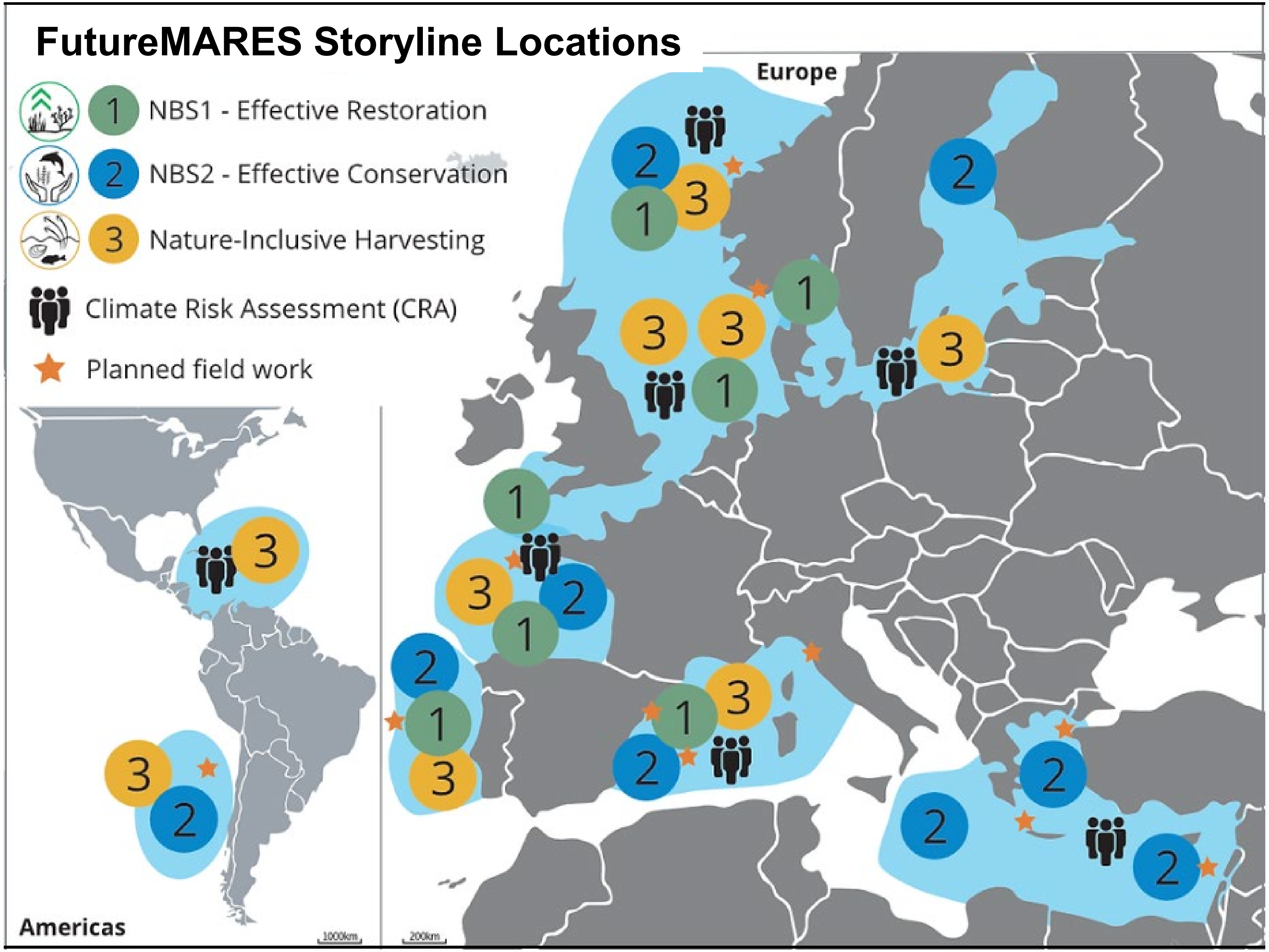
TEXEL, 26 JUNE 2024

European Commission

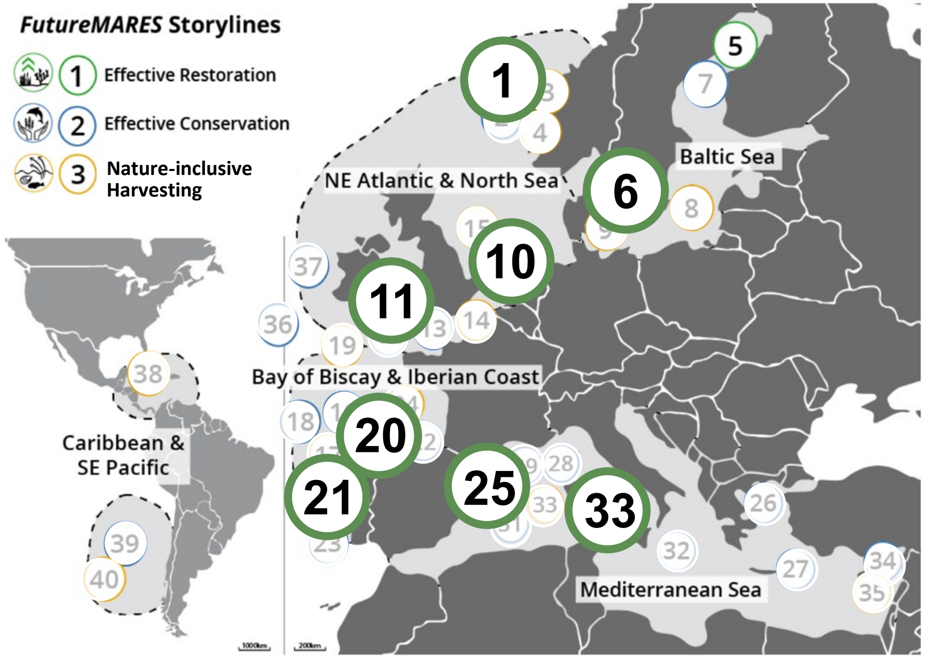
Goal: Provide socially and economically viable actions, strategies and Nature-based Solutions for Climate Change adaptation and mitigation to safeguard future biodiversity, and ecosystem functions, maximising natural capital and its delivery of services from marine ecosystems.



3 Case Studies
40 "Storylines"



NBS1: Restoration of Habitat-forming species Storylines



Ecosystem functions and services

Coastal protection
Carbon sequestration
Biodiversity
Seawater quality/clarity
…

Climate change adaptation & mitigation
Fisheries, tourism, cultural activities

REEF-FORMING ORGANISMS

Oyster/mussels
Dutch coast, NE Atl./North Sea)

KELP/MACROALGAL

Kelp
Norwegian Coast, NE Atl./North Sea

Seaweeds, seagrasses
NE Baltic Sea

Kelp
Portugal, Iberian & Bay of Biscay

SEAGRASS

Zostera marina
Denmark, SW Baltic Sea)

Zostera noltei
Iberian & Bay of Biscay

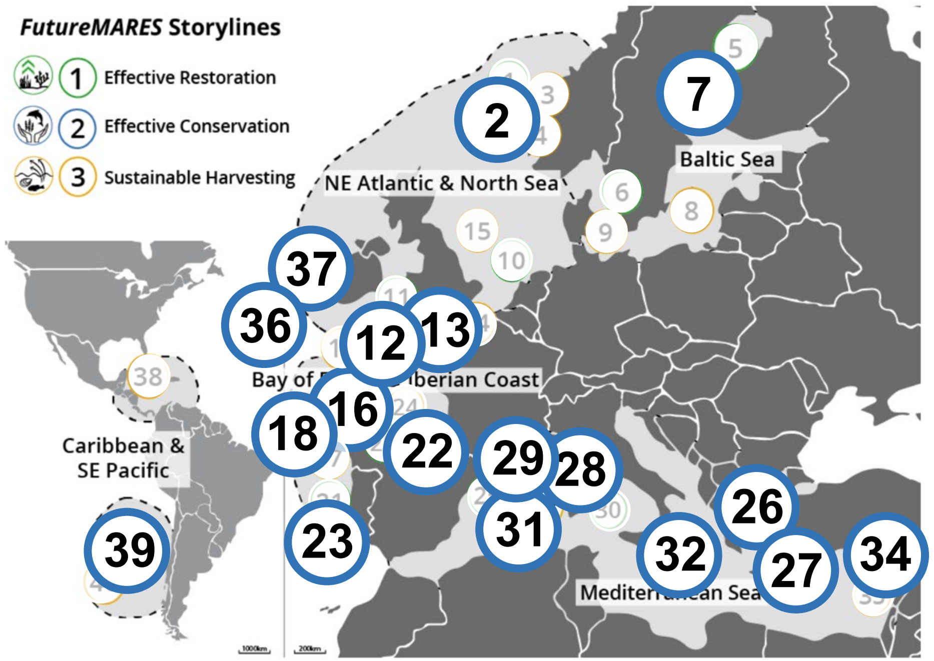
Posidonia oceanica
Western Mediterranean

33

SALTMARSH

Saltmarsh habitats
NE Atlantic/
North Sea (Torridge)

NBS2: Effective Conservation Storylines



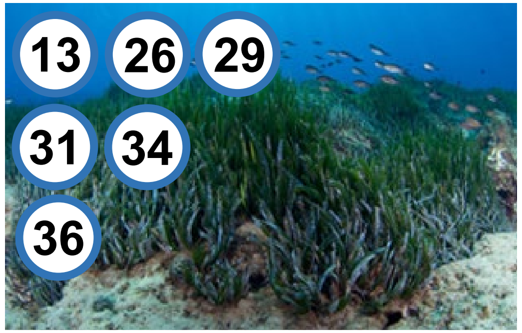
Enhance effectiveness of Marine Protected Area (MPA) networks as part of climate adaptation planning.

Examples:

- Identify climate refugia to set MPAs at regional and subregional scales
- Develop adaptation action plans

HABITAT-FORMING SPECIES

Seagrasses
North Sea,
Bay of Biscay
Karpathos/Greece
NW Mediterranean



Seaweeds / Algal Turf
NE Baltic Sea
SE Mediterranean Sea

Corals
W Mediterranean
E Mediterranean

Kelp
Norwegian Coast
North Sea
N Portugal

TRANSITIONAL WATERS

Diadromous species
Marine-estuarine opportunists
Rocky Intertidal Coasts
Atlantic

CHARISMATIC SPECIES

Mediterranean Sea

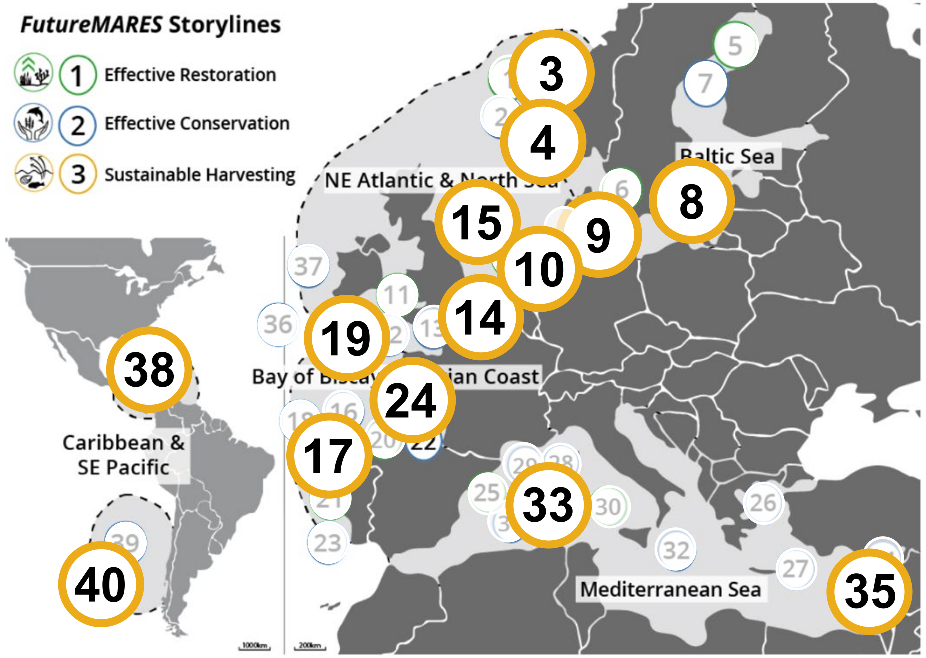
SOFT SHELF SEABED

North Sea

ISLAND ECOSYSTEMS

Chile

NIH: Nature-inclusive Harvesting Storylines



Sustainable seafood harvesting

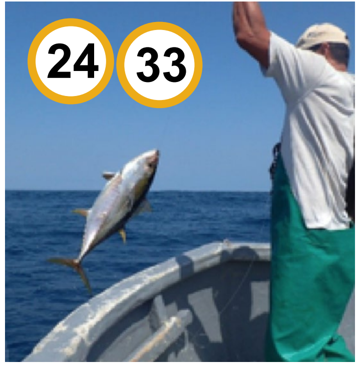
Fisheries & aquaculture
Flexible, adaptive management
Ecosystem-based approach
Cultural heritage
…

CC adaptation
Sustainable production,
Blue Growth

ARTISANAL FISHERIES
Bay of Biscay
NW Mediterranean

CONCH/LOBSTER FISHING
Belize

ECOSYSTEM APPROACH
Chile

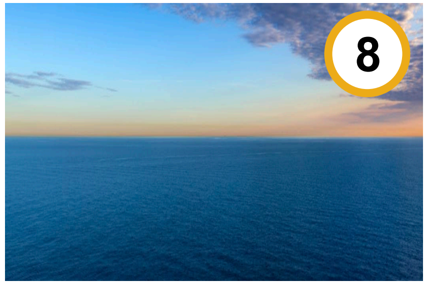


INDUSTRIAL FISHING
Bay of Biscay
SE Mediterranean
NW Mediterranean
North Sea

FISH – ATLANTIC & SCANDINAVIAN
Marine and upstream waters

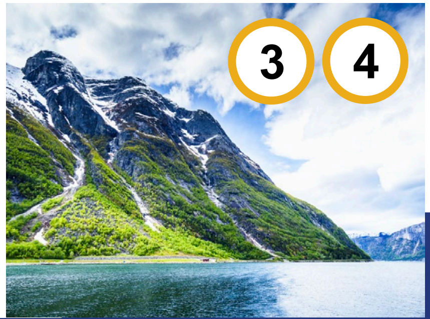
MPAs across basins
Baltic Sea

SUSTAINABLE MUSSEL CULTURE
SW Baltic Sea



SUSTAINABLE SALMON AQUACULTURE
Norway

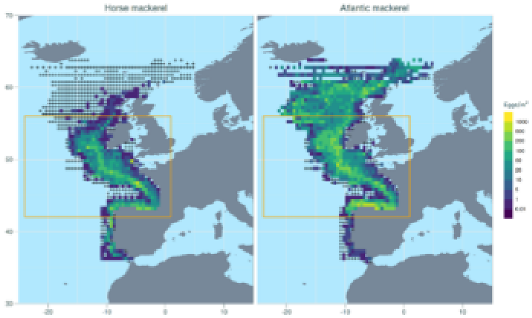
SEAWEED & OYSTERS
NE Atlantic, North Sea



01 UNDERSTANDING HISTORICAL CHANGES

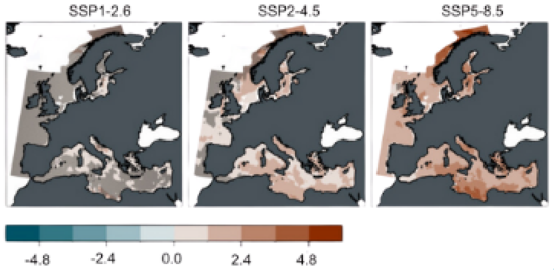
- **Time series**: 4 decades, 1,817 marine species, 65 monitoring programs
- **Northeast Atlantic, Baltic and Mediterranean Seas**
- Historical **changes in species and habitats** related to climate change
- Community Temperature Index (CTI)

! **Warning**: rising temperatures lead to changes in marine biodiversity across Europe!



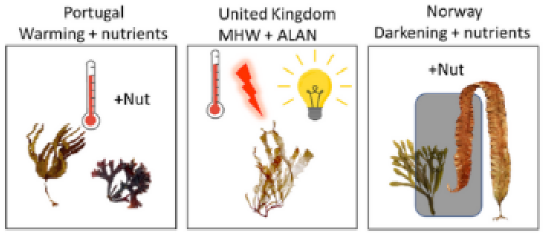
02 CLIMATE CHANGE HOTSPOTS & REFUGIA

- **Warming and acidification** projected for four European Seas
- Mediterranean Sea and subpolar regions along the coast of northern Norway are likely **climate change hotspots**
- Temperate mid-latitude shelf seas are less affected
- **Ocean acidification** highest in Bay of Biscay, southern Adriatic and Aegean Seas
- **Deoxygenation** expected highest in deeper parts of Western Mediterranean Sea due to reduced vertical mixing



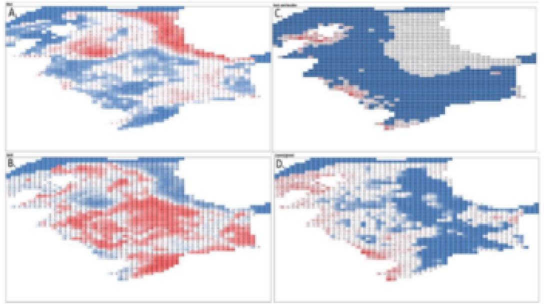
03 MECHANISTIC RESPONSES TO CHANGE

- **Complex interactions** between different **climate change** (e.g., warming) **and local stressors** (e.g., artificial light at night) and how they together impact marine species
- Evidence for **thermal superiority of tropical non-native invaders** over native species in **Mediterranean Sea**, suggesting that they will function much better under future ocean warming than natives
- **Macrophyte species** tested in the project have **inherent adaptation** to local thermal conditions within their distributional range



04 MODELLING AND MAPPING FUTURE CHANGE

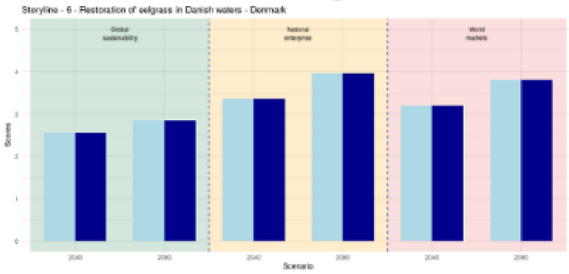
- **Improved habitat suitability models** for key restoration and conservation species
- **Advanced ecosystem simulations** projecting tradeoffs in scenarios of NBS and NIH implementation
- **Maps for marine spatial planning** of NBS, NIH in a future climate
- **Cooperation with NGO** FairSeas (Ireland) mapping 'brightspots' for conservation



05 CLIMATE RISK ASSESSMENTS (CRAS)

- **Socio-ecological CRAs** that highlighted vulnerable areas
- **NBS can reduce climate risks** across all species, regions and future scenarios, and can lead to positive effects on ecosystem goods and services
- **Cost-benefit analyses** show how NBSs can sustain economies from local to regional scales, under alternative future scenarios

Nature-based Solutions Climate risk tool



TOOLS AND RESULTS

1. **Regionalised FutureMARES Scenarios** projecting three different climate futures (following RCPs and SSPs)
2. **New ecosystem health indicators** contributing to EU Biodiversity Strategy
3. **Maps of climate hotspots and refugia** as basis for Marine Spatial Planning
4. **Shiny App - Climate Risk Assessments** enabling users to conduct their own CRAs with/without NBS implementation
5. **Spatially explicit tools** for visualising future climate change hotspots and refugia across European seas
6. **Decision-Support Tools** combining GIS with Bayesian Belief Network analysis to show tradeoffs between scenarios and inform policy

The FutureMARES Scenarios

Global Sustainability (SSP1-2.6)

Low challenges to mitigation and adaptation
a more sustainable path
commit to achieving development
lower material growth, resource and energy intensity

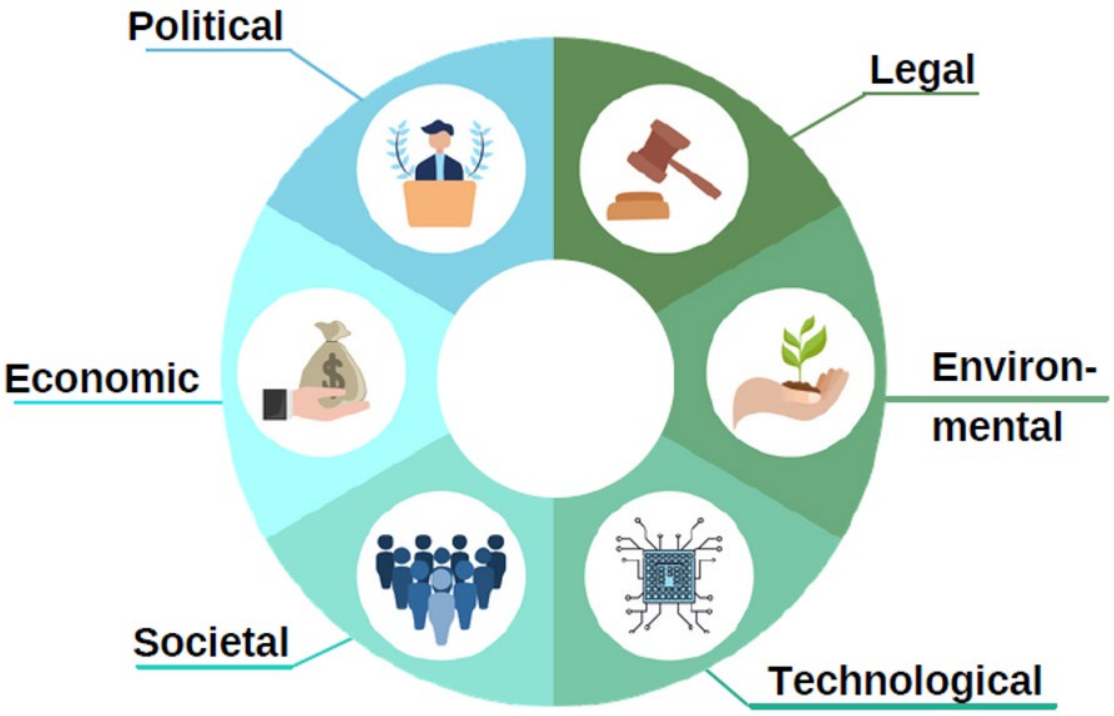
National Enterprise (SSP3-8.5)

High challenges to mitigation and adaptation
A resurgent nationalism
countries focus on domestic or regional issues
Investments in education and technology decline
low international priority to address environmental concerns

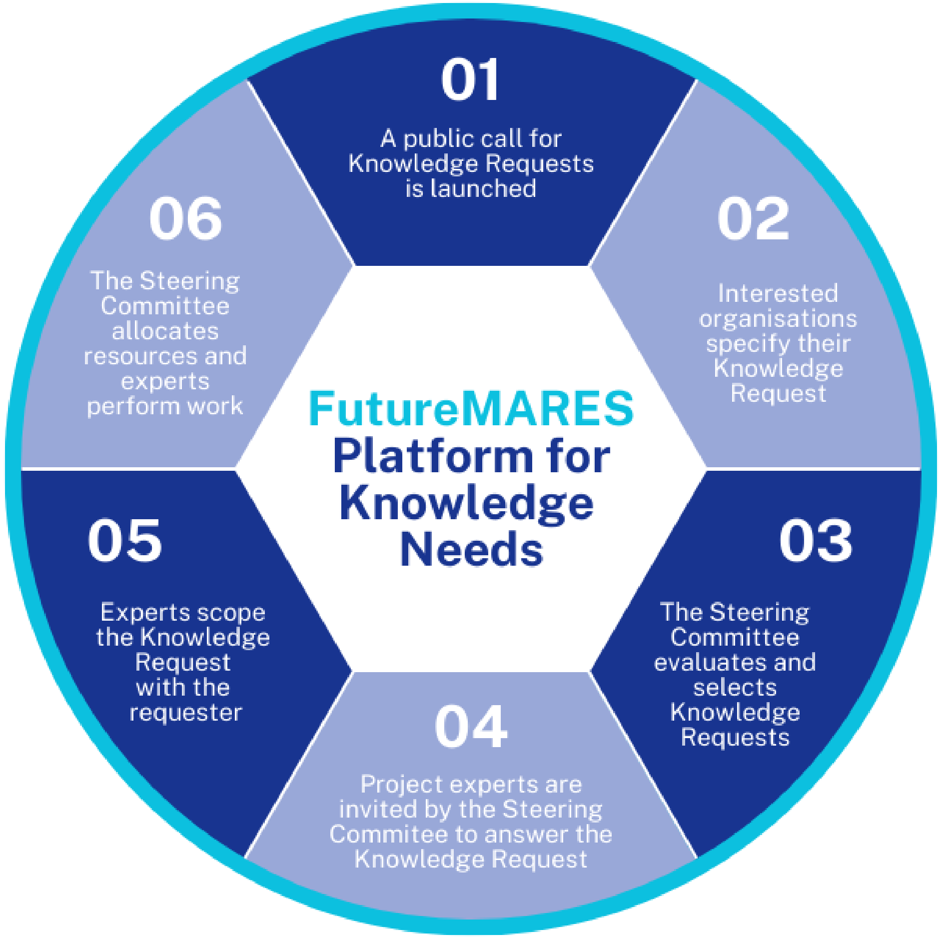
World Markets (SSP5-8.5)

High challenges to mitigation, low challenges to adaptation
competitive markets, innovation and participatory societies
train and educate people for sustainable development
global markets enhance human and social capital
exploiting abundant fossil fuel resources

PESTLE Approach to Create Regional NBS / NIH Scenarios



Knowledge products and expertise at the request of decision-makers



FutureMARES

CALL FOR KNOWLEDGE NEEDS
for Policy Development and Implementation

Deadline 6th July 2022 *extended*

Policy-makers are invited to identify knowledge needs related to the implementation Nature-based Solutions (NBS) to safeguard marine biodiversity and ecosystems in a future climate, and to request the development of specific knowledge products that are in the area of work from *FutureMARES* (please see below: *FutureMARES* goals).

Interested parties should apply until July 6, 2022 by following the procedure detailed below. The results of the selection will be announced in early August, 2022. Requesters will be contacted and each selected request selected will be announced on the FutureMARES website, including the short description provided.

Objective of the call

The Call provides policy-makers with a platform where they can put forward requests for development of specific knowledge products. Products can take many forms such as a literature review, stakeholder consultation, establishing specific working groups or generating results from specific research activities (see below). This call allows *FutureMARES* to develop products that support policy development and implementation on emerging issues (e.g. those unforeseen when the project was designed).

Process

Interested parties should apply before the 6th of July 2022.
Requesters will need to fill in a form outlining the major elements of the request. In this form, the requester is expected to provide some background on why the topic is of interest at European or regional scale, to which sectors or societal groups it is relevant, and indicate the required outputs.
The request form will then be screened by the *FutureMARES* consortium who might contact the requester if any clarification is needed. The selection results will be communicated to the requesters and published on the *FutureMARES* website.

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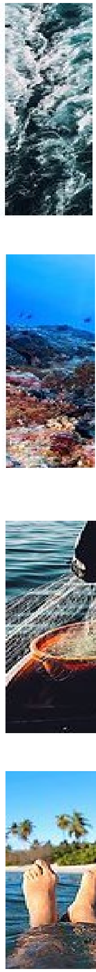
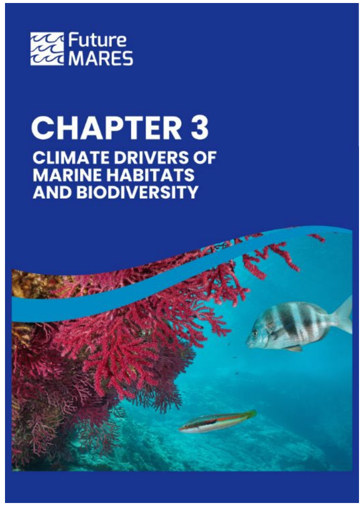
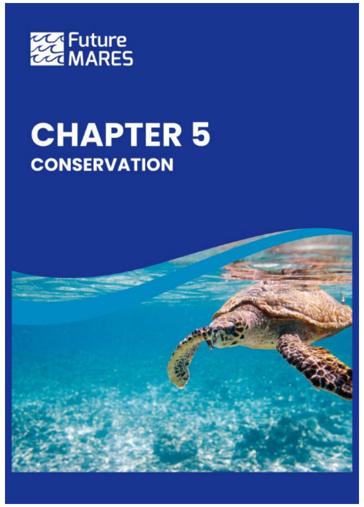


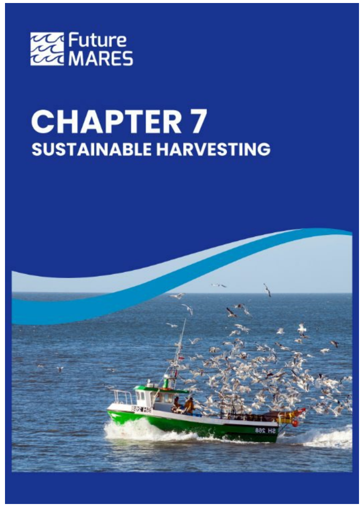
Help shape our Synthesis

https://www.futuremares.eu/

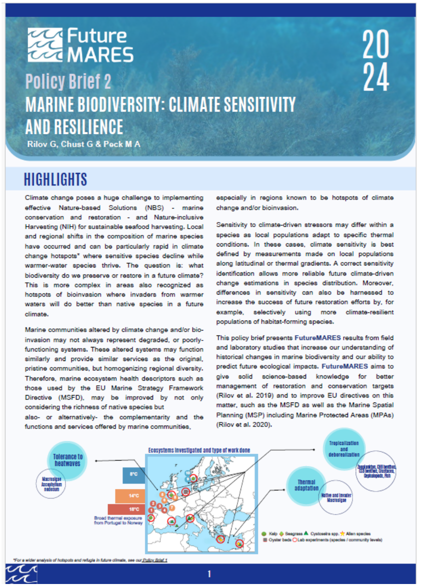
Synthesis Report (9 chapters)







Policy Briefs (5)



FutureMARES Storylines

Storylines 1, 2, 3
Norwegian Coast, inter-relationships among kelp, sea urchins and cod

Storyline 4
Salmon at Hardangerfjord, Norway

Storyline 6
Restoration of eelgrass (Zostera marina) in the south-west Baltic Sea

Storyline 7
Conservation of coastal seaweeds, seagrasses, invertebrates and fish in the north-east Baltic Sea

Storyline 8
Basin scale management & MPAs in the Baltic Sea

Storyline 9
Sustainable mussel culture in the Limfjorden, SW Baltic Sea

Storyline 10
Restoration of oysters in Dutch coastal waters

Storyline 11
Saltmarsh, seagrass and kelp habitats in the North Devon UNESCO World Biosphere Reserve

Storylines 12 &14
Marine spatial planning (broad coverage)

Storyline 13
Conservation of ecosystem services from shelf (soft) seabed in the North Sea

Storyline 15
Seaweed, mussels, and oysters in the north-east Atlantic and North Sea

Storylines 16 &17
Marine-estuarine opportunists in the NE Atlantic Ocean

Storylines 18 &19
Diadromous species in the NE Atlantic Ocean, including transitional and upstream waters

Storylines 20, 22, 24
Nature-based Solutions in the Basque coast of Bay of Biscay: seagrass restoration, protected areas, and sustainable seafood harvesting

Storylines 21 & 23
Kelp forests & biodiversity in northern Portugal

Storyline 25
Restoration of seagrass (Posidonia oceanica) in the Balearic Islands (NW Mediterranean)

Storyline 26
Marine Protected Area network for Aegean biodiversity

Storyline 27
Karpathos & Saria MPAs: seagrasses and meadows, soft/rocky bottom

Storyline 28
Seagrass meadows and macroalgal forests in the MPA network of the Tuscan Archipelago

Storyline 29
Habitat-forming macroalgae / corals in the western Mediterranean Sea

Storylines 30, 31, 33
Conservation / Fisheries Sustainability in the Western Mediterranean from a regional perspective + synergies

Storyline 32
Basin-wide sea turtle conservation in the Mediterranean Sea

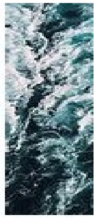
Storyline 34 & 35
Climate change and bioinvasion impacts on reef & canopy-forming macroalgae and shelf fisheries in SE Mediterranean Sea

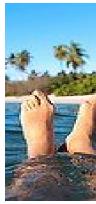
Storyline 36
Biogeography and biodiversity change on coastal communities at continental scales

Storyline 37
Offshore European Seas: Climate Change, Biodiversity and resilience

Storyline 38
Sustainable Seafood Harvesting in the Belize EEZ

Storyline 39 & 40
Ecosystem approach for the Chilean island systems

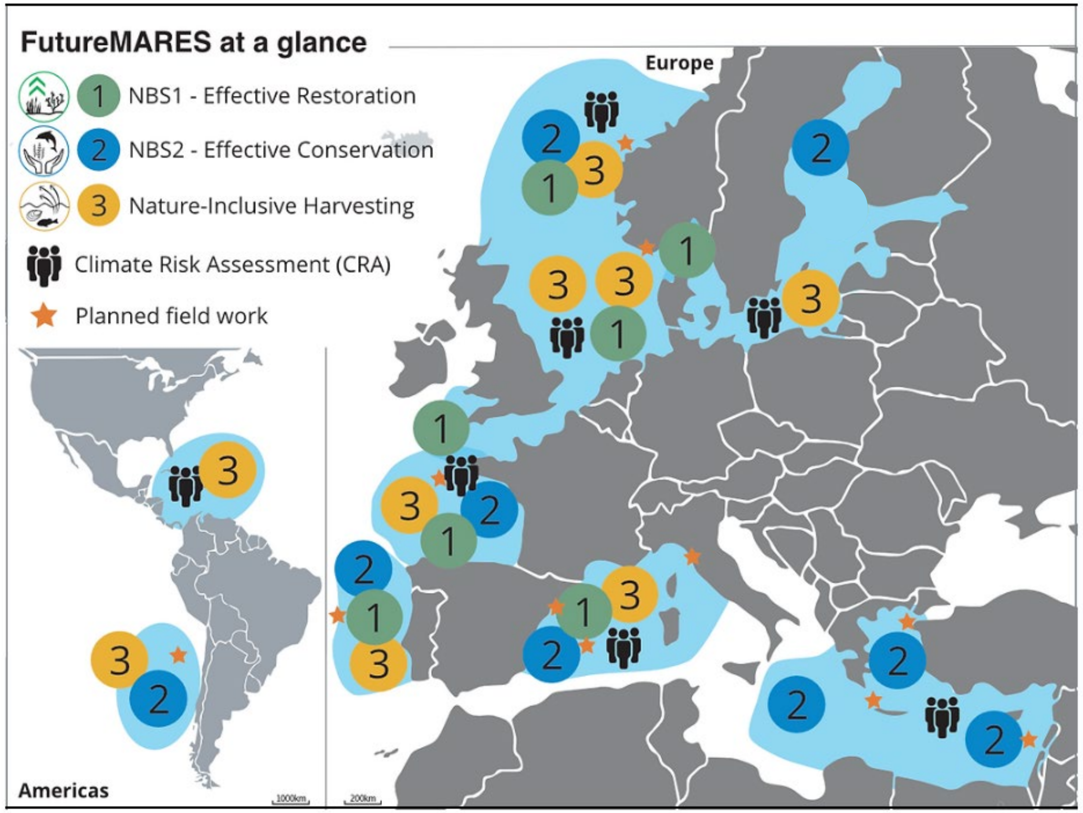




Future MARES

LC-CLA-06-2019 Inter-relations between climate change, biodiversity and ecosystem services
4 years (1st September 2020 – 31st August 2024), 8.5 million €
Contact: Prof Myron Peck (myron.peck@niuoz.nl)
futuremares.eu

Thank you for joining us. We hope you enjoy and participate in the sessions.



Royal Netherlands Institute for Sea Research (NIOZ)
Aarhus University
Aristotle University of Thessaloniki
AZTI – Member of Basque Research & Technology Alliance
Belize Coastal Zone Management Authority & Institute
Biopolis
CCMAR Centro de Ciências do Mar
CEAZA
Cefas
cmcc Centro Euro-Mediterraneo sui Cambiamenti Climatici
ciimar
Consortio di Gestione dell'Area Marina Protettadel Promontorio
CSIC
Deltares
DTU Danmarks Tekniske Universitet
GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel
hcmr ΕΛΚΕΘΕ
INRAE
IRD Institut de Recherche pour le Développement France
Israel Oceanographic & Limnological Research
The Marine Biological Association
NIVA
North Devon Biosphere
PML Plymouth Marine Laboratory
Stockholm University
SYKE
Thünen
UN environment programme WCMC
Universität Hamburg Der Forschung | Der Lehre | Der Bildung
Università di Pisa
University of Southampton
Future Oceans Lab Universida de Vigo
Wageningen University & Research

FutureMARES Science for Policy

Session 1 - Climate Exposure of European Marine Areas: Hotspots and refugia




MOMME BUTENSCHÖN (CMCC): T KRISTIANSEN, R BELLERBY, M PECK

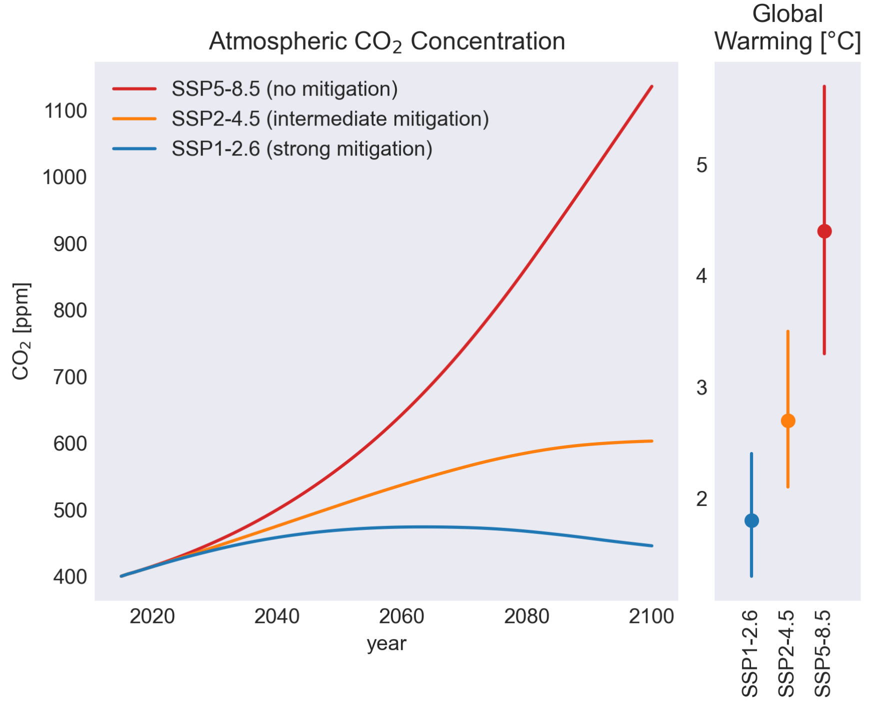
TEXEL, 26 JUNE 2024

How do global changes cause regional hazards and local perturbations?

Warming: geographical shifts, habitat compression, favors invasion of alien species, metabolic stress, alters reproductive patterns, increases infections

Acidification: structural damage to calcifiers, increases metabolic demands

Deoxygenation: increases hypoxic areas, habitat compression, limits and damages all aerobic organisms

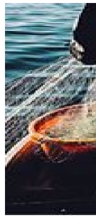


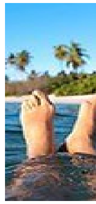
Scenario SSP5-8.5: no mitigation
Scenario SSP2-4.5: intermediate mitigation
Scenario SSP1-2.6: strong mitigation

Warming
subsurface T

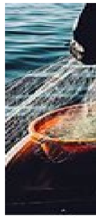
Acidification
subsurface pH

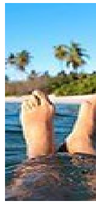
Deoxygenation
bottom O_2





The knowledge of **exposure levels** of marine habitats to **environmental pressures** under climate change is **fundamental for ecosystem-based management and the assessment and planning of NBS**.





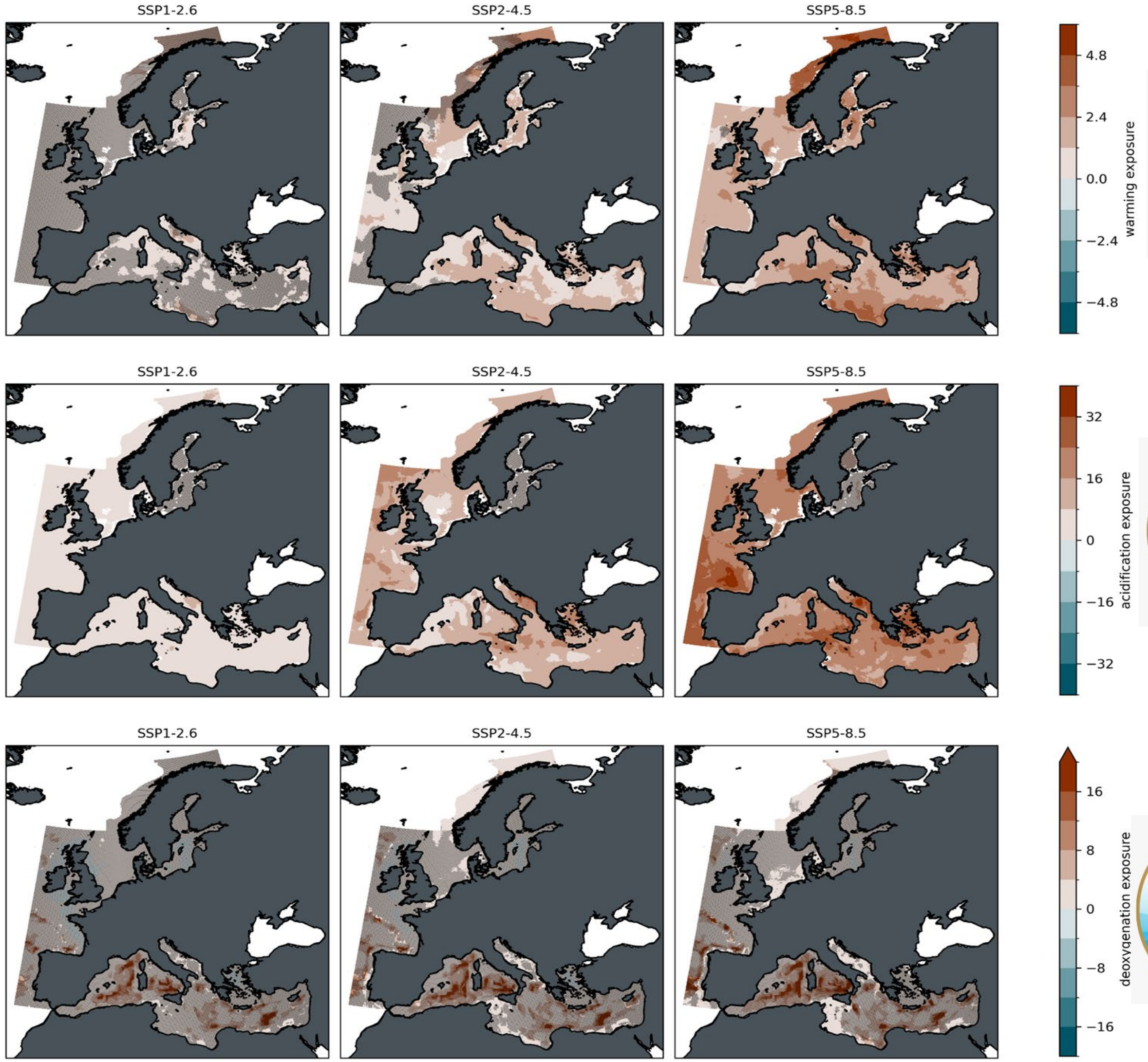
Some information available for specific species in specific locations informing on tolerance intervals and thresholds of resilience.

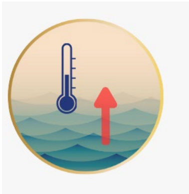
Thresholds established for a specific location and species cannot be readily extrapolated to other contexts in order to derive a broader picture of hotspots and refuges of marine habitats under climate change.

Environmental data with adequate uncertainty constraints, particularly for future conditions, is available mostly at coarse scale, insufficient to inform ecosystem management adequately.

We propose a generalised approach to define and compare the **environmental pressures** of warming, acidification and deoxygenation across the European Seas at local to regional level by **relating the changes in pressure indicators to the natural variability of the system.**

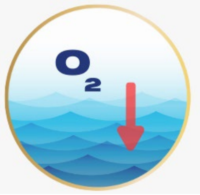
strong mitigation **intermediate** **no mitigation**



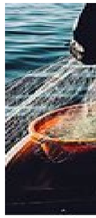


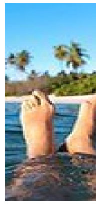
Exposure to **warming** up to **twice the natural variability** under **unmitigated** conditions.
Warming exposure decreases with mitigation to well below 1 under strongly mitigated conditions that do not emerge from model uncertainty for most of the domain.

Acidification levels are **significant** with respect to model uncertainty **across the entire domain.** Exposure is particularly high for this indicator (up to 32 times the natural variability and more under unmitigated conditions).



Deoxygenation is **heterogeneous** and **more uncertain** for most of the domain across all scenarios.
Highest levels occur in distinctive parts of the Mediterranean Sea.





Baltic Sea results highly uncertain due to importance of unresolved coastal processes missing in underlying Eart System Models

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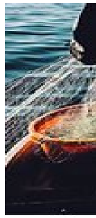
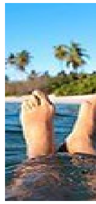
For an equilibrated compound indicator of the different stresses the indicator levels are further classified into categories :

$$C_{\text{pressure}} = \log_2(E_{\text{pressure}})$$

Category 1		Change exceeds natural variability
Category 2		Change exceeds twice the natural variability
Category 3		Change exceeds four times the natural variability
Category 4		Change exceeds eight times the natural variability



Combined ecosystem stress of warming, acidification and deoxygenation

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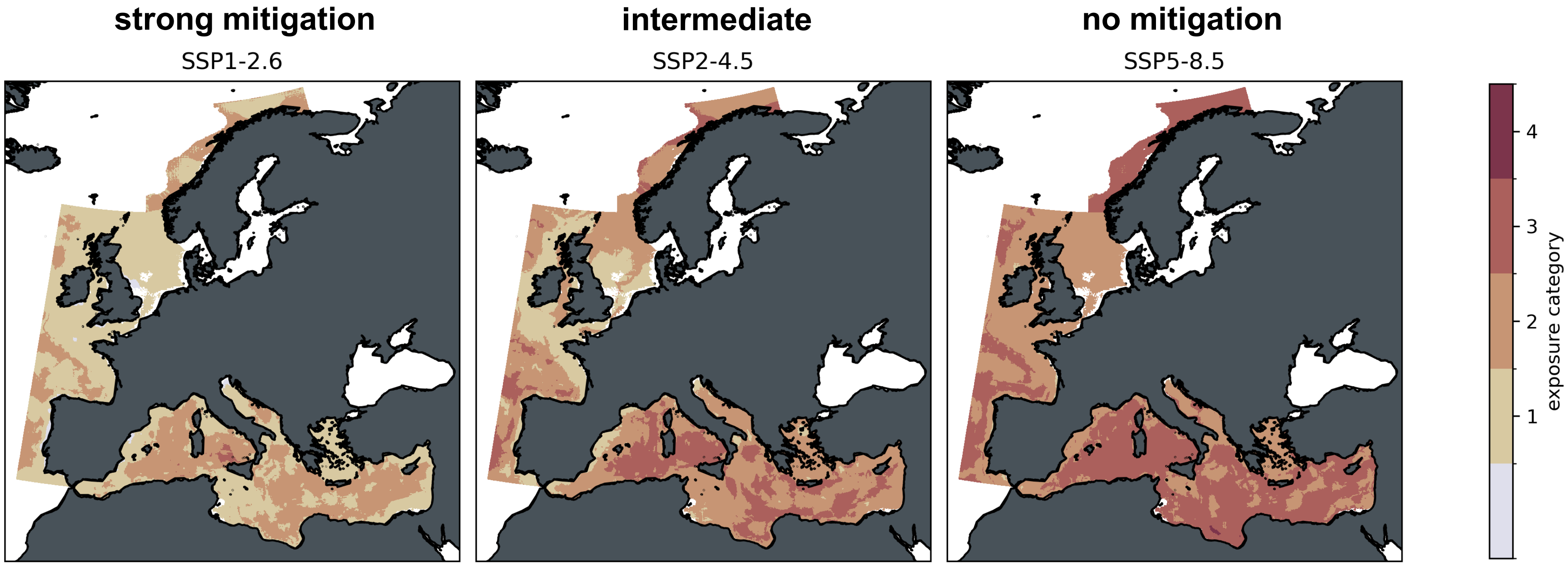
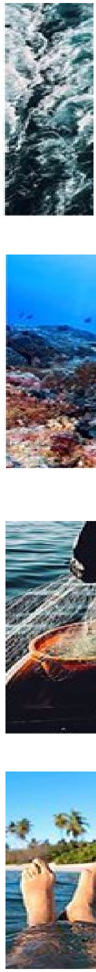


Under **unmitigated change,** the entire domain is subject to stress of **at least category 2**, virtually the **whole Mediterranean and Norwegian Sea** and part of the Northeast Atlantic reach **category 3**.

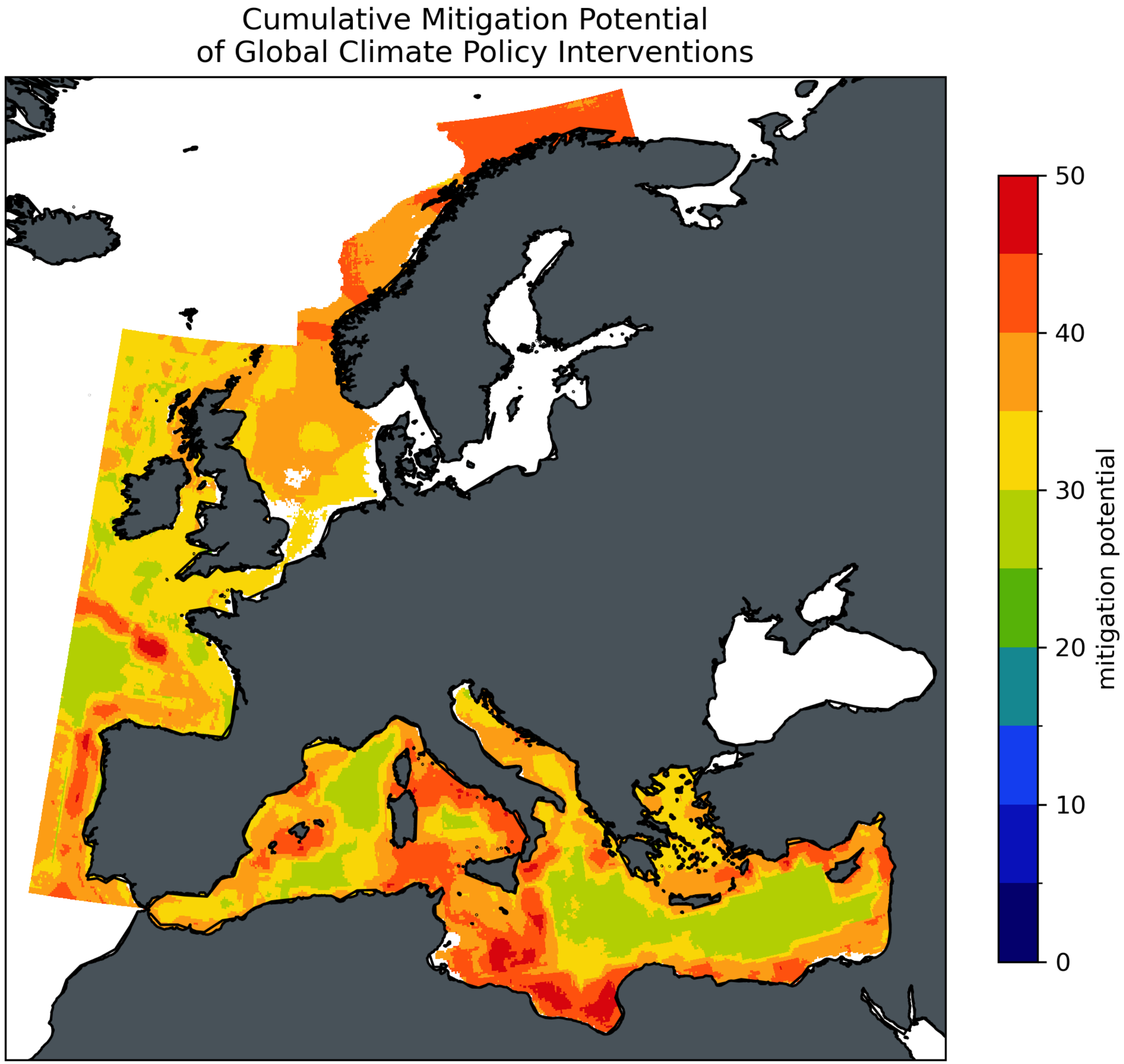
Exposure levels **gradually decrease with increasing mitigation**. The maximum level reached in SSP2-4.5 is category 3. In the **strongly mitigated** scenario, **only category 1 and category 2** are present.

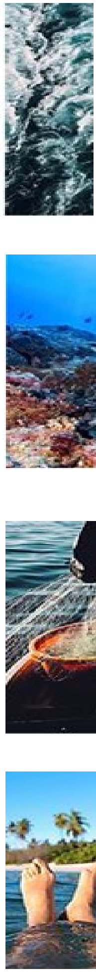


Cumulative Mitigation Potential of warming, acidification and deoxygenation shows how increases in an ecosystem pressure can be avoided by **global** climate mitigation policy.

Mitigation potential is generally >25% throughout most of the area. Areas benefitting most from global climate mitigation policies (**levels more than 40%)** are in the **central Mediterranean, Tyrrhenian Sea, Norwegian Sea,** along the **Eastern Mediterranean coast** and **along the shelf break.**

Even under the greatest mitigation efforts **no more than 50%** of the **cumulative ecosystem pressure** can be **recovered.**





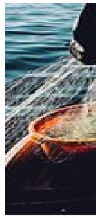
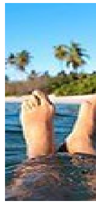
Policy Recommendations

- Climate-driven projections for different scenarios of future environmental stress highlight the **importance of implementing global mitigation policies** to lessen the strain on ecosystems, **particularly by reducing exposure to severe pressures**.

- In a global context where actions to promote climate resilience are more urgent than previously estimated (IPCC 2022), **detailed maps** showing the distribution of these stressors across European Seas provide **valuable insights for local adaptation policies**, supporting **marine spatial planning** and implementing **ecosystem-based management** strategies.

- Identifying areas projected to have very high and very low (if any) levels of environmental stressors **informs decisions on where to establish new sites for conservation** (e.g. Marine Protected Areas) and **habitat restoration**, and the effective management of existing sites to **better safeguard vulnerable and resilient species and habitats**.



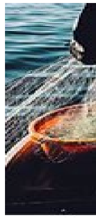
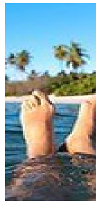



Where can I learn more about these results?

FutureMARES

- FutureMARES Deliverable Reports D2.1, D2.2 and D2.3
- Underlying environmental data publicly available on zenodo and published in Kristiansen et al. 2024
- Exposure to ecosystem pressures and Mitigation Potenial available in FutureMARES Policy Brief
- Publication in prep.



FutureMARES Science for Policy

Session 1: Marine Biodiversity: Climate Sensitivity and Resilience




GIL RILOV (IOLR): M. MULAS, T-G HAIM, E YERUHAM, J SILVERMAN,F BULLERI, C RAVAGLIOLI, L PEDICINI, E CHATZINIKOLAOU, P GRIGORIOU, G CHATZIGEORGIOU, M MANDALAKIS, I RALLIS, B WALLES, L JANSEN, PKAMERMANS, C FAGERLI, E RINDE, A CHABRERIE, F ARENAS, J FRANCO, B REIS, E CEBRIAN, C SITIJA, C GALOBART, A QUEIROS, D ALMEIDA, K ALTER, M PECK, L. PEREIRA, F. LIMA, R. SEABRA, S. RAMIREZ-CALERO, J LEDOUX, A. BARREIRO, N. BENSOUSSAN, P. LÓPEZ-SENDINO, D. GÓMEZ-GRAS, I MONTERO-SERRA, M PAGÈS-ESCOLÀ , A MEDRANO, A LÓPEZ-SANZ, L. FIGUEROLA, C. LINARES, J. GARRABOU, S HERNANDEZ CHAN.

Israel Oceanographic & Limnological Research

ELENA OJEA (UNIVERSITY OF VIGO) WP5 & T5.3 LEAD & ANA RUIZ-FRAU (CSIC) T5.2 LEAD

European Commission

Out there


Future MARES
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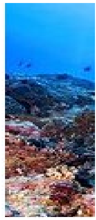
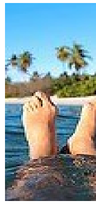
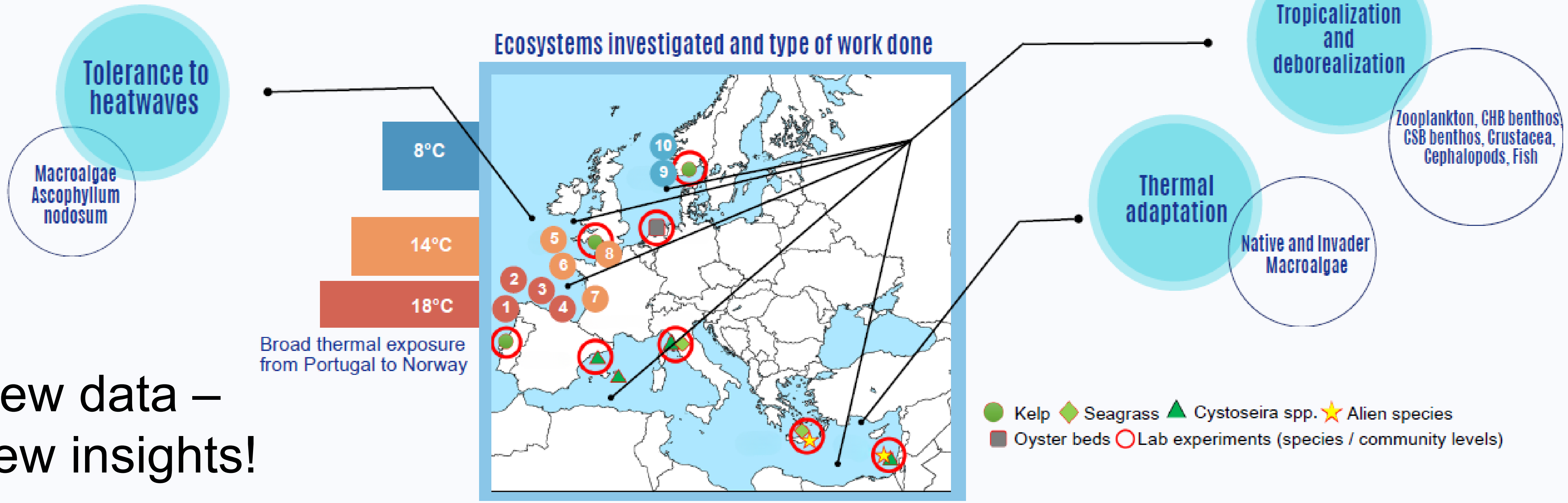
Policy Brief 2
MARINE BIODIVERSITY:
CLIMATE SENSITIVITY AND RESILIENCE
Rilov G, Chust G & Peck M A

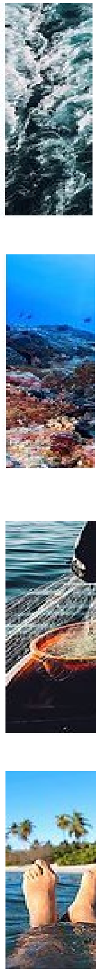




FutureMARES scientists investigated many long-term time series and used multiple field and lab experiments, revealing many important patterns and proccesses relevant to climate change **vulnerability** and **adaptation**

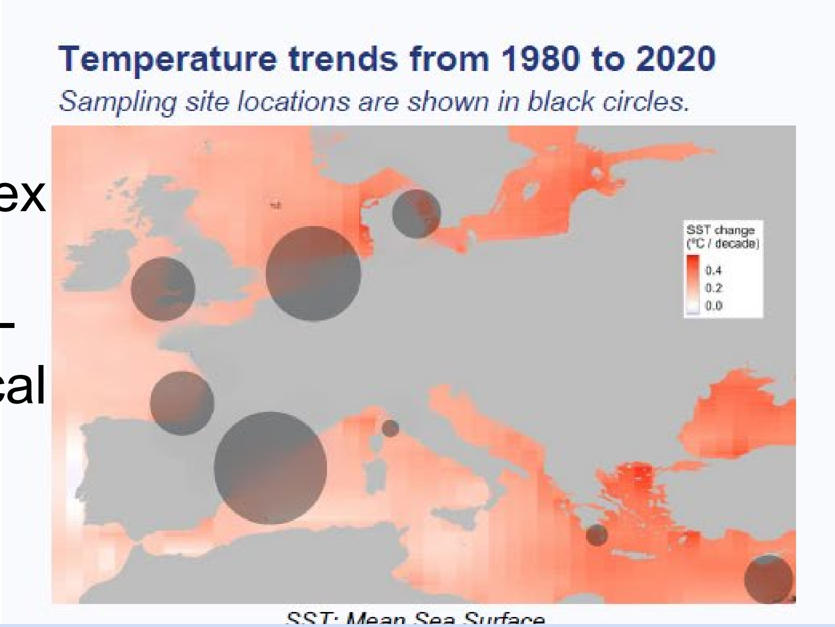


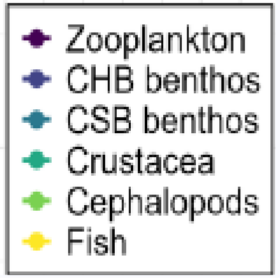
New data – new insights!



1) Tropicalization and deborealization of European seas

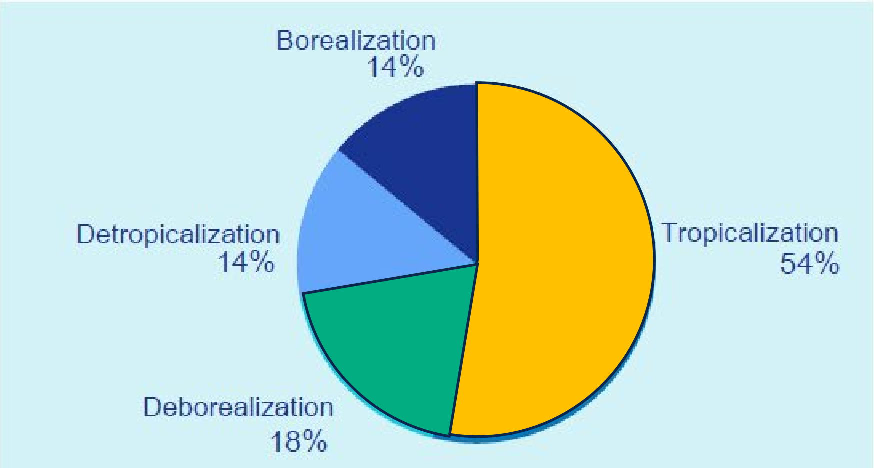
Calculated Community Temperature Index (CTI) – **average thermal affinity** - for many biological groups in many areas





Environmental time series from 65 monitoring programmes, including historical data for 1.817 marine species

Based on the CTI analysis, warming impacted more than 70% of European marine biodiversity time series via either tropicalization or deborealization.



Key messages:

- overall – warm loving species are on the rise while cold loving species are dwindling almost everywhere
- There is a lot of variability in the level and direction of change among areas

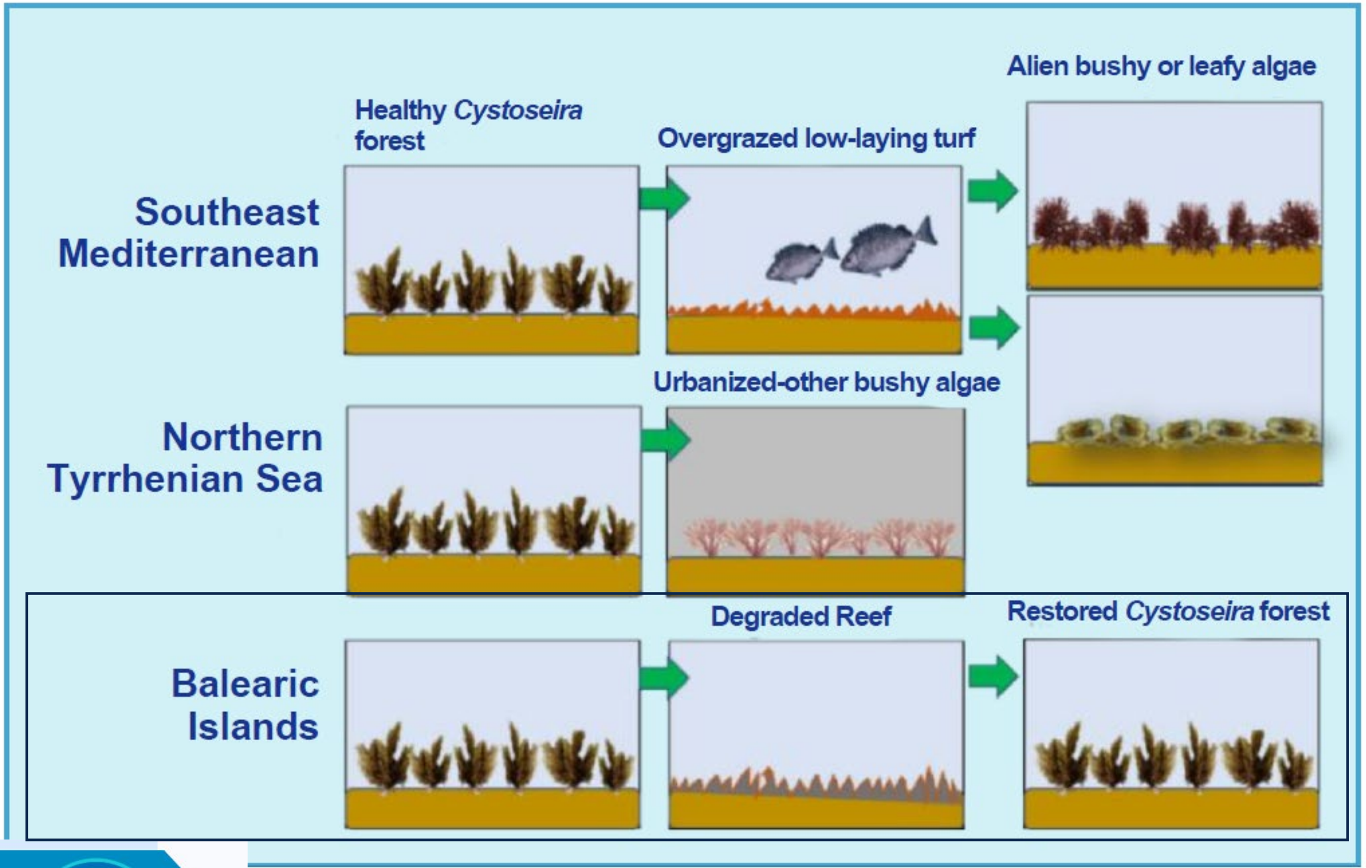
Key challenge:

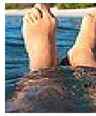
- How can we effectively protect native biodiversity when warming is considerably shifting it?
- What areas to prioritize for protection? climate refugia? areas where key species are resilient?, highly impacted areas?

2) Community shift could lead to alternative ecosystem state while keeping some services

Minorca

Shifts in community state of macroalgal communities in shallow water reefs in Mediterranean Sea in the different study regions.

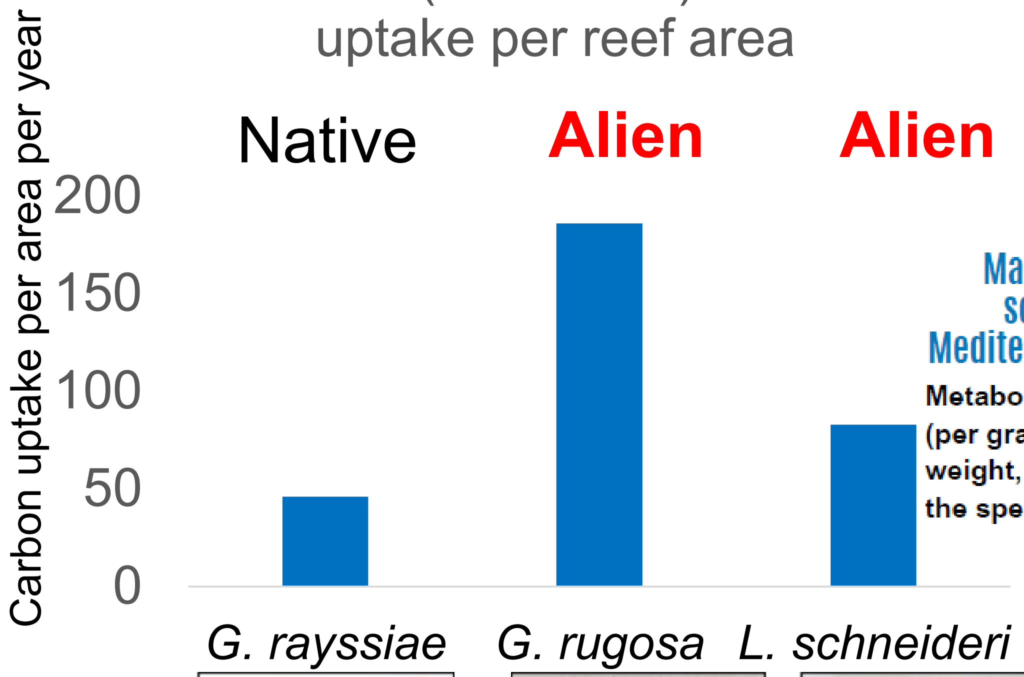


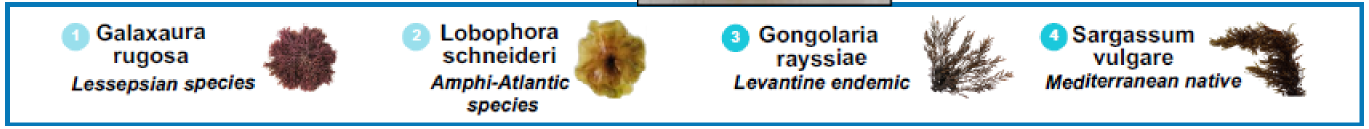


The extreme case of the southeastern Mediterranean – a bioinvasion hotspot
- thermal resilience and annual production of invasive and native macrophytes

Annual (calculated) carbon uptake per reef area

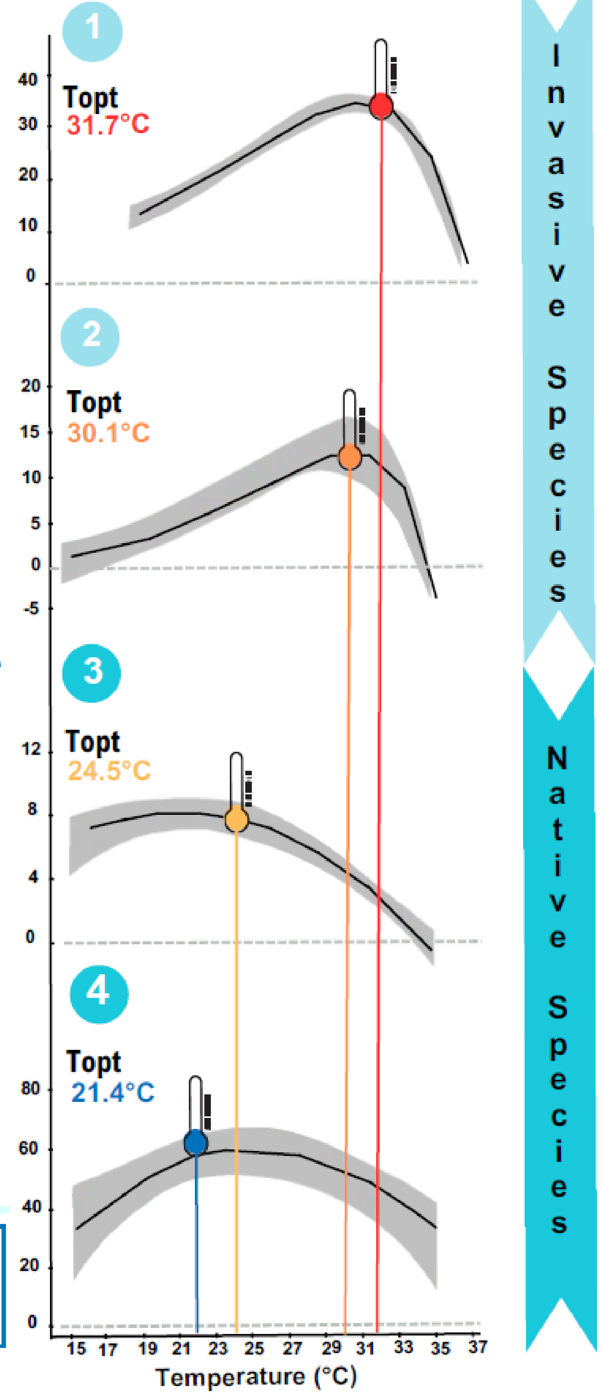
Key message: some alien species may be able to **compensate** for the loss of native species productivity and functions (**C uptake**) in climate change hotspots

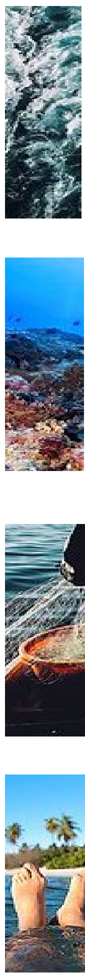




Macrophytes southeast Mediterranean coast

Metabolic performance (per gram wet or dry weight, depending on the species)

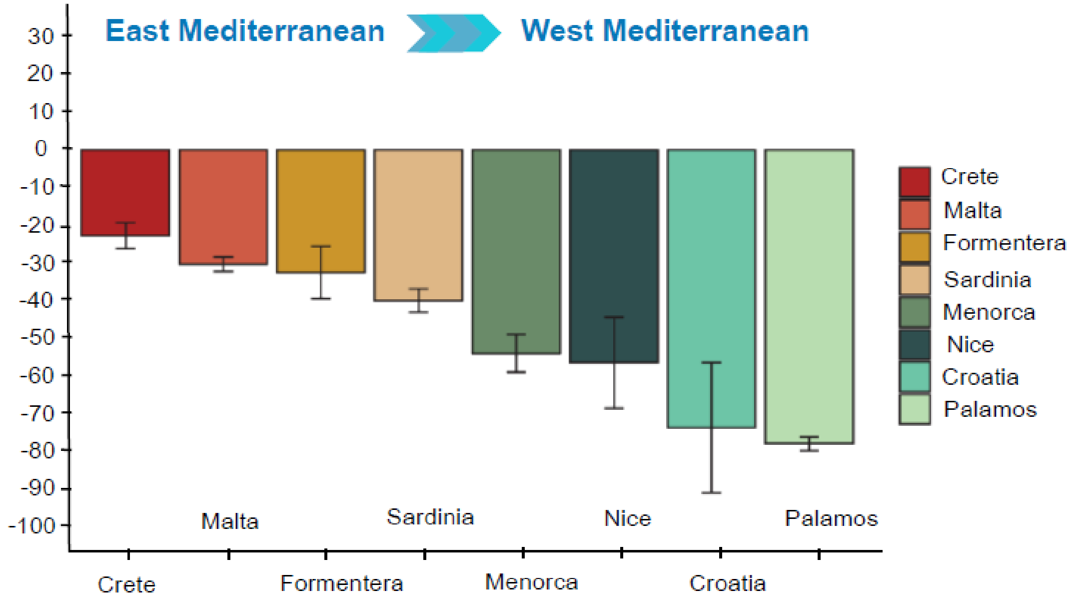




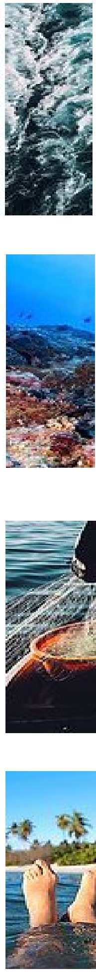
3) Clear evidence of local thermal adaptation and population differences in climate sensitivity

Example 1: Mediterranean canopy-forming algae from different regions exposed to 29°C

Key finding: Southeastern Mediterranean populations are more resilient to warming than northwestern ones



Biomass loss of different populations of *Cystoseira crinita* across the Mediterranean Sea under a warming experiment at 29°C after 80 days of exposure.



Example 1: Atlantic intertidal macroalgae from different regions exposed to arial heatwaves

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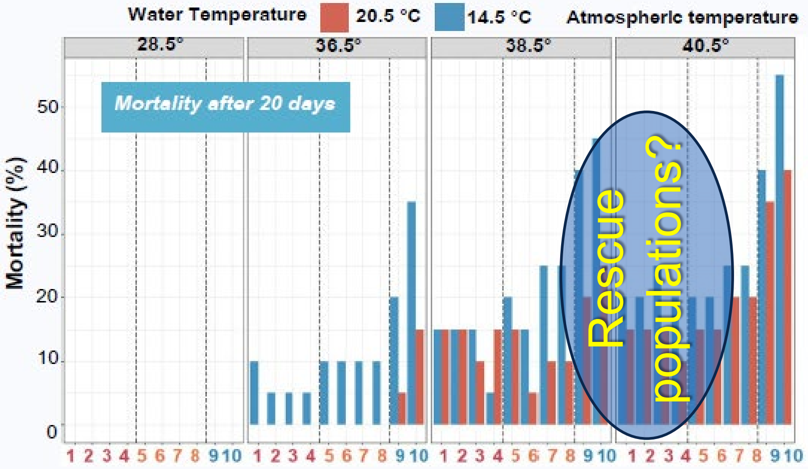
Key finding: Southern Europe populations more resilient to warming than northern ones

Key message: Local adaptation is present; some populations are more resilient – **rescue populations** during major heatwave events?

Key challenge: we **cannot** assume resilience/vulnerability found in one place to be relevant to another

Macroalgae Ascophyllum nodosum

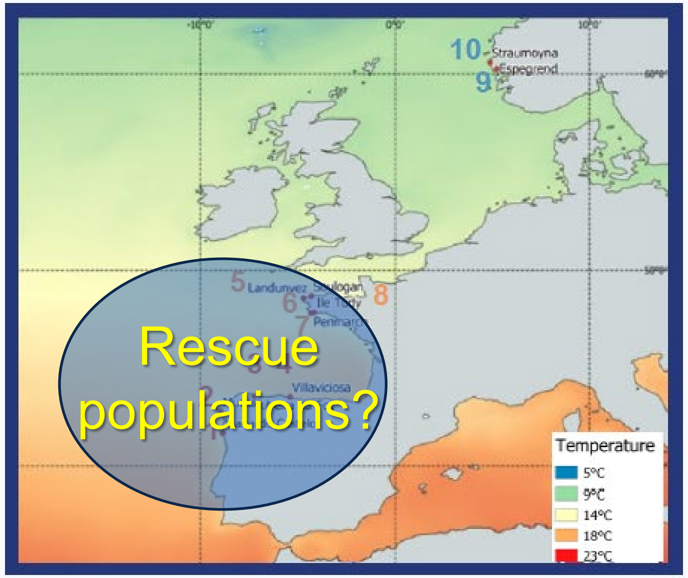
An atmospheric (aerial) heatwave lab experiment was designed to simulate present and extreme future atmospheric conditions



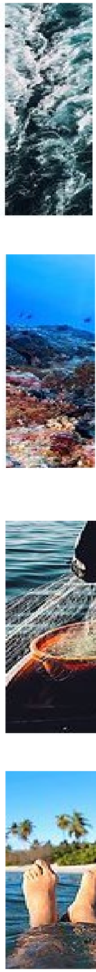
Seawater temperature has synergistic role in shaping the ecophysio-logical response of this seaweed

Identification of heat-resistant ecotypes is a crucial factor for successful restoration efforts

Collection sites of different population of Ascophyllum nodosum



1-Viana do Castelo, 2- Ria de Muros, 3 - Ria da Foz, 4- Ria de Villaviciosa, 5- Landunvez, 6- Île- Tudy, 7-Penmarch, 8- Soulogan, 9- Espegrend and 10- Straumoyna



4) Complex impacts on marine species arise from climate change and other interacting stressors

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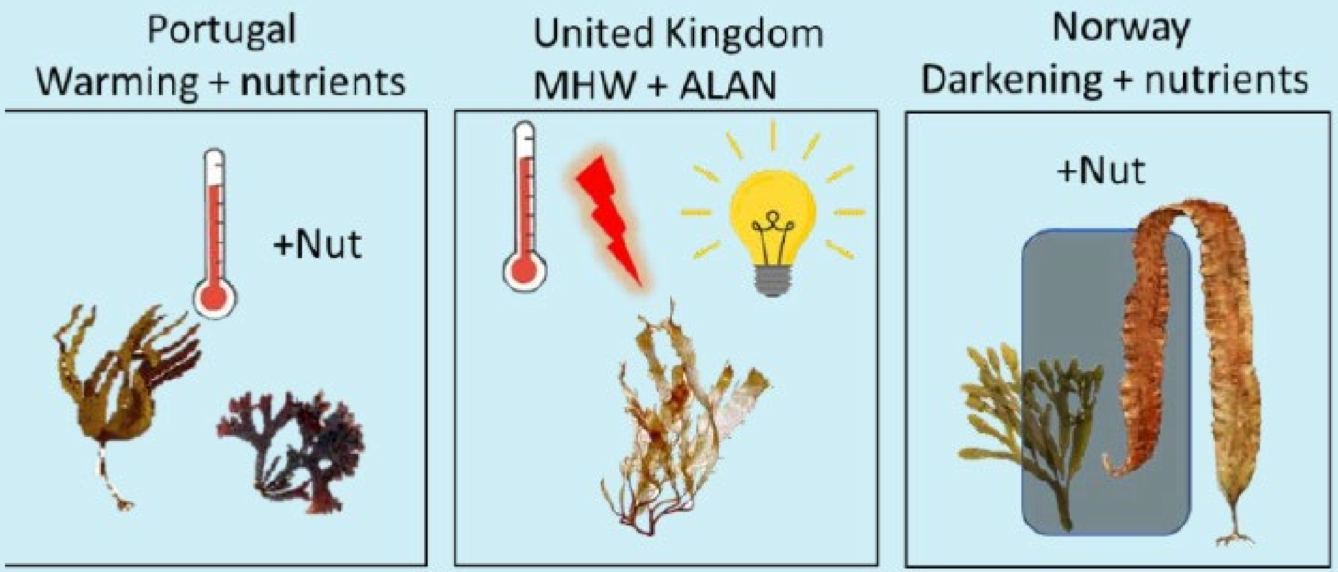
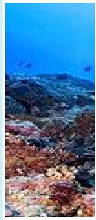
<u>Key message</u>: We find all types of interactions: additive, antagonistic, etc.

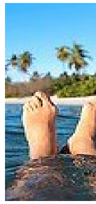
<u>Key challenge</u>:
We cannot assume the results of interactions based on single exposure experiments and need to **test** combined impacts – we need more research on this topic



Multiple stressor experiments tested on Kelp in diverse locations and under different combinations of scenarios

ACTNOW



Alternative functionalities under biodiversity shifts and what should be priorities for conservation

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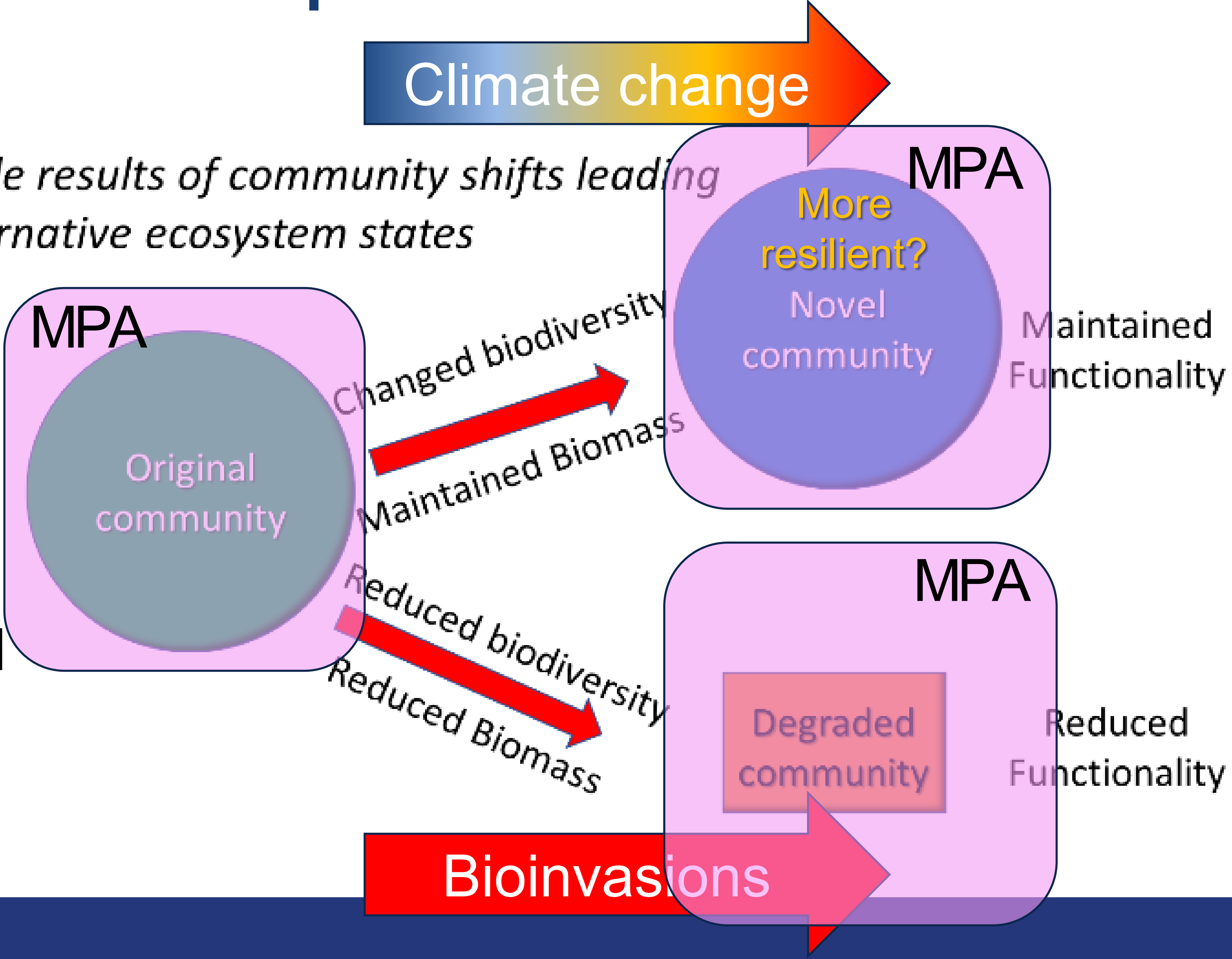
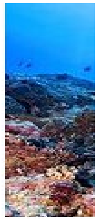
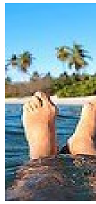
Possible results of community shifts leading to alternative ecosystem states



Where should we focus our conservation efforts?



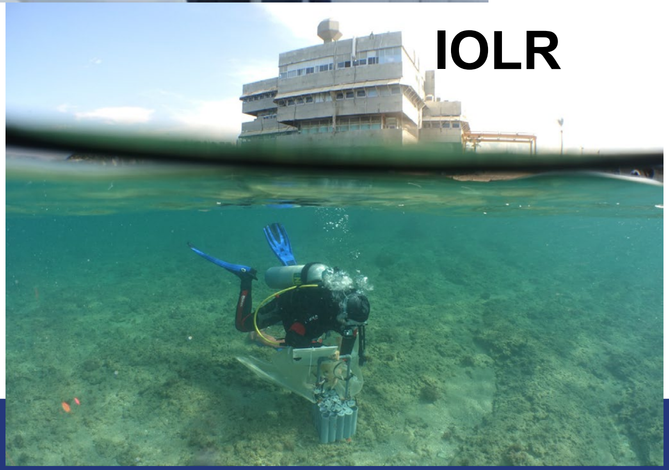


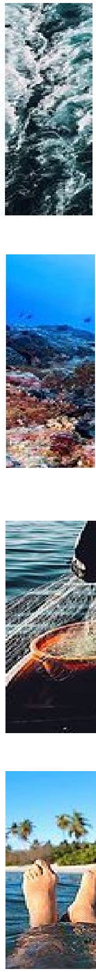
Where we have, and will discuss these results

- November 2020 - An event with stakeholders at the **Mediterranean Pavilion** of **COP27** in Sharm el Sheikh on the challenges of marine conservation at the age of climate change and bioinvasions

- July 4th, 2024 - a stakeholder **event/mini-conference** with scientists and decisionmakers will be held at IOLR, to discuss conservation challenges in climate change and bioinvasion hotspots like the Israeli coast

IOLR





Expectations from the European Commission

- EU decisionmakers should take up these results that demonstrate rapid **shifts in biodiversity to novel communities** in many areas, and the importance of assessing **functionality** of shifted communities when considering GES
  - More research is needed to evaluate functionality and potential services of novel ecosystems !
- In climate change/bioinvasion hotspots, where native biodiversity is rapidly lost and new species are expanding, the MSFD needs to adjust GES **descriptors** to be more **adaptive/flexible,** for example about the view on aliens/invasives – otherwise we are facing a losing battle