

FutureMARES Science for Policy

Session 2: Climate-smart Nature-based Solutions



ANA QUEIROS (PML): L TALBOT, C LYNAM, M COLL, L ESPASANDÍN, R PUNTILO-DODD, A JANC, G LASALLE, J TERRADOS, I CATALAN, F BULLERI, F ARENAS, M DOLBETH

TEXEL, 26 JUNE 2024



Climate-readiness of Nature based Solutions

Contact: anqu@pml.ac.uk

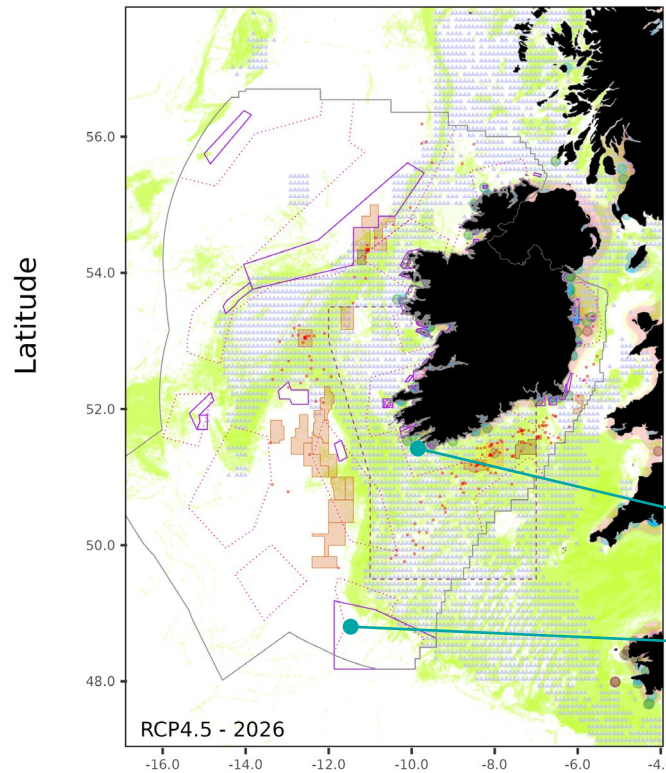
sat@pml.ac.uk



Prof Ana Queiros



Dr Liz Talbot



Objective: In light of climate change, what areas may be able to support the same levels of species & ecosystem function that enable the delivery of effective NBS into the future?

Conducting analysis of ocean climate modelling to help design climate-resilient spatial mechanisms.

Climate change hotspots

Climate change refugia

- a) Prioritise sector (e.g. MPA) in area x promoting climate change adaption potential of sector.
- b) Allow other uses of site x by (which) sector(s).

What no regrets decisions can be made about the allocation of conservation & restoration areas that increases resilience to climate change?

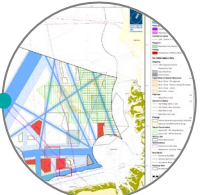
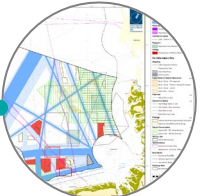
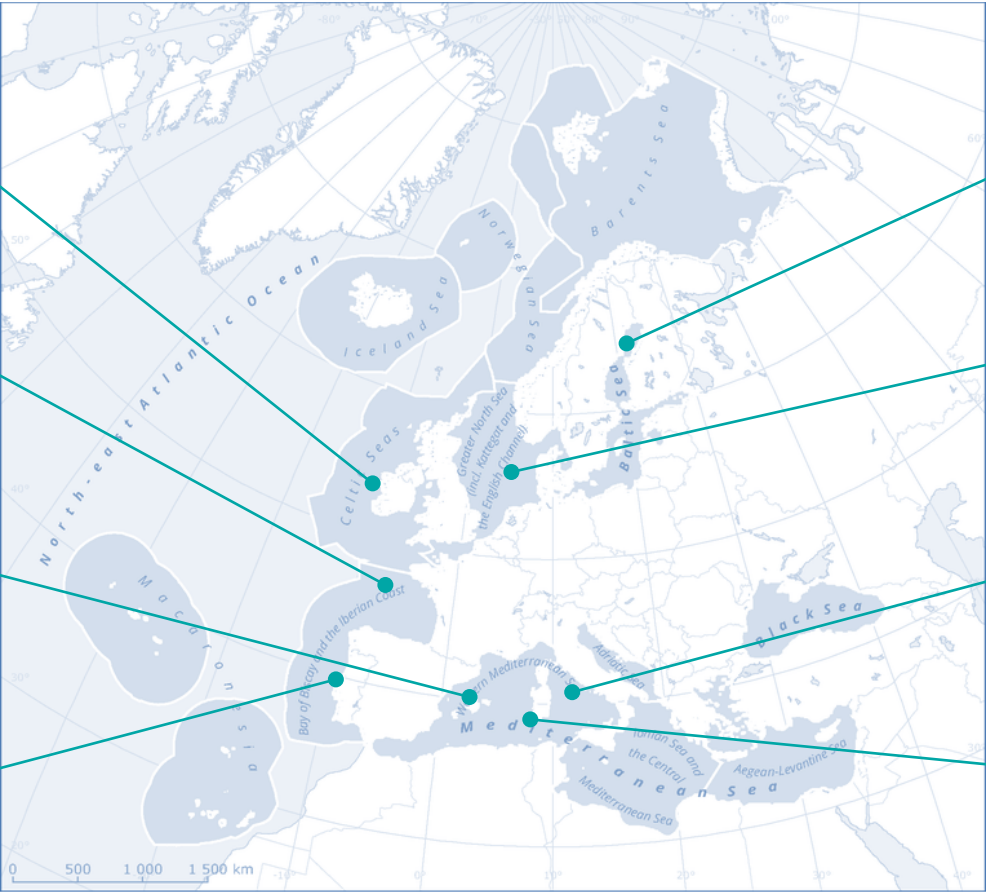
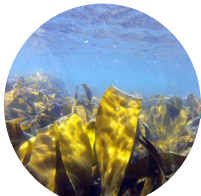


Climate-ready strategies for Nature Based solutions: working with local partners



Storylines: Climate-ready strategies for Nature Based solutions Regional Basin

- Ireland:**
MPA network
- Atlantic:**
Conservation of
Estuarine & shelf
Species
- Balearic Islands:**
Coastal vegetated
habitats &
associated fauna
- Portuguese coast**
Coastal vegetated
habitats &
associated fauna



Archipelago Sea
MSP & MPAs

North Sea and NE Atlantic
MSP & MPAs

Tuscan Archipelago
Coastal vegetated habitats &
associated fauna

**Western Mediterranean
Sea**
(& NW Med) MSP & MPAs



Product 1: Call for Knowledge Needs : A climate-smart path for Ireland's MPA network

Supporting the climate resilient delivery Ireland's MPA Bill & EU Biodiversity Strategy



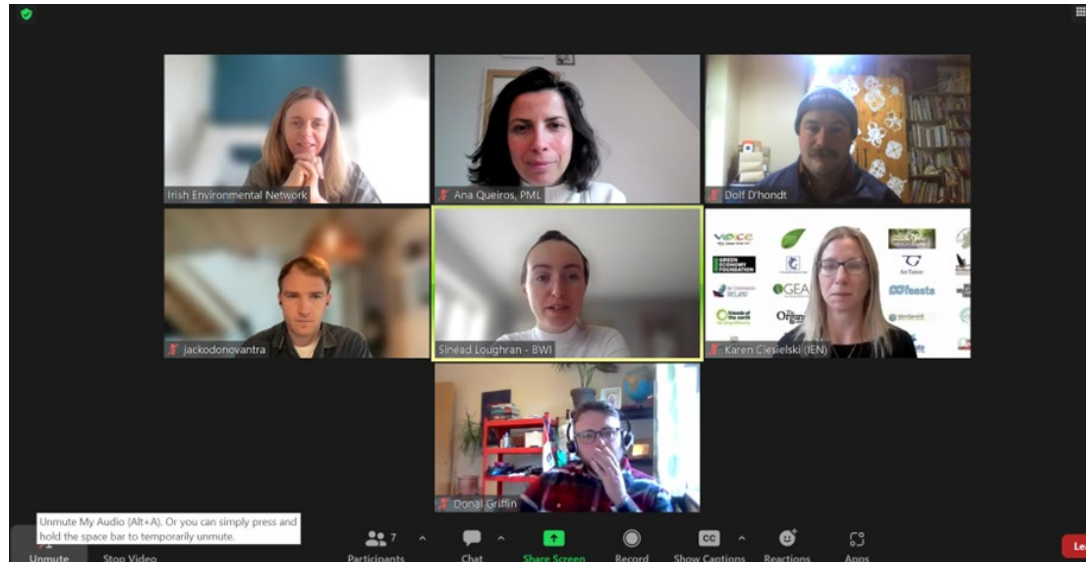
FAIR SEAS

Revitalising Our Seas

Identifying Areas of Interest for Marine Protected Area Designation in Irish Waters



FAIR SEAS



FutureMARES scientists Prof Ana Queiros and Dr Liz Talbot worked with Fair Seas to support their response to the Irish Government consultation on the MPA Bill and encourage the design of a climate-resilient MPA network (summer 2023).

A Climate-resilient Path for Ireland's Marine Protected Areas Network



FAIR SEAS




Supported by Call for Knowledge Needs, T6.1 team worked with Fair Seas delivering new chapter for *Revitalising our Seas* report.

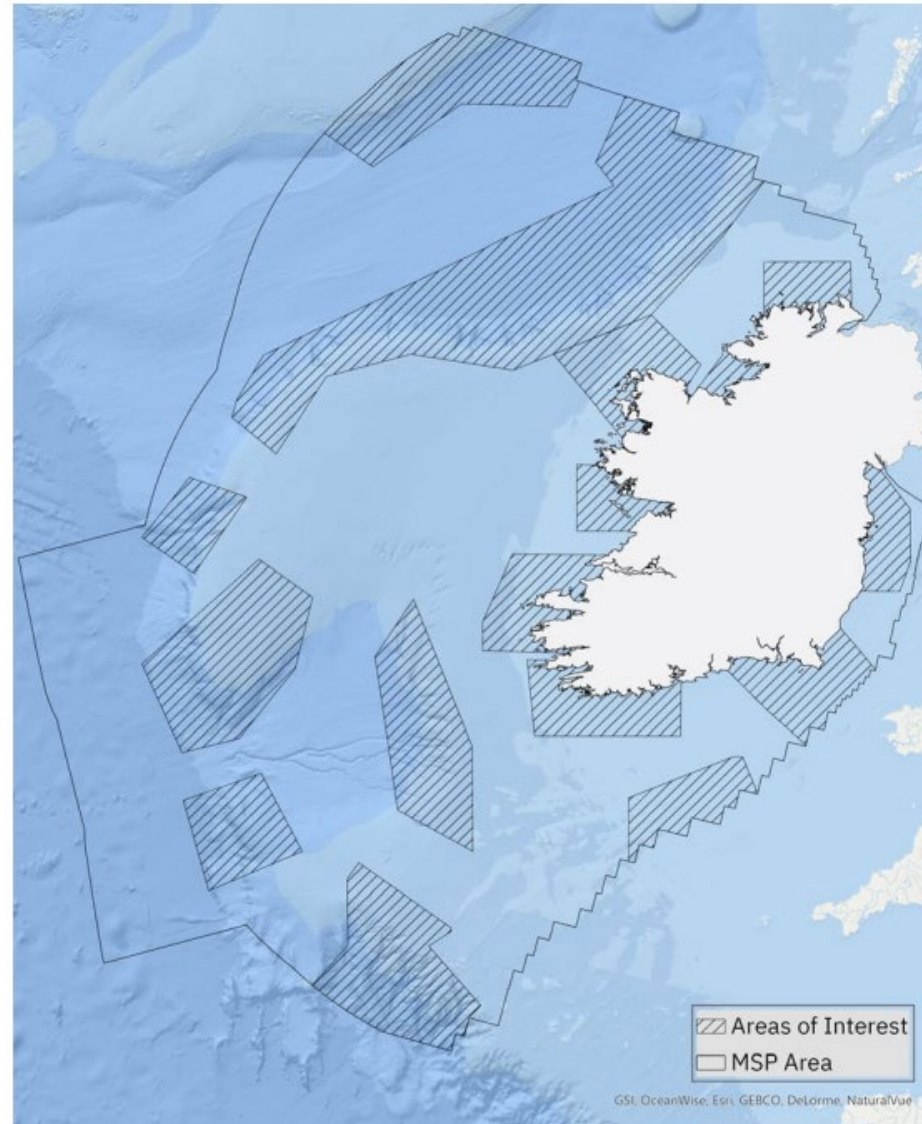
Fair Seas seek to inform on current Irish MPA network expansion legislation. T6.1 advised on extent to which new areas are climate-resilient, for which species groups.

Delivered: October 2023





Figure 2.2.1
Map of full network
of Areas of Interest
within Ireland's
Maritime Area /
Marine Spatial
Planning (MSP)
Assessment Area



	Network of Areas of Interest	Map Date 08/04/2022	175504km ² 35.91% Scale: 1:4,500,000
	Sources Fair Seas	Projected Coordinate System: ETRS 1989 LAEA	

Q1: Are identified Areas of Interest resilient to climate change?

Q2: What no regrets decisions can be made about the siting of MPAs that increase the resilience of nature to climate change?

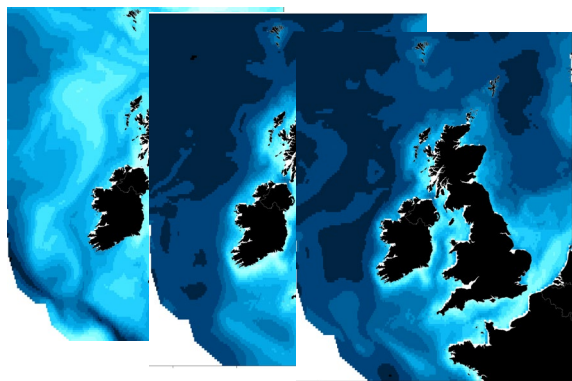
A Climate-resilient Path for Ireland's Marine Protected Areas Network



Approach: *Bright spots framework*

Contact: anqu@pml.ac.uk

sat@pml.ac.uk



State-of-the-art ocean climate modelling representative of the environment and species of interest to **each sector**.

Sector-specific spatial random-effects meta-analysis of ocean climate modelling. (*climate signal detection*)

method: Queiros et al. 2021 GCB

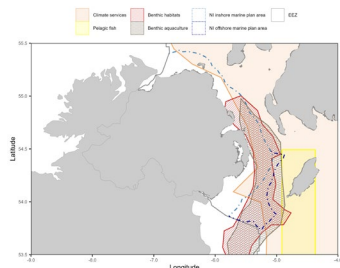
Climate change hotspots

Bright spots

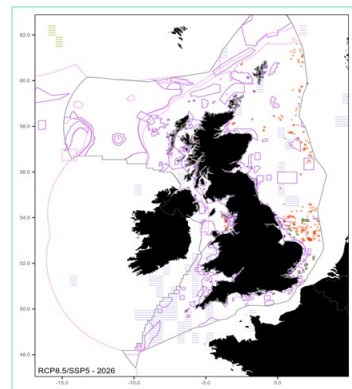
Climate change refugia



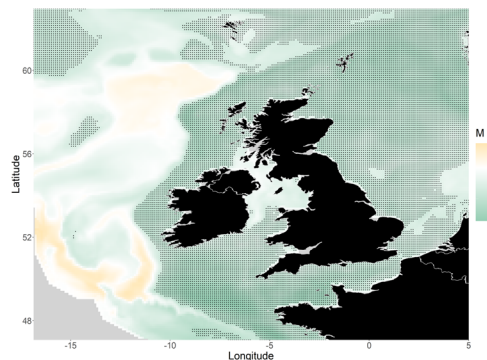
Climate-ready spatial advice



Which areas present potential for **no-regrets spatial decisions** regarding the location of NbS?



Blue economy GIS data overlay allows management scenario exploration of **within / cross sector interactions & climate effects** for each sector.



Sectorial climate-resilience maps (present to end of century)



KEY Species groups

MEGAFAUNA reliant on WATER COLUMNS prey & habitats



MEGAFAUNA reliant on SEAFLOOR prey & habitats



WATER COLUMN SPECIES (beyond megafauna)



SEAFLOOR (BENTHIC) SPECIES



Call for Knowledge Needs; A climate-smart path for Irish MPAs

Modelling data analyses suggests there are opportunities for enable climate-resilient conservation for a number of species groups.



Detailed modelling analyses were carried out and summarized at the appropriate detail level, to support use of report data.

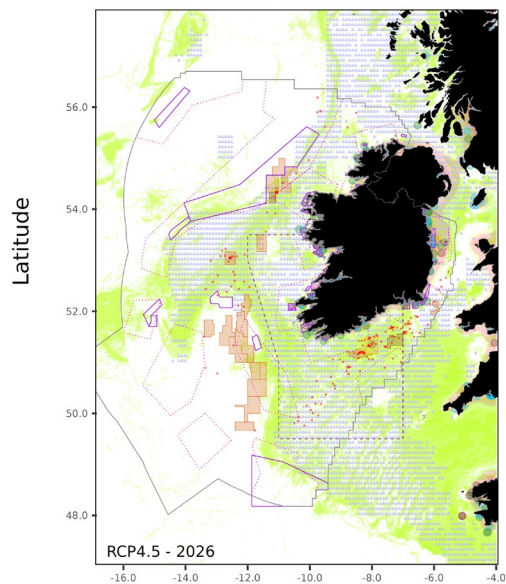


Figure 1

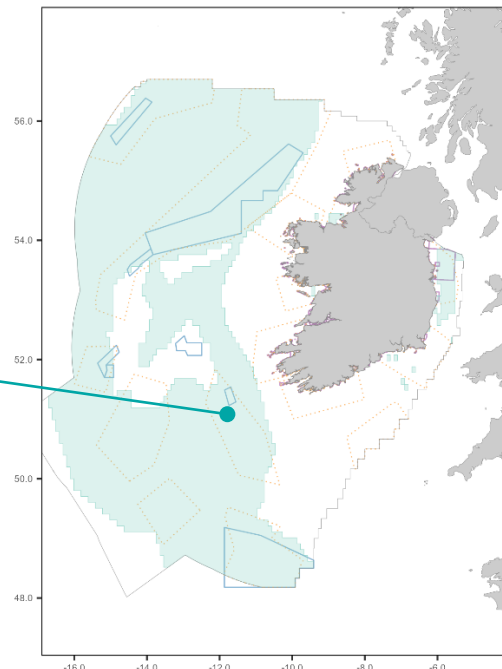
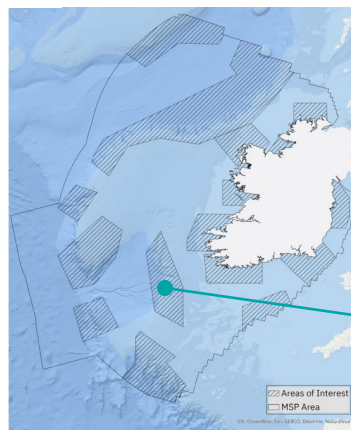


Figure 2

A Climate-resilient Path for Ireland's Marine Protected Areas Network



FAIR SEAS

Main findings: implementation of new proposed areas could lead to protection of long-term climate change refugia for at least one group of species considered in this report (281, 501km², equivalent to 67% of the Irish EEZ, Figure 2)



Report – media pick up & the importance of working with local networks

A Climate-resilient Path for Ireland's Marine Protected Areas Network

Irish Examiner

Fish could disappear from Irish coast

Sean Murray

Fish typically found in our coastal waters may disappear permanently due to rising sea temperatures, a new report has warned.

Fair Seas, an umbrella organisation for a range of environmental groups, has commissioned a new report to identify areas of Ireland's marine environment that have the best chance of preserving ocean species and habitats in the future.

It said all Irish inshore waters will be under pressure from climate change in the decades ahead but that possible solutions can be identified now that may help protect our seas for future generations.

The group has identified that more than half of Irish waters are climate "sanctuaries", which can be more resilient to the effects of climate change.

"The marine heatwaves that struck Ireland and

across the world last summer are a stark reminder of the effects of climate change," said Fair Seas co-ordinator Donal Griffin. "Rising sea temperatures may cause fish and other species typically found in Irish waters to move out of our marine area to cooler northern latitudes."

Researchers have warned that ocean warming can impact animal behaviour and movement, with fears this could accelerate due to record levels of heat being recorded last year.

The Fair Seas report notes that as efforts to combat climate change are still taking shape across the world, excess greenhouse gases will still impact our marine ecosystems for many years.

It believes the latest research can help inform the site selection process for marine protected areas in Ireland, with long-awaited legislation to make these a reality at an advanced stage.



A crayfish in Irish waters: Irish inshore waters under pressure.

The research for Fair Seas was compiled by a team from Plymouth Marine Laboratory. Principal investigator Ana Queiroz said: "Climate-driven changes to habitat conditions are already leading to an unprecedented re-distribution pace for marine species in our coasts and seas. "Marine protected areas that are put in place in recognition of those changes

present an invaluable time-buying strategy to protect our marine wildlife until such a time when we have slowed down the pace of climate change."

The Marine Protected Areas Bill has been long in the works, with campaigners last year expressing disappointment at its delay.

The bill is seen as even more timely after an unprecedented marine heatwave off Ireland's west coast last June, with sea temperatures reaching up to 3C above normal.

Such marine heatwaves can have a disastrous effect on biodiversity in the water for months afterwards.

Campaigners originally hoped to see the bill published by the Government last May, but this was then pushed into the autumn and eventually into the new year. It is now expected to be published within the coming weeks.



FAIR SEAS



Irish Examiner

HOME PAGE / LIFESTYLE / OUTDOORS

Anja Murray: Marine Protected Areas Bill has been bogged down — but is due any day now

At present, marine and coastal nature protected areas (in the form of Special Areas of Conservation and Special Protection Areas) encompass a mere 9% of Irish waters — expanding the MPA network is a biodiversity action that will also contribute to climate change adaptation



The Marine Protected Areas Bill was due to be published before the Oireachtas went on its Easter recess, that deadline has passed but it is understood that the legislation drafting is at an advanced stage now. Pictured: The

IRISH STAR

Heat is on to save marine ecosystems

WARMING MAY CAUSE FISH TO ABANDON SHIP



CLIMATE-RELATED heatwaves could cause marine species to leave Irish waters and disrupt what ecosystems may be left for. She warned last March at a meeting in Dublin that the world's oceans are warming by the end of the century. "It's being smart" about where fish migration routes are, the State should be looking to the ocean. "It's not just about the fish, it's about the people who depend on them. We need to be looking at the ocean as a whole, not just as a source of food."

THE IRISH TIMES

Fair Seas report Protecting marine wildlife

Global sea surface temperatures have been at an all-time record high for an entire year. This almost went unnoticed amid unrelenting extreme weather events but, like the rise in sea levels, it is a slow but inexorable trend.

Vast amounts of excess heat created from greenhouse gas emissions trapped in the atmosphere are absorbed by seas. They are the planet's great carbon store. But sea temperatures have risen each year for the past decade, impairing that ability and causing widespread ecosystem damage.

A report commissioned by the Irish environmental coalition Fair Seas provides an indication of what that threat is likely to be in Ireland this century. That threat by Plymouth Marine Laboratory, it shows all inshore waters – close to coastlines – will be under pressure from climate change, with heightened risk of marine heatwaves.

The marine heatwaves that struck Ireland and across the world last summer were reminders of what risk this brings. Off the north west coast, sea temperatures were up to 5 degrees above normal. Rising temperatures may cause fish and other species in Irish waters to move to cooler northern latitudes.

The findings are not a cause for despondency, however, as Irish marine areas are identified that are more resilient and can promote biodiversity in the face of worsening climate disruption. More than half of Irish waters can become sanctuaries. They are offshore and concentrated off the west coast.

They should be designated as marine protected areas (MPAs). Critical legislation to facilitate the scale-up of MPAs is due to be published by the Government in coming weeks.

Fair Seas hopes its findings help to inform the site-selection process as they provide an opportunity to preserve biodiversity for future generations. As the report highlights, MPAs present an invaluable time-buying strategy to protect our marine wildlife until the pace of climate change has been slowed.

THE IRISH TIMES

Report warns of climate change risk to sea waters

KEVIN O'SULLIVAN Science and Environment Editor

All Irish marine waters close to coastline will be under pressure from climate change by the end of the century with heightened risk of marine heatwaves, according to a report by Fair Seas.

Published yesterday, it identifies key Irish marine areas that are more resilient and can promote biodiversity in the face of worsening climate disruption in coming decades, and thus should be protected as marine protected areas (MPAs).

MPAs are offshore and concentrated off the west coast. Fair Seas co-ordinator Dr Donal Griffin said: "The marine heatwaves that struck Ireland and across the world last summer are a stark reminder of the effects of climate change. Rising sea temperatures may cause fish and other species typically found in Irish waters to move out of our marine area to cooler northern latitudes."

MPAs that are put in place in recognition of those changes present an invaluable time-buying strategy to protect our marine wildlife until a time when we have slowed down the pace of climate change," she added.

"Warming seas threaten marine biodiversity and livelihoods of Ireland's coastal communities," said Grace Carr, marine advocacy officer for the Irish Wildlife Trust.

"It is vital that measures are put in place to carefully manage and monitor the areas showing the greatest resilience to these adverse effects."

Audience: Reached an estimated audience of 5.7m people, the equivalent advertising cost is approximately €75,000.

Storylines: Climate-ready strategies for Nature Based solutions across the EU

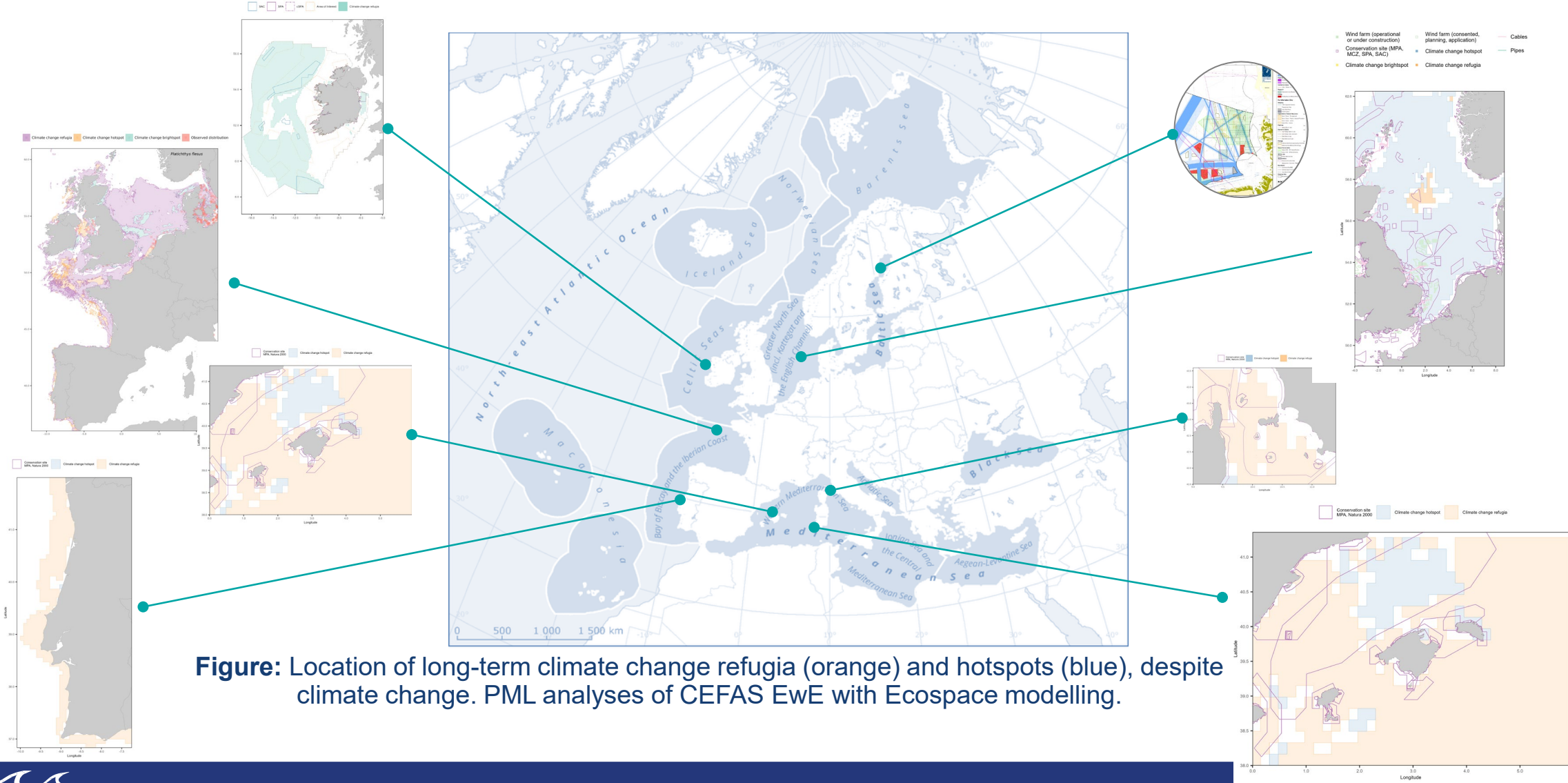


Figure: Location of long-term climate change refugia (orange) and hotspots (blue), despite climate change. PML analyses of CEFAS EwE with Ecospace modelling.



Fisheries regulation – new MPAs - increases climate-resilience of ecosystems to climate change in the North Sea

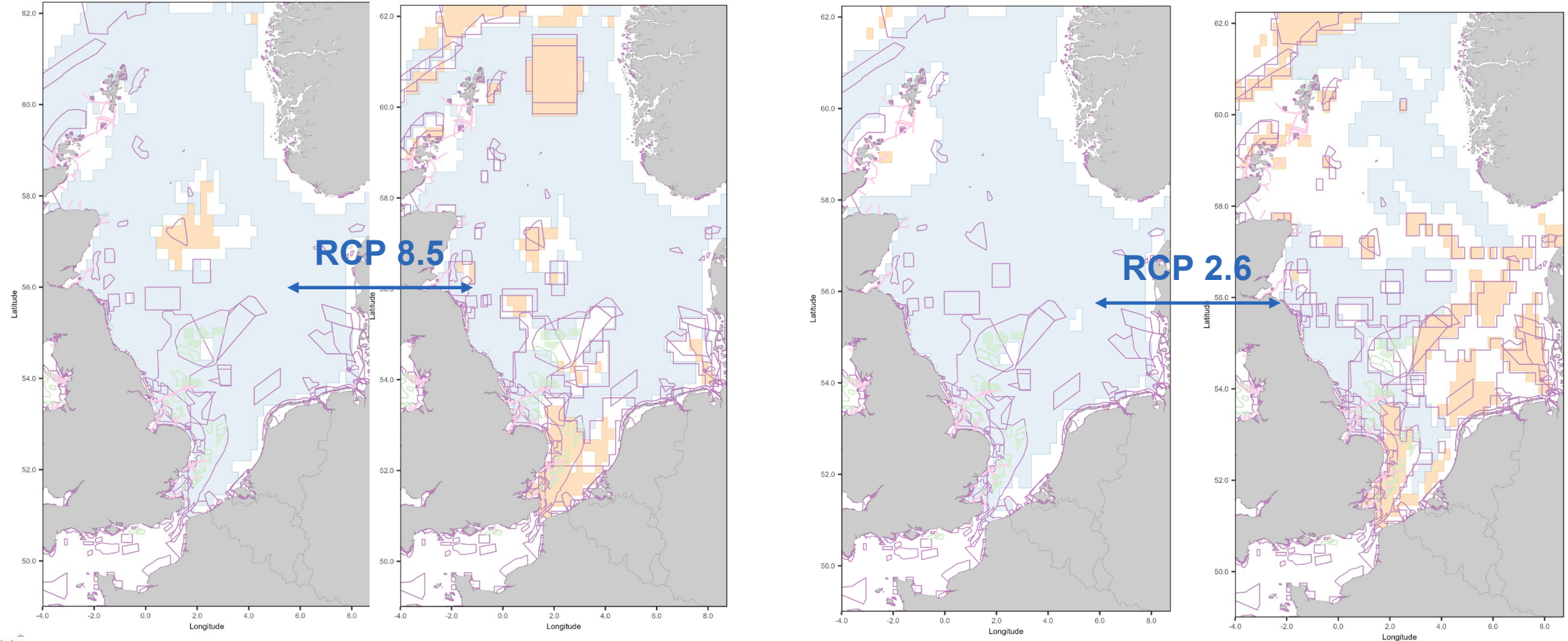


Figure: Location of long-term climate change refugia (orange) increases (hotspots = blue) with more MPAs sited, despite climate change. PML analyses of CEFAS EwE with Ecospace modelling.

- Wind farm (operational or under construction)
- Wind farm (consented, planning, application)
- Conservation site (MPA, MCZ, SPA, SAC)
- Climate change hotspot
- Climate change brightspot
- Climate change refugia
- Cables
- Pipes



Climate-ready strategies for Nature Based solutions: tapping into wider engagement networks



Tapping into wider engagement networks

Science as an ally to policy change

MBON Marine Biodiversity Observance Network

2021 United Nations Decade of Ocean Science for Sustainable Development

Climate-smart, economically viable and socially acceptable spatial ocean management strategies

Prof Ana Queirós
Principal Investigator
Plymouth Marine Laboratory & University of Exeter
anqu@pml.ac.uk @dranaqueiros



World Ocean Summit (Apr 2024)
Ana led panel “Creating an enabling environment for ocean science and governance”.



2021 United Nations Decade of Ocean Science for Sustainable Development

Networking Fridays webinar (Ana presented) – hosted by ML2030 UN Ocean Decade program.
Hosted by AIR Centre. >100 attendees (Feb 2024)



United Nations
Climate Change



Early Warning System: climate-smart, economically viable and socially acceptable marine planning across the UK Nations
Speaker: Prof Ana Queirós anqu@pml.ac.uk

Supporting Challenge 6 Strategic Ambition objectives & framework

- Vision 2030 White Paper ↔ MSPACE (Marine Spatial Planning Addressing Climate Effects)
- Multi-hazard evaluation framework → Implements Bright spots framework for marine climate modelling analysis (Queiros et al. 2021)
- Early Warning Systems → UK Marine Early Warning System
- Capacity building → ASPACE decision support tool (upcoming Summer 2025)
- Holistic focus on environmental, human, & socio-economic factors → ASPACE decision support tool
- Adaptive planning → Climate adaptive Marine Spatial Planning

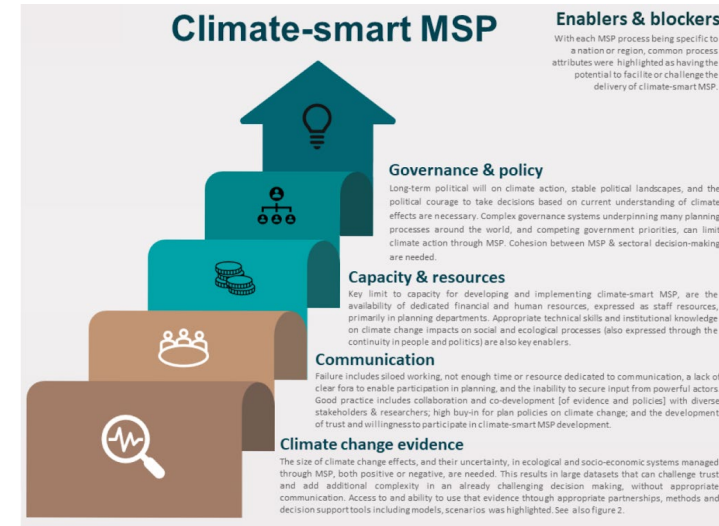
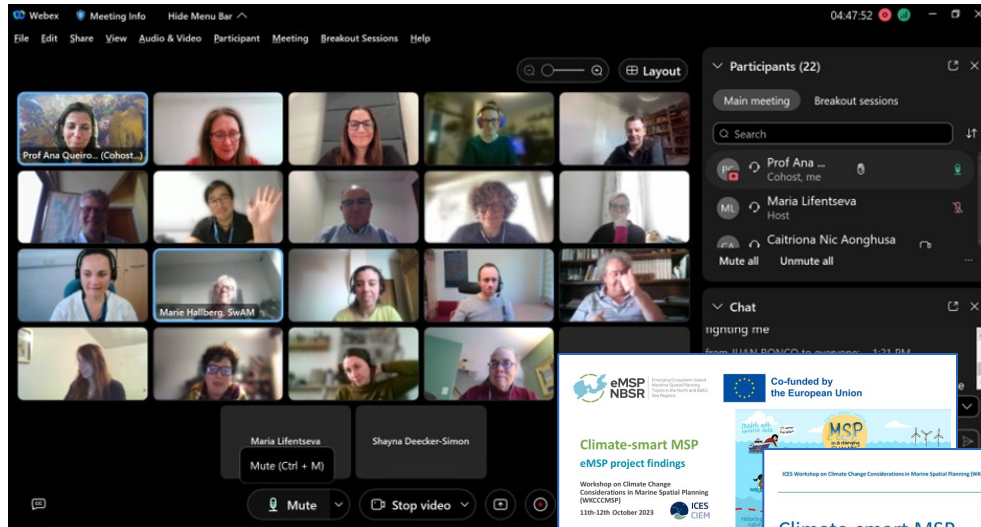
2024 OCEAN DECADE CONFERENCE
BARCELONA, SPAIN 10-12 APRIL 2024
DELIVERING THE SCIENCE WE NEED FOR THE OCEAN WE WANT

Climate-smart approach presented during WG6 sessions, Barcelona, April 2024



Co-hosted ICES Workshop on climate change considerations in Marine Spatial Planning

(WCCCMSP, Delivered Oct 2023)



54 marine planners and researchers from 20 countries:

How is MSP affected by climate change?

How is MPS contributing the climate change adaptation & mitigation?

How can MSP help deliver international climate action?

Results:

Extensive **knowledge sharing** and **solution co-development**.

Advanced collaboration between marine planning, conservation and fisheries management and researchers.

Co-produced **perspective paper** planned for **July 2024**.

Further engagement at UN Ocean Decade Conference (Apr 2024)

Supported by IOC UNESCO, will be followed by session at ICES ASM 2024.



FutureMARES

PML | Plymouth Marine Laboratory



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UNIVERSITÀ DI PISA



Science for Policy

CLIMATE-SMART NATURE-BASED SOLUTIONS



THANK YOU!

CONTACTS: PROF ANA QUEIROS ANQU@PML.AC.UK



FutureMARES Science for Policy

Session 2: Big data for ecosystem services indicators under climate change to evaluate nature-based solutions

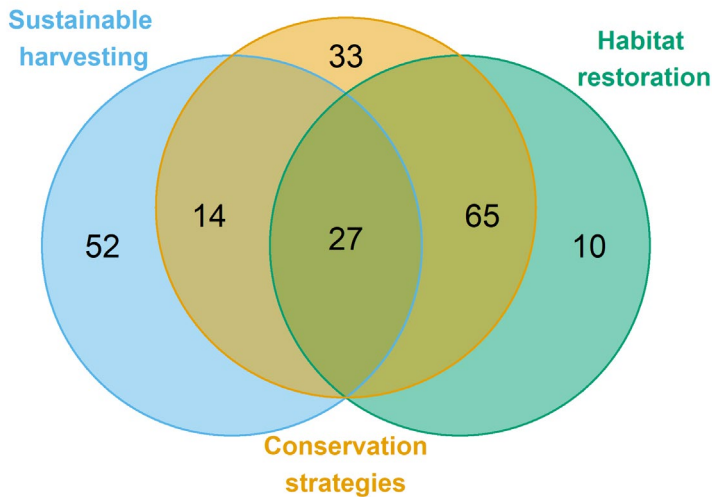


JOSE A. FERNANDES (AZTI), A MURILLAS, G CHUST AND OTHERS

TEXEL, 26 JUNE 2024



Key results and tools



The indicators framework developed in FutureMARES has allowed to select biodiversity, climate change, socio-economic and policy-relevant indicators suitable to evaluate NBS based on 27 case studies across European marine waters.

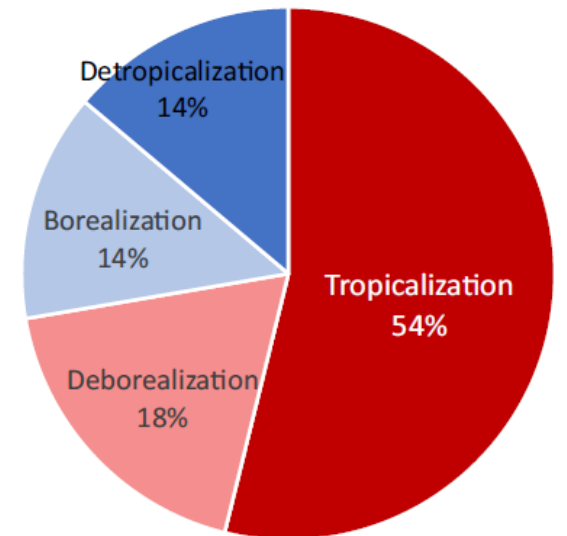
Harvest, pressure and/or habitats are the most used indicators.

Socioeconomic indicators to assess CC mitigation or adaptation are rarely contemplated, only some indicators to aggregate carbon footprint valuation.

Communities and fish size reduction due to climate change is being observed which agrees with previous forecasts and new forecasts confirming that this is expected to continue under current trends and climate change scenarios.

Most communities have responded to warming via abundance increases of warm-water species (54%) and decreases of cold-water species (18%).

Tropicalization dominated Atlantic sites compared to semi-enclosed basins.



The evidence base: 6 scientific publications

Chust et al. (2022) Climate regime shifts and biodiversity redistribution in the Bay of Biscay. **Science of the Total Environment** 803:149622.



Climate regime shifts and biodiversity redistribution in the Bay of Biscay

Guillem Chust^{a,*}, Manuel González^a, Almudena Fontán^a, Marta Revilla^a, Paula Álvarez^a, María Santos^a, Unai Cotano^a, Marina Chifflet^a, Angel Borja^{a,c}, Iñigo Muxika^a, Yolanda Sagarmínaga^a, Ainhoa Caballero^a, Iñaki de Santiago^a, Irati Epelde^a, Pedro Liria^a, Leire Ibaibarriaga^a, Roland Garnier^a, Javier Franco^a, Ernesto Villarino^{a,c,d}, Xabier Irigoien^a, José A. Fernandes-Salvador^a, Andrés Uriarte^a, Xabier Esteban^b, Dorleta Orue-Echevarría^b, Tiago Figueira^f, Adolfo Uriarte^a

Chust et al. (2023) Species acclimatization pathways: Latitudinal shifts and timing adjustments to track ocean warming. **Ecological Indicators** 146:109752.



Original Articles

Species acclimatization pathways: Latitudinal shifts and timing adjustments to track ocean warming

Guillem Chust^a, Fernando González Taboada^a, Paula Álvarez^a, Leire Ibaibarriaga^a

Chust et al. (2024) Cross-basin and cross-taxa patterns of marine community tropicalization and deborealization in warming European seas. **Nature Communications** 15(1), 2126.

nature communications



Article

<https://doi.org/10.1038/s41467-024-46526-y>

Cross-basin and cross-taxa patterns of marine community tropicalization and deborealization in warming European seas

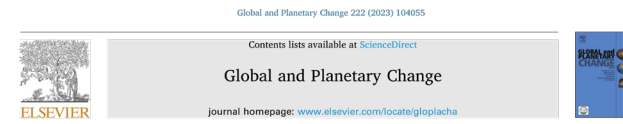
Murillas-Maza et al. (2023) Ecosystem indicators to measure the effectiveness of marine nature-based solutions on society and biodiversity under climate change. **Nature-Based Solutions** 4, 100085.



Ecosystem indicators to measure the effectiveness of marine nature-based solutions on society and biodiversity under climate change

Arantza Murillas-Maza^{a,b}, Stefanie Broszeit^b, Sarai Pouso^a, Juan Bueno-Pardo^c, Ana Ruiz-Frau^d, Jorge Terrados^d, Susanna Jernberg^e, Ane Iriondo^a, Marina Dolbeth^f, Stelios Katsanevakis^g, Paul J. Somerfield^{h,i}, Jose A. Fernandes-Salvador^a

Erauskin-Extramiana et al. (2023). Implications for the global tuna fishing industry of climate change-driven alterations in productivity and body sizes. **Global and Planetary Change** 222, 104055.



Implications for the global tuna fishing industry of climate change-driven alterations in productivity and body sizes

Maite Erauskin-Extramiana^{a,*}, Guillem Chust^a, Haritz Arrizabalaga^a, William W.L. Cheung^b, Josu Santiago^c, Gorka Merino^c, Jose A. Fernandes-Salvador^a

^a AZTI, Marine Research, Basque Research and Technology Alliance (BRTA), Herrera Kaia, Pasaia 48940, Pasaia, Gipuzkoa, Spain
^b Institute for the Oceans and Fisheries, The University of British Columbia, Vancouver, BC V6T 1Z4, Canada

Taboada, F. G. et al. (2024) Shrinking body size of European anchovy in the Bay of Biscay. **Global Change Biology**, 30(1), e17047.

Received: 1 April 2023 | Revised: 21 October 2023 | Accepted: 31 October 2023
DOI: 10.1111/gcb.17047

RESEARCH ARTICLE

Global Change Biology WILEY

Shrinking body size of European anchovy in the Bay of Biscay

Fernando G. Taboada^a | Guillem Chust^a | María Santos Mocoora^a | Naroa Aldanondo^a | Almudena Fontán^a | Unai Cotano^a | Paula Álvarez^a | Maite Erauskin-Extramiana^a | Xabier Irigoien^a | Jose A. Fernandes-Salvador^a | Guillermo Boyra^a | Andrés Uriarte^a | Leire Ibaibarriaga^a



12 talks in scientific conferences, 6 invited talks at policy/industry events, 6 general public and students events, 7 talks at international policy events 3 press releases with tv and radio coverage

- Chust G., *et al.* ICES ASC, 18-24 September 2022, **Dublin, Ireland**.
- Two talks at ICES Annual Science Conference. 9–12 September 2024. **Gateshead, United Kingdom**.
- Erauskin-Extramiana, *et al.* 2023 Species on the Move Conference. Bonita Springs, **Florida, USA**. May 14-19, 2023.
- Erauskin-Extramiana, *et al.* 73rd Tuna Conference. San Diego, **California, USA**. May 22–25 2023.
- Three talks at ICES Annual Science Conference. **Bilbao, Spain**. 11–14 September 2023.
- Lekunberri, X, *et al.* 6th World Conference on Marine Biodiversity. **Penang, Malaysia**. 2–5 July 2023.
- Murillas-Maza, A. 3rd ESP Europe Conference, **Tartu, Estonia**. 2021.
- Two talks at 5th International Symposium on the Effects of Climate Change on the World's Ocean. **Bergen, Norway**. 17-21 April 2023.
- Chust, G. **ICCAT – CC SUR**, Online, 17 April 2024.
- Chust, G. VII Jornada de la flota de cerco. Acerga, 5 April 2024. Sada, **Galicia, Spain**.
- Fernandes, J.A. *et al.* Long Distance Fisheries Advisory Council workshop. **Stockholm**, 15 May 2023.
- Fernandes-Salvador, J.A. II congreso INTERFISH. **Vigo, Spain**. 12-13 April 2023.
- Fernandes, J.A. European Parliament, **Brussels, Belgium**. 29 June 2023.
- Fernandes-Salvador, J.A. ACI Decarbonisation in Shipping: Europe 2023. **Hamburg, Germany**. 7 Sept. 2023.
- Chust, G. “Jornadas para el planeta” within Basque Environment Ocean WEEK **Bilbao**, 8 June 2022.
- Chust, G twice at RiMER course, Feb 2023, Aquarium - **San Sebastián, Spain**.
- Chust, G. Invited lecture in the SIBIC (Sociedad Ibérica de Ictiología) **webinar**. Feb 9th, 2022.
- Fernandes, J.A. Twice at Curso de extensión universitaria sobre Estudios Marítimos. Universidad da Coruña. **Online**.
- Fernandes, J.A., Pint of Science event. Kubrick, **Bilbao, Spain**. 23 May 2023
- **Book chapter**: Chust, G. *et al.* Turnover of fish diversity and fisheries in a warmer global ocean. Elsevier.
- Some of the work to be presented in **DGMARE** organized event where we are invited speakers (end of September 2024).
- Presentations in **ICES groups** where we are chair or members (e.g. WGMLEARN, WGSHP, WGIPEM).
- Murillas-Maza, A. **IUCN Task Force 3** (Governance, Business models and Financial Mechanisms). Online, 27th June 2022
- Fernandes Invited expert **North Sea Advisory Council (NSAC)** meeting. 10 July, Donosti, Spain.
- Fernandes Invited talk. **United Nations Statistics Division** conference, Bilbao, Spain, 10-14 June 2024.
- The Future of Shipping at the biodiversity-climate nexus. World Maritime University, **Malmö, Sweden**. 13-15 May.
- Green transition workshop for **European Commission Joint Research Center** study. 7 April 2022, Donostia-San Sebastian, Spain).



Recommendations for the European Commission

- Include **Community Temperature Index (CTI)**, which consider species composition and abundance response to temperature, **and other climate & biodiversity indicators in Eurostat** and corresponding national and regional official statistical organizations.
- Include **new socio-economic indicators considering CC** (market and non-market based) to the System of Environmental Economic Accounting (SEEA).
- **Increase research funding calls and tenders** to support climate observatories and calculation of indicators that address limitations with socio-economic indicators under CC using big data and artificial intelligence multidisciplinary approaches. Impact assessment under CC after implementing NBS&NIH remains understudied.
- **Establish long-term network monitoring programs** at decadal scales to continue, improve and produce novel approaches for data collection (e.g. ships of opportunity) and its analysis (e.g. big data and artificial intelligence approaches).



FutureMARES Science for Policy

Session 2: Marine Restoration



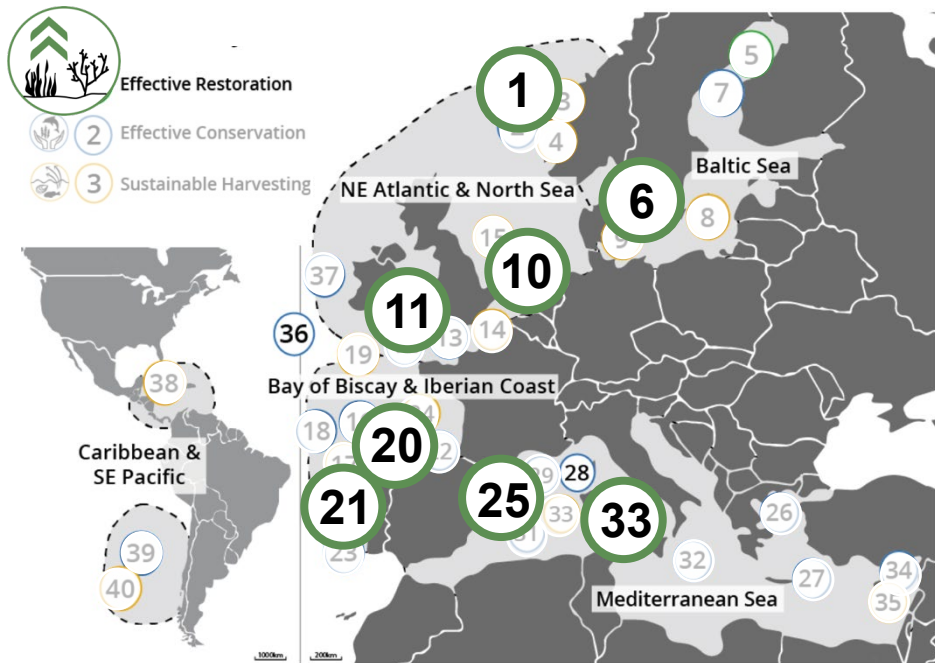
**DORTE KRAUSE-JENSEN (AARHUS UNIVERSITY): A QUEIRÓS, R
WILSON, A PASTOR, M MAAR, F BULLERI, A OSPINA-ALVAREZ, J LARSEN, F THORBJØRN
HANSEN**

TEXEL, 26 JUNE 2024



Restoration of habitat-forming (foundation) species

FutureMARES storylines



REEF-FORMING ORGANISMS
Oyster/mussels
 Dutch coast, NE Atl./North Sea



KELP/MACROALGAE

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 Large-scale restoration-protection synergies

Ecosystem functions and services

- Coastal protection
- Carbon sequestration
- Biodiversity
- Seawater quality/clarity
- ...

Climate change adaptation & mitigation, fisheries, tourism, cultural activities

1. What to restore?

Foundation species

Climate buffer capacity

Climate tolerance

2. Where to restore?

Suitable habitat conditions

Suitable future habitat conditions

Habitat connectivity

3. How to restore?

Passive restoration

- Reduction of stressors

Active restoration of seascape elements

- E.g. removal of dikes, searuchins

Active restoration by re-introduction

- Seeds, transplants, spores
- Potentially protective structures
- Test trials

Donor genetic diversity: 'climate rescuers'

Examples of tools of policy relevance

for e.g. the EU Biodiversity Strategy & EU Nature Restoration Law
-> guidance for Member States on restoration of foundation species

← **Habitat suitability models – current and future**

← **Habitat connectivity models**

Key message:

- Restoration is much more than “active restoration”
- “Passive restoration” stimulates natural recolonization
- Active restoration should target key areas lacking mother populations
- Iterative process: planning, monitoring, evaluation, adjustment

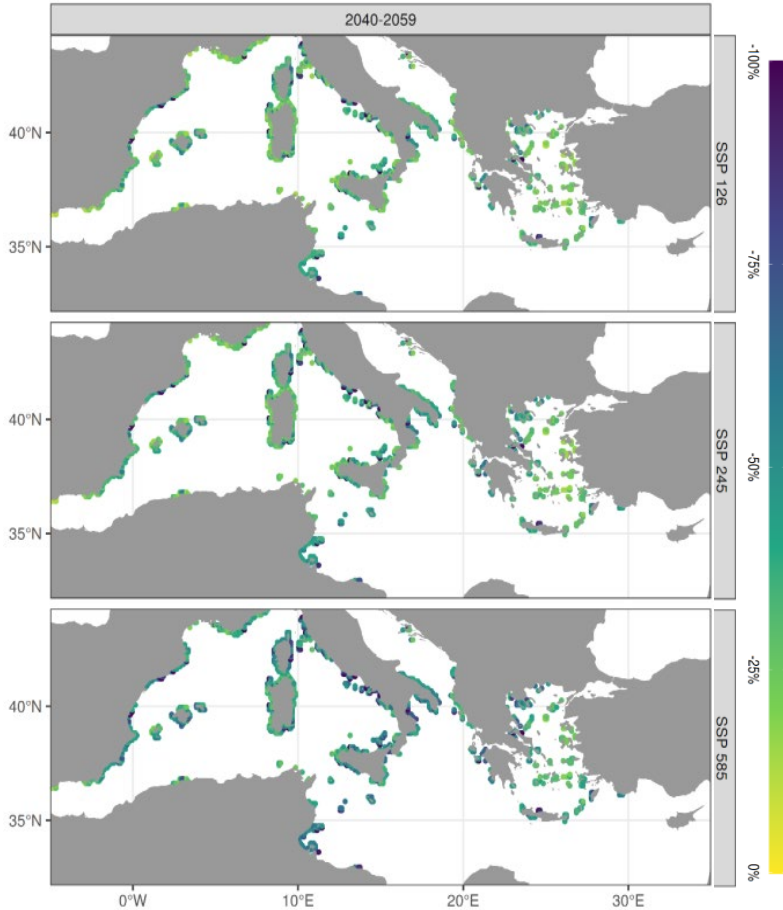


Habitat suitability models to support seagrass and seaweed restoration planning

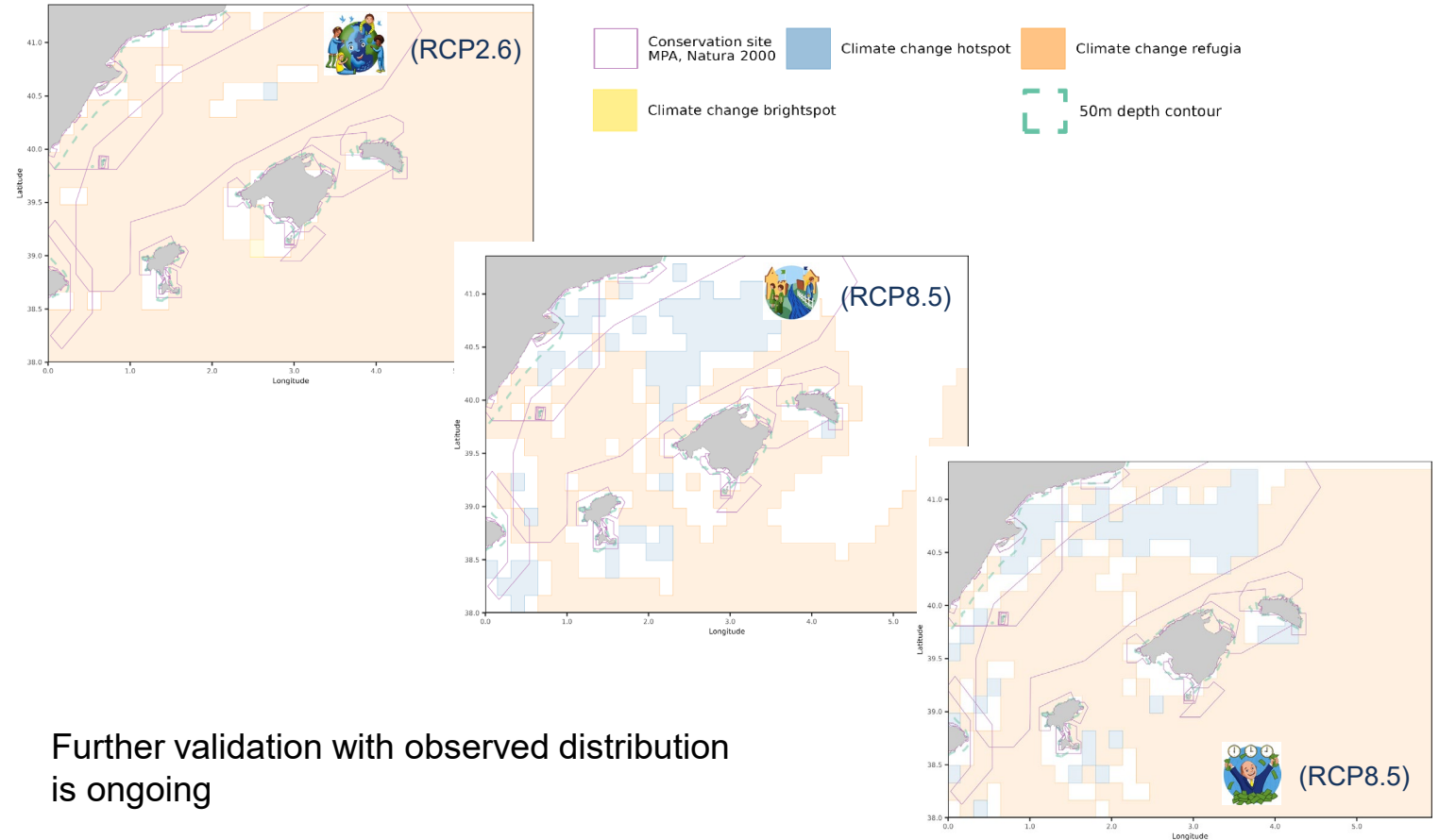
Lead by Wilson, Queirós et al.



Projected change (%) in seagrass (*P. oceanica*) biomass by 2040-2059



Consistently appearing climate change refugia, hotspots around the Balearic Islands 2026-2069



Further validation with observed distribution is ongoing

Key message: Identification of climate change hotspots & climate-smart restoration areas: climate refugia & “bright spots.”



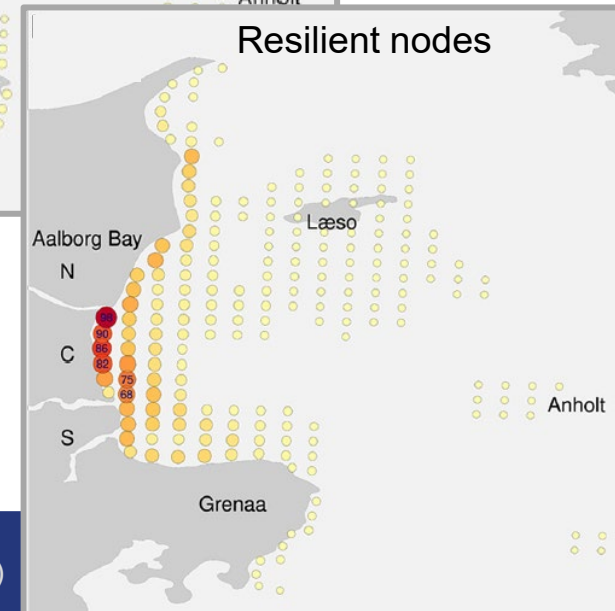
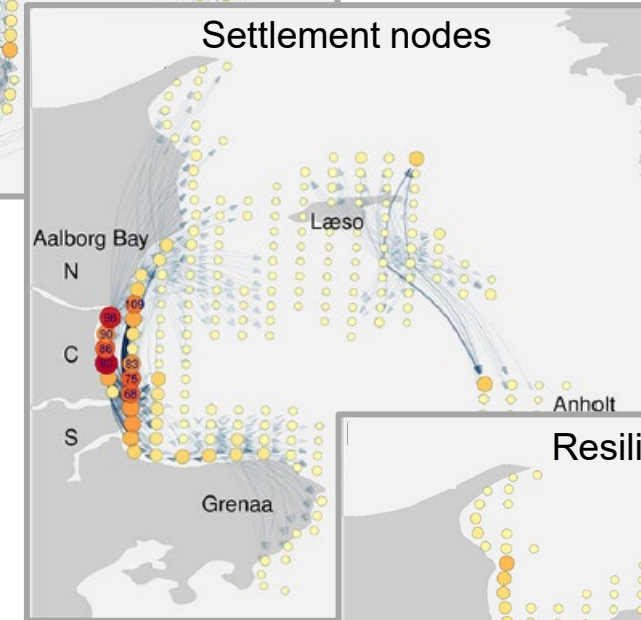
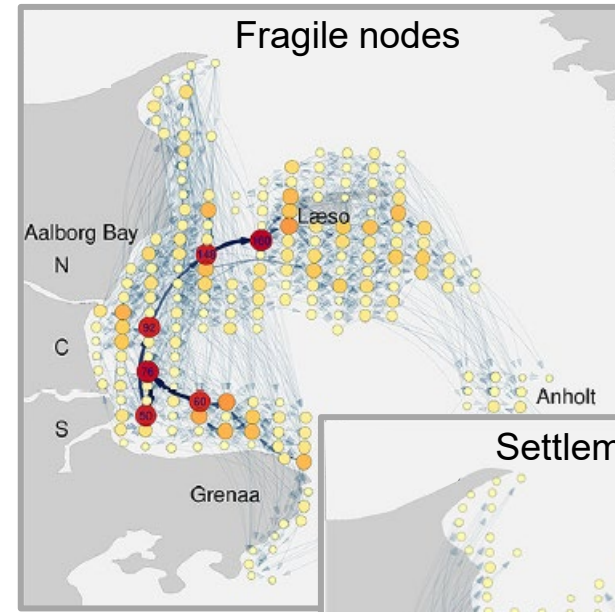
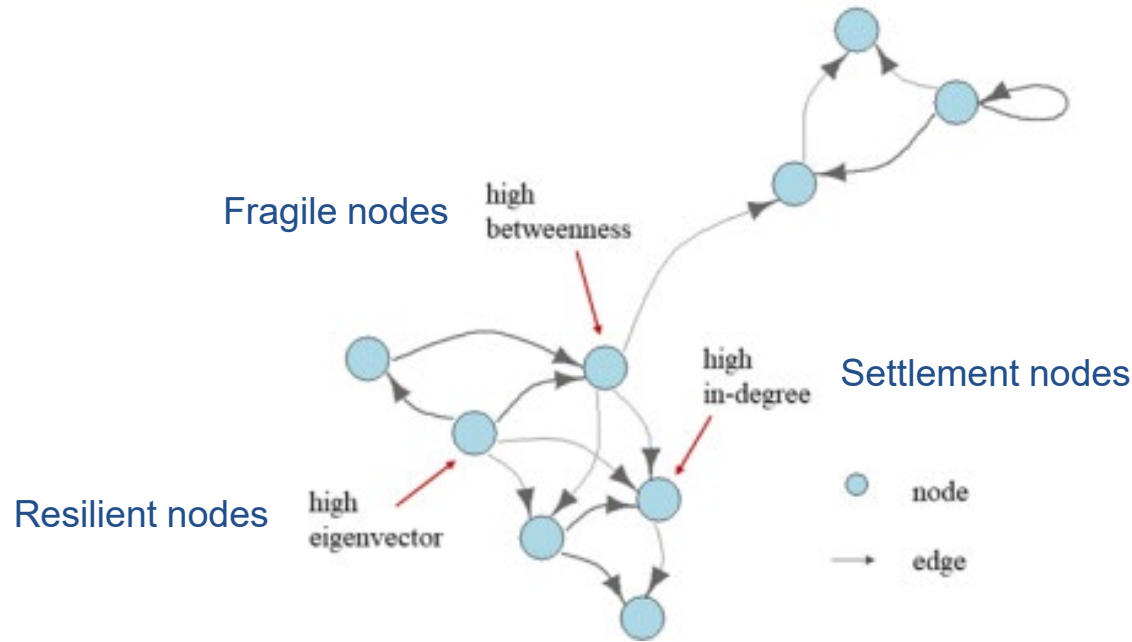
Seagrass connectivity model to guide choice of restoration site

New dispersal model of eelgrass - coupled hydrodynamic and individual-based model, and network analysis

-> For *Zostera marina*, Denmark; *Posidonia oceanica*, NW Med.



Based on historical *Z. marina* distribution, **Kattegat, Denmark**



Key message: Important to restore lost areas of high eelgrass resilience as well as fragile populations which would not naturally recolonize



Dissemination and Opportunities

Habitat suitability models for restoration planning

- Publication status: FutureMARES Deliverable Report 4.1; international manuscript under preparation
- Communicated and discussed with national stakeholders, at international conferences and at policy events (e.g. UN Ocean Decade)

Seagrass connectivity models for restoration planning

- Publication status: FutureMARES Deliverable Report 4.1; two peer-reviewed publications
- Communicated and discussed as above

Opportunities

- Relevance for e.g. national restoration plans (EU Nat. Res. Law)
- Development of similar models for other regions/species

