Climate Change in an Ecosystem Based Management context

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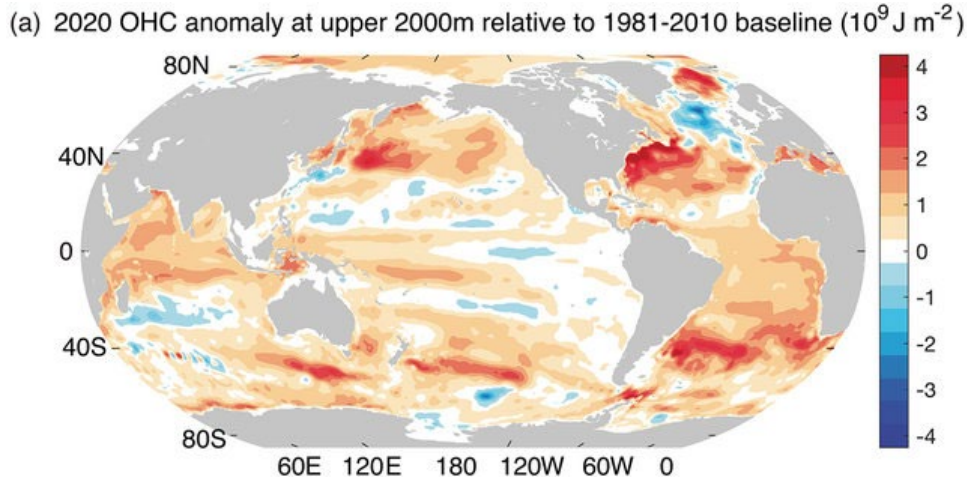
Climate Change work in the ICES network

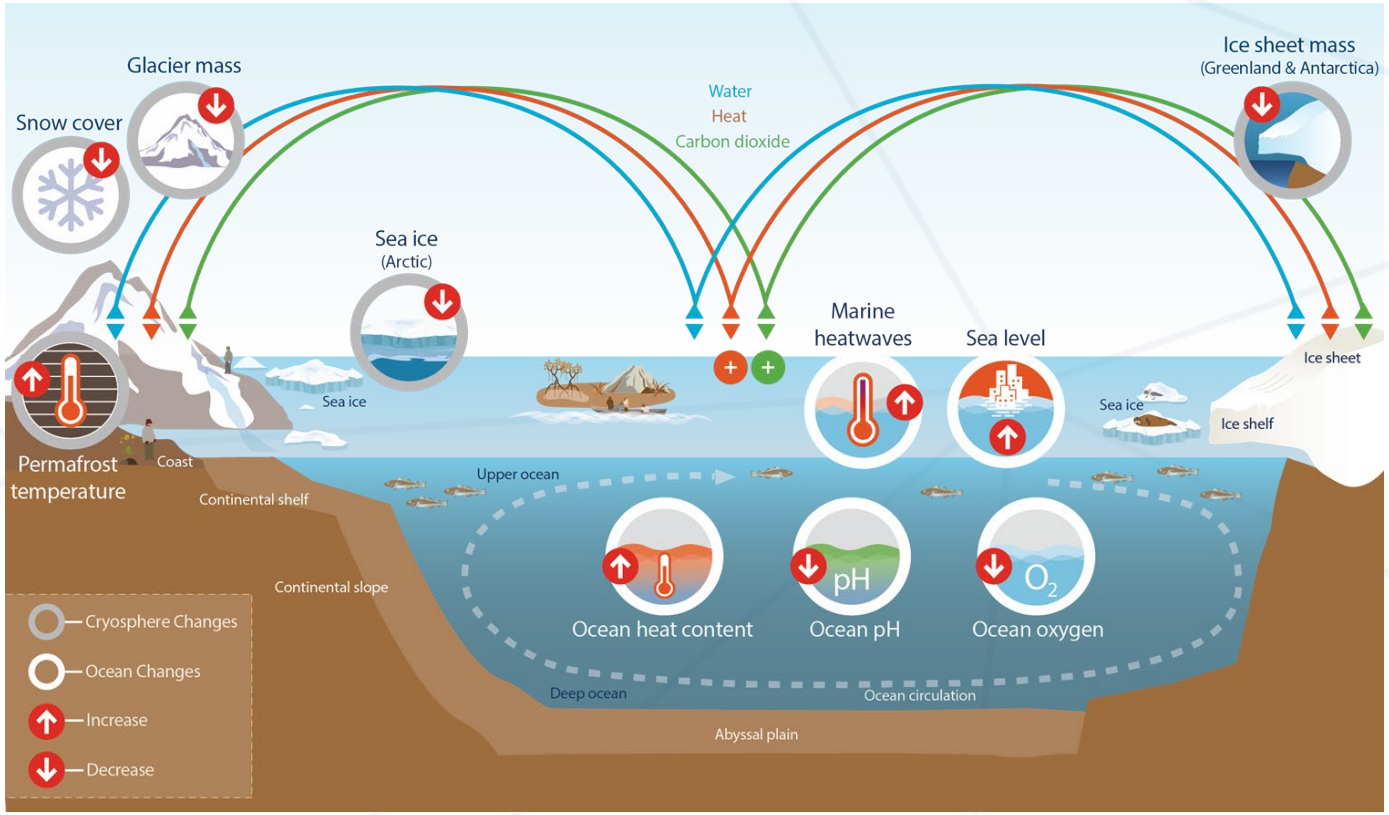
1. Climate change impacts on Fish/Fisheries
2. Management implications
3. Look into appropriate management responses
4. Existing toolbox solutions
5. Climate Informed Advice

Climate change is affecting our oceans' physical environment

- Increasing temperatures
- Acidification
- Decrease in dissolved oxygen
- Decrease in sea ice
- Rising sea level
- Changes in salinity
- Changes in ocean circulation

Climate change impacts vary across regions



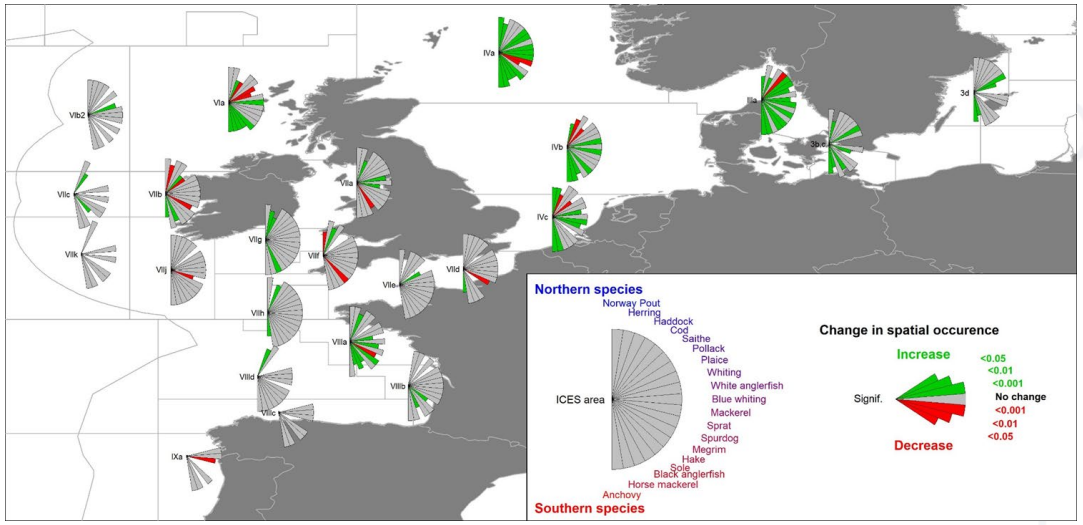


Source: IPCC, Special Report on the Ocean and Cryosphere in a Changing Climate, 2019

Climate Change impacts on marine fish & fisheries (1)

Distribution:

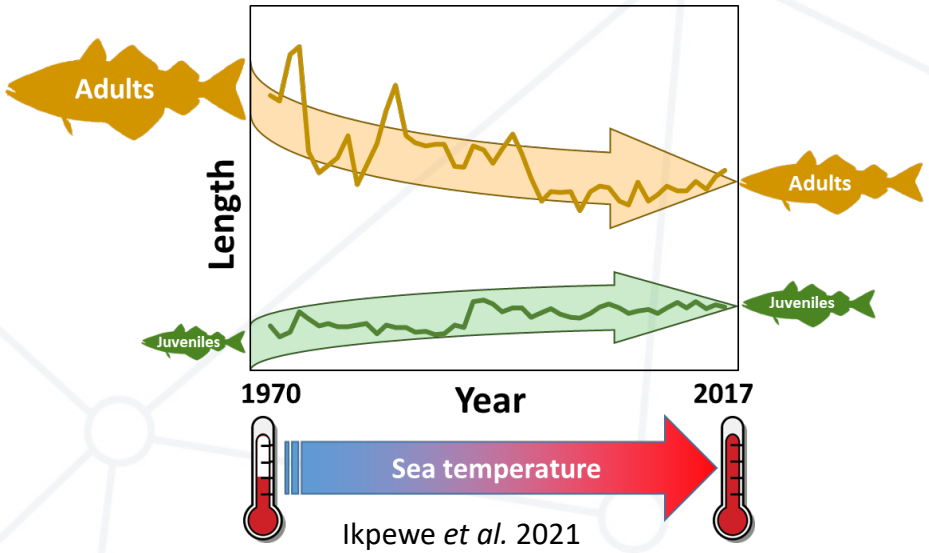
- Contraction of northern species / expansion of southern species
- Changes across TAC areas
- Quotas no longer reflect regional abundances



Baudron *et al*. 2020

Growth and body size:

- Empirical evidence shows that warmer waters lead to faster juvenile growth, but reduced adult sizes
- Knock-on impacts: earlier maturation, loss of fecundity (smaller fish produce smaller, less viable eggs in smaller quantities)
- Loss of yield (smaller fish), and loss of productivity

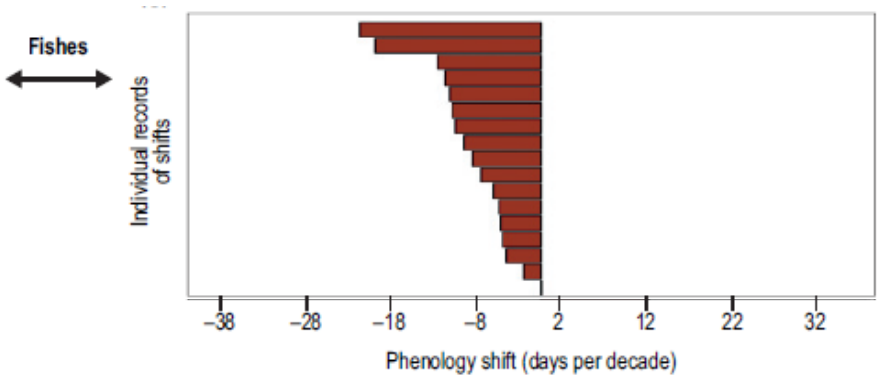


Ikpewe *et al.* 2021

Climate Change impacts on marine fish & fisheries (2)

Phenology/Recruitment:

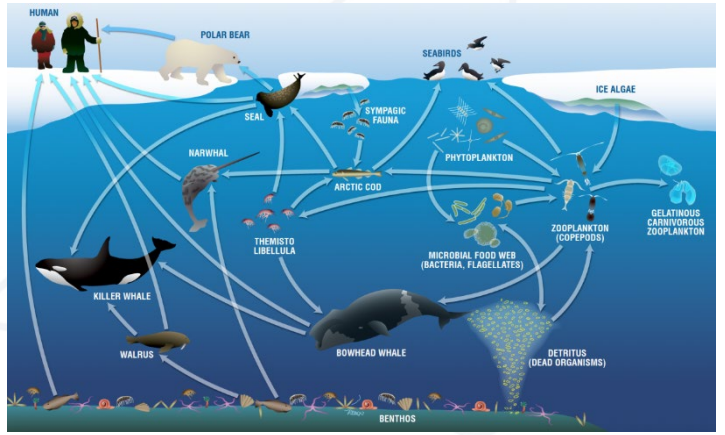
- Higher mortality and lower recruitment affect fish stock productivity and resilience
- Shift towards earlier spawning, hatching, and migration
- Impact on larvae dispersion
- Potential mismatch between fish larvae (predator) and plankton (prey) abundances affect recruitment
- Lower oxygen concentrations affect egg & larvae survival
- Lower salinity affects fertilisation and buoyancy
- Acidification affects survival



Poloczanska *et al*. 2013

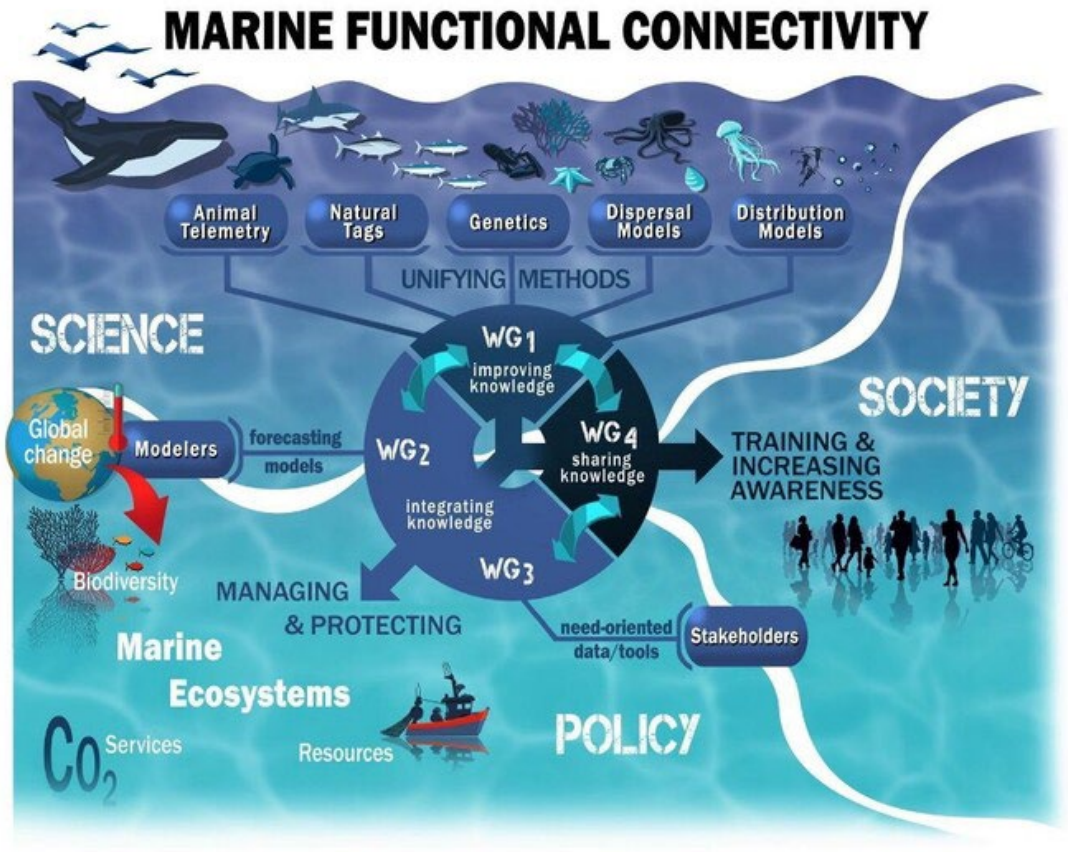
Food webs:

- Changes in distribution, recruitment, body sizes affect food webs and ecosystem functioning lowering the resilience of marine ecosystems to pressures
- Warming reduces biomass transfers in marine ecosystems from secondary production to fish stocks



Marine Functional Connectivity (MFC)

- Marine Functional Connectivity (MFC)
  - movement of organisms, lifetime dispersal, season migrations →exchange of genes, species, functional traits, biomass, energy
  - MFC determines biodiversity patterns, demographic, ecological, evolutionary interdependency of populations/communities
- Effective knowledge on MFC
  - Better management and conservation strategies



Climate Change Impacts on MFC

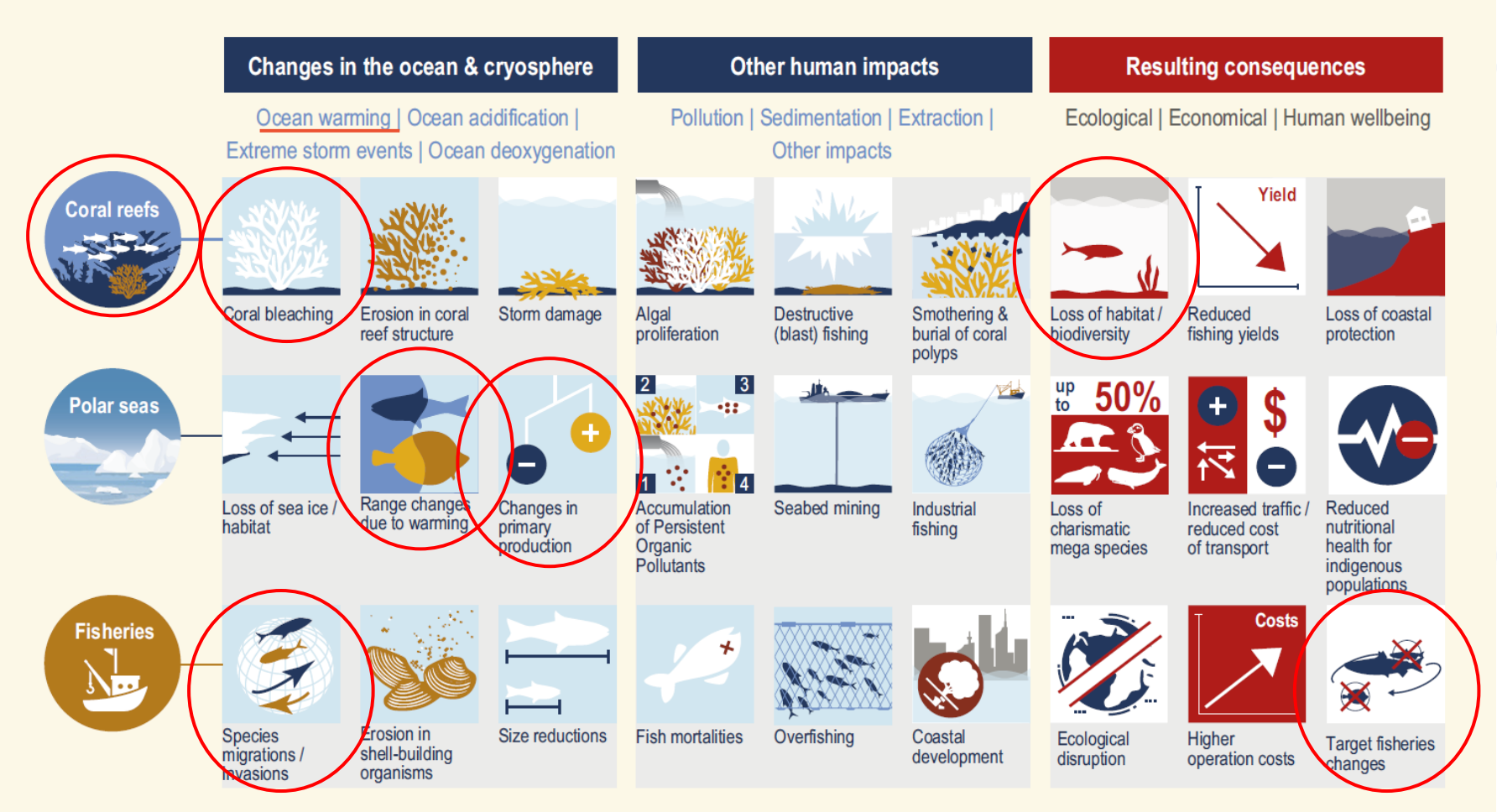
- Observed CC effects on functional connectivity patters → impacts on biodiversity and ecosystem processes
  - Impacts on fish life stages → spawning, larval dispersion
  - Reduced connectivity distance and connections
  - Higher habitat fragmentation
- These changes lead to reduction in marine ecosystems adaptation capacity
  - Reduce migration
  - Longer recovery from “broad disturbances”
- Management Implications:
  - Conservation and restoration measures will have to be local and closer to each other
  - Need for cross-boundary collaboration n decision making

Climate Change impacts on marine fish & fisheries: management implications

Distribution	Productivity	Phenology

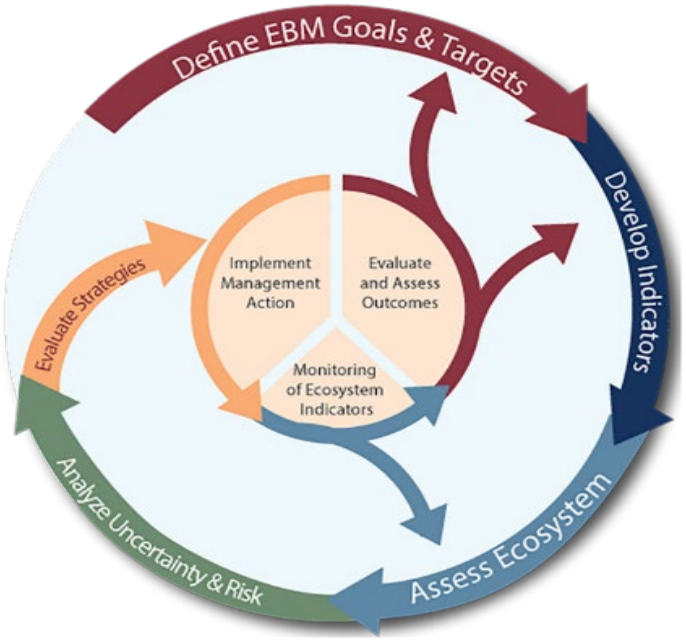
• **Shifts across jurisdictional boundaries**
• Shifts across stock boundaries
• **Changing alignment with quota allocations**
• Increases/declines in catch of target species
• **Re-location of effort**
  • **Management and cost implications**
• Changes in survey catchability
• **Changing interactions: protected species, bycatch**
• Reduced effectiveness of spatial closures
• **Emergent and invasive species**
	• **Uncertainty and errors in stock assessment process**
	  • Life history parameters (growth, maturation, natural mortality, stock-recruitment)
	  • State/regime shifts
	• **Altered feasibility and timelines of attaining management targets**
	  • Dynamic reference points
	  • Rebuilding timeframes
	• **Changing availability of fisheries resources**
	• **Management "surprises"**
	  • Unrecognized/unintentional overfishing
	  • Quick adjustments
		• Changes in survey catchability
		• **Reduced effectiveness of temporal closures**
		  • Fishing seasons
		  • Spawning closures
		• Changes in interaction rates with protected, bycatch species
		• **Altered fishing opportunities due to changing temporal overlap**
		• Supply chain preparedness, market response
		• **Loss of cultural traditions**

Climate Change impacts



Source: IPCC, Special Report on the Ocean and Cryosphere in a Changing Climate, 2019

Adaptive environmental management: Ecosystem Based Management



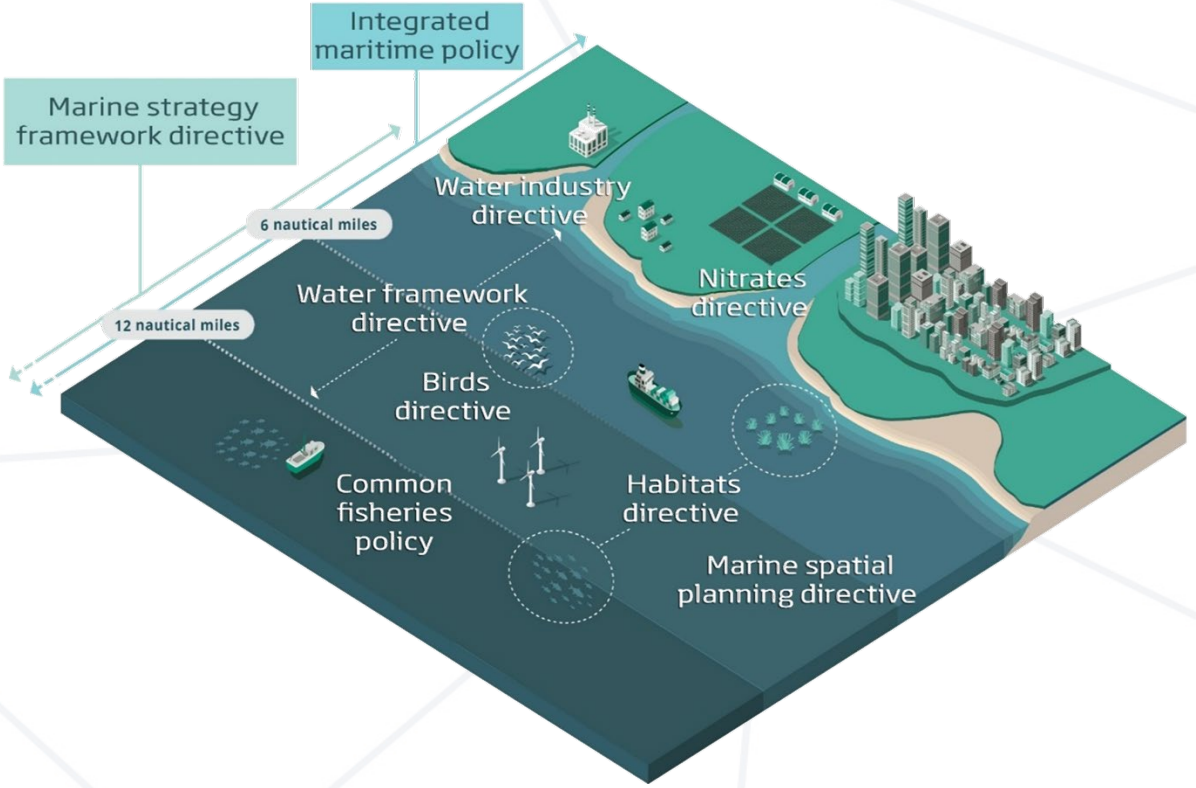
FROM	TO
Individual species	Ecosystems
Small spatial scale	Multiple scales
Short-term perspective	Long-term perspective
Humans: independent of ecosystems	Humans: integral part of ecosystems
Management divorced from research	Adaptive management
Managing commodities	Sustaining production potential for goods and services

Global governance
EBM management approach
robust decision making
public participation

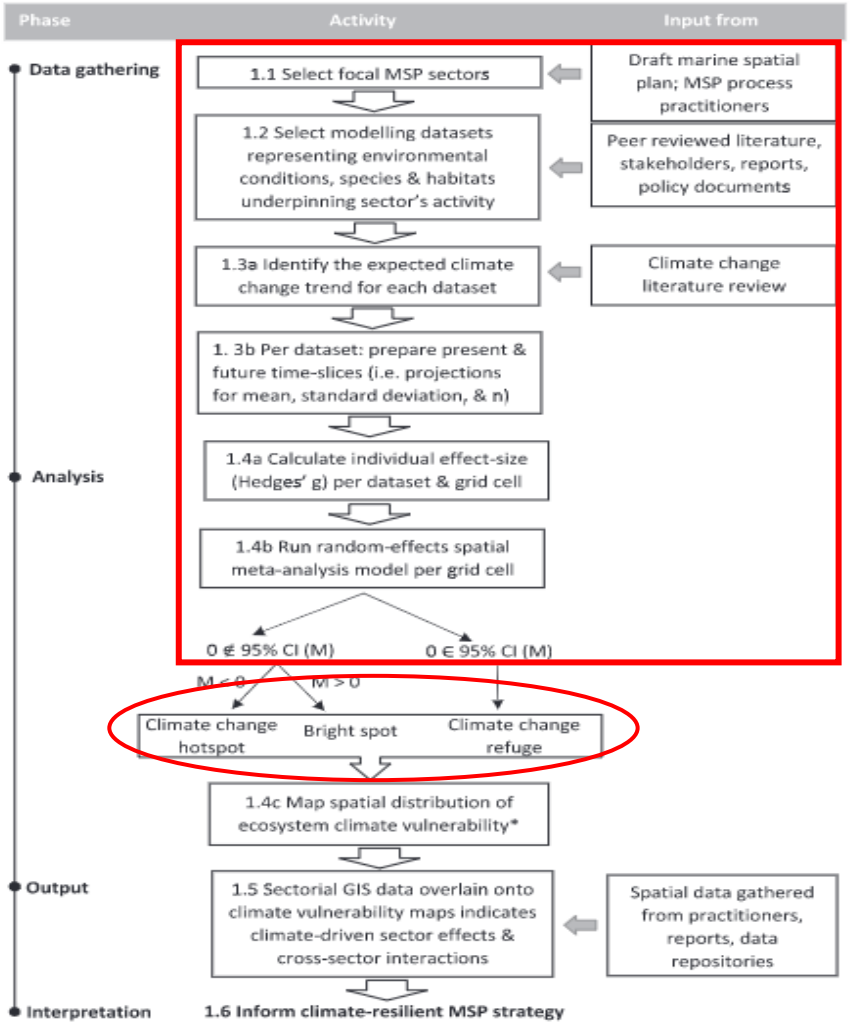
→ conservation of biodiversity
sustainable use of ecosystem services
in a changing climate

Operational EBM Toolbox: Climate adaptive Marine Spatial Planning (MSP)

- Key for EBFM: trade-offs regulating the sharing of marine space between maritime activities & conservation
- Climate Change can disrupt planned distribution of activities
- Need to adjust MSP to shifting living resource distributions for marine conservation, sectorial conflicts management, climate change mitigation
- Evidence analyses support



Climate Adaptive Marine Spatial Planning: Irish case study (1)



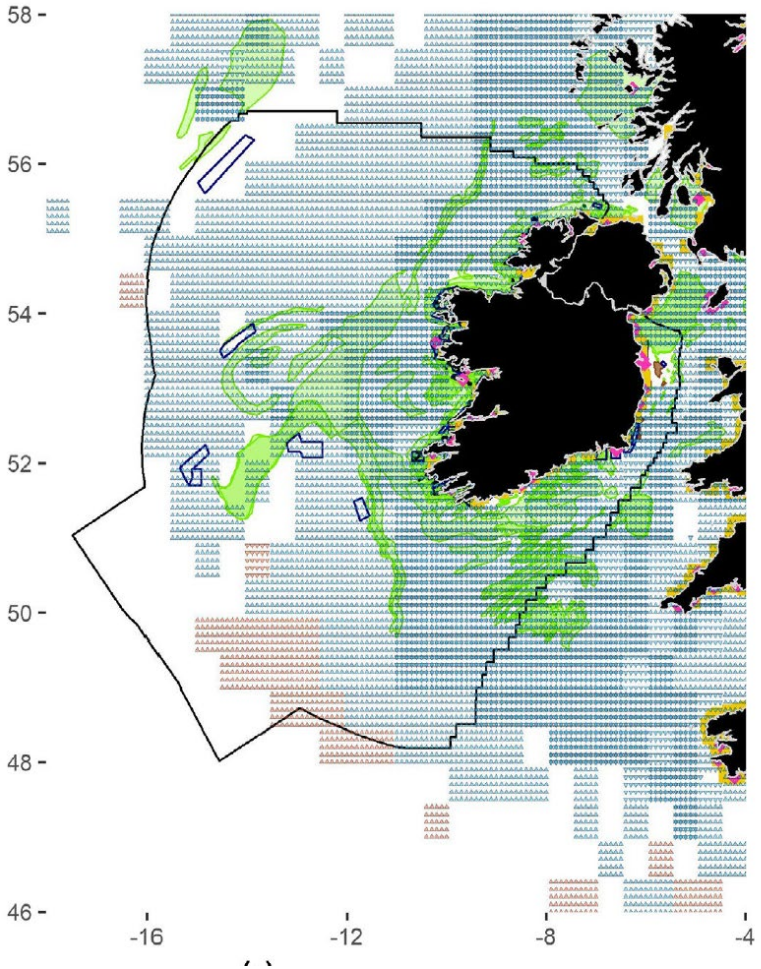
CC hotspots: areas where climate drives the ecosystem towards a new state

CC refugia: areas where the ecosystem remains within the boundaries of its present state

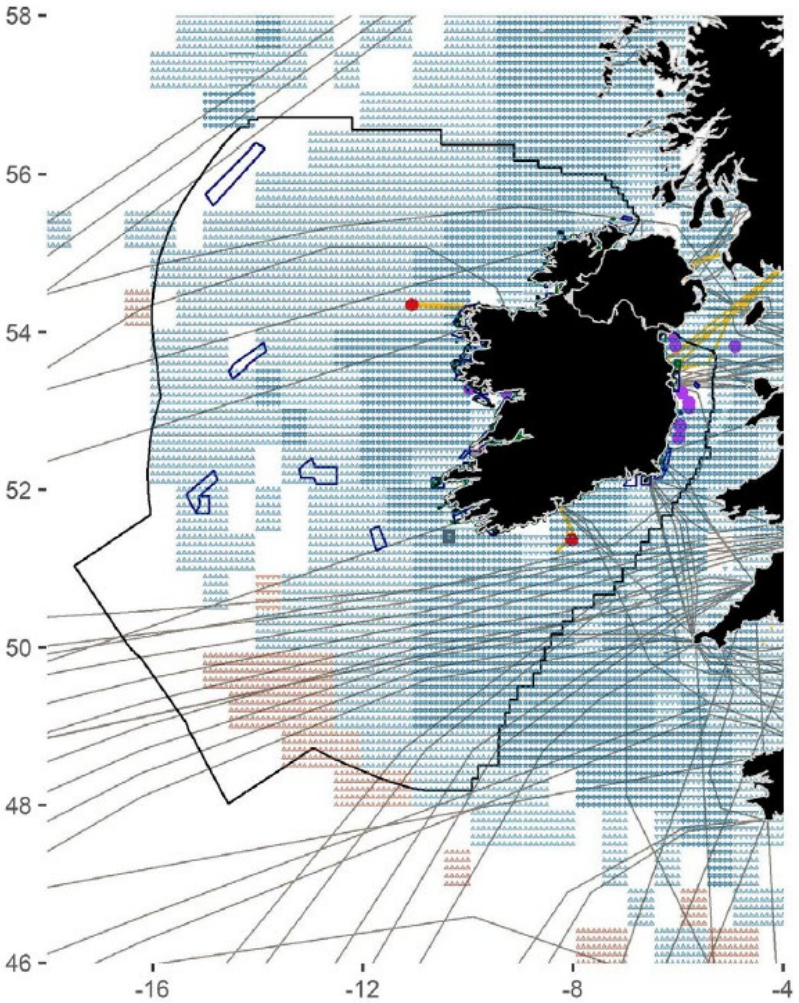
bright spots: areas where oceanographic processes drive a range of expansion opportunities; can support sustainable growth in the medium-term

Example of an analytical approach to climate resilient Marine Spatial Planning (Queiros et al, 2021)

Climate Adaptive Marine Spatial Planning: Irish case study (2)



Blue triangles: CC hotspots
Red triangles: CC bright spots
Upward triangles: pelagic datasets
Inverted triangles: benthic and demersal datasets
Green areas: fishing grounds



Brown shading: areas of aggregate extraction
Grey lines: underground cables
yellow lines: undersea pipelines
Purple circles: planned/active offshore wind installations
red circles: are oil and gas platforms

MSP: Capturing CC bright spots within MPA, biomass slipover to surrounding fishing areas → improved scenario

(Queiros et al, 2021)

Science for sustainable seas

Climate Change in the ICES science network

- ICES/PICES Strategic Initiative on Climate Change Impacts on Marine Ecosystems (SICCME)
- Workshop on Assessing the Impact of Fishing on Oceanic Carbon (May 2023)
- Workshop on Climate Change Considerations in Marine Spatial Planning (autumn 2023)

Climate Change in the ICES Network

- ICES/PICES Workshop on Regional climate change vulnerability assessment for the Large Marine Ecosystems of the northern hemisphere (WKSICCME-CVA)
- The ICES/PICES Workshop on Political, Economic, Social, Technological, Legal and Environmental scenarios used in climate projection modelling (WKPESTLE)
- ICES Working Group on Seasonal-to-Decadal Prediction of Marine Ecosystems (WGS2D)

Climate Change in ICES advice – current

Ecosystem Overviews

- Climate change included as a distinct pressure across activities, pressures & ecosystem state components
- Evidence of ongoing and anticipated effects
- Key knowledge gaps

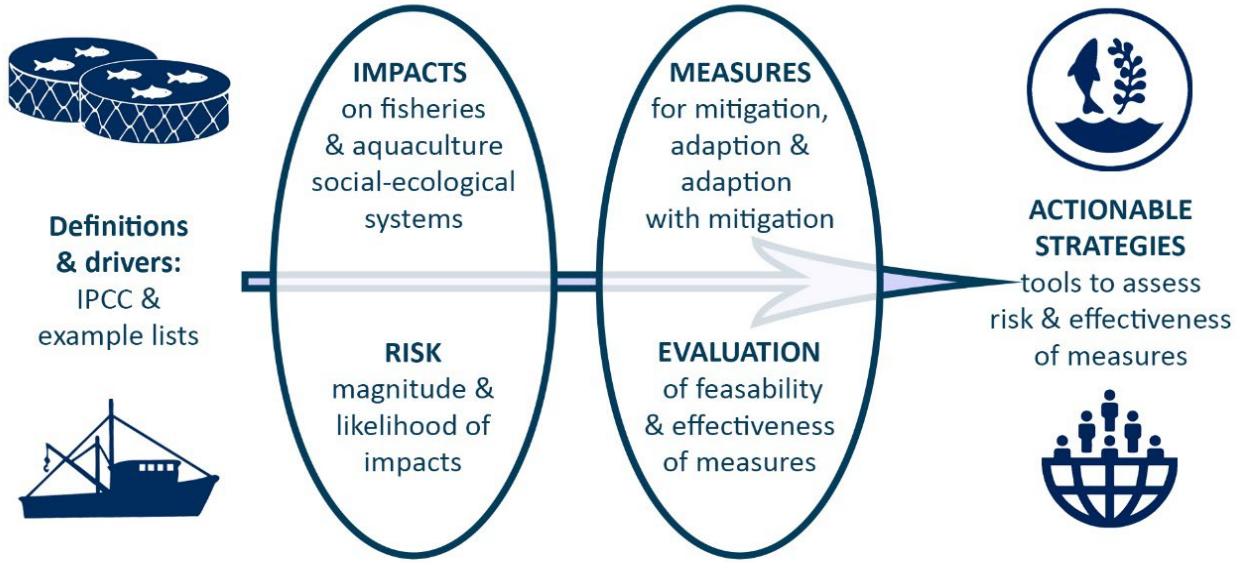
Aquaculture overviews

- Future projections
- Emerging biological/ecological threats/opportunities
- Development trends
- Socio-economic impacts

EU request on distributional shifts in fish stocks in TAC management areas. (WKFISHDISH, 2017 related advice):

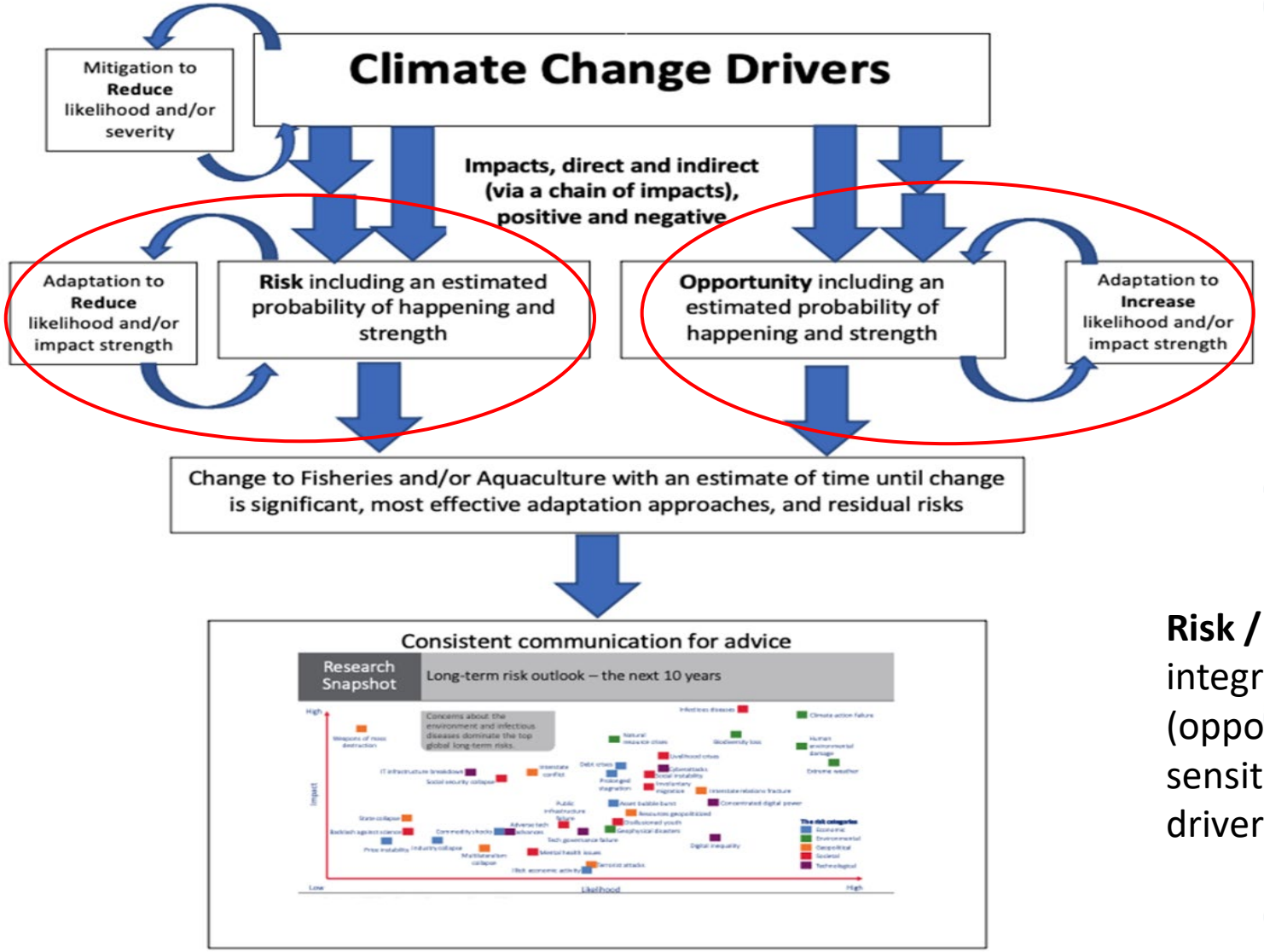
- changes in distributions for 16 out of 21 species examined (North East Atlantic)
- 8 species exhibited distribution changes crossing quota management and allocation boundaries
- Change drivers linked to environmental conditions, ↑T ,(and fishing)
- Future changes in these drivers will further affect the fish distribution→more advice needed

Current toolbox: 2021 ICES Workshop on pathways to climate-related advice (WKCLIMAD)



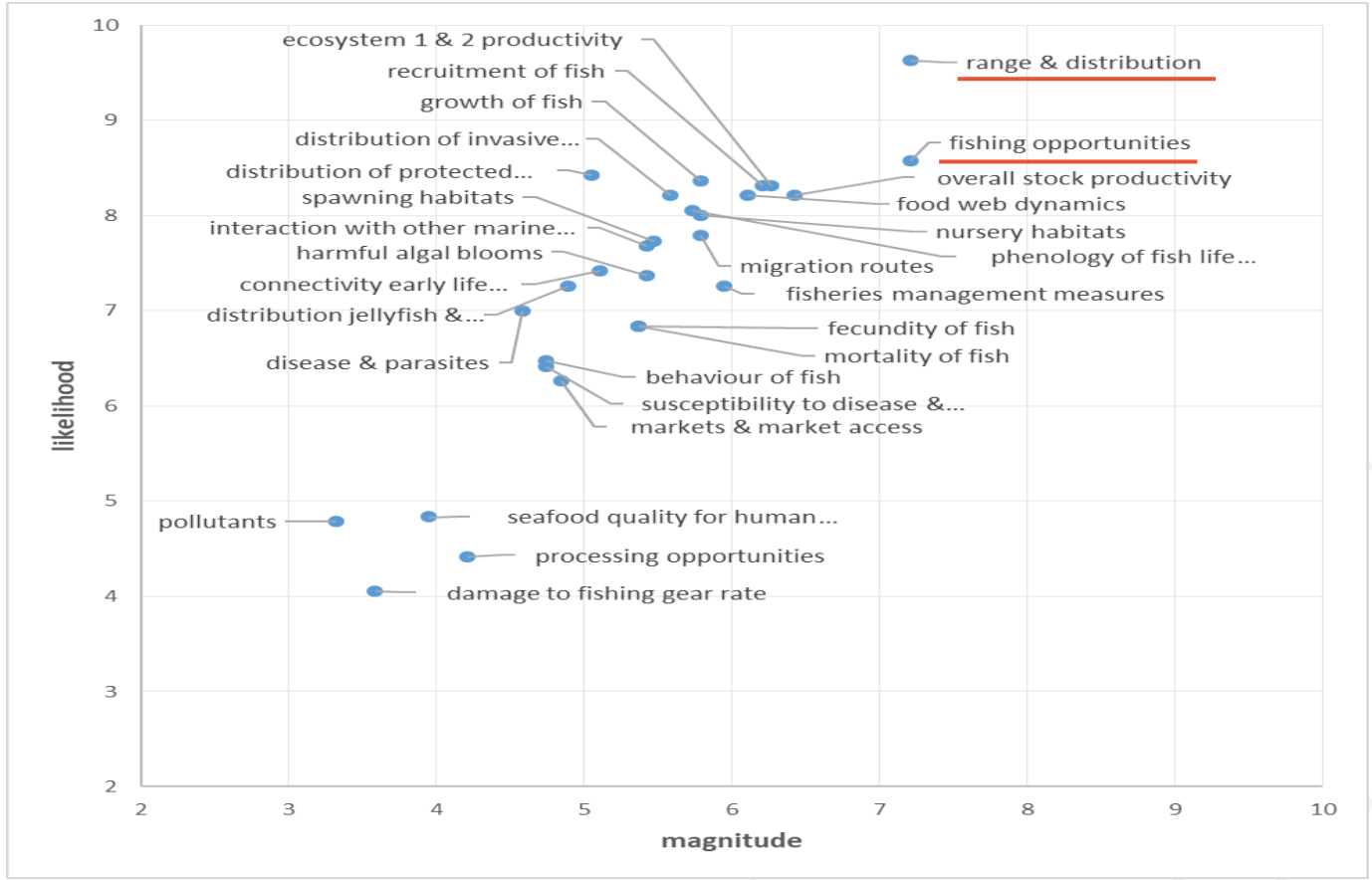
ICES. 2023. Workshop on pathways to climate-aware advice (WKCLIMAD). ICES Scientific Reports. 5:25. 99 pp. http://doi.org/10.17895/ices.pub.22196560

ICES WKCLIMAD 2021 - Risk approach



Risk / Opportunity - The integrated negative (risk) or positive (opportunity) outcome of exposure, sensitivity, response to climate change drivers.

ICES WKCLIMAD 2021 - Climate change impacts on fisheries

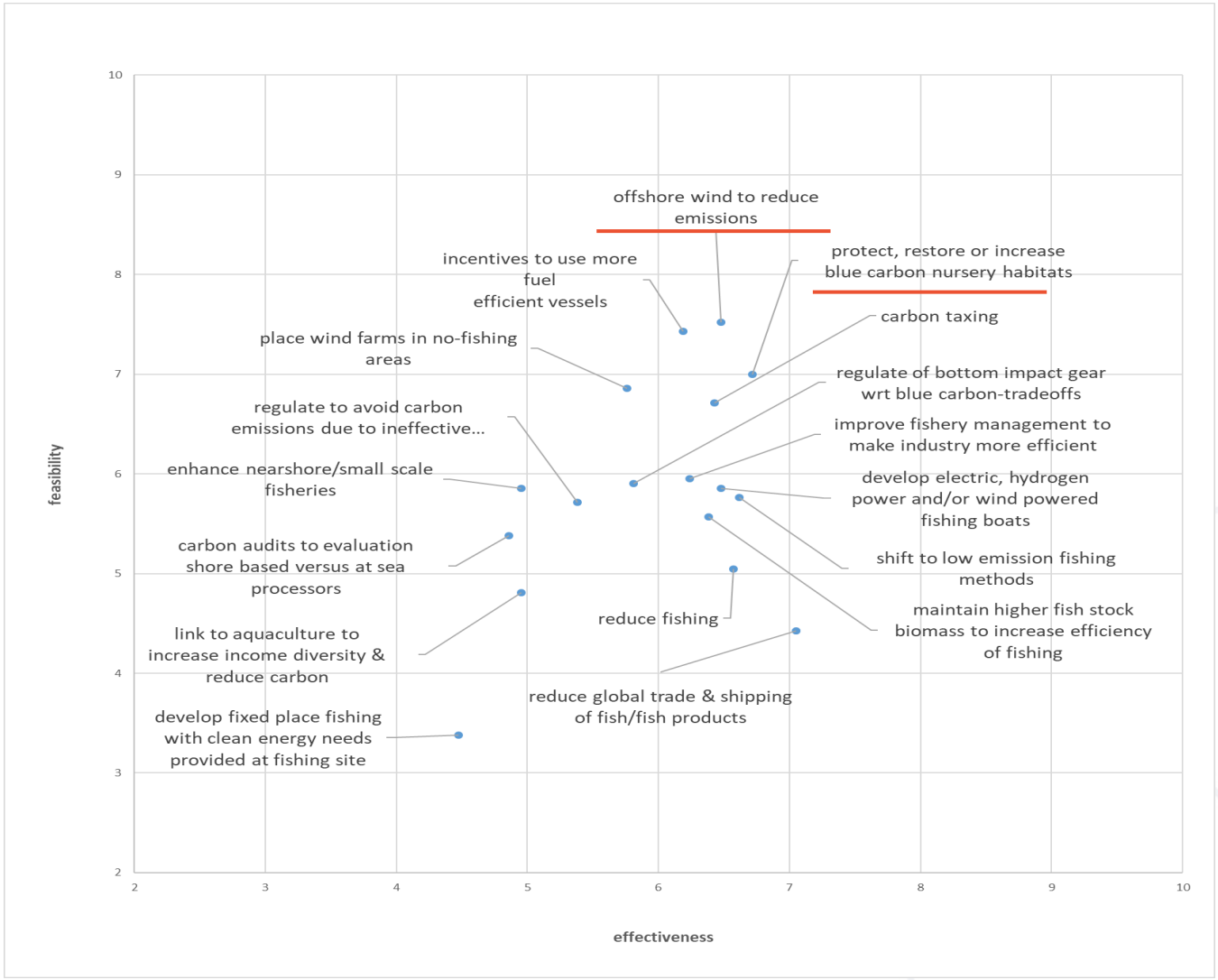


Impacts can affect physical, biological, economic, social parts of the ecosystem:

- direct/indirect
- positive/negative

Analysis of Short-term (2021-2040) climate driven changes/impacts on fisheries based on the likelihood of their occurrence and their anticipated magnitude of impact (+/-) (WKCLIMAD, 2021)

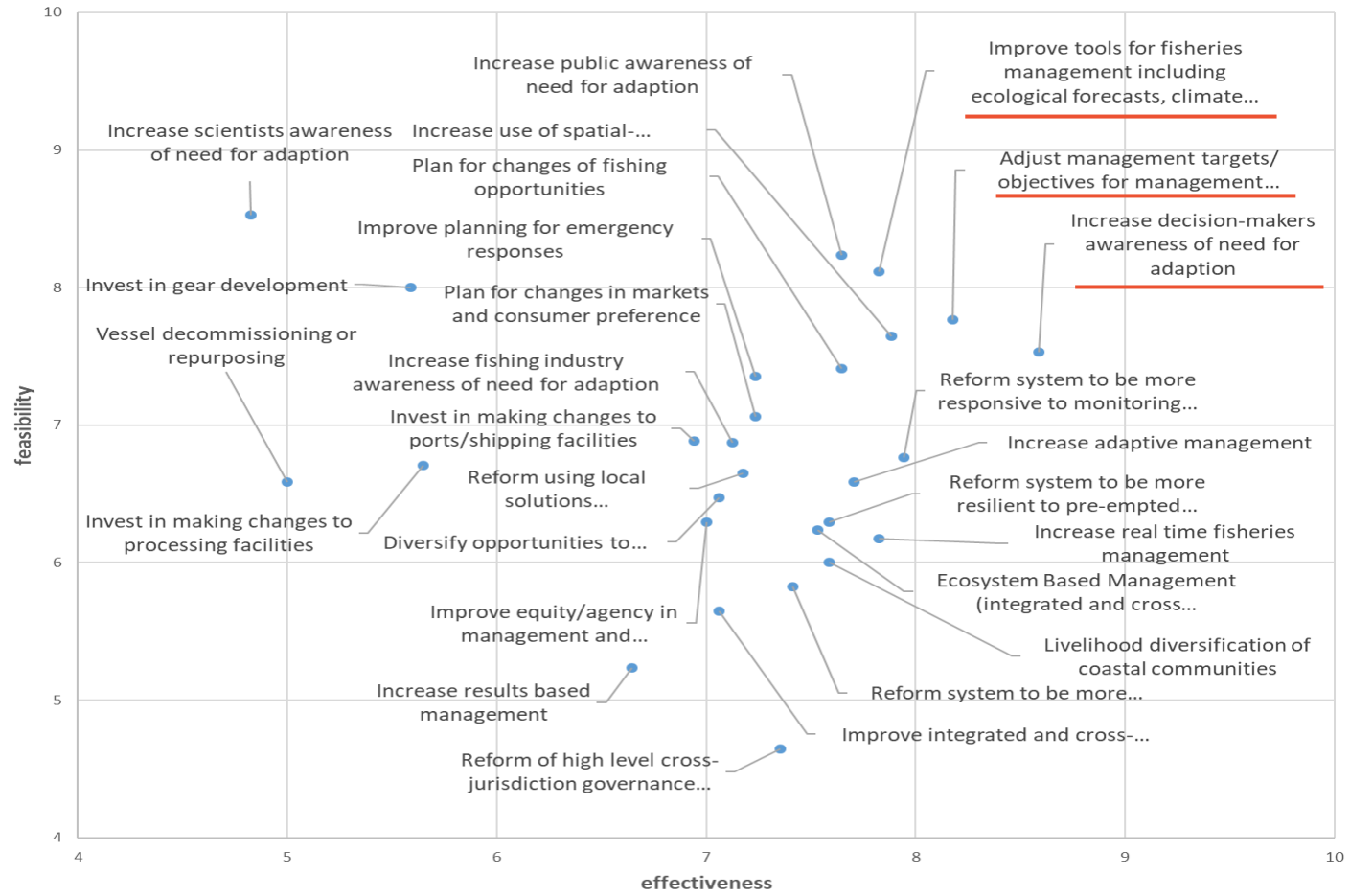
ICES WKCLIMAD 2021 - Mitigation



Climate change mitigation: activities or policies that reduce emissions of greenhouse gases, remove atmospheric carbon

Fisheries: effectiveness and feasibility of CC mitigation measures (WKCLIMAD, 2021)

ICES WKCLIMAD 2021 - Adaptation



Fisheries: effectiveness and feasibility of CC adaptation measures (WKCLIMAD, 2021)

Climate change adaptation: actions, policies, planning to adjust to or reduce the impacts of current or future climate change:

- incremental/passive
- local/regional/large scale

Science for sustainable seas

ICES Framework for Climate Informed EBM-EBFM Advice

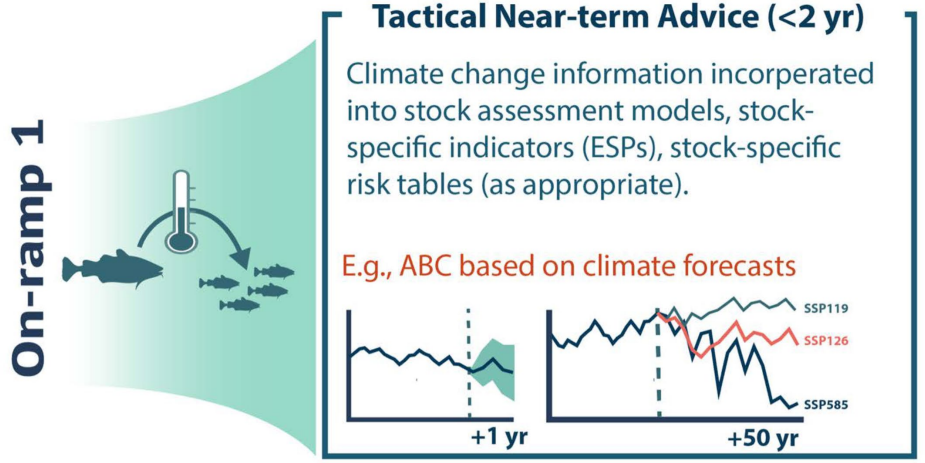
Key properties of Climate informed EBM Advice

1. Align terminology, concepts, and scenarios with IPCC
2. Risk-based framework: magnitude & likelihood of impacts, effectiveness & feasibility of measures, embrace uncertainty
3. Assessment of current conditions, risks/ benefits of achieving public policy objectives
4. Use scenario building at diverse levels: understanding assumptions/trade-offs/risk of inaction

The 10 principles of ICES advice

5. Plurality of knowledge, participation mechanisms, iterative feedback loops → co-creation of operational, relevant advice
6. Delivery through engaging web visualization, ensuring FAIR data principles → engaging, accessible, transparent advice
7. Based on best available science, research synthesis, build capacity beyond ICES traditional competencies

On ramp advice tools (1)



ICES Ecosystem Overviews
Central Arctic Ocean ecoregion
Published 15 December 2022

ICES CIEM

2.1 Central Arctic Ocean ecoregion – Ecosystem Overview

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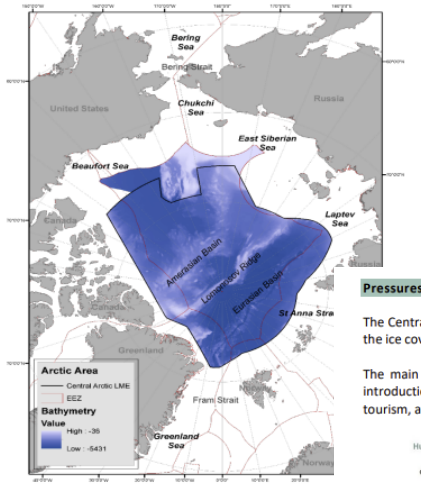
Ecoregion description

The Central Arctic Ocean ecoregion (Figure 1) mostly comprises high seas areas remote from any landmass, including deep basins and slopes up to depths of approximately 500 m, as well as some shallower shelf areas of the bordering Beaufort/Chukchi and East Siberian/Laptev seas. The boundary of the ecoregion follows the outer slopes on the Eurasian side from the Chukchi Sea to the Barents Sea, the shelf edge of north Greenland and the Canadian High Arctic, and runs along the 76°N parallel or the 200-mile Exclusive Economic Zones (EEZs) in the Beaufort/Chukchi seas.



Pressures

The Central Arctic Ocean ecoregion currently and historically has fewer human activities than other ecoregions. This is due to the ice cover, the depth of the ocean, the harsh climate and remote location, and the absence of land and human settlements.

The main human pressures affecting the ecoregion are the introduction of contaminating compounds, marine litter, the introduction of non-indigenous species and underwater noise. Some of the activities causing these are scientific icebreakers, tourism, and military shipping.

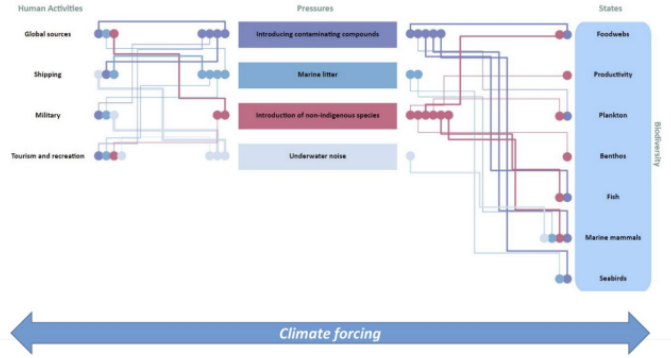


Figure 3 Overview of the major regional pressures, human activities, and ecosystem state components for the Central Arctic Ocean. The width of lines indicates the relative importance of the main individual links. The scaled strength of the pressures should be understood as a relative strength between the human activities listed, and not as an assessment of the intensity of the pressure on the ecosystem. Due to the difference of scales, climate change is not represented as a regional pressure, but climate change affects human activities, the intensity of the pressures, and some aspects of state, as well as the links between these. As the ecoregion is largely understudied, information from adjacent seas and nearby areas was used to inform the assessment of regional human activites and associated pressures.

On ramp advice tools (2)

On-ramp 2

Strategic Near-term Advice (<2 yr)

Climate change context for observed changes in social, ecological, & oceanographic conditions relevant for harvest advice and targets.

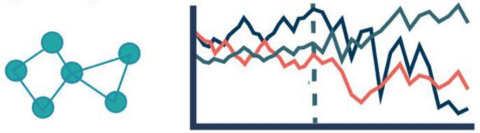
E.g., Forecasts of climate-driven distributions, tipping points , & thresholds

On-ramp 3 (new)

Strategic & Long-term Advice (>2 yr)

Climate - informed long-term strategic decision making & planning informed by IK, LK, and climate & management scenario evaluations, risk assessments, & adaptation efficacy & feasibility evaluations.

E.g., Targets based on climate projections



Evidence case for Climate Informed EBM Advice

Scientific fields in need of strengthening

- future scenarios of management options & ecosystem state
- vulnerability and threat analysis of species, ecosystems, human communities
- spatial planning information and models
- trade-offs, risk assessments
- carbon accounting across the system
- monitoring & systems for early warning

Take away messages – ICES work in climate change

- Observed CC impacts on the ocean's ecosystems are driving changes
- CC complex drivers, impacts, risks and opportunities need to be addressed through a systems thinking, adaptive management approach
- Operational EBM in a climate context → resilient marine ecosystems & ecosystem services
- On-ramp interdisciplinary tools exist
- ICES on course to provide risk-based climate informed advice

Thank you!