Incorporating Climate Change into the North Pacific Fisheries Commission Framework

STRATEGIES FOR ADAPTIVE MANAGEMENT AND SUSTAINABILITY

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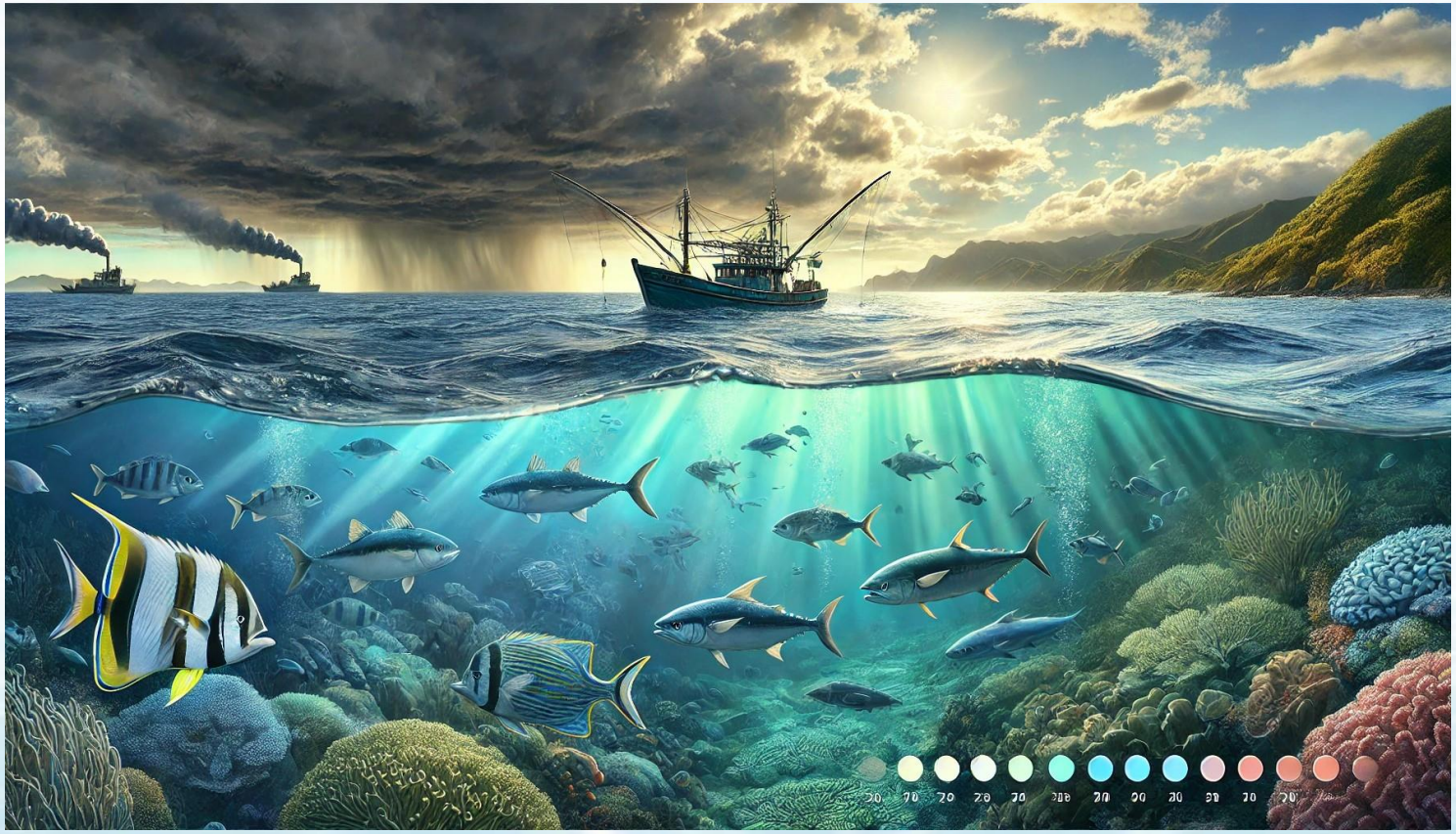
Food and Agriculture Organization of the United Nations

Background



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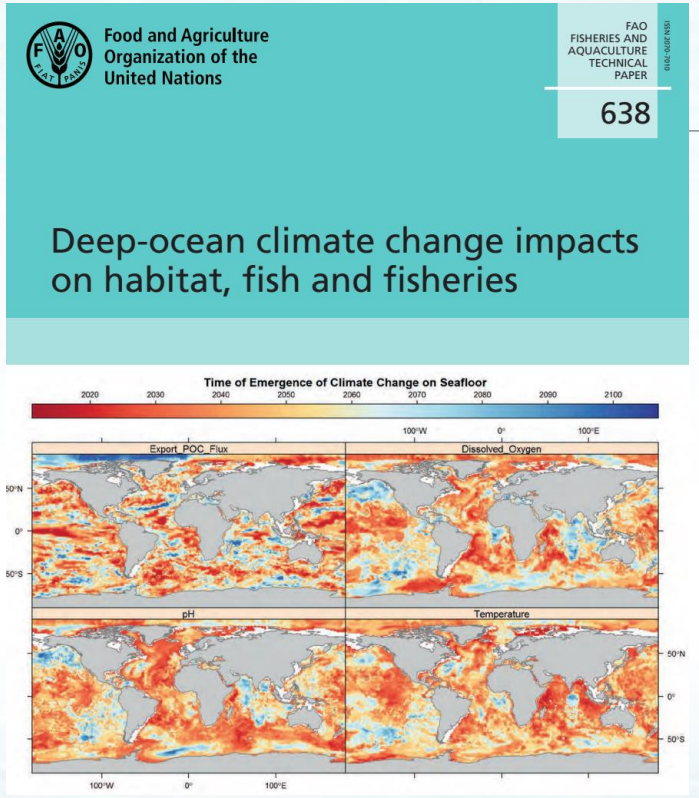
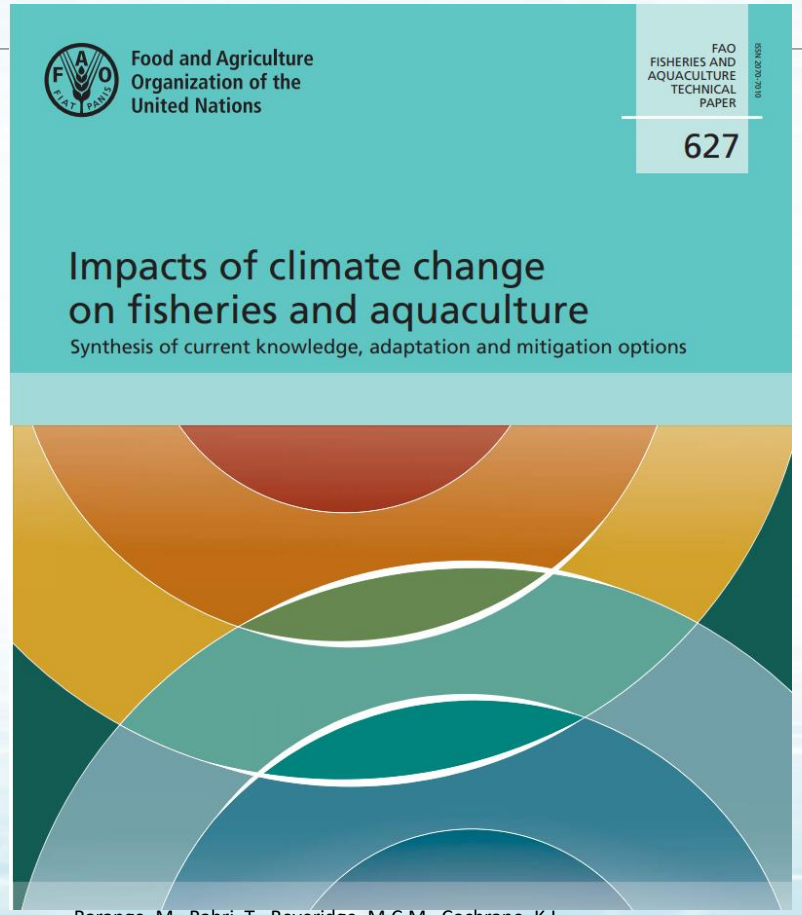
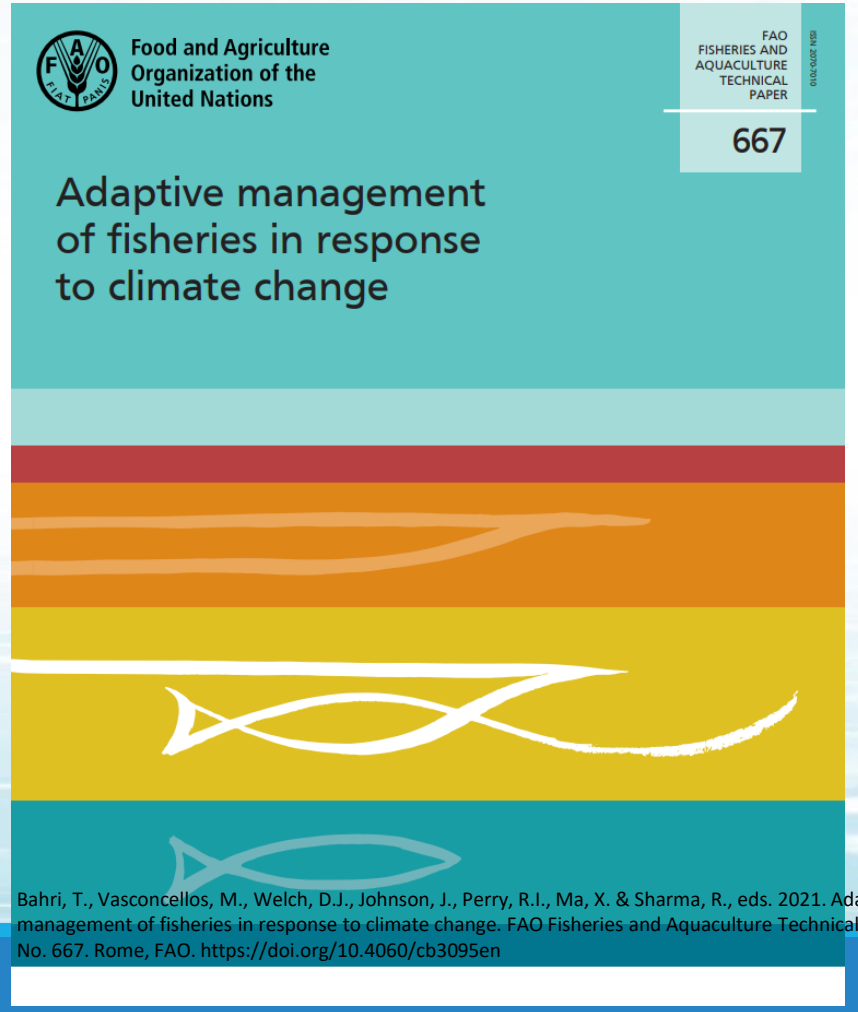


FAO. 2018. Deep-ocean climate change impacts on habitat, fish and fisheries, by Lisa Levin, Maria Baker, and Anthony Thompson (eds). FAO Fisheries and Aquaculture Technical Paper No. 638. Rome, FAO. 186 pp. Licence: CC BY-NC-SA 3.0 IGO.



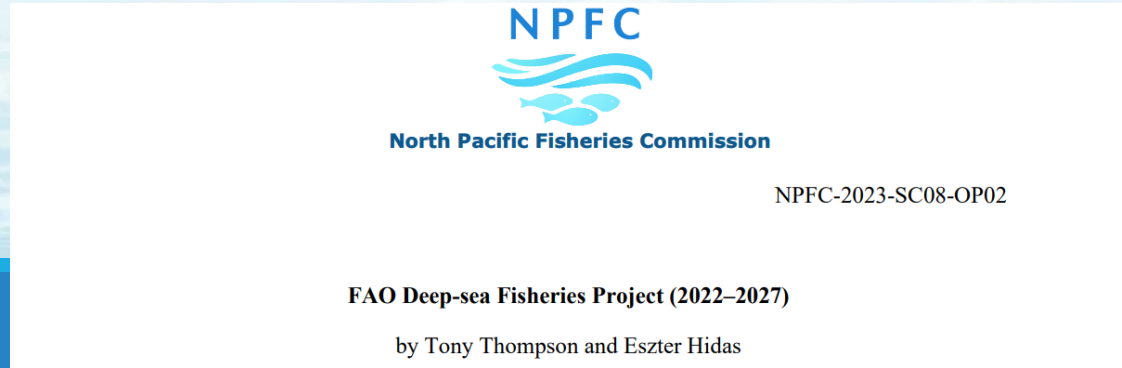
Barange, M., Bahri, T., Beveridge, M.C.M., Cochrane, K.L., Funge-Smith, S. & Poulain, F., eds. 2018. Impacts of climate change on fisheries and aquaculture: synthesis of current knowledge, adaptation and mitigation options. FAO Fisheries and Aquaculture Technical Paper No. 627. Rome, FAO. 628 pp



Bahri, T., Vasconcellos, M., Welch, D.J., Johnson, J., Perry, R.I., Ma, X. & Sharma, R., eds. 2021. Adaptive management of fisheries in response to climate change. FAO Fisheries and Aquaculture Technical Paper No. 667. Rome, FAO. https://doi.org/10.4060/cb3095en

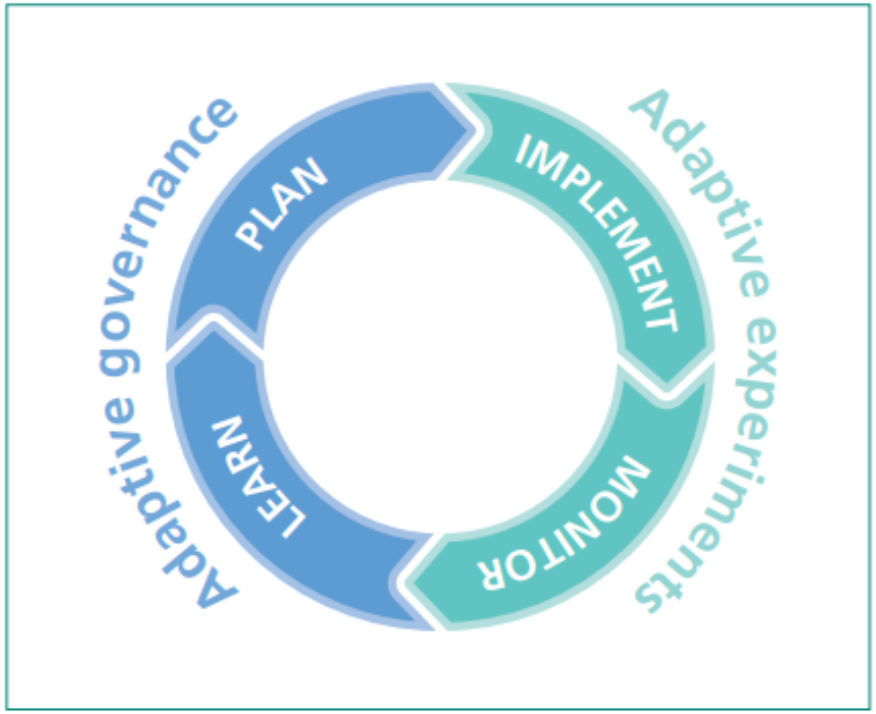
Project Overview

- This project was organized and funded by the “Deep-sea Fisheries under the Ecosystem Approach” (DSF) project is part of the Common Oceans Program “Global Sustainable Fisheries Management and Biodiversity Conservation in ABNJ”
- The **overall objective** is to ensure that DSF in the ABNJ are **managed under an ecosystem approach that maintains** (demersal_ fish stocks at levels capable of maximizing their sustainable yields and minimizing impacts on biodiversity, with a focus on data-limited stocks, deepwater sharks and vulnerable marine ecosystems (and small pelagic stocks in the NPFC).



Summary of Project Goals

- Literature review
- Examine data on distributional shifts
- Review the Recent IPCC climate change scenarios (in 10 & 50 years).
- Identify new data requirements to detect and monitor climate change
- Identify how climate change effects can be incorporated in to stock assessment and management.



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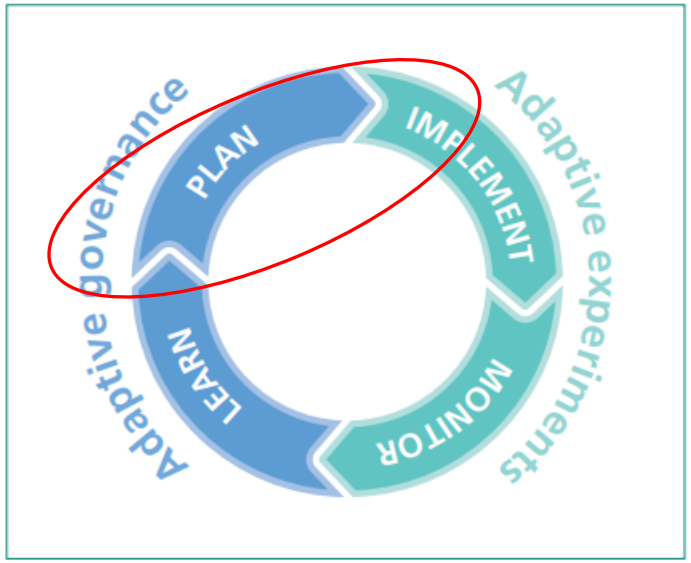
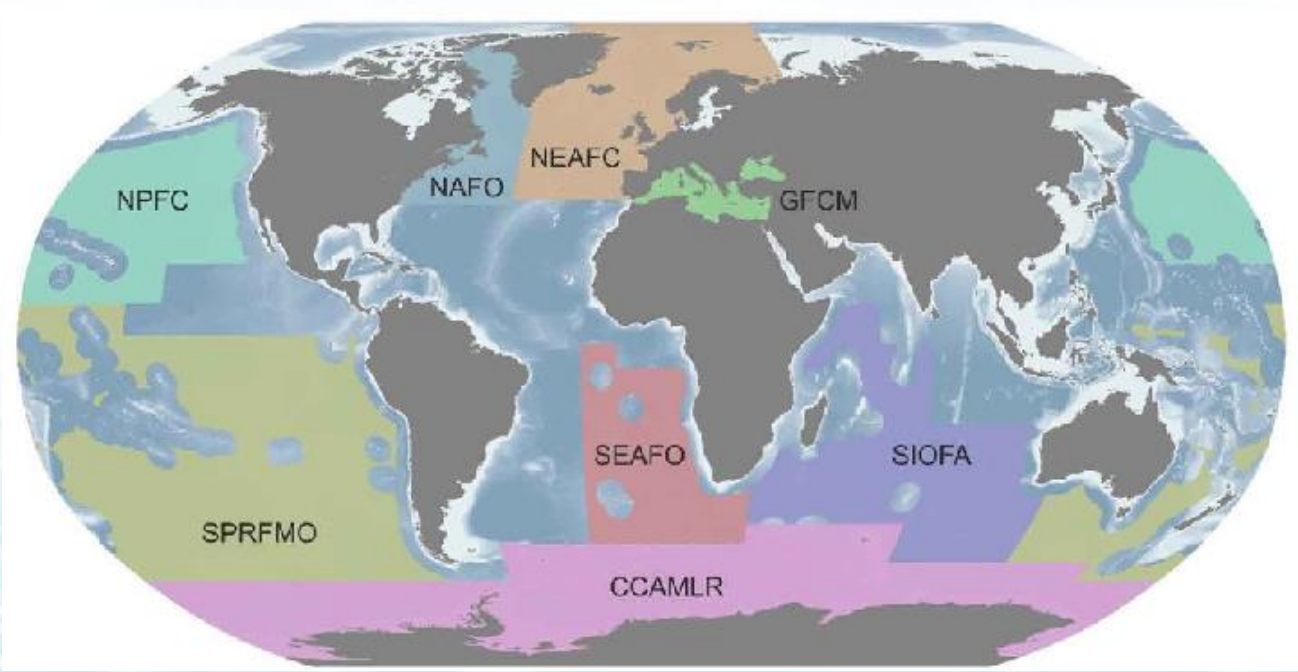


Geographical coverage

The DSF Project supports separate projects globally in ocean regions under the management of deep-sea RFMOs, including;

- North Pacific Ocean(NPFC)
- Northwest Atlantic Ocean (NAFO)
- Northeast Atlantic Ocean (NEAFC)
- South Pacific Ocean (SPRFMO)
- Southern Indian Ocean (SIOFA)



Project Symposium

https://eafm-symposium.nafo.int/

Context

- Marine fisheries face significant challenges from global climate change
- Multiple reports have consolidated knowledge of climate change impacts on marine fisheries
- The incorporation of climate change effects and ecosystem impacts into the assessment and management of fish stocks is both challenging and limited,
- The NPFC Performance review in 2022 made two recommendations to support the uptake of climate change work by the Commission and Scientific Committee (Rec. 4.5.4 and 4.5.5 in NPFC, 2022).
- It is time to "*Develop and implement advanced, science-based decision support to address climate change in north Pacific ocean ecosystems.*"

Evaluating the impact of ocean acidification on fishery yields and profits: The example of red king crab in Bristol Bay

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ABSTRACT

A stage-structured pre-recruit model was developed to capture hypotheses regarding the impact of ocean acidification on the survival of pre-recruit crab. The model was parameterized using life history and survival data for red king crab (*Paralithodes camtschaticus*) derived from experiments conducted at the National Marine Fisheries Service Kodiak laboratory. A parameterized pre-recruit model was linked to a post-recruit population dynamics model for adult male red king crab in Bristol Bay, Alaska that included commercial fishery harvest. This coupled population dynamics model was integrated with a bioeconomic model of commercial fishing sector profits to forecast how the impacts of ocean acidification on the survival of pre-recruit red king crab will affect yields and profits for the Bristol Bay red king crab fishery for

Context…

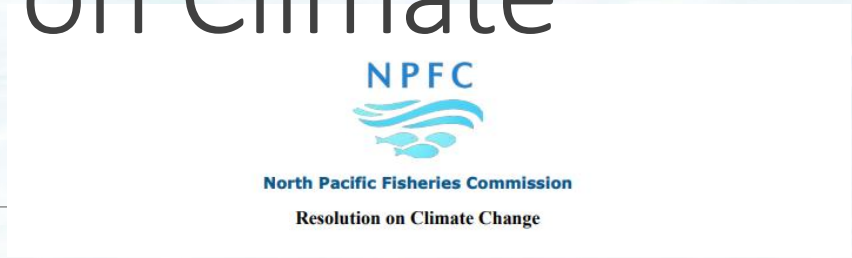
REPORT OF THE

NORTH PACIFIC FISHERIES COMMISSION

PERFORMANCE REVIEW PANEL

TABLE OF RECOMMENDATIONS	PRIORITY	ROLE	TIMING
Recommendation 4.5.4. That the Commission recognize the importance of taking into account the known and anticipated impacts of climate change on the North Pacific Ocean ecosystem, including with respect to changes in the geographic and temporal distribution of stocks, notably Pacific saury.	High	COMM	Short
Recommendation 4.5.5. That the SC make appropriate provision in its current Research Plan to address current deficiencies associated with addressing the impacts of climate change on NPFC ocean ecosystems and associated fisheries.	High	COMM	Ongoing

Context….NPFC Resolution on Climate Change



3. Task the SC to identify relevant data availability and needs and integrate analyses of climate change relevant to NPFC fisheries into its work plan. The SC will consider to the extent possible key vulnerabilities and management implications of changing oceanographic conditions resulting from climate change on NPFC fisheries resources and species belonging to the same ecosystem or dependent upon or associated with target stocks, including the impacts on overfished stocks and vulnerable marine ecosystems. The SC will discuss how best to incorporate existing climate change data and analyses in its work as well as other information that may be needed to assess the impact of climate change on the fisheries managed by NPFC.

Overview of Predicted Climate Changes

- **Rising ocean temperatures:** Predicted to increase by 1.6°C to 4.3°C by century's end.

- **Increased frequency of marine** heatwaves.

- **Ocean acidification** leading to declining pH levels.

- **Oxygen loss** and expanding Oxygen Minimum Zones (OMZs).

Impact: Alterations in fish stock distribution, growth, and reproductive success.

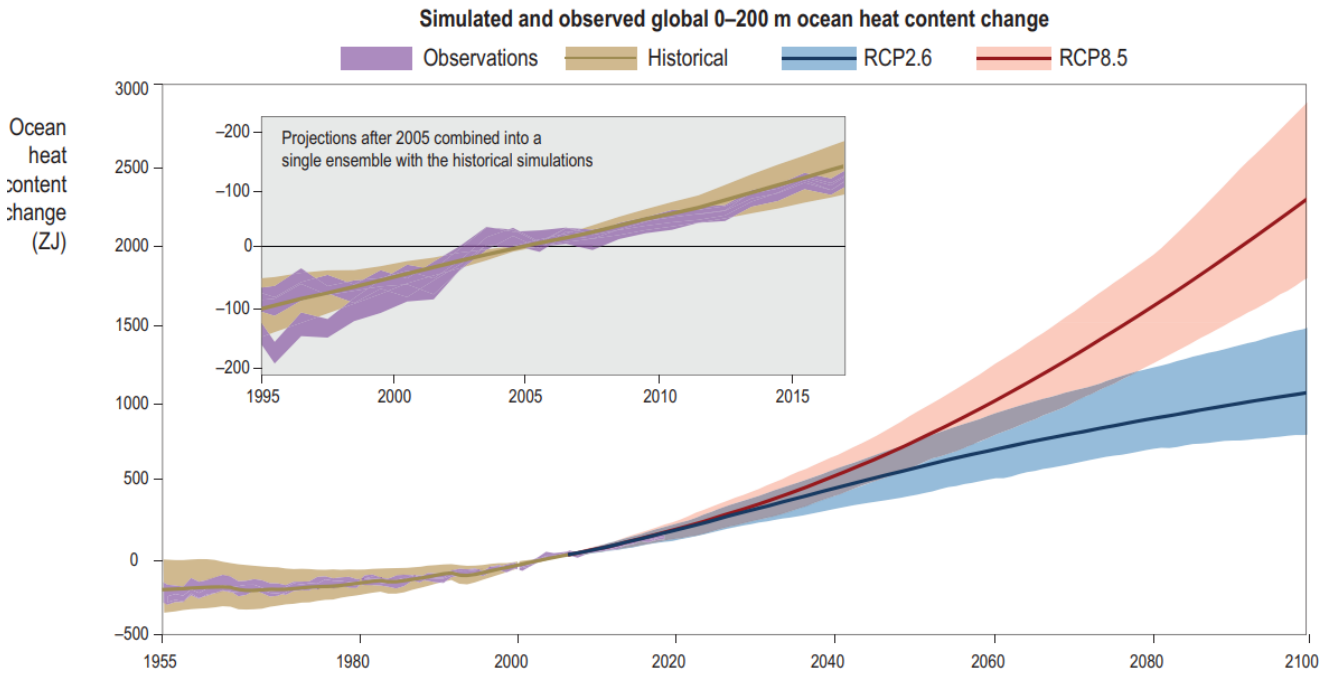


Figure 5.1, SROCC_Ch 5

Predicted Effects of Climate Change

Future Projections Under Scenario RCP2.6

Sea surface temperature in degrees Celsius, change from 1986-2005 baseline.

Year	Mean	Upper and Lower 90% CI	
2024	0.50	0.24	0.76
2034	0.58	0.30	0.86
2074	0.71	0.20	1.23

Ocean pH

Year	Mean	Upper and Lower 90% CI	
2024	8.034	8.025	8.043
2034	8.020	8.011	8.028
2074	8.015	8.007	8.022

Ocean Oxygen % change in the 100-600 m depth range relative to 1986-2005.

Year	Mean	Upper and Lower 90% CI	
2024	-0.639	-0.936	-0.342
2034	-0.798	-1.266	-0.330
2074	-0.687	-1.318	-0.055

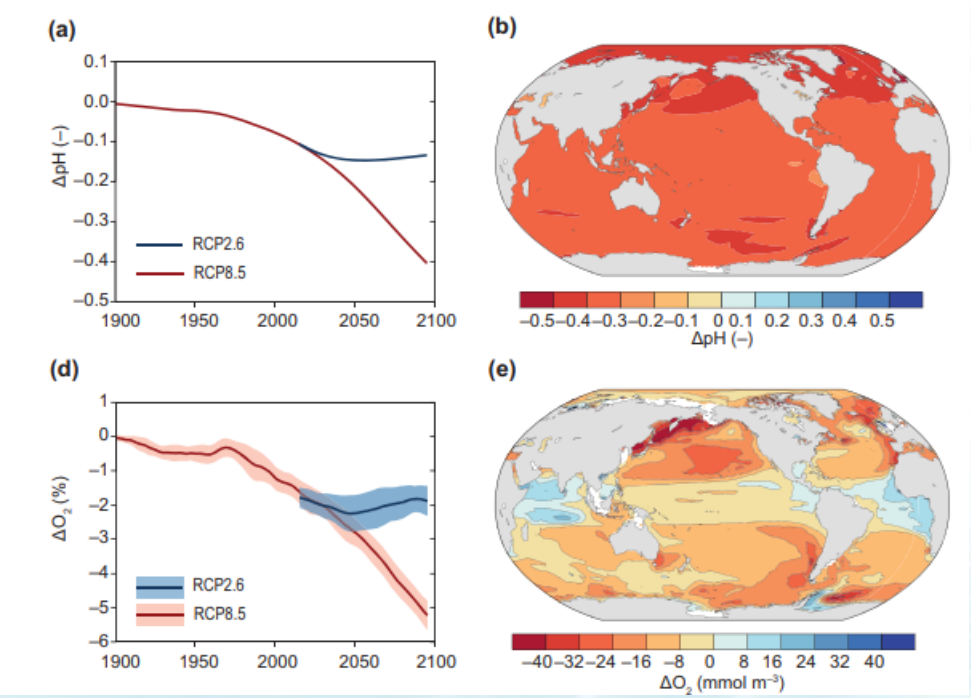
Future Projections Under Scenario RCP8.5

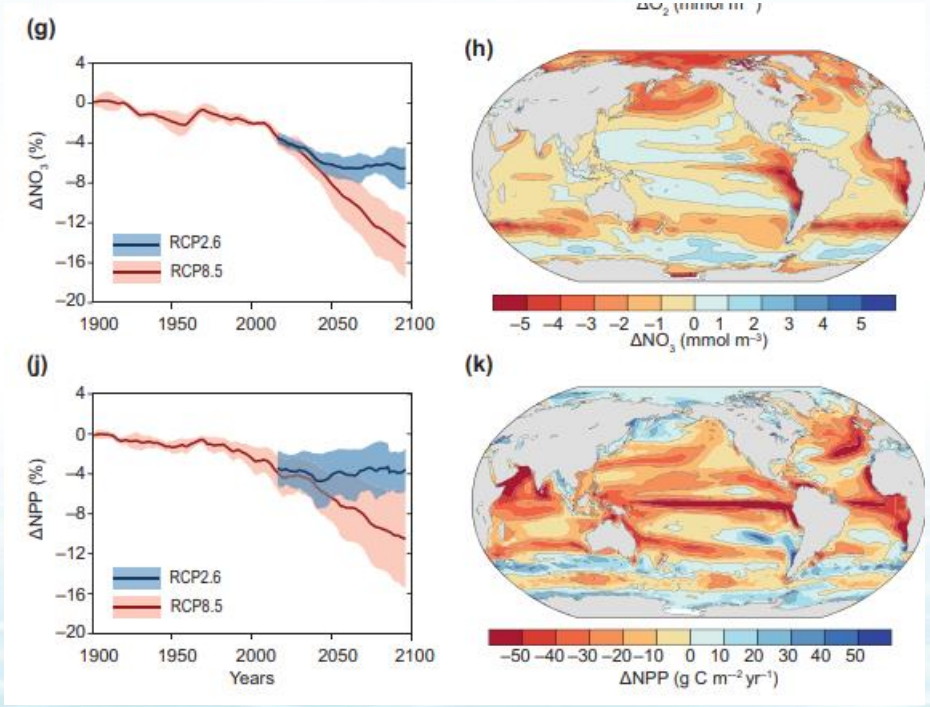
Year	Mean	Upper and Lower 90% CI	
2024	0.51	0.29	0.73
2034	0.77	0.47	1.07
2074	2.02	1.27	2.77

Year	Mean	Upper and Lower 90% CI	
2024	8.029	8.019	8.038
2034	8.000	7.990	8.010
2074	7.842	7.831	7.852

Year	Mean	Upper and Lower 90% CI	
2024	-0.837	-1.214	-0.459
2034	-1.136	-1.448	-0.824
2074	-3.069	-3.911	-2.226

Predicted Effects of Climate Change





How to Estimate CC impacts on NPFC fisheries

1) **Characterize and project climate driven changes** (on temperature, OA, etc.)

2) **Estimate the effects of environmental factors on demographic parameters and processes** (i.e. recruitment, growth, survival, etc.),

3) **Develop population dynamics model(s)**, and a **Regional Marine Ecosystem model** adapted to include environmental data to estimate the effects of environmental change, link this to a stock assessment model,

4) **Project (simulate) under multiple** (environmental, management/HCR) **scenarios**, evaluate the performance of HCR across

4) **Develop climate-informed** (climate ready) management advice in the form of reference points along with an understanding how they may change over time, and the risks associated with alternative future climate scenarios.

Plans, Actions, Implementation, Outcomes, Monitoring, (Re)Assessment…

- Understanding of the ‘status quo’ nature of a target species and its relationship with the related marine environmental variables requires data, models and a management strategy that incorporates reanalysis and adaptation.
- For example, what is inherent spatiotemporal distribution of a species with respect to temperature and dissolved oxygen?
- How does pH affect growth and recruitment?
- Baseline, and continued monitoring is critical.

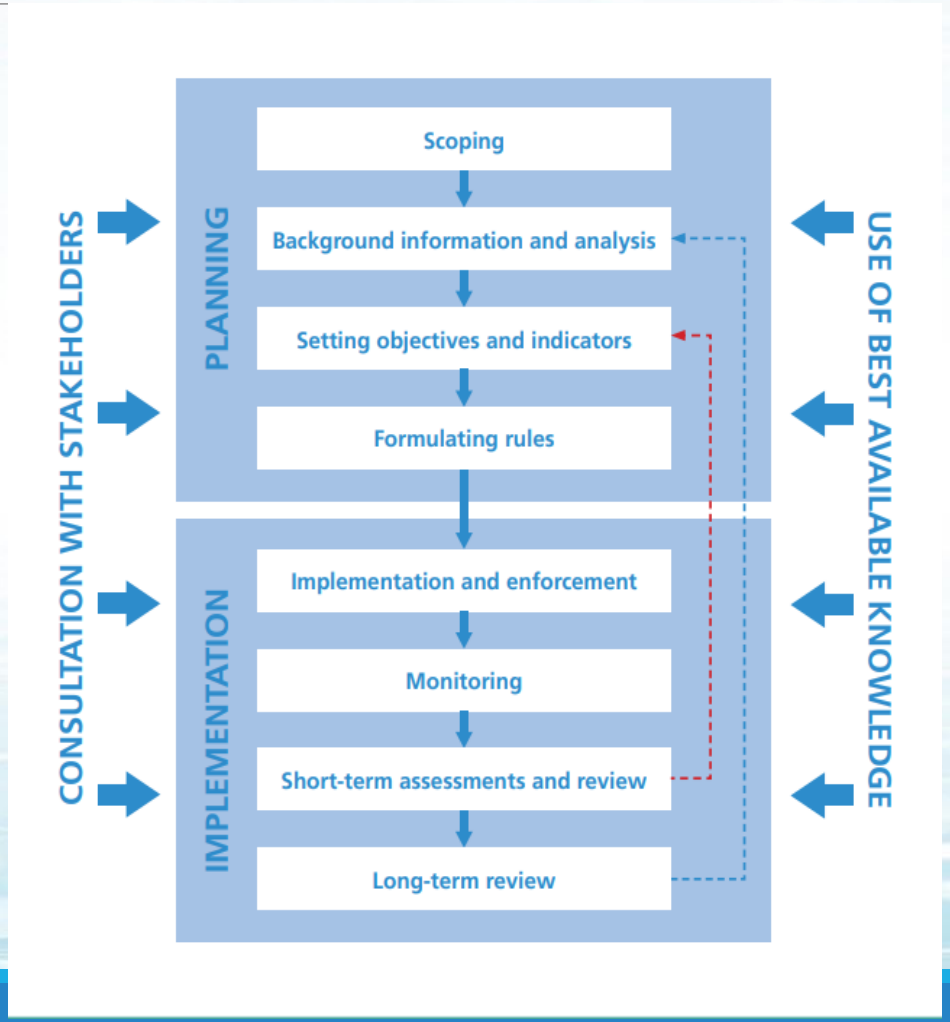


Figure 1 from FAO Adaptive Management CC

Plans, Actions, Implementation, Outcomes, Monitoring, (Re)Assessment…

- Develop hypotheses for environmental effects on stocks of interest
- Laboratory experiments & field sampling to parameterize distribution models for predicting habitat
- Incorporate long term monitoring and environmental data within a stock assessment/Population dynamics model
- Calculate reference points, conduct projections (accounting for process error) demographic parameters.

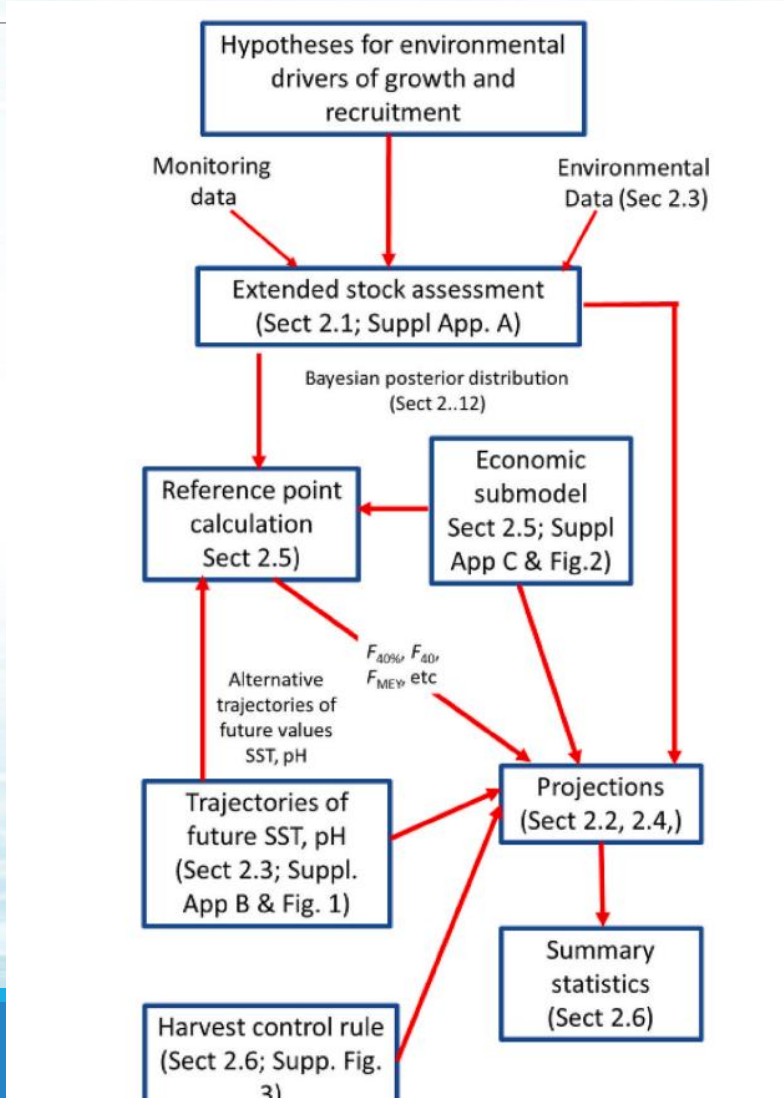
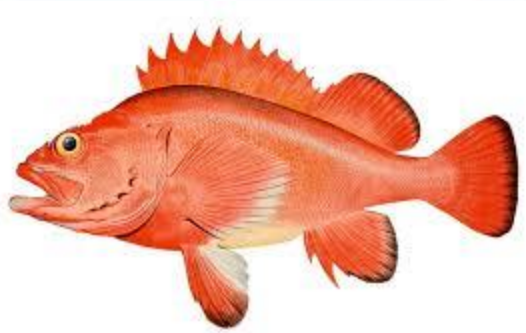


Figure 2. From *Punt et al. 2021 Fig. 1.* Flowchart of the approach for evaluating the impact of climate and demographic variation on estimates of reference points and management

Data gaps – Opportunities for improvement

Species	Actions
Blackspotted and Rougheye Rockfishes	- Develop climate-driven species distribution models to predict habitat shifts due to warming. - Study recruitment dynamics and investigate thermal tolerance to assess vulnerability.
Blue Mackerel and Chub Mackerel	- Enhance monitoring to document shifts in spatial distribution and seasonal abundance. Expand surveys to cover adult population - Use modeling tools to simulate future population dynamics under varying climate conditions.



Data gaps – Opportunities for improvement

Japanese Flying Squid and Neon Flying Squid	- Conduct oceanographic research to assess how changing water temperatures impact migration and breeding cycles. - Collaborate with international partners on multi-species modeling to improve regional population estimates.

Data gaps – Opportunities for improvement

Japanese Sardine	- Track spawning timing changes and larval growth to understand phenology shifts caused by climate. - Utilize survey data to estimate population productivity under warmer conditions.
North Pacific Armorhead	- Monitor population abundance and biomass through improved ecosystem sampling. - Evaluate the potential for habitat shifts in response to reduced oxygen levels at depth.

Data gaps – Opportunities for improvement

Pacific Saury	- Increase focus on foraging ecology to understand the food web dynamics influencing saury abundance. - Develop predictive models for distribution changes to support adaptive management.
Sablefish	- Focus on recruitment studies to better understand survival rates in early life stages affected by climate factors. - Investigate how ocean acidification and temperature changes influence growth and reproduction.
Splendid Alfonsino	- Conduct research on habitat preferences under changing temperature and oxygen conditions. - Improve data collection on spawning behaviors to support sustainable harvest strategies.

Recommendations

Recommendations

Noting that these recommendations will take resources that may not be currently available for the task, both within NPFC Secretariat and in respect of the national resources devoted to NPFC.

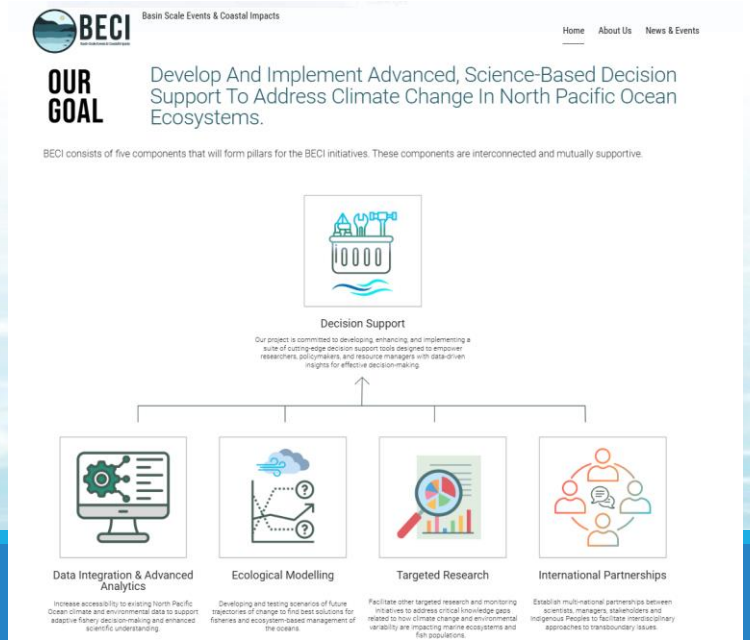
Develop Collaboration for Climate-Resilient Fisheries

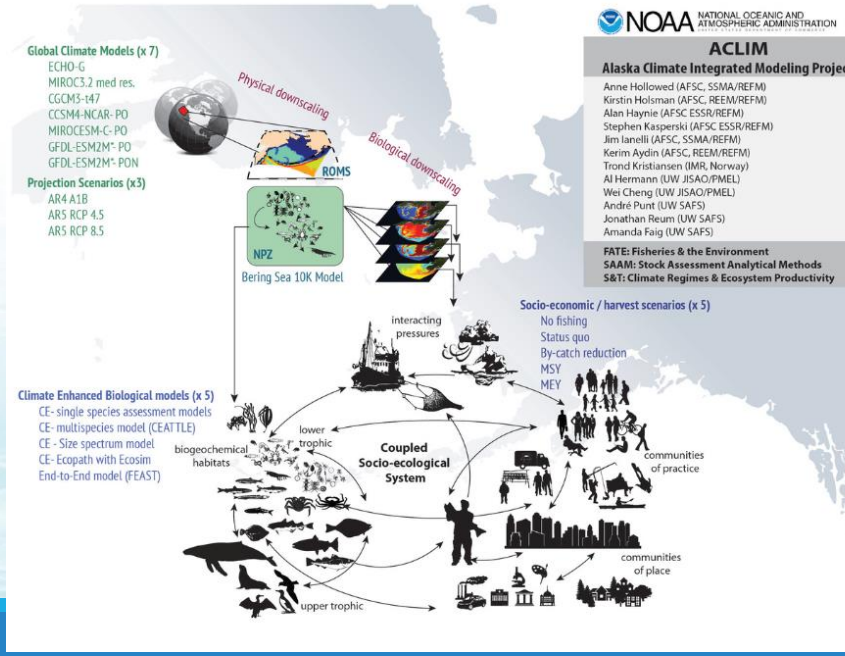
- Partnerships with organizations such as:

-CCMALR

- PICES /BECI

- The Alaska Climate Integrated Modeling Project





Enhancing Monitoring of Fish Stocks

- Expand fisheries-independent surveys for comprehensive monitoring.
- Include both target and bycatch species.

Expanding surveys to Older Life Stages, would expand understanding of population dynamics by improving the ability to assess spawning stock biomass, and potentially provide

Development of a Regional Observer Program

- Establish a standardized observer program.
- Incorporate electronic monitoring and data sharing.
- Ensure consistent and accurate data collection.

Small Species Scientific Group Recommendations

That the species groups build upon on previous reports regarding the effects of climate change on species of interest, review recent literature relevant to the impact of CC; and specifically

- Document the current fishery system (current operating model of the fishery)
- Document what forecasted changes due CC might be and the effects on the current fishery system would be.
- Identify whether the data are being collected to analyze these changes, if not how could data collection improve.

Suggested SC recommendation/request to Commission

With respect to the 'NPFC Resolution on CC' (i.e. Task the SC to identify relevant data availability and needs and integrate analyses of climate change relevant to NPFC fisheries into its work plan…& how best to incorporate existing climate change data and analyses in its work ")

The **SC request that the Commission task & fund the SC** to develop an iterative workplan to:

- Characterize and project of climate driven changes in a the NPFC region
- Identify where data gaps can realistically be closed/ implement data improvement programs
- Estimate of the effects environmental factors on demographic parameters and processes (i.e. recruitment, growth, survival, etc.) via laboratory and simulation studies

Suggested SC recommendation/request to Commission (continued)

- Develop a workplan (continued):
  - Development of Regional Ocean Modeling System, population dynamics model(s) adapted to include environmental data, linked to a stock assessment model.
  - Project and assess the implications of climate change under current and alternative fishing and climate change scenarios.
  - Evaluate the robustness of management scenarios with respect to climate change
  - Provide climate-informed (climate ready) management advice in the form of reference points along with an understanding of how they may change over time, and the risks associated with alternative future climate scenarios.
  - Communicate potential socio-economic implications of climate change (on the distribution, productivity etc.) to fishery dependent communities and other stakeholders

Integrating CC into the NPFC's processes is possible

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journal homepage: www.elsevier.com/locate/ocecoaman

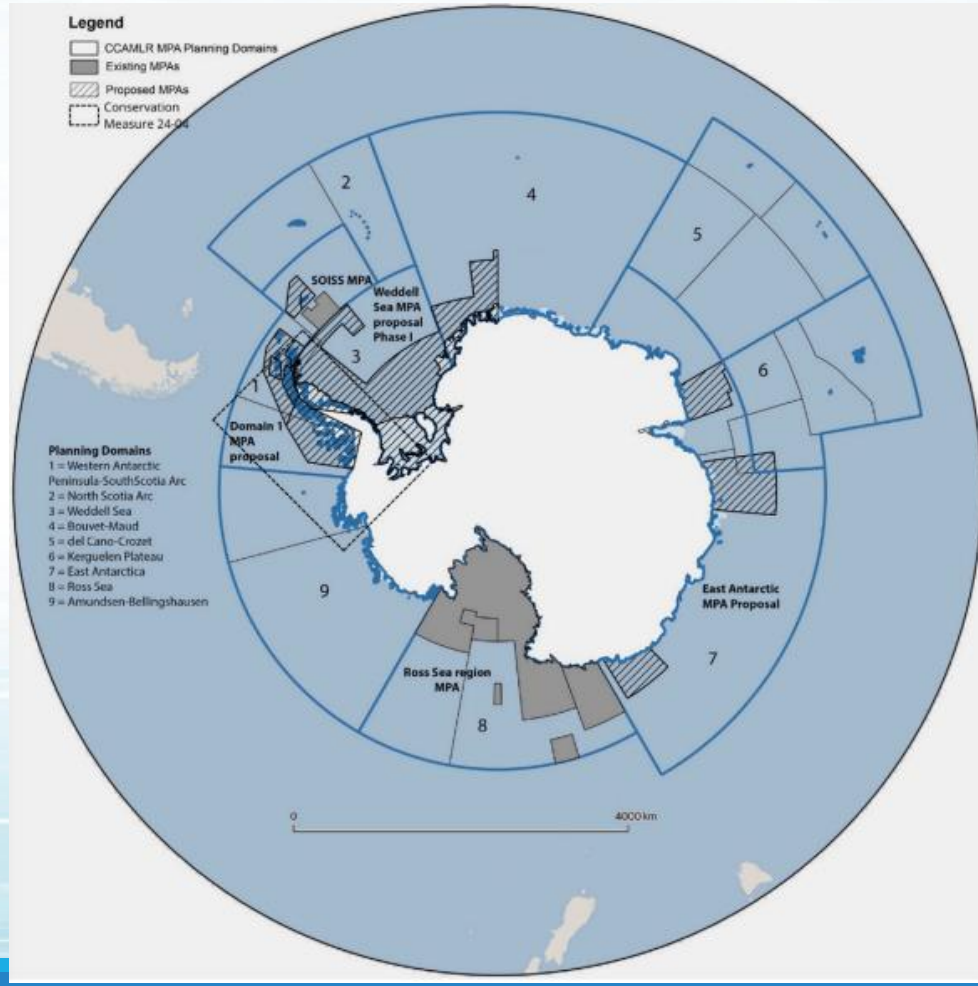
Managing for climate resilient fisheries: Applications to the Southern Ocean

Vasco. Chavez-Molina [a,*], Emily S. Nocito [a], Eloise Carr [b], Rachel D. Cavanagh [c], Zephyr Sylvester [a], Sarah L. Becker [a], Diana D. Dorman [a], Bryan Wallace [d,e], Casey White [a], Cassandra M. Brooks [a]

Table 1

EBFM for climate resilience can draw on a variety of management tools. Some fall under the general umbrella of EBFM as described in Row 1. Others fall under sub-areas identified in the literature: Climate models (Row 2), Integrated stock assessments (Row 3), and MPAs (Row 4). Column 1 describes the different tools, column 2 lists the elements within each tool, column 3 lists the supporting literature and column 4 describes CCAMLR's progress with respect to each of the management tools.

Climate Resilient Management Tools	Elements within each tool	Supporting Literature	CCAMLR's progress
Implementation of **ecosystem-based fishery management tools** specific to enhance the resilience of marine ecosystems and help improve	- Adaptive management - Dynamic management - Holistic ecosystem management - Risk assessments - Integrated	Barnett and Baskett, 2015; Burden and Fujita (2019); Busch et al. (2016); Cavanagh et al. (2016); Free et al. (2020); Gaines et al.	CCAMLR manages Southern Ocean fisheries under a system encompassing the principles of an EBFM approach, and has stated provisions for adaptive



https://nora.nerc.ac.uk/id/eprint/534282/1/1-s2.0-S0964569123001059-main.pdf

Thank you.

Questions?

Note that Registration for the March 2025 workshop is open.