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**Observer paper submitted by The Pew Charitable Trusts and The Ocean Foundation**

**Harvest Strategies and Climate Change - A Review of the Literature**

**Background**  
To support the Scientific Committee’s (SC) discussion on the *tools for incorporating climate change considerations into scientific advice* (Agenda Item 7.1)*,* Pew (Dr. Ellen Ward) has prepared a literature review which synthesizes recent research on climate change and harvest strategies – also known as management procedures. The review highlights the significance of management strategy evaluation (MSE) and management procedures as climate-adaptive fishery management tools, as well as a range of considerations to design climate-ready management procedures. As Members act on NPFC’s [Resolution on Climate Change](https://www.npfc.int/system/files/2023-05/Resolution%20on%20Climate%20Change_0.pdf), and based on the key insights from the literature review, Pew and the Ocean Foundation recommend that the SC:

* Acknowledge the importance of MSE and management procedures as tools to incorporate climate change considerations into scientific advice and precautionary, adaptive management for all NPFC species.
* Propose practical timelines in the [Research & Work Plans](https://www.npfc.int/system/files/2024-05/SC%20Research%20and%20Work%20Plans.pdf) to develop management procedures that plan for the gradual integration of improved scientific information and methods, including on climate change risks and impacts for stocks, fisheries and ecosystems.
* Consider a tailored approach to developing management procedures for data-limited and data-rich fisheries that integrates climate change considerations in a pragmatic way based on available scientific data and information.
* Develop exceptional circumstance protocols for all management procedures as preparation for extreme unexpected or rare events.
* Conduct necessary scientific research (e.g., investigating likely distribution shifts of NPFC stock, their prey, and habitats) to address data gaps that may affect management procedure performance.
* Ensure scientific coordination between NPFC and other relevant RFMOs regarding climate-ready management procedures for transboundary species whose distribution or migrations are likely to be affected by climate change.

**Harvest Strategies and Climate change: A Review of the Literature**

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The goal of this literature review is to evaluate the findings of relevant work in the field of fisheries science and management driving our understanding of the intersection of climate change with harvest strategies/management procedures, in order to evaluate and summarize the state of knowledge in the field. A preliminary review of the literature shows that there are a range of considerations at play when seeking to design climate-informed harvest strategies, as well as a diversity of options available to managers seeking to develop them (for more on the literature included in this review, please see *Annex 1* below). Five major themes emerged in the review of the selected literature:

*(i) Harvest strategies as an effective adaptation tool for managing stocks under conditions of a changing climate*

Since harvest strategies allow for adjustments in response to impacts on stocks from environmental change, including those due to climate change, they can serve as an adaptive tool for managers to use in the face of climate change (Ortega-Cisneros et al. 2021). Researchers evaluating the performance of harvest strategies have found that they support the climate resilience of managed species, with studies finding harvest control rules (HCRs) robust to climate-driven changes in productivity and recruitment variability (e.g., a 2017 HCR adopted for North Atlantic albacore, evaluated by Merino et al. 2019); and biomass-responsive HCRs providing climate resilience benefits compared to HCRs with fixed fishing mortality (Kritzer et al. 2019; Yin et al. 2023). Harvest strategies can thereby serve as a reliable approach for managers looking to improve the climate resilience of their management regimes (Kritzer et al. 2019).

*(ii) Opportunities and limitations to the explicit incorporation of climate-related environmental factors into HCRs and MSE*

Going beyond the climate resilience benefits of harvest strategies as management tools, researchers have sought to integrate climate change into the design of harvest strategies, especially focusing on HCRs and MSE, through the incorporation of mechanistic links between environmental variables and stock dynamics. Here, ‘mechanistic link’ refers to a quantitative relationship represented between two variables—such as: (i) an environmental variable affected by climate change, and (ii) a variable reflecting the biology of the species in question—in this case a process by which (i) drives variability in (ii) (e.g., Haltuch et al. 2019). For instance, Haltuch et al. (2019) employ a mechanistic framework linking climate variability, sea level, zooplankton community structure, and sablefish recruitment, in using MSE to assess robustness of HCRs to climate-driven effects to sablefish recruitment.

For researchers working in other ecosystems, however, a lack of suitable data and scientific understanding of environmental factors driving species population dynamics can limit opportunities to take a mechanistic approach (Bell et al. 2020). For instance, Blamey et al. (2022) use MSE to evaluate the robustness of HS to extreme events for large prawn stocks in Australia, and find that HS incorporating the environmental variable do not provide substantive advantages, which the researchers attribute to a lack of scientific understanding of the environmental relationship to a stock. Faced with modeling limitations from this data scarcity, researchers looking to mechanistically incorporate climate-driven environmental change into HS development have flagged the advantages that improved monitoring and data collection could offer in this regard (Blamey et al. 2022; Bryndum‐Buchholz, Tittensor, and Lotze 2021), while others have recommended deprioritizing the mechanistic approach in favor of other climate planning approaches for HS, such as widening the adoption of threshold F harvest control rules, which allow fishing at a target level until a specified limit is reached (Free et al. 2023). Collie et al. (2021) argue that the priority for managing fish stocks influenced by climate change should remain the application of a dynamic HCR based on current productivity and abundance, rather than focusing on defining a mechanistic cause for species change and using forecasts.

Noting the difficulties of a mechanistic understanding of environment-stock relationships, researchers looking to consider potential future conditions under a changing climate in developing HS have also considered the implications of broadly “plausible” scenarios in harvest strategy development (Punt et al. 2014). These studies typically construct scenarios in which changes to a stock are assumed to play out in relation with an environmental variable, and then use MSE to test the robustness of a HS to those conditions, such as: different degrees of future northward movement of a species associated with increases in water temperature (Jacobsen et al. 2022); the impacts of extreme events (e.g. cyclone) assumed to result in a specific change in the availability of simulated species groups, and longer-term climatic change assumed to result in a given percent migration southward and decrease in abundance of the modeled species (Dowling et al. 2020); or scenarios of differing levels of plankton productivity, with plankton productivity serving as an indicator for climate and ocean changes (Guo et al. 2019). Through such analyses, researchers have tested HS robustness to potential future conditions without the use of a mechanistic environment-stock relationship.

*(iii) “Climate-informed” harvest strategies as those designed to include extreme events as ‘Exceptional Circumstances’*

An aspect of climate-informed harvest strategy development may also include accounting for climate-driven extreme weather and ocean events. For instance, a harvest strategy may be designed at the outset to feature “environmental overrides” by which Total Allowable Catch (TAC) may be adjusted “in response to a spatially or temporally isolated weather event (e.g. a tropical cyclone or coral bleaching)” (Dichmont et al. 2021). Through ocean and ecosystem monitoring, conditions that fall outside those through which a harvest strategy was tested (during the design phase) may further be detected, signaling an ‘exceptional circumstance’ that could in turn trigger re-examination of the harvest strategy if so agreed (Goodman et al. 2022).

*(iv) “Climate-informed” harvest strategies as those that account for shifts in geographic distribution across management regimes*

For cases in which climate-driven shifts in the geographic distribution of a stock may affect multiple fisheries jurisdictions, a climate-informed harvest strategy may also mean coordination across management regimes in the design of harvest strategies that would otherwise be siloed. For instance, in regional fisheries management organization (RFMO) planning for the climate-driven redistribution of tropical tuna resources in the Pacific Ocean, researchers have highlighted the potential for coordination between the Western and Central Pacific Fisheries Commission (WCPFC) and the Inter-American Tropical Tuna Commission (IATTC) to develop harvest strategies for tuna species that are expected to experience an overall shift eastward across the Convention Areas of these RFMOs, as well as a move from Exclusive Economic Zones of Contracting Parties to the high seas, in the coming decades (Lam et al. 2020; Goodman et al. 2022).

*(v) Management options for data-rich and data-poor fisheries*

In addition to the data considerations flagged in section *(ii)* above on the explicit incorporation of climate-related environmental factors into HCRs and MSE, researchers flagged several other data considerations in the context of climate-informed harvest strategies. For cases of data-rich fisheries, near real-time climate, environment or socioeconomic data could be applied to increase the responsiveness of management procedures (Karp et al. 2019). In data-limited fisheries, on the other hand, a “multi-indicator framework” approach may be developed taking into account indicators, or proxies, for environmental and stock changes in combination with one another to inform management decisions (Harford et al. 2021).

**Annex 1. Literature included in the review**

**Google Scholar search:** The search used the [Advanced Search Feature](https://guides.library.ucsc.edu/c.php?g=745384&p=5361954) in Google Scholar. There are a range of [Operators](https://library.acg.edu/how-to-guides/google-scholar/advanced-searching) available to inform the search; here, the AND operator was used to include several phrases, and quotation marks were used to ensure that exact phrases were returned in the search. Advanced search results excluded patents and citations and were sorted by relevance over the time period of 2019 to present. The search was conducted in March 2024.

**Search terms:** To address the use of both “harvest strategies” and “management procedures” as common terms in the literature, two separate searches were performed (Searches A and B, below).

**Search A  
With all of the words:** “harvest strategies” AND “fisheries” AND “climate change”   
*(anywhere in the article)***Article date:** 2019 – 2024

**Search B  
With all of the words:** “management procedures” AND “fisheries” AND “climate change” *(anywhere in the article)*   
**Article date:** 2019 – 2024

**Sources reviewed for the Literature Review:**  
Drawing on the results of the Google Scholar search, for each of Groups A and B, the top 20 sources considered most relevant were evaluated for inclusion in the literature review, with those deemed relevant to the goal of the review then included. In addition, two additional sources were included that were (1) referenced by one of the reviewed articles (Punt et al. 2014), and (2) recommended for inclusion by an expert in the field (Free et al. 2023).

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