Original: English

Report of the ICCAT Climate Change Experts Meeting
(Online, 11-12 July 2023)

1. Opening of the Meeting

The Chair of the ICCAT Climate Change Experts Meeting, Dr Kelly A. Kryc (USA), opened the meeting and welcomed participants to the virtual meeting.

The Executive Secretary welcomed participants to the meeting and provided an overview of the list of delegations from participating CPCs and observers in attendance.

2. Appointment of the Rapporteur

Mr. William Harris (Canada) was appointed as rapporteur for the meeting.

3. Adoption of Agenda and Meeting Arrangements

The Chair opened the floor for any comments on the tentative agenda. There were no comments and the meeting Agenda was adopted and is attached as **Appendix 1**.

The List of Participants is contained in **Appendix 2**.

4. Review of the Terms of Reference and Purpose of the Meeting

The Chair provided an overview of the Terms of Reference (TOR), as set out *Resolution by ICCAT on Climate Change* (Res. 22-13) and noted that the meeting is structured in a manner to achieve the directions laid out in paragraphs 8 and 9.

5. International Work Underway to Understand the Impacts of Climate Change

The Chair introduced the three expert presenters: Dr Laurent Bopp (Institut Pierre-Simon Laplace), Dr William Cheung (University of British Columbia), and Dr Tarub Bahri (Food and Agriculture Organization of the United Nations (FAO)). The Chair explained that the purpose of these presentations was to provide important contextual information to participants to facilitate meaningful discussions. The presentations covered international work underway to: (1) build knowledge of climate change and its impacts on oceans and marine ecosystems, particularly ICCAT-managed species; (2) advance climate-resilient fisheries management; and (3) address management challenges and data gaps.

Presentation from Dr Bopp

Dr Bopp presented "Impact of climate change on the physics and biogeochemistry of the ocean-prospects for fish and fisheries' effects on fish and fisheries" (CLIM_11/2023). Dr Bopp provided an overview of the impacts of climate change and the role of the ocean in the Earth's energy systems, emphasizing observations of warming ocean temperatures, more frequent and intense marine heatwaves, loss of sea ice coverage, and increased ocean acidification and deoxygenation. Dr Bopp detailed the interconnectedness of these impacts, such as losses in productivity due to reduced nutrient availability, a consequence of increased stratification in the water column resulting from ocean warming and deoxygenation. Dr Bopp also highlighted the increase in climate velocities[1] as fish species must migrate greater distances to maintain their thermal habitat.

[1] Loarie *et al*., 2009 (https://www.nature.com/articles/nature08649). Climate velocity describes the speed and direction that a species at a given point in space would need to move to remain within its climatic niche.

Dr Bopp then explained how Earth System Models are used to project the impacts of climate change on the ocean, though the extent of these impacts is strongly dependent upon the range of emissions scenarios selected. Higher emission scenarios are linked to greater ocean warming, acidification, deoxygenation, and stratification, and simulations forecast a global decrease in primary production, especially in the North Atlantic and tropical regions, albeit with large uncertainty and regional variation.

In response to a question from a participant on the sources of uncertainty in projections, Dr Bopp clarified that uncertainty remains a focal point in climate models and that the level of uncertainty in various models is dependent on the metric; for instance, there is greater uncertainty in relation to deoxygenation compared to acidification or sea surface temperature. Dr Bopp then reiterated that this relative uncertainty does not take away from the reality of the projected climate impacts.

One participant asked whether modeling has been done to estimate impacts on fish stocks. Dr Bopp stated that most climate models consider the marine ecosystem, but usually only in a simplified way with phytoplankton and zooplankton. However, Dr Bopp noted that there is work underway to develop more advanced models that simulate impacts on marine biomass. Another participant sought further explanation on seasonal impacts of climate change. Dr Bopp responded that the focus of his presentation was on yearly averages, but data and modeling are available for averages across regions, as satellite observations have demonstrated seasonal changes in chlorophyll and salinity.

One participant noted the linkages between marine biodiversity, climate change, and decarbonization, as well as the need to ensure that the ocean features prominently in global environmental discourse. Senegal then asked for additional information on the use of satellite data. Dr Bopp elaborated that satellites provide extensive data, such as the real-time evolution of marine heatwaves, but it does have limitations, particularly in measuring effects at ocean depths. In these instances, other forms of data collection are used, such as buoys. A participant asked for further information on the potential vertical (as opposed to horizontal) migration of species to greater depths. Dr Bopp indicated that numerous questions remain with respect to vertical shifts, but increases in ocean stratification are anticipated to alter the depth profiles of many species.

The United States asked what kind of correlation exists between ocean warming and acidification in current projections. Dr Bopp responded that, globally, there is a clear linkage between ocean temperatures, salinity, and production; for instance, in a low emissions scenario, limits on ocean warming would result in positive trends in other metrics. However, Dr Bopp added that ocean depths, owing to the much larger time scale of its circulation systems, would continue to experience negative trends for decades into the future.

Presentation from Dr Cheung

Dr Cheung presented "Vulnerability and impacts of climate change on Atlantic tuna fisheries" [CLIM_12/2023]. Dr Cheung emphasized the interconnectedness between marine ecosystems and society, as physical and biological changes to species can have socio-economic impacts, underscoring the importance of a systems-level understanding to identify solutions. Dr Cheung explained the vulnerability of fish species to ocean warming and other climate change-related phenomena, as well as the projected impacts on distribution and biomass, particularly biomass losses in tropical waters. Dr Cheung added that distribution changes may complicate management measures, especially area-based and bycatch measures, and may generate jurisdictional disputes in fisheries management.

To address the impacts of climate change on fisheries, Dr Cheung stressed the importance of transformative adaptation, including: (1) nature-based solutions, such as habitat restoration or ecosystem-based management; (2) rebuilding stocks to reduce vulnerability to climate change, as well as to support food security and biodiversity; and (3) cooperation and inclusive decision-making with stakeholders, such as local communities. Dr Cheung also highlighted the value of increased capacity and knowledge for monitoring and forecasting, particularly in light of anticipated increases in extreme weather and ocean conditions.

One participant noted that there are indications that climate change may positively (albeit temporarily) affect certain fish species managed by ICCAT and questioned the sole focus on negative impacts in the presentation. Dr Cheung acknowledged that some positive impacts may occur in the short term, but projections estimate an overall decrease in global biomass, and that the impacts of climate change need to be assessed in the long-term.

A participant reiterated the importance of acknowledging the interconnectedness of food, people, climate, and biodiversity in fisheries management, particularly in coastal regions. Dr Cheung commented that it may be useful for ICCAT to consider such interconnectedness when incorporating climate change into its decision-making and referred to ongoing work to understand the economics of changing availability of catch, seafood supply, and nutrition. Another participant asked for additional information on research into habitat suitability; in response, Dr Cheung referenced international work to build datasets and models for different species, including ICCAT species.

A participant noted projections of more extreme climate events, and asked how the impacts of these events, including on small and large pelagic species, can be incorporated into policymaking. Dr Cheung responded that nature-based solutions are advantageous in this regard due to their potential for co-benefits, as well as increased marine spatial planning and weather forecasting. The participant also asked, on the topic of bycatch, if there is anticipated to be an increase or decrease in catches of non-target species; Dr Cheung noted that bycatch and invasive species continue to be researched but that increases in bycatch and invasive species interactions in fisheries are expected.

Another participant stated that there is an opportunity (at present) to take steps that would enable immediate improvements to how species respond to climate change. The participant specifically highlighted better consideration of spatial distribution in abundance indices, a practice utilized by the Standing Committee Research and Statistics (SCRS). A participant then asked for views on how scientists could improve synergies in the SCRS to address uncertainties in climate modeling. Dr Cheung referred this question to Dr Bopp, who referenced a paper that provided guidance on how to incorporate climate modeling outputs into scientific processes and noted the value of having multiple scenarios, models, and statistical methods to overcome uncertainties.

Presentation from Dr Bahri

Dr Bahri presented "Climate resilient fisheries management" (CLIM_10/2023), with a focus on the efforts of the FAO. Dr Bahri noted the three main areas of climate work: (i) strengthening the knowledge base on climate change impacts, adaptation, and mitigation to guide policy development; (ii) developing and implementing on-the-ground projects with local partners to reduce vulnerabilities of fishing communities; and (iii) integrating aquatic food into regional and global climate change discussions. Dr Bahri also covered the scientific evidence of climate change impacts, such as the projected decrease in global marine biomass, including tuna and swordfish, with greater decreases anticipated for tropical regions.

Dr Bahri then provided an overview of the FAO Adaptation Toolbox for Fisheries and Aquaculture, and emphasized that adaptation is an iterative and context-based process that requires mechanisms to evaluate success. Given the lack of practical examples, the FAO has commissioned projects in various regions to extract lessons and best practices, which will then be analyzed and publicized. Dr Bahri further explained the role of regional fisheries management organizations (RFMOs) and collaborative efforts undertaken through the Regional Fishery Body Secretariat Network (RSN) but stressed that while RFMOs are increasingly aware of the challenges posed by climate change, many RFMOs continue to operate in a business-as-usual mode.

One participant sought further explanation on policies to manage fisheries and ecosystems affected by climate change. Dr Bahri noted the need for more specific, ecosystem-focused studies in the Atlantic region and areas managed by RFMOs. Another participant sought more information on South Africa's efforts to move its fish processing plants, to which Dr Bahri explained that in response to northward shifts of certain stocks, South Africa has explored moving its processing plants closer to those northern areas; however, Dr Bahri added that this requires considerable financial investment, and investments are often limited to situations where there is strong evidence to demonstrate probable success.

A participant asked whether there are other anthropogenic impacts on fish stocks and fishing communities in addition to climate change. Dr Bahri responded that effective management systems should seek to address other anthropogenic effects, such as pollution.

Another participant commended the efforts of the FAO and asked whether the business-as-usual approach of RFMOs pertained to both science and management work, and how the upcoming FAO-led workshops may address these issues. Dr Bahri stated that few RFMOs explicitly integrate climate change considerations into their management processes, and that the workshops will seek to facilitate discussions on how to accelerate progress by RFMOs. Another participant similarly asked what problems confront RFMOs in this regard. In response, Dr Bahri listed common bottlenecks, such as access to data, quality of projections, and grappling with varying levels of uncertainty.

6. Review of Current Scientific Processes and Technical Work Undertaken by SCRS

The Chair of the SCRS, Dr Craig Brown (USA), presented "Review of current scientific processes and technical work being undertaken by the SCRS to evaluate the effects of climate change on ICCAT fisheries, including information needs and data gaps" (CLIM_14/2023)[2]. Dr Brown noted that environmental factors, such as sea surface temperature, are commonly considered in catch per unit effort (CPUE) data to calculate abundance indices and referenced case examples for western Atlantic bluefin tuna and North Atlantic swordfish. Dr Brown also noted ongoing work to monitor climate effects (e.g., marine heatwaves) on tunas and their survivability during early life stages in the Mediterranean.

Dr Brown further explained that climate change has been more directly considered in management strategy evaluations (MSEs), such as the recent North Atlantic swordfish MSE where climate change may have varying effects on stock distribution, reproduction, and growth, and operating models are tuned to encompass various scenarios to ensure robustness of the management procedures. Dr Brown highlighted several information needs and data gaps, including the lack of sequential climate/environment-related information in its databases, and poorly characterized information in ICCAT data regarding the movement of species.

One participant emphasized the lack of high-quality environmental data as a persistent obstacle to improvements in modeling. Dr Brown agreed and noted that, in particular, there is a lack of precise data to associate time and date of observation with corresponding environmental data. The Chair reflected on the cost-effectiveness of preparing for climate change compared to reacting to it and asked if such an approach would be applicable in the case of ICCAT. Dr Brown agreed and provided the example of the SCRS providing scientific advice on a stock to the Commission based on certain productivity assumptions, but such assumptions may not be appropriate when the advice is implemented, which could leave the stock in a worse state.

Another participant asked how the SCRS and other scientific subsidiary bodies in ICCAT could improve how climate change is integrated, taking into account the existing work of the Subcommittee on Ecosystems and Bycatch (SC-ECO). Dr Brown acknowledged that coordination, as a minimum step, has already been identified as a priority for improvement, especially integration with species-specific bodies. Dr Brown then added that discussions have taken place to include an ecosystems - or climate change-focused section in meeting plenaries and reports. Another participant commented on the value of climate change considerations in the MSE process and urged that this practice continue.

One participant questioned the utility of taking into account climate change considerations given the uncertainty involved, as such uncertainty could prove counter-productive to effective management. Dr Brown indicated that he shares similar concerns but emphasized that uncertainties should not deter the inclusion of such considerations in advice to management; instead, it suggests the need to improve scientific understanding. A participant proposed that climate change considerations be prioritized for the SCRS alongside efforts to address challenges therein. Another participant then asked if the multidisciplinary and financial implications of envisioned projects to incorporate climate change presented a barrier and how it could be addressed. Dr Brown noted that this is a key question and suggested that it may require greater

[2] The Chair of the SCRS noted that the presentation did not represent a consensus view of the SCRS, nor was it an exhaustive account of all environmental, habitat, or climate change considerations made by the SCRS.

commitment from CPCs, both in terms of funding and in human resources, as well as the potential contracting of external services.

A participant highlighted the importance of considering climate change impacts on the food chain in ecosystems and climate modeling, and suggested that this is an area where ICCAT may look to other RFMOs who are more advanced in this regard. Dr Brown agreed, although he indicated the need to prioritize. Another participant proposed that the non-stationarity component in indices could be included in SCRS work and asked if there would be challenges to this and how they could be addressed. Dr Brown stated that non-stationarity is not a new problem, but expressed support for proposals to enhance cooperation between CPCs on the collection of operational-level data from fishing fleets.

7. ICCAT CPCs' Efforts to Evaluate and Mitigate the Effects of Climate Change

United Kingdom

The United Kingdom (UK) presented an "Information paper on the Climate Change Expert Meeting" (**Appendix 3**). This paper shows UK's domestic efforts to understand and forecast the impacts of climate change on fish stocks, with a focus on bluefin tuna. The UK acknowledged that the impacts of climate change extend beyond those on fish stocks, but also fleets, industries, markets, and communities. The UK then noted that the presence of bluefin tuna in the Northeast Atlantic coincided with observations of warmer phases in ocean temperature circulation, and further noted the expansion of bluefin tuna northward in line with shifts in their feeding habitats. The UK highlighted the use of short-term modeling by the International Council for the Exploration of the Sea (ICES), as opposed to commonly used long-term modeling, and summarized findings related to future projections of tuna distribution in the Atlantic Ocean, including the potential for increased occurrence of tuna in UK waters depending on emission scenario. The UK concluded with a series of questions intended to prompt discussion to assist in developing a workplan.

A participant commented on the difficulty of developing models to project the future impacts of climate change, and asked what actions are appropriate in the face of uncertainty in models. The UK explained that modeling future impacts is not impossible, and that in light of the imperfection of models and datasets, their approach is to utilize many models and scenarios to compare results and achieve a more robust projection. Another participant questioned the accuracy of the models that indicated minimal bluefin tuna in the Mediterranean during the feeding season; in response, the UK clarified that they did not produce those models. The participant further pointed out that the need for socio-economic expertise within ICCAT has been a recurrent debate, and suggested that as stocks shift in distribution from the area of competence of one RFMO to another RFMO, the latter would manage the stock.

Another participant asked whether ICCAT has the adaptive capacity to update total allowable catch (TAC) on a regular basis in light of climate change. The UK responded that often reference points are only periodically reviewed and that there may be benefit in focusing on reference points. The SCRS Chair added that dynamic reference points are a familiar concept in ICCAT and that the SCRS has provided advice based on changes in maximum sustainable yield (MSY). Another participant then asked what methodology was used to assess habitat suitability. The UK stated that they used multiple species databases and climate-related datasets from various sources through different biological models and from this, reliable averages could be identified.

Norway

Norway presented "A method for climate impacts on Norwegian fish stocks - potentially useful on Atlantic tunas" (**Appendix 4**). This paper assess the impacts of climate change on Norwegian fish stocks, with potential linkages to ICCAT-managed species Norway showcased a recent study on future climate impacts on various species in their surrounding seas. In this methodology, the study took into account exposure factors, such as temperature and deoxygenation, as well as sensitivity attributes of species, such as spawning and grazing habitats. The study concluded that several stocks will be negatively affected by rising ocean temperatures. In contrast, the study also found that certain stocks with the potential to migrate northward, or those in the middle of their preferred temperature range, are likely able to adapt to warming conditions. Norway further explained that the study demonstrates that marine fish are adapted to defined temperature ranges, and that with similar knowledge, climate impact analyses for Atlantic tunas can be performed.

Korea

The paper "Korea's efforts to mitigate the effects of climate change in the fisheries sector" (**Appendix 5**) was presented. Korea noted the development of the "2050 Carbon Neutrality Roadmap for the Marine and Fisheries Sector", which sets targets for the reduction of greenhouse gas emissions. With this framework, Korea shared several mitigation-oriented policies, such as supplying fishing vessels with energy-efficient fishing equipment, and expanding renewable energy utilization in its fleets and processors. Korea also emphasized the reduction of marine waste, as well as the importance of carbon-neutral ports with the harnessing of hydrogen-focused port operations.

Multiple participants expressed its appreciation for Korea's focus on mitigation measures, and in particular, the breadth of its efforts to achieve carbon-neutral outcomes across the fisheries sector.

European Union

The European Union (EU) presented "EU Fisheries and Climate change - a presentation of the key outcomes of the study on *Climate change and the common fisheries policy* (CFP)*. Adaptation and building resilience to the effects of climate change on fisheries and reducing emissions of greenhouse gases from fishing' a presentation of key domestic efforts to address the effects of climate change on fisheries and reducing emissions of greenhouse gases from fishing*" (CLIM_09/2023). The EU summarized various findings from the study; for instance, that healthier and well-assessed stocks tend to be more resilient to the impacts of climate change, and that short-lived species may be more impacted but also have the potential to recover more quickly. The study also concluded that lower fishing mortality and adaptive management improves resilience through the creation of a buffer from climate-related shocks, but at the cost of reductions in short-term catches. The EU then highlighted several mitigation-related findings of the study, including identifying fuel consumption as dependent upon fishing technique, using energy-efficient technologies for vessels, fishing methods, and gear, as well as allocating more fishing opportunities to operators with more energy-efficient vessels under the CFP.

The United States thanked the EU for showcasing mitigation-related measures, particularly on fuel consumption and energy efficiency, and asked if other parts of the seafood supply chain were also evaluated for potential mitigation efforts. The EU responded that mitigation measures have largely been targeted to the catching sector. PEW Charitable Trusts (PEW) sought further clarification on the EU's use of the target MSY fishing mortality range to buffer against possible losses resulting from biological interactions between stocks. The EU explained that its experience has shown difficulty in managing groups of fish stocks based on single points of MSY as the cycles of biomass between species do not necessarily align, hence the focus on MSY ranges.

Canada

Canada presented "Climate change and Canadian fisheries management" (CLIM_07/2023). on its domestic efforts to address the effects of climate change Canada explained the current and emergent issues confronting Canadian waters and communities due to climate change, and outlined the directives and guiding principles of Canada's *National Adaptation Strategy: Building Resilient Communities and a Strong Economy*. Canada also showcased several policies and programs meant to support climate resilience in fisheries, such as the Sustainable Fisheries Framework and the Aquatic Climate Change Adaptation Services Program, as well as emerging areas of work like the Risk Equivalency Framework (REF). The REF is intended to provide fisheries managers with climate-conditioned advice on harvest rules for species in proportion to their risk to climate change. Canada further highlighted the need for new and targeted solutions to climate-related challenges.

One participant asked how shrimp, in the example of climate-conditioned advice, were affected by climate change, and how Canada managed in those circumstances. Canada explained that ocean warming negatively impacts shrimp through, *inter alia*, decreased oxygen levels and increased predator abundance, and that estimating the impacts was conducted through models to determine productivity. Canada then clarified that the REF process uses a two-step approach, where normal scientific advice is presented alongside climate-conditioned advice, thereby allowing the process of providing advice to continue with the normal advice should the climate-conditioned advice be too speculative.

Brazil

Brazil presented "Signals of climate change effects in pelagic fish stocks in the South Atlantic Ocean" (CLIM_08/2023). Brazil summarized the findings of several studies, such as the movement of warmer and more saline waters southward, and the poleward displacement of wind patterns, which in turn contribute to marine warming hotspots in the South Atlantic Ocean. Brazil highlighted the poleward expansion and retraction of tropical species and temperate species respectively, in addition to variations in mean temperature of catch (MTC) for pelagics due to sea surface temperature changes, albeit with a temporal lag. Brazil then emphasized the importance of incorporating such research and evidence, particularly from the South Atlantic, into analyses, stock assessments, and decision-making.

A participant asked whether, in the methodology for assessing MTC, other parameters, such as ocean salinity, were taken into account alongside ocean temperatures. Brazil clarified that the MTC is a relatively simple index that predominantly utilizes thermal preferences for species. The participant then asked if there were any observed changes to stocks aside from migration because of sea surface temperatures. Brazil answered that such changes were not the focus of the research, but that adaptations such as vertical depth shifts could occur.

One participant commended Brazil's emphasis on the effects of climate change on pelagic species and the continuous change in the balance amongst species. The participant pointed out that tropical tunas are not the only species with distribution shifts, as individual bluefin tunas have been observed in more southern areas. The participant further suggested that knowledge of the linkages between the North Atlantic and South Atlantic should be an area of scientific attention. A participant noted that Brazil's findings were similar to those from studies conducted in the UK. Another participant commented that attention should also be given to the natural adaptiveness of species to temperature and other habitat changes in the models.

United States

The United States presented "United States efforts to evaluate and mitigate the effects of Climate Change in ICCAT and other fisheries" (**Appendix 6**). The United States highlighted the Climate, Ecosystems, and Fisheries Initiative (CEFI), which aims to incorporate ocean and climate modeling into fisheries decision-making and spoke to using scenario planning as a tool for decision-making in uncertain conditions by planning for different potential futures. The United States then provided an overview of certain management and research tools deployed for highly migratory species (HMS), such as climate vulnerability assessments to identify which species are most vulnerable based on exposure and sensitivity factors, as well as the HMS Predictive Spatial Modeling Tool, meant to combine various data sources to predict species interactions with fisheries. The United States also noted ongoing international work, such as Sustainability, Predictability, and Resilience of Marine Ecosystems (SUPREME), a program under the UN Decade of Ocean Science, intended to build a network of global partners to share knowledge and steer effective adaptive fisheries management.

One participant asked how biological processes are accounted for alongside meteorological processes in modeling effects on fish stocks. The United States responded that considerations of abiotic and biotic factors in models is achieved through inputting co-variates, such as sea surface temperature, in the model fitness and selection process. Another participant asked whether any activities had been undertaken through SUPREME. The United States answered that the initial aim for SUPREME is to build a network, so there are no specific outcomes yet; however, the United States noted some preliminary workshops have been held and certain projects endorsed.

Another participant then asked whether there were any lessons learned from scenario planning work that could be applied to ICCAT. The United States explained that, at its present stage, assessment of the outputs of the scenario planning remains its focus. PEW questioned whether the climate vulnerability assessments were multi-species or single species based; in response, the United States indicated that while the assessment process is multi-species, each stock is individually assessed.

8. Discussion of Incorporating Climate-Related Information into ICCAT Decision-Making

Discussion of the Taylor & Walter Paper

Dr Nathan G. Taylor and Dr John F. Walter, III presented their paper "Incorporating Climate Considerations into Fisheries Assessments and Management Advice at ICCAT" (CLIM_05/2023).[3] The paper highlighted the challenges of precisely predicting the future impacts of climate change on fish stocks and emphasized that the non-stationarity of key parameters, such as growth and natural mortality, means that historic assumptions may not be reliable. The paper provided three options for climate science to be included in the assessment process: (i) an indicator-based approach to provide qualitative context; (ii) inclusion of climate change in stock assessments and using resulting forecasts to derive total allowable catch (TAC) advice; and (iii) inclusion of climate change in MSEs to develop climate-ready management procedures.

In the paper, it was argued that developing management procedures, tested and communicated through an MSE, may be the preferred approach to address future uncertainties. This would involve incorporating climate change, either explicitly or implicitly, in operating models so that management procedures can be tuned and selected for climate-change readiness. The paper also highlighted the need for high quality data, the benefit of external and interdisciplinary collaboration between ICCAT and other organizations, and the value of recent scientific advancements, such as advanced genomics.

One participant underscored the importance of high-quality data, particularly in relation to bycatch. Another participant asked whether ICCAT has similar capabilities or methodologies to undertake modeling work as was done for distribution shifts in tropical tunas in the Pacific Ocean. Dr Taylor responded that the development of such models for the Atlantic Ocean would be beneficial, but such models also require considerable work. Dr Taylor added that such models are not the only option to capture spatial effects in the Atlantic Ocean.

Japan stated that the effects of climate change on different species managed by ICCAT are difficult to predict, particularly due to the lack of data, and suggested that improvements to data collection to support modeling be prioritized. Japan also expressed its preference for the option of including climate change considerations in MSEs to develop management procedures, and more, its preference for climate-linked hypotheses used for robustness tests. Japan cautioned against the inclusion of climate change in operating models because this may have a significant impact on TAC calculations and pointed out the importance of having a strong understanding of climate change impacts on fisheries as this would assist in gaining support from stakeholders.

The EU pointed out ongoing work on including climate change in science and management work, including in the SCRS, and stated its preference for a step-by-step approach, starting with a stock-tasking exercise to identify current SCRS work and any gaps. The EU then suggested that this stock-taking could be followed by the presentation of lessons learned from case studies to inform the Commission. One participant expressed support for the EU's suggestions, and noted that the MSE for bluefin tuna implicitly considered climate change.

Another participant pointed out that many of the presentations and discussions thereafter have focused predominantly on adaptation and stated that adaptiveness is not simply about change – it is about decision-making despite imperfect knowledge and utilizing feedback.

A participant commented on the collective responsibility amongst CPCs and other actors in managing ICCAT species and ecosystems, and emphasized the importance of knowledge-sharing and follow-up in this regard. Another participant shared a similar view on the importance of knowledge-sharing and suggested that prioritization of work, such as identifying priority stocks based on their vulnerability to climate change effects, be a focal point. One participant then remarked that the Sub-Committee on Ecosystems and Bycatch (SC-ECO) is already looking to select region-based case studies within the ICCAT Convention Area to develop tools that advance research.

[3] The paper noted that the views expressed therein reflect the views of the authors and should not be taken to represent the views of the ICCAT Secretariat, the United States, or the SCRS.

The United States agreed with Japan that, in the near term, including climate change in MSEs appears to be the most viable path forward to manage in the face of climate change. The United States also provided suggestions on how scientific advice could be communicated to the Commission, such as introducing a section on resilience to climate change in executive summaries of stock assessments and to include tools that account for statistical uncertainty. A participant then pointed out ongoing work at the SC-ECO to develop ecosystem report cards, which could fulfill a role akin to what the United States proposed.

Canada also agreed with Japan on using an MSE-based approach and the importance of data to communicate effectively and transparently with stakeholders but suggested that climate change considerations should not be limited to MSEs alone. Canada further suggested that the SCRS could consider domestic approaches from CPCs and their potential transferability to ICCAT. One participant added that the Plan of Action should provide long-term goals that can be initiated in the near-term, and that authorities should not wait for perfect data before taking action.

Another participant outlined a series of steps for the Plan of Action, starting with the recognition of the importance of climate change and its incorporation in decision-making. This would be followed by a vision statement that captures: (i) impacts of climate change on fish stocks; (ii) adaptation; and (iii) mitigation. Subsequently, the collation of review of literature and other evidence should be prioritized, followed by climate risk assessments for stocks, and ultimately such research and analysis should be incorporated into advice to the Commission.

PEW expressed its support for Canada's point on exploring other ways to incorporate climate change considerations outside of MSEs, and noted the benefit of embracing ecosystem-based management. PEW also expressed support for an iterative approach based on prioritization.

Discussion of the Draft Workplan

The Chair presented the "Draft ICCAT Plan of Action on Climate Change" (**Appendix 7**) and acknowledged the contributions of the SCRS Chair. The Chair noted that her intent was for the document to be comprehensive and ambitious and that she attempted to capture the wide array of possible approaches, techniques, and ideas that were raised by all of the Joint Experts' Group presenters and participants. The document is intended to be a living document that is updated regularly and continues to develop as the Commission continues to consider how to address this issue.

The EU thanked the Chair for her efforts to develop the draft Plan of Action, and expressed the need for additional time to assess the Plan at the meeting given its breadth and implications, particularly its potential financial and human resource commitments. This was supported by a number of other CPCs. The EU stressed the importance of a step-by-step approach and proposed that a scoping exercise be prioritized to identify relevant ongoing work and gaps that would inform subsequent steps. Japan shared a similar view as the EU. The Chair clarified that the Plan of Action reflects the broad discussions that had taken place over the course of the meeting and integrates the feedback provided by CPCs and experts alike on science and management issues.

The UK commented that the format of the Plan of Action differed from its expectations, and in this light, recommended that the Plan include priorities, especially for the SCRS work, and timelines for actions. Norway expressed a similar view to the EU on the need for more time to consider the Plan of Action, and asked how other RFMOs tackle climate change-related issues. The Chair responded that ICCAT has an opportunity to lead on climate change as ICCAT is ahead of the curve compared to other RFMOs in this regard.

The United States and Brazil noted that the discussions and presentations held during the meeting were well-represented in the text. Canada expressed its support for the workplan, though indicated its need to further review the text and provided initial suggestions, including a broadening of the proposed Executive Summary (in SCRS reports) to encompass both ecosystems and climate change considerations, as well as a section dedicated to the Standing Committee on Finance and Administration (STACFAD), in light of the workplan's financial and other resource implications. The UK also provided suggestions, such as a section that defines terms based on relevant Intergovernmental Panel on Climate Change (IPCC) literature, as well as identifying other organizations that ICCAT may collaborate with to avoid duplication of work and reduce the burden on the SCRS and CPCs.

Japan questioned whether the SC-ECO had the capacity to undertake climate change-related research and other activities as envisioned by the Plan of Action. The SCRS Chair indicated that there are concerns that climate change may dominate the workload of the SCRS and SC-ECO, and subsequently reiterated the value of scoping exercises. A Co-Chair for SC-ECO expressed a similar view to the SCRS Chair and suggested that ICCAT would need additional capacity to undertake the projected work effectively. The United States and Gabon emphasized the importance of feedback from the SCRS on the Plan of Action. The SCRS Chair commented that, if time allows, the Plan of Action could be considered in the plenary session of the SCRS meeting.

Japan highlighted that, where possible, climate change considerations have been incorporated into SCRS work and suggested a stock-taking exercise to specify what is and is not covered by existing SCRS work to assist in identifying needs and priorities over the short and long term.

The EU sought clarification on including climate change considerations in the development of joint indices of abundance. The United States responded that joint indices are useful to assess species across the entirety of the Atlantic Ocean since no single fleet has the spatial coverage to provide such breadth of data. The United States added that climate change is not explicitly included in joint indices of abundance; rather, the practice is to include a variable, such as sea surface temperature, as a representative factor. The United States also expressed its support for improved data collection in the Plan of Action to improve current and future tools and methodologies.

The EU then asked whether those MSEs that had been finalized would need to be revisited to incorporate climate change considerations. The Chair clarified that the intention is for climate change to be taken into account in ongoing and future MSEs, but reiterated that such a decision is ultimately for CPCs.

9. Consideration of Next Steps and Adoption of a Workplan

The Chair indicated that a revised version of the Plan of Action, taking into account feedback provided by CPCs, will be circulated following the meeting, as will a Chair's letter that specifies next steps in greater detail. The Chair then noted that she will consult with the SCRS Chair on the revised version of the Plan of Action, as well as on suggesting a path forward for review of the Plan of Action by the SCRS in advance of the 28th Regular Meeting of the Commission in November 2023.

Norway asked whether the Climate Change Experts Meeting has the competence to request that the SCRS undertake any action related to the workplan. The SCRS Chair clarified that while some requests will ultimately require a decision from the Commission, there is flexibility in how Working Groups and subsidiary bodies at ICCAT engage intersessionally that should not inhibit collaboration and progress.

10. Other Matters

No other matters were discussed.

11. Adoption of Report and Closure

CPCs agreed that the final report for the meeting would be adopted by correspondence. The Chair thanked meeting participants for their contributions and closed the meeting.

Appendix 1

Agenda

1. Opening of the meeting
2. Appointment of the Rapporteur
3. Adoption of agenda and meeting arrangements
4. Review of the terms of reference for and purpose of the meeting, as outlined in *ICCAT Resolution by ICCAT on Climate Change* (Res. 22-13)
5. International work underway to understand the impacts of climate change on the ocean, advance climate resilient fisheries management, potential effects of climate change on ICCAT managed species, and associated management challenges. Presentations will be made by the following invited experts, followed by a question and answer period:
   - Dr Laurent Bopp, Institut Pierre-Simon Laplace (IPSL), Paris Sciences Lettres Université (PSL): "Impact of climate change on the physics and biogeochemistry of the ocean - prospects for fish and fisheries"
   - Dr William Cheung, University of British Columbia: "Vulnerability and impacts of climate change on Atlantic tuna fisheries"
   - Dr Tarub Bahri, Food and Agriculture Organization of the United Nations (FAO): "Climate Resilient Fisheries Management"
6. Review of current scientific processes and technical work being undertaken by the Standing Committee Research and Statistics (SCRS) to evaluate the effects of climate change on ICCAT fisheries, including information needs and data gaps (SCRS Chair)
7. ICCAT CPCs' efforts to evaluate and mitigate the effects of climate change in ICCAT and other fisheries, taking into account an Ecosystem Approach to Fisheries Management (EAFM), as appropriate, including, but not limited to, invited experts presentations from:
   - Barbados
   - Brazil
   - Canada
   - European Union
   - Korea
   - Norway
   - United Kingdom
   - United States
8. Discussion of how climate-related information can be incorporated into the ICCAT decision-making process, from both a management and scientific perspective
9. Consideration of next steps and adoption of a workplan
10. Other matters
11. Adoption of Report and closure

Appendix 2

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Context

Climate change can impact fish resources and therefore fisheries in many different ways (see **Figure 1**). It can lead to shifts in the distribution of species, or modification of the growth rate of individuals in a population, but also changes to fisheries 'catchability' and at-sea operating conditions for fishing vessels.

Climate Change and bluefin tuna in the Northeast Atlantic

Both commercial and recreational fishers have reported seeing large numbers of Atlantic bluefin tuna (ABFT), off southern England in recent years. Horton *et al*., (2021) analysed a unique, dataset assembled from a range of sources (including scientific surveys, ecotour records and bycatch data from the Irish albacore fishery) to demonstrate an increasing trend in effort-corrected tuna occurrence.

Historically this species had been present throughout much of the North-East Atlantic, where it had previously been the target of a UK sport fishery (Bennema, 2018). Faillettaz *et al*., (2019) examined century-scale fluctuations in ABFT abundance to demonstrate a strong influence of the Atlantic Multidecadal Oscillation (AMO). The AMO is characterised by long-duration variations in the sea surface temperature of the North Atlantic Ocean, with cool and warm phases that may last for 20-40 years. Spatial patterns of habitat suitability of ABFT in the North Atlantic were assessed for positive (1929–1962; 1995 to present) and negative (1896–1928 and 1963–1994) AMO phases.

This analysis showed that high records of bluefin tuna in the NE Atlantic coincided with high positive habitat suitability observed during positive AMO (warm) phases, while lower records occurred during negative AMO (cooler) phases when habitat suitability became constrained. A similar finding was suggested by Horton *et al.,* (2021) for the UK and Ireland specifically. However, Horton *et al.,* (2021) showed that ABFT did not appear in any considerable numbers off southwest England until 2014, nineteen years into the most recent warm AMO phase.

During 2020-2022, scientific investigations into ABFT migrations and movements were conducted in the UK (in particular, tagging experiments) under the auspices of the ICCAT-aligned THUNNUS UK and CHART programmes. In Ireland a similar catch-tag-release science-based fishery for recreational angling vessels has been in place since 2019.

Atlantic bluefin tuna migrate seasonally into higher latitude waters of the Northeast Atlantic to forage on a wide variety of caloric-rich pelagic prey (Olafsdottir *et al*., 2016), which include mackerel, Atlantic saury, sardine, sprat, herring and anchovy (van der Kooij *et al*., 2015; Pinnegar *et al.,* 2015). Consequently, increases in the abundance of any of these species, either through range-expansion or population growth, could have a bottom-up effect on ABFT residency (Horton *et al.,* 2021).

The thermally suitable feeding habitat of ABFT expanded by 800,000 km^2 from the mid-1980s to the early 2010s, leading to the first documented observation of the species in Denmark Strait near Greenland in 2012 (https://www.nature.com/articles/s41467-022-30280-0) (MacKenzie *et al.,* 2014).

Unusually for fish, ABFT have the ability to regulate their body temperature: their core temperature is therefore often above that of the surrounding waters. Data-storage tags measuring both internal and external temperatures show that the species can dive into colder waters during the day for short periods to feed (e.g., horizontally across fronts or vertically across the thermocline), during which time the core temperature starts to drop, but then return to surface waters during the night to warm-up again (Walli *et al.,* 2009). Such studies suggest that the species needs access to surface waters of at least 10–11 °C to support

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foraging, which can be interpreted as a natural limitation on the distribution of the species and definition of habitat (MacKenzie *et al.,* 2014; Payne *et al.,* 2022).

According to 'ideal free distribution theory', populations retreat into areas of highest habitat suitability (as defined by temperature or prey availability) whenever their abundance decreases, and conversely, they may spill out into non-ideal habitat when populations are at their height. This theoretical framework had been used to try to explain the recent expansion of Atlantic bluefin tuna (Mariani *et al.,* 2015). According to the most recent ICCAT stock assessment for Atlantic bluefin tuna in the 'East Atlantic and Mediterranean' spawning stock biomass (SSB) is currently much higher than was the case over the last decade as a result of strong recruitment and greatly reduced fishing mortality. 'Ideal free distribution theory' suggests that under such conditions we might expect that distant feeding areas are occupied on a seasonal basis and often by larger individuals, in agreement with empirical observations (see Mariani *et al.,* 2015).

Future projections of tuna distribution in the Atlantic

In recent years there has been a proliferation of studies aiming to determine future distributions of commercial fish, and this includes studies of relevance to ICCAT. Some of these studies were initiated in anticipation of transboundary quota disputes and a need to assess present and future 'zonal attachment', others were instigated in recognition that changes are already apparent and that fishers are having to adapt.

In 2018, the ICES Working Group on Seasonal to Decadal Prediction of Marine Ecosystems (WGS2D) attempted to provide a within-year forecast (11 months ahead) of suitable feeding habitat for ABFT in the North Atlantic (ICES 2018). The Working Group made use of the near real-time seawater temperature data from the NMME ensemble of seasonal forecast models (Kirtman *et al.,* 2014). The forecast for the 2019 feeding season indicated that the total area of thermally suitable habitat would be lower than the peaks seen in 2010 and 2012, although the amount of habitat was expected to remain above that seen prior to the mid-1990s. The skill of this modelling framework was assessed using historical data, independent of those used in model development, and this has process been described by Payne *et al.,* (2022).

Muhling *et al.,* (2016) compared outputs from a correlative species distribution model and a simple mechanistic oxygen balance model for ABFT in the North Atlantic Ocean. Both models gave similar results for the recent historical time period (1971 to 2000). When implemented together with future projections from an earth system model, the two modelling frameworks suggested temperature-induced reductions in ABFT habitat in the tropical and sub-tropical Atlantic by 2100. However, the oxygen balance model provided more optimistic results in parts of the subpolar North Atlantic (Muhling *et al.,* 2016).

In a recent UK government-funded project, Townhill *et al.,* (2023) provided future projections of habitat suitability for 49 commercial fish species. These authors employed an ensemble of five different species distribution models using climate projections for three carbon emission scenarios (RCP4.5, RCP8.5 and A1B), with a focus on the north-west European shelf. Habitat suitability was quantified in the recent past (1997-2016) and for two future periods (2030-2050; 2050-2070). Outputs for ABFT suggest that habitat suitability in the United Kingdom Exclusive Economic Zone (EEZ) will increase by 14% under a high-emissions scenario (RCP8.5) and by 5.9% under a medium-emissions (RCP4.5) scenario for the period 2050-2070.

Townhill *et al.,* (2021) used very similar models to develop an understanding of how climate change could affect the distribution of commercially important tuna (southern bluefin, albacore, bigeye, yellowfin and skipjack) in the waters around the UK's Overseas Territories (Tristan da Cunha, Ascension Island and Saint Helena) located in the South Atlantic. Waters around Tristan da Cunha (the southernmost of the 3 UK Overseas Territories) are most suitable for southern bluefin, and overall, the environmental conditions will remain so in the future (see **Figure 2**). Tristan da Cunha is not projected to become more suitable for any of the other tuna species in the future. For the other tuna species, Ascension Island and Saint Helena will become more suitable, particularly for skipjack tuna around Ascension Island, as the seawater temperature and salinity conditions change in these areas' (see **Figure 3**). Sizable marine protected areas (MPAs) have been designated around these territories in recent years, with those in Ascension and Tristan da Cunha specifically closed to tuna fishing. Although these closed areas are small relative to the wider distribution range (and ICCAT area), model projections, such as those provided by Townhill *et al.,* (2021) can be useful in understanding whether protection will benefit tuna populations into the future, particularly where there is high site fidelity.

Erauskin-Extramiana *et al.,* (2018) investigated the effect of environmental conditions on the worldwide distribution and relative abundance of six tuna species (albacore, Atlantic bluefin, southern bluefin, yellowfin, bigeye and skipjack) between 1958 and 2004 and estimated the expected end-of-the-century changes based on a high-greenhouse gas concentration scenario (RCP8.5).

Over the historical period, suitable habitats shifted poleward for 20 out of 22 tuna stocks, based on their gravity centre (GC). On average, tuna habitat distribution limits have shifted poleward 6.5 km per decade in the northern hemisphere and 5.5 km per decade in the southern hemisphere. Larger tuna distribution shifts and changes in abundance are expected in the future, especially by the end-of-the-century (2080–2099). Temperate tunas (albacore, Atlantic bluefin, and southern bluefin) and the tropical bigeye tuna are expected to decline in the tropics and shift poleward. In contrast, skipjack and yellowfin tunas are projected to become more abundant in tropical areas as well as in most coastal countries' exclusive economic zones (EEZ) (Erauskin-Extramiana *et al.,* 2018).

Impacts on prey species for tunas

Townhill *et al.,* (2023) provide habitat suitability projections for 49 commercial fish species in the northeast Atlantic were (see above). These include many species that are important as prey for ABFT, including mackerel, sprat, anchovy, sardine, squid and herring. Around half of the species were predicted to have consistently more suitable habitat in the future within the UK EEZ, including sardine anchovy, sprat and European squid (*Loligo vulgaris*) *etc*. Conversely, results indicated a significant decline in suitability for other important prey species including herring. Notably the models suggested very little change in the suitable habitat of mackerel within the UK EEZ.

A particular focus of scientific attention in recent years has been the apparent westward and north-westward spread of Atlantic mackerel into Icelandic and Faroese waters, with serious repercussions for fisheries quota allocation and as a potential prey resource for species such as ABFT. Whether or not the shift was due to natural stock fluctuations or warming sea temperatures remains a serious point of contention. During the period 2007-2016 the mackerel distribution range increased three-fold and the centre-of-gravity shifted westward by 1,650 km and northward by 400 km. Distribution range peaked in 2014 and was positively correlated to Spawning Stock Biomass (SSB) (ICES 2020). Boyd *et al.,* (2020) constructed an individual-based model (IBM) that incorporates spatial and temporal variation in food availability, temperature and exploitation of Atlantic mackerel, in order to simulate the consequences of management scenarios and/or future climate change. Results suggest that, over the range of scenarios considered, fishing mortality had a larger effect on the mackerel population than climate out to 2050. This result was evident in terms of stock size and spatial distribution in the summer months.

Responses to climate change risks and impacts

A wealth of experience exists around the world, with regard to developing effective adaptation actions in the face of climate change impacts on fisheries. Poulain *et al.,* (2018) provided a comprehensive literature review. This literature review highlighted initiatives led by governments (or RFMOs such as ICCAT), the private sector and fishing communities (see **Figure 4**). Adaptation is a "process of adjustment in ecological, social, or economic systems to actual or expected climate and its effects", which includes actions that moderate, avoid harm or exploit beneficial opportunities.

Questions the ICCAT Climate Change Expert Meeting could consider

In this information paper we have highlighted and summarised a selection of studies into the relationship between changing water temperatures and the distribution and abundance of tuna stocks. Noting the findings of such studies, managers and scientists engaged in ICCAT's work may want to consider the following questions as they think about how to orient ICCAT's work to respond to climate change.
Scientific questions and considerations:

- Should range shift analyses be undertaken on a regular basis, if so, what interval would be appropriate? Will they need to be undertaken for every stock (or groups of species)?
- Should we consider the impact of climate change when setting TACs? Will we need to adjust assumptions on the productivity of certain stocks under certain conditions (sub-optimal conditions

for spawning, reduction/increase in prey etc)? Or do TACs already take account of climate change given that they take into account recruitment and therefore biomass variations between years?

- Do management reference points e.g., F_{MSY}, B_{MSY} need to be regularly revisited as levels of exploitation that can be sustained by the population might vary depending on the climate regime?
- Can we effectively model for future impacts on tuna stocks? Or are likely effects impossible to accurately predict?
- What do other ocean changes e.g., in distribution of prey species mean for tuna stocks? Do we have a good enough understanding of ecosystems and food webs (and changes due to climate impacts) to understand this?

Management questions and considerations:

- Will ICCAT's allocation criteria remain appropriate, or will they need to be updated/be more adaptive?
- If substantial range shifts occur, species might move beyond RFMO Convention Areas. How do we deal with that? Change the Area? Collaborate with other RFMOs?
- What are the implications of range shifts for food security? Will ICCAT need to look at potential socioeconomic impacts based on analysis or modelling of range shifts? Does ICCAT possess the necessary socioeconomic expertise to assess such issues?
- How do we balance the rights of coastal States to harvest new/increased natural resources within their EEZs against those who have fleets who have historically dependent on the resource? What is an appropriate rate of change?
- Where do we draw our knowledge of these matters from? What collaborations and agreements are needed between e.g., ICCAT and other organisations?

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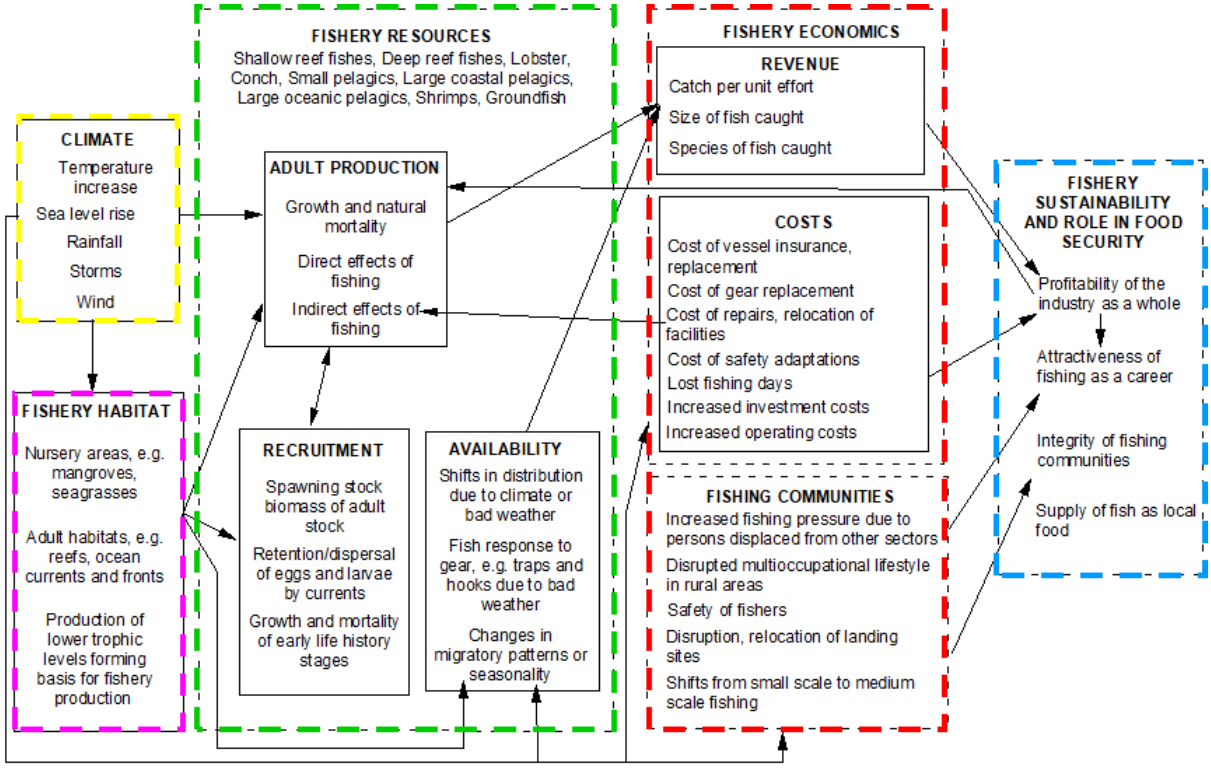

Figure 1. Schematic illustration of the many direct and indirect impacts of climate change on fish populations and fisheries.

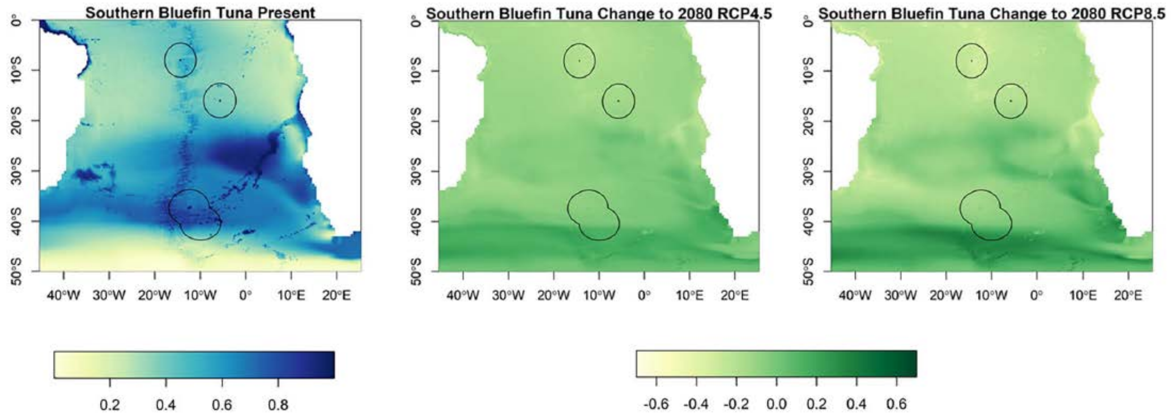

Figure 2. Habitat suitability for southern bluefin tuna from Maxent in the South Atlantic for the present day and the change to 2080 under RCP4.5 and RCP8.5. The EEZs are shown in the black outline. The yellow areas are the most suitable, and the dark blue the least suitable (from Townhill *et al.,* 2021).

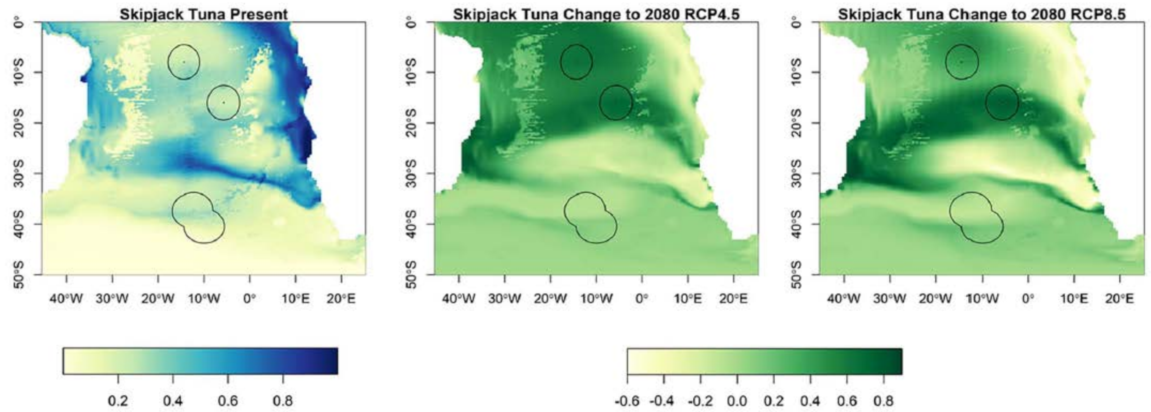

Figure 3. Habitat suitability for skipjack tuna from Maxent in the South Atlantic for the present day and the change to 2080 under RCP4.5 and RCP8.5. The EEZs are shown in the black outline. The yellow areas are the most suitable, and the dark blue the least suitable (from Townhill *et al.,* 2021).

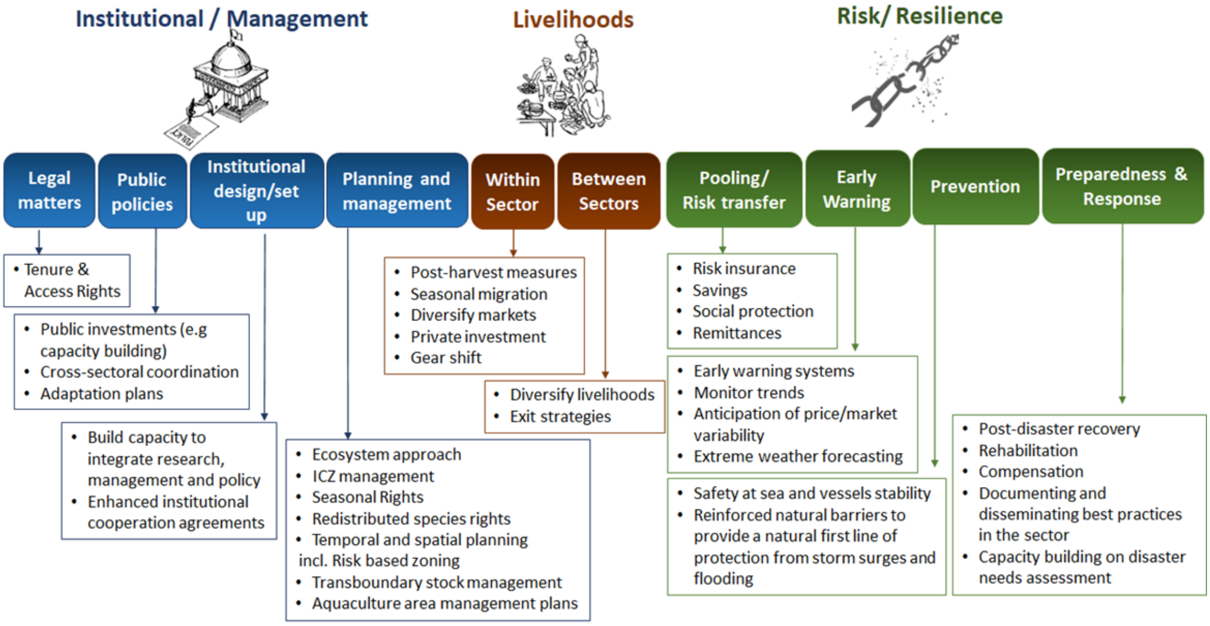

Figure 4. Types and selected examples of adaptation tools and approaches in capture fisheries (derived from Poulain *et al.,* 2018)

Appendix 4

A method for climate impacts on Norwegian fish stocks - potentially useful on Atlantic tunas

(Anne Britt Sandø)

Summary

Climate change has impacted marine ecosystems across the world's oceans with different and specific imprints in the various marine regional ecosystems (Hoegh-Guldberg *et al.*, 2014). In a recent study on future climate impacts on 13 different stocks in the North Sea, Norwegian Sea and Barents Sea (Sandø *et al*., 2022; Sandø *et al*.), we found that it is the current stocks of cod and *C. finmarchicus* in the North Sea, and polar cod and capelin in the Barents Sea, that will be most negatively affected by strong warming. Stocks that can migrate North into the northern seas such as hake in the Norwegian Sea, or stocks that are near the middle of the preferred temperature range such as mackerel and herring in the Norwegian Sea, and cod and *C. finmarchicus* in the Barents Sea, are the winners in a warmer climate.

Method

Based on a method described by Hare *et al.* (2016) and Kjesbu *et al.* (2021), we have provided calculations of climate impacts as a function of different climate exposures such as temperature change, deoxygenation, acidification and changes in plankton production. Furthermore, the strength and direction of the accumulated effects depend on a set of sensitivity attributes such as spawning and grazing habitats, specific prey and species interaction. Based on modelled changes in the physical and biogeochemical variables and knowledge of different stocks' sensitivity attributes, we have weighted the climate exposures and the directions these have on the stocks in three climate scenarios (**Figure 1**).

Time series of the climate exposures are extracted from the regional ocean model NEMO-NAA10km (Hordoir *et al*., 2022) which is downscaled from the Norwegian Earth System Model (NorESM2, Bentsen *et al.*, 2013; Seland *et al*., 2020). To investigate how climate change affects the lower trophic levels in the different northern seas, the physics from NEMO-NAA10km were used as driving forces into the NORWECOM.E2E ecosystem model (Aksnes *et al*., 1995; Skogen *et al.*, 1995; Skogen and Søiland, 1998).

Current research and application of method to Atlantic tunas

The method described in Kjesbu *et al.* (2021) and extended to multiple scenarios in Sandø *et al.* are first attempts to describe future climate impacts on fish stocks in the North Sea, Norwegian Sea and Barents Sea. The study emphasizes that marine fish are ectothermic organisms that are adapted to a defined temperature range where life processes break down when the ambient temperature becomes higher or lower. **Figure 2** illustrates the specific growth rate of early juvenile Atlantic cod as a function of temperature together with optimal and critical temperatures at different life stages. With similar knowledge about critical and optimum temperatures, as well as knowledge about other relevant sensitivity attributes, more detailed and trustworthy climate impact analyses for Atlantic tuna can be performed.

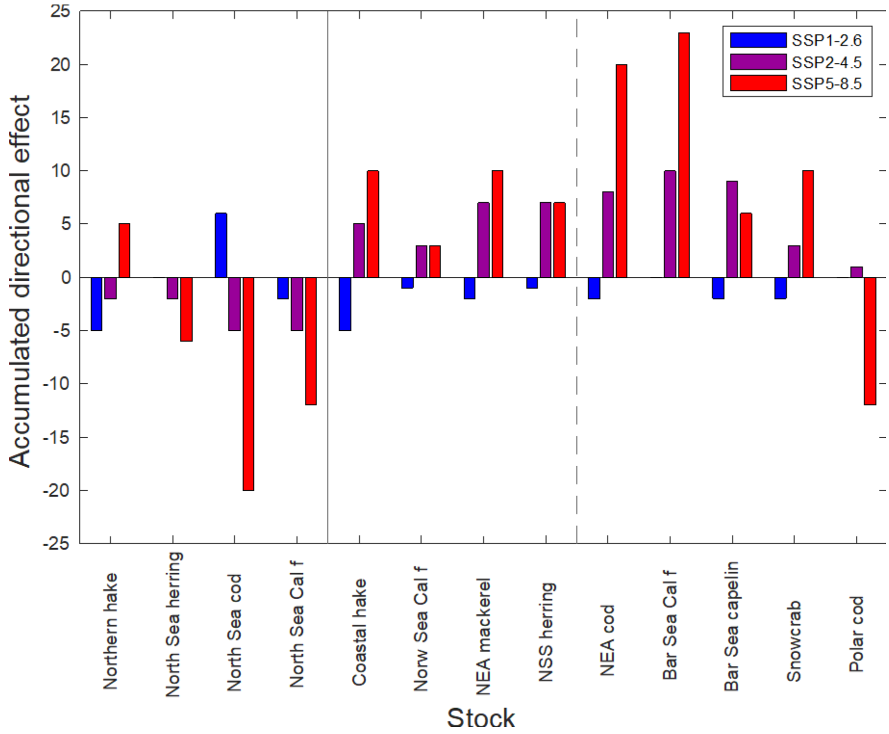

Figure 1. Accumulated directional effects for the various stocks in the scenarios SSP1-2.6.

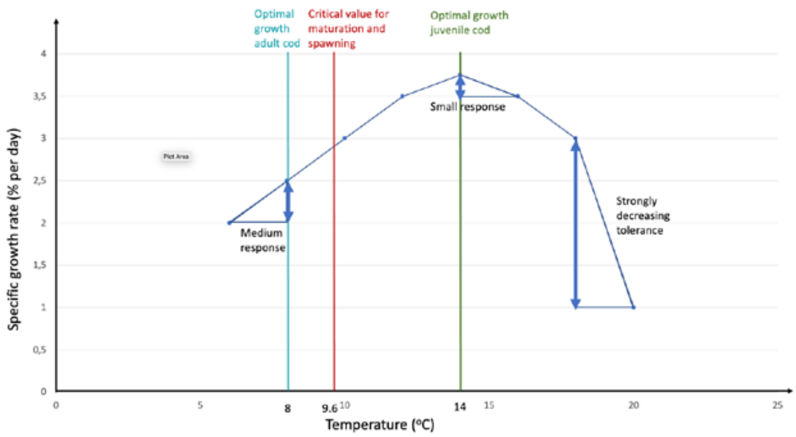

Figure 2. Laboratory measured values of specific growth rate as a function of temperaturefor juvenile Atlantic cod based on laboratory experiments (Otterlei *et al.*, 1999; Björnsson *et al.*, 2007). Optimal growth temperatures at different life stages and the critical temperature for gonadal maturation are indicated with vertical lines.

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Appendix 5

Korea's efforts to mitigate the effects of climate change in the fisheries sector

In December 2021, the Ministry of Oceans and Fisheries announced the "2050 Carbon Neutrality Roadmap for the Marine and Fisheries Sector". Recognizing the significance and potential of the marine and fisheries sector, we formulated this roadmap to set a target of reducing the sector's net greenhouse gas (GHG) emissions to -3.24 million tons by 2050. This ambitious goal represents a reduction of 7.3 million tons compared with the 2018 emissions of the marine and fisheries sector. Although achieving net-zero emissions in the marine and fisheries sector by 2050 is challenging, we have set this target with the intention of pursuing a wide variety of policy measures. These include the replacement of fossil fuels with marine energy and maximizing the absorption of blue carbon. In this meeting, we would like to introduce Korea's policies on tackling climate change, with a specific focus on mitigation measures.

1. Fisheries and fishing villages

Regarding fisheries and fishing villages, the 2050 GHG emissions target is 115,000 tons, aiming for a 96% reduction compared to the 2018 emissions of 3.042 million tons. Some GHG emissions will persist due to the long lifespan of fishing boats and the early stage of low-carbon and zero-carbon technology development. However, to achieve the carbon neutrality target, we will employ diverse means of reduction across the entire fisheries industry. This includes supplying energy-efficient fishery equipment and expanding renewable energy utilization.

To address fishing boats, we are accelerating the replacement and conversion of old engines to improve fuel efficiency. Additionally, we are actively developing and supplying green fishing boats, such as electric and hybrid vessels, to increase the number of low-carbon and zero-carbon ships.

Moreover, we plan to expand the use of energy-efficient equipment like heat pumps and inverters for aquaculture and fishery processing. We will also explore the utilization of various renewable energies, including photovoltaic (PV), small hydro power, and wave power, for unused sites and waters in aquafarms and national harbors. Additionally, we will promote the use of eco-friendly refrigerants in marine product refrigerators and freezers.

2. Ports

Although ports play a crucial role in local and global logistics, they are currently not categorized as a separate item in national GHG statistics. Consequently, there is no official calculation of GHG emissions specifically for ports. However, based on the oil and electricity consumption of shipping companies, it is estimated that emissions in 2019 reached 300,000 tons. To address this, we are committed to achieving carbon-neutral ports by reducing GHG emissions from ports to zero by 2050 and transforming them into hubs of the hydrogen ecosystem.

Our strategies for creating carbon-neutral ports include transitioning the fuel sources of unloading equipment, improving energy efficiency in port operations, and utilizing new and renewable energy sources such as PV and marine energy. Furthermore, we aim to establish 14 hydrogen ports by 2040, enabling the annual supply of 13 million tons of hydrogen through ports. A hydrogen port refers to a port equipped with the components of the hydrogen energy ecosystem, including hydrogen production, import, storage, transportation, and utilization.

3. Marine Waste

Given the high levels of GHG emissions emitted in the waste landfill and during the incineration processes, we will take strong measures to address marine waste. We will ensure that the direct landfill of marine waste is brought down to zero, and that marine waste is used to generate thermal energy. In addition, we will explore possibilities for recycling various marine wastes to minimize waste generation.

As for items, such as marine waste and ports, for which policy measures are in place but GHG reductions are difficult to calculate, we will be prepare measures to enable the calculation and management of GHG emissions. We are improving the GHG statistical system and gradually establish a system, starting from emissions calculation, for effective implementation and management.

Appendix 6

United States efforts to evaluate and mitigate the effects of Climate Change in ICCAT and other fisheries

The United States is confronting the challenge of understanding and responding to the impacts of climate change on our marine resources, while simultaneously trying to safeguard habitats, restore imperiled species, and build healthier and more resilient ecosystems. Climate change is already impacting the nation's marine life and ecosystems and the many communities and economies that depend on them. Climate change challenges our shared goals of sustainable fisheries management and conservation of protected resources and habitats.

The National Oceanic and Atmospheric Administration (NOAA) uses the best available science to evaluate fisheries management strategies in the face of climate change. NOAA is building management and research infrastructure for adaptive, climate-informed fisheries management, such as the U.S. *Climate, Ecosystems, and Fisheries Initiative (CEFI)* (**Figure 1**). To direct the best available climate and fisheries science toward these efforts, NOAA has developed a *Climate Science Strategy* to prioritize and tailor ongoing research efforts toward management strategies and tools. In line with broad initiatives and strategies, NOAA is currently employing a variety of management and assessment tools to help fisheries and managers prepare for and respond to changing ocean conditions, including:

- Producing regional *ecosystem status reports* to track and provide early warnings of climate and ecosystem changes in each region;

- Using *climate vulnerability assessments* of major fish stocks to better understand their vulnerability and support management action; and

- In partnership with U.S. Regional Fishery Management Councils, using *scenario planning* and other tools to identify effective fishery management strategies for current and future conditions.

In this paper the United States provides concrete examples of some efforts to evaluate and respond to the effects of climate change in ICCAT and other fisheries and provides further resources about these efforts.[1]

These efforts are divided into the following categories:

- **Broader initiatives**
- **Current management and research tools for Highly Migratory Species**
- **Domestic management and research tools being applied in other fisheries**
- **Participation and leadership in international efforts**

Broader initiatives

The *Climate, Ecosystems, and Fisheries Initiative (CEFI)*[2] is an effort to build the operational ocean modeling and decision support system needed to reduce climate change impacts on fisheries, increase resilience, and help marine resources and resource users adapt to changing ocean conditions. Unique to NOAA's wide ranging capacity as an agency, this initiative is designed to capitalize on the ocean modeling and forecasting capabilities within our broader organization, and direct those products specifically toward our fisheries management decision making. One key goal of CEFI is to integrate ocean modeling into fisheries decision making, leveraging robust near-term forecasts (*e.g.*, daily to monthly) and longer-term projections (seasonal to multi-decadal) of ocean conditions. CEFI will provide decision makers with the information and capacity needed to assess risks, identify adaptation strategies, and take action to safeguard the valuable marine resources of the United States and the many people, communities, and economies that depend on them.

[1] The NOAA Fisheries website presents a range of efforts across the agency: https://www.fisheries.noaa.gov/topic/climate-change
[2] The CEFI fact sheet is available at: https://media.fisheries.noaa.gov/2023-05/NOAA-Climate-Ecosystems-and-Fisheries-Initiative-Fact-Sheet.pdf The CEFI website is: https://www.fisheries.noaa.gov/topic/climate-change/climate,-ecosystems,-and-fisheries

Specifically within NOAA Fisheries, the *NOAA Fisheries Climate Science Strategy* (Link *et al*., 2015) was developed to meet the growing demand for information to better prepare for and respond to climate-related impacts on U.S. living marine resources and resource-dependent communities. The Strategy is intended to tailor and prioritize ongoing federal fisheries research toward seven key priorities that range from building science infrastructure to identifying climate-informed reference points for management (see **Figure 2**). It is part of a proactive approach to produce, deliver, and use climate-related information to fulfill NOAA Fisheries' mandates in a changing climate. Implementation of the Strategy is intended to bolster our capabilities to track climate change, understand mechanisms of that change, and project future conditions to inform our fisheries management. The strategy calls for each region to develop a climate science regional action plan. Regional action plans were updated in 2023 and include efforts to track change, forecast conditions, assess risk, evaluate management strategies, and prepare for change.[3]

Current management and research tools for Highly Migratory Species (HMS)

Ecosystem-Based Fisheries Management Road Map Implementation Plans[4] are plans to manage Atlantic Highly Migratory Species fisheries in a manner that incorporates the best available information on ecosystem components, including physical, biological, economic, and social interactions, to support sustainable fisheries, as well as the communities that depend on those fisheries, so that both are healthy and resilient to threats and changing conditions.

NOAA Fisheries uses Climate Vulnerability Assessments (CVAs)[5] to identify which species may be most vulnerable based on their exposure to projected changes in the environment (*e.g.,* warming oceans) and their sensitivity or adaptability to handle those changes based on their ecology and life history characteristics. Fisheries managers, climate policy specialists, and a scientific panel of 15 NOAA and external experts came together in San Juan, Puerto Rico, to conduct an *Atlantic Highly Migratory Species (HMS) CVA* workshop from May 16-18, 2023. The in-person workshop was hosted by NOAA Fisheries and specifically focused on the evaluation of life history or behavioral characteristics ("sensitivity attributes") that make HMS (Atlantic sharks, tunas, swordfish, and billfish) more or less vulnerable to climate change. Participants evaluated the sensitivity of HMS to climate change by individually scoring sensitivity attributes, and then discussed the scores and considered new information provided by scientists, Caribbean region experts, and observers to refine their scores and opinions on each stock or species. Once the panelists finalize their evaluation of sensitivity attributes, NOAA Fisheries climate specialists will combine this information with the results of a climate projection model ("exposure analysis") to develop final vulnerability rankings for HMS. The exposure analysis compares the overlap in species distribution with the expected magnitude of climate change[6]. Final results of the HMS CVA will be made available on the NOAA Fisheries website in 2024.

HMS Predictive Spatial Modeling (PRiSM) Tool[7] combines observer data and environmental data to predict the probability of where and when a species may interact with a fishery (Crear *et al.*, 2021). This information can then be used to address a variety of U.S. domestic fishery management questions. For example, there are a number of HMS closed areas that have not been assessed since their implementation in the early 2000s. Since then, ocean conditions, species distributions, and stock statuses have changed and additional regulations have been implemented. Because these areas have been closed, there is little data to determine if the closed areas are performing as intended. Using PRiSM, NOAA Fisheries generated metrics to assess the performance of closed areas as it relates to protecting various bycatch species. This tool could also be used to: determine where fishing or research vessels should be allowed to fish to collect data in the field; help delineate essential fish habitat; assist in ecosystem-based fisheries management; and understand the impacts of climate change on fisheries.

The HMS PRiSM tool has opened up new research opportunities, including exploring the improvement of index standardization to account for the effects of climate change. For example, in reviewing stock assessments for hammerhead sharks in the southeast region, habitat suitability modeling of a survey area was conducted within the HMS PRISM framework using shark bottom longline observer data. Results

[3] Regional Action Plans are available at: https://www.fisheries.noaa.gov/feature-story/noaa-fisheries-releases-updated-climate-science-regional-action-plans
[4] The HMS Ecosystem-Based Fisheries Management Roadmap Implementation Plan is available at: https://media.fisheries.noaa.gov/dam-migration/final_hms_ebfm_implementation_plan_041519.pdf
[5] https://www.fisheries.noaa.gov/national/climate/climate-vulnerability-assessments
[6] NOAA Climate Change Web Portal: https://psl.noaa.gov/ipcc/
[7] Summary of PRiSM: https://www.fisheries.noaa.gov/atlantic-highly-migratory-species/new-scientific-paper-published-noaas-highly-migratory-species

showed that Atlantic scalloped hammerhead distribution encompasses the entire survey area during the warmer months, but the suitable habitat within the spring survey area has expanded further north across the time series, indicating an earlier migration into this region driven in part by ocean warming. The results of the habitat suitability modeling were used to inform index standardization, indicating the need to explore additional variables that support suitable habitat and the need to use a spatiotemporal model to help account for the latent variables influencing these changes. These methods improved model diagnostic results and provided a more biologically plausible trend for scalloped hammerheads; it is now being applied to other species.

More broadly, researchers are engaged in relevant research programs at NOAA Fisheries science centers. Ongoing research aims to support *climate informed management* by reviewing available management approaches, documenting and predicting changes in productivity and regime shifts, and understanding the on-ramps for climate science into the fisheries management process (*e.g.*, Klaer *et al.*, 2015; Morrison and Termini, 2016; Holsman *et al.*, 2019; Link et al., 2021; Szuwalski *et al.*, 2023). U.S. scientists are identifying and integrating *ecosystem indicators into stock assessments* through research that aims to incorporate environmental information into the standardization of indices of abundance and ecosystem status reports (*e.g.,* Schirripa and Goodyear, 2016; Shotwell *et al.*, 2022; Lucey *et al.*, 2023). To describe and quantify the impacts of climate change on fish stocks, researchers are focused on changing *species distribution and habitat association* (*e.g.*, Schirripa *et al*., 2017; Karp *et al*., 2019; Lonhart *et al*., 2019; Schirripa *et al*., 2021). That work includes species distribution modeling, cooperative tagging and survey programs, temperature preference research, and describing the effects of marine heatwaves on marine ecosystems.

Management Strategy Evaluation (MSE) is a tool managers and scientists can use to evaluate different management options given a suite of potential ecosystem, fishery, and biological circumstances. It allows for evaluation of strategies under uncertainty, including that caused by climate change impacts. U.S. scientists and managers use MSE as a key method to evaluate the trade-offs among management objectives and to communicate potential courses of action with decision makers (e.g., Kaplan *et al.*, 2021).

Domestic management and research tools being applied in other fisheries

U.S. Regional Fishery Management Councils [8] are undertaking *scenario planning* processes. Scenario planning is a facilitated strategic thinking and planning process developed to help decision-makers and stakeholders explore alternate potential future states and consider the range of decisions that may arise in preparing for the future (Frens and Morrison, 2021). Scenario planners look for areas of high uncertainty in a system and imagine 3-4 plausible future situations, termed scenarios, that could occur given the uncertainties identified. Participants in scenario planning projects then look for management options or changes that would be useful across any of these plausible future scenarios. In this way, scenario planning can help managers and stakeholders understand where management strategies may need to change to prepare for the future. The end goals of scenario planning are to provide better policy or decision support and stimulate engagement in the process of change.

The Pacific Fishery Management Council implemented scenario planning as part of its Climate and Communities Initiative[9] which was completed in September 2021. This work resulted in three follow-on initiatives based on ideas identified during the scenario planning process that will improve management in a changing climate (deReynier *et al*., 2023). The three Fishery Management Councils covering the U.S. east coast and the Atlantic States Marine Fisheries Commission implemented a similar process, slated for completion in 2023, that aims to identify robust management and governance options to address stocks with changing productivities and distributions.

Additionally, as part of the U.S. fishery management council system, the U.S. Council Coordination Committee recently released an *Evaluation of Conservation Areas in the U.S. EEZ*.[10] This report was developed with the idea of identifying conservation areas that should be included in the American Conservation and Stewardship Atlas, a component of the Biden Administration's America the Beautiful initiative, which aims to conserve 30% of U.S. lands and waters by 2030. These conservation areas were

[8] Regional Fisheries Management Councils: https://www.fisheries.noaa.gov/topic/partners/regional-fishery-management-councils
[9] Climate and Communities Initiative Website: https://www.pcouncil.org/actions/climate-and-communities-initiative/
[10] A description of this program is available at: https://gulfcouncil.org/press/2023/u-s-fishery-management-council-report-finds-more-than-72-of-federal-waters-classified-as-conservation-areas/

developed by all eight U.S. regional fisheries management councils under their authority mandated by the U.S. Magnuson Stevens Fishery Conservation and Management Act.

Risk tables help managers set ecosystem-informed catch limits by improving how uncertainty is accounted for, including that related to climate change impacts. In cases where uncertainty is not well addressed in the stock assessment model, for example, scientists may recommend implementation of catch limits below those resulting from the stock assessment. In such cases, scientists are required to explain the conditions or uncertainties that warrant the reduction. These risk tables are therefore used to help stock assessment experts qualitatively evaluate each type of consideration/uncertainty (including the effects of climate change on marine resources) to support the decision to implement a catch limit below that resulting from the stock assessment itself. The findings are peer-reviewed and adjusted along with the stock assessment itself.

Ecosystem status reports (ESR) (*e.g.*, Lucey *et al.*, 2023) help stakeholders understand what's happening in their ecosystem of interest, including impacts from climate change, and are used to lay a foundation for ecosystem-based fishery management (EBFM). ESRs gather key indicators of an ecosystem and evaluate how that system is connected and changing. By collecting, combining, and synthesizing information about the ecosystem as a whole, rather than individual fish stocks, ESRs provide a holistic view of ecosystem stressors and trends. They can be used to help stakeholders, including Fishery Management Councils, understand the links between the ecosystem and the fisheries of interest. Two newly established ESRs that NOAA has released detail the state of ecosystems in the South Atlantic (2021) and the Florida Keys National Marine Sanctuary (2020). The reports examine trends in ocean acidification, sea surface temperature, and fish stocks, among other factors. With the release of these ESRs, NOAA further builds out the groundwork necessary to move towards EBFM and to understand ecosystems in context. The 2023 Ecosystem reports for the Mid-Atlantic and New England region can be found here and here, respectively.

The Distribution Mapping and Analysis Portal (DisMAP)[11] is a user-friendly and interactive website designed to provide visualization and analysis tools to better track, understand, and respond to shifting distributions of marine species. DisMAP, launched in the spring of 2022, provides distribution information for over 400 marine fish and invertebrate species caught in fishery-independent surveys conducted by NOAA and its partners. The portal allows users to quickly identify species that have experienced changes in their distributions and abundance over time. Users can explore maps of species distributions, view time-series plots showing changes in spatial indicators (e.g., center of biomass), and download data for exploration outside the portal in 9 regions: Eastern Bering Sea, Northern Bering Sea, Aleutian Islands, Gulf of Alaska, Main Hawaiian Islands, U.S. West Coast, Gulf of Mexico, Southeast U.S. Shelf, and Northeast U.S. Shelf.

Participation and leadership in international efforts

SUPREME (Sustainability, Predictability, and Resilience of Marine Ecosystems)[12] is a UN Decade of Ocean Science Program that NOAA Fisheries Office of Science and Technology helped launch. The overall objective of SUPREME is to convene global partners through knowledge networks to share information and support robust climate- and ocean-related forecasts, predictions, and projections to guide effective marine ecosystem management and adaptation strategies in a changing climate. Similar to the U.S. CEFI program, SUPREME aims to advance the modeling tools needed to reduce risks and increase resilience of marine and coastal resources and the people who depend on them. In April 2023, there was a meeting of SUPREME Network members at the 5th International Symposium on Effects of Climate Change on the World's Oceans (ECCWO). This was one of several efforts to increase the SUPREME network globally and build an international community to tackle issues related to fisheries management and climate. SUPREME is also participating in a workshop with other UN Decade programs to co-design actions for the climate-fisheries nexus.

At **COFI35,** Members agreed to additional ambitious outcomes regarding climate change and international fisheries, including the intention to hold a *cross-RFMO climate change workshop* to increase the knowledge and awareness on climate change impacts in fisheries and aquaculture and to provide guidance on climate resilient fisheries management. This workshop is being funded in part by NOAA Fisheries and is intended to facilitate coordination across RFMO Secretariats to advance efforts to adapt to climate change.

[11] DisMAP is online at: https://apps-st.fisheries.noaa.gov/dismap/DisMAP.html
[12] UN Decade SUPREME website: https://oceandecade.org/actions/sustainability-predictability-and-resilience-of-marine-ecosystems-supreme/; The SUPREME fact sheet is available at: https://oceanexpert.org/document/31154

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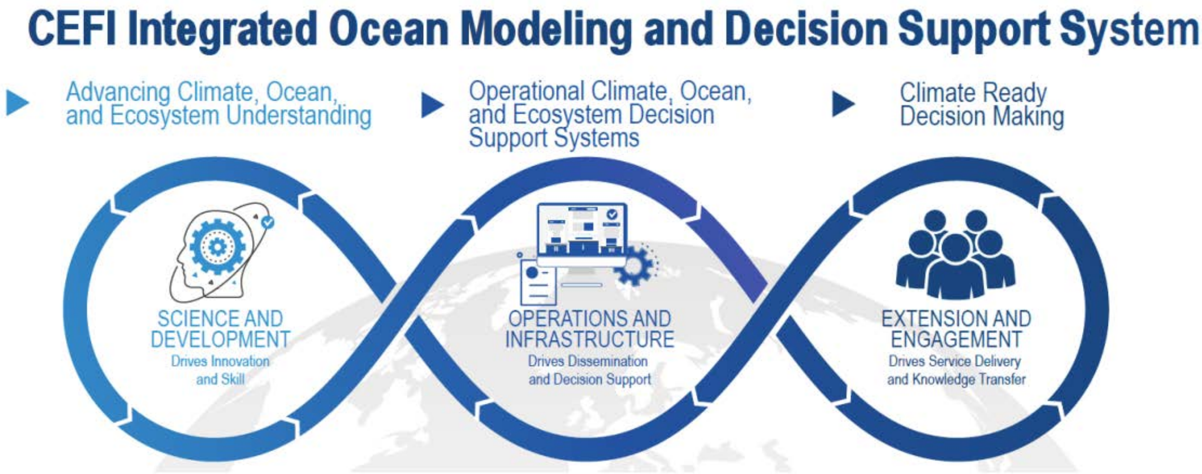

Figure 1. The graphic shows the major components of the NOAA Climate, Ecosystem and Fisheries Initiative's (CEFI) Integrated Ocean Modeling and Decision Support System. The end-to-end system is designed for innovation and feedback to ensure continuous improvement in meeting decision maker needs.

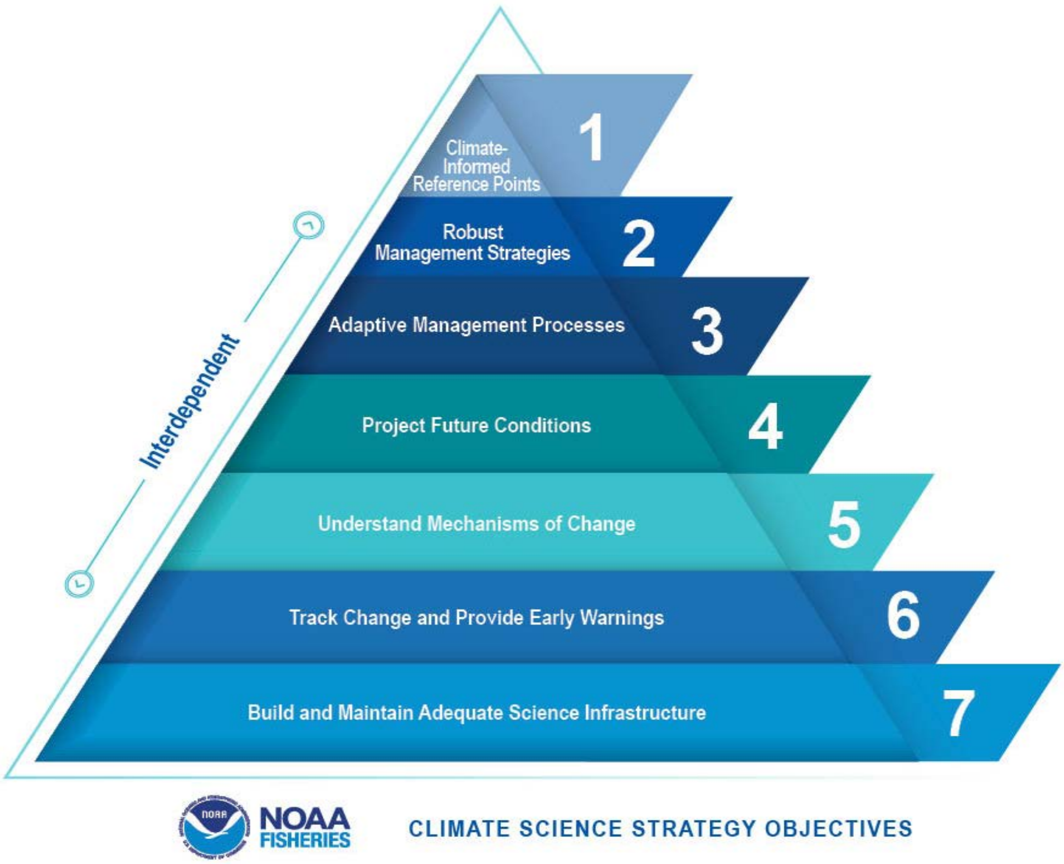

Figure 2. The graphic shows the NOAA Fisheries Climate Science Strategy's seven priority science objectives: (1) climate-informed reference points, (2) robust management strategies, (3) adaptive management processes, (4) project future conditions, (5) understand mechanisms of change, (6) track change and provide early warnings, (7) build and maintain adequate science infrastructure.

Appendix 7

Draft ICCAT Plan of Action on Climate Change

(Presented by the Climate Change Expert Meeting Chair in consultation with the SCRS Chair)

Taking into account the terms of the *Resolution by ICCAT on Climate Change* (Res. 22-13) and the discussions held at the ICCAT Climate Change Expert Meeting (11-12 July 2023), the Commission adopts the following Plan of Action on Climate Change to guide its scientific and management work with a view to better understanding and adapting to climate change and improving the resilience of ICCAT target stocks, non-target species, and species belonging to the same ecosystem or dependent upon target stocks in the Convention area as well as the individuals and communities that depend on these stocks and fisheries. This Plan of Action is intended to be a living document that should be reviewed annually and, as appropriate, revised as new information becomes available and work progresses on this issue.

Standing Committee for Research and Statistics (SCRS)

1. With a view to improving both the understanding of the potential impacts of climate change and the provision of scientific advice to the Commission on potential measures and approaches to support more adaptive and climate resilient fisheries management, the SCRS will, at a minimum, undertake the following:

   – In the short-term, consider and advise the Commission on whether the current SCRS structure is sufficient to meet the developing needs and challenges related to evaluating and providing advice on climate change matters, including if establishment of a new subsidiary body within the SCRS that focuses explicitly on the scientific work related to climate change might be beneficial.

   – When updating the SCRS Strategic Plan, incorporate climate change related activities and considerations, including prioritizing needed scientific work and data collection.

   – As a priority, continue to evaluate through management strategy evaluation (MSE) the performance of management approaches taking into account the potential effects of climate change on ICCAT stocks and species.

   – Continue the ongoing work with respect to ecosystem-based fisheries management, including enhancing information about potential changes to species interactions and spatial overlap in target and bycatch species; and on essential habitats for ICCAT target and bycatch species, including on climate refugia, and advising on any potential benefits of marine protected areas.

   – Continue efforts to identify and address data gaps and other scientific challenges related to climate change, as well as research needs and opportunities to improve the provision of scientific advice to the Commission. Among others, these could include:

     (a) evaluating how non-stationarity in population dynamics might affect the accuracy of scientific advice as well as the robustness and efficacy of management actions, and, where appropriate exploring the need to update scientific models and/or change modeling approaches;

     (b) considering ways to gather high quality fishery dependent data and/or independent surveys to detect climate related changes in productivity as well as spatial and temporal distributions;

     (c) encouraging and, where possible, providing technical support to CPCs in cooperation with the ICCAT Secretariat to increase systematic collection of size and age composition data from fisheries to help detect productivity changes;

     (d) continuing efforts to develop joint indices of abundance, and

     (e) developing a systematic process for including climate change indicators in the stock assessment process to avoid inclusion of potentially spurious correlations.

- Explore and, where appropriate, develop and implement other tools, approaches, and/or techniques to assist in the consideration of climate change impacts in the formulation of scientific advice, including the use of genetic techniques for stock assessments, risk tables, scenario planning, differing climatic projections (emissions-based projections), or other appropriate means.

- Beginning with the 2024 SCRS Report or as soon as possible thereafter, include a section entitled "Resilience to Climate Change" in the Executive Summaries of each stock/species. This section should include, at a minimum, the following information:

  - commentary on the resilience of each stock to the effects of climate change and any uncertainties associated with the scientific advice;

  - a description of if and how the effects of climate change were incorporated into the scientific process;

- Working with the ICCAT Secretariat, consider if current human and financial resources are sufficient to undertake any needed additional research and data collection/evaluation related to climate change. Based on this analysis, seek supplementary funds and/or other resources through the Standing Committee on Finance and Administration (STACFAD) and/or other means, as appropriate.

Commission

2. With a view to supporting the development of effective management strategies and other approaches to adapt to changing conditions due to climate change and improve ICCAT's climate readiness, the Commission will, at a minimum, undertake the following:

   - Include *"Matters pertaining to incorporating Climate Change into the work of the Commission"* as a standing item on the Commission agenda and also incorporate the issue of climate change into appropriate items of the Panel agendas, particularly those related to conservation and management measures and research.

   - Taking into account actions already implemented in ICCAT and the need to ensure the Commission and its subsidiary bodies can effectively carry out their work, consider through STACFAD possible additional approaches to reduce the organization's environmental and climate impacts, including those related to its headquarters' operation and meetings.

   - Consider through STACFAD any SCRS/ICCAT Secretariat requests for supplementary funds or other resources needed to carry out expanded scientific work associated with climate change and prioritize such requests to the greatest extent possible.

   - Establish a Standing Joint Expert Group on Climate Change (JEG-CC) to provide a dedicated forum in ICCAT to:

     - review progress on implementation of this Plan of Action,

     - continue to share information on climate change mitigation and adaptation initiatives of relevance to ICCAT fisheries, including any efforts undertaken to encourage a lower carbon footprint in CPC fisheries, possibly including development of an information repository for access by CPCs and, as appropriate, other Regional Fisheries Management Organizations (RFMOs);

     - engage with stakeholders to strengthen the base of knowledge on climate change and its impacts and ensure more inclusive and informed decision making on climate change adaptation and mitigation strategies, including by encouraging CPCs to include stakeholders on their delegations and, when appropriate, by holding special open sessions of the JEG-CC to hear from stakeholders directly;

- discuss the potential impacts of climate change (such as changes in temporal and spatial distribution of the stocks, reduced recruitment, reduced individual fish size, and increases in bycatch interactions) on relevant conservation and management decisions, including, *inter alia,* Total Allowable Catch (TAC) setting, allocation arrangements, spatial and temporal management, minimum sizes, and risk considerations, and consider adaptation strategies and approaches, including, as appropriate, those that are being implemented by CPCs, that will prepare ICCAT to address such potential eventualities;

- consider and advise the Commission on other potential actions that ICCAT and/or its CPCs could take, individually or collectively, including through cooperation with other RFMOs, to address identified needs and challenges related to climate change mitigation and adaptation;

- consider, in consultation with the SCRS, the need for capacity building and technical assistance, including to gain access to and use climate/environmental data, to improve climate science as it relates to understanding, predicting, and addressing the potential impacts of climate change on ICCAT stocks, species, and related ecosystems, as well as impacts on fisheries, including fishers and communities, and to explore ways to provide such assistance;

- track climate change discussions and activities of other RFMOs and, noting in particular the upcoming Food and Agriculture Organization of the United Nations (FAO)-led cross-RFMO meetings in 2023 and 2024, cooperate and collaborate with the FAO and other Intergovernmental Organizations (IGOs), as appropriate, to facilitate progress on the use of the best available science, to development of guidance on climate resilient fisheries management, and other relevant matters;

- consider other relevant issues with regard to ICCAT and climate change mitigation and adaptation, such as periodically organizing, together with the ICCAT Secretariat, symposia on topics related to climate change and highly migratory species research and management, as approved by the Commission.

3. Progress on the implementation of this Plan of Action will be reviewed by the Commission each year during its Annual meeting. The Plan of Action may be revised by the Commission based on SCRS advice and/or other relevant information. The SCRS should make a special effort to review this Plan of Action and, as appropriate, provide additional feedback to the Commission in 2024.