Are climate change impacts being evaluated in Canadian fisheries management?

Rebecca Schijns and Robert Rangeley, Oceana Canada
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Executive Summary

Overall, Canadian fisheries management has likely overlooked climate-resilient measures (Holsman et al., 2019) for populations that require immediate intervention and has been inconsistent in how it addresses climate change. We identify knowledge and application gaps for vulnerable species that require immediate management action by introducing new metrics that evaluate how climate change is currently accounted for in official reports compared to available scientific literature. Only 28 per cent of stocks consider climate change effects in official science and management documents, despite evidence being available for 82 per cent of these stocks in peer-reviewed literature. Also, there is existing literature to support that climate change is affecting the majority of the 72 per cent of marine populations where climate factors are currently absent from government reports. Officially incorporating climate change effects is more common for healthier, less vulnerable stocks than for stocks with both poor status and high climate risk. Additionally, available climate knowledge is missing in the management of forage fish, groundfish, and large pelagics, a lack that may have wider ecosystem implications.

Oceana Canada recommends the following improvements to fisheries science and management to fully address climate change effects:

- Ensure that the effects of climate change are considered consistently in the science that informs fisheries management decisions through integrating environmental variability into both assessments and advice;
- Assess vulnerability and climate risk in all populations to prioritize species, locations, and timelines necessary to deploy resources that enable climate-resilient management measures (Holsman et al., 2019) for stocks most vulnerable to climate change;
- Include a new section in the Department of Fisheries and Oceans (DFO) Science Advisory Reports or related documents titled "Climate Change Considerations" that explicitly summarizes available knowledge on ecosystem changes and the mechanisms for including relevant information in fisheries science and advice; and
- Implement a long-term National Climate Change Adaptation Strategy that adopts ecosystem-based fisheries management approaches and risk-based frameworks.

Introduction

Climate change is very likely to have a significant impact on all of Canada's marine life in the Pacific, Atlantic, and Arctic, with the effects becoming more pronounced over time (DFO, 2013a, 2013b, 2013c). Climate change is expected to result in physical changes such as increasing sea surface temperature, rising sea level, ocean acidification, marine heat waves, salinity changes, and deoxygenation, all of which directly or indirectly affect marine biodiversity and the fisheries Canada depends on. At the organism level, climate-induced effects on calcification, growth, larval survival, and behaviour can change the characteristics of biological populations and communities (Kroeker et al., 2013). Whole ecosystems are affected when species distributions shift or contract, resulting in predator-prey and scale mismatches between biological units and fisheries management jurisdictions (Link et al., 2010). Food security, potential fish catches, livelihoods, habitat, biological control (e.g., control of pests and disease), moderation of extreme events, and maintenance of genetic diversity (biodiversity hotspots), among other ecosystem services, are all affected by climate change, and impacts may vary greatly across Canada's coasts (Cheung et al., 2022; Golden et al., 2016; Lam et al., 2016; Daly et al., 2021).

Increasingly, the effectiveness of fisheries management will be further undermined by climate change and the resulting rise in uncertainty of scientific advice unless major advances are made to strengthen resiliency of populations by minimizing cumulative impacts, assessing those most vulnerable populations, and adapting management accordingly (Cheung et al., 2022). The effects of climate change are not often factored into fisheries management plans (Boyce et al., 2021) even when there is available evidence that those fish populations in question are likely to be impacted. Management gaps such as these hamper Canada's ability to respond to environmental change (Pepin et al., 2020) and can perpetuate poor decision-making and negative outcomes. Failure to acknowledge how climate change affects fish stocks makes it difficult to implement adaptive and risk-based decisions based on the best available information. Without mitigation and with continued overfishing, global fish biomass would drop 36 per cent from current levels (Cheung et al., 2022). To adapt to climate change, Canadian fisheries require a combination of tools, including strategies and plans to help avoid, minimize, remediate, and offset the effects of climate change. A strong baseline of evidence to inform management decisions, including the need to assess the vulnerability of key commercial fisheries to climate change, is critical to making adaptative decisions.

Canada lacks a clear climate change adaptation strategy for its fisheries. DFO's 2020-2023 Departmental Sustainable Development Strategy (DSDS) outlines key goals to understand climate change impacts and advance a long-term climate strategy for Canada, including to protect 25 per cent of Canada's oceans by 2025 (and 30 per cent by 2030) and to continue implementation of policies for ecosystem approaches for fisheries management under the Sustainable Fisheries Framework (DFO, 2020a). On the international stage, Canada is a signatory to and member of several climate initiatives, such as the UN 2030 Agenda for Sustainable Development, the UN Framework Convention on Climate Change (UNFCC) and the UNFCC Paris Agreement (2015), the Arctic Council (since 2008), and the UN International Panel on Climate Change (IPCC) and has committed to addressing climate change through mitigation and adaptation measures. However, Canada is more vulnerable to climate change than other countries[1] that have the capacity and capability to include climate considerations in fisheries advice (Blasiak et al., 2017), indicating the need to step up as an international leader on climate change.

[1] Canada is 54th out of 147 countries in vulnerability, whereas USA is 142nd, Australia is 133rd and European countries range from 79th to 147th according to Blasiak et al. (2017).

The Aquatic Climate Change Adaptation Services Program (ACCASP) is the only dedicated federal source of aquatic climate change science information (DFO, 2020b). The program was created to evaluate risks, impacts, and opportunities for applying science-based adaption tools in decision-making. Starting in 2014, this program began developing a Fish Stock Climate Vulnerability Assessment Tool (FSCVAT) to help fisheries managers determine which commercially valuable species are most vulnerable to climate change. However, the tool is underutilized[2] since it was never publicly released, and without renewed funding, some of the underlying data are outdated. An evaluation was conducted internally by the Evaluation Division of DFO to assess whether ACCASP has achieved expected results and the efficiency of the program in delivering on its objectives. They found that DFO programs are not systematically incorporating climate change considerations in their program design and delivery since there is no departmental guidance to do so (DFO, 2020b). Among primary themes related to fisheries, climate change and ecosystem approaches are currently the least frequently considered in the science and management of Canada's fisheries (Boyce et al., 2020)

Oceana Canada's recent Fishery Audits have included the recommendation to "integrate ocean ecosystem considerations" (Oceana Canada, 2020, 2021). However, there has not yet been a way to measure progress on a yearly basis. In 2022, Oceana Canada conducted an additional analysis to generally assess the extent that climate change effects are incorporated in fisheries management. By adding new indicators that evaluate the extent that climate is currently considered in formal reports, compared to available scientific literature, we aim to highlight knowledge and application gaps for vulnerable species that require urgent management intervention. We strongly urge the Canadian government to formally adopt and integrate ecosystem and climate considerations in all relevant fisheries science and management decision processes. Doing so will foster healthier populations that are more resilient to cumulative impacts resulting from climate change and allow managers to capture greater uncertainty in fisheries forecasts.

Methods

Three indicators were developed to evaluate the extent to which climate change is considered in formal fisheries science and management documents in comparison to the evidence available in the literature (Table 1). The first indicator is based on the inclusion, mention, or absence of climate change effects in official documents. The second indicator determines whether there is supporting, limited, or no literature indicating that the species in question is experiencing climate change effects. The final indicator categorizes the species' vulnerability based on external literature.

To develop the indicators, we reviewed all Integrated Fisheries Management Plans (IFMPs), Rebuilding Plans, and Canadian Science Advisory Secretariat (CSAS) Science Advisory Reports, Research Documents, and Science Responses available up until July 1, 2022. For stocks assessed by regional fisheries management organizations (RFMOs) and stocks jointly assessed by the U.S. and Canada, relevant websites were reviewed for newly available information. Peer-reviewed literature was searched

[2] A report by Oceans North found that only 2 out of 64 (3%) peer-reviewed studies funded by ACCASP that provided decision-makers with information to plan for and adapt to climate change were mentioned in DFO research documents.

in the Google Scholar database using the species name, region, and climate change terms. The search process was applied to all stocks in the 2022 Fishery Audit dataset (n=230), and the results are available in the Appendix spreadsheet at Oceana.ca/FisheryAudit2022. However, the results were analyzed using the index stock list (n=194) to be consistent with all the other annual indicators tracked in Fishery Audits.

While fisheries management currently lacks a national indicator for climate vulnerability on a single-stock basis, a wide range of studies and methods are available in peer-reviewed literature to support vulnerability indicators. We primarily derived climate vulnerability scores from FishBase (Froese and Pauly, 2022) based on Jones and Cheung (2018) and NOAA's Climate Vulnerability Assessments published by Hare et al. (2016) for the same species in neighbouring regions. Vulnerability scores were inferred for 19 species based on the genus or family level when species-level information was unavailable. Only 16 invertebrate populations were assigned an "unknown" category due to an absence of vulnerability information.

Table 1. Three indicators and comment fields used to evaluate the level of inclusion of climate considerations in Canadian fisheries science and management documents compared to the available evidence in the scientific literature. Indicators are included in the Fishery Audit 2022 spreadsheet available at Oceana.ca/FisheryAudit2022.

Indicator	Key	Definition
CLIMATE_INCLUDED	Incorporated	The effects of climate change are considered in the formal fisheries science and management documents (IFMP, CSAS stock assessment) in a written section or integrated in the modelling/projections
	Mentioned	The effects of climate change are mentioned in some capacity in the formal science and management documents (IFMP, CSAS stock assessment) but not integrated in their own section or part of the modelling/projections
	Absent	There is no mention or inclusion of climate change effects in the formal science and management documents (IFMP, CSAS stock assessment)
CLIMATE_SUPPORT	Supported	There is supporting literature on the species experiencing effects of climate change in either the same region or neighbouring region
	Limited	There is limited supporting literature on the species experiencing effects of climate change in either the same region or neighbouring region (i.e., there are no stock-specific studies, but climate effects are documented at the ecosystem or functional group level)

	Absent	There is no supporting literature to support climate change effects on this species in the same region or neighbouring region
CLIMATE_VULNERABILITY	Low/Moderate/High/Very high/Unknown	Climate vulnerability category from FishBase (Froese and Pauly, 2022) based on Jones and Cheung (2018) and from NOAA's Climate Vulnerability Assessments published by Hare et al. (2016) for the same species in neighbouring regions
CLIMATE_COMMENTS	Comment field	Citations/sources used to complete the climate indicator records, and any comments relevant to how climate change may affect the population in question

Results

Availability of climate change data and knowledge in fisheries management and supporting literature

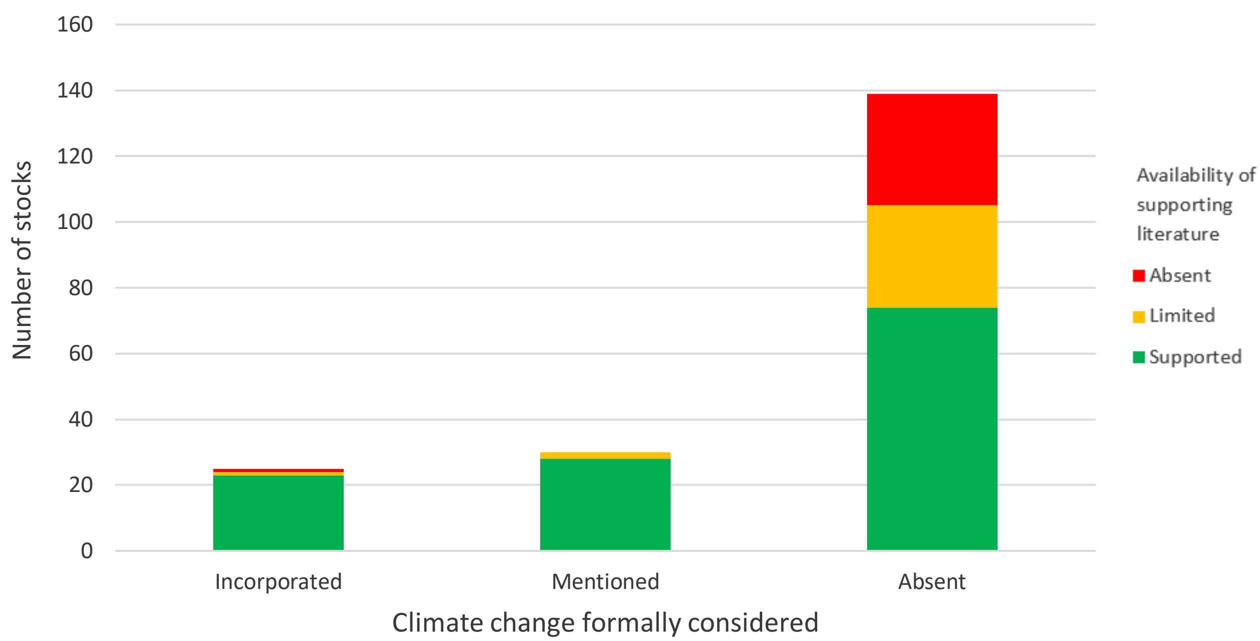


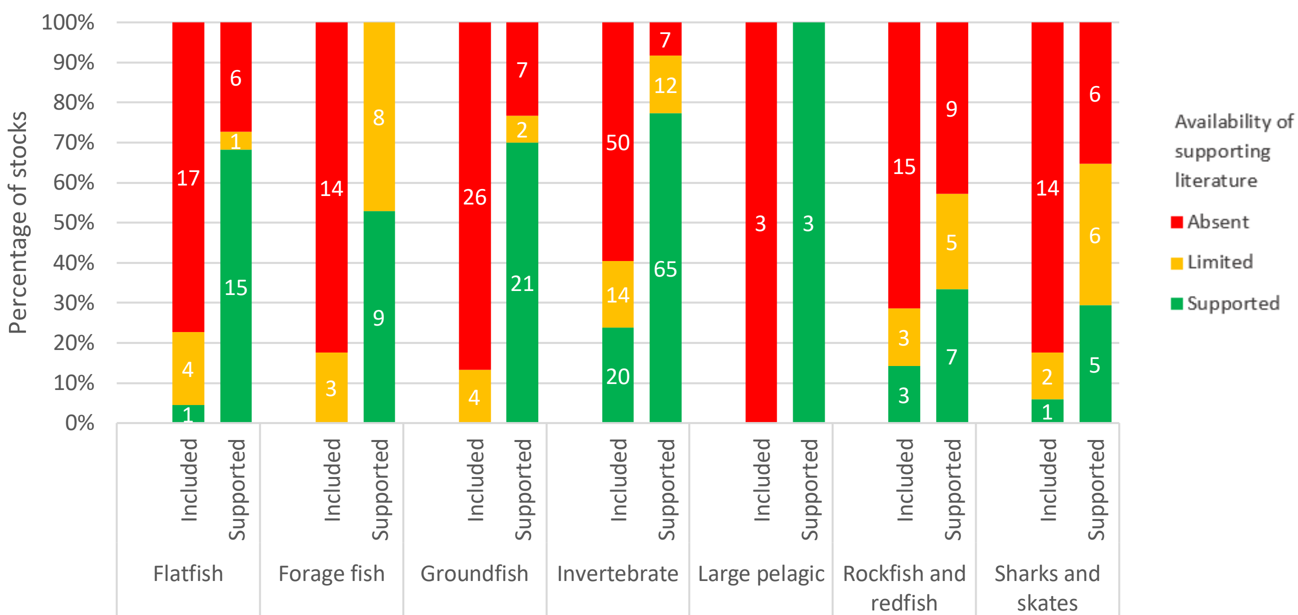
Figure 1. The number of Oceana Canada index stocks (n=194) with climate change formally considered in fisheries science and management documents and the availability of supporting literature within each bar.

Table 2. The percentage and number of Oceana Canada index stocks (n=194) with climate change formally considered in fisheries science and management documents and the availability of climate change effects in supporting literature for stocks.

	Climate change effects available in supporting literature

		Supported	Limited	Absent	Total
Climate change effects formally considered	Incorporated	11.9% / 23	0.5% / 1	0.5% / 1	12.9% / 25
	Mentioned	14.4% / 28	1.0% / 2	0.0% / 0	15.5% / 30
	Absent	38.1% / 74	16.0% / 31	17.5% / 34	71.6% / 139
	Total	64.4% / 125	17.5% / 34	18.0% / 35	100.0% / 194

In 2022, only 12.9 per cent (n=25) of Oceana Canada's marine fish and invertebrate index stocks fully incorporate climate change effects within the latest departmental science and management documents in a dedicated written section or integrated in models (Figure 1; Table 2). Another 15.5 per cent (n=30) mention the effects of climate change in some capacity. However, 71.6 per cent (n=139) do not mention or include climate considerations in science and management documents, despite peer-reviewed evidence that indicates the species in the same or neighbouring area is experiencing climate-induced effects in over half of these stocks (54.1 per cent or n=105). Seven stocks were automatically marked with absent information, due to a lack of available management documents. Overall, there is supporting literature for 82 per cent (n=159) of the stocks in this dataset.



Taxa and climate change considerations included formally or supported by external literature

Figure 2. The percentage of Oceana Canada index stocks (n = 194) with climate change formally included in fisheries science and management documents and the availability of supporting literature within each bar, by taxa groups. The number of stocks in each consideration-taxa combination are reported in white font within the bars.

Table 3. The number of Oceana Canada index stocks (n = 194) with climate change formally included in fisheries science and management documents and the availability of supporting literature within each bar, by seven taxonomic groups.

Taxonomic group	Climate change considerations	Incorporated/ Supported	Mentioned/ Limited	Absent	Total
Flatfish	Included	1	4	17	22
	Supported	15	1	6	22
Forage fish	Included	-	3	14	17
	Supported	9	8	-	17
Groundfish	Included	-	4	26	30
	Supported	21	2	7	30
Invertebrate	Included	20	14	50	84
	Supported	65	12	7	84
Large pelagic	Included	-	-	3	3
	Supported	3	-	-	3
Rockfish and redfish	Included	3	3	15	21
	Supported	7	5	9	21
Sharks and skates	Included	1	2	14	17
	Supported	5	6	6	17

Table 3 shows that formal inclusion of climate change effects is lacking for all forage fish, groundfish and large pelagics and is limited for flatfish, rockfish and redfish, sharks and skates. However, there is supporting literature for 53 to 100 per cent of stocks in these taxonomic groups (Figure 2).

For instance, peer-reviewed literature on all 17 forage fish stocks is readily available and indicates that these species are being impacted by climate change. Climate is mentioned as a source of uncertainty for capelin stocks (n=2) in formal documents, which note that an increase in the magnitude and frequency of environmental anomalies will likely increase the uncertainty of stock dynamics. According to peer-reviewed research, capelin can be viewed as a sea "canary" for how northern maritime ecosystems respond to climatic variability and change (Rose 2005), and populations are moving northward because of climate change (Huse and Ellingsen, 2008). Additionally, formal documents for four critically depleted forage fish stocks[3] do not adequately address the consequences of climate change, even though there is evidence to support such implications. Furthermore, formal documents for three large pelagic stocks[4] do not include climate change effects at all, despite widespread support in the literature.

Compared to other taxonomic groups, the percentage of departmental documents that mention climate change effects is highest for invertebrate stocks, at around 40.5 per cent (n=34). Peer-reviewed

[3] Herring 4T (Spring Spawner), Herring 4VWX, Mackerel (Atlantic) NAFO 3-4 (NAFO subareas 3 and 4), and Herring Haida Gwaii (Pacific QCI). Earlier in 2022, the commercial fisheries were closed on Herring 4T (Spring Spawner), Mackerel and Herring Haida Gwaii, and the commercial TAC on Herring 4VWX was reduced by 33%. Those management actions represent significant actions to conserve and recover these stocks. Future decisions should also consider for the risk and uncertainty associated with climate impacts and be informed by assessments that include available scientific evidence of climate change effects.

[4] Albacore tuna, Atlantic bluefin and swordfish in the Atlantic Ocean

literature explores and documents the effects of climate change in 91.7 per cent (n=77) of invertebrate populations.

Identifying science/management gaps for vulnerable and critically depleted stocks

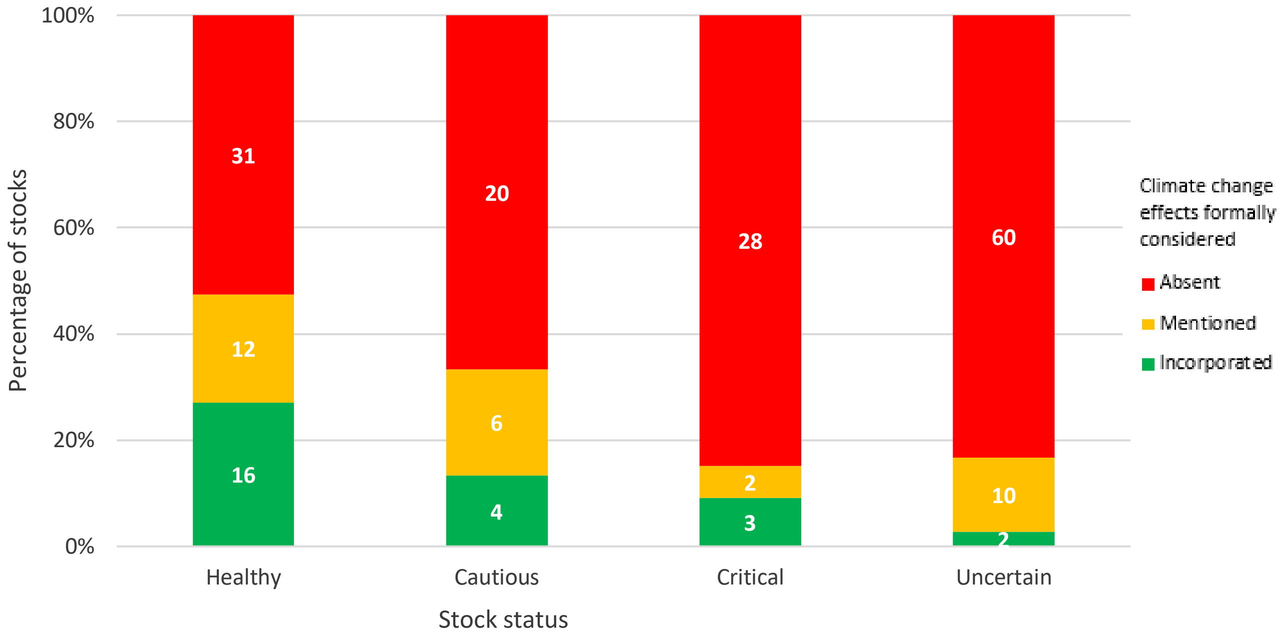
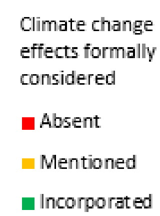


Figure 3. The percentage of Oceana Canada index stocks (n=194) in each of the status zones described in DFO's precautionary approach framework (DFO, 2009) with climate change formally considered in government fisheries science and management documents within each bar. The number of stocks is reported in white font within the bars.

There are more assessments and management plans that fully incorporate climate change effects for stocks that are healthy (47.5 per cent or n=28) than all other states combined (critical, cautious, uncertain). However, even within healthy stocks, over half do not mention or incorporate climate change information (52.5 per cent or n=31). The vast majority of critical and uncertain stocks do not take climate change into account in relevant documents (critical: 84.8 per cent or n=28, uncertain: 83.3 per cent or n=60).



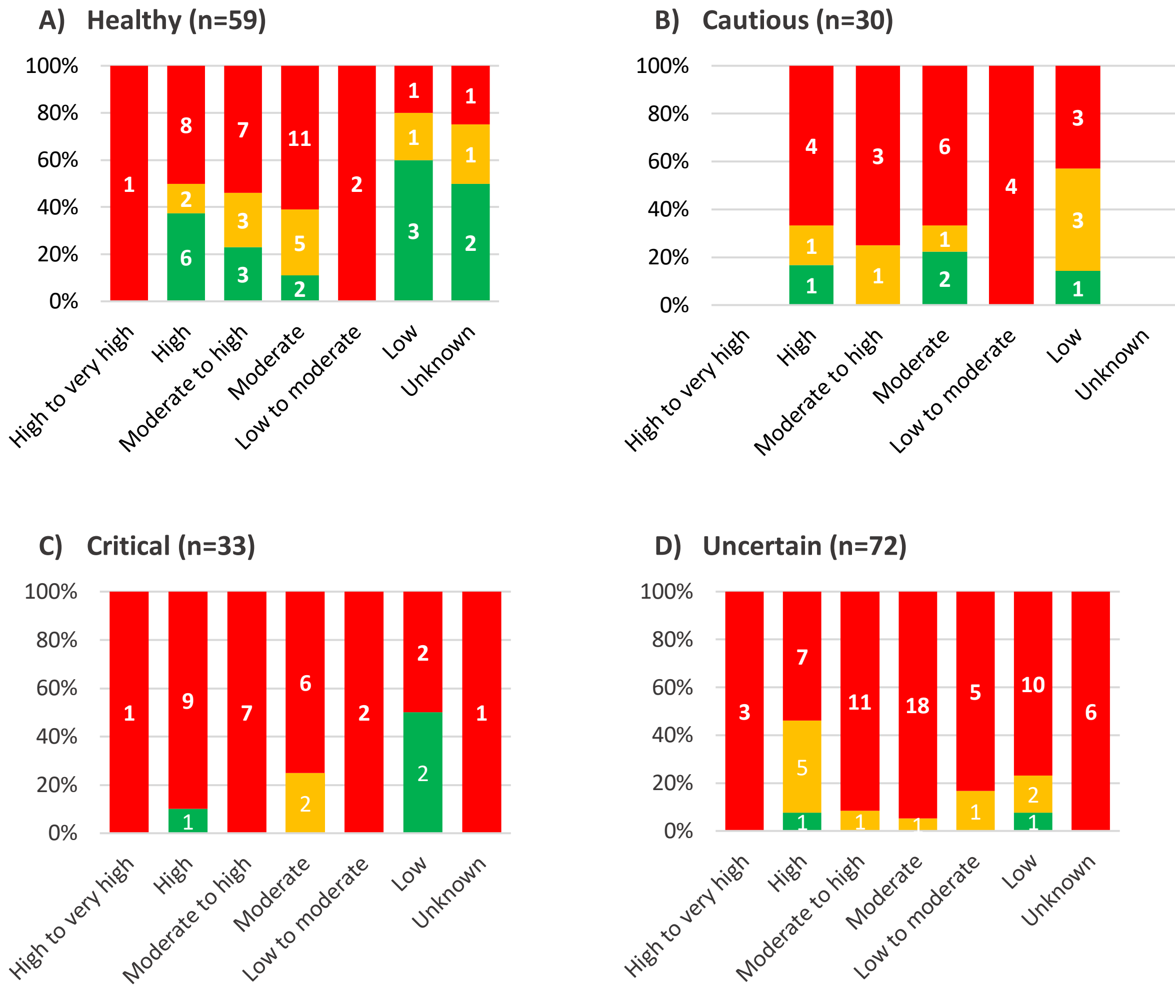


Figure 4. The percentage of Oceana Canada index stocks (n=194) in each of the health status zones (A, B, C, D) described in DFO's precautionary approach framework (DFO, 2009), by vulnerability range, with climate change formally considered in government fisheries science and management documents within each bar. Red bars indicate that climate change effects have not been considered, yellow bars indicate that climate change effects have been mentioned, and green bars indicate that climate change effects have been incorporated into formal documents. The number of stocks within each status-vulnerability combination are reported in white font within the bars.

All the stocks with the highest vulnerability scores[5] are missing formal climate change considerations (Figure 4). Nine critically depleted shrimp stocks in the Pacific (n=8) and Atlantic (n=1) are highly vulnerable to climate effects (Figure 4c). Despite the absence of climate change effects in formal documents for shrimp stocks, there is literature that suggests elevated temperatures, shifts in predator distributions, and ocean acidification may have a significant impact on shrimp, potentially causing population collapse (Walline and Sibley, 1984; Arnberg et al., 2013; Richards and Hunter, 2021). The low

[5] The 5 stocks with "High to very high" vulnerability are 2 whelk stocks in Newfoundland and Labrador and 3 yellowtail flounder stocks in the Gulf and Maritimes region

vulnerability category contains the greatest coverage of climate considerations (63.6 per cent or n=7). There are six stocks that are uncertain status with unknown vulnerability (Figure 4d; all invertebrates). Supporting literature suggests that climate change can impact at least two of these stocks.[6]

Discussion

Overall, there is a discrepancy between available knowledge about climate change effects on marine populations and the incorporation of climate change effects into advisory documents and management of those populations. Climate considerations are more common in departmental documents for healthier, less vulnerable stocks than for critically depleted, highly vulnerable stocks, leaving these stocks in "double jeopardy" from both poor status and high climate risk (Boyce et al., 2022). This suggests that resources for analyzing climate effects might be misdirected, and management may have overlooked actions for stocks in need of urgent attention. Documents for key taxa such as forage fish, groundfish, and large pelagics are missing climate change information that exists in supporting literature, leaving management gaps that may have wider ecosystem implications. Uncertainty is frequently cited as a limitation for using environmental information to provide advice (Boyce et al., 2021), as reflected by the lack of climate considerations for stocks without a defined status.

These findings are similar to both Oceans North's and DFO's comprehensive literature reviews to understand how climate change is currently addressed in fisheries management (Boyce et al., 2020; Pepin et al., 2020). Based on DFO's review of recent stock assessments, it was found that climate, oceanographic, and/or ecological information was incorporated into nearly half of the assessments, but only 27 per cent of the recommendations included these factors (Pepin et al., 2020). If resources and funding are made available, DFO anticipates that the majority of remaining stocks will be able to incorporate ecosystem knowledge into future assessments (Kulka et al, 2022). Oceans North found that climate change themes were present in just 11 per cent of all DFO research documents and often mentioned only once, indicating that it is not routinely considered in the DFO science basis that informs the advisory process (Boyce et al., 2020). Other related themes like climate vulnerability and forecasting were also infrequent (<3 and <19 per cent, respectively) but have been increasing over time (since around 2015), primarily in IFMPs. Overall, the current approach to incorporating environmental parameters into assessments consists of ad hoc methodologies (Kulka et al., 2022). These reviews, in addition to the findings in our current analysis, emphasize the need for an overarching strategy to drive climate adaptation forward.

In 2022, a highly anticipated National Climate Change Adaptation Strategy Consultation was initiated to advance climate preparedness across five key systems: health and wellbeing, natural environment, infrastructure, economy, and disaster resilience (Government of Canada, 2022). Fisheries are listed as an industry at greatest risk of impact within the "economy" system. Among the objectives for 2030, Objective 5 aims to complete conservation and restoration practices and plans, monitoring programs, and management practices for the ecosystem services most affected by climate change to ensure their

[6] Supporting literature for Green sea urchin - Northern Estuary and Gulf of St. Lawrence suggests that climate change is driving pathogenic mortality events and increased frequency and intensity of tropical storms in key habitat in Nova Scotia (Scheibling et al., 2013). In addition, Pacific krill biomass is projected to decline due to climate change (Goyert et al., 2018; Tulloch et al., 2019).

continued viability and adaptive capacity. A national approach would help ensure a climate-change lens is consistently adopted in science advice that informs the delivery of mandated responsibilities.

The national strategy should build off existing knowledge that addresses climate change variability, such as a framework developed by Duplisea et al. (2020) for risk-based decision-making that considers climate to be a risk[7] that increases over time (Roux et al., 2022). Risk management is about making decisions under uncertainty that are informed by assessments that explore the degree of exposure to human pressure and adjust objectives to be within acceptable risk tolerance levels. This approach uses climate-change-conditioned advice (CCCA), which clearly considers climate change when calculating the likelihood that an objective is met (for example, a population is above its target) and advises adjustments to the fishery to compensate for changes. Similar types of risk-equivalency methods are used across many progressive fishing nations and organizations including Australia, New Zealand, the United States and the International Council for the Exploration of the Sea (ICES). In these frameworks, risk is a consistently assessed and applied in management, regardless of data limitations. International jurisdictions also apply Management Strategy Evaluation (MSE) approaches to develop robust decisions on climate change. MSE has been employed in select Canadian fisheries for harvest strategy development (DFO, 2021), but it has not been used to investigate climate scenarios. Given the widespread uncertainty in determining how marine ecosystems will react to pressures from humans in the present and in the future, risk-based frameworks are extremely relevant to ocean governance in the face of climate change (Roux et al., 2022).

Risk-based frameworks and overarching strategies must be supported by the best available science. Using vulnerability assessments to support climate change adaptation is a critical component of marine management that is not widely applied. Recently, Boyce et al. (2022) developed a Climate Risk Index for Biodiversity (CRIB) framework to assess vulnerability and risk for 2,045 species, including 90 fish stocks, in the northwest Atlantic Ocean under high emission and high mitigation climate scenarios. Overall, harvested and commercially valuable species, like lobster and snow crab, experience more than triple the risk of exposure to harmful climate conditions than non-harvested species (Boyce et al., 2022). Invertebrates received the most coverage on climate change in both formal documents and external literature, which could be partly related to their economic importance or to a better understanding of range shifts compared to other taxa and the effects of ocean acidification on shell-forming species. However, harvested species were more adaptive than non-harvested species and also benefitted considerably from emission mitigation that reduced their exposure risk across native spatial distributions (Boyce et al., 2022). Assessing climate risk with spatial and temporal dimensions helps identify the species, location, and timelines necessary to prioritize resources that enable climate-resilient management measures (Holsman et al., 2019).

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[7] It is expected that most stocks will experience increased risk over time. For example, Greenland halibut (turbot) has a specific environment that experiences small annual or interannual fluctuations. Increasing temperatures in the Gulf of St. Lawrence caused by climate change are negatively affecting shrimp, turbot's main prey, and positively affecting redfish, a competitor for turbot. These ecosystem changes are considered an incremental risk to the fishery, where fishing mortality is the main tool to manage the population, so it managing fishing mortality should account for the risk posed by climate effects (Duplisea et al., 2021).

In addition to the marine stocks analyzed, there are also important anadromous and freshwater fishes that are experiencing effects from climate change at every stage of their life cycle. Inland disturbances from forest fires, floods, low summer flow, and high stream temperatures affect species, as do rising sea levels, temperatures, and acidification in the ocean. For example, persistent warmer temperatures and marine heat waves are affecting the quality of food for juvenile salmon, resulting in poorer year classes (Jackson et al., 2018; von Biela et al., 2019). DFO found that assessments of salmonids were more likely to make use of climate, oceanographic, and ecological data than other taxa (Pepin et al., 2020). The Pacific Salmon Foundation's Watershed Program developed vulnerability assessments for Pacific salmon populations across British Columbia to help inform and prioritize conservation and mitigation actions to increase salmon resilience. The assessments use indicators on stream temperature, flow, sea surface temperature, and shoreline inundation, along with the magnitude of exposure, biological sensitivity, and adaptive capacity to determine each population's relative vulnerability (Pacific Salmon Foundation, 2022). Management should use vulnerability assessments of anadromous and freshwater fish species in order to inform measures to protect both critical watersheds and vulnerable species.

Climate change and its effects on fish populations have far-reaching consequences for Canadian society. The perspectives and input of harvesters and Indigenous peoples, who are at the forefront of the fish stewardship, are critical to identifying priority areas for dealing with climate change and fisheries concerns. In the Pacific, harvesters are concerned about fishery management, access, and habitat loss, and they support participatory processes that will contribute to adaptive management effects (Harper et al., 2022). Perceived impacts from climate change are linked to cultural values such as identity, tradition, and freedom, and First Nations across coastal British Columbia express the need for community-based strategies to manage and adapt to those impacts (Whitney et al., 2020). Harvesters in herring and salmon fisheries are perceived as more socially vulnerable, whereas crab, halibut, and rockfish harvesters are perceived as less vulnerable to climate effects (Harper et al., 2022). In the Atlantic, both New Brunswick and Nova Scotia are expected to see declines in shellfish accessibility, and while Prince Edward Island and Newfoundland and Labrador are expected to experience relatively minor net changes in access, they are highly socially vulnerable to potential losses in fisheries (Wilson et al., 2020). Therefore, accounting for social vulnerability and fishers' perspectives are also key to developing effective strategies for building resilient seafood economies as well as for adapting to challenges and emerging opportunities.

Appropriate management measures can both improve fisheries status and offset climate change effects (Gaines et al., 2018). Unfortunately, with each passing day that adaptation efforts are put off, the risks that climate change pose to fisheries continue to grow. Knowledge and application gaps are evident throughout Canada's fisheries, pointing to the opportunity to intervene with robust and well-informed management. Oceana Canada recommends ensuring that the effects of climate change are consistently considered in the science that informs fisheries management decisions by integrating environmental variability into both assessments and advice that are based on risk and uncertainty. Measures should be taken to prioritize rebuilding critically depleted populations that are highly vulnerable to climate change effects (Stortini et al., 2015), as well as those stocks important for food security, economy, social, and cultural values underpinning coastal communities. The suite of tools developed by scientists and knowledge holders should help shape a national strategy to mobilize action on climate change to sustain sociocultural systems and ensure thriving fisheries for future generations.

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