Migratory Species and Climate Change Expert Workshop

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DECISION 14.214(b) CLIMATE CHANGE VULNERABILITY ASSESSMENT METHODOLOGIES

(Based on a document prepared by the UK Government)

15 January 2025

Background paper on addressing CMS Decision 14.214 b):

Identify those migratory species that, on balance, are likely to be negatively impacted by climate change, especially those that are likely to need human-mediated interventions, such as translocations, to moderate the impact of climate change

Summary

At CMS COP14 in February 2024, Decision 14.214(b) requested the Scientific Council, subject to the availability of external resources, to "*identify those migratory species that, on balance, are likely to be negatively impacted by climate change, especially those that are likely to need human-mediated interventions, such as translocations, to moderate the impact of climate change*" (CMS, 2024a).

This paper provides an overview of possible approaches to addressing this decision and provides options for a way forward for consideration by the CMS Migratory Species and Climate Change Expert Workshop.

Key questions for the workshop

The CMS Migratory Species and Climate Change Expert Workshop is invited to review this document and its Annexes and to consider the following questions:

- What are the key aims and desired outcomes from Decision 14.214 (b)?
- What is/are the most appropriate approach(es) to achieving this?

Contents

1. Background

Responses to climate change tend to be species-specific, making it difficult to identify individual policy interventions to reduce the impact of climate change on migratory species. To address this knowledge gap, Resolution 9.7 in 2008 urged Parties to "*identify which migratory species are most likely to be directly or indirectly threatened or impacted by climate change or climate change mitigation or adaptation activities, based on best available evidence and by initially assessing Appendix I species and species listed on Appendix II already known to be affected by climate change*" (CMS, 2008).

The Zoological Society of London (ZSL) was commissioned to conduct a preliminary review of climate change impacts on migratory species. A preliminary report published in 2010 proposed a methodology to assess migratory species' vulnerability to climate change and applied this methodology to 44 species listed on CMS Appendix I, and one species listed on Appendix II (McNamara, 2010). The results for these case study species are presented within the ZSL report (McNamara, 2010). However, no subsequent work was undertaken to review the methodology or apply it to further migratory species, and it was proposed at the 2011 meeting of the CMS Working Group on Climate Change that the ZSL methodology could be integrated with others, such as that developed around the same time by IUCN (Böhm, 2011).

At CMS COP12 in 2017, Resolution 12.21 contained a "*Programme of Work on Climate Change and Migratory Species*" (CMS, 2017) which proposed that Parties and other stakeholders should: "*identify and promote a standardized methodology for evaluating species' vulnerability to climate change*", and to apply this methodology to species listed on the CMS Appendices, then to other migratory species.

In support of CMS work on climate change, the UK Government, through a contract to the British Trust for Ornithology (BTO) funded by the Department of Environment, Food and Rural Affairs (Defra) via the Joint Nature Conservation Committee (JNCC), commissioned a review of the latest evidence on the impacts of climate change on migratory species, with regard also to conservation actions, indicators and ecosystem services (Martay *et al* 2023). The review examined the literature on the impacts of climate change on each class of species within the CMS Appendices from 2005 to present, to identify new research that has been undertaken since the previous reviews of climate change impacts on migratory species (McNamara, 2010; Robinson et al 2005).

At CMS COP14 in 2024, Resolution 12.21 was revised and its Programme of Work on Climate Change and Migratory Species contained the following actions (CMS, 2024b):

- "Undertake climate change vulnerability assessments for CMS-listed species at an appropriate scale (national, regional, international), including consideration of the impacts of changes in the ecosystems that migratory species use, to identify those species most susceptible to climate change."
- "Undertake climate change vulnerability assessments for other migratory species, not currently listed on CMS, to identify which, if any, may benefit from work under the CMS family instruments."
- "Model projected future impacts of climate change to inform vulnerability assessments and action plans."
- "Determine if species vulnerable to climate change should be listed on the CMS Appendices, as appropriate."

Further, Decision 14.214(b) requested the Scientific Council, subject to the availability of external resources, to "identify those migratory species that, on balance, are likely to be negatively impacted by climate change, especially those that are likely to need human-mediated interventions, such as translocations, to moderate the impact of climate change" (CMS, 2024a).This paper evaluates possible options for achieving Decision 14.214(b) and presents a case study of a suggested approach.

2. Defining the aims and scope of Decision 12.214(b)

Decision 12.214(b) contains two clauses: (i) "identify those migratory species that, on balance, are likely to be negatively impacted by climate change", and (ii) "especially those that are likely to need human-mediated interventions, such as translocations, to moderate the impact of climate change".

Clause (i) requests that the Scientific Council identifies migratory species likely to be negatively affected by climate change. It does not limit the scope to species listed on the CMS Appendices, and it does not request that species' relative vulnerability to climate change are assessed, quantified or ranked. Nevertheless, it may be appropriate to prioritise species listed on Appendix I and then Appendix II, and the identification of species at greatest risk from climate change impacts, or at risk of the greatest impacts, may facilitate the optimal targeting of responses.

Clause (ii) requests that the Scientific Council identifies species that are likely to need interventions, such as translocations. This suggests that, in addition to assessing species' vulnerability, CMS seeks to identify target populations for intervention and appraisal of necessary conservation responses should be evaluated alongside to develop recommendations. Alternatively, it may be appropriate to assume that species at particular risk from climate change impacts are likely to require conservation interventions, and thus to address this clause by assessing species' relative vulnerability to climate change.

Before selecting a methodology to implement Decision 12.214(b), it will be important to determine the goals of the Decision, which may be one of more of the following:

- *How* migratory species are likely to be affected by climate change (*i.e.* mechanisms of impact).
- *Which* migratory species are at risk from negative impacts of climate change?
- *Which* migratory species are *at greatest risk* from negative impacts of climate change?
- *What* conservation measures do migratory species require to mitigate the impacts of climate change?
- *Which* species most urgently require conservation measures to allow them to adapt to climate change?

Consideration should be made of likely resource implications and utility of answering these questions. For example, it may be deemed to be essential to assess species' relative vulnerability to climate change in order to prioritise species for adaption measures. Conversely, a more basic assessment of climate change pressures on migratory species may inform selection of conservation measures, whilst existing metrics of species' risk (such as the IUCN Red List or CMS Appendices) could be relied on to prioritise species.

Further important decisions include:

- The geographic scope(s) of the assessment (*e.g.* global, regional, national)
- The time-scale under consideration.

3. Assessing how species are likely to be impacted by climate change

Identification of the climate change-related pressures that species may be exposed to, and the range of mechanisms by which those pressures are likely to affect the species, can be a valuable exercise in itself to inform identification of effective conservation responses. Further, it is an important first step to inform selection of an approach for any further assessment of species' climate vulnerability, and the variables and/or traits to include (Foden *et al* 2019).

Assessment of climate change pressures and mechanisms of impact may be made through a systematic literature review, and/or through expert consultation (*e.g.* McNamara, 2010). The full range of pressures and impact mechanisms that species are likely to be exposed to should be considered, and the likely relative or absolute magnitude of impacts can also be categorised and potentially prioritised, taking into account knowledge of species; sensitivity and adaptive capacity (Foden *et al* 2019).

For a recent study focussing on Western European seabird species (Häkkinen *et al* 2022), the authors compiled information from existing literature on direct and indirect pathways by which climate change may affect the focal species. They then asked species experts to review and edit this list and to rate how concerned they were about each threat on a scale of 1-5. The responses were compiled and scores combined to assign each threat an overall rank.

4. Assessing which migratory species are at greatest risk from negative impacts of climate change

A large number of studies – known as Climate Change Vulnerability Assessments (CCVAs) – have attempted to assess species' relative climate change vulnerability. Climate change vulnerability is commonly defined by the conservation community as per the IPCC's fourth assessment report, which defines vulnerability as a function of sensitivity, adaptive capacity and exposure (the magnitude and rate of climate change to which the system is exposed) (Intergovernmental Panel on Climate Change, 2007). Sensitivity is defined as, "*the degree to which a system is affected, either adversely or beneficially, by climate variability or change*" (Intergovernmental Panel on Climate Change, 2007). Adaptive capacity is defined as, "*the potential, capability, or ability of a species, ecosystem or human system to adjust to climate change, to moderate potential damage, to take advantage of opportunities, or to respond to the consequences*" (Intergovernmental Panel on Climate Change, 2007). Exposure is not defined by the IPCC, but is defined by the IUCN SSC as "*the nature, magnitude and rate of climatic and associated environmental changes experienced by a species*" (Foden, 2016). In practice, the distinction between sensitivity and adaptive capacity is ambiguous, and there is much inconsistency in the use of one term or the other among CCVA methodologies.

Identifying and making use of existing studies of species' climate change vulnerability to fulfil Decision 14.214 (b) may be an efficient use of resources and would allow us to take into account a wide range of mechanisms of climate change impacts and the full range of methods for identifying them. However, existing studies are unlikely to have applied a consistent methodology across all migratory taxa, meaning that it would not be possible to provide a consistent ranking of species' climate change vulnerability across all species within scope.

A wide range of methods have been developed to assess species' vulnerability to climate change. It may be possible to utilise an existing method, potentially with adaptations, to conduct our own assessments of the climate change vulnerability of migratory species. Whilst this would require greater resource input that simply taking the results of published assessments, it would allow us to make more consistent assessments across all species of interest, and could therefore allow for assessment of which migratory species are likely to be at greatest risk from climate change and require intervention.

If it is determined that neither existing assessments nor existing methodologies meet our needs, then it may be necessary to design a new CCVA methodology.

4.1. Additional considerations on the use of climate change vulnerability assessments to prioritise species for climate change adaptation measures

When considering prioritisation to effectively produce a species '*triage'* list there are many variables to consider other than its climate change vulnerability alone, such as having a high extinction risk according to the IUCN Red List, small or declining population size or restricted distribution, along with any existing species conservation actions that may act to mitigate climate change impacts and other threats. It is important to consider the scope of impacts of climate change in relation to other threats that may be impacting the species.

4.2. Review of approaches and methodologies of published species climate change vulnerability assessments

The assessment of species' vulnerability to climate change has received much research attention over recent decades, but most approaches can be placed into one of three main types (or a combination thereof): 1) trait-based; 2) correlative; and 3) mechanistic The summaries of these approaches below are based on reviews carried out by Pacifici *et al*. (2015) and Foden *et al*. (2016).

4.2.1. Trait-based approaches (TVAs)

Trait-based Vulnerability Assessment (TVA), such as that developed for CMS by ZSL in 2010, were among the earliest used approaches, but they remain largely unvalidated. They use species' biological traits to assess their vulnerability to climate change, often in combination with a measure of their exposure to climate change. They allow relatively rapid vulnerability assessment for multiple species without requiring modelling expertise, capture the many cross cutting mechanisms of climate change impacts, and consider traits affecting species' individual responses to climate change. They are applicable to all species, irrespective of their range size or availability of fine-scale distribution data, meaning they can be widely applied to most taxonomic groups. This makes them particularly useful for broad-scale conservation assessments (Foden and Young 2016) and they have been widely-used by conservation organisations to inform species prioritisation exercises for conservation responses *e.g*. *(Advani, 2014; Foden et al 2013; McNamara, 2010; Young et al 2015)*.

However, the precise relationships between species' traits and their vulnerability to climate change are often poorly known, so the criteria used to assign vulnerability scores may be estimated or based on arbitrary thresholds. The relative contributions of traits to a species' overall vulnerability to climate change are likely to differ and are often poorly understood, and thus are often not accounted for in species' overall vulnerability classifications, with many methods simply weighing traits equally. TVA methods also often utilise traits that are specific to a particular species group, meaning that results are not comparable between groups. Most TVA methods have not been validated, so their reliability in correctly predicting the species that will be most affected by climate change is not known, and different TVA methods that make use of different traits and thresholds can produce different results for the same species (Lankford *et al*. 2014).

4.2.2. Correlative approaches

Correlative approaches (also known as niche-based or species distribution models) use models to relate a species' observed geographic distribution to current climate and project its future distribution according to climate projections based on inferred climatically suitable areas. These approaches have been applied to a wide range of taxa at various spatial scales (Garcia *et al*. 2014; Gregory *et al* 2009).

Correlative approaches assume that species' distributions are in equilibrium with their climates, ignoring the potential influence of other factors on species' distributions, such as barriers and habitat loss. They ignore mechanisms of climate change impacts other than changes in climatic suitability, as well as species' biological traits that may affect their susceptibility to climate change. Correlative approaches require sufficient reliable data on species observations, so may not be possible for poorly-known species, and they require modelling expertise and technical capacity.

Nevertheless, correlative approaches have been found to correctly predict observed range shifts caused by climate change (Stephens *et al* 2016). They can be applied quickly and relatively cheaply, and in the absence of species' biological data. An additional benefit is that their outputs can be useful to inform spatial planning of conservation responses.

4.2.3. Mechanistic Approaches

Mechanistic models predict species' responses to climate change by modelling how their biological processes or physiological tolerances relate to climate variables (Kearney & Porter, 2009; Monahan, 2009). They can include a wide variety of climate change impact mechanisms, such as changes in habitat suitability, land use, and species interactions, and they can incorporate species-specific variables such as dispersal distances. Because they take account of the mechanisms of climate change impacts, they can be particularly useful for informing conservation responses. However, they require detailed data on species' physiology, demography and distributions, and technical expertise, and they are relatively expensive. For these reasons, they are more suitable for vulnerability assessments of better-known species.

4.2.4. Combined Approaches

There is growing consensus that combined approaches may achieve better results than using one of the above approaches alone (Foden, 2016). For example, Thomas *et al.* (Thomas *et al* 2011) combined observed population trends and projected changes with species' traits (such as generation length) using defined criteria to categorise UK species by climate change vulnerability. TVA approaches can be combined with correlative approaches by incorporating species' traits into models of distribution changes under climate change, or by using correlative models to assess species' exposure to climate change and incorporating the results into TVAs (Garnett *et al* 2013; Willis *et al* 2015; Young *et al* 2012). Correlative or mechanistic approaches can be incorporated into species' IUCN Red List assessments, based on the IUCN Red List Categories and Criteria (Mancini *et al* 2024).

4.3. Considerations for choosing a method to assess species' climate change vulnerability

This section summarises some of the main considerations that should be made when selecting a methodology to assess species' vulnerability to climate change.

4.3.1. Is the method robust?

Many CCVAs have not been validated with real-world data. A study that compared the outputs of several approaches with trend data for British birds and butterflies found that the success of the approaches varied, with trend-based approaches performing better than trait-based approaches, and disagreement between the vulnerability categories assigned to species by different approaches (Wheatley *et al*. 2017). Trait-based approaches may make use of estimated or arbitrary quantitative thresholds and make assumptions about the relative contributions of traits to species' vulnerability.

4.3.2. Can the approach meet the objectives?

Whilst all approaches described here aim to assess climate change impacts on species, not all are able to identify which species are likely to be at greatest risk from climate change. Mechanistic or correlative approaches are able to quantify some impacts of climate change, but not necessarily all mechanisms by which species may be affected. TVAs can incorporate a broad range of climate impact mechanisms, and they may be used to rank or score species' climate change vulnerabilities, but scores may not be comparable across taxonomic groups.

4.3.3. Are sufficient data available?

The information required to assess species' climate change vulnerability varies widely between CCVA approaches. Whilst a trait-based assessment may be applied using basic information about species' distributions and biological traits, correlative approaches are likely to require more detailed distribution and environmental information, whilst mechanistic approaches require detailed data on species' physiology, demography and distributions.

4.3.4. Are sufficient capacity and expertise available?

Mechanistic and correlative approaches require capacity and expertise to produce quantitative models. Trait-based approaches can often be applied relatively rapidly to multiple species or entire taxonomic groups, and may require only the abilities to collate information into a spreadsheet and make simple calculations. All approaches require at least some level of biological expertise.

4.4. Review of some published species Climate Change Vulnerability Assessments and their methodologies

A literature review was carried out to identify and review published CCVAs that assessed large numbers of species and that may be suitable to use or adapt to address Decision 12.214(b). The review identified four trait-based or combined approaches:

1. CMS/ZSL Methodology (McNamara, 2010)
2. IUCN CCVA Methodology (Foden *et al* 2013)
3. NatureServe Climate Change Vulnerability Index (CCVI) (Young *et al* 2012, 2015)
4. WWF Climate Change Vulnerability Assessment for Species (Advani, 2014)

A more detailed review and comparison of these four published CCVA methodologies can be found in Annex A.

The number of CMS Appendix I listed species assessed under each of these four methods was reviewed, and their vulnerability ratings compiled, to provide a snapshot view of the existing coverage of Appendix I species by these methodologies. Of 188 species listed on Appendix I, 44 species were assessed by ZSL and 103 were assessed by IUCN.

4.4.1. CMS/ZSL Methodology

The CMS/ZSL method was developed for CMS in 2010 and was applied to 44 pilot species listed on CMS Appendix I and one species listed on Appendix II. It uses a qualitative scoring system that involves selecting the most appropriate scenario of five across each of 12 ‘factors’, classed under the following four headings:

- Vulnerability of habitats
- Ecological flexibility
- Species interactions
- Synergistic threat processes.

The same factors are applicable across all species assessed, and climate change impacts are taken into account within the scenarios.

Limitations include: scope for assessor subjectivity and bias, substantial resource requirements per species assessment, and limited consideration of a species’ exposure to climate change. A species may be graded as having a high vulnerability based on its degree of specialisation or dispersal ability, in the absence of other indications of climate sensitivity or known impact mechanisms.

4.4.2. IUCN CCVA Methodology

The IUCN CCVA methodology was applied to all the world's birds, amphibians and warm-water reef-building corals, resulting in climate change vulnerability assessments of 16,857 species (Foden *et al.* 2013). It assesses species' sensitivity and adaptive capacity through assessment of seven standardised '*trait sets*' and combines the results with a measure of exposure to climate change derived using spatial analysis. The assessment of each trait set is not standardised and is tailored according to the availability of information relevant to that trait set for the taxonomic group being assessed. Scoring criteria or thresholds are semi-quantitative and vary according to the trait. The methodology has a clear logical framework which aims to provide a degree of consistency across species, and some traits can be assessed using large existing datasets across batches of species. Disadvantages include a lack of consideration of current/past climate change impacts and inconsistencies in the traits considered for different taxonomic groups. Assessment of exposure requires capacity for spatial analysis.

4.4.3. NatureServe Climate Change Vulnerability Index

The NatureServe Climate Change Vulnerability Index is designed to provide a rapid, cost-effective means of estimating a plant, fungus, or animal species' relative vulnerability to climate change, and is widely used in North America. The method, which is available as an Excel spreadsheet, uses a trait-based approach to assess species' sensitivity and adaptive capacity. Exposure is assessed by uploading or drawing a map of the species' range in an online tool, which calculates projected changes in temperature and drought within the species' range. Scoring is semi-quantitative and relies on selecting from multiple-choice options. The provision of an Excel spreadsheet and online tool makes the method very user-friendly, and it considers a broad range of traits across all focal species. An unusual aspect of this method is its ability to reflect uncertainty. However, the tool is designed for use in North America, so its spatial analysis tool may not be useful for species in other regions, and species can only be assessed one-at-a-time. As with other methods, the scoring system involves a degree of expert judgment that may introduce bias.

4.4.4. WWF Climate Change Vulnerability Assessment for Species

The WWF Climate Change Vulnerability Assessment for Species method was developed in 2014 and was designed to be easy to use and to highlight species' areas of vulnerability to climate change so that these can be addressed through adaptation management recommendations in species conservation strategies. The tool does not assign species an overall score or grading for climate change vulnerability. The methodology uses qualitative criteria to assess species' vulnerability according to traits reflecting their sensitivity, adaptive capacity and exposure, as well as other threats, and no spatial analysis is required. Advantages of this method include its ease-of-use and wide applicability. Its broad questions allow for the inclusion of a wide range of climate change impacts. Key disadvantages include the lack of an overall species climate vulnerability score and a large scope of assessor subjectivity and bias.

4.4.5. Conclusions

The four examined CCVA methodologies have a large degree of commonality, and all consider many of the same traits reflecting sensitivity, adaptive capacity and exposure. Key points of difference include:

- the assessment of exposure (including whether spatial analysis is required)
- whether the scoring is qualitative or (partially) quantitative
- the degree of assumptions made
- algorithms for arriving at an overall species' vulnerability score (or lack of)
- the degree of prescriptiveness of trait assessment methods and their consistency across taxonomic groups
- treatment of uncertainty
- consideration of past or modelled climate change impacts
- whether traits can be assessed across batches of species simultaneously
- Capacity requirements and ease of use
- Data and information requirements

Among the above four methods, those produced by ZSL (McNamara, 2010) and IUCN (Foden et al 2013) stand out as having included substantial numbers of CMS-listed species. Although these assessments are outdated, they provide valuable species information on aspects such as biology, reproduction and distribution, so utilising these may be a good use of resources. They may also be used for identifying species to prioritise for further assessment.

There are 1,205 species listed on CMS. In line with Decision 14.214(b) *identify those migratory species that, on balance, are likely to be negatively impacted by climate change;* a rapid approach can be applied using the published CCVAs to identify species to prioritise for further assessment/in depth review, *i.e*. those which were assessed as having a high vulnerability to climate change impacts, as a priority. However, coverage of CMS-listed species by published CCVAs is partial and there are no CCVAs produced for all CMS listed species using a single methodology, meaning that it would not be possible to provide a consistent quantitative ranking of species' climate change vulnerability across all species within scope using existing published information.

The 'CMS Climate change Vulnerability matrix2024' spreadsheet in Annex D provides a dataset of all CMS listed species, their distributions, climate change vulnerability assessment information, IUCN Red List status and status in captivity. Due to limited time availability this dataset is a sample for reviewing and monitoring 1,205 species. It is apparent there are numerous gaps across fields to populate however this would serve as a template for managing and compiling data across CCVAs.

Previous CCVAs have focussed on assessing vulnerability and identifying species at highest risk but do not consider conservation action, nor do they provide time scales of climate change impacts other than the IPCC projection scenarios. A limitation found in this review is that time frames were not included in CCVAs as a measure of vulnerability in order to inform prioritisation. Another limitation of producing CCVAs is their ability to encapsulate the complexity and scale of climate change impacts, across the large distances of species migration routes crossing numerous habitats, boundaries and threats.

5. Assessing what conservation measures migratory species require to mitigate the impacts of climate change

Whilst the approaches described above can be used to assess mechanisms of climate change impacts on species, and/or which species are at greatest risk from climate change impacts, they will not necessarily allow for the identification of necessary and appropriate conservation responses. However, they can be used to identify conservation responses in conjunction with other information such as the feasibility of actions and their likelihood of success, as well as actions that are already being taken.

Information on the pathways by which climate change impacts on species will be important for the identification of potential conservation responses. For example, a recent study that used a literature review combined with expert surveys to assess the pathways by which climate change may affect western European seabird species (Häkkinen *et al* 2022, described in Section 3) used a similar process to collate information on potential conservation responses to the identified threats. They incorporated information on actions' effectiveness from Conservation Evidence (https://www.conservationevidence.com/), in order to link climate change impacts with effective conservation responses in a pressure-state-response framework.

The results of CCVAs may also help to inform the selection of appropriate climate adaptation measures. For example, the WWF Climate Change Vulnerability Assessment for Species methodology was designed to highlight species' areas of vulnerability to climate change so that these can be addressed through adaptation management recommendations in species conservation strategies (Advani, 2014, 2023).

When selecting and/or prioritising conservation measures, the feasibility and likelihood of success of conservation measures should be considered. Certain habitats may not be conservable, such as beaches for turtle nest sites due to sea level rise, and cliff hosting seabird colonies affected by landslides. The migratory range classification, migration dependency and habitat specificity requirements of certain species within taxonomic groups need to be considered. A species' existence in captivity and any associated captive breeding programmes should also inform prioritisation for *ex-situ* conservation.

Existing conservation measures should be reviewed to identify gaps. Useful resources may include existing conservation action plans produced under CMS and across other MEAs such as AEWA and OSPAR, as well as information on conservation actions compiled in species' IUCN Red List assessments.

6. In-depth case study: Polar bear

Using the ZSL Phase 1 methodology which was based on exposure, sensitivity and adaptive capacity using the trait-based approach, a CCVA template was designed using a combined approach of the previous methodologies to provide a comprehensive review of a species' climate change vulnerability assessment, and in doing so to draw out lessons on the limitations of existing methodologies and highlight potential improvements.

Ursus maritimus (polar bear) was selected as a case study as this species does not appear to have an in depth published CCVA (other than WWF and Martey *et al*. 2023). Being listed on CMS Appendix II, it is a species for which the impacts and vulnerabilities to climate change are widely acknowledged and for which there is extensive data and literature available. Similar to the narwhal, the polar bear would most certainly have a high vulnerability rating.

This case study template used a selection of species traits and focussed more on the observed impacts of climate change and key areas of vulnerability based on (some) data on observed geographical range shifts, migration patterns, changes in fecundity and population declines alongside a reduction in sea ice habitat and reduced prey availability. Migratory responses to climate change may vary across and within populations, particularly for species with large geographic ranges and such an assessment would serve to identify which subpopulations are at higher risk (Pilfold *et al* 2016).

Completing in-depth reviews based on evidence of distribution and population changes as a direct impact from climate change is highly beneficial for identifying specific conservation actions, specifically for identifying (sub)population(s) which become fragmented or isolated or have lost critical (breeding) habitat due to climate change. Previous methods have been based on risk. This approach proposes evidence-based approach with targeted recommendations.

An in-depth species level assessment draws out specific impacts of climate change to address. Due to the time limitations and extent of published data on the species, the case study review is not complete, however it can be used to devise conservation actions and recommendations at sub-population level to help prioritise intervention, as well as addressing gaps in data. This case study demonstrates the benefit of having in depth reviews which a CCVA based on a scoring method alone would not provide and an approach to move towards qualitative than quantitative assessment. An additional benefit of in-depth review would be to prioritise other associated species; in the polar bear's case, where the main threat to the species is availability of prey due to a decline in sea ice extent, it would be beneficial to have an in-depth review for ringed seals *Pusa hispida* and bearded seals *Erignathus barbatus*, and other marine and terrestrial species occupying the same niche.

Upon completion of an in-depth review, it is highly recommended to continue the assessment using a decision tree to identify highly vulnerable species which are likely to need human-mediated interventions, such as translocations, to moderate the impact of climate change. With regard to translocation, these would be smaller scale interventions requiring targeting specific habitats and species populations. An in-depth assessment would be required to identify the target populations. It can be generally accepted that there is limitations on human-mediated interventions such as translocations/restoration for migrant whales and sharks which would benefit more from international co-operation to minimise other threats such as pollution, fishing activities and unregulated commercial trade and also serve to identify and secure healthy genetically viable populations.

7. Recommendations for addressing Decision 14.214 (b)

This review demonstrates the scale of the complexity and resource requirement to identify accurately species which require urgent human-mediated interventions to mitigate the impacts of climate change. Bearing this in mind, it may be most appropriate to adopt a phased approach to addressing Decision 14.214(b).

7.1. Recommendations for Phase 1

To allow identification of migratory species that are likely to be negatively impacted by climate change, and identification of appropriate conservation responses to mitigate those impacts, it will be important to identify the mechanisms by which species are likely to be - or are being – impacted (see Section 3). These mechanisms may then be matched with conservation responses that, on the basis of current evidence, are likely to be effective in addressing them (see Section 5).

Given the complexity and resources required to review climate change impact mechanisms, it is likely to be necessary to restrict the focal species to those listed on the CMS Appendices, or possibly only those listed on Appendix I. Depending on the resources available, it may be necessary to further subset the work required – e.g. by biogeographical region, flyways (for birds), or UN Region.

It is recommended for Phase 1 to:

- i) **Review the climate change impact mechanisms affecting i) species listed on CMS Appendix I; and ii) if resources allow, species listed on CMS Appendix II.**
- ii) **Identify appropriate and evidence-based conservation responses to address the climate change impact mechanisms identified in part i.**

Phase 1 may be achieved through conducting a literature review, ideally supplemented with consultation with species experts to ensure inclusion of impacts and responses that may not be represented in the published literature, and to ensure that the feasibility of conservation responses is taken into account. Experts could also be asked to rank or score the relative importance of impact mechanisms and/or responses. Impact mechanisms and responses should be recorded using standardised classification systems to facilitate consistency across species. The use of existing classification systems may optimise the wider applicability of the outputs. The template provided in Annex C may be helpful to ensure that all relevant impact mechanisms and responses are considered.

The outputs of Phase 1 would include lists of the main climate change impact mechanisms likely to affect the focal species and the conservation responses that are likely to be effective in addressing them. This information could help to inform prioritisation of species and/or conservation responses to direct resources towards, in order to address climate change impacts on migratory species. For example, the outputs could be used to focus CMS resources on the conservation responses likely to benefit the greatest number of species, alongside consideration of the potential for international cooperation in implementing responses.

Note that in the preparation of this document it has not been possible to consider the list of avian species from disaggregation of taxa listed on CMS Appendix II as families and genera (CMS Resolution 14.19), or the list of potential avian taxa for listing (CMS Resolution 14.20). That would clearly be something to take into account when conducting the review above.

7.2. Recommendations for Phase 2

Following identification of CMS-listed migratory species that are likely to be negatively affected by climate change, and associated potential conservation responses, it may be beneficial to further identify those species in most urgent need of climate change mitigation actions. Here several options to achieve this are presented for consideration by the CMS Migratory Species and Climate Change Expert Workshop.

Option 1: Utilise existing species prioritisation metrics

What would this entail?

The outputs of Phase 1 would provide information on how CMS-listed species are likely to be affected by climate change, and what conservation responses may be effective in addressing these impacts. This information could be combined with existing metrics of species' conservation priority, such as the CMS Appendices and/or the IUCN Red List, to further prioritise species for action. For example, a decision could be made to focus attention on addressing climate change impacts on migratory species that are listed in CMS Appendix I, and/or those that are listed as Endangered or Critically Endangered on the IUCN Red List.

Advantages of this option

Since this option would not require any additional research or analysis, it would be very quick and cheap to implement, and the requirements for additional evidence would be very low. The ability to prioritise species quickly may be crucial in cases where a rapid conservation response is required. Depending on the metric used, this option could direct resources towards addressing climate change impacts on those species that are at most risk overall, taking into account all threats to the focal species, as well as cases where the causes of population declines are not well known. This approach would rely on well-established and widely recognised metrics, and thus avoid the need to use an additional prioritisation methodology that may be unvalidated or introduce additional assumptions. Minimising the need for multiple lists of priority species may improve clarity for decision makers.

Disadvantages of this option

This option would not answer the question of which species are *at greatest risk* from negative impacts of climate change, and thus would not allow for prioritisation of migratory species for human-mediated interventions to address climate change impacts, based on their relative climate change vulnerabilities. Existing metrics of species' conservation priority may not adequately reflect climate change impacts (e.g. Akçakaya et al., 2014), meaning that there may be a risk of overlooking species that are in urgent need of climate change mitigation action.

Option 2: Utilise an existing methodology to assess species' climate change vulnerability

What would this entail?

A wide range of methods have been developed to assess species' relative vulnerability to climate change. It may be possible to utilise an existing method, such as one of those summarised in Section 4.4 and further reviewed in Annex A, potentially with adaptations, to conduct assessments of the climate change vulnerability of CMS-listed migratory species.

Advantages of this option

This option would allow assessment of the relative climate change vulnerability of focal species and thus prioritise species for climate change mitigation actions on the basis of their vulnerability to this specific threat. Making use of an existing methodology would likely require lower resource requirements in comparison to designing a new methodology, so may represent an efficient use of resources.

Disadvantages of this option

This option would be considerably more resource-intensive than Option 1, and would take longer, which could delay the implementation of conservation responses. Methodologies may require data that is not available for all CMS-listed species. Some published methodologies use different traits or measures to assess species in different species groups, so it may not be possible to produce a consistent ranking of climate change vulnerability across all species groups that are listed on the CMS Appendices. Most CCVS methodologies are difficult to validate in the real-world and they may use arbitrary thresholds or expert judgement, so the reliability of their outputs is poorly known. When prioritising species for conservation action, it is important to keep in mind that climate change impacts may act in combination with other anthropogenic threats (Capdevila et al., 2025), and that the species identified as being at most risk from climate change may not be the same as the species identified as being affected by climate change that are at most overall risk.

Option 3: Develop a new species climate change vulnerability methodology

What would this entail?

A new CCVA methodology could be designed and implemented to assess CMS-listed species' relative vulnerability to climate change.

Advantages of this option

As with Option 2, this option would allow assessment of the relative climate vulnerability of focal species and thus prioritise species for climate change mitigation actions on the basis of their vulnerability to this specific threat. Designing a new methodology would allow combination of the best attributes of existing methodologies and tailor the methods specifically to migratory species and their particular traits and climate change impact mechanisms.

Disadvantages of this option

Most of the disadvantages described for Option 2 also apply to Option 3, although designing a bespoke methodology may provide the opportunity to eliminate some of the potential disadvantages relating to the assessment methods, such as inconsistencies in measures used across taxonomic groups or reliance on expert judgement. This option is likely to be the most resource-intensive, since resources would be required to both develop and to implement a methodology, and given the large number of previous CCVAs that have been published, creating a new methodology may represent an unnecessary duplication of effort.

8. Considerations for the workshop directed to the Scientific Council

The CMS Migratory Species and Climate Change Expert Workshop is invited to review this document and its Annexes and to consider the following:

1. What are the key aims and desired outcomes from Decision 14.214 (b)?

2. With reference to Section 7, what is/are the most appropriate approach(es) to achieving this? What is the preferred option for Phase 2?

Possible further work:

1. Consider compiling and reviewing results from published species Climate Change Vulnerability Assessments (as in Annex D). These would not be consistent across taxa, but could be an easy next step to identify/tag species at particular risk from climate change.

2. Compile and further review methods for undertaking Climate Change Vulnerability Assessments.

3. Consider feasibility of producing taxon specific Climate Change Vulnerability Assessment templates (based on Annex C), applying agreed methods, criteria and guidance. Consider using templates to apply across multiple species within and across taxonomic groups such as those already identified and assessed by Martay et al (2023), e.g. Afro-Palearctic passerines, South American grassland birds, marine mammals.

4. Compile case studies to test proposed methodology for species prioritisation and in-depth reviews to assist with decision trees for targeting intervention priorities.

5. Seek to complete Climate Change Vulnerability Assessments for all Appendix I and II species using a standardised taxon specific CCVA template.

6. Consider revising terminology or continued use of the term ‘Vulnerability’ in light of evidence of species already being impacted by climate change.

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