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SUBSIDIARY BODY ON SCIENTIFIC, TECHNICAL AND TECHNOLOGICAL ADVICE
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Agenda item 4.2

RECOMMENDATION ADOPTED BY THE SUBSIDIARY BODY ON SCIENTIFIC, TECHNICAL AND TECHNOLOGICAL ADVICE

XX/4. Voluntary specific workplan on biodiversity in cold-water areas within the jurisdictional scope of the Convention

The Subsidiary Body on Scientific, Technical and Technological Advice recommends that the Conference of the Parties at its thirteenth meeting adopt a decision along the following lines:

The Conference of the Parties,

Recalling paragraph 4 of decision XI/20, in which it urged Parties to advocate and contribute to effective carbon dioxide emission reductions by reducing anthropogenic emissions from sources and through increasing removals of greenhouse gases by sinks under the United Nations Framework Convention on Climate Change,[1] including the Paris Agreement,[2] and noting also the relevance of the Convention on Biological Diversity and other instruments,

1. *Notes* that cold-water areas sustain ecologically important and vulnerable habitats, such as cold-water corals and sponge fields, which play important functional biological and ecological roles, including supporting rich communities of fish as well as suspension-feeding organisms such as sponges, bryozoans and hydroids, some of which may be undergoing change due to the combined and cumulative effects of multiple stressors, including both global stressors, in particular ocean acidification, and local stressors;

2. *Welcomes* the scientific compilation and synthesis on biodiversity and acidification in cold-water areas,[3] and *takes note* of the key findings of this synthesis, as summarized in annex I;[4]

[1] United Nations, *Treaty Series*, vol. 1771, No. 30822.

[2] United Nations Framework Convention on Climate Change, Conference of the Parties, twenty-first session, decision 1/CP.21 (see FCCC/CP/2015/10/Add.1).

[3] UNEP/CBD/SBSTTA/20/INF/25.

[4] UNEP/CBD/SBSTTA/20/4.

3. *Adopts* the voluntary specific workplan for biodiversity in cold-water areas within the jurisdictional scope of the Convention contained in annex II to the present decision as an addendum to the programme of work on marine and coastal biodiversity, which can be used as a flexible and voluntary framework for action;

4. *Encourages* Parties, other Governments and competent intergovernmental organizations, where applicable, within their respective jurisdictions and mandates and in accordance with national circumstances, to implement the activities contained in the workplan and further strengthen current efforts at the local, national, regional and global levels to:

(a) Avoid, minimize and mitigate the impacts of global and local stressors, and especially the combined and cumulative effects of multiple stressors;

(b) Maintain and enhance the resilience of ecosystems in cold-water areas in order to contribute to the achievement of Aichi Biodiversity Targets 10, 11 and 15, and thereby enable the continued provisioning of goods and services;

(c) Identify and protect areas capable of acting as refugia sites and adopt, as appropriate, other area-based conservation measures, in order to enhance the adaptive capacity of cold-water ecosystems;

(d) Enhance understanding of ecosystems in cold-water areas, including by improving the ability to predict the occurrence of species and habitats and to understand their vulnerability to different types of stressors, as well as to the combined and cumulative effects of multiple stressors;

(e) Enhance international and regional cooperation in support of national implementation, building on existing international and regional initiatives and creating synergies with various relevant areas of work within the Convention;

5. *Invites* Parties, other Governments and research and funding organizations to promote, as appropriate and within their competencies, and in accordance with national circumstances, activities to address research and monitoring needs identified in annex III to the present decision;

6. *Requests* the Executive Secretary, in collaboration with Parties, other Governments and relevant organizations, to facilitate, promote and support the implementation of the workplan contained in annex II to the present decision by, among other things, facilitating capacity-building activities, subject to available financial resources, and the sharing of information on experiences and lessons learned from the implementation of the workplan, including through collaboration with the Food and Agriculture Organization of the United Nations, the International Maritime Organization, the International Seabed Authority, regional seas organizations, regional fisheries management bodies and other relevant organizations.

Annex I

KEY MESSAGES FROM THE SCIENTIFIC COMPILATION AND SYNTHESIS ON BIODIVERSITY AND OCEAN ACIDIFICATION IN COLD-WATER AREAS[5]

Cold-water biodiversity and ecosystems

1. Cold-water areas sustain ecologically important habitats, including cold-water corals and sponge fields. The associated biodiversity of cold-water coral habitats is best understood, while the work on the functional ecology and biodiversity of cold-water sponge fields is expanding.

2. Cold-water coral habitats are typically more biodiverse than surrounding seabed habitats and support characteristic animal groups. For example, cold-water coral reefs support rich communities of suspension-feeding organisms, including sponges, bryozoans and hydroids.

3. Cold-water coral habitats can play important functional roles in the biology of fish. New evidence shows that some fish are found in greater numbers in cold-water coral habitats and some species use cold-water coral reefs as sites to lay their eggs.

Pressures and threats to biodiversity in cold-water areas

4. Ocean acidification has increased by ~26% in H+ ion concentration since pre-industrial times. Increased releases of CO_2 due to the burning of fossil fuels and other human activities are leading to increases in sea surface temperatures and ocean acidification.

5. The saturation state of carbonate in seawater varies by depth and region. The saturation state is typically lower in polar and deep waters due to lower temperatures. When carbonate becomes undersaturated calcium carbonate, which many organisms use to form shells and skeletons, it will dissolve if it is not protected by a covering of living tissue.

6. The increase in stratification from increased temperatures can lead to reduced ocean mixing, which can also disrupt export of surface carbon to greater depths. Increased ocean temperature contributes to deoxygenation by decreasing oxygen solubility at the surface and enhancing stratification. This leads to a decrease in the downward oxygen supply from the surface, meaning that less oxygen is available for organism respiration at depth, and areas with lowered oxygen levels may expand.

7. The combination of ocean acidification, increases in ocean temperature and deoxygenation can lead to significant changes in organism physiology and habitat range in cold-water areas. Ocean acidification is detrimental to many marine species, with impacts on their physiology and long-term fitness. Shoaling of the aragonite saturation horizon will also leave many calcifying species in potentially corrosive seawater. Increases in temperature can impact the physiology of many organisms directly, and indirectly lead to increasing deoxygenation and expansion of low oxygen zones. This can lead to community shifts, changes in nitrogen cycling, and modification of habitat ranges.

8. Destructive fishing practices can significantly impact vulnerable marine ecosystems. Many cold-water ecosystems have slow growth rates, and recovery from impacts may take decades to hundreds or even thousands of years. Decreases in biodiversity, biomass and habitats (through destruction or alteration) could entail consequences for broader biogeochemical cycles.

9. There are potential impacts on marine biodiversity and ecosystems in the deep-sea from marine mining exploration and exploitation. Impacts may include habitat destruction, ecotoxicology, changes to

[5] Based on UNEP/CBD/SBSTTA/20/INF/25.

habitat conditions, discharge of nutrient enriched deep-water to surface communities and potential displacement or extinction of local populations, in addition to point source mining impacts, understanding the consequences of mine tailings disposal over wide areas is particularly important.

10. Hydrocarbon exploitation can impact cold-water biodiversity on different geographic scales. While drill cuttings can cover and disturb local benthos around platforms, major oil spill accidents would have the potential to result in environmental impacts at great depths and/or through the water column over many hundreds of square kilometres.

11. Deep-sea sediments accumulate plastic microfibres and other pollutants. The abundance of plastic microfibres in some deep-sea sediments was found to be four times higher than at the surface, meaning that the deep sea could be a significant sink of microplastics.

12. Invasive species can cause species extirpation and damage to ecosystem services. Major pathways to marine bioinvasion are discharged ballast water and hull fouling.

13. Bioprospecting has increased rapidly over the last decade, and can often occur in the deep ocean, where extremophiles are found. These areas often have very specific environmental conditions, and bioprospecting in these areas can risk damage to the habitat if an organism is deemed of high interest.

Global monitoring of ocean acidification

14. Global monitoring of ocean acidification is increasing, while there is a need for further development of predictive models. A well-integrated global monitoring network for ocean acidification is crucial to improve understanding of current variability and to develop models that provide projections of future conditions. Emerging technologies and sensor development increase the efficiency of this evolving network. There is a need for greater cross-sectoral partnership between government, industry and academia to facilitate establishing globally integrated monitoring system.

15. Seawater pH shows substantial natural temporal and spatial variability. The acidity of seawater varies naturally on a diurnal and seasonal basis, on local and regional scales, and as a function of water depth and temperature. Only by quantifying these changes is it possible to understand the conditions to which marine ecosystems are subjected currently. This will, in turn, increase understanding of how marine ecosystems will change in a future climate.

Resolving uncertainties

16. Greater understanding of the interaction between species within food webs is needed. Whether an impact of climate change on one organism will impact the fitness of other organisms is poorly understood at present. Mesocosm experiments, where communities are subjected to projected future conditions can help to address this.

17. Impacts of ocean acidification need to be studied on different life stages of cold-water organisms. Early life stages of a number of organisms may be at particular risk from ocean acidification, with impacts including decreased larval size, reduced morphological complexity, and decreased calcification. Further work needs to be done on different life stages of many cold-water organisms.

18. Existing variability in organism response to ocean acidification needs to be investigated further, to assess the potential for evolutionary adaptation. Multi-generational studies with calcifying and non-calcifying algal cultures show that adaptation to high CO_2 is possible for some species. Such studies are more difficult to conduct for long-lived organisms or for organisms from the deep sea. Even with adaptation, community composition and ecosystem function are still likely to change.

19. Research on ocean acidification increasingly needs to involve other stressors, such as temperature and deoxygenation, as will occur under field conditions in the future. Acidification may interact with many other changes in the marine environment on both local and global scales. These “multiple stressors” include temperature, nutrients, and oxygen. In situ experiments on whole communities (using natural CO_2 vents or CO_2 enrichment mesocosms) provide a good opportunity to investigate the impacts of multiple stressors on communities in order to increase understanding of future impacts.

Initiatives to address knowledge gaps in ocean acidification impacts and monitoring

20. There are a growing number of national and international initiatives to increase understanding of future impacts of climate change. Through linking national initiatives to international coordinating bodies, addressing global knowledge gaps and monitoring will become more effective.

Existing management and need for improvement

21. The legal and policy landscape relating to addressing impacts to cold-water biodiversity includes largely sectoral global and regional instruments. While instruments related to integrated management approaches exist, they do not presently cover the entirety of cold-water ecosystems comprehensively.

22. Reducing CO_2 emissions remains the key action for the management of ocean acidification and warming. Additional management options, such as reducing stressors at the national and regional levels, can be used to help marine ecosystems adapt and buy time to address atmospheric CO_2 concentrations.

23. Our understanding of the impacts of individual stressors is often limited, but we have even less understanding of the impacts that a combination of these stressors will have on cold-water marine organisms and ecosystems and the goods and services they provide. There is a pressing need to understand the interactions and potentially combined and cumulative effects of multiple stressors.

24. Because individual stressors interact, managing each activity largely in isolation will be insufficient to conserve marine ecosystems. Multiple stressors must be managed in an integrated way, in the context of the ecosystem approach.

25. Scientific studies suggest that priority areas for protection should include areas that are resilient to the impacts of climate change and thus act as refuges for important biodiversity. In cold-water coral reefs, this may include important reef strongholds (reef areas likely to be less impacted by acidification by being located at depths above the aragonite saturation horizon), or areas important for maintaining reef connectivity and gene flow, which may be crucial for coral species to adapt to the changing conditions.

26. Management strategies should also protect representative habitats. Representative benthic habitats that are adjacent or connected to impacted areas can act as important refuges and source habitat for benthic species.

27. There is an urgent need to identify refugia sites nationally, regionally and globally. Efforts to describe and identify ecologically or biologically significant marine areas (EBSAs), including through the work on EBSAs under the Convention on Biological Diversity and the work on VMEs under the Food and Agriculture Organization of the United Nations, may help regional and global efforts to identify the location of habitats that may be resilient to the impacts of acidification and ocean warming, or that may help in maintaining gene flow and connectivity.

28. Cold-water biodiversity supports economies and well-being, and thus all stakeholders have a role in its management. Awareness-raising and capacity-building at all levels are important for future management effectiveness.

Annex II

VOLUNTARY SPECIFIC WORKPLAN ON BIODIVERSITY IN COLD-WATER AREAS WITHIN THE JURISDICTIONAL SCOPE OF THE CONVENTION

Context and scope

1. This workplan has been developed pursuant to paragraph 16 of decision XII/23. It builds upon the elements of a workplan on physical degradation and destruction of coral reefs, including cold-water corals (decision VII/5, annex I, appendix 2). It should be implemented on a voluntary basis as part of the programme of work on marine and coastal biodiversity (decision VII/5, annex I).

2. The workplan will support the achievement of Aichi Biodiversity Targets in marine and coastal areas, addressing in particular Aichi Biodiversity Target 10. The scope of the workplan is cold-water areas in the deep and open ocean, including both benthic and pelagic areas. These areas support a diverse range of marine species and habitats, including deep-water coral and sponge grounds that play important biological and ecological roles in the world's oceans. There is increasing evidence that cold-water areas are being significant affected by direct human pressures and as well as wider impacts of global climate change and ocean acidification.

3. The workplan should be implemented alongside efforts to reduce anthropogenic emissions from sources and through increasing removals of greenhouse gases by sinks under the United Nations Framework Convention on Climate Change.

Objectives

4. The objectives of the workplan are the following:

(a) To avoid, minimize and mitigate the impacts of global and local stressors, and especially the combined and cumulative effects of multiple stressors;

(b) To maintain and enhance the resilience of ecosystems in cold-water areas in order to contribute to the achievement of Aichi Biodiversity Targets 10, 11 and 15, and thereby enable the continued provisioning of goods and services;

(c) To identify and protect areas capable of acting as refugia sites, and adopt, as appropriate, other area-based conservation measures, in order to enhance the adaptive capacity of cold-water ecosystems;

(d) To enhance understanding of ecosystems in cold-water areas, including by improving the ability to predict the occurrence of species and habitats and to understand their vulnerability to different types of stressors as well as the combined and cumulative effects of various stressors;

(e) To enhance international and regional cooperation in support of national implementation, building on existing international and regional initiatives and creating synergies with various relevant areas of work within the Convention.

Activities

5. Parties are encouraged to take the following actions, in accordance with national and international laws and using the best available scientific information:

5.1 Assess needs and develop integrated policies, strategies and programmes related to biodiversity in cold-water areas:

(a) Integrate issues related to biodiversity in cold-water areas into national biodiversity strategies and action plans (NBSAPs);

(b) Assess the management and regulatory actions in place nationally and regionally to address the combined and cumulative effects of multiple stressors on cold-water biodiversity, and develop and enhance national mechanisms for inter-agency coordination and collaboration in implementing cross-sectoral regulatory approaches, including the consolidation of existing national initiatives;

(c) Assess the degree to which local stressors (such as destructive fishing practices, marine mining, hydrocarbon exploitation, anthropogenic noise, shipping, pollution and bioprospecting) are addressed by existing sectoral regulations, and adjust regulatory frameworks to address these stressors, where appropriate;

(d) Integrate long-term climate-related impacts on cold-water biodiversity into the assessment of local stressors;

(e) Ensure close coordination among national and subnational governments, and facilitate the involvement of indigenous peoples and local communities;

(f) Develop regional strategies to address common stressors, complementing national strategies.

5.2 Strengthen existing sectoral and cross-sectoral management to address stressors to cold-water biodiversity, including from overfishing and destructive fishing practices, pollution, shipping, seabed mining, by taking the following actions, as appropriate, and in accordance with national and international laws and circumstances:

(a) Strengthen fisheries management approaches, including the application of the ecosystem approach to fisheries, at national and regional scales, including through regional fishery bodies, to address unsustainable fishing practices, including overfishing, illegal, unreported and unregulated fishing and destructive fishing practices, and ensure effective enforcement, using relevant guidelines of the Food and Agriculture Organization of the United Nations, such as the FAO Code of Conduct for Responsible Fisheries and the International Guidelines for the Management of Deep-sea Fisheries in the High Seas;

(b) Avoid, minimize and mitigate land-based and sea-based pollution, deoxygenation, and introduction of invasive species through ballast water and biofouling to prevent adverse impacts on cold-water ecosystems and species, including through the implementation of instruments, tools and guidelines by the International Maritime Organizations (IMO) and other relevant global and regional organizations;

(c) Avoid, minimize or mitigate adverse impacts related to hydrocarbon extraction in areas that are known to contain cold-water coral and sponge reefs and other sensitive cold-water biodiversity;

(d) Avoid, minimize or mitigate adverse impacts of seabed mining on cold-water biodiversity, in accordance with the instruments, tools and guidelines of the International Seabed Authority with regard to mining in the deep seabed beyond national jurisdiction;

(e) Avoid, minimize or mitigate impacts from undersea cables in areas that are known or highly likely to contain vulnerable cold-water coral and sponge reefs.

5.3 Develop and apply marine protected areas and marine spatial planning in order to reduce the impacts of local stressors, and especially the combined and cumulative effects of multiple stressors, on cold-water biodiversity in the context of the ecosystem approach and national development planning:

(a) Increase spatial coverage and management effectiveness of marine protected areas and other area-based conservation measures in cold-water areas;

(b) Identify and prioritize, as appropriate, in conservation, protection and management approaches, specific types of cold-water areas such as:

- Ecologically or biologically significant marine areas (EBSAs), vulnerable marine ecosystems (VMEs) and particularly sensitive sea areas (PSSAs) in cold-water areas;

- Cold-water areas identified in vulnerability assessments using ecological and socioeconomic criteria;

- Habitats that have not been affected by the impacts of ocean acidification or ocean warming, and can thus serve as refugia sites;

- Healthy cold-water coral reefs, sponge reefs and other cold-water marine ecosystems, in order to prevent their degradation by human-induced stressors;

- Areas with healthy cold-water coral communities that are at depths above the aragonite saturation horizon;

- Habitats that are important for maintaining connectivity, gene pool size and diversity, and gene flow;

- Representative benthic habitats across the range of ecosystems, including those adjacent to degraded areas.

5.4 Expand and improve monitoring and research on biodiversity in cold-water areas to improve fundamental knowledge of how, and over what time scales, climate change and other human-induced stressors will impact the long-term viability of, and ecosystem services provided by, cold-water biodiversity, habitats and ecosystems, including through activities outlined in annex III, with a focus on activities that:

(a) Improve understanding of biodiversity in cold-water areas, including species identification, species distribution, community composition and taxonomic standardization, to provide baseline information for assessing the effects of climate change and other human-induced stressors;

(b) Assess the socioeconomic implications of the ongoing and predicted future pressures on cold-water biodiversity;

(c) Improve understanding of how climate change, acidification and other human-induced stressors will impact the physiology, health and long-term viability of cold-water organisms, habitats and ecosystems;

(d) Improve monitoring of environmental conditions in cold-water habitats to understand variability in carbonate chemistry;

(e) Develop or expand upon predictive model research to determine how projected climate change will impact cold-water biodiversity over different time scales.

5.5 Improve coordination and collaboration in research, information sharing and capacity-building to address policy and management needs, and to increase public awareness:

(a) Develop research collaboration as part of national programmes, including sharing of information relevant to cold-water biodiversity and opportunities for scientific collaboration and capacity-building, addressing the research needs identified in annex III;

(b) Develop a coordination strategy to leverage the efforts of various science organizations that actively research cold-water biodiversity, including through initiatives such as the Global Ocean Acidification Observing Network (GOA-ON) and the International Atomic Energy Agency's Ocean Acidification International Coordination Centre (OA-ICC), and provide a platform for information sharing between these initiatives in support of the work of the Convention;

(c) Improve knowledge-sharing among various actors and provide opportunities for participation in assessment, monitoring and research;

(d) Develop and implement targeted education and awareness campaigns for diverse stakeholders on the socioeconomic value of cold-water biodiversity and ecosystems, and the role of various stakeholders in increasing the resilience of cold-water biodiversity by reducing direct stressors;

(e) Collaborate with indigenous peoples and local communities, fishers, civil society and members of the public to improve information available for assessment, monitoring and validation of predictive models, including through application of traditional knowledge, fisher's knowledge and citizen science;

(f) Raise awareness among policymakers of key scientific findings related to cold-water biodiversity, and facilitate incorporation of the activities of this workplan into relevant national strategies and action plans, as well as relevant research and monitoring programmes at the global, regional and national levels.

5.6 Identify and provide sustainable sources of financing at the national, regional and global levels to enable the actions outlined in this workplan:

(a) Secure, through national budget systems (for example environment, climate-change adaptation funds), the necessary financial resources to implement measures to enhance knowledge about the resilience of biodiversity in cold-water areas, and to support the prioritization of the monitoring and research needs in annex III;

(b) Apply comprehensive and diverse financing schemes for management of stressors impacting biodiversity in cold-water areas;

(c) Remove key bottlenecks and improve access to funding through capacity-building and streamlining of funding processes.

Annex III

MONITORING AND RESEARCH NEEDS FOR SUPPORTING THE IMPLEMENTATION OF THE VOLUNTARY SPECIFIC WORKPLAN ON BIODIVERSITY IN COLD-WATER AREAS WITHIN THE JURISDICTIONAL SCOPE OF THE CONVENTION

1. Improve understanding of biodiversity in cold-water areas to provide baseline information used for assessing the effects of climate change and other human-induced stressors:

1.1 Support the ongoing research on biodiversity in cold-water areas to fill in gaps in fundamental knowledge of species identification, species distribution, and community composition, including taxonomic standardization;

1.2 Identify key habitat providers and their functional role within ecosystems to understand which organisms may be a priority in conservation and management;

1.3 Understand the biodiversity that key cold-water habitats support globally, and assess the gaps in current knowledge;

1.4 Map biodiversity and coral viability along natural gradients of carbonate saturation in order to identify the main predictors of coral biodiversity and health, assess changes related to carbonate saturation state, locate hotspots of biodiversity and endemism, and help validate predictive models and improve understanding of how acidification affects ecosystem function and viability.

2. Assess the socioeconomic implications of current and predicted future pressures on cold-water biodiversity:

2.1 Enhance understanding of the ecosystem goods and services of cold-water areas;

2.2 Investigate connectivity (genetic and transfer of mobile species) between cold-water areas at multiple scales;

2.3 Investigate flow-on effects to ecosystems and ecosystem services that have significant environmental, social, cultural and economic impacts.

3. Conduct research to assess how climate change and other human-induced stressors will impact the physiology, health and long-term viability of cold-water organisms, habitats and ecosystems:

3.1 Carry out controlled laboratory experimentation, where feasible, on key individual species (ecosystem engineers, keystone species) to understand their metabolic, physiological and behavioural responses, their tolerance limits/thresholds to ocean acidification, potential interactive effects of warming and deoxygenation and to human-induced stressors;

3.2 Implement experiments using mesocosms in the field to understand fundamental ecological responses to ocean acidification, including how acidification may alter plankton productivity, larval ecology, food webs and the competitive interactive strength of taxa;

3.3 Assess experimental designs for ocean acidification biodiversity research at the individual, population and ecosystem level to identify best practices;

3.4 Identify the adaptive (or evolutionary) capacity of species with regard to single and multiple stressors, to assess the long-term resilience of key ecosystems and their continued provisioning of goods and services;

3.5 Conduct long-term experiments to assess whether organism survival comes with hidden energetic, structural or reproductive costs over a longer period;

3.6 Conduct experiments to assess whether larval stages are more susceptible to potential impacts at different life stages of organisms, and whether this impacts the long-term fitness of key species;

3.7 Incorporate broader assessments of ecological, physiological and microbiological impacts of acidification into research to consider wider impacts on individuals, species and ecological interactions.

4. Improve monitoring of environmental conditions in cold-water habitats to understand variability in carbonate chemistry:

4.1 Develop or expand upon existing physicochemical water chemistry monitoring programmes in cold-water areas to better understand the natural spatial and temporal variability of ocean carbon chemistry;

4.2 Integrate physicochemical water chemistry monitoring within national jurisdictions into international programmes, such as the Global Ocean Acidification Observation Network (GOA-ON) and initiatives such as the Global Ocean Observing System (GOOS);

4.3 Support the development of technology for the rapid and economical assessment of seawater carbonate chemistry;

4.4 Integrate carbonate chemistry sampling into marine monitoring programmes, where possible.

5. Develop or expand upon predictive model research to determine how projected climate change will impact cold-water biodiversity over different time scales:

5.1 Improve ocean carbonate models to understand the temporal and three-dimensional spatial changes in carbonate saturation state and its main drivers, including changing atmospheric CO_2 conditions and ocean currents;

5.2 Document existing gaps in data knowledge on national, regional global scales that limit the predictive power of models;

5.3 Couple ocean carbonate chemistry mapping and oceanographic models to biophysical and ecological information to predict the temporal and spatial variability of acidification impacts in order to help identify areas under the greatest threat and possible refugia;

5.4 Optimize habitat modelling to predict key habitats and biodiversity occurrence from seawater carbonate chemistry, oceanographic and water mass modelling and larval dispersal.

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