Climate-resilient, depth-resolved marine protected areas for areas beyond jurisdiction around Africa

Dominguez Martinez Rosa Mar[1,2,3], Kochzius Marc[2], Richardson Anthony[4] and Brito-Morales Isaac[4]

[1] Università degli Studi di Firenze, Dipartimento di Biologia (UNIFI), Via Madonna del Piano 6, 50019 Sesto Fiorentino, Italia
E-mail: rosamardomin@gmail.com
[2] Marine Biology, Ecology and Biodiversity, Vrije Universiteit Brussel (VUB), Pleinlaan 2, 1050 Brussels, Belgium
[3] Department of Organism Biology, Faculty of Sciences, Université Libre de Bruxelles (ULB), Avenue Franklin D. Roosevelt 50, CPI 264/1, 1050 Brussels, Belgium
[4] The University of Queensland (UQ), Brisbane 4072, Australia

Climate change is the biggest threat that biodiversity faces in our time, it poses an increasing stress on populations which are forced to adapt or migrate to avoid extinction[1,2]. Protected areas are a powerful, cost-effective tool for biodiversity conservation, especially when forming a network that allows connectivity among populations[3]. The open ocean, or areas beyond national jurisdiction (ABNJ), represents most of the Earth's surface and habitable space, and below its surface there is a highly valuable and little-known biodiversity that is at risk of extinction [4,5]. For centuries we thought these ecosystems were too vast to be harmed, but with the stress that climate change poses on ecosystems and the increasing impact of anthropogenic activities, there is an urgent need for the implementation of marine protected areas (MPAs) that integrate climate change into conservation and target ABNJ[4,5]. The development of theoretical tools that forecast environmental changes (climate change metrics), combined with biological information, allows us to estimate shifts in biodiversity distribution and ecological turnover in future ecosystems[6,7]. This study will explore the use of climate velocity (a measure of the speed and direction of shifting isotherms) in ABNJ around Africa as a proxy for species movement under climate change to identify areas that might serve as refugia for species under shifting environmental conditions.

Using historical sea surface temperature values, climate velocity will be calculated for each 0.25° cell using the long-term temperature changes over their spatial range[8]. Future values will be estimated from CMIP6 models under three climatic scenarios, and classified by depth layer into surface (0-200 m), mesopelagic (200-1000 m) and bathypelagic (1000-4000 m). Then, conservation and fishing will be incorporated into spatial prioritisation with *Prioritizr* package in R software by parameterising a cost layer combining climate velocity and occurrence of commercial species as penalties, which will place MPAs in regions that can simultaneously minimise conflict with commercial fishing and have low climate velocity, while meeting conservation targets at different depth layers. The selection of species important for fisheries will be based on length measurements recorded in FishBase[9] (longer species are more valuable), also including smaller commercially important species such as anchovies and sardines, while conservation targets will be set as minimum thershold of the occurrence of species in the IUCN Red List. The distribution of both groups of species (for conservation and fishing) will be estimated based on occurrence and distribution records in AquaMaps[10].

References

1 Brito-Morales, I. *et al.* Climate Velocity Can Inform Conservation in a Warming World. *Trends Ecol. Evol.* **33**, 441–457 (2018).
2 Barber, Q. E., Nielsen, S. E. & Hamann, A. Assessing the vulnerability of rare plants using climate change velocity, habitat connectivity, and dispersal ability: a case study in Alberta, Canada. *Reg. Environ. Chang.* **16**, 1433–1441 (2016).

[3] Batllori, E. *et al.* Potential relocation of climatic environments suggests high rates of climate displacement within the North American protection network. *Glob. Chang. Biol.* **23**, 3219–3230 (2017).
[4] Levin, L. A. & Bris, N. L. The deep ocean under climate change. *Science (80-.).* **350**, 766–768 (2015).
[5] Dunn, D. C., Crespo, G. O. & Halpin, P. N. Incorporating the dynamic and connected nature of the open ocean into governance of marine biodiversity beyond national jurisdiction. *Predict. Futur. Ocean.* 425–435 (2019).
[6] Garcia Molinos, J. *et al.* Improving the interpretability of climate landscape metrics: An ecological risk analysis of Japan's Marine Protected Areas. *Glob. Chang. Biol.* **23**, 4440–4452 (2017).
[7] Garcia, R. A. *et al.* Multiple dimensions of climate change and their implications for biodiversity. *Science (80-.).* **344**, (2014).
[8] Burrows, M. T. *et al.* The pace of shifting climate in marine and terrestrial ecosystems. *Science (80-)* **334**, 652–655 (2011)
[9] Watson, R. A. A database of global marine commercial, small-scale, illegal and unreported fisheries catch 1950-2014. *Sci. Data* **4**, 1–9 (2017)
[10] Kesner-Reyes *et al.* AquaMaps: algorithm and data sources for aquatic organisms. *Froese, R. and D. Pauly. Editors* (2012)

Keywords: Climate change; Stirling; Marine spatial prioritisation; Biodiversity conservation; Marine protected areas