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# Biological interactions: The overlooked aspects of marine climate change refugia

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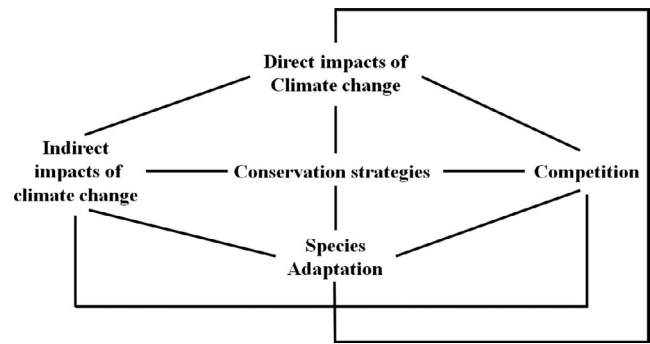
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effects of climate change and must abandon their original unsuitable habitats will strive to benefit from any potential refugium that they manage to reach. Those species can be historical competitors (e.g., reef corals and macroalgae) or novel competitors (endemic and invasive species). Therefore, refugia must either be available for colonization or support the persistence of existing communities (McLaughlin et al., 2017).

To date, three major type refugia for marine species—including higher latitudes, deep areas, and upwelling regions—are suggested to act as global warming refugia for many species, including reef corals, macroalgae, and kelp. However, all of these regions are generally predicted to experience higher rates of intensified ocean acidification in the coming decades (Gattuso & Hansson, 2011). Thus, the direct negative effects of ocean acidification may favor some species, such as mat-forming algae, in competition with ecosystem engineers such as reef-building coral and kelp (Connell, Kroeker, Fabricius, Kline, & Russell, 2013). As a result, competition within refugia would become even more complicated. Therefore, how competition will shape communities within marine refugia may not only be determined by the refugium limitations and competition level, but also by the rate in which climatic change (and other non-climate factors) can alter the competition capabilities of the species involved.

Overall, changes in biotic interactions under climate change represent a known cause of species extinction (Blois, Zarnetske, Fitzpatrick, & Finnegan, 2013), thus they cannot be ignored in climate change refugia studies. Such biotic interactions are even more important than the direct abiotic impacts of climate change (Ockendon et al., 2014). Therefore, the identification of effective climate change refugia/refuges without considering biological interactions—particularly those induced and/or intensified by climate change such as competition, marine diseases, and phytoplankton blooms—seems to be simplistic. Although, such interactions will undoubtedly increase the complexity and practicality of projections, their implications are, in my opinion, inevitable. To support my claim, I exemplify the Persian Gulf, which has been suggested to act as a coral reef refugium against global warming by the year 2100 (Figure 1; Cacciapaglia & Van Woesik, 2016). However, along with multiple mass bleaching events, the Persian Gulf has already experienced mass mortalities of corals due to diseases and phytoplankton blooms (Riegl, Bruckner, Samimi-Namin, & Purkis, 2012; Riegl et al., 2018 and references therein). Therefore, I suggest that simply pinpointing potential marine climate change refugia based on their capacities to buffer global warming or ocean acidification (i.e., the direct impacts of climate change) should not be incorporated into modern conservation frameworks and marine spatial planning initiatives. Consequently, I propose that to be realistic and reliable, future climate change refugia studies must consider the reciprocal interactions among climate change, biological factor and conservation strategies (Figure 2). Without effective management plans, even the least vulnerable ecosystems may be at risk (see Beyer et al., 2018). Such strategies can also reduce non-climate change stressors, which should not be ignored while identifying marine refugia (Kavousi & Keppel, 2018). I emphasize my



**FIGURE 2** Simplified suggested structure of reciprocal interactions that should be considered in future management studies to better assess the chance of target marine species in potential refugia to survive climate change

understanding of how the suggested study structure can be complicated, time-consuming, and costly to perform. However, the painful truth is that conserving our oceans against climate change is complicated by multilevel impacts that require the application of complex, multilevel research methodologies and management strategies.

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#### REFERENCES

- Assis, J., Araújo, M. B., & Serrão, E. A. (2018). Projected climate changes threaten ancient refugia of kelp forests in the North Atlantic. *Global Change Biology*, 24(1), e55–e66. <https://doi.org/10.1111/gcb.13818>
- Beyer, H. L., Kennedy, E. V., Beger, M., Chen, C. A., Cinner, J. E., Darling, E. S., ... Hoegh-Guldberg, O. (2018). Risk-sensitive planning for conserving coral reefs under rapid climate change. *Conservation Letters*, 11(6), e12587. <https://doi.org/10.1111/conl.12587>
- Blois, J. L., Zarnetske, P. L., Fitzpatrick, M. C., & Finnegan, S. (2013). Climate change and the past, present, and future of biotic interactions. *Science*, 341(6145), 499–504.
- Bongaerts, P., Ridgway, T., Sampayo, E. M., & Hoegh-Guldberg, O. (2010). Assessing the 'deep reef refugia' hypothesis: Focus on Caribbean reefs. *Coral Reefs*, 29(2), 309–327. <https://doi.org/10.1007/s00338-009-0581-x>
- Cacciapaglia, C., & Van Woesik, R. (2016). Climate-change refugia: Shading reef corals by turbidity. *Global Change Biology*, 22(3), 1145–1154. <https://doi.org/10.1111/gcb.13166>
- Connell, S. D., Kroeker, K. J., Fabricius, K. E., Kline, D. I., & Russell, B. D. (2013). The other ocean acidification problem: CO<sub>2</sub> as a

- resource among competitors for ecosystem dominance. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 368(1627), 20120442.
- Gattuso, J. P., & Hansson, L. (2011). *Ocean acidification*. New York, NY: Oxford University Press.
- Kavousi, J., & Keppel, G. (2018). Clarifying the concept of climate change refugia for coral reefs. *ICES Journal of Marine Science*, 75(1), 43–49. <https://doi.org/10.1093/icesjms/fsx124>
- Keppel, G., Van Niel, K. P., Wardell-Johnson, G. W., Yates, C. J., Byrne, M., Mucina, L., ... Franklin, S. E. (2012). Refugia: Identifying and understanding safe havens for biodiversity under climate change. *Global Ecology and Biogeography*, 21(4), 393–404. <https://doi.org/10.1111/j.1466-8238.2011.00686.x>
- Maynard, J., Van Hooidonk, R., Eakin, C. M., Puotinen, M., Garren, M., Williams, G., ... Harvell, C. D. (2015). Projections of climate conditions that increase coral disease susceptibility and pathogen abundance and virulence. *Nature Climate Change*, 5(7), 688–694. <https://doi.org/10.1038/nclimate2625>
- McLaughlin, B. C., Ackerly, D. D., Klos, P. Z., Natali, J., Dawson, T. E., & Thompson, S. E. (2017). Hydrologic refugia, plants, and climate change. *Global Change Biology*, 23(8), 2941–2961. <https://doi.org/10.1111/gcb.13629>
- Ockendon, N., Baker, D. J., Carr, J. A., White, E. C., Almond, R. E., Amano, T., ... Pearce-Higgins, J. W. (2014). Mechanisms underpinning climatic impacts on natural populations: Altered species interactions are more important than direct effects. *Global Change Biology*, 20(7), 2221–2229. <https://doi.org/10.1111/gcb.12559>
- Riegl, B., Bruckner, A. W., Samimi-Namin, K., & Purkis, S. J. (2012). Diseases, harmful algae blooms (HABs) and their effects on Gulf coral populations and communities. In B. Riegl, & S. J. Purkis (Eds.), *Coral reefs of the Gulf* (pp. 107–125). Dordrecht, the Netherlands: Springer.
- Riegl, B., Johnston, M., Purkis, S., Howells, E., Burt, J., Steiner, S. C., ... Bauman, A. (2018). Population collapse dynamics in *Acropora downingi*, an Arabian/Persian Gulf ecosystem-engineering coral, linked to rising temperature. *Global Change Biology*, 24(6), 2447–2462.