Appendix S1

*Future research*

The new on-shelf kelp occurrences represent an opportunity for nearshore kelp research that dispenses with the costly ocean-going means that were previously required to investigate the Formigas kelp stands. Given the depth of most stands, advancing the study of the Azores kelps will continue to require remote imaging technologies and/or technical diving. DDCs remain particularly relevant to expand surveys of kelp occurrence and therefrom build a representative dataset to model the distribution of the Azores populations. The mesophotic reefs located around the largest Azores islands (São Miguel, Pico, Terceira and São Jorge) should constitute a survey priority since they remain scarcely explored. Elsewhere in Macaronesia, sampling efforts should target the understudied mesophotic reefs of the Gorringe seamount and the Madeira archipelago, which represent major stepping stones in westwards colonization pathways into the Azores.

Given the distinct acoustic signature of kelp stands (e.g., Méléder et al. 2010, Blight et al. 2011, van Rein et al. 2011), seabed sonars might be used for mapping kelp at local scales and collecting ground-truthing data for predictive distribution models. The resulting habitat extent estimates are key to inform conservation managers and fulfil assessment and reporting requirements stemming from the European Union directives.

The collection of voucher specimens will be fundamental to resolve the taxonomic uncertainty of image-based identification. This can be most efficiently done by technical divers and ROVs deployed with grabbing tools. It is likely that further mesophotic species are brought to light which, like kelps, are thermally excluded from the shallower depths and have previously eluded conventional SCUBA diving surveys. Broad algal groups that we have recorded on imagery but remain largely unidentified include: small frondose Rhodophyta (namely, Rhodymeniales and Peyssonneliacea), non-geniculate Corallinales (including rhodolith-forming species), Ulvacea and siphonous or giant-celled Chlorophyta (namely Bryopsidales). Integrating molecular and morpho-anatomical taxonomical approaches will be instrumental to resolve cryptic and pseudo-cryptic diversity (Spalding et al. 2019). The resulting species-level inventories of the Azores shelf biota would further contribute to characterizing the colonization spans of Macaronesia’s indigenous shelf biota and investigating shifting biogeographical affinities across the different bionomical belts.

At island scale, it would be important to model habitat suitability and investigate the drivers of the patchiness of kelp occurrences observed on individual island shelves and seamount summits. The consideration of climate change scenarios in these studies will be important to assess niche resilience and the delivery of ecological functions and services associated to this biogenic habitat.

Given the Azores active volcanism and tectonics, it will be relevant to investigate the role of eruptions and island flank collapses in shaping connectivity patterns and habitat suitability at geological time scales. Relevant historical cases include the Surtseyan eruptions of Dom João de Castro Bank (1720), Sabrina (western São Miguel, 1811), and Capelinhos (western Faial, 1957-58). All of these events have smothered and reset sublittoral communities in shelf sectors with conditions comparable to sites where we have recorded kelp (e.g., the Formigas Bank and western Terceira).

Fine genetic studies using DNA sequencing will be instrumental to settle the taxonomical status of the Azores kelps and investigate connectivity patterns among the different metapopulations. The application of genetic clocking principles would further contribute to resolving the chronology of the genus *Laminaria* speciation along the eastern Atlantic shores (Bolton 2010).

Additional mesophotic research may be inspired by the numerous knowledge gaps identified by Loya et al. (2019) on issues of biodiversity, ecology, ecophysiology, community functioning, ecological functions and ecosystems services. In view of the high biomass exhibited by some of the Azores kelp stands, we suggest investigating the significance of the mesophotic primary production in the trophic webs of island margins and euphotic seamount tops. Similarly, it would be important to ascertain the role of mesophotic environments as nurseries, refugia and spillover sources for shallower species in mid latitudes (see Lesser et al. 2009, Baker et al. 2016), notably coastal fishes. The use of non-destructive techniques such as baited cameras (or BRUVs) should be favored.

**References**

Assis, J., Serrão, E. A., Coelho, N. C., Tempera, F., Valero, M. & Alberto, F. 2018. Past climate changes and strong oceanographic barriers structured low-latitude genetic relics for the golden kelp *Laminaria ochroleuca*. *J. Biogeogr.* 45:2326–36.

Baker, E.K., Puglise, K.A. and Harris, P.T. 2016. *Mesophotic coral ecosystems — A lifeboat for coral reefs?* UNEP and GRID-Arendal, Nairobi and Arendal, 98 pp.

Blight, A., Foster-Smith, R., Sotheran, I., Egerton, J., McAllen, R. & Savidge, G. 2011. *Development of a Methodology for the Quantitative Assessment of Ireland’s Inshore Kelp Resource*. Marine Institute, Oranmore, 67 pp.

Bolton, J. J. 2010. The biogeography of kelps (Laminariales, Phaeophyceae): a global analysis with new insights from recent advances in molecular phylogenetics. *Helgol. Mar. Res.* 64:263–79

Lesser, M. P., Slattery, M. & Leichter, J. J. 2009. Ecology of mesophotic coral reefs. *J. Exp. Mar. Bio. Ecol.* 375:1–8.

Loya, Y., Puglise, K. & Bridge, T. 2019. *Mesophotic Coral Ecosystems*. Springer, Cham. 1003 pp.

Méléder, V., Populus, J., Guillaumont, B., Perrot, T. & Mouquet, P. 2010. Predictive modelling of seabed habitats: Case study of subtidal kelp forests on the coast of Brittany, France. *Mar. Biol.* 157:1525–41.

Spalding, H. L., Amado-Filho, G. M., Bahia, R. G., Ballantine, D. L., Fredericq, S., Leichter, J. J., Nelson, W. A., Slattery, M. & Tsuda, R. T. 2019. Macroalgae. *In* Loya, Y., Puglise, K. & Bridge, T. [Eds.]. *Mesophotic Coral Ecosystems*. Coral Reefs of the World. Springer, Cham. pp. 507–36.

van Rein, H., Brown, C. J., Quinn, R., Breen, J. & Schoeman, D. 2011. An evaluation of acoustic seabed classification techniques for marine biotope monitoring over broad-scales (>1 km2) and meso-scales (10 m2-1 km2). *Estuar. Coast. Shelf. Sci.* 93:336–49.