University of the Highlands and Islands
Oilthigh na Gàidhealtachd agus nan Eilean

An assessment of the ecological coherency of the global marine protected area network under future climate change

Jorge García Molinos[1], D. Schoeman, B. Halpern, E. Poloczanska, C. J. Brown, A. Richardson and M. T. Burrows[1]

[1]Scottish Association for Marine Science (SAMS)

SAMS NCEAS NATURAL ENVIRONMENT RESEARCH COUNCIL Oceans 2025

United Nations Decade on Biodiversity

Connectivity

Viability

Adequacy

Replication

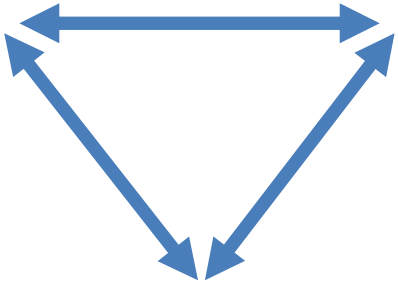
Representativity

Resiliency/stability

Species & climate change

In situ adaptation

Changes in timing of events (phenological shifts)



Changes in space (distribution shifts)

Aims

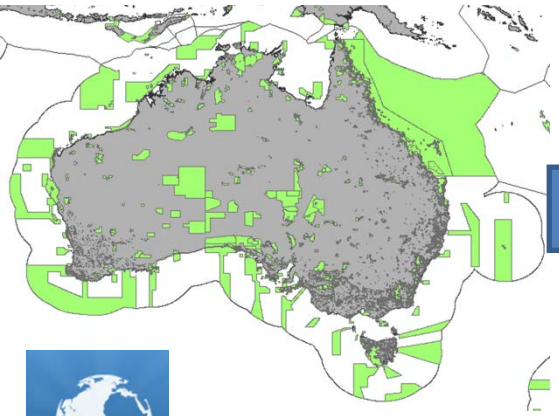
- Estimate the current **representativeness** and **adequacy** of MPA networks in terms of biodiversity

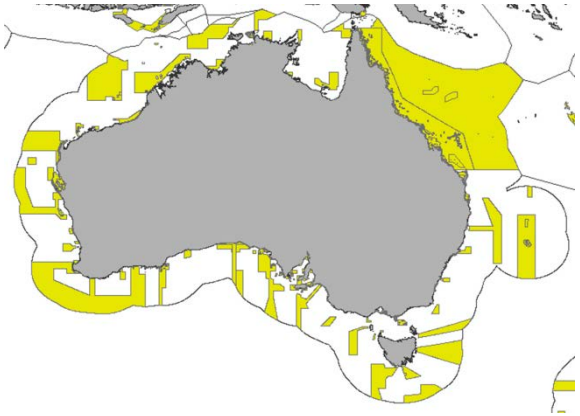
- Estimate the climatic **connectivity** of MPA networks under different future climate change scenarios in relation to the expected movement of climate migrants

Metrics & network properties

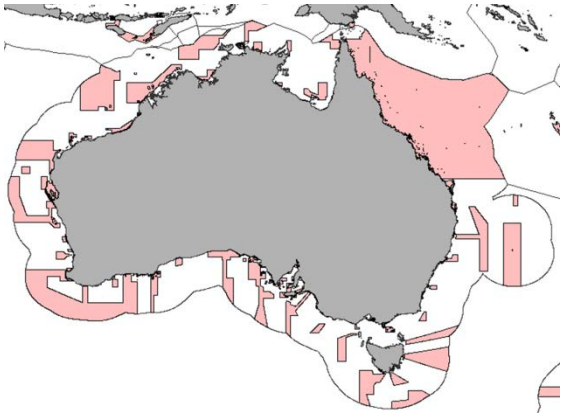
Network property	Type	Definition
Representativeness	Biodiversity	Proportion of the EEZ species pool hosted by the MPA network
Adequacy	Biodiversity	Overall mean of the proportion of each EEZ species range covered by the MPA network
Connectivity	Climate	Proportion of the climatic corridor covered by the MPA network
Connectivity	Climate	Proportion of the network overlapping the climatic corridor

Our working definition of MPA network





Terrestrial & marine BNJ excluded



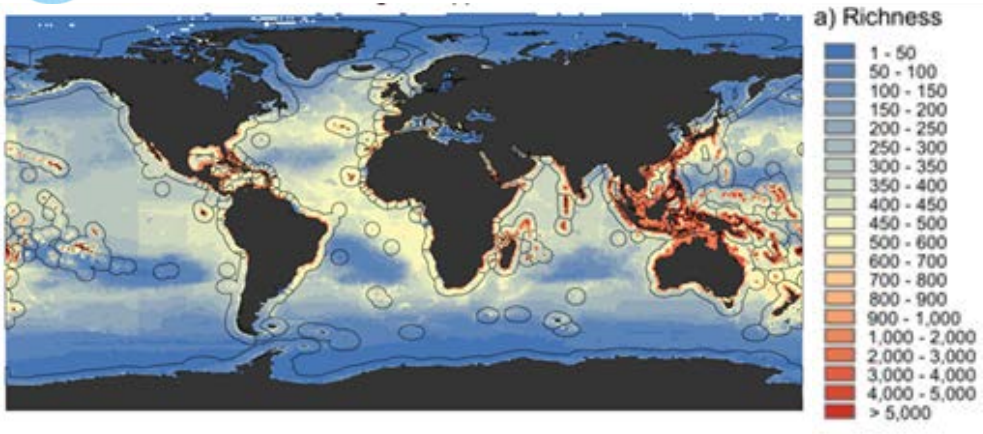
Overlapping MPAs merged

The multi-part polygon encompassing all patches of protected seascape within the spatial extent of an individual EEZ

Current representativeness & adequacy

Current representativeness and adequacy

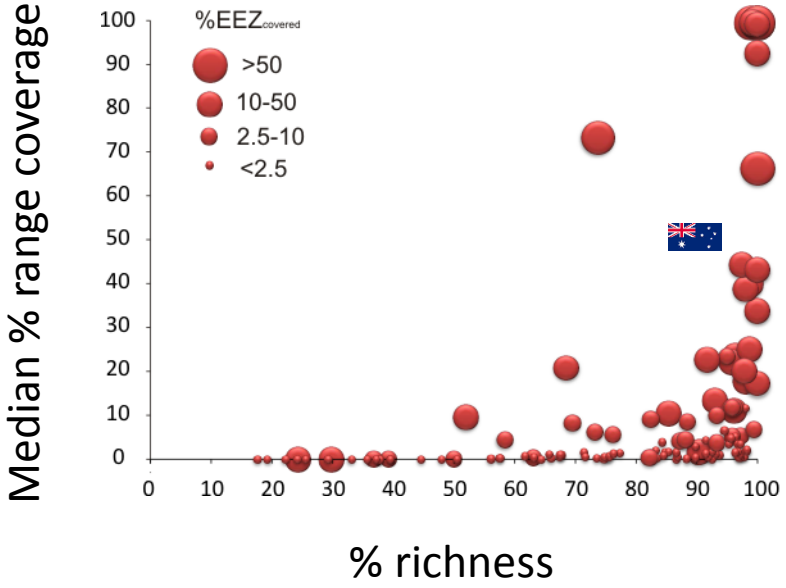
http://www.aquamaps.org/ 12,796 species 23 phyla

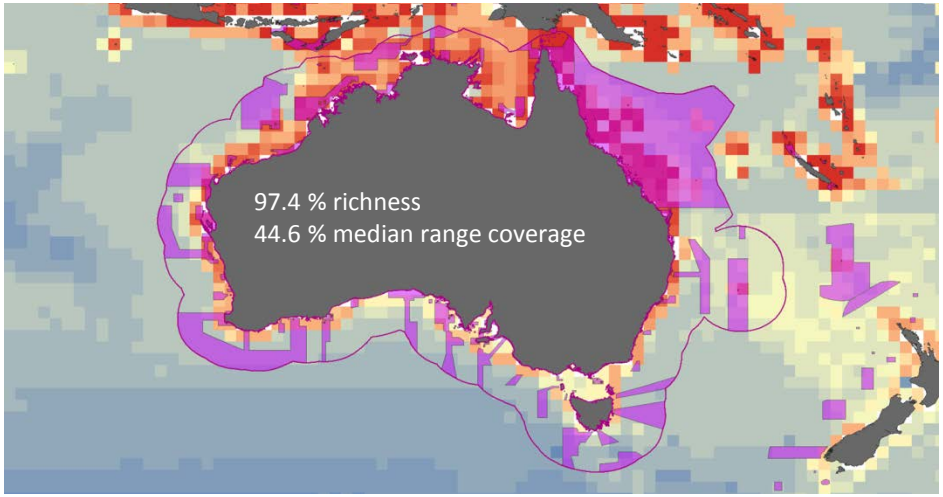


High representativeness / low adequacy

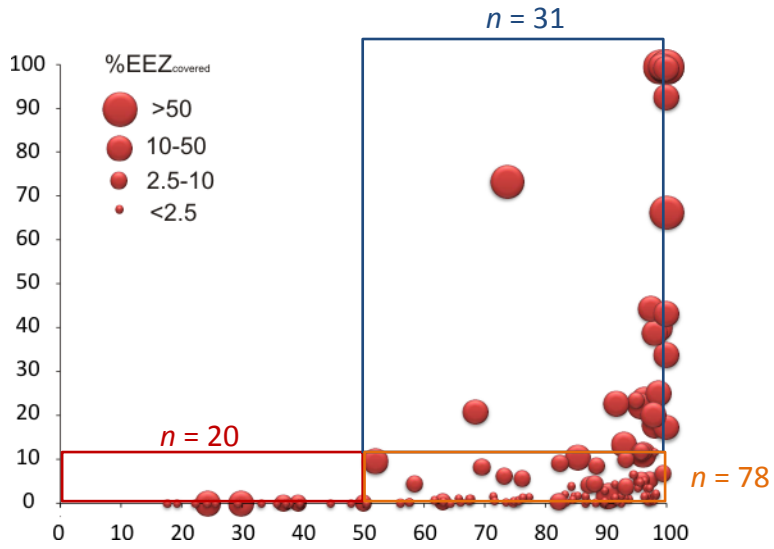
88.4 (67.6, 96.7) % of species coverage

2.9 (1, 10.9) % of range coverage





Current representativeness and adequacy

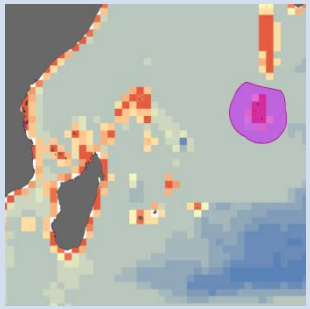


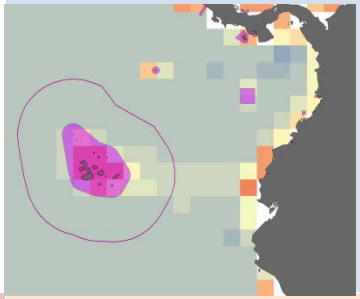
Median % range coverage

% richness

High representativeness/adequacy

British Indian Ocean (UK)
99.96 % EEZ
100 % richness
100 % median range coverage

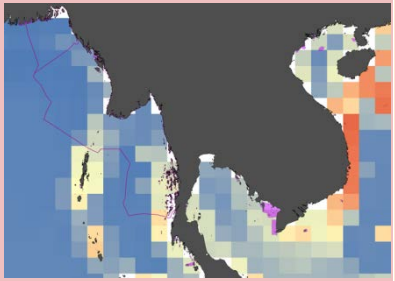


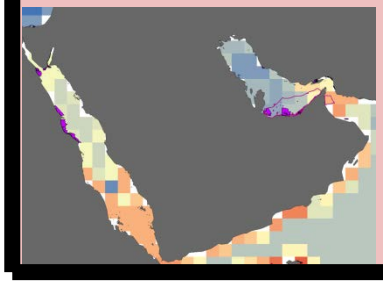


Galapagos Islands (Ecuador)
16.56 % EEZ
99.88 % richness
99.63 % median range coverage

Low representativeness/adequacy

Bangladesh / Myanmar
0.96 / 0.04 % EEZ
22.25 / 24.2 % richness
0 % median range coverage

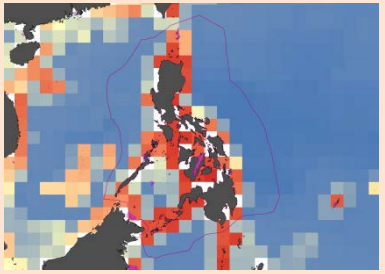


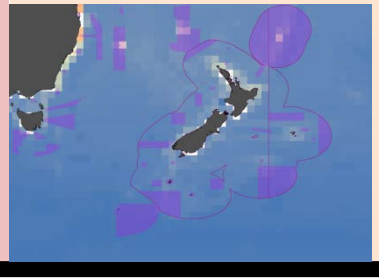


United Arab Emirates
11.15 % EEZ
24.29 % richness
0 % median range coverage

High representativeness/low adequacy

Philippines
0.84 % EEZ
98.26 % richness
2.2 % median range coverage



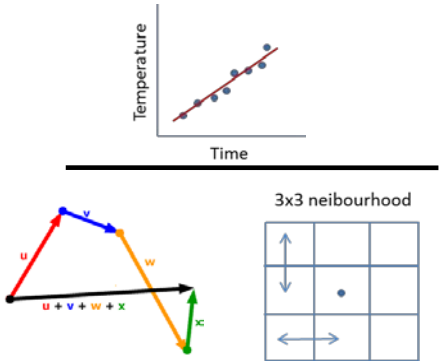


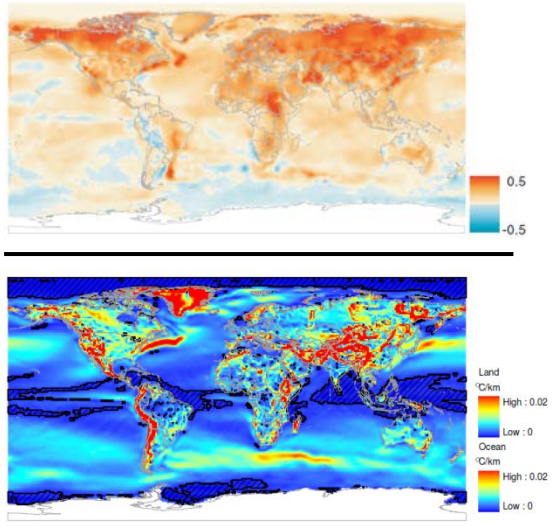
New Zealand
29.8 % EEZ
97.92 % richness
17.78 % median range coverage

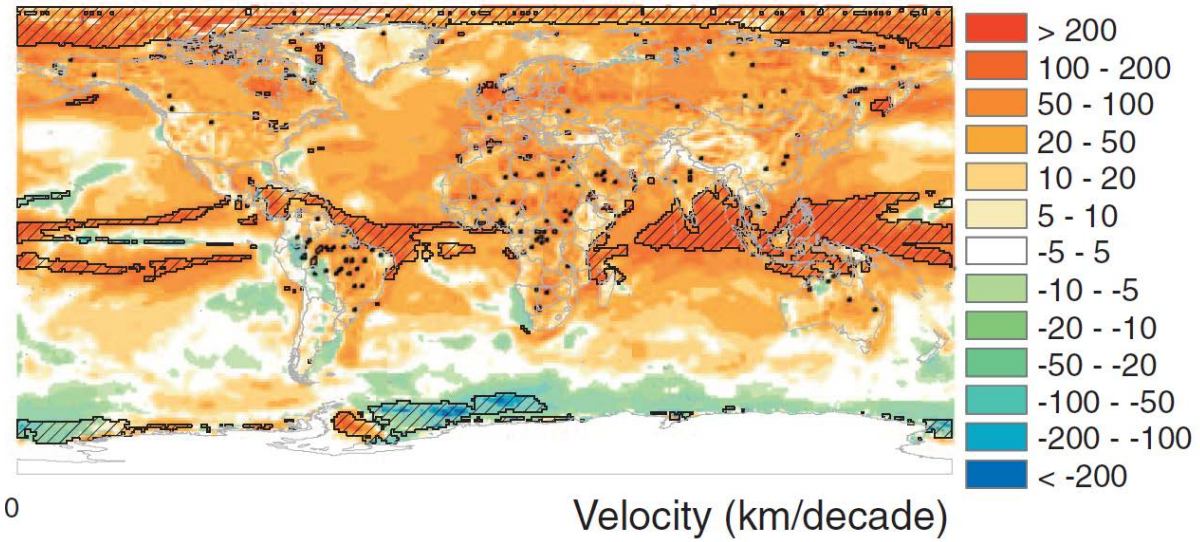
Future climatic connectivity

The velocity of climate change (VoCC)

$$\text{VoCC (km / yr)} = \frac{\text{Temporal trend (°C/ yr)}}{\text{Spatial gradient (°C/ km)}}$$



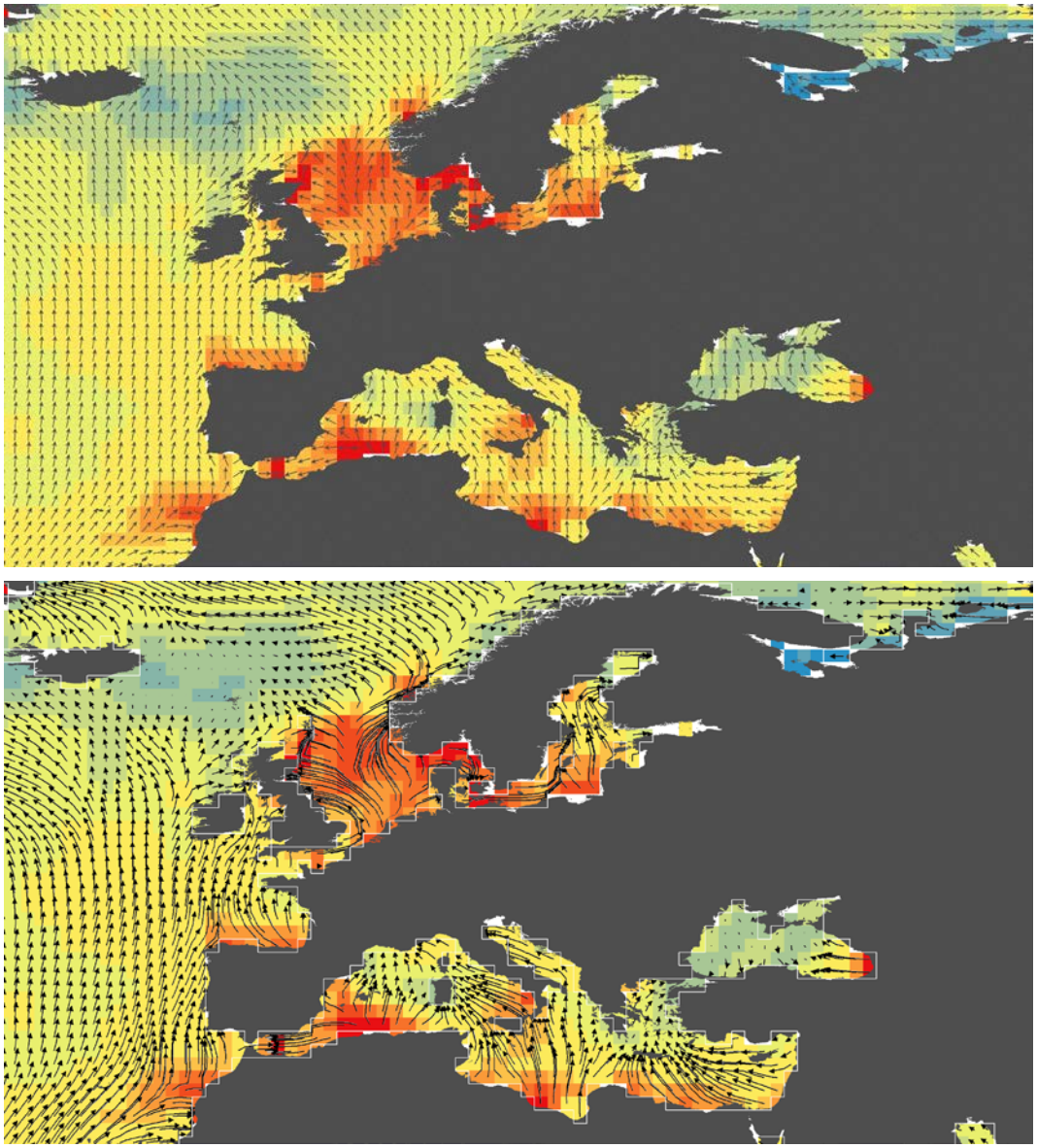




Burrows et al. 2011. Science. 334, 652-655

Poloczanska et al. 2013. Nature Climate Change. 3, 919-925
Pinsky et al. 2013. Science. 341, 1239-1242

Making it more dynamic: VoCC trajectories

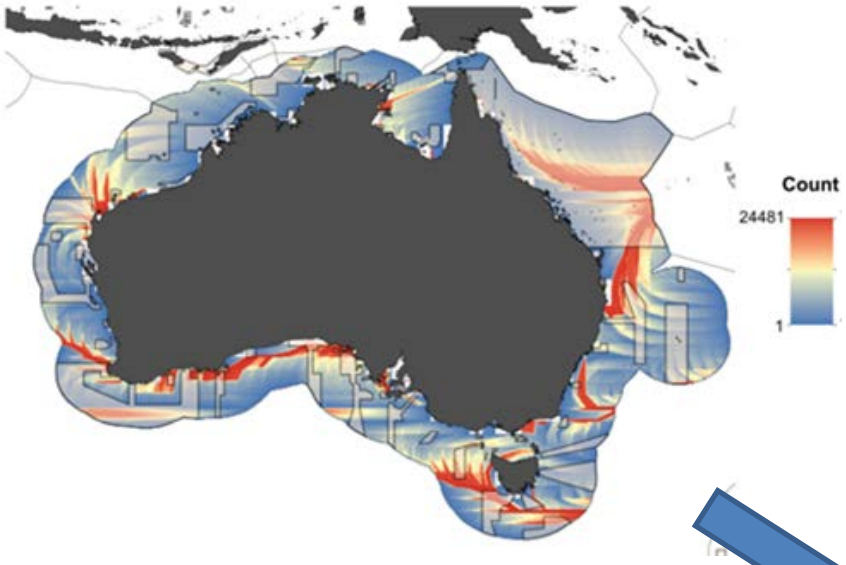


VoCC 1960-2009
(km yr^{-1})

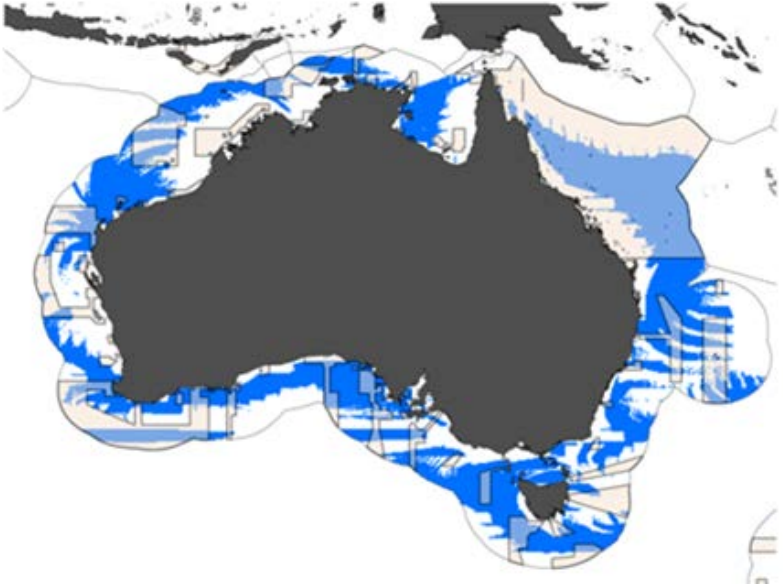
Burrows et al. 2014. Nature. 507, 492-495

Hiddink et al. 2014. Global Change Biology. doi: 10.1111

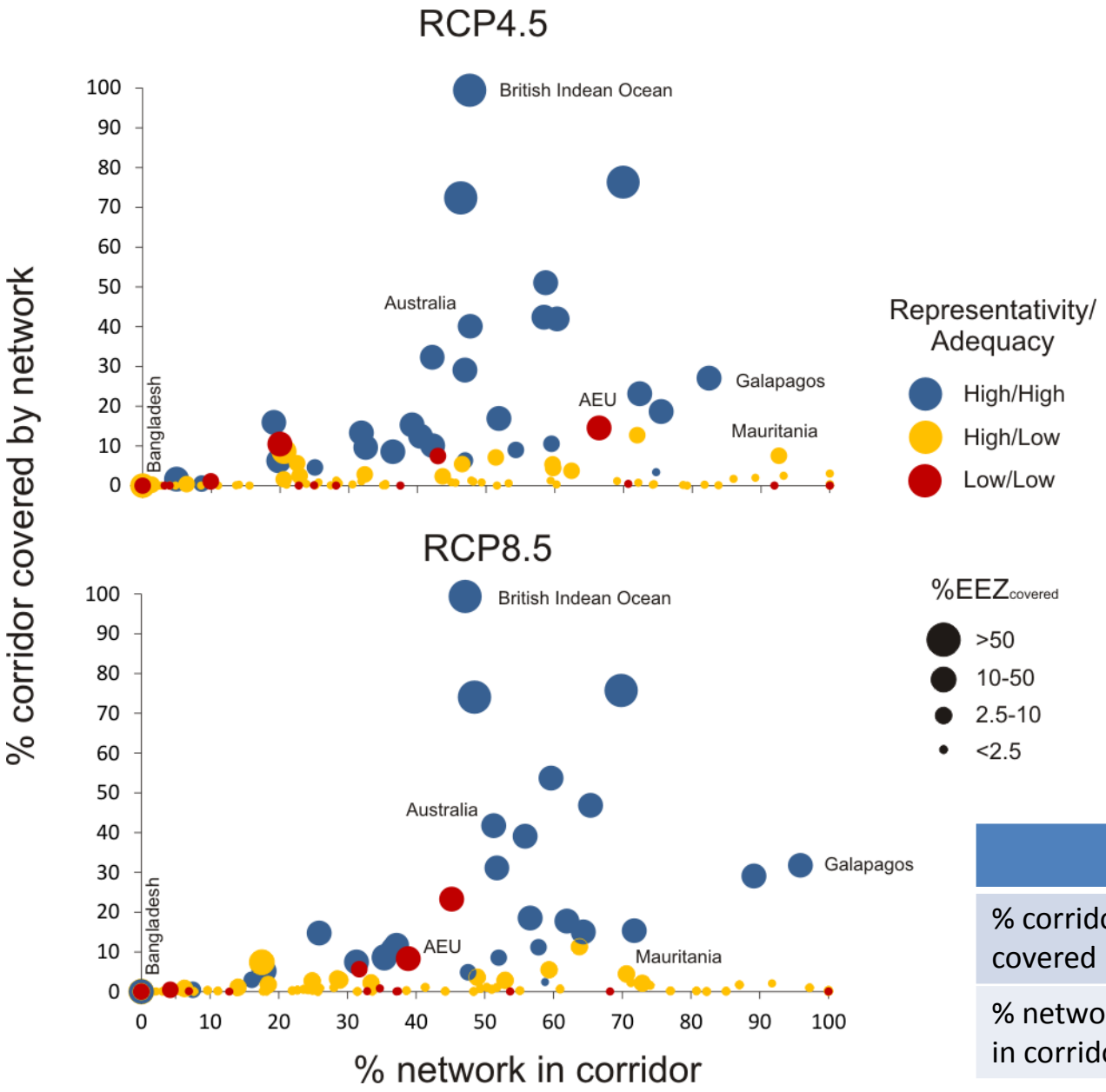
Climatic connectivity (2006-2100)



Climatic corridor
cells > median n trajectories
per cell by EEZ

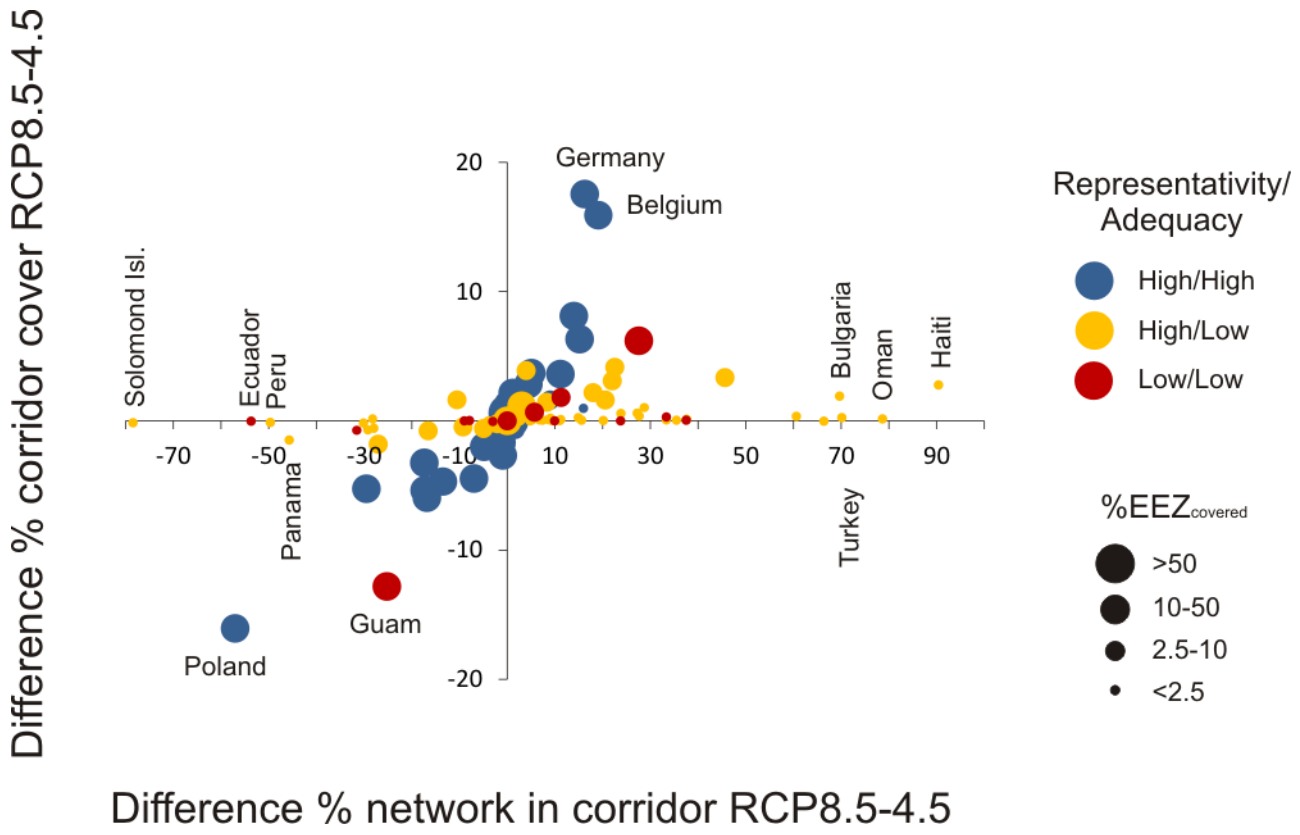


Climatic connectivity (2006-2100)



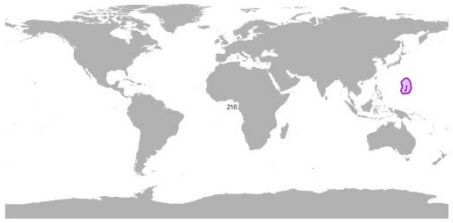
	RCP4.5	RCP8.5
% corridor covered	0.02, 0.4, 4 % (Q25, Q5, Q75)	0.06, 0.6, 6 %
% network in corridor	4.8, 31.5, 54.4	9.3, 35.3, 59.7

Climatic connectivity (2006-2100)



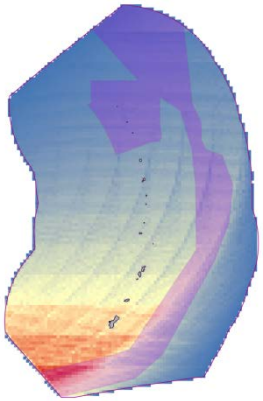
Climatic connectivity (2006-2100)

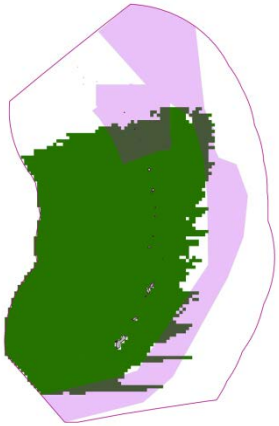
Northern Mariana Islands and Guam

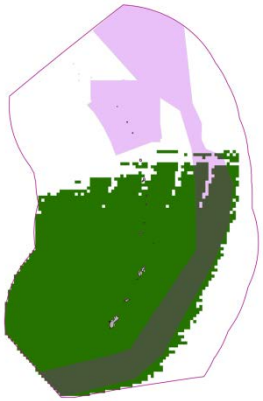


RCP4.5
(10% corridor coverage, 20% network overlay)

RCP8.5
(23% corridor coverage, 45% network overlay)

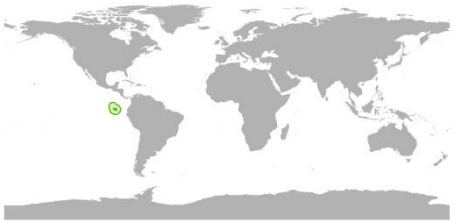




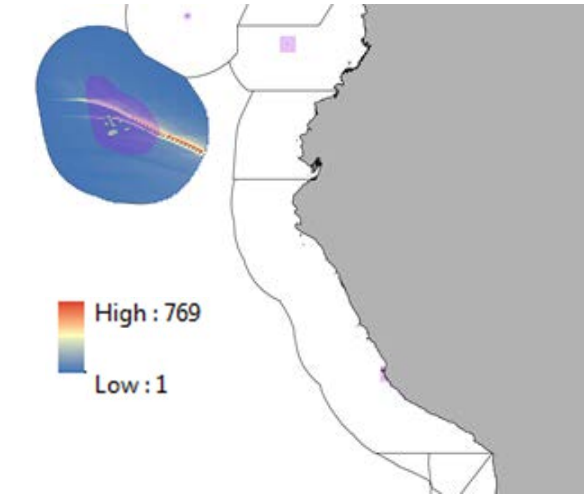


Climatic connectivity (2006-2100)

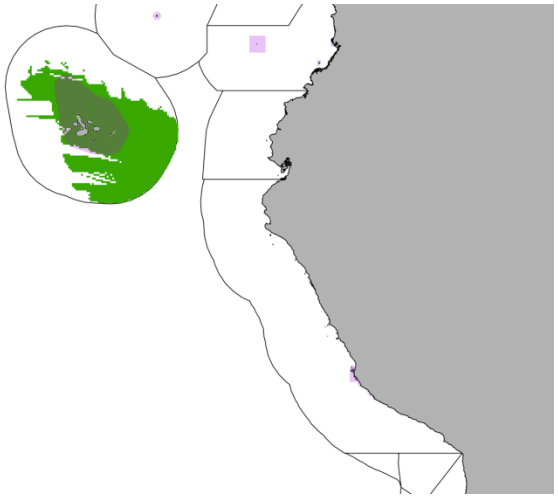
Galapagos Islands (Ecuador)



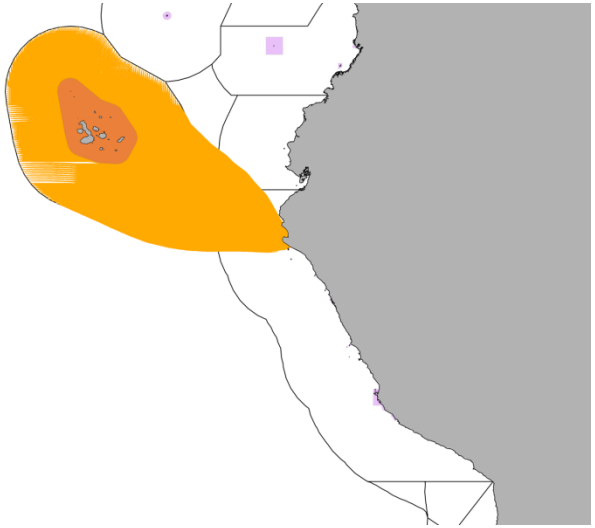
Trajectory count RCP4.5



Climatic corridor



Trajectory path



Conclusions

- At a global coarse scale, exiting global network of MPAs provides a high representativeness of current marine biodiversity but low adequacy

- High adequacy is mainly associated to the size of the MPAs rather than their location

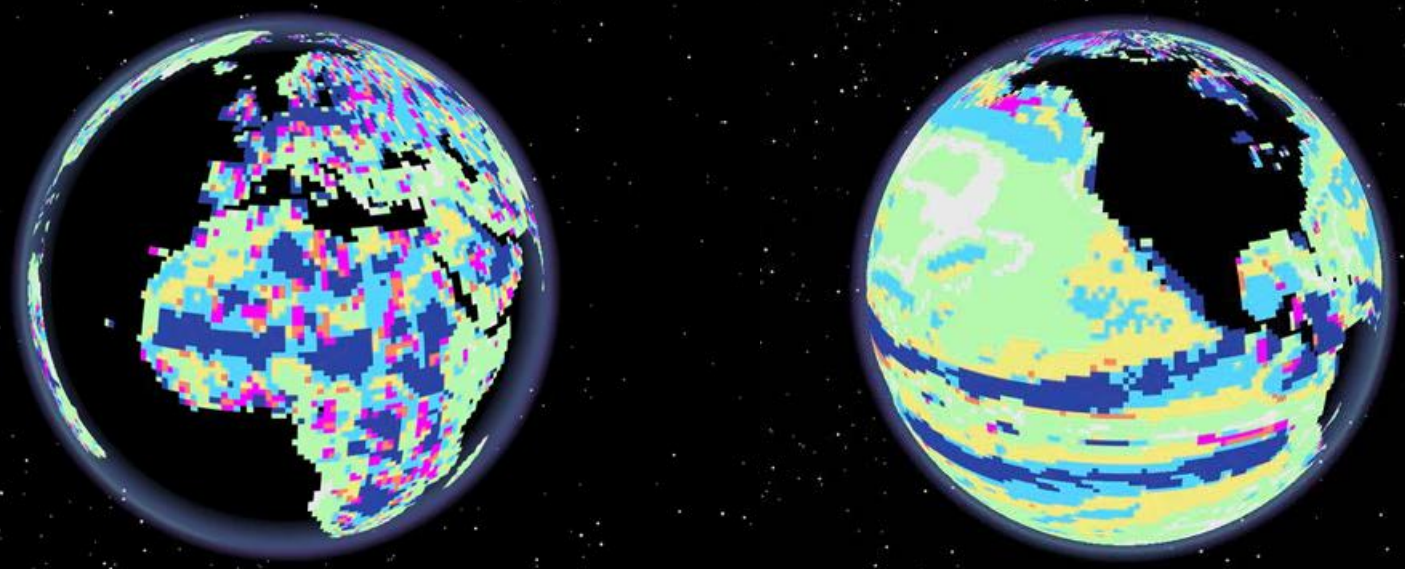
- Network climate connectivity was poor suggesting that the potential paths of ocean warming-driven distribution shifts are not well covered by the existing network of protected areas

- Strong variability between climate change scenarios

- Trans-boundary management

- **Many other things to consider!**

Thank you!



Jorge.Garcia-Molinos@sams.ac.uk