

Scotia-Canadian Ocean Research Exchanges (SCORE)

Latitudinal Gradient of Marine Diversity: A new quantitative approach integrating species similarity to determine and model the mechanisms supporting the global biogeography of biodiversity

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Section 1 – Exchange details and work undertaken

The exchange was for the duration of four months from 26th of April 2022 until the 5th of September 2022. I was hosted in the [Future of Marine Ecosystems \(FOME\) lab](#) at Dalhousie University, Halifax, Nova Scotia. I sought to work with Associate Professor Derek Tittensor in the Department of Biology as his work has been instrumental in biodiversity and climate change. It was not an easy exchange with lack of funding set-up for the first two months of my stay and travel hiccups. A more streamlined centralised funding approach would be suitable. This was the first year of the SCORE program and I hope it continues. I would be happy to assist with further details or comments to make it easier for those who partake next time.

Research summary

The initial aim of the research was to discuss the feasibility of using the neutral model used by Derek Tittensor and Boris Worm in their [2016 paper](#). Their work presents a unique approach to modelling diversity neutrally i.e., without species differences to generate latitudinal diversity gradients. This is an attractive approach as phytoplankton species lifecycles are relatively similar and computationally it would be a faster and cheaper approach. On deeper inspection of the method, the modelling code was extremely unique, not using R language or MATLAB. This presented a significant time cost to on-ramp working with the model. As noted previously Derek's work with species distribution modelling presented a more feasible and useful approach to utilising the funding and time we had. We are planning to re-evaluate the neutral modelling at a later date in the PhD program.

Species distribution modelling of phytoplankton has been performed in the literature very recently and [Righetti et al, 2019](#) present a latitudinal diversity gradient therein. Their results are very compelling yet recent in-situ data from the Atlantic meridional transect indicate that phytoplankton diversity potentially have a bi-modal diversity gradient. The notable difference in our approach was utilising the BIOMOD R package along with NPPEN and an in-house AQUAMAP model, totalling 10 models for evaluation compared to three in Righetti et al's approach.

Our new aim was to assess the latitudinal diversity gradient of phytoplankton using this approach from collaboration with Dr Gabriel Reygondeau at the University of British Columbia. Prior to the exchange my work with Leinster and Cobbold's diversity index which integrates taxonomic diversity indicated that richness alone is biased to sampling effort. This species distribution model (SDM) approach rectified this and will allow further research to assessing the role of sampling effort in species distribution modelling and the validity of this approach.

In tandem, I worked with Derek and the students at the FOME lab to build a new R package for code for working with the SDM species data from the [AQUAMAP](#) project consisting of 33,500 species models. This enhanced my knowledge in using R language and introduced me to using GitHub. The latter is very useful for sharing code and working distantly with others. This is not available to the wider scientific community yet but is planned in the future once the new version of models has been run.

I also collaborated on a soon to be published thesis of Emma Bradshaw in the lab concerning climate change and coral reef habitat suitability. I was tasked with plotting and presenting the results of the paper, and this is on-going work. In further collaboration, I worked with Dr Kristina Boerder on her

pilot Eelgrass restoration project in Nova Scotia. It prompted discussion of Marine Scotland's Scottish coastal observatory ([SCObs](#)) method using miniloggers as 1) great citizen science project and 2) a method for collecting coastal temperatures easily. This kind of data collection has not been utilized in Canada anywhere and it would be a great project to have both sides of the North Atlantic collecting similar comparable datasets in light of climate change monitoring. As this summer was the beginning of the project it was not feasible, but the discussion prompted Dr Boerder to consider this next year and herself and Derek will be visiting Scotland to review blue carbon eelgrass work.

We ran into issues with data compatibility with the existing methodology of species distribution modelling used by Dr Reygondeau that delayed progress. As this is pre-published, I cannot disclose in detail the methodology issues. We found a resolution when I started working with Dr Reygondeau's PhD student who had adapted the methodology to research mesozooplankton distributions. As a result, I was successful in modelling 741 phytoplankton species globally using this method. Results do indicate that the latitudinal diversity gradient may not exist for phytoplankton, but further analysis is required. It is planned we will publish this work at the end of my PhD, with many thanks to MASTS and OFI for the funding to make this possible.

Section 2 – International collaboration

Very early on it was evident that researchers in Canada were working on similar research goals to what I am aware of here in Scotland. I was most interested in the blue carbon work Dr Kristina Boerder has been pushing in Nova Scotia and beyond. We discussed the Blue Carbon forum as a possible avenue for future collaboration. This is not my area of work per se, but my time at Marine Scotland introduced me to this area. I will be continuing to work on the coral reef paper with Derek and Emma with the aim to submit around November which will be a great collaboration. I also envision that the work conducted this summer will be published when the time is available. I ran out of time and funding but in future endeavours with the FOME lab I would like to set up a coastal observatory like [SCObs](#) operated by Marine Scotland as this kind of citizen collected data is extremely useful for assessing the impacts of climate change in the North Atlantic.

Section 3 – Relevant objectives to UN Sustainable Goals and COP26 legacy

The fundamental issue of assessing global biodiversity quantitatively is wide differences in effort of sampling the marine environment for observational data which introduces bias to results. I have been working with the sum of all marine phytoplankton data on earth to investigate if this important group follows the latitudinal diversity gradient. As phytoplankton support fisheries and the carbon cycle, it is imperative we understand how diversity is structured globally (UN Sustainable Development Goals 13 & 14). This will enable further research to understand how different regions of phytoplankton communities may be affected by climate change and as a result how socially important resources such as fisheries may be impacted if their prey changes.

The work outlined in Section 1, feeds into creating useful information for planning and scoping further actions to address the urgent ongoing climate change crisis. Easily accessible useable information on diversity globally is paramount to strategically use resources to protect and manage ecosystems and fisheries resources. It is planned that the phytoplankton modelling performed will join a global database of marine species from zooplankton to whale sharks for stakeholder assessments. This will be invaluable to understanding changes in our ecosystems in the years to come.

Section 4 – Ongoing and Future working objectives

During my time at the FOME lab it was apparent that there were many things we wanted to work on but had to focus and use the time and funding wisely. As a result, I have been in discussions with preparing a post-doctoral funding application to use what I have learned in my PhD and apply it to other groups of fauna and flora. I also plan to visit Dalhousie in February of 2023, funding allowing, to strengthen my existing working relationships and develop the work conducted this summer into a pre-

print paper. I am also in the process of setting up an organisation which is now a United Nation stakeholder partner to facilitate inter-disciplinary solution finding for challenges in marine research and industry. I also hope to see Dr Kristina Boerder and Associate Prof Derek Tittensor when they visit the UK to collaborate with other eelgrass restoration projects ongoing here. I would also like to expand my working relationship with researchers at the University of British Columbia. Overall, the exchange was very fruitful and both sides benefited from the exchange.

Section 5 – Expenditure during exchange

The funding set-up for me was £3210 in funding from SCORE and \$7000 CAD* from Dr Derek Tittensor as an in-kind contribution of financial support. Without the latter this exchange would not have been possible, I am extremely grateful. For clarity I paid the rental deposit from my own savings as finding a place was not an easy task and we had to act immediately. I also paid Rhei directly my half of the rental cost for the months of May and June and then claimed this from my SCORE funding at Strathclyde. For the months of July and August I paid the rent from my Canadian bank account and then claimed this back from the SCORE funding too. The contribution in-kind from Dr Derek Tittensor was used to pay for Dalhousie University costs and fees and to support my living costs while in Halifax.

Item number	Description	Cost (GBP)
1	Flights to and from Halifax	£637.99
2	Rental cost for month of May	£702.84
3	Rental cost for month of June	£718.11
4	Rental cost for month of July	£746.56
5	Rental cost for month of August**	£404.50
	TOTAL	£3210

**The month of August was paid with the remaining SCORE funding (£404.50) and the remainder by me.

The following costs were associated to working at Dalhousie University and for the Ocean Frontier Institute conference.

Item number	Description	Cost (CAD)
1	Registration Application	\$115
2	OFI Conference	\$115
3	Dalhousie access fee	\$130
4	Access to Dalplex (Gym)	\$87.57
5	Dalhousie health insurance	\$243
	TOTAL	\$690.57

*The contributions made in-kind from Dr Derek Tittensor were used to pay for the above fees and costs while any remaining money was used to support myself in Halifax.