Assessing connectivity between MPAs: keystones, umbrellas, flagships and indicators – which taxa to include?

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Project description: Connectivity is a key factor in the designation of marine protected areas (MPAs). The 'big question' for managers is which species to focus on when measuring connectivity. Focal species, which underpin management decisions and guide conservation of natural environments, have been previously classified[1] as keystones, umbrellas, flagships and indicators, with lively debate around the exact definition of these terms. With MPAs now also intended to offer protection to highly mobile species (e.g. cetaceans, sharks, anadromous fish and marine birds), the question of which taxa to study to comprehensively assess connectivity between MPAs is highly complex.

To date, marine conservation studies have focused on habitats and management areas, or coastal and bathymetric features. In consequence, managers and scientists have often had to guess which taxa might best be studied to elucidate connectivity between MPAs, and some of the taxa selected, especially those whose basic biology and dispersal mechanisms are poorly understood, have yielded data of little value.

This project combines three approaches to elucidate the question 'which taxa to study?':

1. Meta-analysis of diverse data sources for marine species to determine the key drivers in patterns of connectivity;
2. Modelling of connectivity using the Marine Geospatial Ecology Tools package (MGET) (http://mgel.env.duke.edu/mget) in species identified in the metadata analysis;
3. Use of pre-existing population genetics tools (microsatellites and SNPs) to facilitate empirical testing of gene flow and connectivity between taxa in British MPAs.

The metadata analysis will review data from a diverse range of British and European marine taxa and will consider commonalities in patterns (breaks, absences, stepping stones and open connections) to identify the location of biogeographical features affecting multiple, diverse species. For example, we will explore the recently proposed division of the English Channel into separate bioregions based on taxon distribution data, together with spatial genetic data from the PI's lab for the pink seafan The metadata analysis will review data from a diverse range of British and European marine taxa and will consider commonalities in patterns (breaks, absences, stepping stones and open connections) to identify the location of biogeographical features affecting multiple, diverse species. For example, we will explore the recently proposed division of the English Channel into separate bioregions based on taxon distribution data, together with spatial genetic data from the PI's lab for the pink seafan[2].

The modelling and population genetics analyses will focus on species identified from the metadata analysis. Specifically, we will explore connectivity: a) within species whose distribution spans major

barriers to connectivity, and b) in focal species associated with the 31 recently designated Marine Conservation Zones around Britain.

Together, the three complementary themes of this project combine to a) identify natural breaks in connectivity in a range of UK marine species, b) explore associated hydrological features contributing to patterns of connectivity, and c) provide the first formal assessment of connectivity between recently designated MPAs in UK waters.

[1] Simberloff, D. (1998) Flagships, umbrellas, and keystones: is single-species management passé in the landscape era? Biological Conservation, 83: 247–257. [2] Holland, L.P., Dawson, D.A., Horsburgh, G.J., Krupa, A.P. and Stevens, J.R. (2013) Isolation and characterization of fourteen microsatellite loci from the endangered octocoral Eunicella verrucosa (Pallas, 1766). Conservation Genetics Resources, 5:825–829..

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Training opportunities: The student will join the Molecular Ecology & Evolution research group (http://projects.exeter.ac.uk/meeg/). Dr Stevens' group currently includes 2 PDRAs, 3 PhD students, 1 MRes student and technician support, while Dr Simpson' group comprises 1 PDRA, 2 PhDs and 2 MRes students; both are part of the larger Environment & Evolution (E&E) research theme within Biosciences. Dr Stevens shares a newly refurbished laboratory, fully equipped with all instrumentation required for modern molecular ecology research, including PCR machines, a 2D gel electrophoresis system, a NanoDrop instrument, a new Fluidigm EP1 SNiP analyser and a Beckman CEQ automated capillary sequencer. All 10 PIs within the E&E theme run active and successful research programmes, primarily in the field of aquatic environmental research, and the student will benefit from being part of a dynamic and rapidly expanding postgraduate research community.

The Researcher Development Programme from the University of Exeter's Employability and Graduate Development unit is informed by the national Vitae Researcher Development Framework, and provides transferable skills training in over 40 topics including writing for publication, data collection and management, effective presenting and communicating research, impact, public

engagement, interdisciplinary working, and mathematical and statistical skills for life sciences. Participation in the programme is mandatory for successful progression. On commencing the PhD, the student will complete and submit a learning agreement outlining key progress targets for the duration of the PhD. After 6 months the student will have a review meeting with the supervisory team and an assessor to compare progress against agreed targets. After 18 months the student will complete a 5,000-word upgrade report to outline research progress and demonstrate ability to critically evaluate the work against existing literature. This report will also include a detailed thesis plan, giving dates for expected completion of laboratory work and writing. The student will then be assessed by viva with an upgrade panel including 1-2 assessor(s) and the supervisory team.

The student will receive detailed training in a range of discipline and project-specific skills, including R for statistical programming and the MGET package for modelling of biological connectivity and simulations of larval dispersal based on hydrodynamic data/models. The student will also be trained in the use of standard molecular laboratory techniques, including DNA extraction and quantification, primer design, microsatellite optimisation, analysis and scoring, single nucleotide polymorphism (SNP) analysis and scoring, and use of bioinformatics pipelines and population genetics software for analysis of the resulting data.

To aid in the student's understanding of the policy and legislation-related aspects of the project and to provide the student with a structured learning experience with the CASE partner –Natural England (NE)– the student will undertake a 3-month placement at the Winchester and Exeter offices of NE. During this placement the student will have the opportunity to shadow Dr Jen Ashworth and other Natural England staff in the Marine Evidence and Monitoring team (Winchester) and to participate in internal NE training courses on a range of aspects of marine legislation and implementation. Understanding the overall work of NE will help to place the marine-related activities in broader context. The placement will also include visits to protected areas and the opportunity to observe and participate in intertidal survey work. We anticipate this placement to run at the start of Year 2 of the project. The student will undertake ad hoc visits to the NE office in Exeter to access training materials and grey literature relevant to the metadata analysis.

In addition, NE has many online learning resources that will be available to the student and that can be accessed externally or via the Exeter office. Natural England's Marine Function unit runs regular webinars as training for staff and the student will also have access to these. Access to these materials will be of particular value at the start of the project, during the metadata analysis, and in the latter part of the project when the student will be required to relate his/her empirical and modelling data to broader aspects of marine connectivity policy, implementation and legislation.

Training in marine science policy and legislation during the placement with NE will be critical for the student in helping to blend the findings of bench/field science with MPA design and designation. Specifically, Dr Ashworth and NE staff will provide training in: defining MPA types, MPA planning and marine nature conservation legislation; application of data to MPA designation; use of data to provide conservation advice for MPA casework; the workings of a Non-Departmental Public Body.

The project will deliver a student possessing a unique mix of skills, including detailed knowledge of state-of-the-art molecular genetics techniques and modelling skills necessary to undertake modern

conservation biology, and an understanding of the practices and nuances of designing and implementing environmental/marine legislation. This combination of skills will empower the student for a career in environmental biology and management.