HIFMB NEWS #03/23

© photo: Seadam | Dreamstime.com

TOP STORY

Quantifying Compositional Dissimilarity of Ecological Communities via Diffusion Maps

Understanding how ecological communities accumulate compositional change over environmental and spatial gradients has important practical implications. For example, we might wish to predict the amount of biodiversity in a region based on its environmental heterogeneity. In this case, we need to quantify how much compositional change to expect for a given change in environmental conditions. The first step is the calculation of compositional dissimilarity, or distance, between communities.

Typically, compositional dissimilarity is formulated in terms of species overlap and bounded between 0 and 1. Two assemblages with identical composition have a distance of 0 and two assemblages that share no species have a maximum distance of 1. But how do we compare multiple communities that share no species? For example, assume we traverse an environmental gradient and observe that assemblage 1 contains species A, B, and C; assemblage 2 contains species D, E, and F; and assemblage 3 contains species G, H, and I. Are assemblages 1 and 3 more dissimilar than assemblages 1 and 2?

A solution can be found by considering that compositional data forms structures, termed manifolds, in multivariate space. For example, consider a simple case where three species exhibit a bell-shaped response to a single environmental gradient and the height of each response curve corresponds to their expected abundance (Fig. 1a). Assume that we sample along the gradient at equally spaced intervals. Each sample is a vector of species abundances and the data defines a three-dimensional space with one dimension for each species. If we plot the proportional abundances of each species, the →

» We can think of changes in species composition as tracing a curve, or manifold, in a high-dimensional data space. Finding and characterizing such manifolds with diffusion maps allows us to describe how communities change. «

Jordan Gault, ecologist

→ samples trace a manifold through the data space (Fig. 1b). Because the manifold represents the assemblages that can be realized with respect to the environmental gradient, a natural measure of dissimilarity between assemblages is the distance between them along the manifold. However, calculating the distance directly between two pairs of assemblages does not necessarily approximate the distance between them along the manifold. For instance, calculating the distance directly between assemblages at the beginning and end of the gradient (Fig. 1b; red arrow) indicates that they are quite similar. In fact, they can only occur at opposite ends of the gradient, representing traversal of the entire manifold (purple arrow).

Notice that the problem occurred when calculating the distance between the very dissimilar first and last assemblages. If we instead calculate the distance directly between the first and second assemblages, this closely approximates their distance along the manifold. In fact, calculating the distance between dissimilar objects in high-dimensional space will typically introduce bias and error (see the video linked below for a great explanation of why this is true). However, the distance between sufficiently similar objects is more reliable. We can leverage this fact to calculate trustworthy distances between very dissimilar data points.

We applied diffusion maps, a manifold learning method, to measure distances between assemblages along such manifolds. Diffusion maps use the notion of a diffusion process on a network in the data space to quantify distance between different points along the manifold. To do this, we consider each data point (species assemblage) as a node in a network where links between data points are defined by some measure of distance between them. Crucially, data points are linked only to a few of their nearest neighbors. The outcome is a network of data points where each node is connected to only a few nearest neighbors (Fig. 2). We can then explore the structure of this network by considering the random diffusion of particles between the nodes. The intuition is that the further apart data points are in the network, the longer it would take particles to travel between them via random diffusion.

Because diffusion maps essentially integrate over local distances to calculate global distances along the entire manifold, we can now calculate the distance between multiple assemblages that share no species in common. If we sample along a gradient where communities shift from one distinct assemblage to another multiple times, each distinct assemblage can be connected to the others by a network of local distances between intervening samples. This makes diffusion maps an especially promising approach for biodiversity assessments at regional scales encompassing many distinct communities.

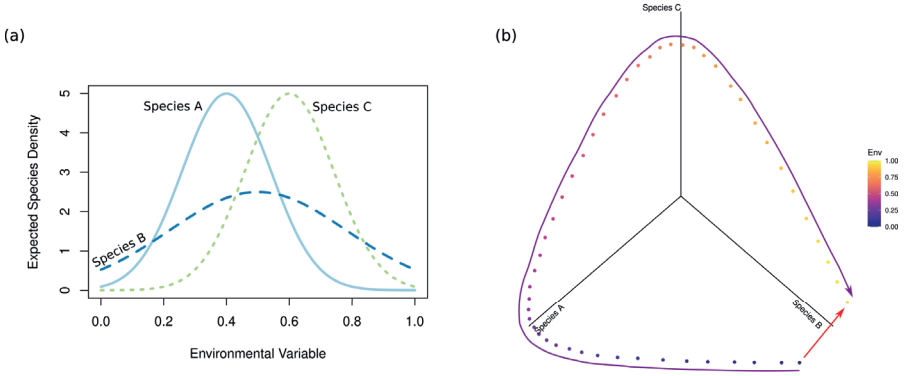


Figure 1: Compositional data can form complex structures in multivariate space. (a) Expected species abundance follows a bell-shaped curve along an environmental gradient. (b) Plotting species abundances traces a manifold in a 3-dimensional data space.

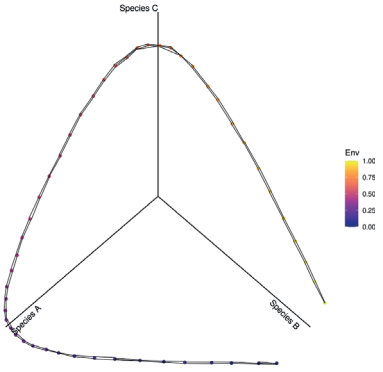


Figure 2: Diffusion maps treat the data as a network with nodes connected to only a few nearest neighbors.

Gault J A, Freund J A, Hillebrand H, Gross T (2023). Dissimilarity analysis based on diffusion maps. Oikos. doi:10.1111/oik.10249

youtube.com/watch?v=Yp_1f1q-4F0&t=399s (Curse of Dimensionality)

IN THE FIELD WITH...

Iliana Baums: "With Eyes Wide Open we Develop Technologies to Restore Coral Reefs"

Coral reefs are essential for the survival of billions of people. But IPCC predictions left no doubt that we would need new technologies to restore coral reefs devastated by rising water temperatures.

Therefore, coral scientists, managers, and restoration experts have been working for many years to develop the technologies needed to grow corals and outplant them effectively. I am proud that we have listened to the warnings and started on time. Although far from complete, amazing progress has been made and has resulted in the genetic diversity of Florida's corals not being completely lost.

Currently, water temperatures in Florida are so high that coral colonies of all species have bleached. NOAA Coral Watch predicts that corals will be exposed to bleaching temperatures into November. Due to this prolonged heat wave, we expect mass mortality of coral colonies in the Florida Keys and the Caribbean. However, despite the high temperatures, corals spawned in early August. It was a remarkable, sad sight to see white corals spawning. We collected this spawn and used it to make targeted crosses. The resulting larvae are now growing into juveniles in aquariums. We hope to use these crosses to maintain the genetic diversity of the endangered corals and possibly increase the temperature resistance of the corals.

But despite all technological progress, we will only succeed in preserving coral reefs if CO_2 emissions are rigorously reduced. Should this happen, I am optimistic that we will be able to begin the long process of reef restoration with the corals we saved.

© private

Iliana Baums, Professor for Marine Conservation, on a field trip in Florida

EVENTS

"Superb Format, Engaging, Enriching - Loved it!"

More than 120 visitors from ten countries made the 4th Symposium on Functional Marine Biodiversity a great event characterized by mutual respect, interest and exchange.

The Statemuseum for Nature and Man in Oldenburg provided an inspiring setting for debates across disciplines, from both natural and social science perspectives. These four sessions provided the framework:

- Tipping points in biodiversity change
- Approaches to decision making and ecosystem management
- The multi-data matrix behind functional biodiversity
- Biodiversity perception

As in previous years, the symposium was characterized by extended presentations and ample time for discussion.

Parallel to the symposium, the sound installation *Mirrors* by Geraint Whittaker and Ilse van Opzeeland ran in the museum. It took visitors on an acoustic journey of the minke whale on its way from Antarctica to Namibia, combining recordings by the AWI's Ocean Acoustic Group with a fictional narrative.

HIFMB INSIDE

3 Questions to: Meinhard Simon

© photo: Monika Feiling

Meinhard Simon, Professor for Biology of Geological Processes and Aquatic Microbial Ecology at the Institute for Chemistry and Biology of the Marine Environment (ICBM), went into retirement in July. He is thus the first founding member to retire. Time for a little look back:

Meinhard, you were part of HIFMB from the beginning as one of eleven founding members from the University of Oldenburg and AWI. What expectations did you have with the new institute?

All the expertise that accumulated during the last 10 to 15 years before the foundation already showed, how strong Oldenburg and the surrounding locations were regarding marine biodiversity research and beyond, also in modelling. It was the obvious consequence and also my expectation to bring this expertise together in a new institute.

What has been achieved since then in the last six years has far exceeded my expectations in terms of the visibility of HIFMB, because it has been established in a very short time. Not only in Germany, but I think even more so in the European landscape and beyond. And I think part of this was also the very successful recruitment of the new professors here.

And what do you take away from the six years since the institute came into being?

I wouldn't say „take away" because I still feel very connected to what's going on at HIFMB, also in close relationship with ICBM.

What I will remember and what for me is a crucial element of HIFMB is the postdoc pool. I think if you not only hire new postdocs, but you bring them together as a cohort on a joint topic, that's a very good basis for all kinds of research related to HIFMB.

Last but not least, what three words would you use to describe the HIFMB?

That's very hard to pin it down to three words – allow me a few words more: European landmark in marine biodiversity excellence.

RESEARCH

Top Recent Publications

Dlugosch L, **Bunse C**, Bunk B, Boettcher L, Tran D Q, **Dittmar T**, [...] & **Simon M.** (2023). Naturally induced biphasic phytoplankton spring bloom reveals rapid and distinct substrate and bacterial community dynamics. *FEMS Microbiology Ecology, 99 (8).* doi.org/10.1093/femsec/fiad078

Whittaker G R. (2023). Creatively connecting science, society and the sea: a mini-review of academic literature focusing on art-science collaborations and the ocean. *Frontiers in Marine Science, 10.* doi.org/10.3389/fmars.2023.1234776

Peters K. (2023). Seven thoughts on seven ethics. Dialogues in Human *Geography, 13 (2), 306-315.* doi.org/10.1177/20438206231171209

Mahato M. (2023). Whale Fall: Sequences 1, 2, 3. *Ecotone, 18 (2), 69-78.* doi.org/10.1353/ect.2023.a903408

Thomas M K & **Ranjan R.** (2023). Designing More Informative Multiple-Driver Experiments. *Annual Review of Marine Science, 16.* doi.org/10.1146/annurev-marine-041823-095913

Lombard A K, Clifford-Holmes J, Goodall V, [...], **Peters K**, [...] & Morgera E. (2023). Principles for transformative ocean governance. *Nature Sustainability.* doi.org/10.1038/s41893-023-01210-9

+ More on Google Scholar: scholar.google.de/citations?user=uCoLTyAAAAAJ&hl=en

VIEW FROM NORTHWEST #17

Muddy Boots on the Beach

"As a child I did not even have a word for nature, it was just outdoors". Marie Vandewalle, one of the invited speakers said this during her talk at the 2023 HIFMB symposium, and this sentence struck me in multiple ways. First, it gave words to something I had thought about as being true for my childhood as well, which was spent to a large extent outdoors without any concept of nature, or biodiversity or their value. I was not even interested in animals or plants, but almost every day (perhaps not true I also read a lot) I "went outdoors" without being a "nature lover". Outdoor just existed, it did not need a meaning or value. Second, it reminded me that as head of admission for a marine master program, every second motivation letter I read would start with how the applicant was already attracted to nature (or biology or the ocean) as a kid playing on the beach. I can now (as I skipped this job years ago) confess that I always thought this was a little creepy.

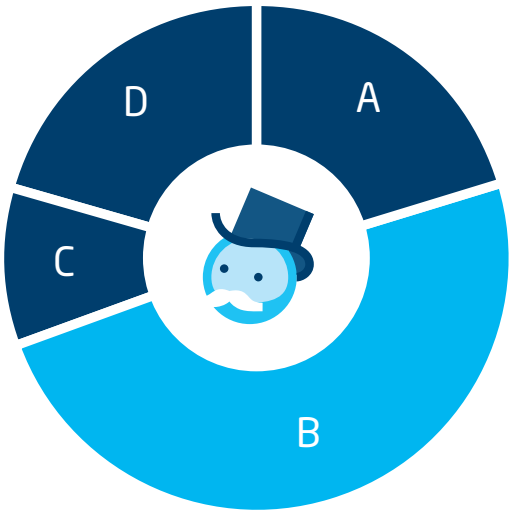
For one, I found that building sand castles has not a lot to do with a graduate science program. Then, I wondered about the importance of this attachment to nature, whether muddy boots are a pre-requisite for being an ecologist. While I liked beaches as a kid (and still do), my biology study was not motivated by nature (I wanted to do genetics) and my excitement about biodiversity (and emotional attachment to nature) came very late during my studies (or perhaps even during my PhD). To be honest, when I started my studies I was barely able to distinguish three bird species. I started with plant identification in my 3rd study year because I hated being asked about things I did not know about. Phytoplankton and benthic microalgae I learned to identify during my diploma and PhD theses. Therewith came fascination for biodiversity, which I would consider my biggest driving force nowadays. So perhaps the lack of muddy boots in my actual work life - my last field work is ages away and it never was a major part of my science - can be made up when muddiness is earned cumulatively over lifetime. Because that mud was easily found outdoors.

Sincerely, Helmut Hillebrand
Director — Professor of Pelagic Ecology
helmut.hillebrand@hifmb.de

HIFMB TEAM

Fun Fact*

Which Classic Board Game Has Turned You into a Fury?



A	20,5 %	Ludo
B	49 %	Monopoly
C	10 %	Activity
D	20,5 %	Risk

* answered by HIFMB employees

PUBLISHER

Helmholtz Institute for Functional Marine Biodiversity at the University of Oldenburg (HIFMB)

Ammerländer Heerstraße 231 / 26129 Oldenburg / Germany / T +49 471 4831 2546 / info@hifmb.de

Twitter @HIFMB_OL / V.i.S.d.P.: Ruth Krause / Legal Notice: **hifmb.de/legal-notice**

Sign up for our online newsletter: hifmb.de/newsletter

hifmb.de