Getting to the bottom of biodiversity


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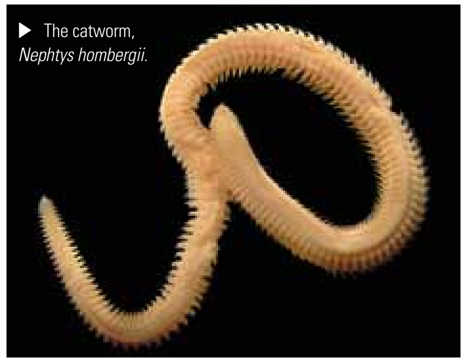
The new technique of macroecology lets ecologists take isolated samples of plant and animal life and piece the results together to understand how species are spread across a wide area. Tom Webb explains how marine science is helping in the search for a general theory of biodiversity.


▶ The catworm, *Nephtys hombergii.*
Hans Hillewaert/www.eol.org


▶ The sea potato, *Echinocardium cordatum.*
K. Telnes/www.seawater.no

The chilly waters of the North Sea don't feature on many eco-tourists' lists of must-see marine biodiversity hotspots. Yet despite the oil rigs, the fishing and the ferries, the surprisingly diverse animal communities of this humdrum sea are revealing important new facts about how life on Earth is distributed. By linking the natural history of individual species to patterns in diversity across the entire sea, we are also beginning to understand how future impacts such as climate change may alter biodiversity across large areas.

In a study funded by NERC's Strategic Oceans Funding Initiative, we looked at the North Sea benthos – those animals living on or in the seabed – and showed that we can predict the distribution of species based on their biological characteristics. In particular, traits such as body size seem to determine the spatial patterns of the whole North Sea benthic community. But these effects are subtle: big species are not necessarily more widely distributed than small species; rather, they are more evenly distributed within their ranges. On the other hand, small species, and species which can't move long distances, appear to have very clustered distributions.

This is important because human activities in the North Sea affect some species more than others. Commercial fishing, in particular trawling, has a disproportionate effect on large species, even those not deliberately targeted by fishermen. If those large species are lost from the system, this has implications for the structure of the whole community. It does suggest, though, that we can monitor an activity's effects on the system by looking for changes in the relative degree of clustering of species. This may be useful because it is easier and faster to assess the numbers of species in samples than it is to obtain detailed knowledge of their biology.

Size matters

In fact, as part of the same project we're finding out just how difficult it is to get information on the biological characteristics of most marine animals. For many species, there is simply no documented knowledge of their ecology and behaviour – things like what they eat, how many offspring they produce, or how long they live. Typically we have this data for fewer than a quarter of species. If this is true for the North Sea, our ignorance surely plumbs even greater depths in less well-studied and less accessible regions, including much of the developing world and the vast abyssal plains of the deep sea.

A lack of available information may explain the fact that our study did not identify other facets of animal biology as important drivers of species distribution. For instance, most bottom-dwelling species are relatively sedentary as adults, and so their best chance of moving large distances comes when they reproduce. Broadly speaking, species fall into two camps: those which launch their larvae into the plankton where they drift around for days or even weeks before settling back to the seafloor as adults; and those which keep their offspring close to them. We expected that the choice of larval developmental strategy would have a big effect on adult distributions, with species with a planktonic phase spread more widely. Although we did observe a trend in this direction, it was not statistically significant – but this may be because we had data on developmental mode for only 124 of 575 species.

Body size is the trait that bucks this trend for lacking data – it is far easier to measure an organism than to find out anything about its lifestyle, and we can usually find basic estimates of size for around two thirds of the species in our samples. Studying body size in combination with information on the distribution and abundance of species thus promises more insights in future.

Such insights are possible due to a 'macroecological' approach – a relatively new technique well suited to address the difference in scales between ecological samples and the big environmental questions that we face. Most field ecologists work at small spatial scales, typically identifying and counting organisms in a series of small samples – the classic ecologist's quadrat usually measures between 10cm and 1m on each side.

The equivalent sample for marine benthic systems is the grab sample, where sediment from a small area (most often $0.1m^2$) of the seabed is extracted, brought up to the surface and then sieved to reveal the species living in it. Macroecology lets us combine many such samples – in this case, taken from more than 230 locations throughout the North Sea – so that ecologists can address far bigger questions, such as how species are moving in response to climate change.

Biodiversity on land and sea

Our study is unusual because most of our knowledge of biodiversity comes from ecosystems on land. Macroecology, in particular, has developed largely through the study of a few well-known groups like birds and butterflies. But any study of birds is only focused on a small component of diversity. In taxonomic terms, all birds belong to a single group called a class; the next level up in the taxonomy, the phylum, groups birds with all other vertebrates.

Other animal phyla include molluscs, arthropods and annelid worms. So although birders might get excited by small differences between bird species, all birds are more similar to each other than any worm is to any mollusc, and it's only by studying more diverse systems that we can start to understand how major differences in biology affect patterns in geographical distribution.

This is where the advantages of working in marine systems become most apparent. For example, a single $0.1m^2$ sample of North Sea sediment may contain up to 90 species, and these species are very diverse – there are many worms, but also molluscs, starfish and crustaceans. In the dataset we used, single samples contained representatives of as many as seven different phyla. Studying systems with such taxonomic diversity means that in the same set of samples, there is tremendous variety in biological characteristics too.

There are other good reasons to study marine systems. Over 90 per cent of the so-called 'habitable volume' of Earth – regions suitable for life – is marine. Life originated in the sea, and the diversity found in the North Sea is not a fluke of sampling: around two-thirds of animal phyla are found only in the oceans. But the seas are increasingly threatened by many human activities.

As well as climate change, which is not only warming the oceans but also making them more acidic, marine fish make up an important part of the diet of a large proportion of the world's people, and the seabed is an important source of natural resources including oil and gas.

Any general theory of biodiversity therefore has to encompass the marine environment. 1.2 billion people live near the coast and this total is expected to continue increasing rapidly. If this happens, then understanding how marine species are distributed may be crucial to our future well-being.

MORE INFORMATION

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A full report of this work, carried out in collaboration with Dr Elizabeth Tyler in Sheffield and Dr Paul Somerfield at Plymouth Marine Laboratory, is published as an Open Access paper in *Marine Ecology Progress Series* 396: 293-306.
www.int-res.com/abstracts/meps/v396/p293-306/