Global ocean trawl reveals plethora of new lifeforms

Three-year *Tara* Oceans project publishes first analyses of rich diversity of planktonic life.

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The *Tara* Oceans schooner.

S.Bollet/Tara Expéditions

A team of researchers who spent three and a half years on a schooner fishing for microscopic creatures in the world's oceans have reported the initial results of their survey — revealing a rich, diverse array of planktonic life.

Part scientific expedition, part adventure and part public-outreach effort, the project took place aboard the 36-metre *Tara*, which set sail from Lorient, France, in September 2009. Scientists onboard collected some 35,000 samples at 210 stations over the voyage, in a bid to build up a holistic view of Earth's upper oceans.

The haul, details of which are analysed in five papers published today in the journal *Science*[1–5], includes a catalogue of more than 40 million microbial genes — most of which were not previously known — as well as some 5,000 genetic types of virus, and an estimated 150,000 kinds of eukaryote (complex cells), many more than the 11,000 types of marine eukaryotic plankton already known.

It is no surprise that the oceans contain such huge numbers of organisms with such vast genetic variety, says Jack Gilbert, a microbial ecologist at the Argonne National Laboratory in Illinois. What excites Gilbert most is that the reports show how a genetic database can be used to both predict ecological relationships between microbes, and to analyse how marine ecosystems might respond to environmental changes.

"The whole project provides a really valuable database to enable us to interrogate the microbial ecosystems of our oceans in an unprecedented way," Gilbert says.

Fantastic voyage

"Instead of studying one species, organism or molecule at once, we are trying to understand the behaviour of the system," says project director Eric Karsenti, a cell biologist at the European Molecular Biology Laboratory in Heidelberg, Germany.

Following the model of the J. Craig Venter Institute's Global Ocean Sampling Expedition, which ran from 2004 to 2007, the *Tara* Oceans team extracted fragments of DNA from all the organisms in their ocean samples. The researchers then sequenced and analysed the DNA using bioinformatics software to determine how many different kinds of creature they had. This approach, called metagenomics, allows scientists to make predictions about the functions of genes even if the parent organisms cannot be isolated or grown in a lab.

Whereas the Venter Institute's work focused on bacteria[6], the *Tara* Oceans project targeted the entire microscopic ecosystem — from viruses up to fish larvae 100,000 times larger. It also searched a greater range of depths, from the sunlit upper waters down into the 'midnight zone' up to 2,000 metres below. And the team took detailed environmental measurements with each biological sample.

One analysis[2] identified temperature — rather than factors such as salinity or oxygen — as the key influence on the structure of microbial communities in the upper ocean regions, driving home concerns that global warming could dramatically affect the composition of marine ecosystems.

Plankton interactions

But most interesting, Gilbert says, was how the team used genetic data to predict interactions between individual organisms. In one example[4], the researchers predicted that a flatworm belonging to the genus *Symsagittifera* would have a symbiotic interaction with a photosynthetic microalga of the genus *Tetraselmis*. To check, they identified specimens of the worm and studied them under a microscope. Sure enough, they saw algal cells inside the worms and matched the DNA label of these algae to the ones predicted to be symbionts. "It was a beautiful study that shows you what network analysis, or 'interactive-omics', can actually achieve," Gilbert says.

A fundamental insight arising from the study was that 72% of associations between organisms were positive — that is, most coexisted in predicted symbiotic or parasitic relationships, rather than in exclusionary relationships, says Karsenti. It suggests that collaboration, not competition, could be the major force driving the structure of ecosystems and the evolution of the organisms within them. "In the theory of evolution, we always say it's survival of the fittest," says Karsenti. "I don't think this is the way it works. It's more like survival of the system."

The ability to correlate ecosystem composition with environmental parameters means that the data could be fed into models of global ocean currents and oceanographic variation, Karsenti says. That might predict not only what ecosystems will form where, but also how they might respond to changes such as global warming. "In the end, the goal is to get some kind of 'weather forecast' predictions for the ecosystem," he says.

Much of the data remain to be analysed, including those collected from *Tara*'s expedition to the Arctic Ocean. But the bioinformatics data and oceanographic measurements are now publicly available for anyone to access.

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Clarifications

Clarified: This story has been modified to clarify the implications of the dominance of collaborative organism relationships on the evolution of ecosystems.

References

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