Abstractions

FIRST AUTHOR

Altruistic behaviour, cooperation and deceit are not the most obvious concepts to associate with fish, but the work reported on page 975 explores these very characteristics in the piscine world. Redouan Bshary, a zoologist at the University of Neuchâtel in Switzerland, teamed up with Alexandra Grutter, a biologist at the University of Queensland in St Lucia, Australia, to study cleaner fish (*Labroides dimidiatus*) and their interactions with their 'clients'. The cleaner fish eat parasites on the clients, but they sometimes 'con' the clients by eating their mucus instead. After spending hundreds of hours underwater observing the fish, Bshary and Grutter did controlled experiments in tanks. They found that both parties keep score of long- and short-term benefits to fine-tune their interactions. Bshary came up for air to talk to *Nature* about the work.

How much fun did you have at sea?

Lots! I sat in coral reefs about 2–5 metres deep, with the cleaner fish 2–3 metres away. There was always something going on. The clients want the cleaners to eat the parasites, but the cleaners want to eat the mucus. There is a conflict of interest, so the client has to make the cleaners want to clean them, by chasing them or biting them. Sometimes the cleaners cheat by eating mucus rather than parasites. To pacify their client, they give massages.

How did you replicate this in the lab?

In our experiments, we replaced the clients with plexiglass plates that are moved with a lever, so we could control how the 'client' responds. We put pieces of prawn on the plate in place of mucus, and fish flakes in place of the parasite. The cleaner fish like prawns and they don't like fish flakes. If the fish ate what they like — a piece of prawn — we took the plate out of the aquarium. So the cleaner fish learnt that eating their preference removes their food source.

What immediate effects did this have on your own dietary preferences?

After measuring prawn consumption for a month, you don't want to eat prawns. It took two months for me to eat prawns again.

Most humans don't like parasites or mucus, so how could this translate?

In humans, it is probably about giving (money or direct help) for prestige — you can even self-advertise your deeds. Americans say, 'do something good, then talk about it', so you get social or professional prestige.

Do you use these theories to manipulate people?

No — not consciously! ■

MAKING THE PAPER

Irina Marinov

An in-depth look at how the oceans take up carbon dioxide.

Carbon dioxide is a well known greenhouse gas and a major contributor to global warming. As researchers and policy-makers struggle to find ways to reduce atmospheric concentrations of the gas, some scientists are switching their gaze from the sky to the sea. The world's oceans absorb and store a sizeable amount of atmospheric CO_2, but the exact mechanisms behind the process are not yet fully understood.

On page 964 of this issue, Irina Marinov, now based at the Massachusetts Institute of Technology, and her colleagues at Princeton University in New Jersey provide fresh insight into the oceans' ability to soak up CO_2. Marinov and her team focused on the Southern Ocean, the expanse of water that surrounds Antarctica and absorbs the lion's share of CO_2. Their work involved modelling CO_2 uptake in the ocean — but the model was inspired by the combination of two factors.

A meeting about iron fertilization of the ocean, which Marinov attended in 2003, provided the first spark. This technique involves seeding certain sections of the ocean with iron to encourage the growth of carbon-loving phytoplankton. The organisms use up and break down CO_2 and other nutrients, lowering the concentration of CO_2 in the water and so allowing more atmospheric CO_2 to dissolve in the sea.

The meeting described how researchers had been experimenting with iron fertilization in the Southern Ocean, where lack of iron prevents phytoplankton from growing. The scientists chose where to seed the ocean based on the biology and chemistry of the water. It occurred to Marinov that they might be overlooking one important factor: ocean circulation patterns.

That thought led Marinov to the second key element in her team's model: computer simulations of sections of the Southern Ocean. She was aware of simple mathematical models developed by Robbie Toggweiler and his colleagues at the Geophysical Fluid Dynamics Laboratory in Princeton, New Jersey, which divided the ocean up according to circulation patterns. Most scientists tend to treat a body of water such as the Southern Ocean as a uniform system, but Toggweiler's work implied that various parts of an ocean behave differently.

So Marinov and her team combined the two ideas to produce a new model of the Southern Ocean. "The mathematical techniques we used were simple, standard even, but we used them in a more creative way," she says.

In the model, the researchers removed most of the nutrients and associated CO_2 from the surface water to simulate increased photosynthesis by phytoplankton. This allowed them to work out the maximum amount of CO_2 that a specific body of water could take up. They then deployed the mathematical models of ocean circulation to see what would happen.

After several months of running simulations, the group found that nutrient depletion was more efficient at drawing down atmospheric CO_2 in the most southerly regions of the Southern Ocean. In this region, the circulation pattern moves the surface water down into the ocean's depths, where the sequestered carbon might be trapped for a relatively long time.

The study has implications for the design of future iron-fertilization experiments, Marinov says. "Our conclusion is that you need to focus on the Antarctic," she says. ■

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