In a spin over super-sized ocean eddies

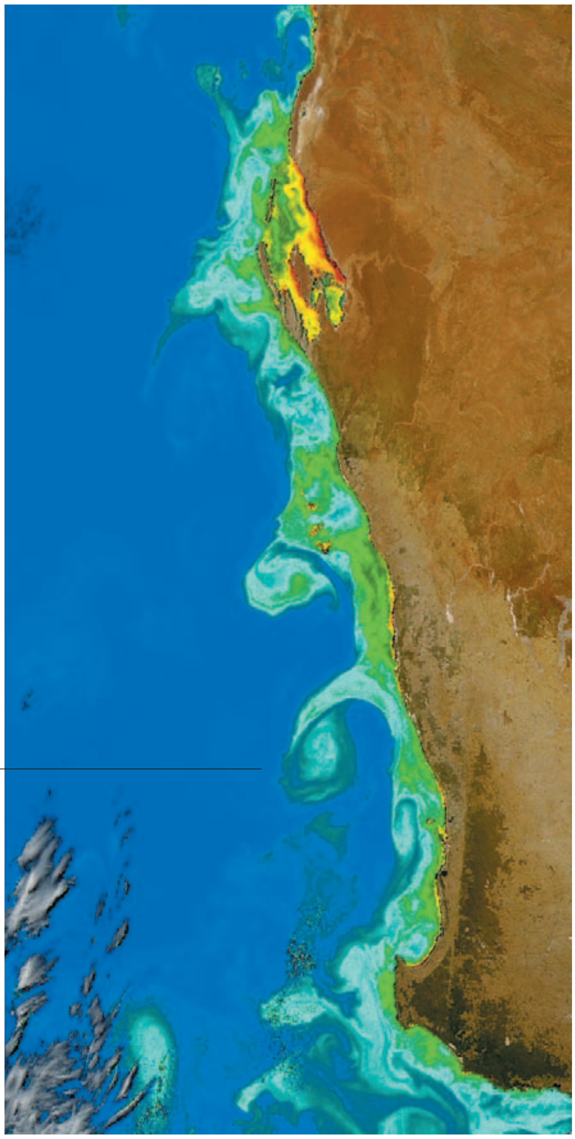
Marine scientists are slowly unravelling the secret lives and effects of vast, current-driven whirlpools off the Australian coastline. Their new insight is expected to greatly assist sustainable management of key fisheries. **Wendy Pyper** reports.

UWA Centre for Water Research

The eddy cruise team aboard the state-of-the-art research vessel *Southern Surveyor*.

Space provides an excellent vantage point from which to view and study gigantic ocean eddies. Hundreds of kilometres across, the massive whirlpools appear as bulges and depressions on satellite maps. Until recently, little was known about them.

Scientists have learned to track and characterise these phenomena with concentric rings, much like the isobars describing highs and lows on weather maps.



UWA Centre for Water Research

Satellite-generated maps of water movement and temperature off the WA coast, reveal eddy positions and size.

A colour-coded eddy swirl, many kilometres across, mixing water of different temperatures together off the coast of WA.

What is being slowly learned about ocean eddies suggests that they are dynamic ecosystems in themselves, and have fundamental influences on fisheries and related ocean habitats that they sweep past.

From their offices in Hobart and Perth, CSIRO Marine Research scientists, Dr David Griffin and Dr Ming Feng, are tracking a number of these huge eddies spinning off the Western Australian coastline. Their work has supported a team of scientists from the University of Western Australia, Curtin and Murdoch Universities, Fisheries WA, and Georgia Tech. in the United States, who recently got up close and personal with eddies of interest, on a 23-day 'eddy cruise', aboard the research vessel *Southern Surveyor*.

Eddies and fisheries

Cruise leader, Dr Anya Waite of the University of Western Australia's Centre for Water Research, says ocean eddies hold scientific interest for two main reasons. Firstly, the physical characteristics of the eddies themselves are phenomenal, with some achieving 200 km in diameter and 300 m in depth, with currents of up to two metres per second, and a full rotation every four to six days.

Secondly, ocean eddies are thought to influence the productivity of fisheries, such as, for example, the Western Australian rock lobster fishery. The mechanism by which this happens is, so far, unknown, but if it can be deduced, the information could prove vital to improving the sustainability of fisheries.

'If we can understand how different eddies impact on productivity, we may be able to predict changes in it, based on the satellite maps,' Waite says.

'It will also help us understand the limitations to productivity in our oceans so that we can make better decisions about whether a fishery is under-exploited.'

Understanding eddy impacts on productivity in unstudied ecological systems is also critical, as new fisheries, such as the deep-sea crab fishery on Western Australia's seamounts, open up in these areas.

'We don't know anything about some of the ecosystems we're fishing in, so we don't have a framework for sensible management decisions. If we can determine how eddies effect these systems, we'll be in a better position to avoid large scale problems down the track,' Waite says.

'If we can understand how different eddies impact on productivity, we may be able to predict changes in it, based on the satellite maps,' Waite says.

As with most scientific questions, layers of complexity conceal quick insight. According to Waite, there is a link between the productivity of the rock lobster fishery and the Leeuwin current – recently confirmed as the world's longest, it is a large, warm current that flows southwards, off the Western Australian coast. Ocean eddies are thought to form when the Leeuwin hits the coastline and becomes unstable.

'It's like when you're mixing coffee,' Waite explains. 'Sometimes when milk hits the coffee it stays in one place. At other times you get big swirls.'

In oceanic terms, these swirls become individual eddies spinning clockwise or anticlockwise, or pairs of eddies, known as eddy 'dipoles', spinning beside each other in opposite directions like an eggbeater. Eddies spinning in a clockwise direction draw cold, nutrient-rich water up from below, while those spinning anticlockwise funnel surface water downwards.

The scientists hypothesise that the Leeuwin current impacts on the rock lobster fishery via the eddies it spins off. Depending on their rotational direction, these eddies can support the growth of plankton on which rock lobster and fish larvae feed.

'There are two ways eddies could impact fisheries,' Waite says.

'If they spin clockwise and draw up nutrients from below, they fuel the growth of phytoplankton and zooplankton. The other way is that they carry productive water from the coastline into the open ocean.'

Eddy mapping

To look at the physical, chemical and biological characteristics of eddies, the cruise team deployed a range of sophisticated underwater instruments, including a 'Sea Soar' mapper. Looking much like a model aircraft, it is designed to glide in water rather than air, and when towed behind a vessel, undulates up and down in the water column sampling such things as temperature, salinity and phytoplankton.

The Sea Soar identified phytoplankton hotspots, comprised mainly of diatoms and picoplankton.

UWA Centre for Water Research

The Sea Soar sampler, here about to be deployed, moves through eddies from the surface to their deepest reaches, collecting samples of eddy creatures and other vital profile information.

UWA Centre for Water Research

The researchers found that eddies dredge up and carry around all manner of weird sea life. Some species live within eddies and rely on their dynamics.

The location of these hotspots may help scientists deduce the movement of nutrients within eddies.

The team also analysed the nitrogen signature of plankton and fish and lobster larvae taken from these hotspots, to determine whether the phytoplankton are growing on nitrogen sourced from the deep ocean (drawn up by the eddy) or the atmosphere, and what the larvae are eating.

'By mapping the system we were able to see how much of the production in eddies is driven by deep nitrogen, and how much from the atmosphere. From that work we can understand what controls productivity,' Waite says.

In comparison to eddies formed in other parts of the world, such as those spun off the Californian current and the Gulf Stream, Waite says early results from the Leeuwin current eddies are unexpected.

'We're not finding phytoplankton production in the same areas of the eddies as we'd expect, and we think that the Leeuwin current is doing something special,' she says.

'The anticlockwise, down-welling eddy was significantly more productive than the up-welling one, so we think the up-welling eddy is being capped by a layer of warm water from the Leeuwin current, shutting down productivity.'

Waite hopes further experimentation over the next three years will solve this mystery.

'The long-term goal is that we can understand more about the links between climate and fisheries. As the Leeuwin current is influenced by climate, we can use climate change patterns to predict whether productivity of the rock lobster and other fisheries will go up or down,' she says.

'To do this we need to understand the more complex relationships between the Leeuwin current and ocean eddies, and how the movement and productivity of eddies impact on fisheries.'

More information:
Information on the Leeuwin current and its impact on the rock lobster fishery can be found at: http://www.marine.csiro.au/LeafletsFolder/44leuwin/44.html
Satellite maps of the Leeuwin current and other regions: http://www.marine.csiro.au/remotesensing/oceancurrents/

Contact:
Dr Anya Waite, (08) 6488 3082, waite@cwr.uwa.edu.au
Dr David Griffin, (03) 6232 5244, david.griffin@csiro.au

This project was funded by the Strategic Research Fund for the Marine Environment, a collaborative venture between the Western Australian government and CSIRO Marine Research. The research was conducted onboard the Southern Surveyor.