currentdirections • SRFME
SEPTEMBER 2003
Strategic Research Fund for the Marine Environment

THIS ISSUE:

Sensing WA coastal waters from space

Satellites are fast becoming the new window on the sea in Western Australia, helping scientists to unravel the links between oceanographic and biological processes in the state's coastal waters.

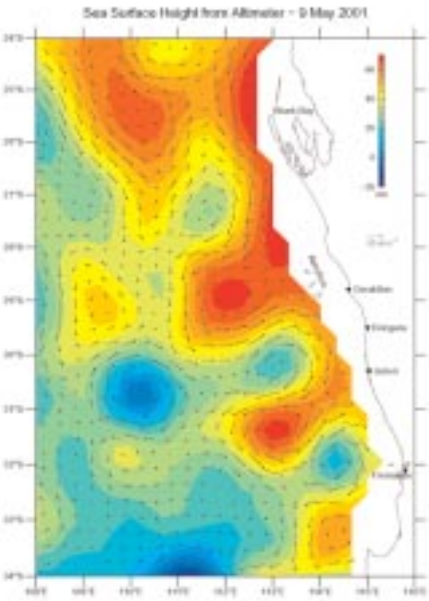
Satellite technology, together with specialised sensors and image processing systems, is providing efficient and cost-effective tools for mapping and monitoring the changing face of the ocean on a daily basis.

According to CSIRO scientist Alan Pearce, remote sensing is essentially the measurement of the properties of a surface without physically touching the surface.

Pearce says all three SRFME projects (biophysical oceanography, coastal processes and integrated modelling) will be making increasing use of satellite remote sensing to provide a large-scale perspective of changing ocean conditions over months and years.

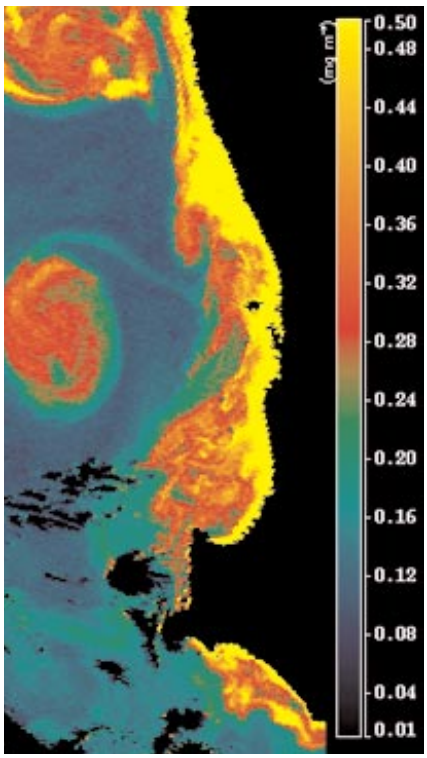
It is helping answer how commercial fish stocks might respond to changes in ocean conditions, and how climate change and direct human impacts may alter the functioning of the Western Australian coastal ecosystem, now and in the future.

While the satellites will never replace boat sampling, they provide a valuable 'big picture' context to supplement the monthly boat surveys. And, in an efficient twist, the same boat surveys will also be used to verify the satellite information. ■



> *Satellite information is providing insight into how Western Australian coastal ecosystems function, and how they vary with changes in the physical characteristics of the ocean. This baseline information, combined with field surveys, is critical for predicting how the ocean will respond to future changes, including human impacts.*

Ocean eddies are clearly seen using TOPEX altimeter (sea-surface height) data (above). The eddies may serve to bring larvae back in toward the coast, and provide nurseries for fisheries recruitment.



> *SeaWiFS and MODIS measurements of chlorophyll – the pigment found in the tiny plant cells called phytoplankton at the base of the marine food chain – in Western Australia's coastal waters. By measuring chlorophyll concentrations, scientists can determine the areas and seasons of greatest biological productivity. Zooplankton feed on the phytoplankton, and are in turn eaten by small invertebrates and fish, which themselves fall prey to large fish and so on up the food chain.*

This SeaWiFS chlorophyll concentration image shows a large counter-clockwise eddy off the coast of Perth. The chlorophyll concentration inside the eddy is higher than the open ocean "background level", indicating a region of higher biological productivity.

REMOTE SENSING
in SRFME

CSIRO oceanographer Alan Pearce says the advent of new satellite sensors, with better resolution and a wider range of spectral bands, will enable scientists to assess links between oceanographic and biological processes across the continental shelf.

Satellite-borne sensors measure radiance across a broad range of the electromagnetic spectrum. These measurements are used to infer ocean properties such as sea-surface temperature, sea-surface height, chlorophyll concentration and biological productivity.

Long-term satellite data archives are analysed to detect climatic variations, stronger or weaker ocean currents, rising or falling ocean temperatures and varying levels of chlorophyll that may affect the breeding, abundance and distribution of marine species.

> Global ocean temperatures are one of the major indicators of climate change and variability. CSIRO's Alan Pearce says SRFME scientists will derive monthly sea-surface temperature and chlorophyll statistics for the sampling areas from 1997 to 2005 to examine interannual variability and possible El Niño/Southern Oscillation (ENSO) links.

A matter of scale

According to CSIRO's Peter Fearns, most of the satellites providing data for SRFME operate at a resolution of 1 kilometre and provide an overview of the whole region, every day (cloud permitting). They also provide important information on areas adjacent to the study focus area. This broader view is helping scientists to understand the factors producing change in a region, and also showing the areal extent of change. For example, is an observed change locally induced or due to factors some distance away?

Fearns says that high-resolution sensors, which can 'see' at scales of 10-30 metres, offer a different advantage. "We can start to look at benthic habitats" says Fearns. "We can see whether a seabed is seagrass, or sand, or coral and rock."

"Satellites won't replace *in situ* sampling," he says. "But they do give us another way of looking at the ocean. It would never be affordable to measure ocean characteristics with boat surveys on such a large scale." ■

> CSIRO scientist Ming Feng will use altimeter (sea height) data to detect ENSO-related climate variability signals in the Leeuwin Current. He also plans to track eddy variability signals in the current using altimeter data in combination with in situ observations.

> CSIRO's Peter Fearns is measuring the productivity of Western Australia's coastal waters by measuring phytoplankon levels. Compared with in situ sampling, remote sensing "steps you back a level", he says. "You can see everything, quite often and quite cheaply."

> Hyperion satellite image of Cockburn Sound, providing 200 spectral channels at a 30 metre resolution. Hyperion images are being used to study the seabed at selected coastal sites.

‘Current’ information for fisheries

Satellite information is being used by SRFME scientists to link fluctuations in fishery yield to changing physical conditions.

Examples include established links between the strength of the Leeuwin Current and rock lobster recruitment, the transport of pilchards on the south coast near Albany, and the abundance of whitebait and juvenile Australian salmon.

Influences such as the Leeuwin Current (which appears on satellite maps as a jet stream of southward-flowing warm water off the West Australian coast) are known to play a major role in the life histories of these and other species.

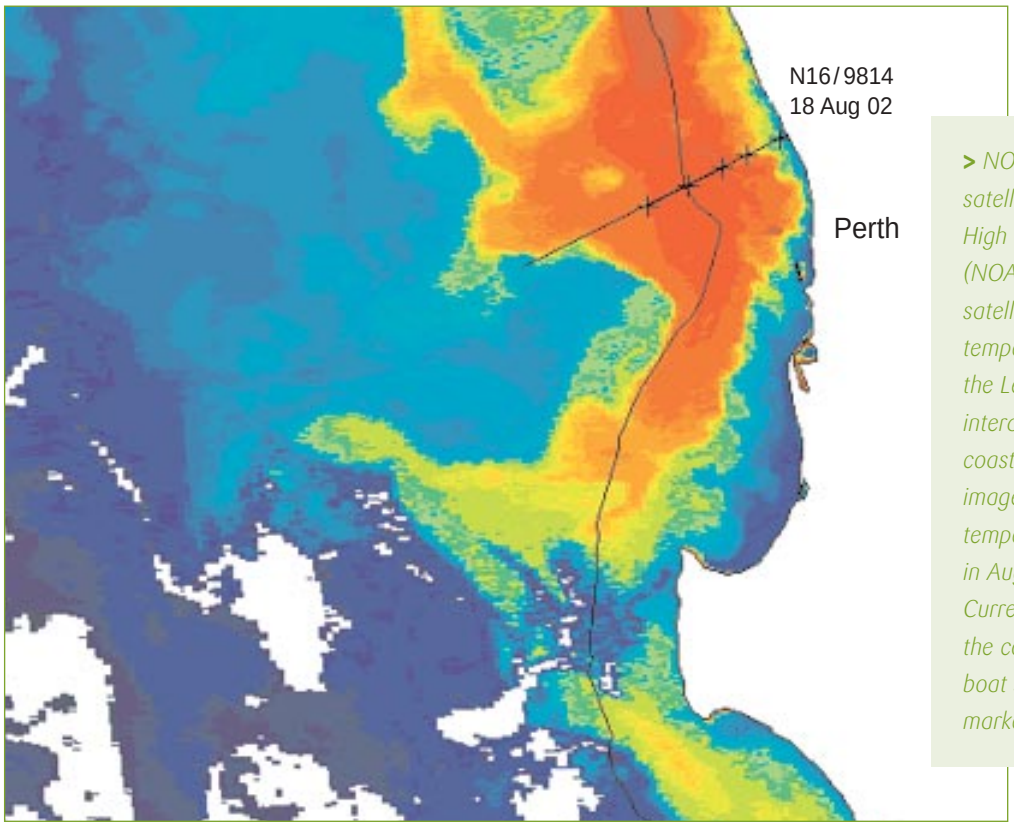
New research incorporating both remote sensing and field surveys is beginning to unravel some of the mechanisms behind the relationship.

In addition, satellite information has revealed a narrow, cooler current (the Capes Current) flowing close inshore northwards past Capes Leeuwin and Naturaliste between October and March. CSIRO and University of Western Australia scientists revealed that northward winds in summer may cause some weak localised upwelling between the Capes (visible in satellite imagery), probably linked to the Capes Current.

It is thought that fluctuations in recruitment/catches of the west coast salmon fishery may be associated with variations in the strengths of the Capes and Leeuwin Currents. Leeuwin Current strength is, in turn, affected by El Niño events.

> *A decade long archive of sea-surface temperatures and ocean colour (productivity) data maintained by CSIRO’s remote sensing unit, and a much longer archive of fish catches, will benefit fisheries operations and management Australia-wide.*

CSIRO ocean current data from satellite altimeters and computer models, as well as satellite-derived maps of ocean chlorophyll concentration, will provide more information on the links between fisheries and oceanography. ■



> *NOAA orbiting meteorological satellites with Advanced Very High Resolution Radiometers (NOAA-AVHRR) and NASA’s MODIS satellites are providing sea-surface temperature data to assist in defining the Leeuwin Current and its interaction with Western Australia’s coastal waters. This NOAA-AVHRR image shows the sea-surface temperature off southwest Australia in August 2002, with the Leeuwin Current (in red) streaming down the coast. The SRFME Two Rocks boat survey station positions are marked with x’s.*

THE SATELLITES

- NOAA-AVHRR provides information on the sea-surface temperatures used in defining ocean currents
- SeaWiFS provides information on chlorophyll concentration, which is used to estimate oceanic primary productivity
- MODIS provides information on both sea-surface temperature and chlorophyll concentration
- HYPERION hyperspectral satellites reveal seabed habitat in selected areas at a resolution of 30 metres
- TOPEX/Poseidon, ERS and Jason satellites provide information on sea-surface height, wind and waves

How satellites work

Satellites typically scan continuously across a line at right angles to their orbital direction. An image of the region over which the satellite has passed can then be built up by combining the successive scan lines along its path, in the same way that a television picture is created.

Data for the image are then remapped to correct the geometric distortions caused by the satellite's view of a curved earth, and colourised to indicate surface temperatures or other features. In the case of sea-surface temperatures, warmer areas are usually shown in red and yellow, with green and blue indicating progressively cooler water.

The TOPEX satellite

Satellite instruments

- **Radiometers:** measure both visible and infra-red radiation from the ocean to determine ocean colour and sea-surface temperatures.
- **Scatterometers:** estimate wind speed and direction at the surface to determine influences on sea-surface temperature and the way in which ocean currents are driven.
- **Satellite altimeters:** detect gradients in the height of the sea-surface, providing an indication of ocean current patterns.
- **Ocean colour instruments:** measure the colour of oceanic near-surface waters and can hence estimate the concentration of chlorophyll (a measure of ocean productivity) by using the known reflectance of phytoplankton cells in the visible part of the light spectrum.

Student input

SRFME has a major focus on fostering student collaboration and has awarded 3 PhD fellowships to students Leon Majewski, Florence Verspecht and Wojciech Klonowski. The three research projects are closely linked, and all involve numerical modelling of the water column as well as in-situ sampling.

Leon Majewski is studying methods for improving remotely sensed estimates of productivity, while Florence Verspecht is investigating physical and chemical factors affecting the productivity of shallow coastal waters. Wojciech Klonowski's project is using remote sensing to develop methods of retrieving water column and substrate optical properties from shallow coastal waters. The information will be valuable in developing an understanding of Western Australia's coastal environment, from the nature of its seabed habitats to the productivity of its waters. ■

SRFME Strategic Research Fund for the Marine Environment

Government of Western Australia

CSIRO MARINE RESEARCH

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