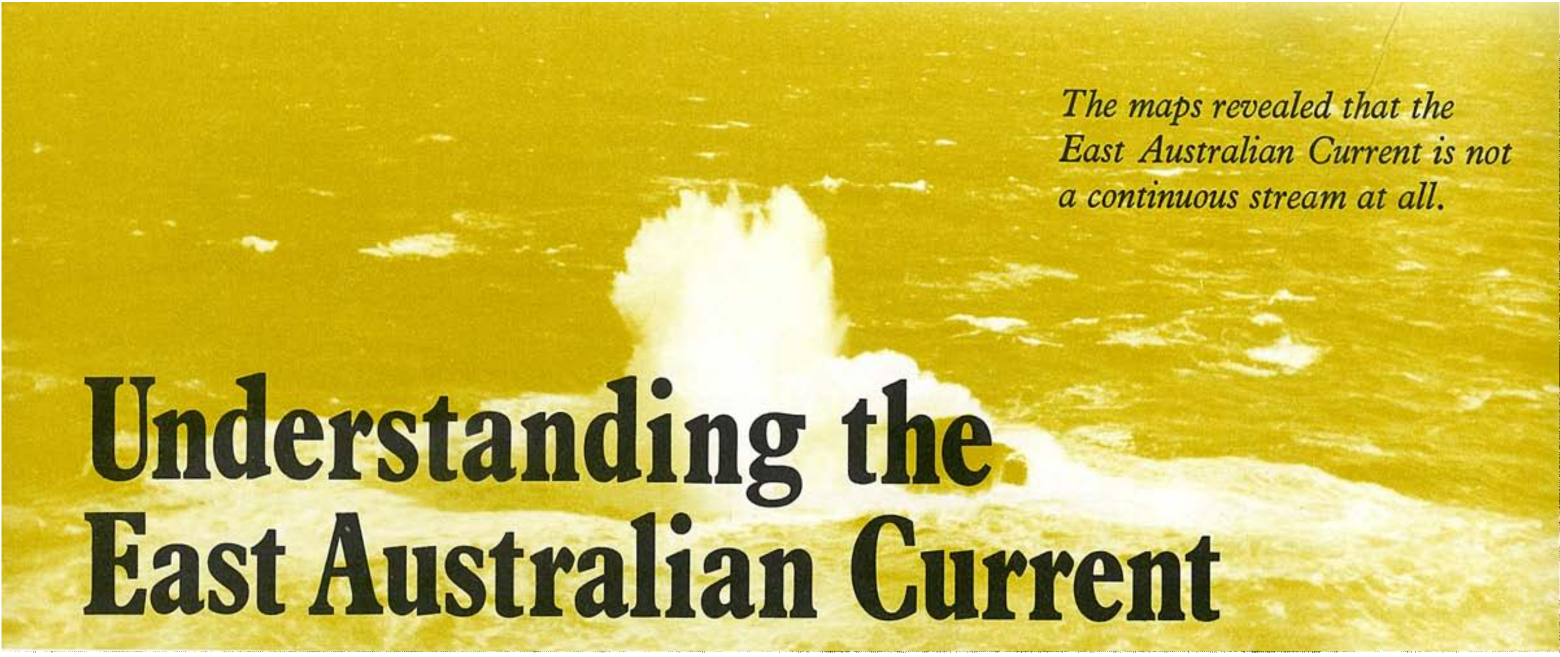


The maps revealed that the East Australian Current is not a continuous stream at all.

Understanding the East Australian Current

Right from the earliest days of European settlement, captains of ships sailing along Australia's eastern coast have known of a southerly 'set' that flows roughly from Rockhampton to Sydney. In time this became known as the East Australian Current. It was first charted from records accumulated for more than a century in ships' logs, and it appears in navigational charts as a strong, narrow, south-west-flowing coastal current that leaves the coast and sweeps eastwards at about the latitude of Sydney.

The captains also knew that the current is very variable. When southward bound down the coast, they would often ride it for 150 km or so, and then suddenly lose it. Even today, many captains follow the current, using the water temperature as a guide—they assume that they have lost it if the temperature drops suddenly, and may alter course away from the coast to try to pick it up again. The current can reach a speed of 4 knots—enough to allow an appreciable fuel saving.

The CSIRO Division of Fisheries and Oceanography began the huge task of trying to work out the mechanism of the East Australian Current in 1950—and studies are still continuing.

Oceanographers think that the East Australian Current is caused mainly by the winds—the south-east trades and the westerlies—but they don't yet know how. The fact that the earth is a rotating sphere greatly complicates things. What they do know is that the wind somehow maintains the surface of the Coral Sea about 50 cm above that of the Tasman Sea in the latitude of Eden on the far south coast of New South Wales. Water from the Coral Sea flows down this 50 cm drop—something like a river—close to the coast. Offshore, the situation is different. Instead, the water flows eastwards perpendicular to the pressure gradient, and the earth's rotation keeps the gradient in balance.

These ideas account for the existence of the East Australian Current, but they do not explain why it should be so erratic. To confuse matters more, early studies by the Division of Fisheries and Oceanography invariably revealed the presence of an unrecorded northwards-moving countercurrent about 200 km out from the coast.

Mr Bruce Hamon and his colleagues of the physical oceanography research team began to understand what was happening after analysing measurements taken during 16 cruises off south-eastern Australia aboard the two naval research frigates H.M.A.S. *Gascoyne* and *Diamantina.*

The sea surface has hills and valleys like the land, but, being not more than 50 cm, the height differences are too small for the human eye to detect. Dense water is found in the valleys, and lighter water, which is less salty and often warmer, makes up the hills. By taking measurements of temperature and salinity at known positions, Mr Hamon was able to calculate the water densities at these points. From these he plotted contour maps of the sea surface that look very like weather charts. As with weather charts, the currents flow parallel to the contour lines, and they flow fastest where the lines are closest together. Water flows in an anti-clockwise direction around the hills, and clockwise around the valleys.

Current not continuous

The maps revealed that the East Australian Current is not a continuous stream at all. Instead it passes down the coast from Brisbane as a series of eddies, about 200 km wide, that move southwards at a speed of about 80 km per month. The currents around the eddies can still be measured at 1500 metres depth, and the total flow around an eddy is about half that of the Gulf Stream—enough to fill the vast Lake Eucumbene of the Snowy Mountains Scheme in 2 minutes! The variability of the East Australian Current is probably caused by the passing eddies, while the northward current 200 km out to sea probably represents the circulation on the seaward side of the eddies.

The East Australian Current transports warm water, poor in nutrients, and of low salinity, from the Coral Sea southwards into the Tasman Sea—regardless of the actual direction of the motion around the eddies. Coral Sea-derived water has been found as far south as the eastern end of Bass Strait, and Mr Hamon suspects that the water is carried south by the body of the eddies, since nobody has ever demonstrated a continuous current that far south.

Oceanographic cruises are an effective, but very expensive, way of getting information. Also, until now the Division of Fisheries and Oceanography has been limited by having to depend on vessels of the Royal Australian Navy, which are not always available. The Division's recently announced 1860-tonne research ship will help greatly, but even so, one ocean-going vessel will not be able to cover all the waters around Australia in detail.

Crews take samples

Because of these difficulties, in 1966 Mr David Rochford began arranging for routine samples of water temperature and salinity to be taken from merchant ships. When approached, the owners and crews of a number of ships readily agreed to take the samples, free of charge, using equipment supplied by CSIRO. So, for the past 6 years between 20 and 30 ships plying the waters between Sydney, Melbourne, New Zealand, the islands of the Coral Sea, and New Guinea have been taking samples every 2 hours as a matter of course.

Understandably, the program has had its problems, since the ships' crews are not trained observers and they are carrying out the observations in addition to their normal duties. So it is a considerable tribute to everybody involved that, of the 25 000 measurements taken each year, only about 100 are rejected as useless.

The crew takes the measurements at specially adapted points in the water-intake pipe. Ideally this measuring point is located as near as possible to the ship's hull so that the water doesn't increase in temperature as it comes into the warm engine room. However, installation of the equipment always has to comply with safety requirements, so it's not always in the best position. Inaccuracies of up to half a degree Celsius do therefore creep into the temperature measurements.

At the same time as he takes the temperature, the crewman collects a sample of sea-water in a bottle, which is sealed and sent for analysis at the Division's laboratory at Cronulla. He also informs the bridge when each sample has been taken, and the officer on watch independently notes down the time and ship's position.

The 20–30 ships have given a very good cover of the Tasman and Coral Seas. Back at the Cronulla laboratory the results are plotted onto charts showing the temperatures and the salinities at the surfaces of the two Seas for each month of the year.

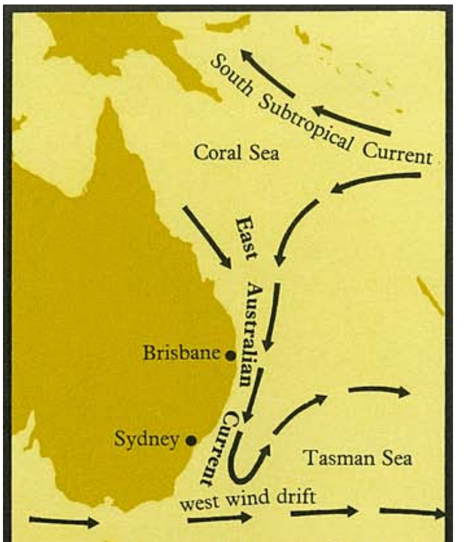
The survey has indicated that the water in the western part of the Tasman Sea is gradually becoming warmer; its average temperature has increased by more than a degree Celsius since 1966.

Independent studies at the CSIRO Division of Atmospheric Physics had already hinted that the coast of New South Wales tends to receive more rainfall if the Tasman Sea becomes warmer. Certainly the recent warming appears to have been accompanied by increasing rainfall along the New South Wales coast. Nevertheless, much more detailed studies of the interaction between the weather and the sea temperature will have to be carried out before we can be certain the connection really exists. Unfortunately there are no records of sea temperatures 150 km or more off the coast, and even the readings taken at coastal stations do not go back far enough to give more than an unreliable hint.

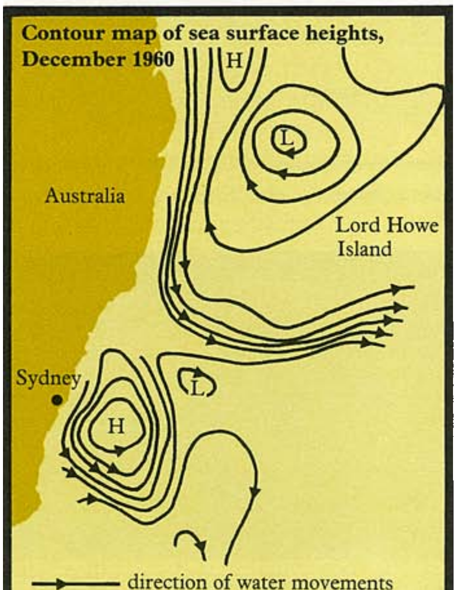
In an effort to gain more information, the Division of Atmospheric Physics, the Bureau of Meteorology, and the Division of Fisheries and Oceanography are co-operating in a project in which buoys that automatically measure the sea surface temperature will be placed at 11 stations around the Australian continent. These buoys will radio back information to the nearest lighthouse twice a day. So far, about half of the buoys are on station.

Plankton blooms

You might expect variations in the East Australian Current to affect the marine plants and animals (including fish) growing in the waters off the New South Wales coast. By and large, the waters of the Coral and Tasman Seas contain very few nutrients—especially in the surface layers, where most of them have been used up by the plankton organisms. So these waters support very little life.

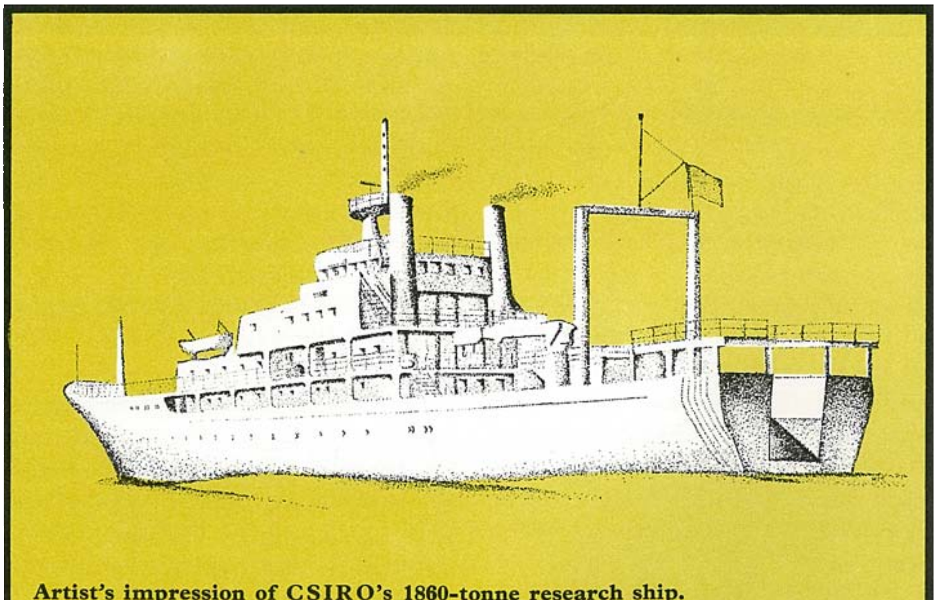


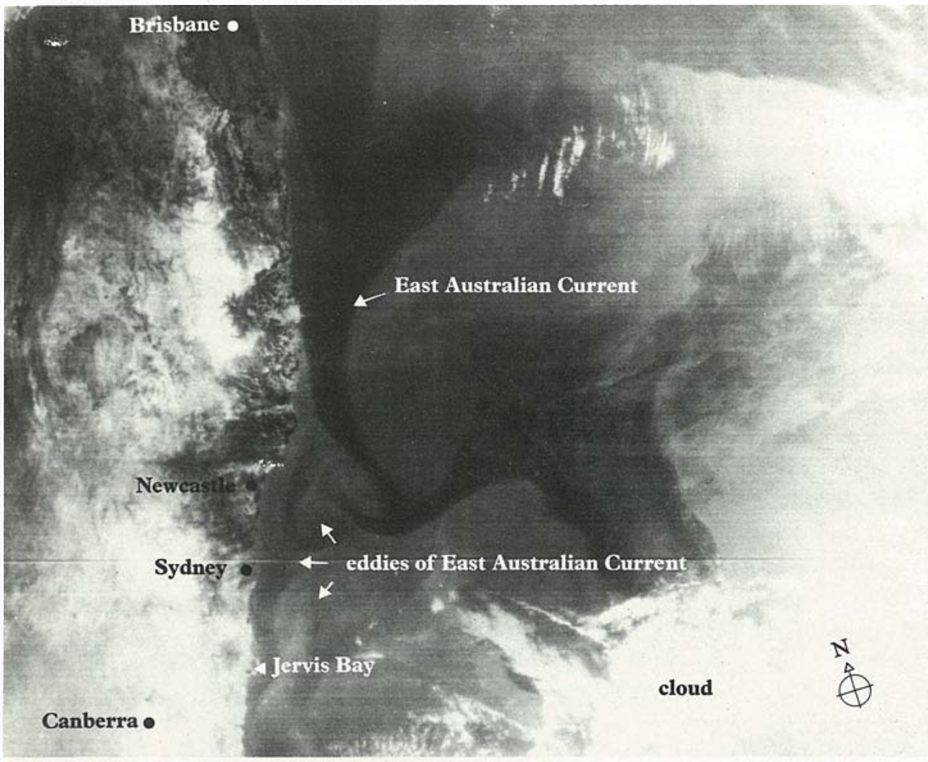
Where the Current is



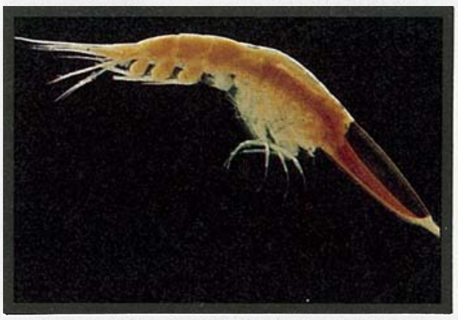
Contour map of sea surface heights, December 1960

The East Australian Current is not an unbroken stream, it's made up of a series of eddies.


Artist's impression of CSIRO's 1860-tonne research ship.



The warm waters of the East Australian Current appear black in this infra-red photo taken by the Nimbus III satellite.



This minute shrimp-like animal floats near the sea surface together with other tiny animals and plants of the plankton.

Fishing for blue-fin tuna off southern Australia.

Even so, for more than 30 years we have known that blooms of plankton occur most years in spring on the inner 15 km of the continental shelf off New South Wales. Such blooms imply that considerable quantities of nutrients are coming from somewhere, and they seem to be connected with the eddies of the East Australian Current. They are apparently caused by colder water containing more nutrients rising up from between 100 and 200 metres below the surface—too deep for the sun's rays to penetrate and promote plant growth.

Studies of such upwellings off Evans' Head near Ballina revealed that their peaks seemed to happen about every 1–2 months—about the time it takes for the eddies of the Current to pass by. Certainly they could not be correlated with any other factor—such as when offshore winds blew.

However, not all water upwellings cause planktonic blooms; often they contain no nutrients. Probably these come from less deep down. In fact, any upwellings coming up from a depth of less than 100 metres would be originating in waters with low nutrient contents, so blooms could not be expected.

Temperature fronts

A feature of the East Australian Current is the presence of temperature fronts in its surface waters in the latitudes between Sydney and Eden. These warm fronts sometimes reflect the positions of eddies, but not always. Water poor in nutrients occurs on the warm side of the fronts, and for some years the Division of Fisheries and Oceanography has been issuing

Studying an estuary

Port Hacking is an estuary formed in a sunken valley south of Botany Bay. It is the site of a major study by the Division of Fisheries and Oceanography into how an estuary works. The Division's headquarters is located at the mouth of the estuary.

The south-west arm of Port Hacking juts into the Royal National Park, and it is relatively well cut off from the flows of water in the rest of the estuary because of a shallow sill across its mouth. This arm is therefore about as close as can be got to being unpolluted and in its pristine condition.

The Division, with cooperation from the New South Wales Department of Fisheries and universities, is trying to study almost every possible aspect of this ecosystem. It is using the information gleaned to develop a numerical model of the physical, chemical, and biological processes of the south-west arm. The aim is to be able to predict how the estuary would react if polluted by various man-made wastes.

Later the Division will go on to compare this model of a clean estuary with the situation in polluted ones. Urban development has greatly affected the water catchment of the rest of Port Hacking, so very possibly the Division will begin its comparisons there.

The near-pristine south-west arm was partly chosen because its deeper waters often contain no oxygen. Deoxygenation of estuarine waters often results from pollution, although in this case it is natural.

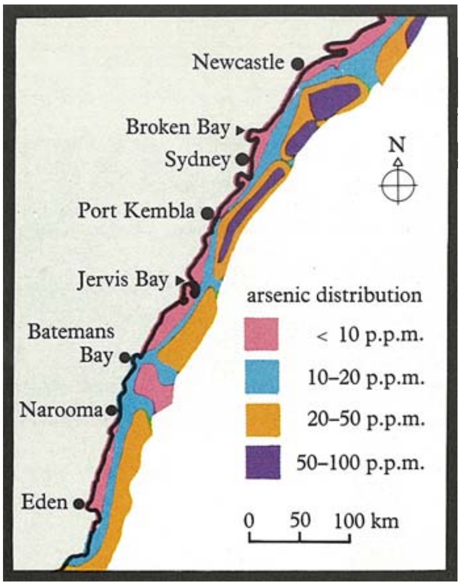
Remarkably few scientific studies have been made of how civilization affects estuaries, and many, like the current Port Phillip Bay study or the Botany Bay project, are attempts to find out what is happening after the event. It is hard to know how an estuary is coping with the wastes pumped into it if you don't know what processes should be going on beneath its waters. The Port Hacking study should help to remedy this lack of knowledge.

maps of these fronts each week to fishermen, since blue-fin tuna tend to concentrate along them. The information has enabled the fishermen to increase their catches and to reduce the time they spend searching for tuna.

Using a computer model of the East Australian Current, Dr Stuart Godfrey has come up with an explanation of how the fronts form. His calculations suggest that, between Sydney and Eden, the warmer subsurface layers of the Coral Sea-derived water of the Current rise to the surface and veer eastwards to form the sub tropical part of the eastwards drift across the Pacific Ocean. The fronts form where the warm water reaches the surface. Meanwhile the colder, deeper layers of this water from the Coral Sea continue southwards towards Bass Strait. This confirms Mr Hamon's explanation of how water that undoubtedly originated in the Coral Sea reaches the southern part of the Tasman Sea even though the East Australian Current apparently veers eastwards further north.

Incidentally, studies by Mr Stan Hynd of the Division and by Japanese scientists of how fishing affects the blue-fin tuna reveal what could be a disturbing state of affairs. There appears to be only one stock of this fish for the whole of the southern hemisphere. It breeds near Java, and the young fish take about 5 years to migrate along the Australian continental shelf. These young fish form the basis of the tuna fishery off southern Australia. They then migrate into the ocean belt between Antarctica and the southern continents, where the Japanese fish for them and catch them as 7- or 8-year-olds.

Recently, the Australian catch has been going up because more efficient fishing methods have been introduced. At the same time the Japanese catch has been falling, even though the Japanese are also using much more efficient fishing techniques. The most obvious explanation is that the Australian fishery is getting the tuna first, leaving less for the Japanese. The justice of this situation would obviously be open to argument. Japanese fisheries scientists have calculated that the breeding stock of tuna is now only about one-tenth of what it used to be, and believe increased Australian fishing may well push the tuna population below the point of no return. However, more recent analyses have cast considerable doubt on this conclusion, so Australian, Japanese, and FAO scientists agreed last October to carry out special studies to resolve the matter once and for all.



Arsenic levels on the continental shelf.

Our ultimate sump?

Each year a great deal of waste is dumped into the waters off the eastern Australian coast from the industrial cities of Sydney, Wollongong, Newcastle, and Brisbane. Presumably some of these wastes are picked up by the East Australian Current, but at present we have little idea about where they go, or what effect they have on the marine environment.

Dr Peter Davies of the Bureau of Mineral Resources, Geology, and Geophysics has recently discovered concentrations of arsenic on the continental shelf off the region between Port Kembla and Newcastle, which suggests that at least this poisonous substance is not all washed away. Other substances remain on the surface, and the Division of Fisheries and Oceanography's program of releasing drift bottles and drift cards has indicated that the surface waters between south-eastern Australia and New Zealand can move in a circle.

Recently, a free-drifting radio buoy released by the Division off Wollongong on April 30, 1973, was picked up a year later near Eden after travelling on a circular course via Norfolk Island. The Division tracked its course using information supplied by the French EOLE satellite, which picked up signals transmitted by the buoy. Its transmitter appeared to fail on March 10, 1974, by which time the buoy was located close to the coast near Brisbane. Then the satellite picked up further transmissions from it 12 days later. By then it was moving southwards near Jervis Bay.

Nobody should conclude too much from the voyage of this one buoy, but it does indicate that surface water sweeping out towards New Zealand on the East Australian Current can sometimes return to the eastern Australian coast.

. . . at least this poisonous substance is not all washed away.

More about the topic

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