Moored ADCPs in Action Down Under

Array of Teledyne RDI ADCPs Measure East Australian Current

Teledyne RD Instruments

Overview

Off the east coast of Australia, strong flows stream poleward from the tropical South Pacific. This East Australian Current (EAC) moves sizable amounts of heat into colder, temperate waters. Thus, persistent changes in the EAC's flow patterns can alter the ambient environment—from biodiversity to weather and climate.

This major ocean current has been studied by Australian oceanographers for more than 50 years. The EAC system is very dynamic, both in where it leaves the Australian coast and in the eddies it spawns. This variability clouds the typical state. Yet seasonal and decadal changes in the southern extent of the warm EAC water have been recognized. These changing water properties cause marine casualties—from fisheries off New South Wales to kelp forests off Tasmania.

To discern the typical state of this major boundary current, an extensive mooring array was deployed in 2012. This work was part of the Australian Integrated Marine Observing System (IMOS). Installed for 16 months at first, the array has been redeployed.

Moorings were set across a line at 27°S off Brisbane—upstream from the EAC's more variable action. Several mooring lines carried up- and down-looking ADCPs to record the history of strong currents in the EAC's upper kilometer.

The distribution of EAC currents at 27°S was coherent though very dynamic. Averaged over the deployment, the ADCP measurements showed strong currents in the EAC are limited to the upper 600 m.

Fantail packed with mooring components including Teledyne RDI ADCPs

Credit: B. Sloyan (CSIRO) https://www.tinyurl.com/y9pcs3ff

Instruments

Products:
Self-Contained ADCP: Long Ranger 75 kHz, 150, and 300 kHz

Application:
Monitoring major boundary current

Project:
Defining volume and property fluxes of East Australian Current

Organizations:
Commonwealth Scientific & Industrial Research Organization, Australia (CSIRO)
Australian Integrated Marine Observing System (IMOS)

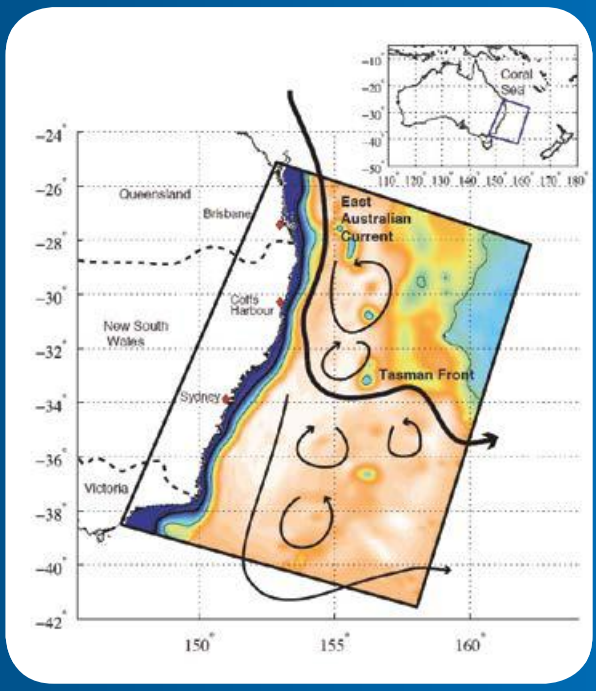
Principals:
Dr. Bernadette Sloyan
Ken Ridgway
Rebecca Cowley

Data Collection Date:
2012-13, and ongoing

Location:
Off Brisbane, Australia

The volume moving poleward was 22 million cubic meters per second—about 70% of transport through the Florida Straits.

Statistical analysis of time series of currents showed two dominant modes for the EAC's position: hugging the continental slope or flowing farther offshore. These modes varied with multi-monthly periods that were attributed to remote forcing.



East Australian Current System

Credit: C. Kerry et al. (Univ. NSW), 2016 goo.gl/F2krAU

Situation: East Australian Current

Well-known to seafarers for centuries, strong currents dominate the eastern seaboard of continents. These major ocean flows are energetic, narrow, and deep. Found around the globe, they move heat away from equatorial and tropical regions into colder, temperate waters. Persistent changes in the path and properties of these flows are possible due to climate change.

The EAC runs poleward along the western edge of the South Pacific. Fed by tropical waters, the EAC moves warm water southward for 2500 km along the Australian coast. Changes in the EAC's transfer of heat into the colder Tasman Sea are causing warming there at a surprising rate—twice the global average.

Furthermore, these flows convey organisms, nutrients, chemicals, debris, and pollutants. All these things affect life in and out of the sea and along coastlines. In addition, these strong currents affect shipping to this island nation.

Much of the EAC turns eastward near Coffs Harbour on the north coast of New South Wales, where it heads across the Tasman Sea toward New Zealand. This turning point vacillates. Some residual flow moves south largely as energetic eddies.

Seasonal and decadal changes in the southern extent of the warm EAC water have been recognized. These changes are attributed to altered atmospheric conditions—notably wind patterns. These changing water properties cause marine casualties, from fisheries to kelp forests.

Studied by Australian oceanographers since the 1960s, the EAC system is known to be very dynamic. To clarify the effects of a changing climate, scientists wanted a baseline definition of this major boundary current.

An extensive mooring array—including numerous up- and down-looking ADCPs—was installed several times. Moorings were set across a line at 27°S off Brisbane—upstream from the EAC's more fitful regions.

Highlights:

- The EAC moves warm tropical water southward into the colder Tasman Sea
- Numerous up- and down-looking ADCPs were installed on moorings off Brisbane
- ADCPs operating at 75, 150, and 300 kHz were combined to profile currents to 1000 m
- ADCP measurements showed the EAC's strong currents are, on average, limited to the upper 600 m
- The volume moving poleward was 22 million cubic meters per second—about 70% of transport through the Florida Straits
- At times, the EAC was concentrated over the continental slope; at other times, it was farther offshore, wider, and deeper

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Solution: Moored ADCP Array

ADCPs provided a fresh solution for measuring strong surface currents compared with mechanical current meters, which must be immersed in the flow being measured. ADCPs looking upward can measure strong surface currents while deployed in slower waters below. This helps reduce drag on the mooring. To this end, ADCPs are mounted in the flotation buoy atop subsurface moorings.

Sustained time series are needed to see characteristic values of the EAC's current and property transport. In strong surface currents, surface drifters, floats, and gliders are quickly swept away. Instead, a moored array was used to collect a sustained record. ADCPs measured currents in the crucial upper kilometer.

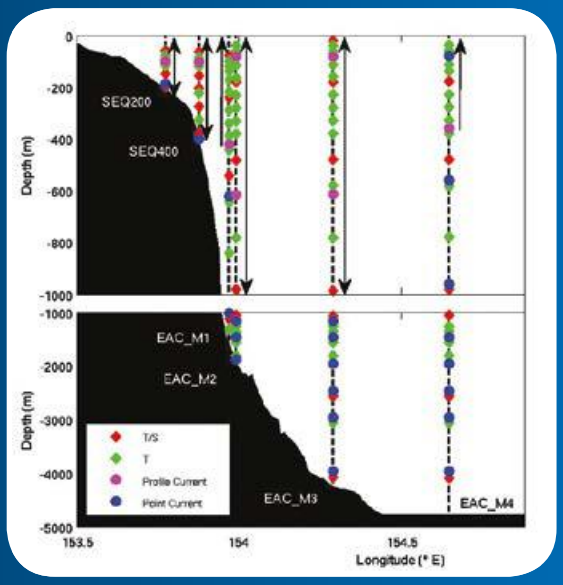
The EAC moored array included seven moorings that carried almost 150 instruments. These moorings were heavily instrumented in the upper ocean to measure with high vertical resolution.

Across the continental slope, each mooring carried up- and down-looking ADCPs. Installed in combinations, they profiled currents to 1000 m depth. A range of frequencies were used: 75, 150, and 300 kHz. The higher frequency ADCPs profiled the upper ocean with finer resolution.

Moorings also carried many temperature and salinity probes that revealed fluxes of water properties.

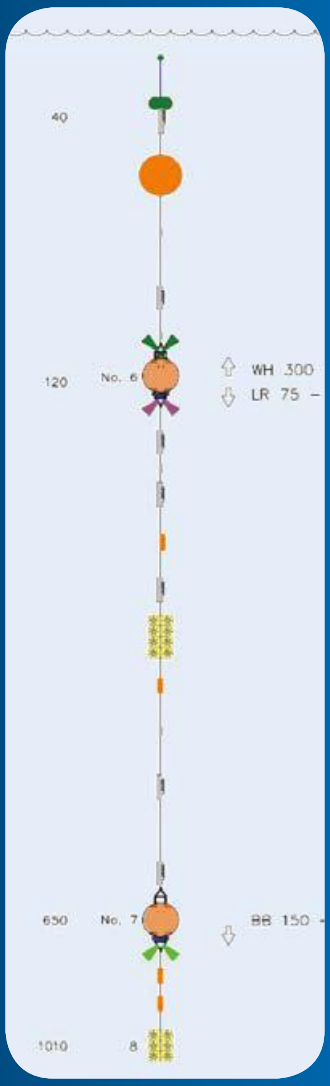
Most moorings were over the continental slope where the poleward current is generally located. Two moorings were located farther offshore in 5000 m depths to capture the width of the EAC system.

In fact, fairly large equatorward transport was seen at the offshore edge of the mooring line—27% of the poleward volume.



EAC Moored Array (without M5)
Black arrows show ADCP profiling coverage; colored dots show sensors.

Credit: B. Sloyen et al. (CSIRO), 2016
https://www.tinyurl.com/y8zbkey3



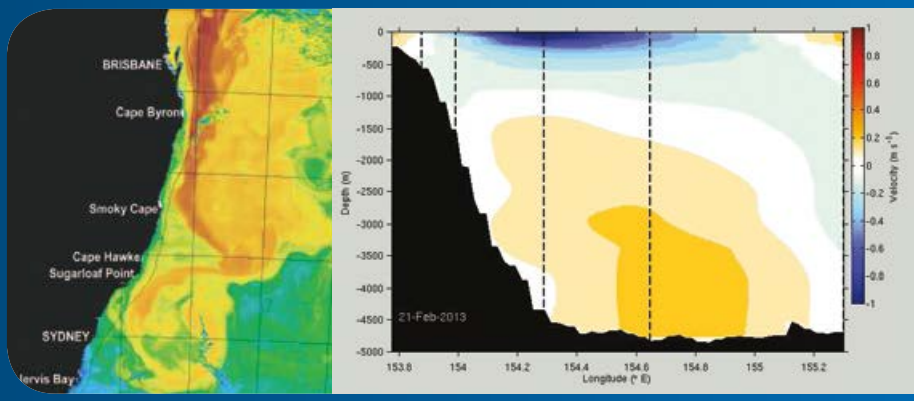
Three ADCPs profile to 1000 m in EAC M2 Mooring Line

Credit: IMOS Instrumentation, 2015
goo.gl/wKKVKv

Results: EAC Characteristics

For climate studies, it is especially valuable to know volume and property transports in strong boundary currents. Discerning these traits of the EAC required sustained observation. Researchers combined elements of IMOS's Coastal and Deepwater programs to create a monitoring array that spanned 150 km. They recorded baseline results off Brisbane that have been cited by a dozen papers in the last 12 months.

Averaged over the deployment, the ADCP measurements showed that strong currents in the EAC are limited to the upper 600 m. A subsurface peak at 50-100 m depth provided a bullseye in the flow distribution.



Left: NOAA satellite image showing surface temperature signature of the EAC NOAA 11 TMS 45S 29 Sep 1991 1615z 1999 © CSIRO
Right: Snapshot of EAC's north/south flow across the moored array

Credits: Left: G. Cresswell (CSIRO), 2001 goo.gl/hG4QkX
Right: B.Sloyan et al. (CSIRO), 2016 https://www.tinyurl.com/yb9reya3

On average, poleward currents reached 1500 m; below that depth, currents were slight. For this situation, the volume moving poleward was 22 million cubic meters per second—about 70% of transport through the Florida Straits.

Snapshot views of the moored section showed the distribution of EAC currents to be coherent, although the distribution is also dynamic. You can see an impressive animation at this link: goo.gl/EdTcaz.

At times, the EAC was concentrated over the continental slope, but at other times it was wider and deeper. When the EAC was more confined, flows at depth could be equatorward across vast expanses. At other times, equatorward flow had disappeared.

Statistical analysis of the current time series shows two dominant modes. The EAC was either hugging the continental slope or centered farther offshore. In the latter mode, flows nearer to the shelf headed equatorward. These modes varied with multi-monthly periods that were attributed to remote forcing.

About two of three Australians live on the eastern seaboard. The influence of the EAC on their living environment is now more widely appreciated.

Yet for deeper understanding of how climate change is affecting the EAC, scientists need to clarify long-term trends and large-scale connections. And in this push, Teledyne RDI ADCPs provide a crucial contribution—profiling the pivotal upper ocean.

References:

1. B. Sloyan, K. Ridgway, and R. Cowley (CSIRO) 2016. The East Australian Current and Property Transport at 27°S from 2012 to 2013. https://www.tinyurl.com/y8zbkey3
2. IMOS Instrumentation, 2015 goo.gl/wKKVKv

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