LARGE OCEAN MOORING ARRAYS AROUND SOUTH AFRICA
Development in Deep Ocean Mooring Systems

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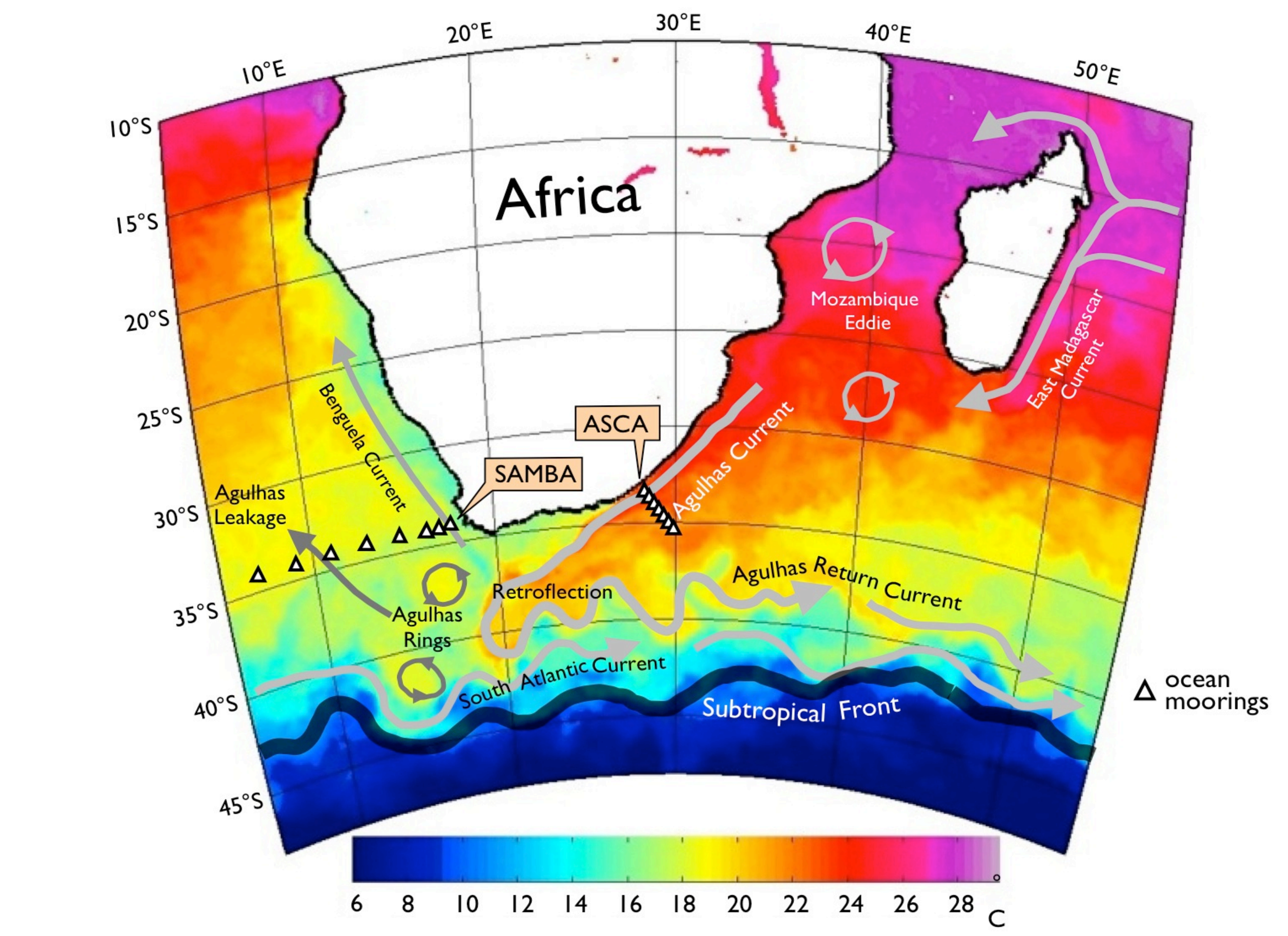


Figure 1: Sea surface temperature (SST) for 23 May 2009 shown as colour with a schematic of the mean transport overlaid in grey. Figure adapted from Beal et al (2011). SST data are from the NAVOCEANO K10 analysis with combined satellite infrared and microwave measurements, made available through the GHRSST project (Donlon et al, 2007). The grey triangles represent the two large mooring arrays – the South Atlantic Moored Buoy Array (SAMBA) and the Agulhas System Climate Array (ASCA). South Africa is at a geographical advantage positioned between three large oceans – the Indian, Atlantic and Southern Oceans, and bordered in the east by the Agulhas Current, the largest western boundary current in the Southern Hemisphere; a highly productive eastern boundary current to the west, the Benguela Current; and the perpetually eastward flowing Antarctic Circumpolar Current to the south.

Large arrays of moored instruments collecting *in situ* ocean current, temperature, salinity and dissolved oxygen data are the most effective way of providing long term, continuous observations and monitoring changes on daily to interannual time scales. Such arrays are able to resolve mesoscale dynamics, transport variability and the impact key oceanographic features such as the Agulhas Current and the Benguela Jet (Figure 1) have on the Meridional Overturning Circulation (MOC) in the Atlantic Ocean (Figure 2), which is a fundamental driving force of the Earth's climate systems.

Two arrays have been developed and partially deployed thus far. The first, the South Atlantic Moored Buoy Array (SAMBA), has been deployed from the west coast of South Africa into the South Atlantic as part of the South Atlantic Meridional Overturning Circulation (SAMOC) initiative (Ansorge et al 2014). This array has been designed to answer the following scientific objectives:

- To characterize the time-mean and time-varying components of the MOC, as well as the heat and salt carried by the MOC
- To provide a means to observe the changes in the ventilation characteristics and relative contributions of different water masses to the MOC

The South Atlantic Moored Buoy Array (SAMBA) encompasses four full-depth moorings of 75 kHz Acoustic Doppler Current Profilers (ADCPs) and Sea-Bird Electronics (SBE) MicroCATs, two shelf moorings and eight Current- and Pressure-Inverted Echo Sounders (CPIES) installations (Figure 4 and 6). The four tall and two shelf moorings will have been deployed for one year when the maintenance cruise takes place in October 2015. The CPIES, which extend to the 0° longitude were serviced in July 2015 along with those deployed along the Good Hope Line (Figure 3) extending southwards.

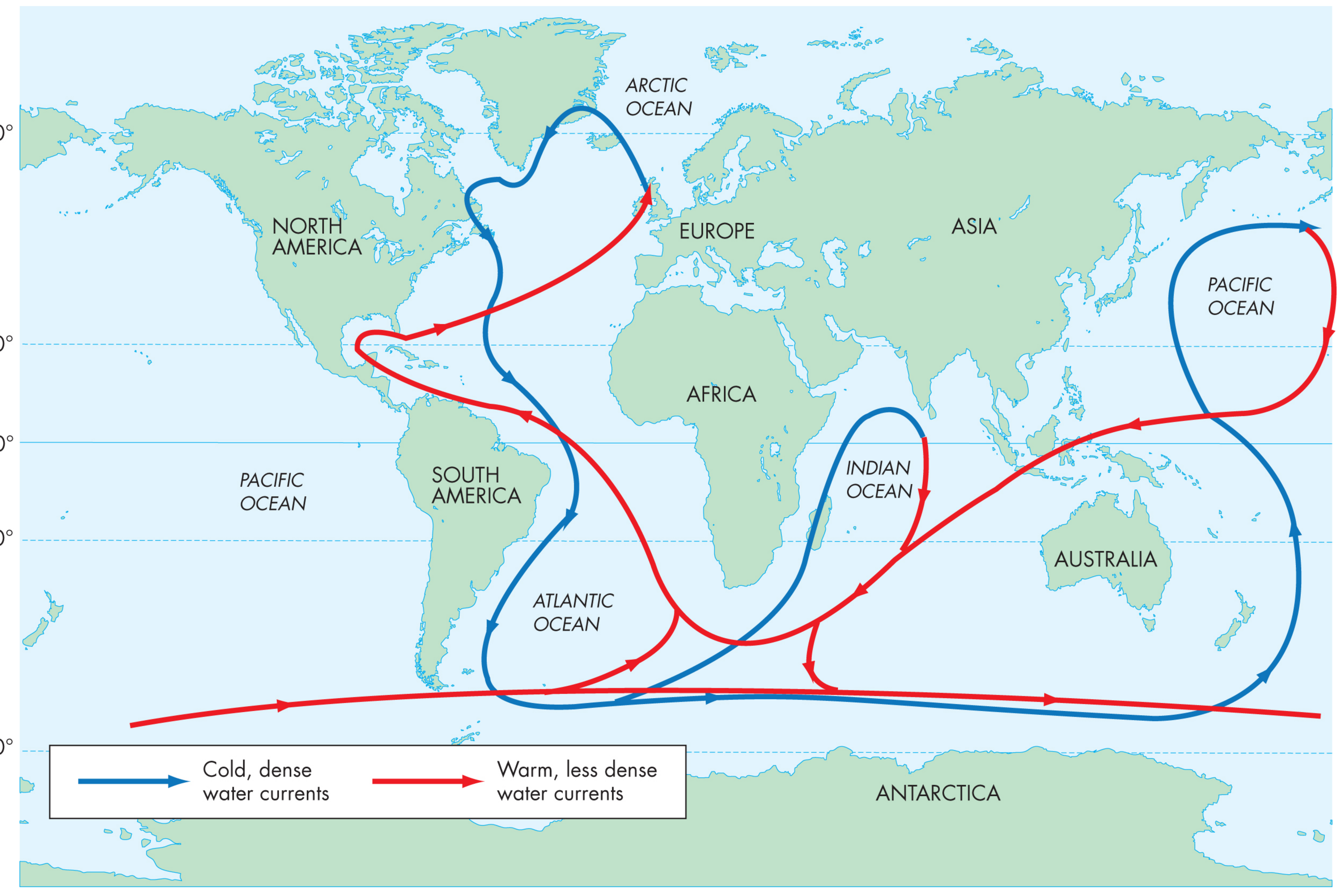
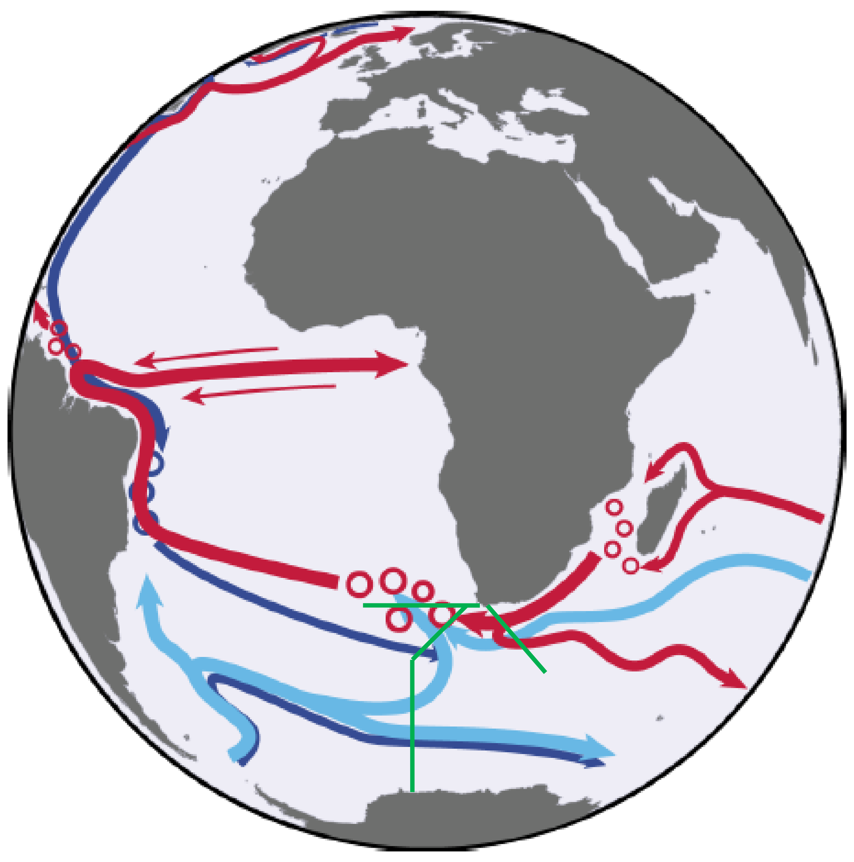


Figure 2: A simplified schematic of the Thermohaline Circulation, illustrating the Meridional Overturning Circulation (MOC) in the Atlantic Ocean (https://images.google.com/)

Figure 3: The present global thermohaline circulation, in a simplified diagram, taken from Durgadoo (2013). Recently subducted waters are transported along the lower limb of the global circulation in relatively strong, narrow currents called Deep Western Boundary Currents (1500-4000m, dark blue lines) to the rest of the global ocean, where the waters are upwelled and then transported along the intermediate (1000-1500m, light blue lines) and upper (surface-1000m, red lines) pathways of the global circulation. The monitoring lines (from left to right: SAMBA, GoodHope and Crossroads) occupied under SAMOC-SA are shown by the three green lines, which span the region south of Africa.



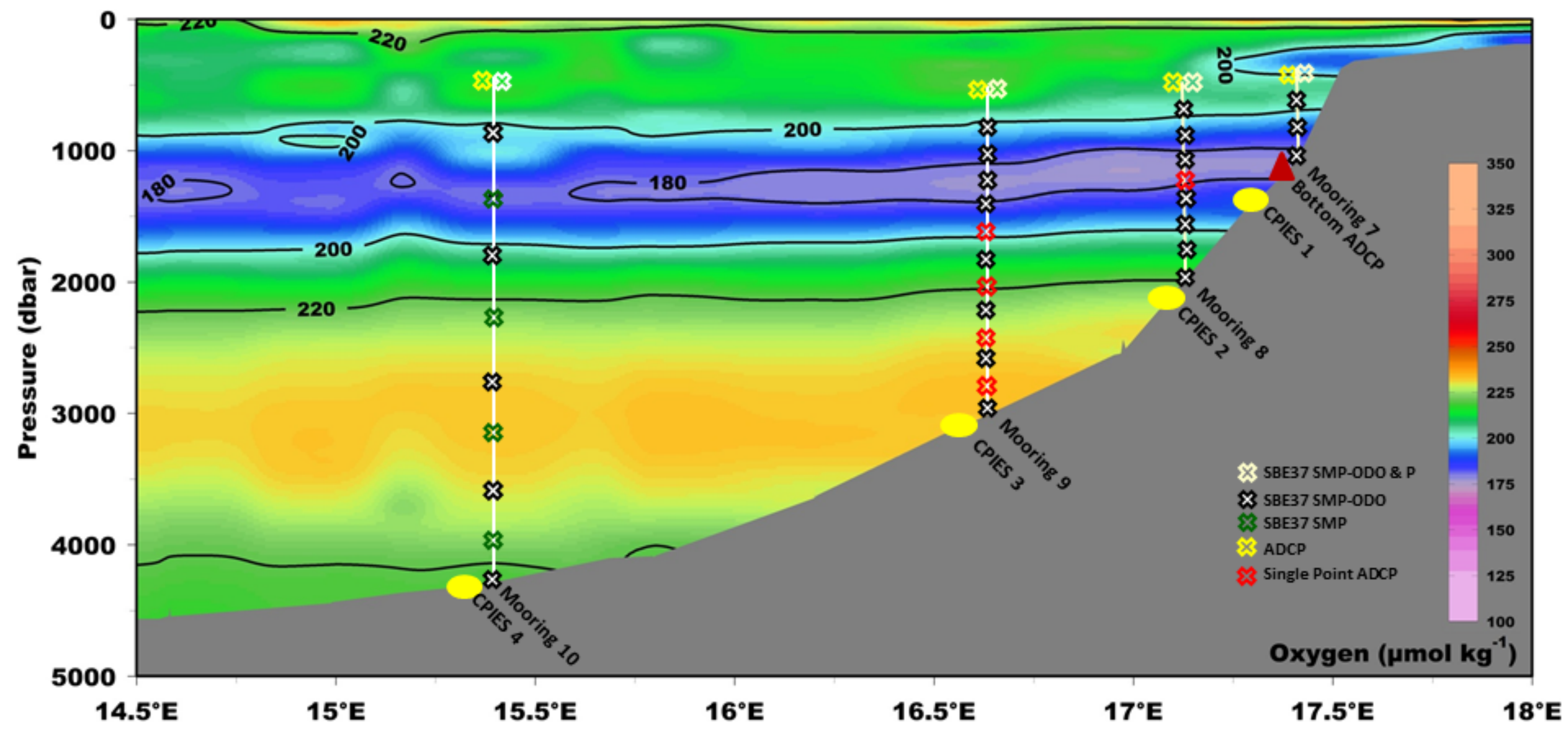


Figure 4: The SAMBA tall moorings (mooring 7 to 10), along with CPIES 1 to 4 and the Bottom mounted ADCP overlaid on a composite of historical Good Hope Line dissolved oxygen CTD data illustrating the low oxygen levels targeted for investigation using Sea-Bird MicroCAT sensors equipped with dissolved oxygen sensors. CTD data provided by Prof. Sabrina Speich, and figure prepared by Mr. Marcel van den Berg.

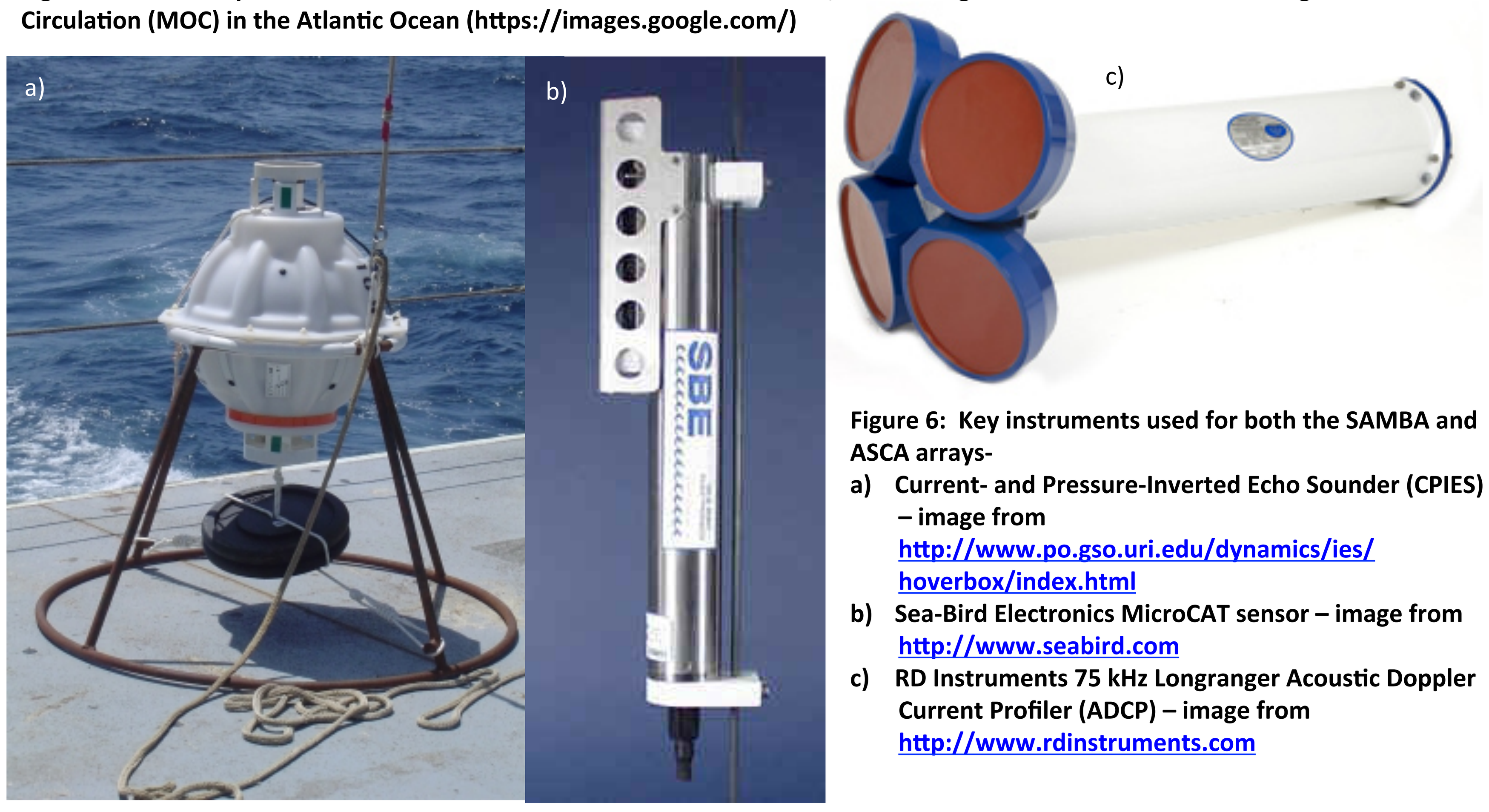


Figure 6: Key instruments used for both the SAMBA and ASCA arrays-
a) **Current- and Pressure-Inverted Echo Sounder (CPIES) – image from http://www.po.gso.uri.edu/dynamics/ies/hoverbox/index.html**
b) **Sea-Bird Electronics MicroCAT sensor – image from http://www.seabird.com**
c) **RD Instruments 75 kHz Longranger Acoustic Doppler Current Profiler (ADCP) – image from http://www.rdinstruments.com**

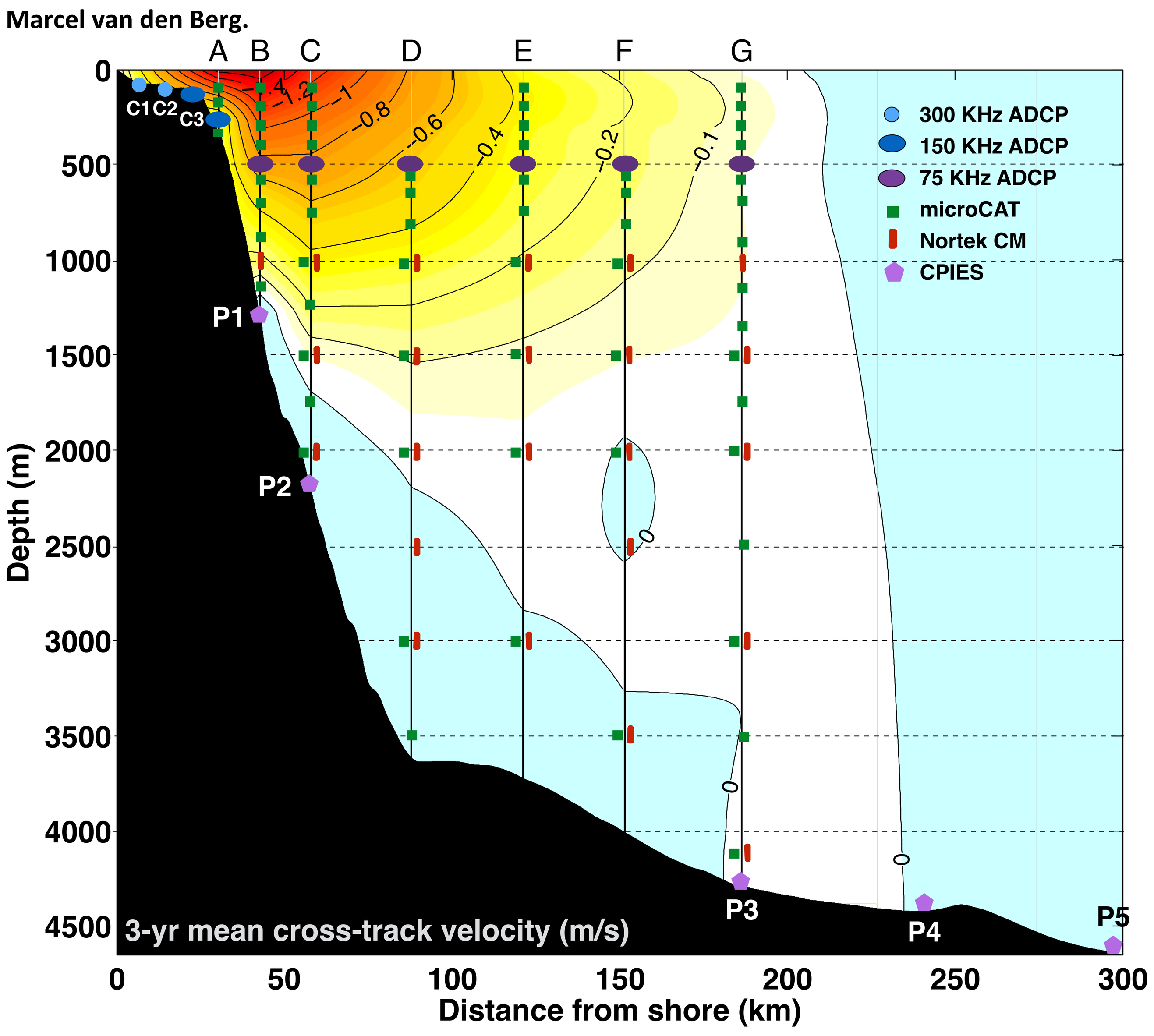


Figure 5: The full ASCA array of shelf and tall moorings, along with CPIES placements. The mooring design is overlaid on a composite three-year cross-track velocity vertical section illustrating the mean placement and strength of the Agulhas Current. Data and figure prepared by Prof. Lisa Beal.

The SAMBA array builds on to key results obtained from the GoodHope line, which has been occupied since 2004 by various countries able to do repeat hydrographic and XBT surveys, along with autonomous sampler deployments. Results included redefined pathways of Indian waters to the South Atlantic (Speich et al 2007), quantification of regional dynamics and variability of the Antarctic Circumpolar Current for the upper 2500 m (Swart et al 2008) and refining the mesoscale flows of deep and bottom waters (Gladyshev et al 2008).

The key scientific objective of the second array deployed in to the Agulhas Current off the east coast of South Africa, the Agulhas System Climate Array (Figure 4), is to provide long term observations of Agulhas Current volume, heat and salt transport and its variability from mesoscale (eddies), through seasonal to interannual timescales, and critically, its contribution in terms of heat and salt to the Thermohaline Circulation and thus its impacts on climate variability and climate change. The array currently has four of its seven tall moorings deployed thus far encompassing 75 kHz ADCPs, single point current meters and SBE MicroCATs (Figure 5), along with two shelf moorings. In April 2016, a maintenance cruise will service the existing array and deploy a further three tall moorings and the five CPIES installations.

ASCA follows on from the successful 3-year installation of moorings in the same region known as the Agulhas Current Time-Series experiment (Beal et al 2015). Through this work they showed the Eulerian mean of the Agulhas Current to be 219 km wide, 3000 m deep and with peak surface speeds of 1.8 m s^{-1}. Through new methods (described further in Beal et al 2015), a volume transport poleward of 84 Sv (± 2 Sv) was calculated. When using traditional methods, a volume transport poleward of 77 Sv (± 5 Sv) was calculated, which did not accurately take in to account meanders occurring within the Agulhas Current.

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