Neutrally buoyant floats in the UK

The invention

John Swallow was recruited to NIO by George Deacon in 1954. His research background had been in marine geophysics and he had completed his PhD on marine seismic investigations made on the 1950-2 round the world voyage of *HMS Challenger*. At NIO he was given the task of devising a method to measure currents in the deep ocean – one of the outstanding problems of that era. His experience of the compressibility of rocks and of sea water led him to devise a float that was less compressible than seawater and that if properly ballasted would drift with the water at a predetermined pressure level and would have an acoustic beacon that could be tracked from an attendant ship. The body of the float was made from two sections of aluminium scaffold tube that had had its wall thickness reduced in a vat of caustic soda. (The floats were ballasted in a tube of artificial seawater in the stairwell of the old NIO building. Sadly no-one ever took a photo of John Swallow doing this).

The first trials aboard *RV Sarsia* in 1955 were successful and John went on to use the new technology to explore currents in the NE Atlantic and also the deep outflows through the Faroe-Shetland Channel and south of the Denmark Strait. In 1957 the floats were used to confirm the prediction made by Henry Stommel from Woods Hole of a southward-flowing undercurrent beneath the Gulf Stream. Stommel had also predicted a slow, deep interior circulation away from the ocean boundaries and obtained funding from the US National Science Foundation to use Swallow's floats to confirm this. The work was done during 1960 from the ketch *RV Aries* based in Bermuda. Rather than confirming the prediction, the measurements showed surprisingly energetic and variable flows. This was the first evidence of what we now refer to as mesoscale variability – the ocean analogue of atmospheric weather.

Jim Crease with float-tracking hydrophone aboard RV Aries

Exploring the oceans' variability.

In 1969 and 70 John used his floats in the NW Mediterranean during the MEDOC experiments to reveal the circulation around "chimneys" in which water cooled at the surface could penetrate to the deep sea. Art Voorhis from Woods Hole also used floats fitted with angled fins that could measure the vertical water movement. During the late 1960s Doug Webb and Tom Rossby in the USA had developed long range (SOFAR) versions of the Swallow float that could be tracked using low frequency sound signals received at military listening stations in the NW Atlantic. These opened the way to explore the ocean mesoscale across an entire ocean basin. In 1972 this was done in the Mid Ocean Dynamics Experiment (MODE), a joint experiment between the IOS and a number of US laboratories. Nick Millard and Brian McCartney developed a transponding version of the float that could be tracked to ranges between 50 and 100km with results displayed on an analogue recorder "The Dobfax" designed in large part by Dickie Dobson. These floats were used in Minimode, an experiment embedded in MODE, to study the differences in current

Recovering a minimode float

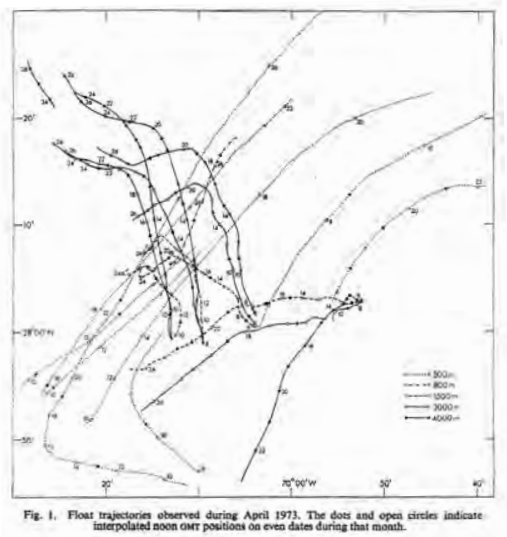
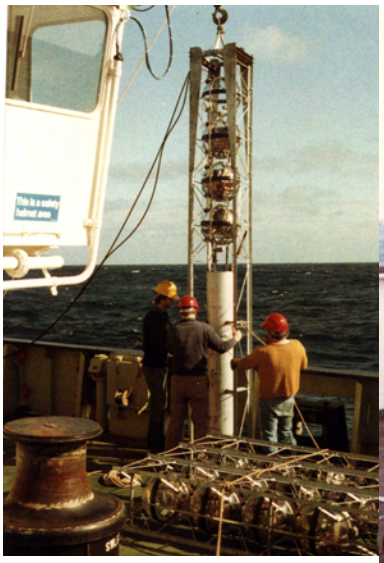


Fig. 1. Float trajectories observed during April 1973. The dots and open circles indicate interpolated noon GMT positions on even dates during that month.

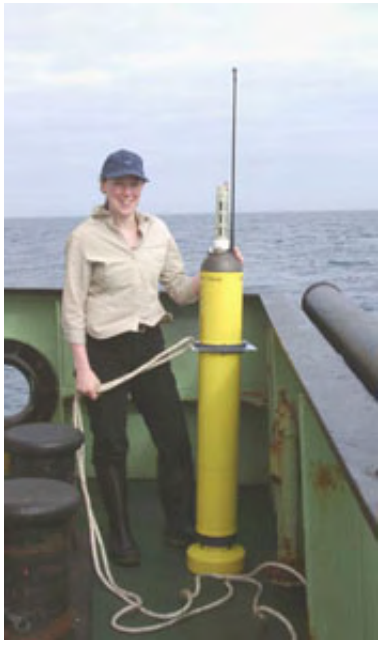


Above. A deep SOFAR float being deployed from RRS Charles Darwin. Right. Nick Millard with a prototype bottom tracking transponding float in the 1980s. Ian Waddington in background.

structure over rough and smooth bottom topography. During the 1980s as part of commissioned research into environmental issues involved in radioactive waste disposal in the deep ocean both Minimode floats were used as well as a deep version of the SOFAR floats developed by Rossby and Webb. This deep float work was carried out jointly between IOS and the MAFF Fisheries Laboratory at Lowestoft.

Global capability

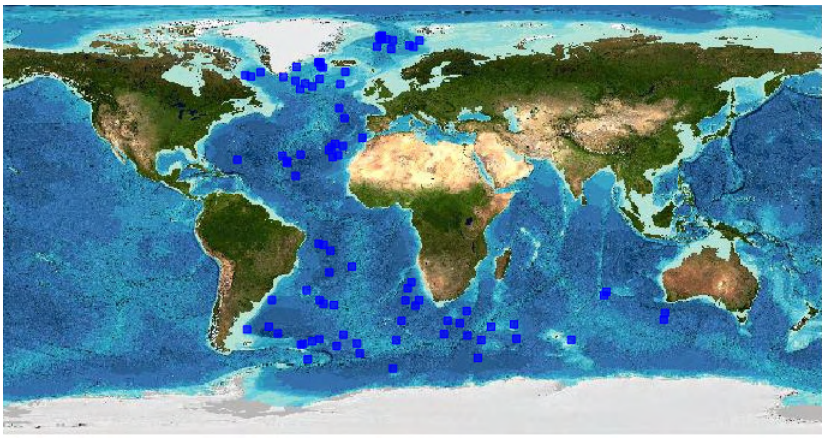
In the late 1980s planning was taking place for a global-scale World Ocean Circulation Experiment to explore the ocean' role in earth's climate. One requirement was a means of measuring subsurface currents globally and to do this Doug Webb and Russ Davis (Scripps) devised a version of the Swallow float known as the Autonomous Lagrangian Circulation Explorer (ALACE). Each of these floats surfaced at regular intervals by pumping oil from an interior reservoir to an external bladder. At the surface they were positioned by satellite and so were free of the need for an acoustic tracking network. They returned to depth by returning the oil from the bladder. These floats were used extensively in WOCE in the 1990s and later evolved into a profiling (PALACE) version that measured and relayed temperature and salinity profile data. IOS operated a number of PALACE floats in the mid 1990s to explore the winter deep water formation off southwest Greenland.



Penny Holliday with an Argo float

In 1999 a plan was proposed to deploy and sustain a global fleet of 3000 profiling floats to monitor the structure of the uppermost 2000m of the ice-free oceans. The project, Argo, was to complement the new Jason radar altimeter satellites.

Through unprecedented international collaboration the 3000 float target was reached in 2007 and the array has been maintained since then. It was described in the NewYork Times in August 2014 as "one of the scientific triumphs of the age". It is now the principal means of monitoring ocean heat content. The UK (a joint effort between the National Oceanography Centre, the Met Office and the British Oceanographic Data Centre) operates about 4% of the global array. Argo is a remarkable legacy of John Swallow's invention.



UK Argo floats at end of 2014

Additional information sources

- Bibliography of research using all types of Swallow floats.
- The development of float technology (UK perspective)
- The development of float technology (US perspective)