Voyage of the argonauts

A global network of sea-going floats is set to transform our understanding of the world's oceans. As the data start to roll in, researchers are lining up the problems they hope to solve. Rex Dalton reports.

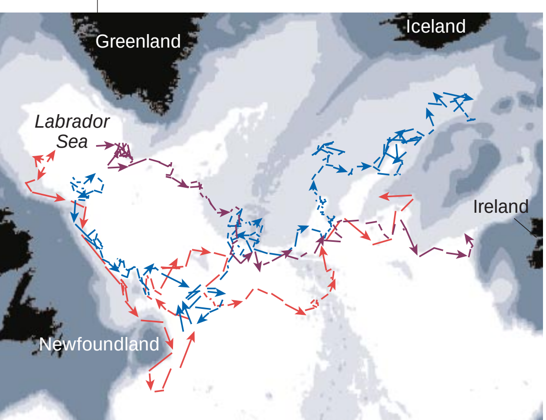
WEBB RESEARCH

A drop in the ocean: water currents, temperature and salinity in remote areas are now being recorded by floats parachuted in for the job.

The cool, dense currents within the Labrador Sea were long thought to chart a hidden course down Canada's eastern seaboard. Hundreds of metres below the sea's surface, the cold waters were believed to slip southwards past Newfoundland before ducking under the warmer waters of the Gulf Stream and dispersing into the North Atlantic.

But four years ago, a group of oceanographers used data from 200 ocean-going floats to disrupt this neat picture. The floats were cast into the Labrador Sea and programmed to drift at different depths below its surface, rising every few days to transmit data to satellites overhead. To the surprise of the researchers, some of the floats took an unexpected course, travelling east around Greenland and across the Atlantic towards Iceland and Britain.

"It was odd," recalls Russ Davis, who ran the experiment from the Scripps Institution of Oceanography in La Jolla, California. "Something very unusual and unexpected was happening." After further study, Davis and his colleagues incorporated this current into a whole new pattern for the circulation of the Labrador Sea (see left), one which has changed our view of the North Atlantic[1]. "It was probably the single most interesting discovery I've been involved with in my career," says Davis, reflecting on his 34 years of service.



K. L. LAVENDER, R. E. DAVIS & W. B. OWENS

Flow chart: data from floats in the Labrador Sea revealed completely new currents.

Data streams

But the Labrador revelation could be just the first of many. Dean Roemmich, also at Scripps, estimates that over 300 data-collecting floats are now sending back temperature and salinity measurements from the world's oceans. Almost 700 more will added over the next year. If the aims of this international endeavour, known as the Argo project, are realized, 3,000 floats will form a global network throughout the oceans by 2005.

Understanding ocean circulation is top of the project's agenda. Ocean currents move large volumes of warm and cold water around the globe, so circulation has an important effect on climate. Researchers have mapped out broad circulation patterns, but much of the details of this movement, and the changes in temperature and salinity that accompany it, have not been filled in. "The ocean is the most poorly observed part of the climate system," says Sydney Levitus, director of the World Data Center for Oceanography in Silver Spring, Maryland.

Argo is the latest strand in the Global Ocean Observing System (GOOS), a decade-old drive by the Intergovernmental Oceanographic Commission, part of UNESCO, to put this right. The scheme aims to establish a permanent system for observing, modelling and analysing the world's oceans. The temperature of the ocean's surface, for example, can be measured by satellites, and instruments towed by ships can probe below the sea's surface. But by providing a regular flow of data from different depths and from across the globe, Argo will give the GOOS observation network a big boost. "For the first time," says Kensuke Takeuchi, an atmospheric physicist at Hokkaido University in Japan, "we will know the global-scale variation in the ocean in detail in real time."

Thirteen nations, including France, Britain, India, Japan and the United States, are now contributing floats to Argo, the total cost of which is likely to be between US$30 million and $40 million. The various participants have each designed different floats, but all the devices operate on similar principles. The ones developed at Scripps, for example, are cylinders around 150 centimetres long and 20 centimetres in diameter. Buoyancy is adjusted by pumping oil in and out of a bladder. This increases or decreases the float's volume, changing its density and causing it to rise or fall through the water.

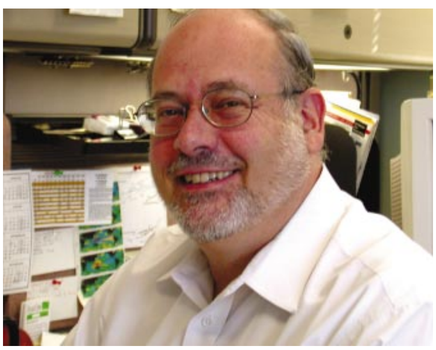
The float's ballast and bladder are tuned before launch so that it dives to a specific depth, which can be up to 2,000 metres. The US floats are programmed to surface and send data to satellites once every 10 days, and should be able to make up to 150 dives in their four- to five-year research lifetime. To minimize costs, floats are deployed by research vessels that happen to be going to or past target areas. This month, for example, an ocean-research vessel leaving Hobart, Australia, will deploy two floats in the Coral Sea and four in the Pacific Ocean west of Guam.

Probe overboard

Engineers have also perfected a method for high-speed deployment, which can be used by crews of cargo vessels who are willing to throw the floats overboard, but who cannot stop to check on them if something goes wrong. The floats are contained in corrugated paper boxes that disintegrate rapidly in sea water. These boxes are also used to parachute the floats down to the sea from US Navy aircraft on training exercises.

Once deployed, the floats take temperature and salinity data as they move vertically through the water. Because the floats can only communicate when they are on the surface, newer generations capture data on the ascent rather than the descent to make the measurements more timely. Data from all the Argo floats are sent to three satellites owned by the US National Oceanic and Atmospheric Administration, and relayed to computers at the Brittany laboratories of IFREMER, the French marine research agency, and the Japan Meteorological Agency, based in Tokyo. From there, they can be freely accessed by interested scientists.

Climate modellers are particularly keen to get their hands on Argo data. These researchers often test their simulations by feeding them climate data taken, for example, in the 1950s. The models are then evaluated by comparing their predictions for the years between then and now with real measurements. But these tests are of limited value because data on the oceans are threadbare compared with those taken on land.



Full stream ahead: Sydney Levitus sees Argo as a major boost for climate research.

"Argo will fill in these gaps," says Detlef Quadfasel, an oceanographer at the Danish Center for Earth System Science in Copenhagen. "It will give a coverage similar to that which meteorologists have had on land for over 100 years."

Argo should also help to tackle more localized problems. Quadfasel set sail on 19 February for the Greenland Sea to investigate curious data produced by Argo floats in the region. One of the floats is trapped in an eddy, a column of water that spins round like a slow-moving whirlpool. Eddies at high latitudes interest oceanographers because they might act as pipes, channelling surface water down to lower levels of the ocean. Theoretical studies of eddies suggest that they should collapse after a few weeks or months[2], but the Greenland Sea float has been trapped in its eddy since last March — hence Quadfasel's decision to study it first-hand.

Other groups plan to use Argo data to hunt for 'signals' of climate change — changes in the atmosphere or oceans that can be attributed to climate change rather than to normal variability. In 2000, a group of researchers from the Hadley Centre for Climate Prediction and Research in Bracknell, UK, predicted that some areas of the Indian Ocean should provide such a signal.

Heat sinks

According to their model, climate change should significantly decrease the salinity, and increase the temperature, in water about 500–2,000 metres below the ocean's surface[3]. These changes would be caused by patches of surface water sinking to deeper levels. The signal arises because the variations in temperature and salinity caused by exposure to the atmosphere are more pronounced when compared with the surrounding deeper water, which has not been in contact with the surface.

The potential importance of this region led researchers at the Southampton Oceanography Centre, UK, to deploy some of Britain's Argo floats in the Indian Ocean. Two are already adrift, and researchers from the centre are setting sail this week to release 25 more. Eventually, they hope to have about 40 across the ocean. When the data start coming in, they should help to clarify how accurate the model is, and just how climate change will affect the ocean.

Researchers are already looking towards the next generation of equipment. Future floats will, for example, carry biochemical or physical instruments, such as turbulence sensors to help measure mixing between upper and lower regions of the ocean. And engineers at Scripps and the University of Washington in Seattle are developing floats that can be programmed to follow specific paths rather than drifting with the current. The Scripps prototype is designed to cruise

L. RIDDLE

Networking: Dean Roemmich (right) and Russ Davis with one of the Argo floats.

for up to a year, covering around 7,000 kilometres in that time. "It's not quite ready for prime time," says Davis, "but it's close."

Argo researchers also hope to make use of the 66 low-orbiting Iridium satellites. Originally intended to provide a global mobile-phone network, they are now being used for US military communications after their original backers went bankrupt. By increasing the number of satellites available to the project, the Iridium system would cut the time the floats have to spend at the surface before they can send their data. And unlike the present system, the Iridium satellites would also let researchers transmit signals to the floats, allowing them to reprogram the devices mid-voyage.

With new floats in the pipeline and a mass of data waiting to be analysed, these are exciting times for the Argo project. After years of planning, the Earth's oceans will soon have a network of mobile observatories, albeit simple ones, that can begin to provide the kind of coverage that land-based centres currently offer. Those involved have no doubts about the project's impact. "Argo," says Takeuchi, "will open a new era for oceanography." ■

Rex Dalton is *Nature*'s West Coast US correspondent.

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3. Banks, H. T., Wood, R. A., Gregory, J. M., Johns, T. C. & Jones, G. S. *Geophys. Res. Lett.* **27,** 2961–2964 (2000).

Argo project
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