Peter Saunders

September 18, 1932 - August 20, 2020

Meteorologist, oceanographer, colleague and friend.

A synopsis of Peter's life in science by John Gould.

I met Peter Saunders on my first visit to the USA – to Woods Hole Oceanographic Institution (WHOI) – in November 1970. WHOI was, and remains a mecca, for oceanographers and there were strong links between the Institution and the UK's National Institute of Oceanography (NIO, later to become the Institute of Oceanographic Sciences, IOS) where I worked.

My first impression was that Peter was a gentle Englishman asked the most incisive questions at the end of any seminar. That description of Peter held throughout his working life - a life that took him from the heights of the atmosphere to the depths of the ocean.

The earliest things I know are that Peter gained his PhD from Imperial College in London. His supervisor was the eminent meteorologist Frank Ludlam[1]. Peter's PhD thesis[2] was on "Atmospheric convection". In it he described the mechanisms involved in the growth of cumulus clouds – the ones that bubble up on a fine summer day. While much of his work was theory, he made observations of these clouds during an extended visit to the International Institute of Meteorology in Stockholm, Sweden.

In late 1959 Peter with his wife Brenda moved to the USA where, as holder of a Carl-Gustav Rossby fellowship, he took up a post as a researcher at WHOI. He joined a group led by Joanne Simpson (Malkus) and worked at WHOI for 15 years. His research there is beautifully described in a memoir he wrote for the journal Weather, "A meteorologist in Woods Hole in the 1960s"[3]. As a meteorologist he studied the very lowest layer of the atmosphere and its interaction with the ocean, including the formation of marine fog and 'sea smoke'; the latter a frequent phenomenon in cold New England winters. Much of the research was conducted

1 https://rmets.onlinelibrary.wiley.com/doi/pdf/10.1002/j.1477-8696.1997.tb06305.x
2 https://spiral.imperial.ac.uk/bitstream/10044/1/13527/2/Saunders-PM-1960-PhD-Thesis.pdf
3 https://rmets.onlinelibrary.wiley.com/doi/abs/10.1002/wea.160

from WHOI's own aircraft, a Douglas DC4, looking down at the ocean surface with a radiometer.

Left Peter aboard the WHOI aircraft[4], Right C45Q at Otis Airforce Base.
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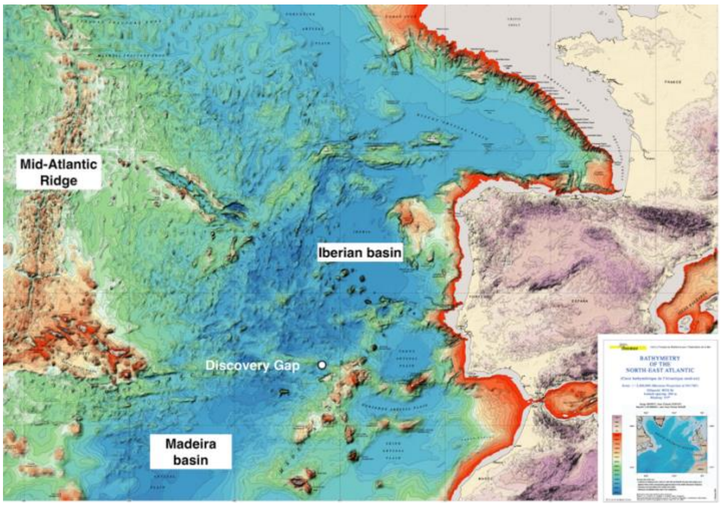
When Peter was at WHOI the physical oceanography department was housed in the Smith Building on Water Street, where stimulating discussions between local scientists and international visitors were often conducted around the coffee pot and through a haze of cigarette and cigar smoke. In the corridor, at ground level, was "Saunders' rail". A speaker was not allowed to be interrupted if they had their foot on the rail.

Peter remained at WHOI until the 1970s when he started to work on the interactions between the atmosphere and the upper ocean with UK scientists. Then, in 1976, Peter and Brenda with their children, Stephen, Dawn and Derek, returned to the UK. Peter was recruited by the Institute of Oceanographic Sciences at Wormley, just south of Godalming in Surrey. His expertise in marine meteorology was to be applied to a major, UK- led, experiment in the summer of 1978. This, the Joint Air-Sea InteractioN (JASIN), experiments[5] involved 14 ships and 3 aircraft, with more than 50 teams of investigators from 9 countries. The work focussed on the Rockall area west of the UK. Peter went to sea as the joint cruise leader (with Raymond Pollard) on the Royal Research Ship Discovery cruise 94[6]. Peter used floats tracked by underwater sound to examine the currents in the upper ocean and the way in which they respond to changing winds. That year was a tipping point for marine science as it marked the launch of the first satellite, SeaSat[7], designed to study the oceans. Now there was the prospect of all-weather ocean monitoring. JASIN was important in validating the Seasat measurements.

Peter's focus on the upper ocean continued until a change in UK Government policy (the Rothschild principle) led to laboratories like IOS having to seek funding directly from government departments. A major project undertaken by IOS investigated the implications of the disposal of radioactive waste on or under the sea bed and the potential pathways from a source on the seabed back to humans. This involved a multidisciplinary approach to learn about the movement of water through deep sea sediments, the chemistry of sediment-water interactions, ocean biology from plankton to fish and, for the physicists such as Peter, learning how water near the sea bed mixed with the shallower layers and how the deep and

4 https://www.whoi.edu/oceanus/feature/the-airplane-that-studied-the-ocean/
5 https://royalsocietypublishing.org/doi/10.1098/rsta.1983.0001
6 https://www.bodc.ac.uk/resources/inventories/cruise_inventory/reports/d94.pdf
7 https://www.jpl.nasa.gov/missions/seasat/

intermediate depth water moved around. Peter, perhaps because of his knowledge of the boundary layer between the atmosphere and ocean, applied himself to learning about what happened to water immediately above the sea floor. The area chosen was the Northeast Atlantic, where the Institute had worked since the 1950s. Much of the ocean there is about 5km (3 miles) deep.



The NE Atlantic and the position of Discovery Gap

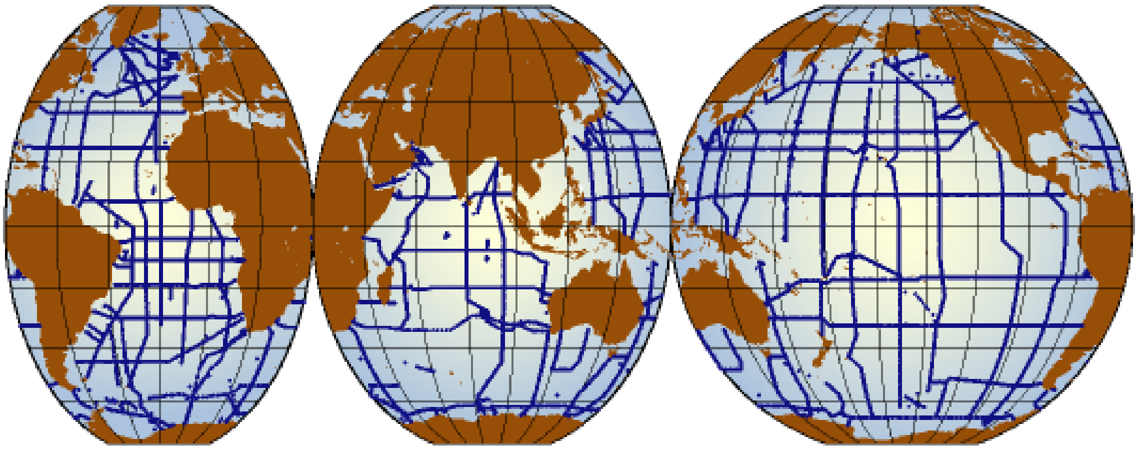
Here we need to provide a bit of background about ocean currents. The deep ocean is filled with water that originates in the polar regions where it cools, sinks and then spreads, mixing and warming as it moves equatorwards. The rate at which it moves is very slow so that one of the few ways to measure its progress is to monitor the flow through the narrow passages that link the huge, flat-floored ocean basins. Peter measured the flow through Discovery Gap[8], a channel linking the Madeira Basin to the Iberian Basin. RRS Discovery cruises in the summers on 1982 and 1983[9] deployed and recovered an array of current meters in the channel and made detailed measurements of the temperature and salinity of the water flowing northwards. Peter calculated that 200,000 tonnes of water colder that 2.05°C was flowing northwards each SECOND. This was an important addition to our knowledge.

Peter working in Southampton with some early 1990s computing equipment.

Marine science was changing rapidly by the mid 1980s. We have already mentioned the role of satellites and during that decade plans were made for new satellites to be launched around 1990. These would give all-weather coverage of the ocean circulation. Another factor was

8 https://journals.ametsoc.org/jpo/article/17/5/631/7415/Flow-through-Discovery-Gap
9 https://www.bodc.ac.uk/resources/inventories/cruise_inventory/report/2545/
https://www.bodc.ac.uk/resources/inventories/cruise_inventory/report/2680/

the increasing power of computers. The oceans are too big and complex to define solely with observations and therefore oceanographers (and meteorologists) were among the first to harness the power of supercomputers to model the ocean and atmosphere. The UK began a community project to develop a Fine Resolution Antarctic Model (FRAM) that would try to represent the climatically important Southern Ocean. The new computer power allowed the model to take into account the small eddies that fill the ocean. (These are the smaller cousins of the high and low pressure systems in the atmosphere). Oceanographers around the world also started to plan the most ambitious project -a World Ocean Circulation Experiment, (WOCE). Its objective would be to develop models of the ocean for climate change research and to collect the data needed to test them. The data would come from satellites and from traditional, ship-based measurements, that would stretch the resources of the major sea-going nations. The UK was to be a major contributor and would also host the international co-ordination office at IOS in Wormley.



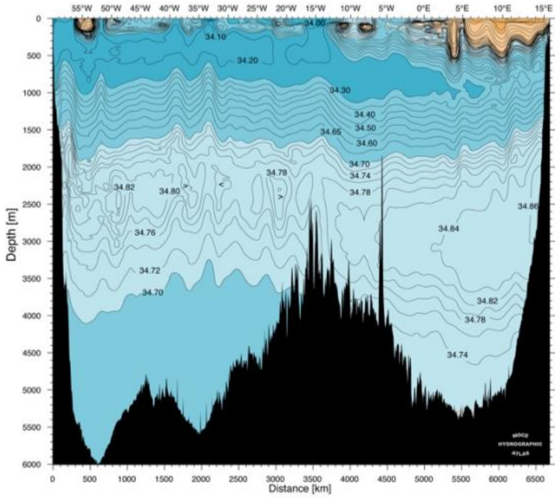
The grid of WHP stations every 50km along the blue lines

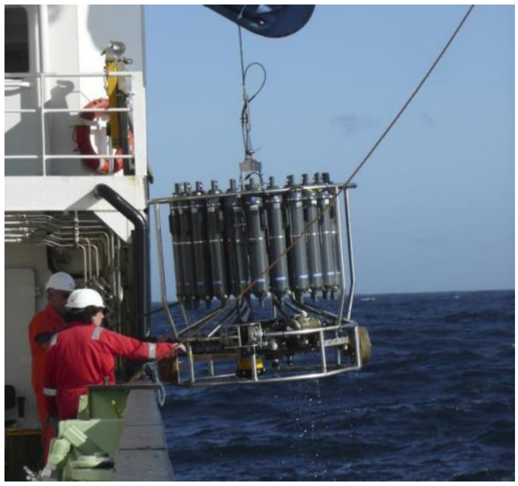
Peter had several important roles in WOCE. As a meticulous observationalist he was a natural choice to lead the international group that defined the programme of surface-to-bottom observations of temperature, salinity and ocean chemistry – the WOCE hydrographic Programme (WHP) .It was a great challenge to define and enforce standards and protocols to which all countries would adhere and to plan where and when, during the 1990-1998 observational phase the ships should make their measurements.

Peter also played an active seagoing role in the run up to and during WOCE. He transferred his Discovery Gap experience to studying the outflow of water from the Arctic as it streamed along the seabed: first between Scotland and the Faroe Islands, then south of Iceland and finally westwards through gaps in the mid-Atlantic Ridge, the chain of underwater mountains separating the east and west Atlantic. Again, this involved putting arrays of moored current meters out for a year and measuring the temperature and salinity by lowering a probe (CTD) and water sampling bottles to within a few metres of the sea bed. This was nervewracking in mountainous topography and rough North Atlantic weather. Peter made definitive measurements of these flows; values that now help define the transport of heat between equator and poles that regulates earth's climate.

Peter was also one of a relatively small number of scientists who bridged the gap between the rather separate communities of ocean modellers and sea-going oceanographers. A key test of a model is how well it represents "the real world", Peter tried to answer that question working with the FRAM and later the UK OCCAM model. Models also require us to have an exact knowledge of the relationship between temperature, salinity, pressure and water density linked by what is known as an "Equation of State". Peter applied his rigorous physics to such fundamental questions as the exact relationship between pressure and depth in the ocean.

Peter's last cruise was a contribution to the WHP. He led a team of 24 scientists and technicians on Cruise 199[10] of the newly enlarged RRS Discovery to occupy the line designated A11 across the South Atlantic from Punta Arenas in Chile (22 Dec 1992) to Cape Town (1 Feb 1993). The ship made a total of 91 top-to-bottom stations as well as measuring the variations in current speed and direction from surface to sea bed. The data provided a vital estimate of the transport of climatically important ocean properties between the Southern Ocean and the Atlantic. For several of the scientists it was one of their first experiences of deep-sea oceanography; they could not have had a better teacher than Peter.





Salinity across the South Atlantic on the A11 section and the CTD/sample bottle package used to collect such data.

As WOCE ended many things were changing. The Institute in Wormley closed in 1994 and came together with the Oceanography and Geology departments of the University of Southampton to form a new Southampton Oceanography Centre (now the National Oceanography Centre). At age 60 Peter formally retired (he had reached a grade that is equivalent to the status of a full Professor) but he continued to work with scientists at NOC on the careful analysis of the outflows from the Arctic. Through the WOCE co-ordination office he made a major contribution to assuring the quality of the WHP data and with the final publication and dissemination of the WOCE results.

Peter's extensive list of peer-reviewed papers is testament to the breadth and importance of his scientific contributions – from high in the atmosphere to the depths of the ocean and spanning 6 decades that have seen a revolution in our ability to observe and understand our world.

Many tributes have been paid to Peter and all refer to his gentle manner, incisive brain and generous nature. They also note that, as a member of the NIO/IOS cricket team, he was both " ….a batsman who could be relied upon to score more runs than the rest of the team put together-more annoyingly his style was effortless" and " a slow spin bowler who enjoyed banter with the team in the after-match refreshments".

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10 https://www.bodc.ac.uk/resources/inventories/cruise_inventory/reports/d199.pdf

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