The development of PUBS and DOBS (1967 – 1995)

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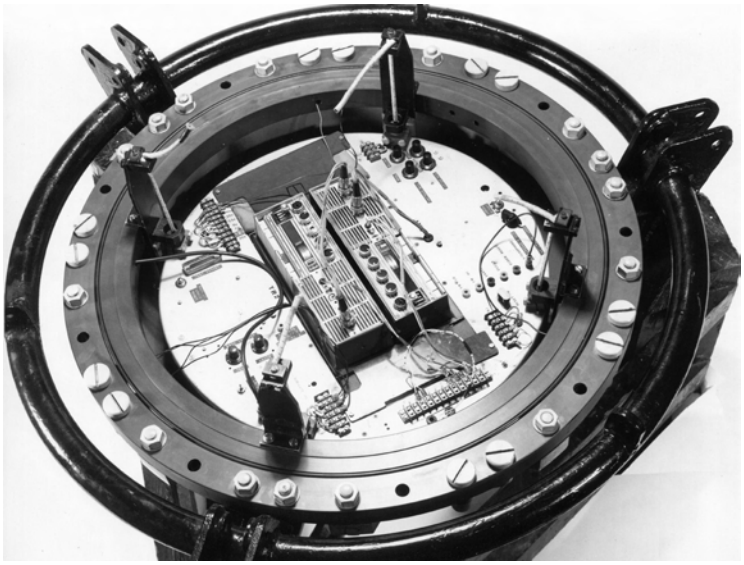
The project to build the Pop-Up Bottom Seismic Recorder (known as PUBS) started at NIO in August 1967. The rationale for building an instrument that could record near-surface explosions on the sea-bed in oceanic depths was that it would provide a fixed and quieter sensor location, contact with the 'solid' Earth and the ability to observe first arrivals from the sediment layer. A few very expensive US instruments, designed for long-term monitoring of nuclear explosions, existed at the time but no ocean-bottom seismic recorder was known to exist in the academic world.

The first significant problem to be tackled was finding an instrument housing that could also provide buoyancy in oceanic depths. The solution was a 28-inch diameter hemisphere forged in aluminium alloy made by High Duty Alloys Ltd of Slough. It was initially rated to 5000m depth but eventually could be used to 6000m.

A deep-water hydrophone was designed and built at NIO with help and advice from Mike Somers and Ron Stubbs. A pair of reel-to-reel Uher analogue tape recorders recorded the data. The recording head was replaced to provide four-channels (data and time). This provided a maximum of 12h 48m of continuous recording time. The system was designed to record seismic signals in the range 2-100 Hz.



The final critical component was a system to release the PUBS from its ballast weight to allow it to begin its ascent to the surface. Initially (1968) a 'burnt-wire' was used but this was soon replaced by pyroreleases. The pyros were fired by an acoustic signal, unique to each PUBS, from the research ship using another NIO-developed system built by Mac Harris and his group.

Figure 1. PUBS lower hemisphere with instrumentation in place showing the two Uher tape-recorders and instrumentation package suspended by four bungee cords. (NIO neg 4402-2, December 1975).

After various minor improvements, by May 1970 twenty-three PUBS launches had been carried out with the loss of only one instrument out of the three that had been built by then. Vibrational noise picked up by the hydrophone from the tape recorder was reduced by suspending the whole internal package on bungee cord. In 1974 the single, load-bearing pyros were replaced by the very reliable dual pyro, low-load-bearing link designed by Dennis Gaunt. By May 1976 sixty-three deployments had been achieved with a PUBS recovery rate of 95%. An internal, gimballed, three-component geophone set was being installed in addition to the hydrophone sensor. Airguns were being used as a sound source and earthquakes had also been recorded on the Mid-Atlantic Ridge.

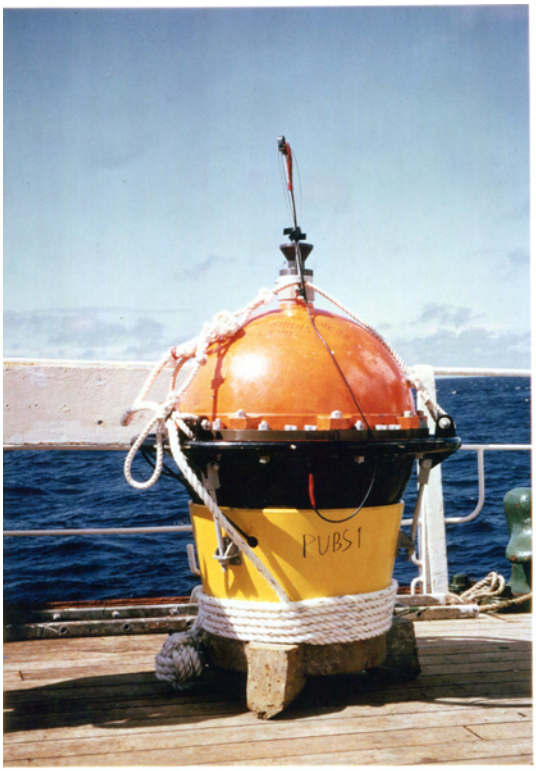


Figure 2. A PUBS on the foredeck of RRS Discovery ready for deployment. Note the radio beacon aerial attached above the inverted cone of the end-cap transducer which was used to pick up the acoustic release signal. A flashing light is mounted out of sight behind the transducer. The polypropylene rope coiled around the yellow fibre-glass cone unwound during the PUBS's ascent and became a floating stray-line which could be grappled at the surface. Ca. 1981.

Around 1977, each pair of Uher tape-recorders was replaced by a single Nagra 6-channel, modified tape-deck which provided up to 8d 13h of continuous recording. The tape-recorder could now also be programmed to record in pre-determined recording windows.

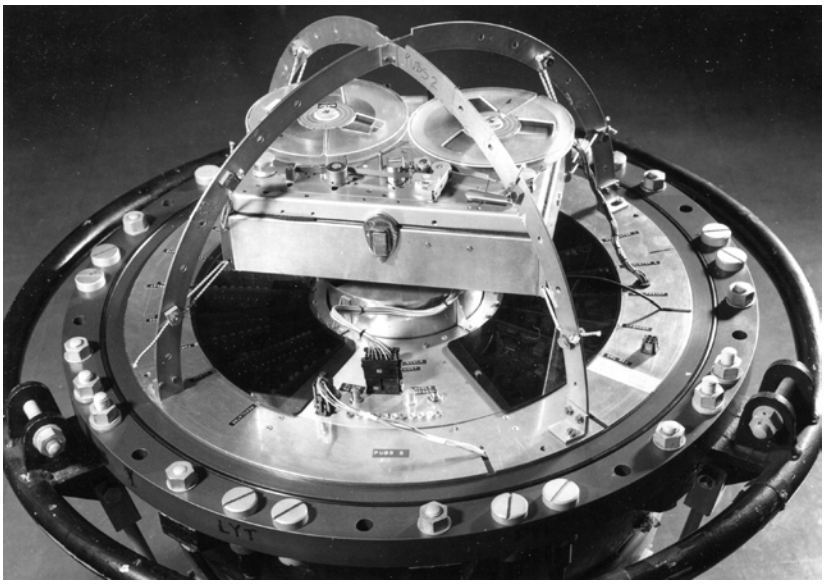


Figure 3. NAGRA tape deck, suspended by elastic cord to dampe vibration, in place above the 3-component gimballed geophone housing and other circuitry. (NIO neg. 5904-6, August 1981).

Probably the most significant improvement in the PUBS's design occurred in 1985 when Ken Peal, from Woods Hole Oceanographic Institution (WHOI), USA, spent a 12-month sabbatical at IOS working with Bob Kirk to develop a digital tape-recording system to replace the analogue tape recorders. The first data with the new Digital Ocean Bottom Seismographs (now called DOBS) were acquired at sea in April 1986.

Later, in 1990, the Peal/Kirk digital system was replaced a 40 Mbyte, six-channel, commercially built, portable digital acquisition system (PDAS-100) supplied by Teledyne Geotech. In the same year, an external, three-component geophone package was developed. The objective was to reduce recorded noise from the PDAS hard disk drive and to make higher fidelity measurements of Earth motion. The geophone package was tested, in free-fall and ascent, in the mining tank at HMS Vernon in Portsmouth to see if it had any impact on the DOBS's vertical trajectory. Fortunately, none was detected.

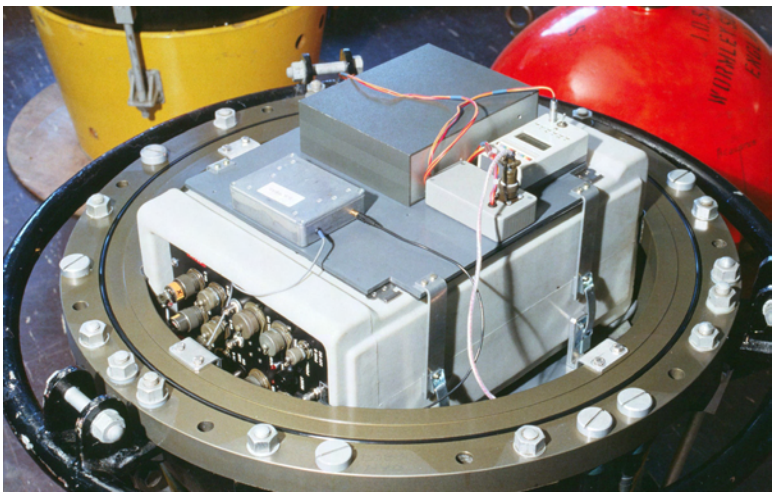


Figure 4. A PDAS system fitted (just) inside the lower hemisphere of a DOBS. The hard disk lies on top of the PDAS

By 1991, thirty academic groups around the world were known to be operating ocean bottom seismographs (often incorrectly referred to as ocean bottom seismometers). IOSDL owned just four DOBS. Today experiments are frequently conducted using a few dozen of such instruments which are now smaller and record data in solid state memories so that there are no moving parts to cause vibration (see below).

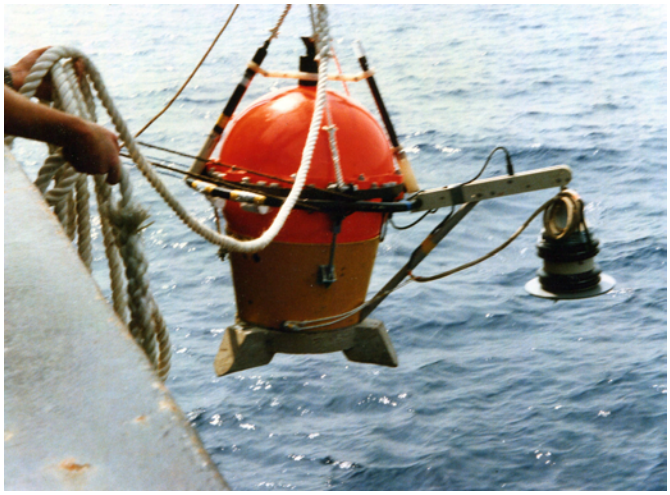


Figure 5. A DOBS fitted with an external 3-component geophone package being deployed during RRS Charles Darwin cruise 75 in 1993.

Over 27 years, from 1968 until 1995, the PUBS/DOBS became the workhorse for seismic refraction measurements at sea; a total of 268 deployments had been made with very few losses. The PUBS/DOBS provided the basis of many publications by Bob Whitmarsh and colleagues both within NIO/IOS/IOSDL and from other labs in the UK and abroad.

By the late 1990s, institutions in several countries had developed large pools (several tens or more) of ocean bottom seismographs (OBSs) and it was recognised that to remain competitive, a similar pool was required in the UK. A consortium led by the Southampton Oceanography Centre, and including the University of Durham and Imperial College London, secured funding from NERC to acquire a pool of 28 OBSs which were delivered in 2003. The instruments were purchased from Scripps Institution of Oceanography and separate electronic components were purchased to allow some of them to operate alternatively as electric field recorders. Initially, 10 of the 28 involved Scripps loggers installed in the original DOBS pressure housings, but the DOBS pressure housings were retired several years later because they were too heavy for the rapid turnaround expected in modern experiments. Since 2003 the OBS pool has been operated jointly by the Universities of Southampton and Durham; in 2007 it became a NERC facility and since then it has grown to around 50 instruments, with a nascent capability in broad-band seismology and magnetotellurics.

Figure 6. The DOBS team on RRS Charles Darwin cruise 75 in 1993 ready to deploy a DOBS. From left to right, unknown crew member, Bob Kirk, Martin Saunders, David White, Christine Peirce (University of Durham).

This account cannot end without mentioning the efforts at sea of many colleagues and crew who helped to launch and recover the heavy PUBS/DOBS and sometimes spent long periods on deck, night and day, occasionally in poor weather, straining their eyes for the sight of that elusive flashing light or orange sphere at the surface. The patience and skill of the many bridge officers who, often seemingly effortlessly, brought their vessel within grappling range of the relatively small floating PUBS/DOBS is also gratefully acknowledged.

Further information

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