

## Deep Arvor: results of the first industrial prototypes at sea

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The Deep-Arvor float was designed by Ifremer to achieve up to 150 profiles from 4000 meters depth, with continuous pumping of the CTD. The objectives were to keep a high level of measurement quality with an affordable instrument, to limit its weight, and to maintain the self-ballasting feature of the Arvor-Provor family. After the validation of the first two models at sea, the industrialization was entrusted to NKE instrumentation. The first manufactured prototypes of Deep-Arvor were successfully deployed in May 2014 during the Geovide cruise in the North Atlantic Ocean.

The design focused on the improvement and the extension of the 2000m Arvor model. The SBE41CP CTD, fitted with a reinforced pump housing and a Kistler pressure sensor, was recommended to us by Seabird for an operational depth up to 4000 meters. The hydraulic engine was adapted to address the high pressure constraint and the Iridium-GPS antenna was strengthened. The main evolution was the use of filament winding technology in order to combine the ability to withstand the increased pressure with the desire to minimize the weight of the hull. The heart of Deep-Arvor remains the well proven I535 electronic controller, already used in the Arvor for several years. Additional sensors can easily be added to the top end-cap including an oxygen measurement sensor (Aanderaa 4330 optode). The profile data comprises three separate areas and each one has distinct resolutions, from one meter to several tens of meters, allowing spot sampling or bin averaged data acquisition. The amount of transmitted data can reach 2000 points per profile. To save energy, the user can program the float in order to alternate its profile depth (e.g 1 cycle at 4000 meters every 10 cycles at 2000 meters). A "smart grounding" feature is used to manage operations in regions shallower than 4000 meters. Finally, the features of the Deep-Arvor can be summarized as follow: the capability to realize 150 cycles to 4000 meters (more than 4100 dbars), its weight (26 kg), its various sampling rates, and its flexible programming.

The floats and their sub-assemblies underwent intensive tests: several hydraulic engines passed the equivalent of 150 cycles at operating pressure, the composite housings were first tested at 4580dbar and then withstood the cycles of compression and steady states, which are representative of their life. The effect of swell was assessed and real time missions were done in pressure tanks or in the pool.

The two early Deep-Arvor models, restricted to 3500dbar, have been tested at sea since 2012. The first one disappeared after 60 cycles while the second one is approaching 90 cycles. Many mission configurations have been successfully tested by remotely modifying the period of cycling, the parking and profile depths, the acquisition of oxygen data or not, the resolution of the profile (100 to 1000 CTD+DO samples), etc...

The two industrial 4000m prototypes were deployed in the North Atlantic Ocean during the Geovide cruise (fig1 & fig2). The first one was deployed the 23<sup>rd</sup> of May 2014. By the middle of September, 25 cycles at 4000m have been performed. Since July, this float has been cycling every 10 days in the Iberian Basin (fig3). The main objective is to monitor the SBE41CP stability in this stable area. The second prototype was deployed the 31<sup>st</sup> of May 2014 in the west European basin. By the middle of September, 54 cycles at 4000 meters have been done. This float has been cycling every 2 days to facilitate rapid testing.

A complete set of technical information is transmitted to allow accurate monitoring. The first results show a good reproducibility of the behavior of these floats, concerning the displacement and the ability to reach the target pressure, the stability at depth, the grounding behavior and the energy balance.

A first analysis of the data suggests a fresh bias, which is apparently not pressure dependent, of order 0.01-0.02 psu depending on

the float, and an underestimation of the oxygen concentration of about 9 micromol/kg for the float deployed in 2014. A larger bias was observed on the oxygen data of the first prototypes because a multi-point calibration was not performed on the optode. A more careful analysis of the data is ongoing; the manufacturers of the sensors will then be contacted.

Today, the Deep-Arvor float is fully operational at sea. The first two models have accumulated 150 cycles at 3500 dbar and the two industrial prototypes are cycling, having successfully reached 80 cycles at 4000 meters depth. This float offers a good performance / cost ratio. In the coming months, several Deep-Arvor floats will be deployed by Ifremer in the North Atlantic Ocean for a pilot experiment and by other European institutes.

*This development has been achieved within the NAOS project - Novel Argo Ocean observing System ([www.naos-equipex.fr](http://www.naos-equipex.fr)) funded by the French Research National Agency. The Deep-Arvor is now commercialized by NKE instrumentation.*

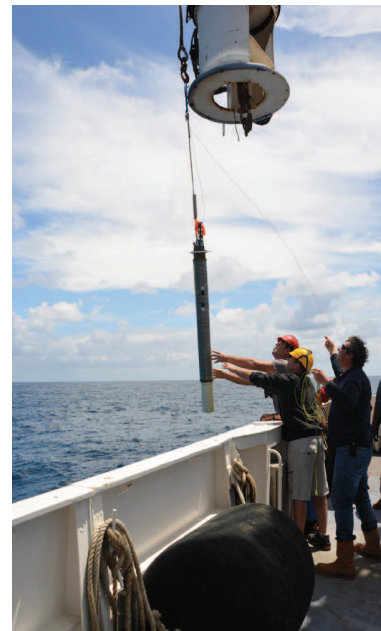


Fig1 (to the left): Deployment of Deep-Arvor during Geovide cruise (May 2014)

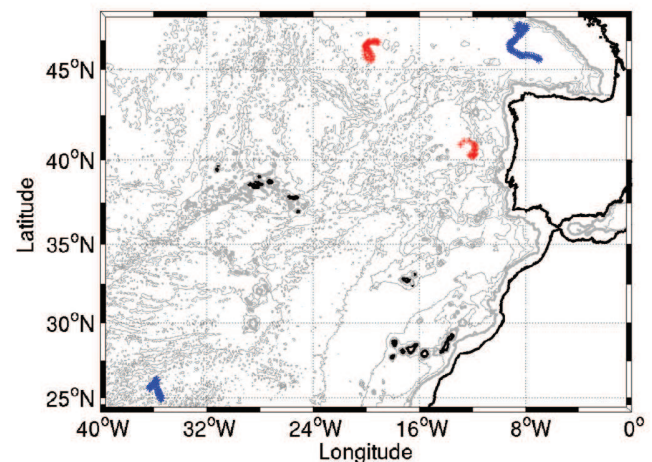


Fig2 (below): Position of the 4 Deep-Arvor. The two early Deep-Arvor models are represented by the blue dots. The two floats deployed in 2014 during the GEOVIDE cruise are represented by the red dots.

Continued on page 6

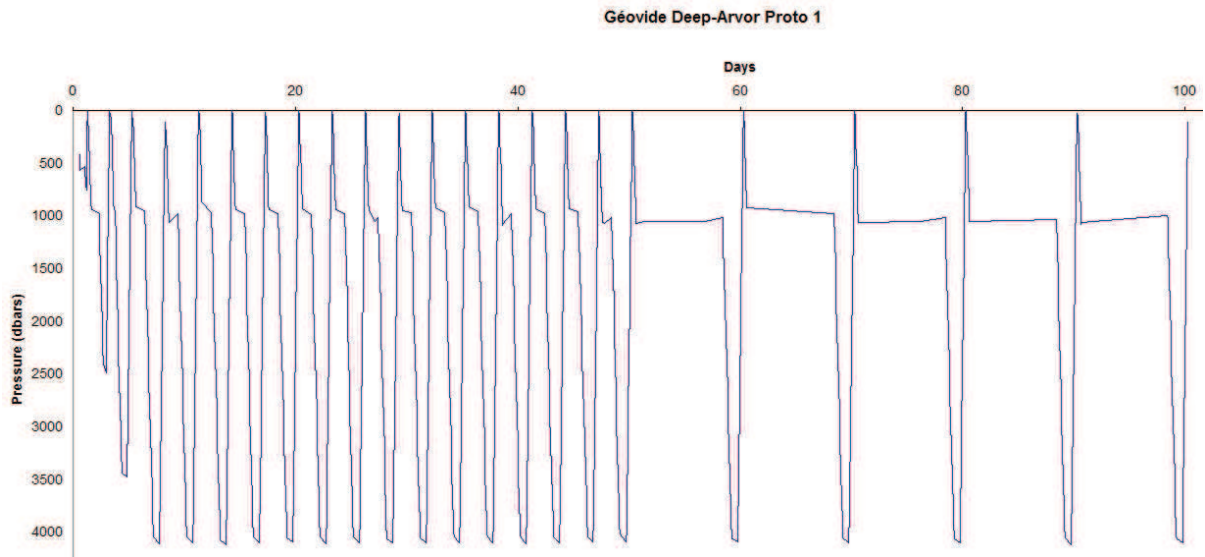


Fig3 :First cycles of the Deep-Arvor-#1, deployed in 2014

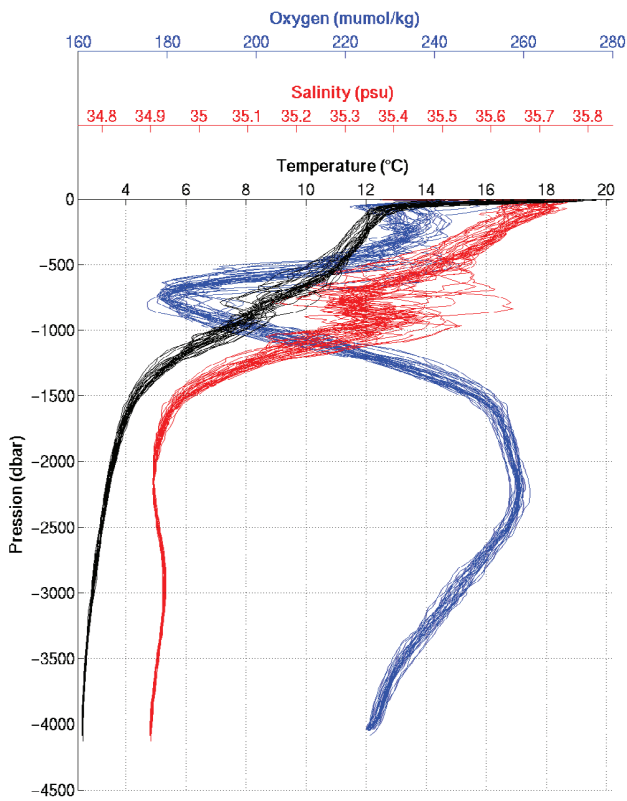


Fig4:Deep-Arvor 2014 - #1 data

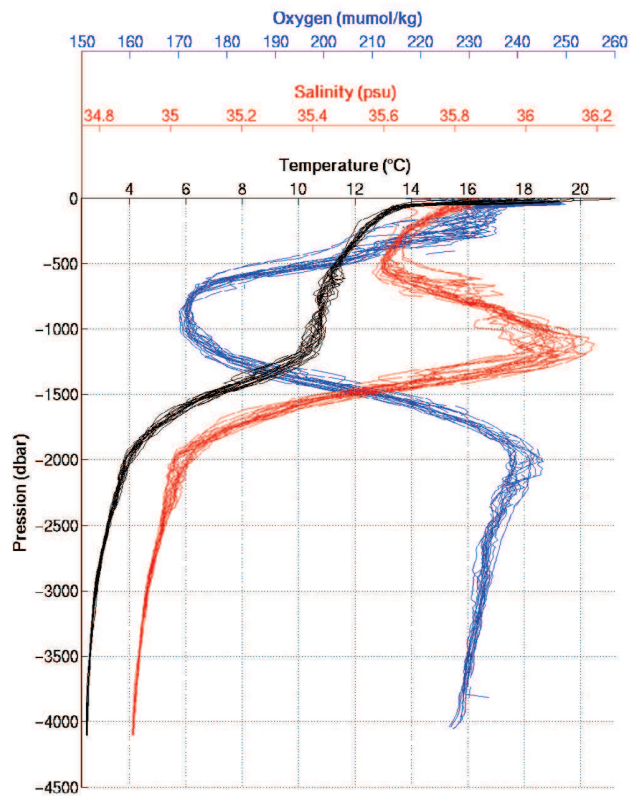


Fig5:Deep-Arvor 2014 - #2 data