Notice of an error in pressure calibration of Argo Program CTDs manufactured between September 2015 and June 2018

Summary
In June of 2018 SBE 61s tested for full scale pressure accuracy by Scripps failed to meet specifications. The investigation into the problem revealed that a bug in firmware was introduced in the development of the SBE 41plus that extended to the SBE 41N and the SBE 61. The bug is confined to one operating command, "tpr", which causes the CTD to output raw pressure sensor analog to digital counts.

The "tpr" command is used in pressure sensor calibration. The result of the bug is that pressure calibration coefficients are calculated with raw pressure data that is in error. The magnitude and sign of the error depends on each individual analog to digital converter. Most analog to digital converters produce little or no error and are within the pressure accuracy specification. Data from Dana Swift's acceptance testing of SBE 41 and 41plus CTDs is used to estimate the frequency and magnitude of the error.

This bug was introduced in September 2015, Table 1 lists starting and ending CTD serial numbers that are affected by the pressure calibration error. Note that SBE 41plus and SBE 41N share the serial number sequence.

	Starting Serial Number	Ending Serial Number
SBE 41plus / 41N	41-7504	11055
SBE 61	61-5578	5645

Table 1, Range of affected CTD serial numbers.

Float original equipment manufacturers (OEM) and Navis floats use the 41plus, Biogeochemical and deep pH Navis floats use the 41N, and Deep Argo floats use the SBE 61.

A work around implemented in Sea Bird's pressure calibration process was put in place on 18 June 2018, pressure calibrations done after date are correct even if they are within the serial number range shown in Table 1.

Impact to the Argo float fleet
An estimation of the number of effected CTDs can be made from Dana Swift's SBE 41 acceptance testing data. These data are gathered by placing the CTD in an temperature controlled environment and measuring the CTD pressure accuracy at full range (2000 decibars). Table 2 shows the percentage of CTDs that are out of specification at cold temperatures and full range for the SBE 41 and SBE 41plus CTDs.

	SBE 41	SBE 41plus
Average Error in decibars	-1.52	-0.48
Standard Deviation	1.13	1.40
Total Tested	391	210
Total out of Spec	35	12
Percent out of Spec	9%	6%

Table 2, Acceptance testing results for SBE 41 and SBE 41plus

As can be seen in Table 2 and Figure 1, in spite of the introduction of a bug in the 41plus the overall pressure performance has improved over the SBE 41. Previous efforts to improve the pass rates of pressure acceptance testing have focused on the pressure sensor temperature response model. Progress made in this effort are reflected in the better performance of the 41plus.

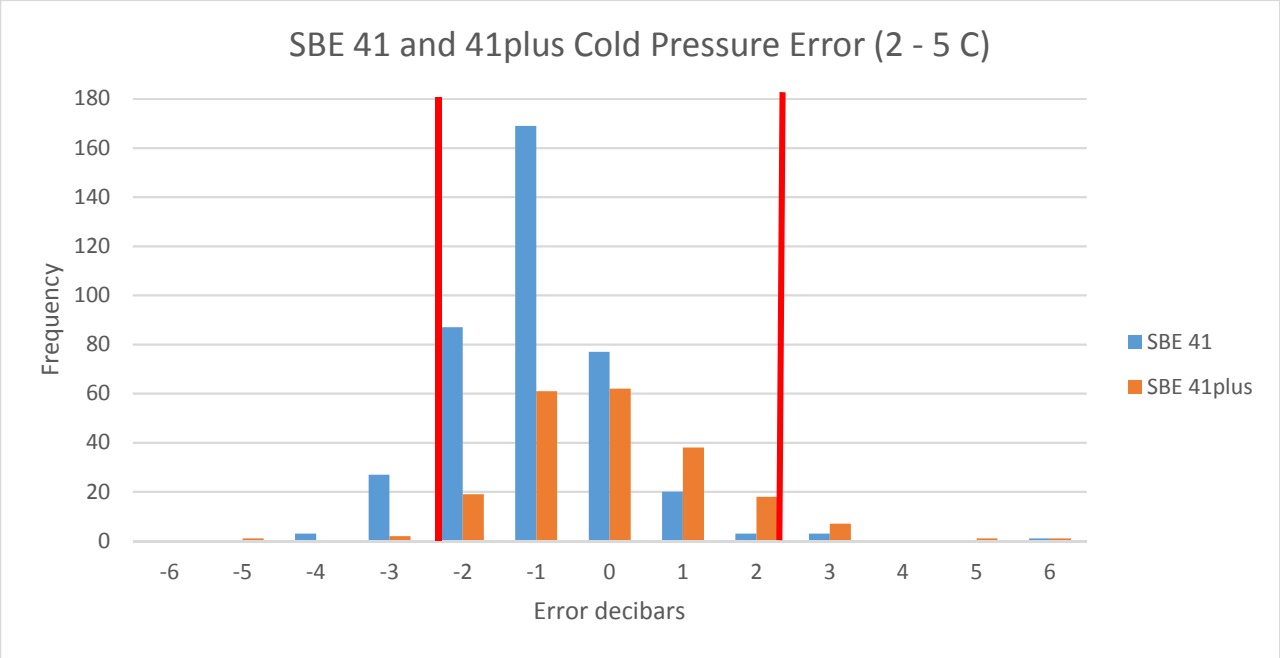

Figure 2, histograms of pressure error for SBE 41s tested between January 2011 and December 2013 and SBE 41plus tested between January of 2014 and December 2017. The red lines indicate the pressure sensor accuracy specification of +/- 2 decibars.

Sea-Bird Scientific apologizes for the error in pressure measurements that this firmware bug introduced. We are grateful to Charles Parker for pointing out the inconsistency in pressure data reported by SBE 61s in his acceptance testing and to Dana Swift for providing the data used to estimate frequency and magnitude of the error.

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