

PERFORMANCE OF A SEAGUARD® RCM ON A TEST MOORING OFF THE NOVA SCOTIAN SHELF IN SUMMER OF 2008. PRELIMINARY RESULTS

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Introduction

The oceanographic instrumentation market is a competitive one. The leading players in the industry devote great amounts of energy and resources to develop new products that set themselves apart from the rest.

AADI's Seaguard® RCM is part of a new generation of instruments based on the SEAGUARD® datalogger platform and the ZPulse™ Doppler Current Sensor. The ZPulse™ uses acoustic pulses that contain several frequency components, resulting in lower statistical variance in the current measurements (Jakobsen et al., 2008). This method maintains the quality of the data while decreasing power consumption by using fewer pings in the measurement process. This sensor also comes with a robust electronic compass and tilt sensor. The Seaguard® RCM also allows the integration of additional sensors.

The recently released Teledyne RDI's Doppler Volume Sampler (DVS), is a low-power instrument intended for long-term deployments that allows for up to 5 bins of velocity data over a range of up to 5 m (RDI, 2008).

The DVS uses four transducers arranged in a Janus configuration and by taking measurements over an ultra-low range profile, puts forward a new approach to single point current measurements.

From May 8th to June 3rd, 2008 a current meter mooring was deployed off the coast of Nova Scotia, Canada, with the purpose of evaluating the performance of both the

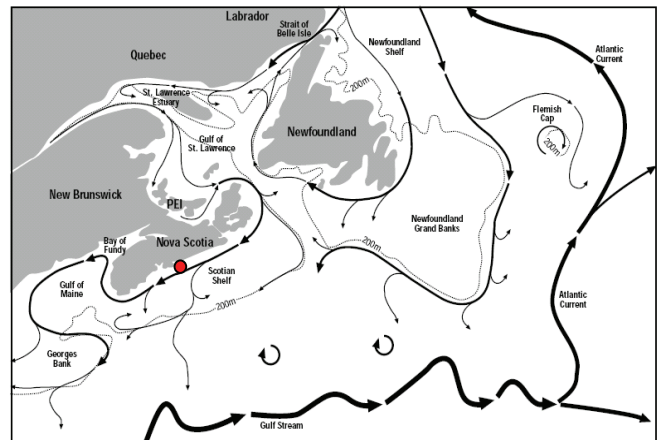


Figure 1. The red dot indicates the approximate location of the current meter mooring. Circulation patterns in the area are also shown.

(Adapted from <http://museum.gov.ns.ca/mnh/nature/nhns/t6/t6-1.htm>)

Seaguard® RCM and the Doppler Volume Sampler™ (DVS) under similar environmental circumstances and sampling strategies, investigate any observed bias in the data and study its causes.

Deployment Area and Mooring Design

The mooring was deployed from the Canadian Department of Fisheries and Oceans' CCGS Hudson on May 8th 2008 on the Scotian Shelf at a location with coordinates 44° 17.53' N; 63° 16.04' W. The water depth at this location was 155m approximately.

The location of the mooring is shown in Figure 1. This zone is generally dominated by the Nova Scotia Current, characterized by an established flow to the southwest.

The area is occasionally affected by warm-core eddies as they shed from the Gulf Stream and move over the Scotian shelf slope. These eddies can disrupt the long-term pattern of the Nova Scotia Current with episodes of cross-slope flows that favor water and matter exchange.

This area may also be subject to synoptic-scale upwelling events associated with sustained southwesterly winds.

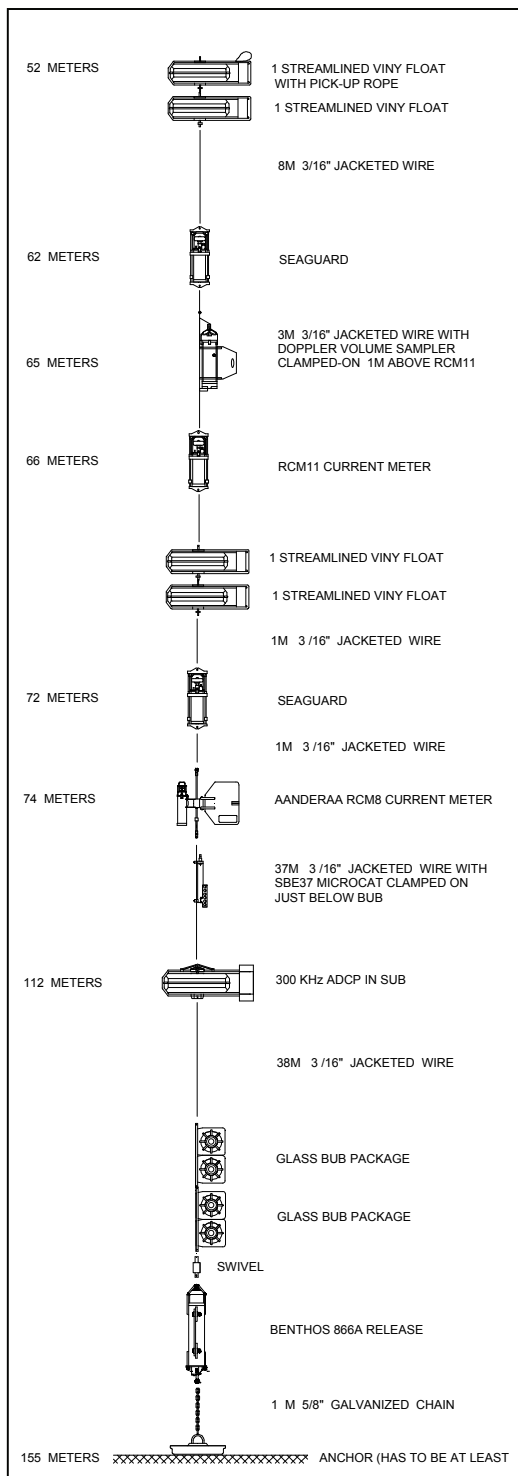


Figure 2. Mooring diagram

The mooring setup is shown in Figure 2. Five single point current meters were deployed; Aanderaa's RCM-8, RCM-11 and two Seaguards, and an RDI's DVS.

Additionally, a SBE Microcat was deployed approximate 1m below the RCM-8. Also, a 300 KHz Workhorse ADCP was placed below the single-point meters on a streamlined float.

Data Analysis

The RCM-11 placed at 66m experienced a compass malfunction that rendered the data unusable for this analysis.

No filtering, despiking, post-averaging or any other data manipulation procedure was applied to the 10-minute sampling datasets. The only modification to the data was the removal of the segments of the data series when the instruments were not in the water, and in the case of the DVS and ADCP data, the exclusion of the data prior May 12th.

In the morning of May 12th the pressure sensor on the Seaguard at 62m registered a negative shift that indicated a depth change close to 2m (Figure 3). Since the Seaguard at 72m did not record a similar pressure shift, it is reasonable to assume that shift occurred as a result of something that happened above this depth. It was later determined that the mooring line had been entangled during deployment and that at this point in time it had disentangled itself (Murray Scotney p.c.).



Figure 3. Pressure record from the Seaguards at 62m and 72m from May 10th to May 15th

Tilt and Signal Strength

Both the Seaguard and the DVS provide a record of quality control parameters such as instrument tilt and signal strength. Figure 4 shows the tilt record for both instruments.

The Seaguard tilt record appears to be noisier. A likely contribution to this fact is that this instrument measures tilts every second and then applies this tilt to the current measurements resulting from the next second's pings, but it only records the last tilt value for each sampling interval. Therefore, the stored tilt data are not representative of the instrument's tilt during the entire interval.

The measure of signal strength in the DVS is the echo intensity, measured in counts. In this case, the time series of the echo intensity for each beam is considered.

In the case of the Seaguard, the signal strength is directly measured in dB.

Regardless of what physical magnitude each instrument uses to estimate the strength of the signal received after being reflected from the environment, the consistency between the respective indicators suggests that both instruments are sensing in a similar fashion the variability of the backscatter levels in the environment (Figure 5).

Time Series of Current Measurements

The time series plots of the current speeds and direction measurements are presented in Appendix I. The data from the Seaguards and the RCM-8 starts on May 8th. The data from the rest of the instruments starts on May 12th.

The data collected by the DVS contained 5 depth cells (bins), each one meter apart. The first two bins showed almost identical data. The data from the third bin contained sporadic gaps. The two last bins yielded no usable data.

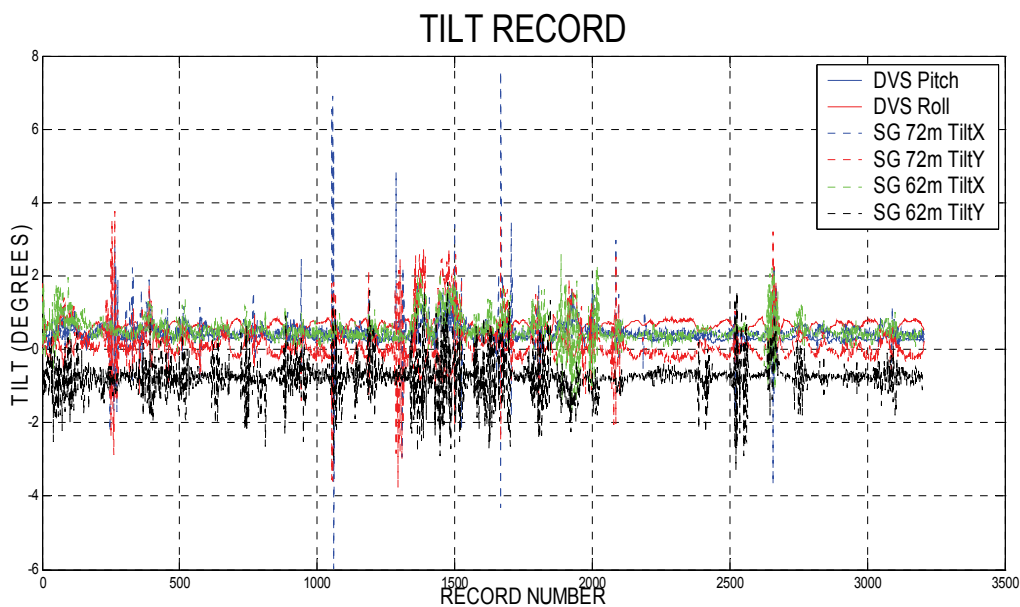


Figure 4. Time series of the tilt record for the different instruments

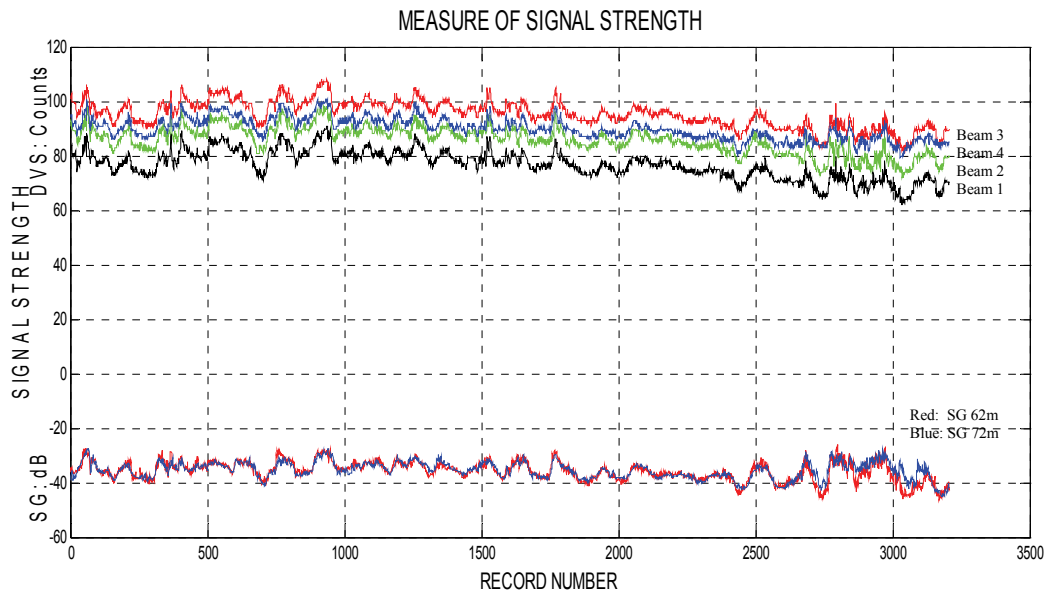


Figure 5. Time series of the signal strength

The plots in Appendix I indicate high level of consistency among the different time series.

The only notable departure from this behavior is shown by the direction data from the RCM-8 at low speeds, when the current is not strong enough to guarantee the orientation of the instrument's vane with the flow direction. This is clearly visible on May 19th, 21st, 29th and to a certain degree on June 3rd.

The effective range of the ADCP moored at 112m covered the deployment depths of all the single-point instruments participating in this comparison mooring, allowing for comparison with them.

The resulting paired data series were used to build Progressive vector Diagrams (Figure 7). These, in general, show good agreement; not only the distances covered by the Progressive Vector Diagrams are reasonably close, but also the synoptic variability events present in the diagrams are common for both datasets.

Figure 8 shows the scatter plots resulting from comparing the speed data from different sources.

The correlation with the ADCP data is acceptable for all the instruments. For the acoustic based instruments there seems to be a direct proportionality between this correlation and the proximity to the ADCP.

The closest Doppler instrument to the ADCP is the Seaguard at 72m. The speed data from this instrument correlates at $0.94 R^2$ with the ADCP data. As the distance from the ADCP increases, the correlation falls to $0.9 R^2$ in the case of the DVS at 64m and then to $0.85 R^2$ for the Seaguard at 62m.

Figure 9 shows a comparison between the data from the Seaguard at 62m and the closest to it instrument, the DVS at 65m. As suggested by the high R^2 values, the correlation is almost perfect.

In Figure 10 the ADCP-minus-Single point "error" is shown for the different instruments. The resulting scatter distributions suggest a positive trend. At

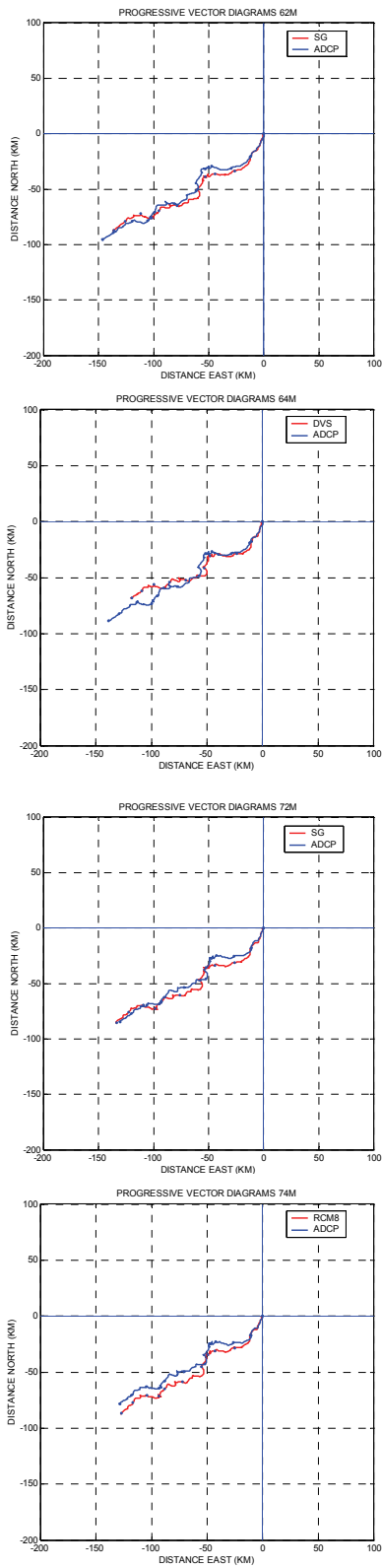


Figure 7. Progressive vector diagrams

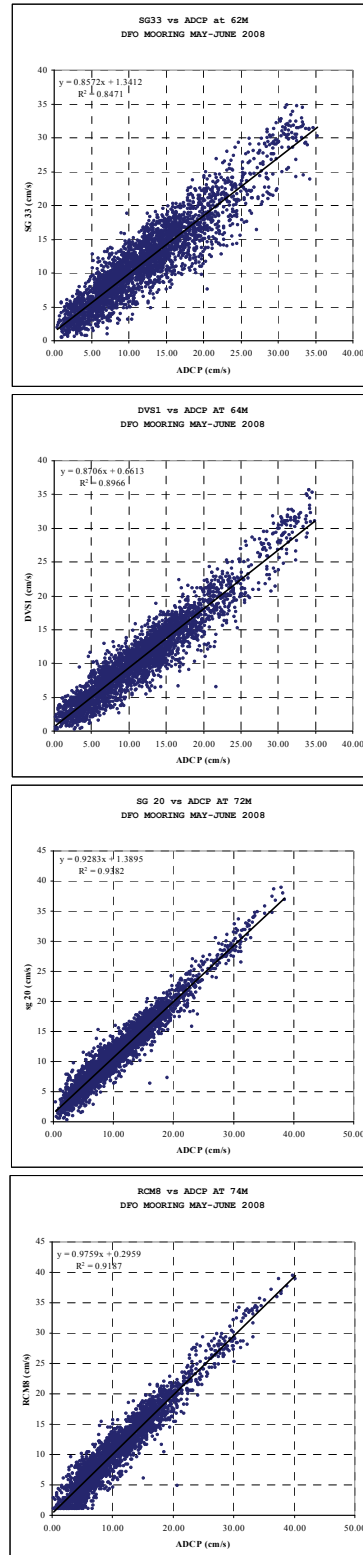


Figure 8. Single-point vs. ADCP scatter plots

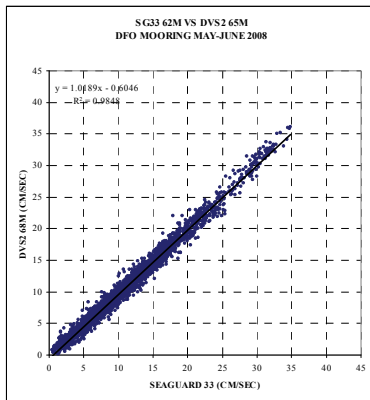


Figure 9. Scatter plot of the speed data from the Seaguard at 62m vs. the DVS at 65m. Note the high correlation between the two datasets

lower speeds the single-point measured speeds tend to be higher than ADCP determined speeds. At higher speeds values, the opposite is true. The zero-crossing point (both speeds are equal) is located between 5 and 15 cm/s.

In Figure 10 it is also observed that slope of this trend is more pronounced as the distance from the ADCP increases. It is minimal at 74m and it increases to reach a maximum value at 62m.

These trends in both current speed correlation and error slope point to an apparent shortcoming of using current profilers when used as a control in current meter comparison moorings. The bias does not seem to be platform-related because it is observed regardless of the method of deducting the current vectors from the Doppler shift (each type of instrument uses a different method).

A plausible explanation could be that the ADCP is assuming constant temperature and salinity values over its effective range and this assumption is less valid as the distance from the ADCP increases, resulting in pre established sound speeds that are less and less accurate as the acoustic beam travels

away from the ADCP transducer. Appendix II shows the time series of speed of sound as determined by the available salinity, temperature and pressure information. The speed of sound was calculated using the equation by Chen and Millero (1977), recommended in Fofonoff and Millard (1983).

The ADCP at 112m measured temperature, however it was set with a constant salinity value of 34 *psu*. The corresponding values of speed of sound were calculated using constant values of salinity and pressure and variable temperature values. From the standpoint of the ADCP, that is how the speed of sound behaved in the entire water column.

In the case of the RCM-8 and the Microcat the speed of sound calculations were realistic because all the necessary information was available.

Appendix II shows that the assumption of a homogeneous distribution of the acoustic properties in the water column is questionable. The speed of sound calculated with the data from the RCM-8 and the Microcat followed each other closely. The speed of sound assumed by the ADCP however, not only was generally higher, but also the character of its variability differed and often contradicted the pattern followed by the speed of sound according to the other instruments.

A simple correction of the ADCP determined current values for the sound speeds estimated at different depths (where enough data is available for its calculation), would only consider the conditions at the source of the acoustic beam and at the given depths, and would not be able to account for the density variability along the path in between.

Table 1 shows a statistical summary of the speed data collected by all the instruments.

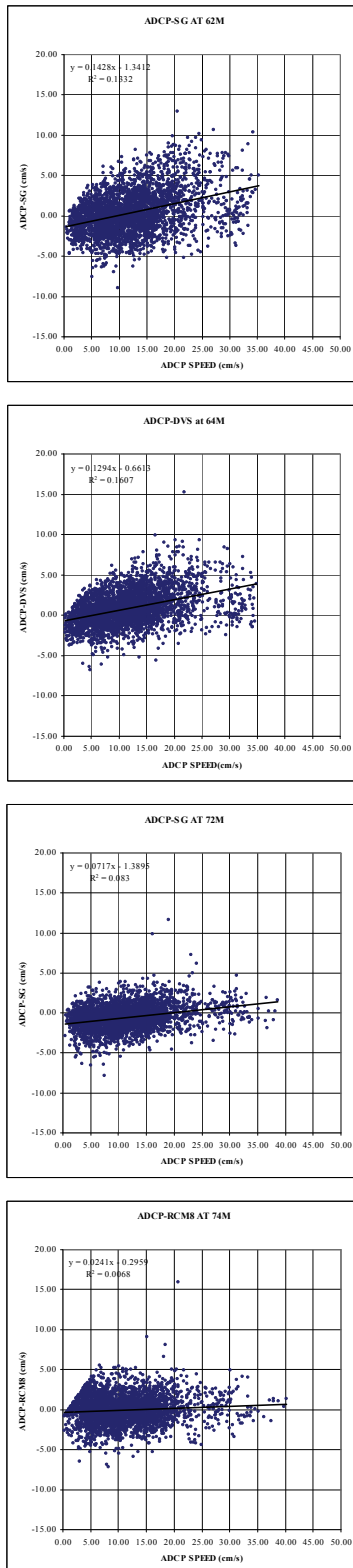


Figure 10. ADCP-single point “error” inherent to the measurements

Table 1. Statistical summary of the current speed data (cm/s)

	SG @ 67M	ADCP @ 67M	DVS @ 69M	ADCP @ 69M	SG 20 @ 72M	ADCP @ 72M	RCM8 @ 75M	ADCP @ 75M
No of pings	300	80	280	80	300	80	***	80
Mode	burst	4 min. burst	burst	4 min. burst	spread	4 min. burst	spread	4 min. burst
MEAN SPEED	12.69	12.34	11.10	11.99	12.74	11.58	11.94	11.45
MIN SPEED	0.43	0.45	0.20	0.24	0.22	0.39	1.10	0.25
MAX SPEED	36.44	35.29	35.70	34.94	38.86	38.56	39.46	40.19
SPEED STD	6.7	6.74	6.18	6.72	6.31	6.23	6.65	6.14

The two Seaguards and the RCM-8 recorded mean speeds that were slightly higher than the mean speed measured by the ADCP at the corresponding depths. In the case of the DVS, the opposite happened.

The speed extremes reveal a wider range of measurements in the Doppler single-point meters; the single-point minimums are lower than the ADCP minimums and the single-point maximums are higher than the ADCP maximums. The RCM-8 does not follow this pattern. Its minimum, as expected, is much higher and its maximum is lower than those registered by the ADCP at that depth.

The statistical analysis of the direction measurements did not show any differences outside of the expected range given the nominal accuracy of the instruments.

The Doppler based single-point current directions data had a higher standard deviation than those collected by the ADCP at the corresponding bins.

Summary and conclusions

During the test deployment all the instruments involved collected high quality, low noise data.

The correlation between the single point Doppler based measurements and the ADCP records at the corresponding bins decreases as the distance from the ADCP increases.

Also, the ADCP appears to be under-measuring at lower speeds and over-measuring at high speeds. This tendency tends to increase with the distance from the ADCP.

The potential effect of the stratification of the water column (as well as the assumption of constant salinity and pressure at the ADCP depth) on the accuracy of the current estimations by the ADCP is out of the scope of this paper, and perhaps needs to be further investigated in order to determine its pervasiveness and study all the factors of interest.

Acknowledgments:

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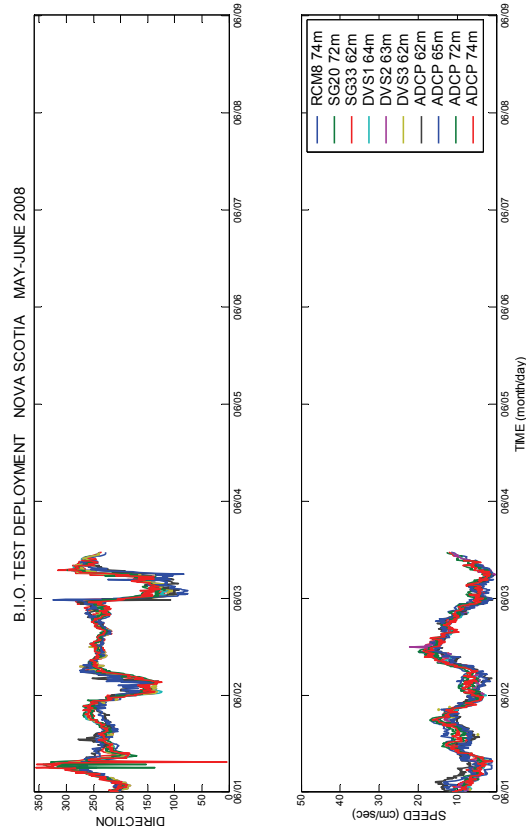
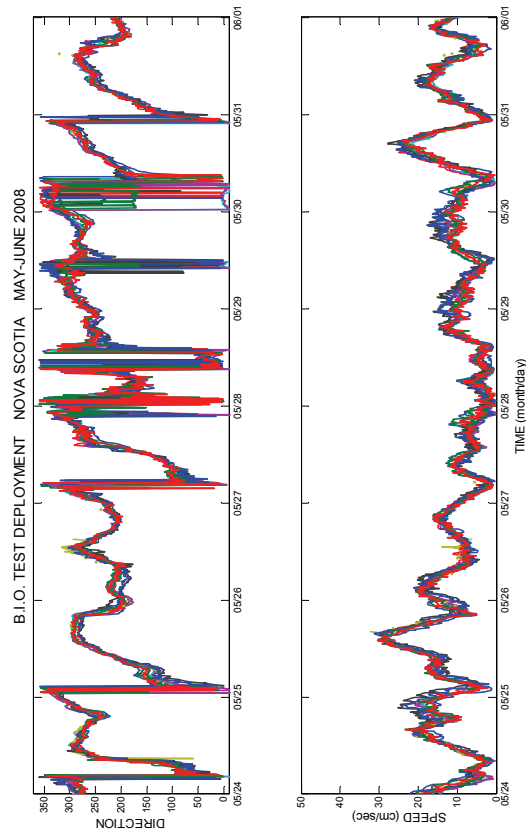
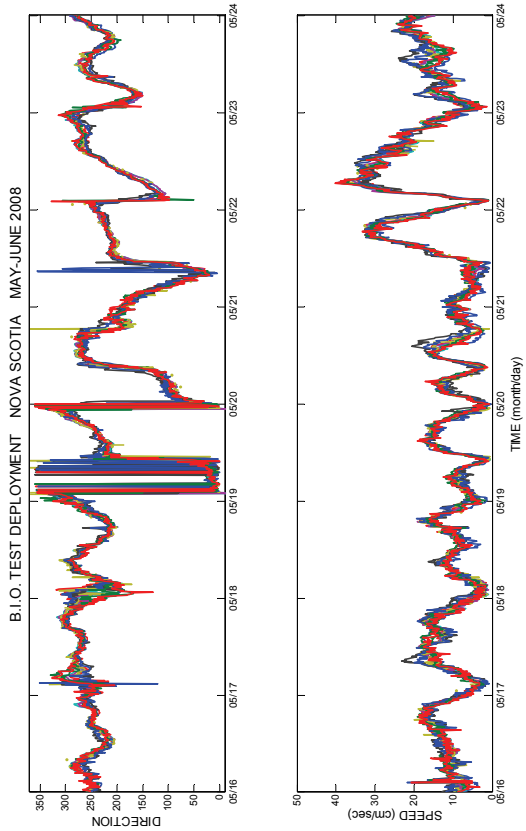
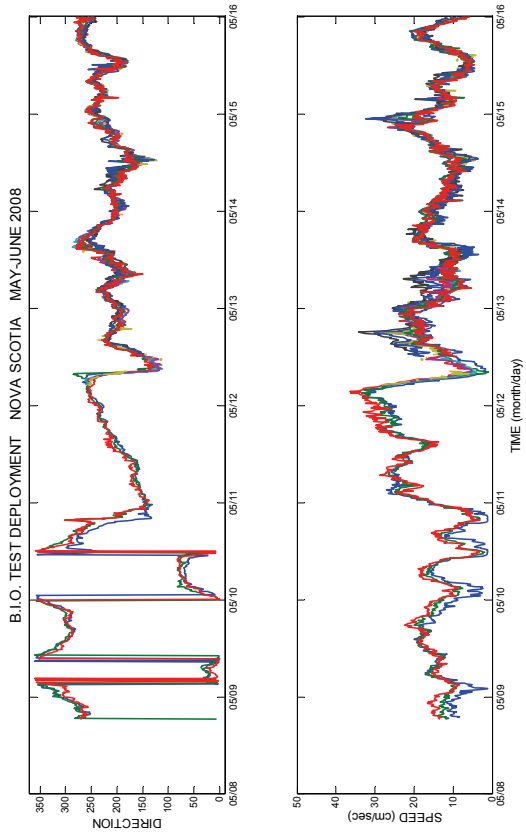
We also thank Gerry Mullison from Teledyne RDI for sharing the DVS data to complete this study.

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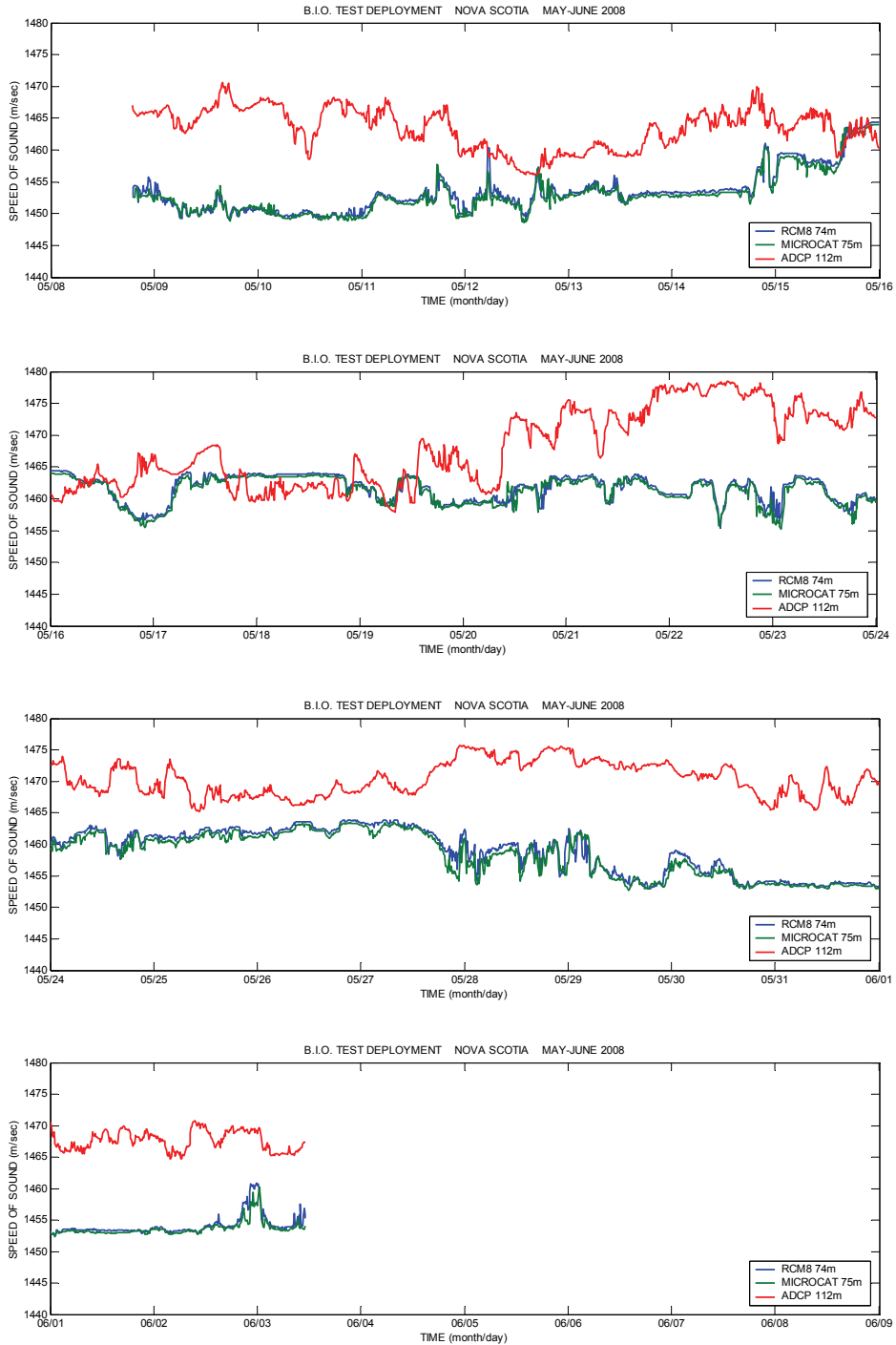
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Appendix I. Time series plots of the current speed and direction data collected by all the instruments on the mooring



Appendix II. Time series of the speed of sound, as it is “seen” by the different instruments