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SEAGUARD® Current Meters

Sensor Reliability and Data Quality from Tidal to Hadal (11000m)

Summary: SeaGuard® Recording Current Meters (RCMs) are used from 1-6000m depths and the Z-Pulse Doppler Current and Oxygen Optode sensors have been deployed to 11000m. SeaGuard® RCMs have been compared with other CMs by independent users in six different deployments. Environmental conditions ranged from the deep sea to dynamic coastal conditions where instruments are subjected to high current speeds up to 120cm/s and significant tilt up to 50°, from heave-pitch-roll-yaw movements. The Aanderaa SeaGuard® RCMs' have been the only instruments with 100% data return and high quality current speed and direction measurement at all times and under all conditions. SeaGuard® RCMs were also tow tank tested and found to give accurate (±1.5%) speed data.

Aanderaa Data Instruments has supplied users with reliable oceanographic instruments for almost 50 years. Many mechanical current meters (CM) from the early 1970 are still in active use. RCM 9/RCM 11 Acoustic Doppler single point CMs were introduced in 1996/2000 respectively and have earned a reputation for high accuracy, extreme reliability and ease of use.

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The SeaGuard® is a flexible multi-sensor platform released in 2007. Depending on the customer needs, these instruments exist in different configurations. The most common version is however as current meters. At present, the SeaGuard®s single point Doppler Current Sensor can measure currents at any depth from shallow coastal waters (Fig 1) to the oceans' deepest trenches (Fig. 2 and 3). This report summarizes the performance of SeaGuard® RCM's in user organized current meter inter-comparison and tow tank tests.

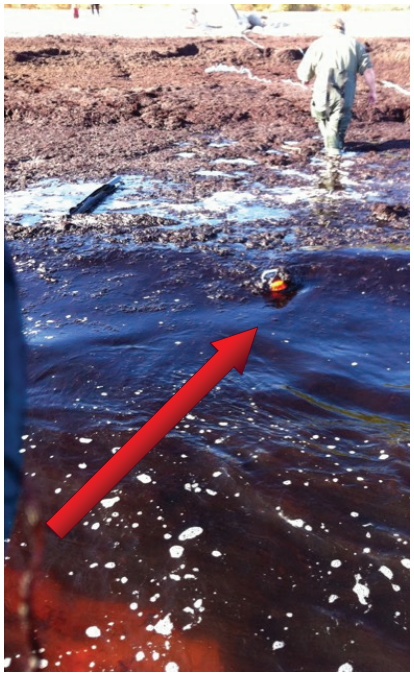


Fig 1: SeaGuard® RCM (with CTD & O_2) being installed to estimate degree of algae decomposition before harvesting in biogas production project

Fig 2: Hadal fish (photo courtesy Alan Jamieson) taken with Ocean lab lander at 7500m off New Zealand.

SeaGuard® Doppler Current Sensors and O_2 optodes are used to 11000m within Hades project.

Current meter inter-comparisons

Since the release in 2007 SeaGuard® RCMs have been tested in six independent user organized current meter inter-comparisons with very different background conditions and deployment lengths (see table). In contrast to other participating instruments, all SeaGuard®s returned 100% data and the quality of the collected information was high in all tests. Detailed results from the first four inter-comparisons in the Table below were presented in Drozdowski (2009) and Victoria (2011), the major conclusions were:

- As long as the tilt of the instruments is below 20 degrees all single point current meters collected high quality data giving similar speed and direction. The only exception was at the lowest speed (below 3 cm/s) at which the mechanical current meter (RCM 8) showed important directional differences.
- The correlation between the single point measurements and the corresponding bins of the ADCP were in general poorer than between adjacent pairs of single point meters.
- In dynamic conditions the horizontally directed acoustic beams of the SeaGuard® in combination with a solid-state compass and tilt sensor made it possible to collect clean and correct current data even at high tilts (up to 50 degrees) on constantly tilting moorings. The SeaGuard® is the only current meter that can handle such conditions.

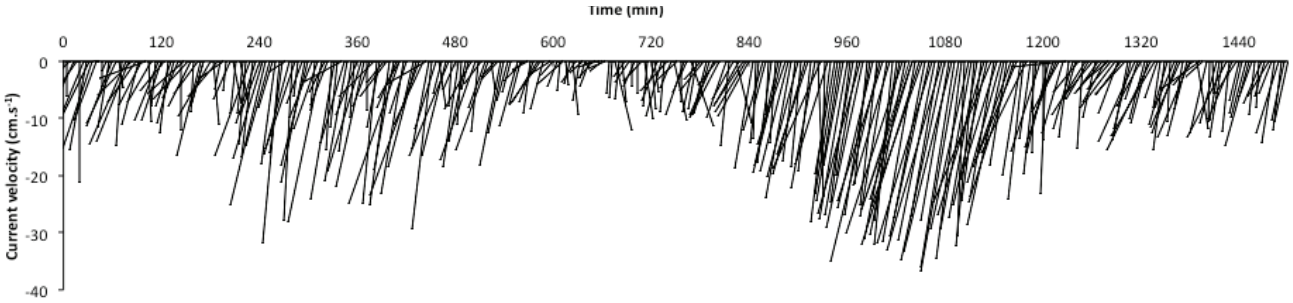


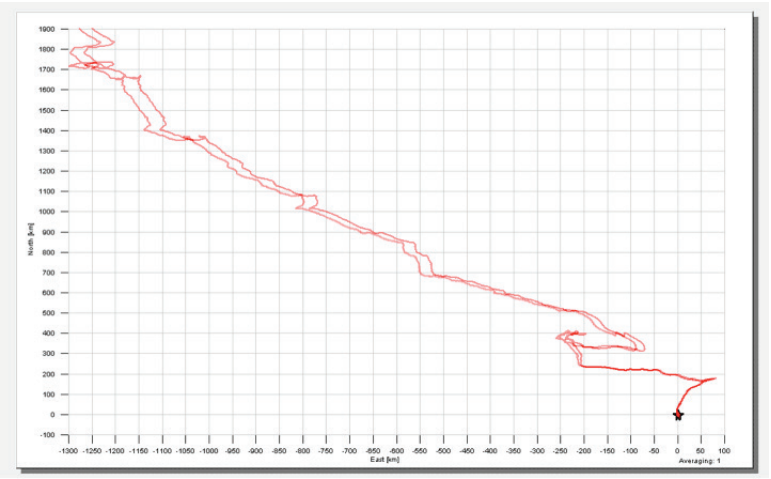
Fig 3: Currents measured with SeaGuard® Doppler Current sensor at 7000m depth in Hades project. Data courtesy of Alan Jamieson, Oceanlab, Aberdeen, Scotland.

Year	Tester	Instruments	Duration/Sampling	Conditions	Availability
2008	Bedford Institute, Canada	SeaGuard® (2), RCM 8, RDI-DVS, RDI-ADCP (300)	1 month, 10 min	155m, Nova Scotian Shelf, max speed 40m/s	Results in paper & report, see references
2008-2009	Bedford Institute, Canada	SeaGuard® (2), RCM 11, RDI-ADCP (300)	12 months, 60 min	1600m, Scotian Slope, max speed 26cm/s	Results in paper & report, see references Upcoming peer reviewed paper
2008-2009	NOAA-PMEL, USA	SeaGuard®, Sontek Argonaut	9 months, 20 min	10m, Pirata buoy, Atlantic, wave zone, max speed 60cm/s	Results in paper, see references
2009	WSA, Germany	SeaGuard® (2), Nortek Aquadopp (2)	1 month, 5 min	5-10m, Ems and Elbe rivers, max speed 120cm/s, high tilt	Results in paper, see references
2009-2010	Univ of Rhode Island, USA	SeaGuard® (2), RCM 11 (2), VMCM (2), Nortek Aquadopp	11 months, 30 min, low backscatter conditions	4000 m, Drake Passage, max speed 65cm/s, downdrag	Results in coming paper & at Ocean Science, Salt Lake 2012
2010-2011	Univ of Miami, USA	SeaGuard®, RDI-DVS, Nortek Aquadopp	18 months, 20 min, low backscatter conditions	4000 m, Tropic Atlantic, max speed 54cm/s, long mooring, downdrag & tilt	

Drake Passage Inter-comparison:

Two SeaGuard®s were set at 30 min sampling interval on a 160m tall mooring deployed at approximately 4000m in the Drake Passage. Fig. 3 shows the Progressive Vector Diagrams corresponding to the unedited data from the two instruments. The Current speed and direction data demonstrated high agreement with each other; both instruments produced clean low noise level measurements; and they tracked well with data from most other instruments (VMCM and RCM 11). Average differences in current speed between the two SeaGuard® RCMs was 0.08cm/s and in direction 0.47deg. In addition the instruments collected quality data with other on-board sensors and the instruments' clocks , which were factory calibrated for Arctic water temperatures, had only a few seconds drift over the 11 months. A scientific paper about the performance of the 7 participating instruments is in preparation. Preliminary results were presented at the Ocean Sciences Meeting in Salt Lake City by Kennelly et al. (2012).

Fig 3: Progressive vector diagram for two SeaGuard® RCMs deployed in Drake Passage



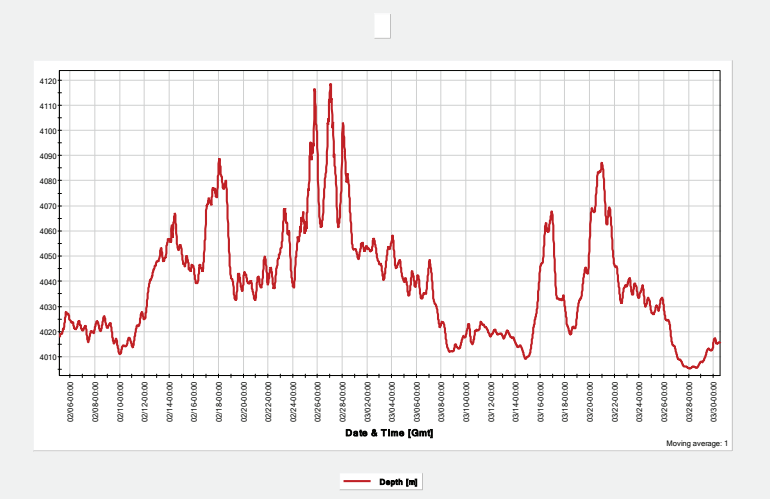
Subtropical North Atlantic Inter-comparison

During an 18 month deployment three current meters were compared on a tall mooring. The compared instruments were located approximately 800m above bottom in 4000m of water in a zone expected to be low in acoustic scatterers. The SeaGuard® RCM showed the lowest statistical noise and its current and direction data corresponded well with most of the other instruments.

SeaGuard® can carry additional high quality sensors without a significant increase in battery consumption and weight. Other measurements done in these tests included: temperature, conductivity, pressure, turbidity and oxygen. At 4000m the pressure sensors were able to track sub-cm water level variations and give useful information on mooring down-drag (see Fig. 4).

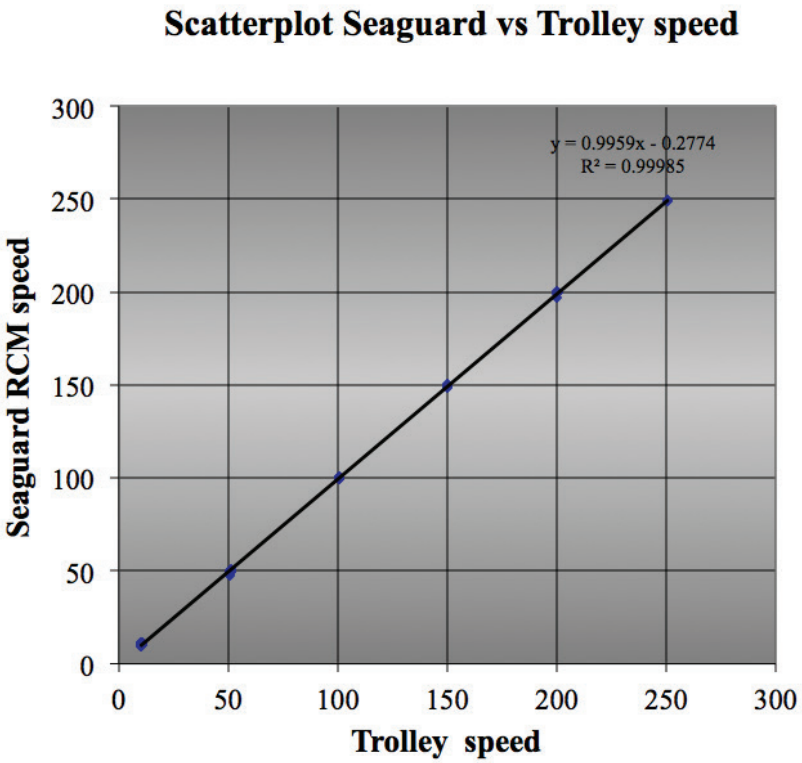
Few/no longer continuous measurements of oxygen variations exist from greater depths than 2000m. SeaGuard®s on both the 4000m deployments (see table) carried stable oxygen optodes (e.g. Johnson et al., 2010; Nicholoson et al., 2008). In spite of being located several 1000km apart ambient dissolved oxygen decreased about 1% per year at both locations.

Fig 4: Depth variations on mooring. Max down-drag was 150m. SeaGuard® pressure sensors can measure sub-cm variations in water level from full ocean depth.



SeaGuard® RCMs in recent tow tank tests

Due to low scatter conditions and/or acoustic reflections in tow tank walls it has been difficult to do high quality validation of the absolute accuracy of acoustic Doppler instrument calculation of water speed. Recently SeaGuard® RCMs were submitted to a series of successful tow tank tests at a Chinese facility which confirmed the high accuracy of the SeaGuard® (Fig 5). These trials also allowed for verification and optimization of the algorithms for current speed compensation at the highest tilt levels (20-50 deg). In the same tank around 50 RCM 11 instruments have been successfully tested throughout the years.



accuracy of the speed measurements was ±1.5%

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CS101 March 2012