Fol. 41 C

International Council for the
Exploration of the Sea

C.M. 1990 / C:30
Hydrography Committee

# A FIELD INTERCOMPARISION BETWEEN AN ACOUSTIC CURRENT PROFILER / ADCP AND TWO SAVONIUS TYPE CURRENT METERS

By
Trygve Gytre and Øivind Østensen
Inst. of Marine Research P.O. Box 1870/72 Nordnes
5024 Bergen

**Abstract**

During an introductory experiment in Lofoten May 1990 data from a vessel mounted ADCP on an anchored research vessel were intercompared with corresponding data from two anchored rotor current meters in a region where the current speed varied between 0 and 30 cm/s. The results showed good agreements when the ships heading was stable. When the anchored ship described "S" or "O"- shaped horizontal motions due to varying wind stress, the ADCP added up to 15 cm/s. to its output signal.

## Introduction.

For many years the majority of moored current meters have exploited different versions of the Savonius rotor as a sensor for current speed.
When such a a rotor rotates with a frequency F due to a driving current speed V, the current speed may be expressed as $V = g(F)$ where $g(F)$ is a polynominal of the form:

$$A0 + A1 \times F + A2 \times F2 + A3 \times F3$$

A0 represents the current speed threshold velocity which depends on the rotor`s bearing friction and its moment of inertia.
Most instruments measure F by counting the number of rotor rotations N during a fixed time interval T and then calculating N/T .
In order to express the vectorial current speed components during each T, the direction must be continuously or very frequently measured by a compass.
In the last 10 years a new generation of current meters -the Acoustic Doppler Current Profiler (ADCP) which is based on remote measurements of the Doppler frequency in different layers of the water has gradually entered the market.
This new sensor has a technical potential to dominate future current measurements.
Therefore the field behaviour of the ADCP compared to that of rotor based current meters under different field conditions has a significant interest.
This paper describes an initial intercalibration experiment during a survey which was primarily dedicated to turbulence and recruitment research. That meant that the available ship time could not be solely dedicated to this experiment.

During survey with the research wessel G.O. Sars outside the Lofoten Islands May 1990 the data from an anchor station containing 1 Aanderaa model RCM-7 rotor current meter and 1 Sensordata model SD-2000 "MINI" rotor current meter ( both manufactured in Bergen) were intercompared with the current speed data presented by a ship mounted Acoustic Doppler Current Profiler (ADCP) (made by RD Instruments,California. USA)

## Instrument description.

Fig. 1 shows the basic mechanical design of the Aanderaa model RCM-7 vector averaging current meter. It consists of a recording unit and a vane assembly mounted on each side of a gimble.
The current speed is measured by a modified Savonius type rotor with a given threshold velocity of 2 cm/s. The current direction is measured by a compass with an analog electric output resolution equal to 0.35 degrees..
The real accuracy in direction depends on the ability of the vane to direct the instrument in the current direction. Since the instrument recording unit and the vane are on opposide sides of the gimble, the instrument drag reduces the net directional force. The factory states an accuracy of +/- 5 degrees for speeds from 0- 100 cm/s and +/- 7.5 degrees for 2.5- 5 cm/s.
Data from the RCM-7 are vector integrated during the measuring period and then successively recorded in a RAM memory . Readout is made by opening the instrument and transfer the recorded information to computer via a readout unit.

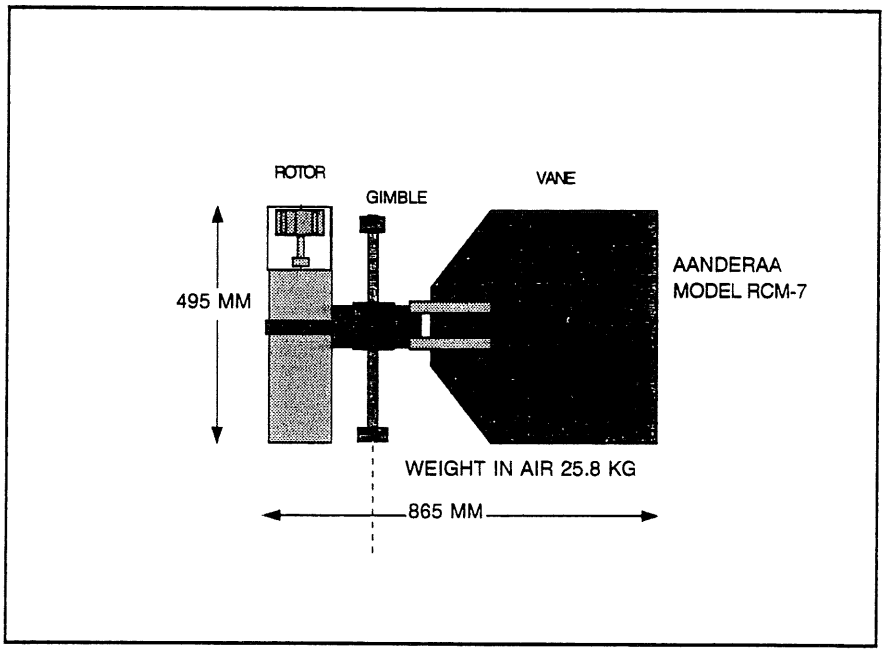



Fig. 1 Model RCM-7 Current meter

Fig. 2 shows the mechanical design of the Sensordata model SD-2000 "Mini Current Meter"
The instrument consists of a recording unit and a vane assembly on one side of a gimble and a balancing rod on the opposite side. This design makes the drag of the recording unit to coinside with the vane drag.
Model SD-2000 measures the current speed with the same rotor as the RCM-7 .
The rotor revolutions are counted and the compass is measured once during periods of 4 minutes. The compass has an accuracy of +/- 7.5 degrees. After each 4 minute period the instrument generates a programmable delay of N x4 minutes until next period. (N can be set from 1-99)
Recorded data from SD-2000 memory are delivered non galvanic as coded flashes of light from the instrument transparent top cap into a PC via an optical "readout head ". Fig. 3 shows the principle for data readout.

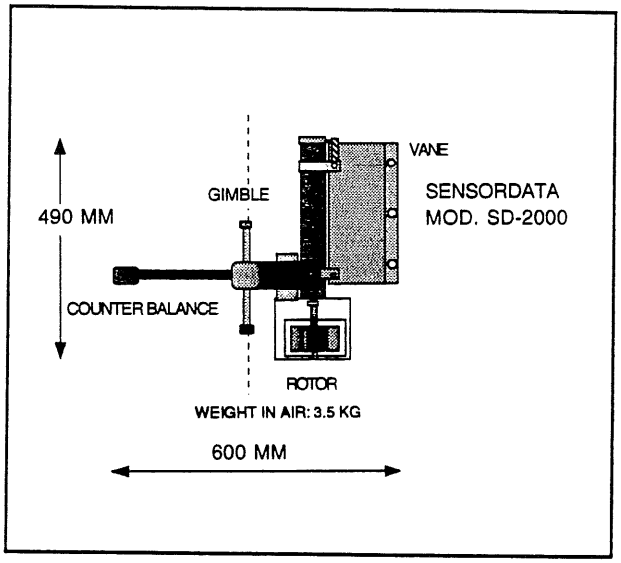



Fig. 2 Mod. SD-2000 current meter

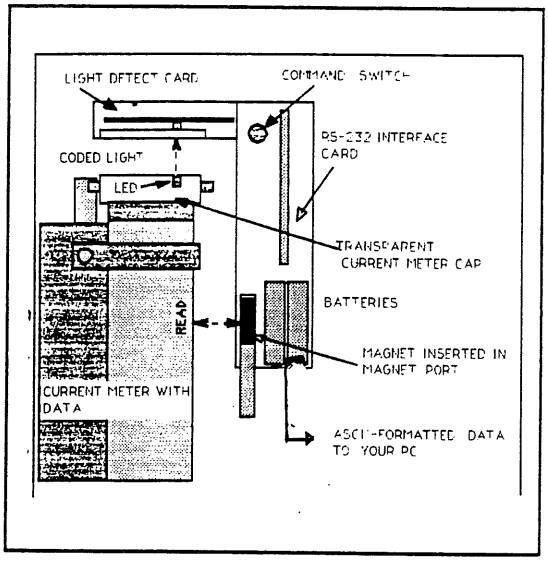



Fig. 3 Principle for data readout from SD-2000

The RD INSTRUMENTS ADCP which is installed on the M/S G.O. Sars transmits 150 kHz acoustic pulses of programmable duration along four inclined beams defined by highly directional transducers.
Backscattered sound from small particles in the water is received by the transducers with a Doppler frequency shift proportional to the relative velocity between the scatterers and the transducers. During the experiment the ADCP was set to measure the current speed referred to the bottom in 8 m deep bins. The signals were spatially and temporally integrated and processed to give the North and East velocity component each 10. minute .
Fig. 4 shows how the data were acquired from the ADCP.
The ship was anchored in direction 220 degrees. Due to variations in the wind stress, the ship`s heading direction angle varied within +/- 7 degrees.
During the intercomparision the signals from bin 2 (17-25) meter were used.

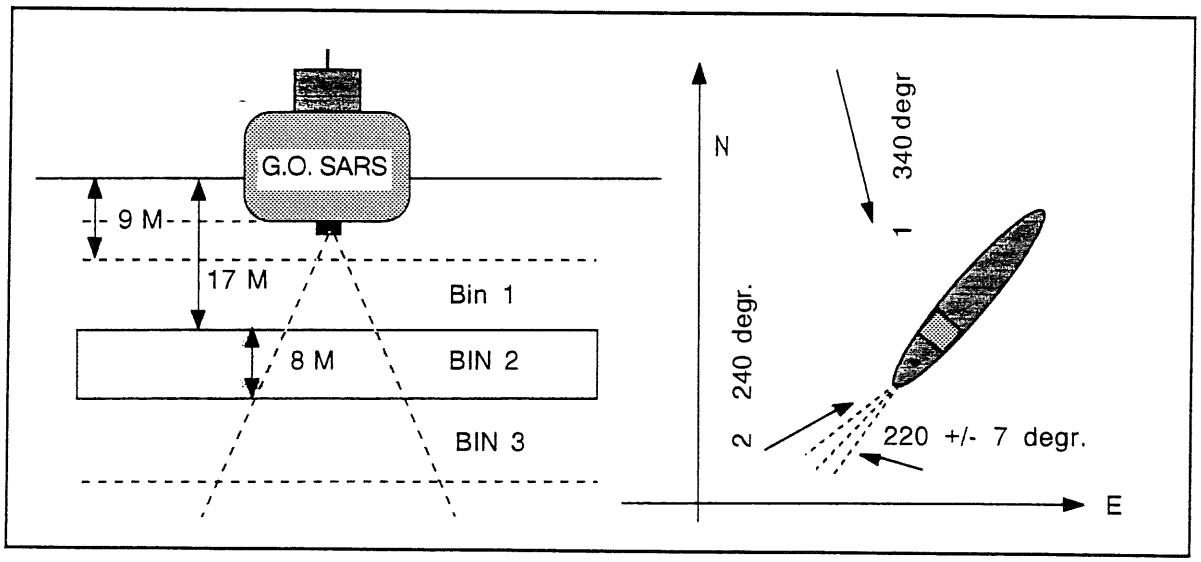



Fig. 4 Setup of the RD Instruments ADCP

The intercomparision experiment was arranged as shown on fig. 5.
The RCM-7 instrument was programmed for 10 minute intervals.
The SD-2000 was programmed for 8 min. intervals. (10 minute intervals cannot be programmed on SD-2000) Both instruments were started simultaneously.
Due to the biologic experiments carried out at the same time the ship could only be anchored in the shown position for 32 hours .

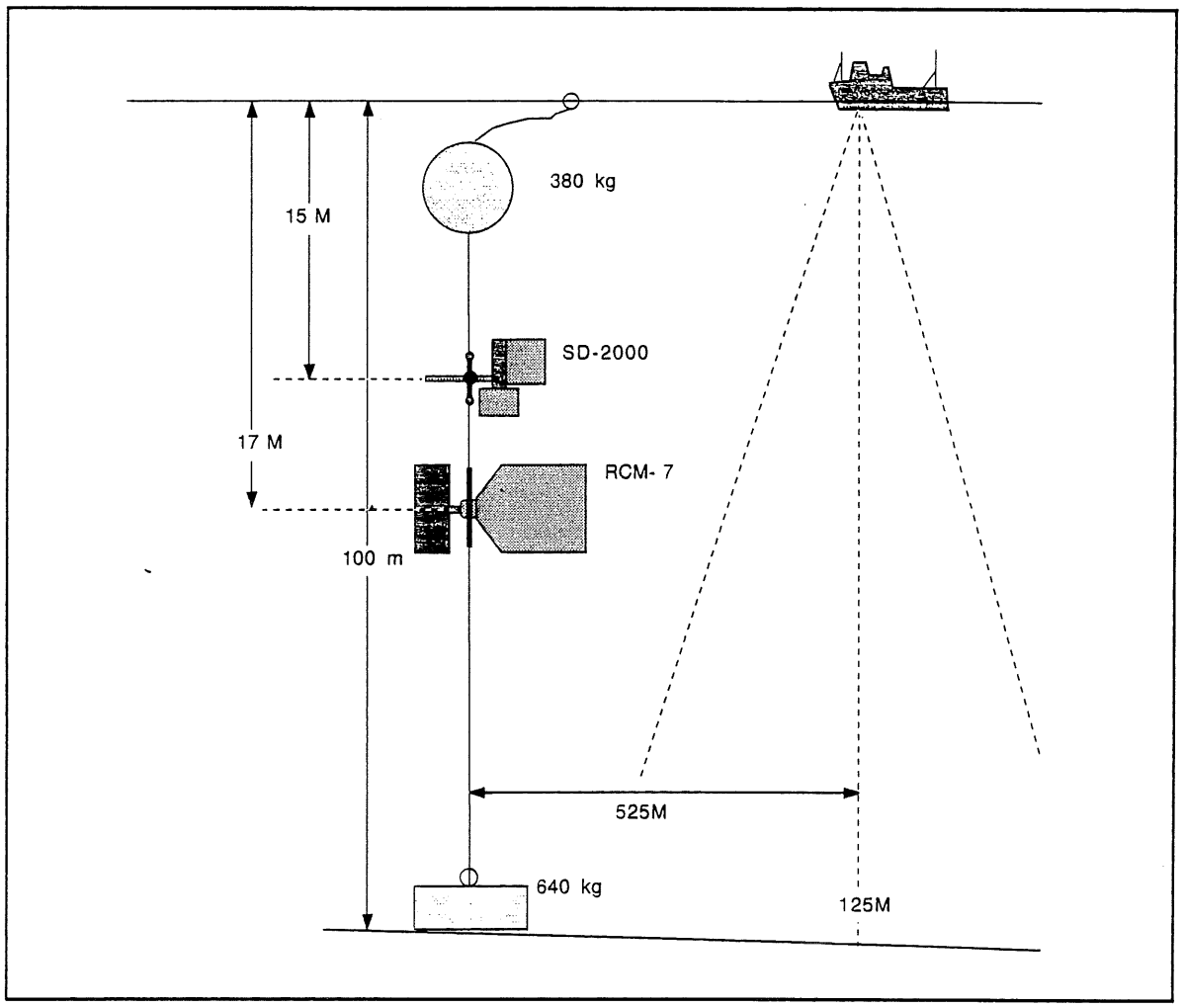



Fig. 5 The intercomparision experiment setup

.During period 1 the wind direction was 340 degrees, causing the ship to continuously change direction and describe elipsoidal paths within the +/- 7 degrees constraints set by its moorings. During period 2 the wind direction was 240 degrees. Since the wind then virtually acted in the ship`s direction,the ship motions were significantly smaller.

Fig. 6 shows the actual wind velocity as recorded by the ship`s weather station.
The raw data from all instruments used were read out through their respective readout devices using the factory recommended readout formulae. Then they were converted to ASCII files and processed by the same graphic processing program.

Fig 7 shows the ship horizontal motions expressed by its variations in heading direction around 220 degrees and the current speed measured by the three instruments during 32 hours.

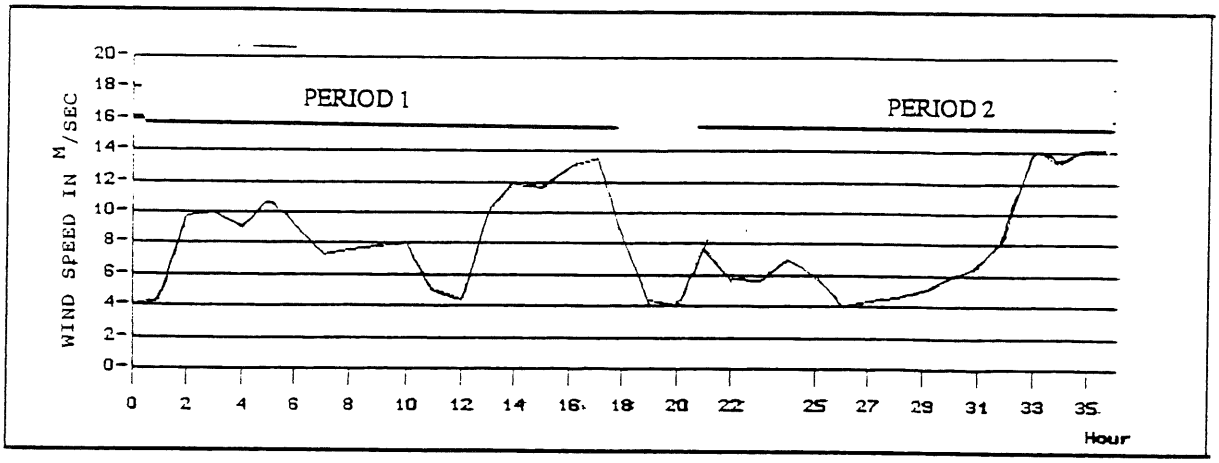



Fig. 6 Wind velocity during the intercomparision

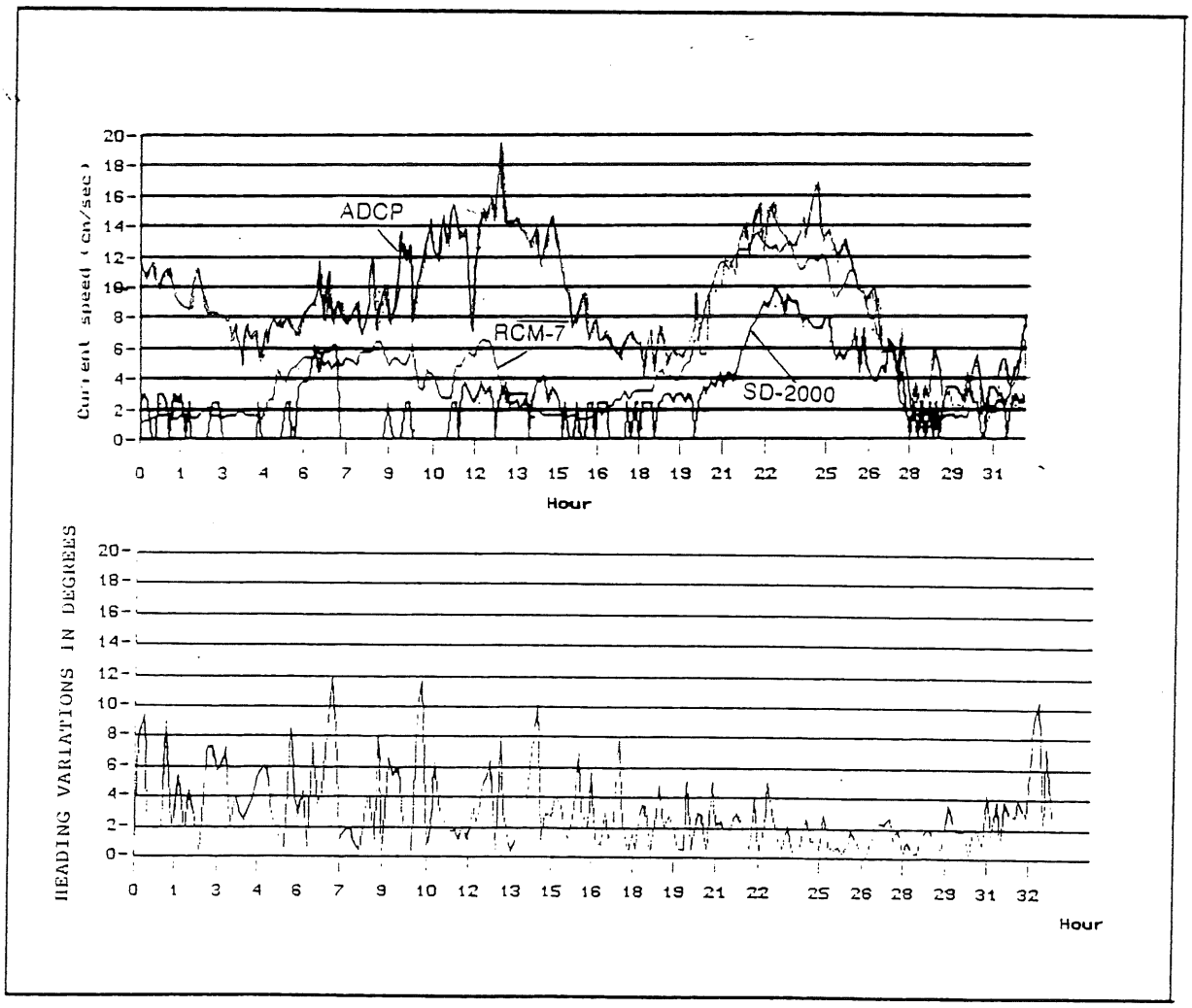



Fig. 7 Horizontal ship motions and recorded current speeds from ADCP, RCM-7 and SD-2000

Fig. 7 shows that the current speed measured by the ADCP was significantly higher than the speed measured by the rotor current meters during period 1.
When the horizontal ship motions were small (most of period 2), the ADCP and the RCM-7 showed close to identical data. During this period the data from SD-2000 showed a lower current

speed than the other instruments.
The anchor station shown on fig. 3 was operative for 8 days making a prolonged intercomparision between RCM-7 and SD-2000 possible.
Fig. 8 shows an 8 day intercomparision between the two rotor current meters.

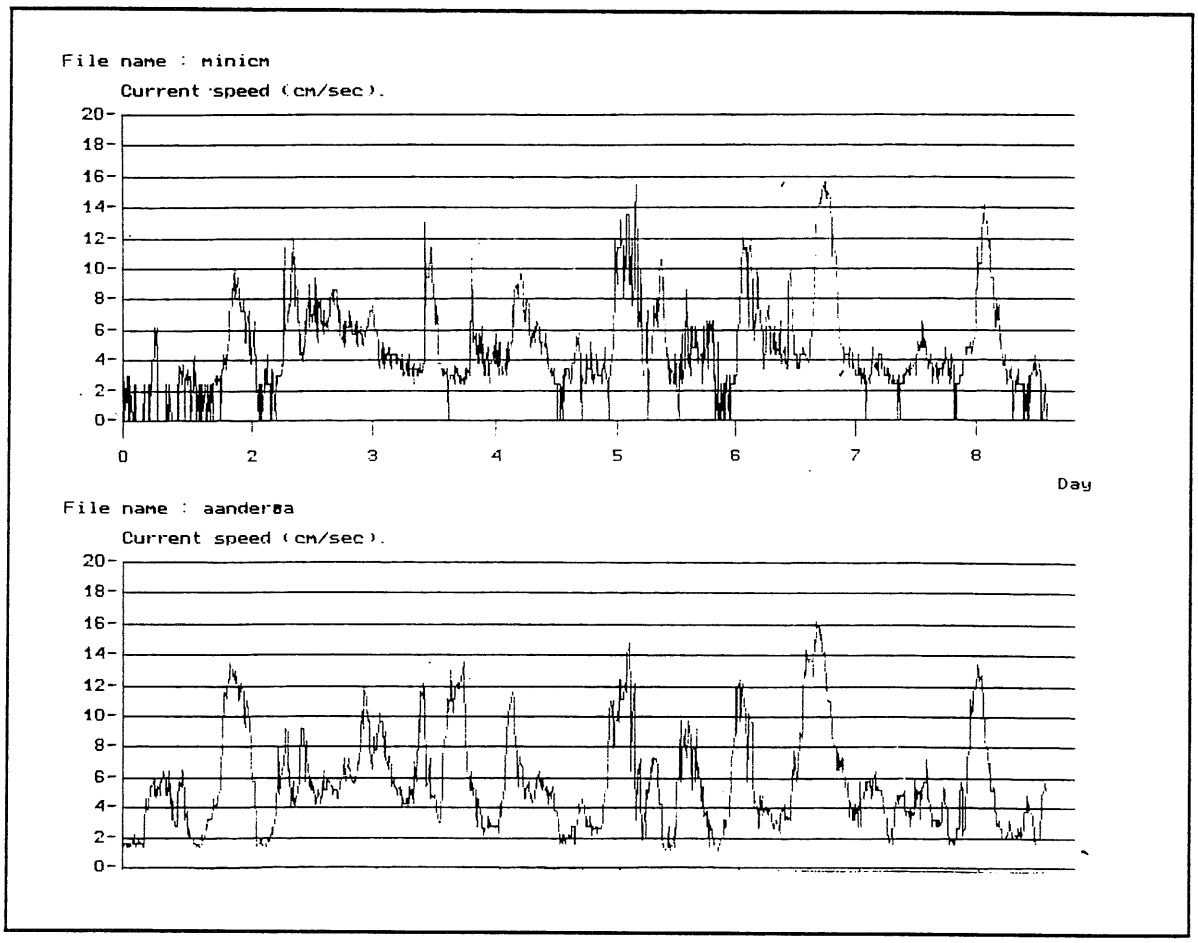
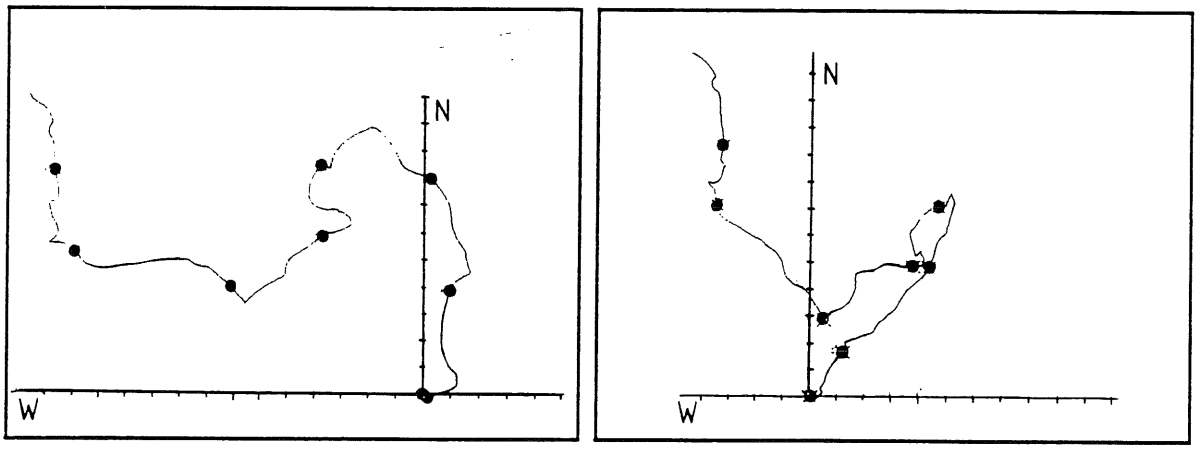



Fig. 8 Current speed measured by the rotor current meters RCM-7 and SD-2000

Fig. 9 shows the progressive current vector diagrams for this prolonged period.




RCM-7 SD-2000

Fig. 9 Progressive current vector diagrams from RCM-7 and SD-2000 during 8 days.

**Discussion:**

The data were intercompared after they had been preprocessed in the instrument or in their respective readout devices
The ADCP integrates the water velocity over 10 minutes . If the ship moves, this motion should in principle be completely removed from the apparent current speed..
During the experiment the anchored ship followed elipsoidal paths with period time of 30 - 40 seconds. Fig. 8 shows that the ship heading direction changed significantly during period 1 when the ADCP measured up to 100 % more than the RCM-7 . In period 2, when the heading direction was much more stable, the presented data from RCM-7 and the ADCP were more close to each other.
The actual ADCP integrated the apparent "bottom velocity" and the bin velocity separately for 10 minutes. Then the built in computer subtracted the two velocities to arrive at the net current speed. Apparently 10 minutes of integration time using this procedure is not sufficient to compensate for horizontally, sideways ship motions.
According to Trump (1989) data from vessel mounted ADCP units can be improved by rotating the beams 45 degrees off the ship axis, by individually selecting the reference layer and by carefully monitoring the ship motions. Østensen (1990) has made similar conclusions as Trump with reference to ship motions.
The RCM-7 reader used at Inst. of Marine Research adds 1.5 cm/s to all observed current speeds. Hence the current speed presented from RCM-7 can never be zero, even if the rotor has not moved at all during the integration period.
The SD-2000 readout program defines the current speed as 0.0 cm/s if the rotor has not moved during the integration period. If the raw data shows that the rotor has generated more than 1 bit, the program adds the threshold velocity 2 cm/s to the observed current speed.
When integrating small current speeds, this difference in basic processing wil be accumulated and soon become significant. This can be easily observed from the progressive vector diqagrams in fig. 9.
The current speed measured by SD-2000 seems to be somewhat lower than that of RCM-7 .
The rotors used in SD-2000 and RCM-7 are identical and should show the same current speed. Difference in integration method, unequal vane drag, random differences in rotor friction and unequal flow disturbances from the mooring line may account for the differences experienced.
Conclusion:
The results indicate a high correllation between the direct current speed measured by RCM-7 and SD-2000 for the actual 10 and 8 minute respective time interval settings.
If all zero current speed values from SD-2000 are changed to 1.5 cm/s as done with the data from RCM-7, the practical difference in the results will be small.
The ADCP seems to reliably measure current speed with a noise level down to appr. 2 cm/s when the sideway ship motions are negligible. If the ship performs "S"- or "O"- shaped horizontal motions when measuring, the presented current speed increases significantly.
Based on experiences with these introductory measurements the authors plan a new series of dedicated intercomparision experiments .

References:

( 1) Trump, C.L. "Three practical hints on using vessel mounted ADCPs"
Mar.Techn. Soc. J, : vol. 23 no 3 pp. 28-35; 1989

( 2 ) Østensen, Ø. "Observed performance of the ADCP onboard M/S G.O. Sars"
Internal IMR- note no. 3 1990.