Moorings in the Flamborough frontal region (Challenger 56 and 58)

Moorings were deployed at five sites off Flamborough Head to study the circulation in the Flamborough frontal region. These were identified as FA, FB, FC, DA and DB. The water column was stratified at all of the sites.

The mooring scheme was as follows:

FA: U-shaped mooring with three Aanderaa current meters 30m, 20m and 10m above the sea bed, and a spar buoy at the surface. This marker buoy was attached to the anchor by wire, the anchor was attached by a ground line to a further anchor, this was attached to a sub-surface buoy (a 0.8m diameter steel sphere); the current meters were attached to this line.

FB: U-shaped mooring with two Aanderaa current meters 24m and 10m above the sea bed, and one InterOcean S4 current meter 39m above the sea bed, and a spar buoy at the surface. This marker buoy was attached to the anchor by wire, the anchor was attached by a ground line to a further anchor, this was attached to a sub-surface buoy (a 0.8m diameter steel sphere); the current meters were attached to this line.

Pop-up thermistor chain mooring, 16m - 41m above the sea bed.

FC: U-shaped mooring and surface spar buoy with a thermistor chain 18m - 43m above the sea bed.

POL 250kHz Acoustic Doppler Current Profiler (ADCP) and IOS acoustic release mounted on a low profile frame positioned on the sea bed. The instrument was located 0.8m above the sea floor. On recovery the release was triggered by sending acoustic signals from the ship so that the frame separated from the ballast weight. The frame, under its own buoyancy (glass spheres), then rose to the surface ready for picking up.

DA: U-shaped mooring with two Aanderaa current meters 21m and 10m above the sea bed and one S4 current meter 31m above the sea bed, and spar buoy at the surface. This marker buoy was attached to the anchor by wire, the anchor was attached by a ground line to a further anchor, this was attached to a sub-surface buoy (a 0.8m diameter steel sphere); the current meters were attached to this line.

Pop-up thermistor chain mooring, 8m - 33m above the sea bed.

DB: U-shaped mooring with two Aanderaa current meters 25m and 10m above the sea bed and one S4 current meter 41m above the sea bed and a toroid buoy at the surface. This marker buoy was attached to the anchor by wire, the anchor was attached by a ground line to a further anchor, this was attached to a sub-surface buoy (a 0.8m diameter steel sphere); the current meters were attached to this line.

Pop-up thermistor chain mooring, 16m - 41m above the sea bed.

POL 250kHz Acoustic Doppler Current Profiler (ADCP) and IOS acoustic release mounted on a low profile frame positioned on the sea bed. The instrument was located 0.8m above the sea floor. On recovery the release was triggered by sending acoustic signals from the ship so that the frame separated from the ballast weight. The frame, under its own buoyancy (glass spheres), then rose to the surface ready for picking up.

InterOcean Systems Model S4 Current Meter

The InterOcean Systems Model S4 electromagnetic current meter is a self-contained 0.25m diameter sphere, with no protruding sensors. It measures current by creating a magnetic field and sensing the voltage induced in two orthogonal directions, by the movement of the sea water, an electrical conductor, through the field. This information is combined with instrument orientation, sensed by a flux-gate compass, and the north and east components of current computed. The S4s were used in vector average mode throughout the survey. They sampled every 0.5 seconds and averaged the vectors over a 10 minute recording interval.

S4 specification

	Range	Accuracy
Speed	0 to 350 cm/s	+/- 2 cm/s
Direction	0 to 360 degrees	+/- 2 degrees

Aanderaa RCM7 and RCM4 Current Meters

The Aanderaa RCM7 and RCM4 current meters are self-recording current meters. Temperature is measured by a thermistor fitted into a stud extending into the water. A vane is attached to the meter in order to align the compass with current flow and keep the meter in an upright position. The RCM4 measures current speed with a savonius rotor situated on top of the meter and magnetically coupled to an electronic counter. The number of revolutions over the sampling interval of 10 minutes gives the average speed over that interval. The RCM7 measures current speed with a half shrouded paddle wheel situated on top of the meter. During the selected recording interval of 10 minutes the number of rotor revolutions and the direction of the compass are sampled every 12 seconds and broken up into north-south and east-west components. When the 10 minute recording interval has elapsed, the resultant average vector and its angle is calculated and recorded.

RCM4 and RCM7 specification

	Range	Accuracy
Speed	2 to 250 cm/s	+/- 2 cm/s
Direction	0 to 360 degrees	+/- 5 degrees
Temperature	-2.46 to 21.4 degC	+/- 0.05 degC

Acoustic Doppler Current Profiler (POL 250kHz version)

The ADCP (POL 250kHz version) sends out short acoustic pulses, typically lasting a few thousandths of a second, at a fixed frequency. The acoustic pulses are transmitted in two narrow beams at right angles to each other and 30 degrees to the vertical and are reflected back to the ADCP by small particles, such as plankton, which move with the water. The frequency of the reflected signal is changed by a small amount proportional to the current speed, the Doppler shift. By measuring the frequency change along the two beams the speed and direction of the currents are determined. The currents at different heights through the water are obtained by chopping the return signal into segments by time.

The 250KHz ADCP has a range of 100m and can measure up to 24 bins. However the technique has some limitations which reduce the amount of good data return. The closest bins to the transducers can give erroneous data due to the time taken for transients to decay and the far end bins can be affected by interference from side lobes reflected from the sea surface. Hence the good data return bins are usually between 25% of the depth from the surface and 10% of depth from the bottom.

ADCP specification

	Range	Accuracy
Speed	2 to 350 cm/s	+/- 4 cm/s
Direction	see below - ADCP angle correction	
Tilt	Two tilts measured at 90 degrees to each other (these were not used in processing)	

ADCP set up details

Sample period	10 minutes
No. of bins (cells)	8
First bin height	11.1m
Bin separation	5.7m
Bin heights (1-8)	11.1m, 16.8m, 22.5m, 28.1m, 33.8m, 39.5m, 45.1m, 50.8m

ADCP angle correction

The compass, manufactured by Digicourse (no longer in production), measures the angle between magnetic north and the frame. The two beams can be converted into east and north components by using the angle obtained by the compass and trigonometry. During the North Sea Project the compass showed a tendency to return arbitrary zero directions thus giving directions of flow different from those predicted by tidal models and previous current meter records. Also the frame moved on the sea floor during some storm events. A correction was then required to the frame angle for each deployment.

The ADCP data were first processed through the software. The statistical analysis gave the angle of maximum variance, which was taken to represent the M_2 major axis tidal ellipse angle. The compass, although giving incorrect readings of frame angle, was recording direction to an unknown fixed position. The frame angle was adjusted by adding a correction angle.

The correction angle was calculated from the difference between the M_2 major axis tidal ellipse angle from a model and the angle of maximum variance calculated from the initial raw data analysis. The model gave a depth average value, so the angle of maximum variance obtained from the data bin closest to this depth was needed. The bin used was found by taking the bin nearest to a value z=0.4D, where D is the total depth of water and z is the height from the bottom (Prandle, 1982). There is an 180 degree ambiguity in the calculation of the angle of maximum variance which was resolved by study of the M_2 tidal phase given by the model and by other observations.

In the table below each instrument is identified by a mooring code together with an instrument identifier (e.g. A indicates Aanderaa RCM, S - InterOcean S4, D - ADCP, TC - thermistor chain) and instrument number. The data file name is also given.

Please note: these data have not yet been fully quality controlled by BODC.

Mooring/ Meter No.	Start Date dd-Mon-yy	Record Length (days)	Comment
FA/A9643	09-Jul-89	38.0	Good record obtained (NJUL8930.AS).
FA/A9650	09-Jul-89	38.0	Good record obtained (NJUL8920.AS).

FA/A9652	09-Jul-89	38.0	Good record obtained, several spikes in the current direction channel, possibly due to fouling, have been flagged. (NJUL8910.AS).
FB/S1258	09-Jul-89	39.0	Good record obtained (OJUL8939.S4).
FB/A3277	09-Jul-89		
FB/A9680	09-Jul-89	39.0	Good record obtained (OJUL8910.AS).
FB/TC1648	09-Jul-89		
FB/TC1648	19-Jul-89		
FC/TC1685	09-Jul-89		
FC/D0007	09-Jul-89	0.0	Meter failed, no data returned.
DA/S1195	11-Jul-89	36.0	Good record obtained (LJUL8931.S4).
DA/A9634	11-Jul-89	35.0	Good record obtained (LJUL8921.AS).
DA/A7570	11-Jul-89		
DA/TC1702	11-Jul-89	0.0	Mooring lost.
DB/S1196	11-Jul-89	0.0	Meter failed, no data returned.
DB/A3559	11-Jul-89		
DB/A0568	11-Jul-89	8.0	Current speed and direction flagged at start of record, otherwise good record obtained. (MJUL8910.AA).
DB/TC1701	11-Jul-89		
DB/D0009	11-Jul-89	7.0	Good record obtained, except data from bin 8 (top) noisy, excluded from data set since spikes outweigh signal. (MJUL8901.DP).

References

Howarth, M.J. 1990. Atlas of tidal elevations and currents around the British Isles. Department of Energy, Offshore Technology Report, OTH 89 293, 16pp

Prandle, D. 1982. The vertical structure of tidal currents and other oscillatory flows. Continental Shelf Research, 1(2), 191-207