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Cruise Report
RV POSEIDON Cruise P471 Leg 3

Akureyri - Trondheim
15. July – 24. July 2014
Chief Scientist: Kerstin Jochumsen

1. Objectives

The purpose of the cruise was the collection of high resolution hydrographic and current data along the Iceland-Scotland-Ridge, and the recovery of two PIES. The data will contribute to ongoing studies of the variability of exchanges between the Atlantic and Arctic basins, and to the monitoring of the AMOC. Special focus of the hydrographic sections was on the overflow east of Iceland, which is intermittent and highly variable. Furthermore, a repeat section in the Faroe-Shetland Channel was carried out.

Additionally, seven MSc / Phd students were participating, obtaining practical education on board, which is an integral part of the *Physical Oceanography* (BSc/MSc) curriculum at the University of Hamburg. The aim was to make the students familiar with the scientific instrumentation and the working schedule on a research ship. To participate on a research cruise yields a unique understanding of the difficulty of in-situ observations and the possible errors. The students also contributed to the calibration and scientific interpretation of the data.

2. Cruise participants and crew

Scientific cruise participants

Kerstin Jochumsen	IFM-CEN	Chief scientist
Dagmar Hainbucher	IFM-CEN	Scientist, CTD and oxygen titration
Nuno Nunes	IFM-CEN	Scientist, CTD and oxygen titration
Leonard Borchert	IFM-CEN	MSc student
Maciej Miernecki	IFM-CEN	Phd student
Marcel Ricker	IFM-CEN	MSc student
Louisa Tiemann	IFM-CEN	MSc student
Johannes Timm	IFM-CEN	MSc student
Benjamin Richaud	ParisTech	MSc student
Emma Gardner	IFM-CEN	MSc student

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Crew list

Matthias Günther	Master
Theo Griese	Chief Officer
Sebastian Pengel	2nd Officer
Kurre Klaas Kröger	Chief Engineer
Björn Brandt	2nd Engineer
Joachim Mischker	Bosun
Bernd Rauh	Ships Mechanics
Felix Meyer	Ships Mechanics
Marcel Deeke	Ships Mechanics
Niels Petersen	Ships Mechanics
Olaf Bischek	Able bodied Seaman
Ralf Meiling	Motorman
Gerd Neitzel	Electrician
Klaus Peter Malchow	Cook
Sylvia Kluge	Stewardess

3. Narrative

RV Poseidon left the port of Akureyri (Iceland) on July 15th shortly after breakfast. The departure from the fjord was delayed due to an engine test, which was completed successfully during the morning. The external engine technicians left the ship before lunch and RV Poseidon then started the transit to the working region. The underway measurements were started at 16:08 UTC during the same day.

On July 16th at 18:09 UTC the first CTD station was reached. Three sections consisting of altogether 23 CTD stations were conducted to cover the overflow east of Iceland. The last station was finished at 21:26 UCT on July 17th.

During the night from 17th of July to 18th of July the clock was switched forward one hour, so that the vessel adopted to the UTC+1 time zone. During the afternoon of the 18th of July a salinometer session was planned. Unfortunately, the instrument did not flush correctly and during a cleaning procedure with isopropanol the pump broke down. The salinometer was opened and one of the pump connections was fixed. Afterwards the cleaning was finished, using isopropanol, soap and destilled water, and the salinometer worked properly. Two boxes (of 30 bottles each) were measured in the following session (starting at 16:00 UTC).

At 20:13 UTC in the evening of the 18th RV Poseidon reached the position of PIES FBC-11, which had been deployed by the Faroese colleagues in 2011. Firstly a CTD cast for calibration was carried out. The aim was to directly recover the instrument (without telemetry) in order to save time. The RELEASE command was send at 21:02 UTC and some pings were noticed and interpreted as a response. However, the instrument did not surface and another attempt of releasing was started an hour later. This time the deckunit shut down while sending commands, therefore the hydrophone was changed. The new hydrophone worked properly together with the deckunit and a CLEAR and RELEASE command was send at 22:14 UTC. The

expected response of the PIES is two 12 kHz pings after a CLEAR and six 12 kHz pings following the RELEASE. Both were received and shortly after the PIES switched to the continuous pinging mode (every 4 seconds), which indicates successful actions of the acoustic command subsystem. Nevertheless, the PIES did not surface. RV Poseidon then waited at the PIES position until 02:30 UTC, as the continuous pinging mode was expected to end after approx. three hours, when "telemetry after failed release" should become an available option. Unfortunately the PIES did not end the continuous pinging and did not respond to the TELEM command send at 02:35 UTC. Presumably the PIES was in suspend mode due to low battery, which had disabled the telemetry option. This was surprising, since other PIES deployed at similar environmental conditions had no battery problems after three years. However, there was no chance to get the data from the instrument and the recovery and telemetry attempts were therefore aborted. PIES FBC-11 is now considered lost.

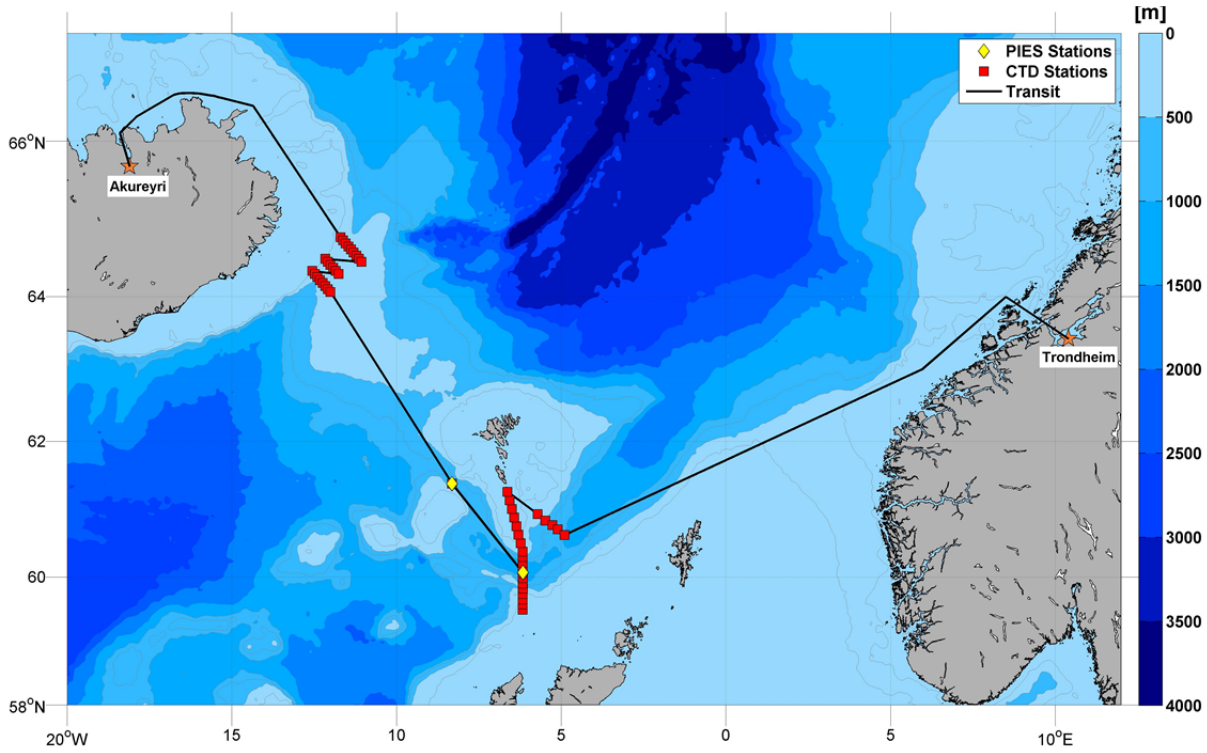


Figure 1: Cruise track of RV POSEIDON cruise P471-Leg 3 from Akureyri (Iceland) to Trondheim (Norway). Red squares mark CTD station positions and yellow diamonds PIES recovery/telemetry stations.

After a transit of 101 nm RV Poseidon reached the second PIES to be recovered during this leg. Due to the experience with the first PIES telemetry was now executed before release to secure the data of PIES FSC-11. After a CTD cast for PIES calibration the telemetry was started at 18:51 UTC on the 19th of July. The telemetry went smoothly and was finished at 02:57 UTC in the morning of the 20th of July. RV Poseidon then headed to the starting position of CTD section Z, crossing the Faroe Shetland Channel.

The first station on section Z started at 07:28 UTC in the morning of the 20th of July. In the afternoon, the vessel reached again the position of PIES FSC-11 and

recovered the instrument. The recovery went smoothly: PIES FSC-11 was commanded to release at 17:09 UTC, was spotted at the surface at 17:43 UCT and on deck at 17:51 UTC. Section Z was continued afterwards and finished at 10:00 UTC in the morning of the next day.

The 21st of July was used to conduct another set of five CTD stations in the Faroe Shetland Channel. Their positions were on the Fair Isle – Munken section and close to a mooring array. The stations will be used for comparison with the moored instruments. The end of station work was reached at 20:40 UTC on the 21st of July and RV Poseidon started the transit towards Trondheim (Norway). The recording of the underway measurements was stopped at 13:00 UTC on the 23rd of July. The vessel reached the harbor of Trondheim in the morning of the 24th of July at 9:00 UTC.

4. Technical Information

CTD/Rosette and water samples

In total 49 CTD stations were conducted during the cruise, using a SeaBird SBE911 plus CTD-O_2 profiler, equipped with a pressure sensor, two pairs of Seabird temperature / conductivity sensors, two oxygen sensors and a fluorometer. The CTD was mounted on a rosette frame and attached to a SeaBird carousel water sampler with twelve bottles. A downward looking altimeter, with a range of approx. 100 m was installed, so that the distance to the bottom could be determined with a high accuracy. The CTD profiles usually ended 10 m above the sea floor. Data was recorded using the SeasaveV7.23.1 software, which takes time and position information from the ships' NMEA. The whole CTD system is owned by GEOMAR, Kiel, and part of the ships' equipment. The serial numbers of the CTD system are:

Instrument/Sensor	**Serial Number**
SBE 911plus	09P10108-0410
Temperature 1 SBE-3plus	4673
Conductivity 1 SBE-4C	3366
Pressure 410K-105	61184
Temperature 2 SBE-3plus	4547
Conductivity 2 SBE-4C	2512
Altimeter PSA 916	41840
Oxygen 1 SBE 43	1314
Oxygen 2 SBE 43	2591
Fluorometer	3219

At all stations 2-10 water samples were taken from selected depth levels within the water column, for analysing oxygen and salinity content. After collection, the oxygen samples were stored in darkness for 2 to 24 hours (minimum and maximum, respectively). The titrations were done by Dagmar Hainbucher and Nuno Nunes, using a Metrohm 848 Titrino plus system (SN 10304277), equipped with a Metrohm Pt Titrode (SN 01290932). A Dynamic Equivalence Point method was used to

automatically determine the oxygen concentration of the samples. The comparison of the oxygen values obtained in the lab with the CTD profiles revealed an unusually large deviation (> 0.3 mg/l) with the primary oxygen sensor. Additionally, many outliers were found at this sensor and a large hysteresis. For the final calibrated data set thus the secondary oxygen sensor will be used.

The salinity samples were analysed using a Guildline Autosal Salinometer (SN 59.083). The measurements were performed by the students and supervised by Kerstin Jochumsen and Nuno Nunes. Calibration during operation was done using IAPSO Standard Seawater (batch: P156, K15=0.99984, S=34.994), which was measured at the beginning of the salinometer use, as well as after two boxes were finished or the session ended. Half a box of thermosalinometer samples was measured with wrong suppression; these data have to be recalibrated in the postprocessing and eventually may have to be discarded.

Current measurements

Vertical profiles of horizontal currents were obtained by an LADCP system attached to the rosette water sampler. The system consisted of two Workhorse ADCPs (WHM300) manufactured by RD instruments and operating at a frequency of 300 kHz. The serial numbers of the upward looking device was SN 14411 (SLAVE) and SN 14109 was downward looking (MASTER). The data were corrected for CTD movements in the processing procedure, which was done with the LDEO LADCP software (A. M. Turnherr, 2010). The files of station 753 were lost due to a naming problem and an accidental overwrite.

Reference: Turnherr, A. M., 2010: A Practical Assessment of the Errors Associated with Full-Depth LADCP Profiles Obtained Using Teledyne RDI Workhorse Acoustic Doppler Current Profilers. Am. Met. Soc. DOI:10.1175/2010JTECHO708.1

Underway measurements

Underway temperature and salinity measurements were made with a SeaBird thermosalinograph installed in the ship's port well. Additional water samples were taken for salinity calibration purposes, which were analysed with the same Autosal Salinometer as the CTD water samples (see above). Underway current measurements were obtained from a vessel-mounted 75 kHz Ocean Surveyor (ADCP) from RDI, covering approximately the top 500-700 m of the water column. The bin size was set to 16 m, the ADCP run in narrowband mode. The instrument was controlled by computers using the conventional VMDAS software under a MS Windows system. Pinging was set as fast as possible, giving a velocity profile approx. every 3.8 s. The ADCP data was processed with the software package ossi17 (ocean surveyor sputum interpreter), developed by GEOMAR, Kiel, which also corrects for the misalignment angle (Tim Fischer, pers. communication), which was calculated to be approximately -4 degrees.

5. Moorings

Name	Recovery date (UTC)	Latitude	Longitude	Depth
PIES FBC-11	recovery failed	61° 23.51' N	08° 18.72' W	861 m
PIES FSC-11	20.07.2014 17:09	60° 04.21' N	06° 09.62' W	1107 m

6. Preliminary Results

The working area is a region of large temperature and salinity gradients, as fresh local and polar waters are found in close proximity to salty and warm Atlantic waters. The surface temperature and salinity distributions were monitored with the ships' thermosalinograph (Figure 2). The Atlantic inflow branches north of the Faroes and in the Faroe Shetland Channel were clearly distinguishable from the fresher and colder waters north and east of Iceland. The thermosalinograph data was calibrated with the salinity of water samples measured using the salinometer. Derived from the differences of the data the offset was found to be in the order of 0.06 in salinity.

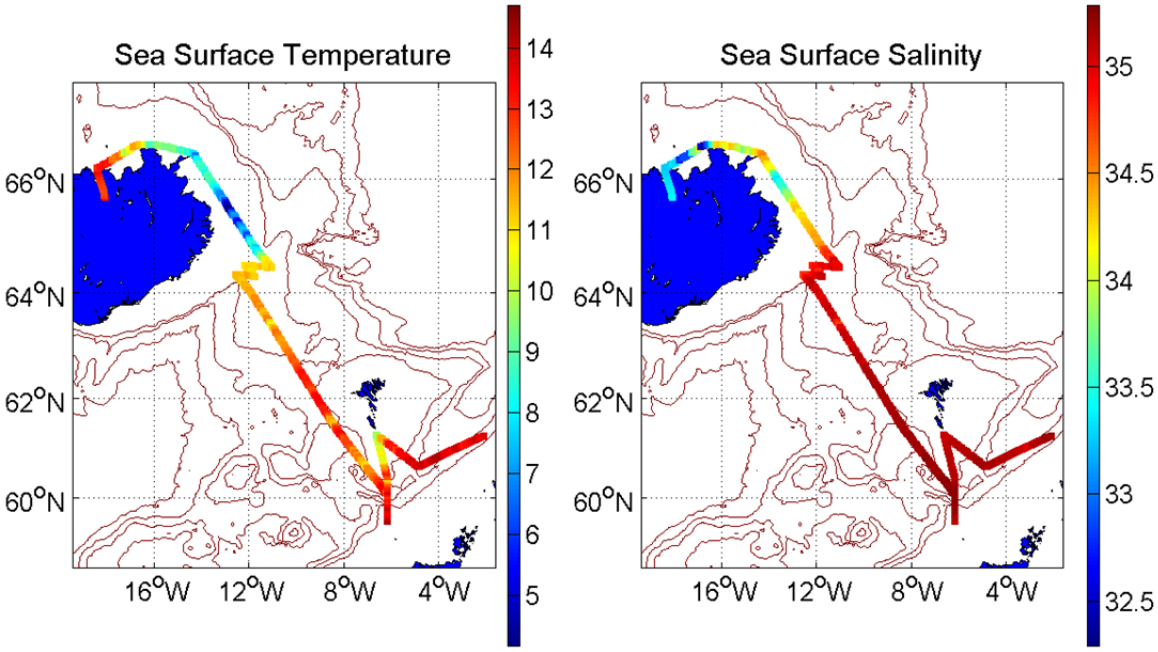


Figure 2: Sea surface temperature [°C] (left) and sea surface salinity (right) in the working area between Iceland and the Faroe Island region from the vessel mounted thermosalinograph.

Three hydrographic and current profile sections were conducted in the region of the weak overflow east of Iceland (sections A1, A2, A3). A nearly 300 m thick layer of dense water (σ_θ > 27.8 kgm^{-3}) was found on the northern section, which was reduced to only 150 m in the middle section (Figure 3). Section A2 is crossing the shallowest part of the channel, thus the water found there presumably contributes to the overflow water mass layers in the Atlantic. The dense layer was reduced further at section A3, where also the properties of the bottom waters differed much from the other sections (Figure 5). This distribution corresponds to the theory of intermittent overflows in this region; the profiles of section A3 were taken when no pulse of overflowing water was present.

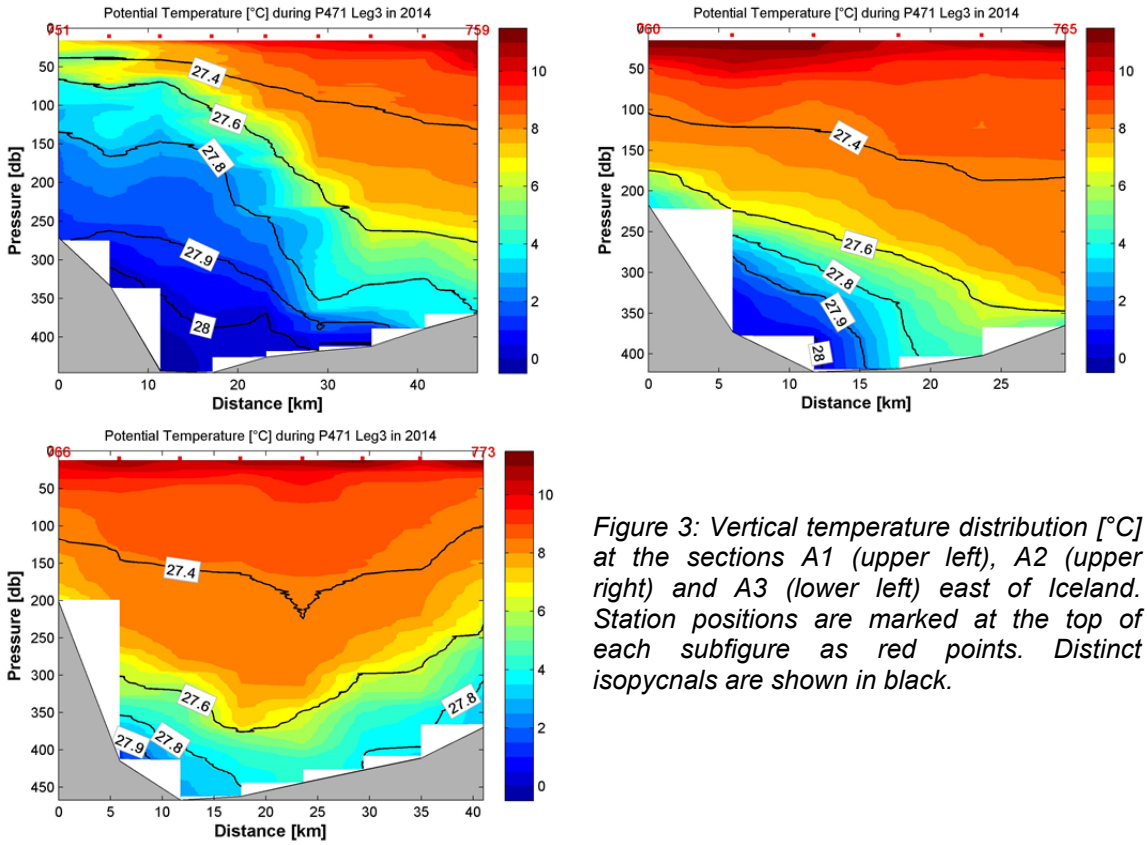


Figure 3: Vertical temperature distribution [°C] at the sections A1 (upper left), A2 (upper right) and A3 (lower left) east of Iceland. Station positions are marked at the top of each subfigure as red points. Distinct isopycnals are shown in black.

The measurements in the Faroe Shetland Channel (Figure 4) covered the Atlantic inflow focused on the Shetland side of the section, as well as the dense waters, which form the Faroe Bank Channel Overflow further downstream. Recirculations in both the upper and lower layer are apparent in the velocity section. The small horizontal scales of these features increase the error of transport estimates obtained from moored instruments, as recently discovered for the Atlantic inflow.

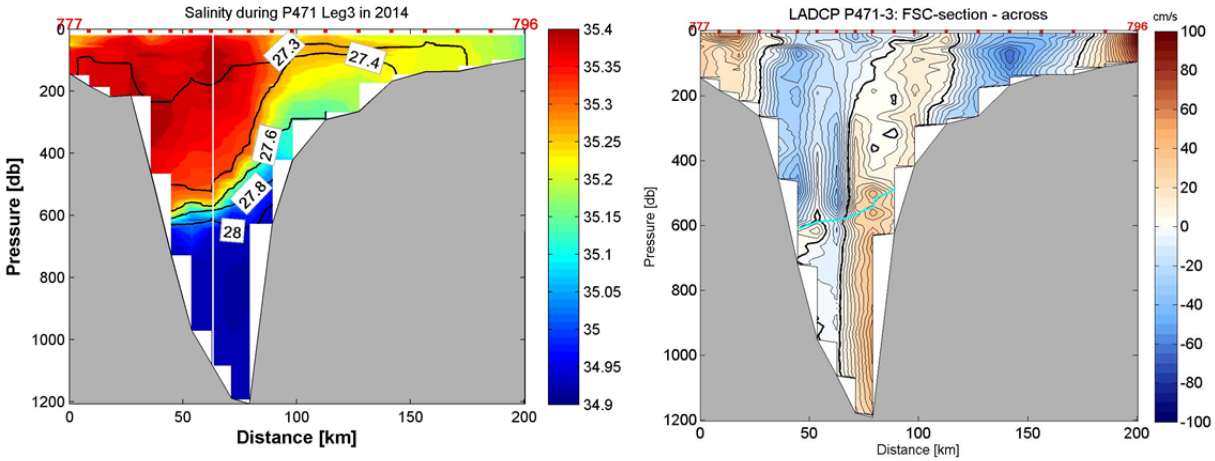
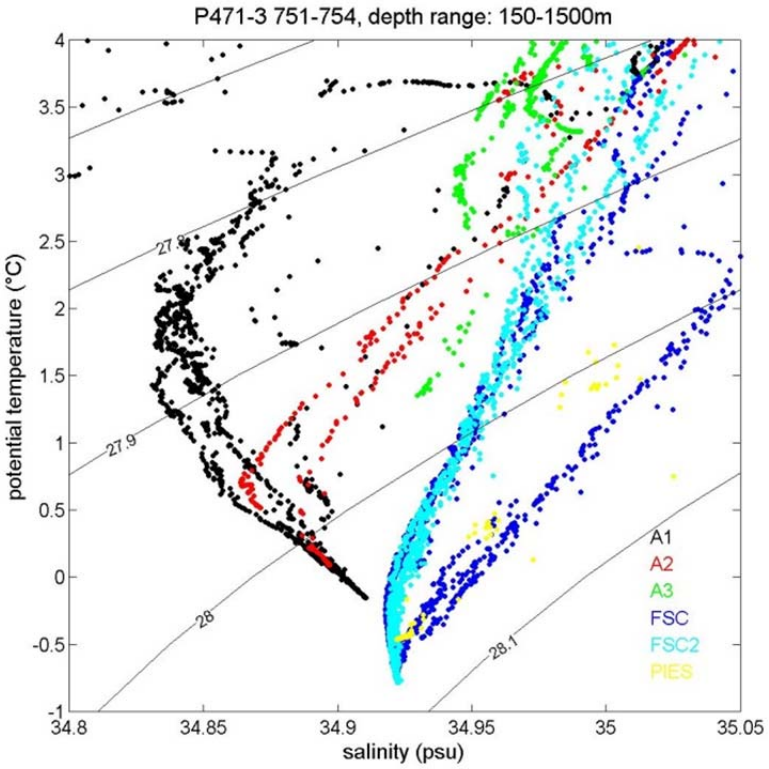


Figure 4: Vertical salinity distribution (left) and cross-section currents from lowered ADCP measurements (right) at the Faroe Shetland Channel section. Station positions are marked at the top of each subfigure as red points. Distinct isopycnals are shown in black (left) or cyan (right; σ_θ=27.8 kgm^{-3}). The position of PIES FSC-11 is indicated by the white vertical line in the left subfigure. Negative velocities in the right subfigure depict northeastward flow.

Figure 5: Potential temperature [°C] vs. salinity diagram for all CTD profiles measured during P471-3. The sections are separated by different colours (see figure legend).



7. Acknowledgements

We thank Captain Matthias Günther, his officers and the crew of RV POSEIDON for the support of our scientific programme, as well as for their competent and friendly help. The cruise was funded through the BMBF project RACE (Regional Atlantic Circulation and Global Change, 03f0651a), TP 1.3, “Rolle der Overflows bei der Variabilität des Wärmetransports über den Grönland-Schottland Rücken”.

8. List of Stations

CTD/RO Conductivity-Temperature-Depth and rosette station
MOR Mooring station (PIES)
AM Acoustic communication (telemetry)

station	date	time	latitude	longitude	depth	type	comments
751	16.07.2014	18:09	64° 46,67' N	11° 41,88' W	288	CTD/RO	
752	16.07.2014	19:15	64° 44,33' N	11° 37,19' W	312	CTD/RO	
753	16.07.2014	20:14	64° 42,00' N	11° 32,42' W	450	CTD/RO	
754	16.07.2014	21:16	64° 39,60' N	11° 27,63' W	460	CTD/RO	
755	16.07.2014	22:18	64° 37,20' N	11° 22,78' W	443	CTD/RO	
756	16.07.2014	23:18	64° 34,81' N	11° 17,97' W	434	CTD/RO	
757	17.07.2014	00:18	64° 32,40' N	11° 13,19' W	421	CTD/RO	
758	17.07.2014	01:16	64° 29,97' N	11° 8,36' W	399	CTD/RO	
759	17.07.2014	02:13	64° 27,59' N	11° 3,54' W	382	CTD/RO	
760	17.07.2014	06:22	64° 29,97' N	12° 9,89' W	230	CTD/RO	
761	17.07.2014	07:15	64° 27,55' N	12° 4,87' W	387	CTD/RO	
762	17.07.2014	08:12	64° 25,19' N	12° 0,14' W	435	CTD/RO	
763	17.07.2014	09:11	64° 22,80' N	11° 55,20' W	432	CTD/RO	
764	17.07.2014	10:09	64° 20,39' N	11° 50,44' W	412	CTD/RO	
765	17.07.2014	11:02	64° 17,99' N	11° 45,61' W	372	CTD/RO	
766	17.07.2014	14:17	64° 20,41' N	12° 33,49' W	211	CTD/RO	
767	17.07.2014	15:16	64° 17,99' N	12° 28,72' W	427	CTD/RO	
768	17.07.2014	16:16	64° 15,61' N	12° 23,96' W	477	CTD/RO	
769	17.07.2014	17:15	64° 13,17' N	12° 19,26' W	470	CTD/RO	
770	17.07.2014	18:14	64° 10,74' N	12° 14,42' W	451	CTD/RO	
771	17.07.2014	19:13	64° 8,32' N	12° 9,75' W	437	CTD/RO	
772	17.07.2014	20:17	64° 5,99' N	12° 5,14' W	418	CTD/RO	
773	17.07.2014	21:26	64° 3,62' N	12° 0,16' W	379	CTD/RO	
774	18.07.2014	20:13	61° 23,48' N	8° 18,67' W	859	CTD/RO	calibration CTD for PIES FBC-11
775	18.07.2014	21:02	61° 23,51' N	8° 18,72' W	861	MOR	recovery attempt of PIES FBC-11
776-1	19.07.2014	17:23	60° 4,11' N	6° 9,84' W	1101	CTD/RO	calibration CTD for PIES FSC-11
776-2	19.07.2014	18:51	60° 4,05' N	6° 9,80' W	1101	AM	telemetry of PIES FSC-11
777	20.07.2014	07:28	59° 29,98' N	6° 10,11' W	150	CTD/RO	
778	20.07.2014	08:33	59° 34,76' N	6° 10,07' W	195	CTD/RO	
779	20.07.2014	09:40	59° 39,57' N	6° 10,09' W	221	CTD/RO	
780	20.07.2014	10:46	59° 44,53' N	6° 10,09' W	222	CTD/RO	
781	20.07.2014	11:51	59° 49,31' N	6° 9,78' W	467	CTD/RO	
782	20.07.2014	13:05	59° 54,07' N	6° 9,82' W	713	CTD/RO	
783	20.07.2014	14:29	59° 58,92' N	6° 9,81' W	979	CTD/RO	
784	20.07.2014	16:02	60° 3,68' N	6° 9,95' W	1088	CTD/RO	
785	20.07.2014	17:09	60° 4,21' N	6° 9,62' W	1107	MOR	recovery of PIES FSC-11
786	20.07.2014	18:42	60° 8,43' N	6° 9,92' W	1204	CTD/RO	

787	20.07.2014	20:22	60° 12,77' N	6° 10,00' W	1224	CTD/RO
788	20.07.2014	22:07	60° 18,16' N	6° 10,00' W	626	CTD/RO
789	20.07.2014	23:23	60° 23,00' N	6° 9,91' W	429	CTD/RO
790	21.07.2014	00:58	60° 30,59' N	6° 13,93' W	301	CTD/RO
791	21.07.2014	02:29	60° 38,26' N	6° 17,72' W	274	CTD/RO
792	21.07.2014	03:58	60° 45,87' N	6° 21,60' W	175	CTD/RO
793	21.07.2014	05:30	60° 53,50' N	6° 25,68' W	139	CTD/RO
794	21.07.2014	06:55	61° 1,07' N	6° 29,52' W	140	CTD/RO
795	21.07.2014	08:18	61° 8,76' N	6° 33,58' W	124	CTD/RO
796	21.07.2014	09:40	61° 16,39' N	6° 37,89' W	101	CTD/RO
797	21.07.2014	13:49	60° 56,70' N	5° 42,67' W	335	CTD/RO
798	21.07.2014	15:23	60° 50,94' N	5° 28,91' W	594	CTD/RO
799	21.07.2014	16:53	60° 46,95' N	5° 15,92' W	826	CTD/RO
800	21.07.2014	18:22	60° 42,95' N	5° 5,99' W	910	CTD/RO
801	21.07.2014	19:56	60° 38,02' N	4° 53,98' W	1022	CTD/RO