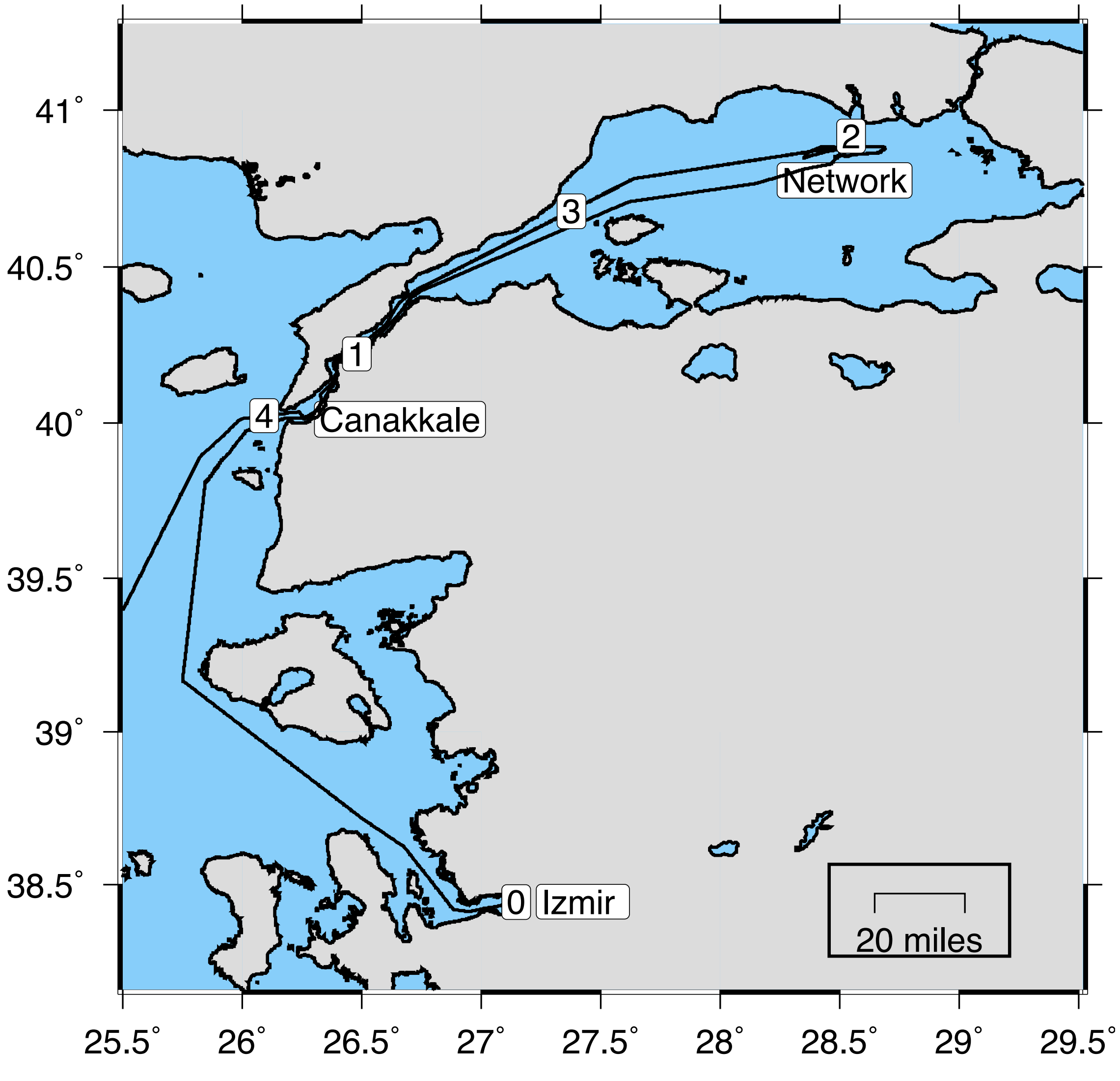
Final Cruise Report
Poseidon No. 484, leg 1

24th April – 27th April., 2015

Izmir – Canakkale (Turkey)

Dietrich Lange, Heidrun Kopp

and cruise participants



Preamble

This report is an extended version of the "*Technical Cruise Report Poseidon No. 484, leg 1*" which was submitted Mai 2015 alongside with the geodetic and seismolocial data.

The technical report was supplemented with preliminary results of the OBS stations monitoring the local seismicity in the vicinity of the geodetic network (section 7.1). Furthermore we added results from the geodetic instruments using 5 months of the geodetic data downloaded during POS484, leg1 (section 7.2).

1.) Introduction and Objectives of cruise POS484, leg1

The area around the Marmara Sea, one of the most densely populated parts of Europe, is subject to a high level of seismic hazard. The MARsite project proposes to identify the Marmara region as a 'Supersite' within European initiatives to aggregate on-shore, off-shore and space-based observations, comprehensive geophysical monitoring, improved hazard and risk assessments encompassed in an integrated set of activities to respond to all priorities identified in the ENV.2012.6.4-2 call. The overall project objectives of MARsite are to:

- Achieve long-term hazard monitoring and evaluation
- Improve existing earthquake early-warning and rapid-response systems
- Improve ground shaking and displacement modelling
- Pursue scientific and technical innovation
- Interact with end users

The MARSITE project includes 21 partners from Europe, under the coordination of KOERI. Ifremer coordinates Work Package 8 (WP8), the objective of which is to implement an integrated approach based on multiparameter seafloor observatories, to continuously monitor the micro-seismicity along with the fluid expulsion activity within the submerged fault zone

The objective of the RV Poseidon 484, leg 1 cruise was to recover a small aperture array of 6 OBS stations installed to monitor micro-seismicity along the Marmara fault segment of the North Anatolian Fault Zone (NAFZ) (location of the working area is shown in Figure 1) and contributes to the long-term hazard monitoring and evaluation objective of MARsite. After recovery the stations (Figure 2) were reinstalled with a slightly larger aperture of 15 km (Figure 4). Second objective was to check the state of health of an array of 10 geodetic transponders (Figure 3) including download of data logged since November 2014. The Marmara segment of the NAFZ is the only segment that has not been activated in the present series of major earthquakes and may have accumulated a slip deficit of up to 4-5 m since the last event in 1766.

2.) Narrative of cruise POS484, leg 1

RV Poseidon left the harbour of Izmir on Thursday April 24, 2015 at 08:00 local time (equals 06:00 UTC time). Weather conditions during the whole cruise were good with little wind and cloudy to sunny sky. The ship arrived in the working area (Figure 1) on 25.04.2015 at 12:00 local time and started to recover the 6 OBS stations. It took 3 hours to recover all 6 OBS stations due to the small aperture of the seismic array (Figure 2). All releasers opened and stations could be recovered without problems. The state of sea was very calm during the whole time in the working area. Starting at 15:15 the Sonardyne modem was lowered to 60 m water depth in order to read out the data of the 10 geodetic stations which were installed with RV Pourquoi Pas? between 27 October and 1st November 2014 (Figure 3). The geodetic stations worked very well and most of the baselines had visibility and all sensors worked as expected. Over night Poseidon took a waiting position until the next day (Sunday 26 April 2015) and started at 07:06 (UTC time 05:06) with the deployment of the first OBS station (station name MAR2). At 14:20 local time all 6 stations were installed with new batteries at their new positions (Figure 4) and Poseidon headed to the port of Canakkale where she arrived on the 27 April 2015 at 10:00 local time. Thereafter Poseidon headed towards the Tyrrhenian sea (Italy) for the second leg of POS484.

3.) Location and station maps

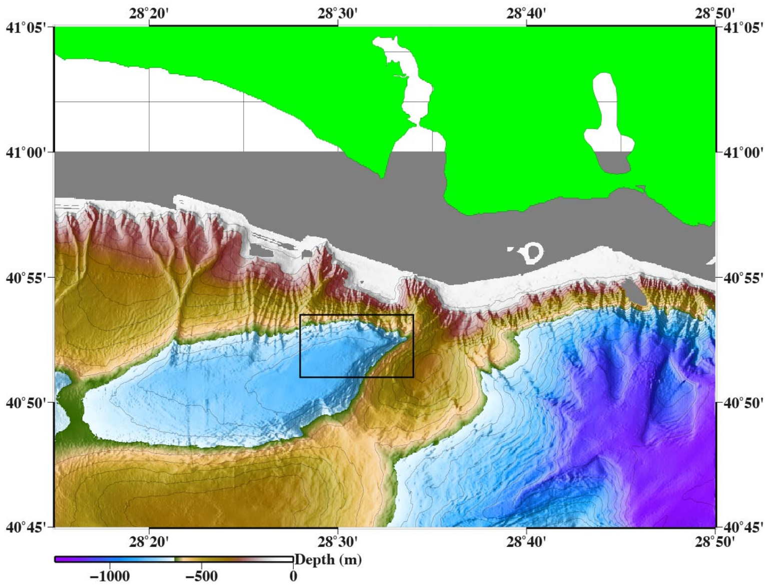


Figure 1: *Map of the working area. Detailed maps of recovered, serviced and redeployed equipment are shown in Figures 2, 3 and 4.*

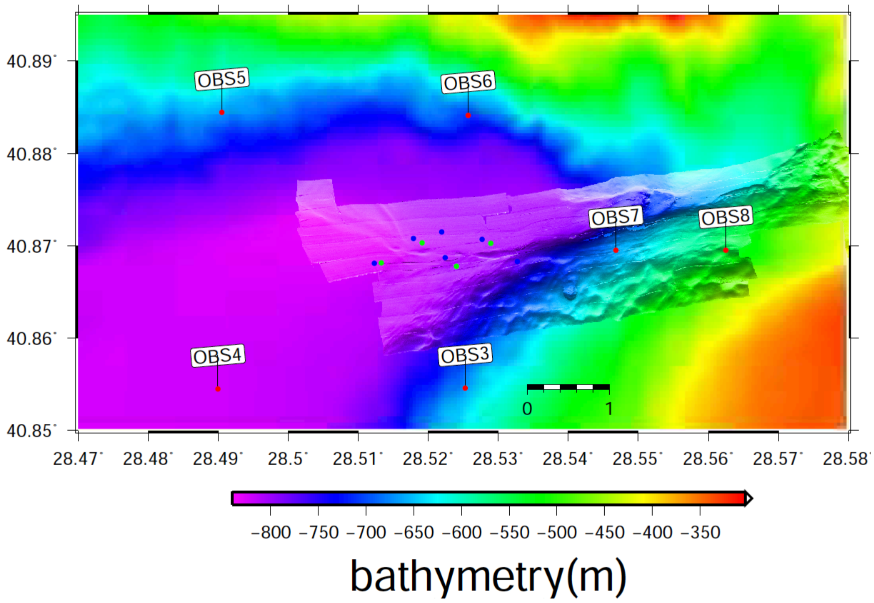


Figure 2: *Map showing the location (red points) of the 6 OBS stations which were installed in November 2014 and de-installed during POS484, leg 1. The OBS stations were recovered and redeployed with a larger aperture configuration which is optimized to resolve microseismiciy down to 15 km along the small (~20 km) segment oft the strike-slip fault. The geodetic stations serviced during POS484, leg 1 are shown with blue (GEOMAR) and green (IRFEMER) points. Bathymetry from echosounder data. In the region of the geodetic network high-resolution bathymetry from AUV mapping is shown. In order to enhance the fault structure the AUV bathymetry was illuminated from the South.*

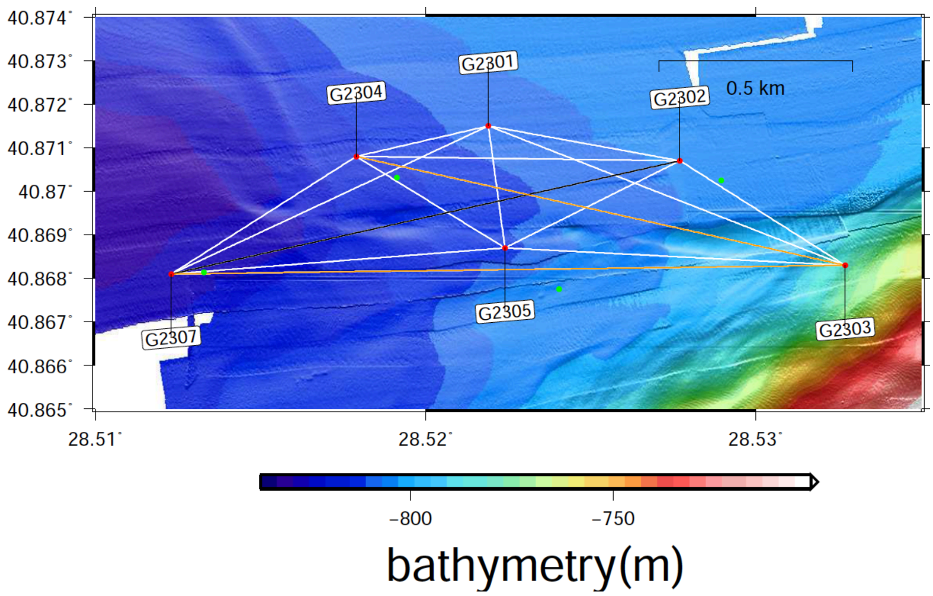


Figure 3: *Map showing the location of the geodetic stations (red point indicate geodetic transponders from GEOMAR labelled with transponder IDs and green points indicate transponders from IFREMER). Bathymetry from AUV mapping. Baselines of the intercommunicating transponders of Geomar working with 17kHz are shown with lines. The black baseline (G2302-G2307) has no line of sight. The long baselines with lengths of larger than 1000 m (shown in orange) are configured to work only unidirectional. White lines show bidirectional baselines. All geodetic transponders worked as expected.*

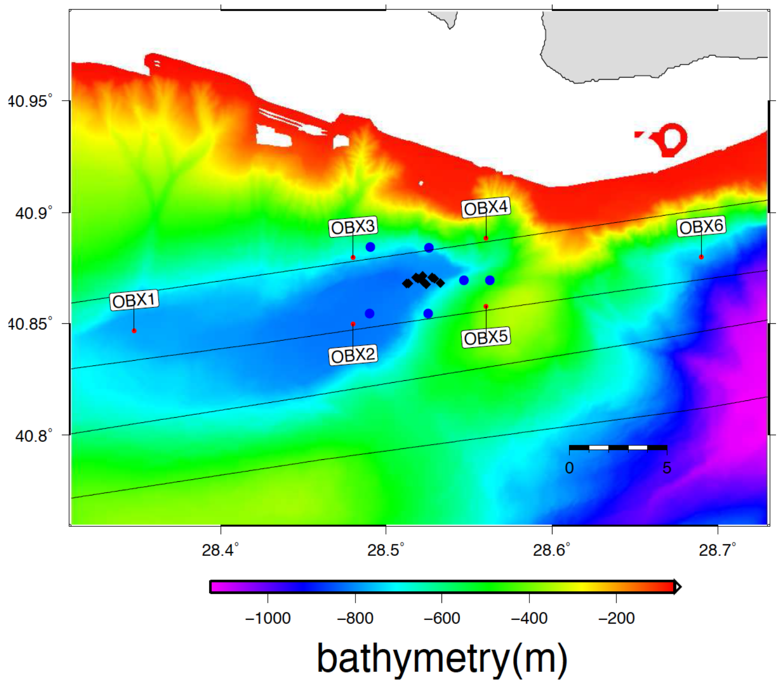


Figure 4: Station configuration oft the 6 redeployed OBS instruments. While network configuration was optimized for detection of very small events in the the first phase (November 2014 until April 2015) the redeployed station geometry is optimized for a slightly larger area of ~20 km along the fault.

4.) Coordinates

Table 1: *Coordinates of the geodetic stations. Water depths of the geodetic stations refer to the seafloor and were taken from the AUV bathymetry.*

Name	**longitude**	**longitude**	**latitude**	**latitude**	**depth**	**Looger ID**
	(°)	**min**	**(°)**	**min**	**(from AUV)**	
Geomar stations:						
G4	28	30.7380	40	52.0860	827	G2307
G1	28	31.0740	40	52.2480	813	G2304
G2	28	31.3440	40	52.1220	804	G2305
G3	28	31.6620	40	52.2420	805	G2302
G5	28	31.9620	40	52.0980	779	G2303
G6	28	31.3140	40	52.2900	807	G2301
Brest Stations:						
F1	28	31.1475	40	52.2189	-	F2001
F2	28	31.4426	40	52.0654	-	F2002
F3	28	31.7371	40	52.2149	-	F2003
F4	28	30.7976	40	52.0884	-	F2004

Table 2: *Coordinates for the deinstalled recovered OBS stations. Water depths of the geodetic stations refer to the seafloor and were taken from the AUV bathymetry.*

Station	lat. (°)	lat.	lon. (°)		depth (AUV)	depth
		min.		min.		(echosounder)
OBS8	40	52.1710	28	33.752	549.000	800
OBS7	40	52.1710	28	32.807	663.000	700
OBS6	40	53.0480	28	31.540	-	682
OBS5	40	53.0670	28	29.431	-	658
OBS4	40	51.2690	28	29.397	-	823
OBS3	40	51.2750	28	31.514	-	689

Table 3: *Coordinates of the new positions of the OBS stations.*

Name	longitude	longitude	latitude	latitude	depth (m), approx.
	deg.	min	deg.	min	
OBX1	28	20.8732	40	50.8087	700
OBX2	28	28.8000	40	50.9969	800
OBX3	28	28.8000	40	52.7871	700
OBX4	28	33.6000	40	53.3024	600
OBX5	28	33.6000	40	51.4728	300
OBX6	28	41.4000	40	52.8000	700

5.) Crew, POS 484, leg 1 (Izmir – Canakkale)

5.1 Ship's crew

No.	Rank	Name	Given name
1	Captain	Ricke	Klaus
2	1. Off.	Thürsam	Dirk
3	Naut. WO	Nannen	Hero
4	I. Techn. Off.	Kröger	Kurre-Klas
5	II. Techn. Off	Pieper	Carsten
6	Boatswain	Mischker	Joachim
7	A/B	Kuhn	Ronald
8	A/B	Bischeck	Olaf
9	A/B	Rauh	Bernd
10	A/B	Pleuler	Merlin-Till
11	A/B	Meyer	Felix
12	Motorman	Engel	Rüdiger
13	Electrician	Blunck	Volker
14	Cook	Malchow	Klaus-Peter
15	Steward	Gerischewski	Bernd

5.2 Scientific crew

1.	Heidrun Kopp	GEOMAR	Chief Scientist
2.	Helen Piete	IUEM	Scientist
3.	Sekic, Pierre	IFREMER	PhD student
4.	Ekrem Hacioglu	Directorate of Mineral Research and Exploration, Ankara	Observer
5.	Schröder, Henning	GEOMAR	PhD student
6.	Patrick Schröder	GEOMAR	Technician
7.	Petersen, Florian	GEOMAR	Student
8.	Hoffmann, Jasper	GEOMAR	Student
9.	Lange, Dietrich	GEOMAR	Scientist

6.) Acquired data

1.) Multibeam bathymetry not in operation.
2.) 41 MB acoustic measurements from geodetic station network
3.) Data records from 6 Ocean-Bottom seismometers:

Table 4: *Details of acquired OBS data.*

station	skew (ms)	raw data (GB)	Logger ID	Remarks
OBS8	477	8.3	991234	
OBS7	359	7.02	110101	
OBS6	--	0	010406	Fuse broken, was not running
OBS5	--	0.2	991258	Recording stopped after one day.
OBS4	--	8.2	020801	Could not be syncronized
OBS3	1011	8.2	991250	

All aquired data were submitted in Mai 2015 alongside with the "*Technical Cruise Report Poseidon No. 484, leg 1*" on an USB stick.

7.) Preliminary results

7.1.) Detections and local seismicity from the OBS array. Preliminary results.

We detected local seismicity of the OBS array (Figure 2, red points) and located local and regional events in the Marmara sea. For detection we used the available data of four stations (OBS8, OBS7, OBS3,OB4). Local seismicity epicentres shown in Figure 5 are based on P and S arrival times of OBS8, OBS7 and OBS3. The timing of OBS4 could not be synchronised during recovery, but relative P-S times were incorpoerated for location. The network was optimized for event detection and location of arrays in the close vincinity of the NAF. Due to its small aperture of ~2km its not suitable for locating events occurring outside the local network. All events are clearly outside the network. We did not detect local events within a radius of ~10 km around the geodetic network indicating that the fault in the close vicinity around the geodetic network was not moving seismically during the deployment. Due to the location of seismicity clearly outside the network epicentre and depth information have significant uncertainties. However the OBS data, together with the landstations, will improve hypocentral observations for the seismicity during the OBS deployment. We provided all the OBS data, detection list with P and S phase arrival times to Kandilli observatory so that the offshore information will be merged with the landdata. A list of all local events is shown in

Figure 5.

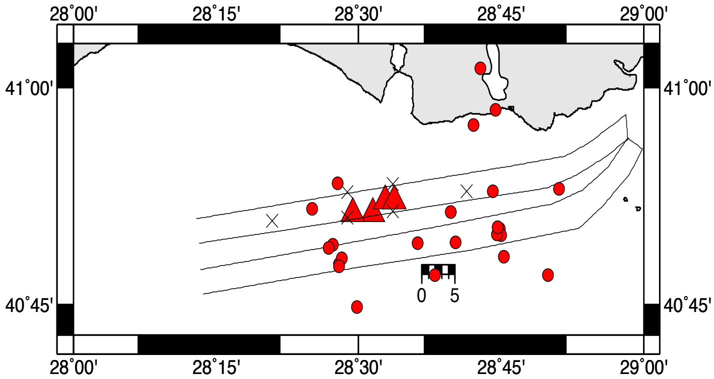


Figure 5: *Seismicity located between November 2014 and April 2015. Local events are indicated by red circles and stations are shown with red triangles. The shipping lane is shown with black lines. Due to the location of seismicity clearly outside the network epicentre and depth information have significant uncertainties.*

7.2.) Preliminary results from the geodetic deployment.

The geodetic array was installed in November 2014 and is designed to measure deformation across the NAF for up to 5 years. All instruments logged sound speed, temperature, pressure and baselines with a sample rate of 2 hours. Although the local sound speed sensors (located at each transponder) show a long time drift the baseline accuracy (Figure 7) foreach pair of stations is measued with an precision of smaller then 1 cm (Figure 6 & 9) for all baselines. This is achieved by calculating local sound velocities from temperatures (Figure 8) and pressure (Figure 10) using a constant salinity (Figure 7) and the equation from Chen and Millero (1977). The expected movement based on gedodetic observations onshore is between 2-3 cm/yr for a fully locked fault zone. As a result the short timeseries of 5 months is too short to allow to disinguish between locked or creeping behaviour of the NAF. However, due to the capability oft the geodetic network measuring for a period up to 4 years (Geomar instruments) and 5 years (Univ. Brest instruments) the network will most likely be capable to distinguish between a fully locked and creeping behaviour as the tectonic deformation continues in within the next years.

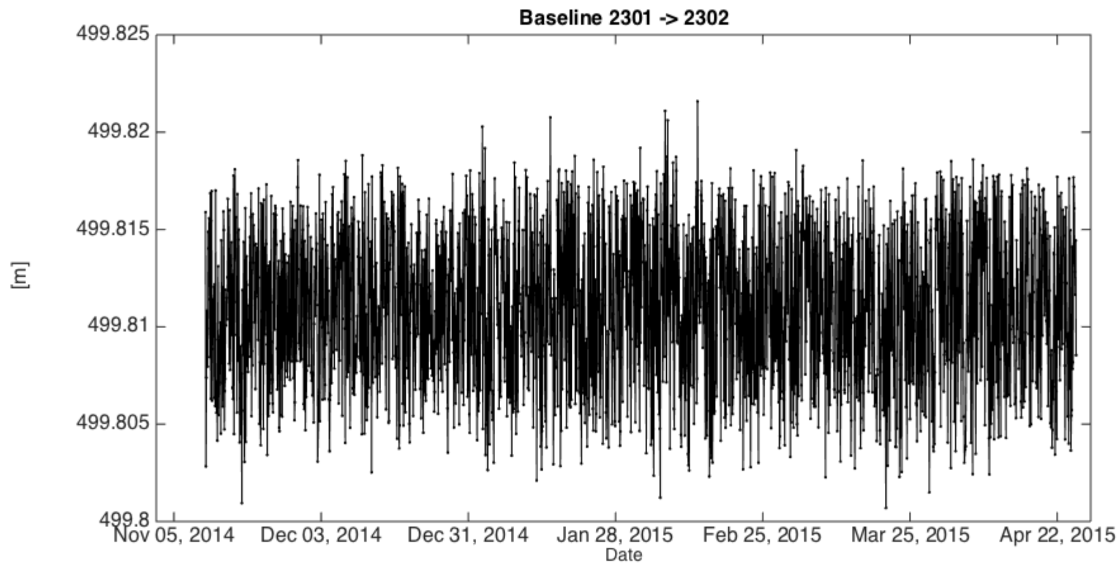


Figure 6: *Baseline example showing the distance between station 2301 and 2302 (Figure 3). Due to the long term sensor drift of the local sound speed sensors sound speed was calculated from pressure, temperature and salinity (Figure 7, center panel).*

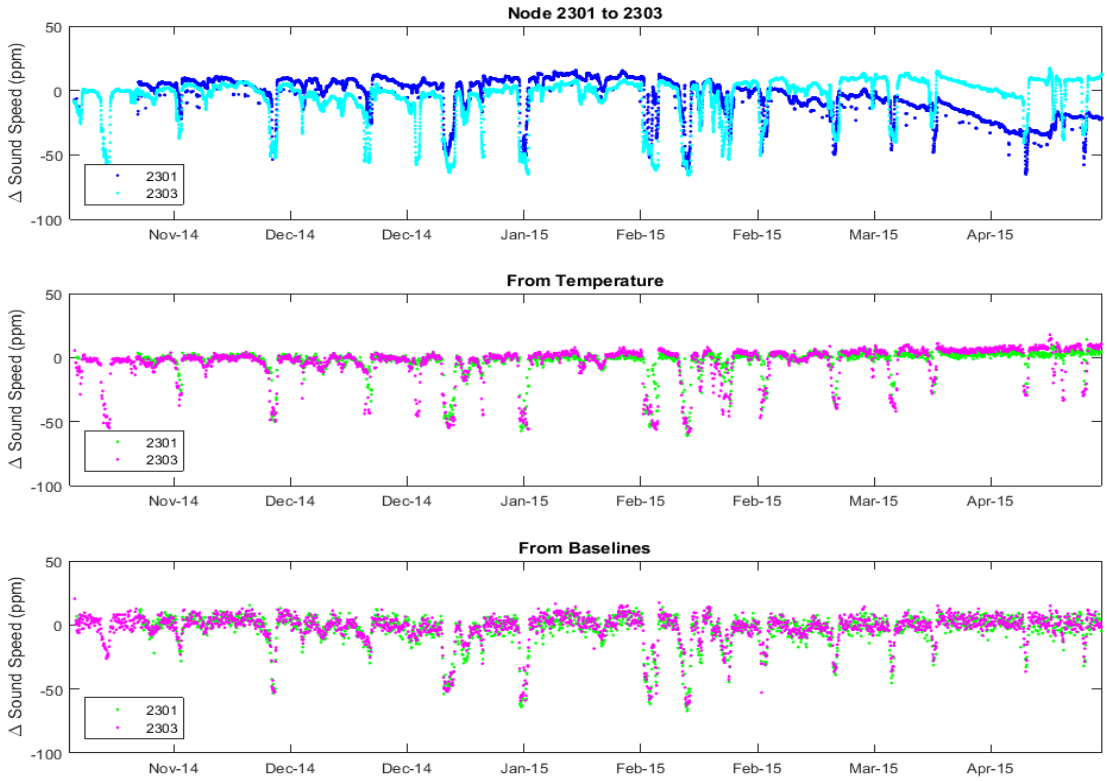


Figure 7: *Soud speed changes for station 2301 and 2303. Each of the three sets of sound speeds is normalised by each mean, scaled to parts per million and then the mean of this result is again removed. So all three estimates should average zero ppm. Upper panel shows measured shound speed changes with the fluctuations of sound speed from cold water flows. The drift of the sound speed sensor can be seen between Februar 2015 and April 2015. Centre: The sound speed sensor data is compared to the temperature data and the baseline data. Sound speed is calculated using the equation from Chen and Millero (1977) and measured temperature, pressure and a constant salinity of 38.4 psu. Bottom: Sound speed calculated from the time of flight between the two transponders and a constant distance.*

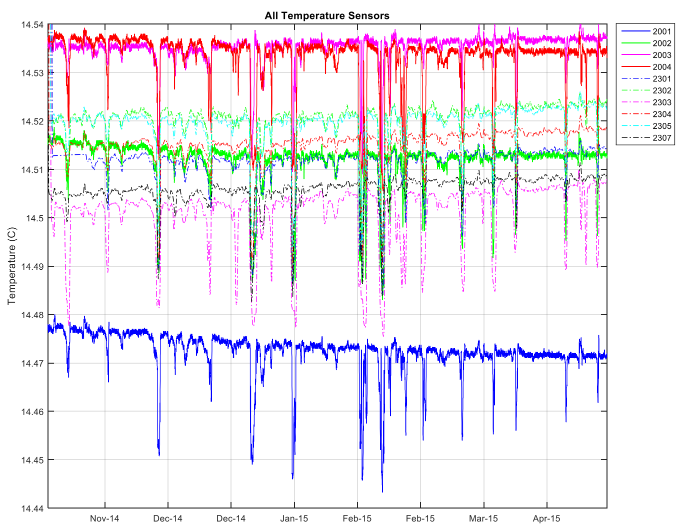


Figure 8: *Temperature data for all geodetic beacons. The IUEM nodes 2001- 2004 have Valeport SVT sensors. The GeoMar nodes 2301 – 2307 were Sonardyne HRT sensors. A small amount of averaging has been applied to smooth out the mostly quantisation noise. It can be seen in the plots that the GeoMar 6000m units are much slower to respond to the temperature changes, due to the thick stainless steel housings*.

Figure 9: *The relative baseline changes from transponder 2301 was calculated using the temperatures from unit 2301 and the Chen and Millero equation to generate the sound speeds. The average pressure for each unit is used, and a salinity of 38.4 psu. The results are filtered, most of the spikes due to temperature episodes are gone but some remain perhaps due to the time response and a genuine salinity change.*

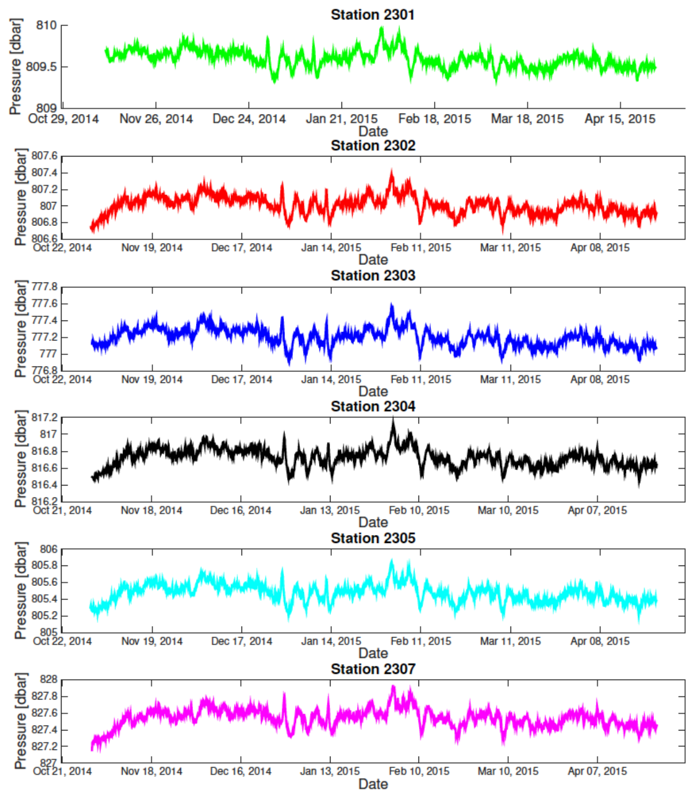


Figure 10: *Measured pressure (converted into depths) for the GEOMAR transponders.*

Acknowledgments

We thank Master and crew of the RV Poseidon cruise POS484 for excellent sea-going support and a great working environment. Adrian B. Parsons prepared figure 7,8 and 9.