METEOR-Berichte

Submesoscale dynamics at the Benguela eastern boundary upwelling system – frontal instabilities, mixed layer eddies and upwelling filaments

Cruise No. M132

15th November – 11th December 2016

Walvis Bay – Cape Town

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1 Summary

Meso- and submesoscale processes occur at oceanic fronts, inducing lateral exchange. These processes include e.g. eddies, filaments and shear instabilities. They modify the local stratification, the biological productivity of the region and the distribution of tracers. Coarse resolution ocean and climate models neglect these small scale processes and therefore cannot reproduce their impact. During cruise M132 high resolution in-situ measurements were carried out in order to understand frontal instabilities and develop a basis for a better representation in models. The working area was small and centered at the eastern boundary of the Atlantic Ocean.

The focus was on the dynamics of upwelling filaments, which occur often at the upwelling front off Namibia. We studied the vertical structure of filaments, as well as the mechanisms of filament dissipation. In addition, the upwelling front was crossed repeatedly, as we also aimed at understanding frontal turbulence and temporal variability. Used for data acquisition were several underway systems (e.g. Scanfish, underway-CTD), autonomous platforms (gliders) and station-based measurements (CTD, MSS). Furthermore, a catamaran equipped with an ADCP and a thermistor chain was deployed and towed in the wake of the ship to study the uppermost layer of the ocean without the ship induced turbulence. A Lagrangian experiment using surface drifters for dispersion studies was performed as well. The cruise contributes to projects L3 and T2 in the DFG funded TRR 181 „Energy transfer in Atmosphere and Ocean”.

Zusammenfassung

Lateraler Austausch über ozeanische Fronten wird durch meso- und submesoskalige Prozesse hervorgerufen. Diese Prozesse beinhalten u.a. Wirbel, Filamente und Scherinstabilitäten. Sie beeinflussen die lokale Schichtung der Wassersäule sowie die biologische Produktivität und die laterale Ausbreitung von Spurenstoffen. Grob auflösende Ozean- und Klimamodelle vernachlässigen diese kleinskaligen Prozesse und unterschätzen deren Auswirkungen. Während der Reise M132 wurden hochauflösende in-situ Messungen durchgeführt, um diese Prozesse zu erfassen und eine Basis für verbesserte Repräsentationen in Modellen zu schaffen.

Im Fokus der Reise stand die Dynamik von Auftriebsfilamenten, die an der Temperaturfront vor Namibia häufig auftreten. Hierbei interessieren uns vor allem deren vertikale Struktur und die Mechanismen, die zur Dissipation der Filamente beitragen. Die Auftriebsfront wurde mehrfach überquert, um die dort auftretende Turbulenz und ihre zeitliche Variabilität zu beobachten. Zur Erfassung der Daten wurden verschiedene Unterwegs-Messsysteme eingesetzt (z.B. Scanfish, underway-CTD), autonome Plattformen (Glider) ausgesetzt und Stationsarbeiten (CTD, MSS) durchgeführt. Zudem wurde ein Katamaran, ausgestattet mit einem ADCP und einer Thermistorkette, ausgesetzt und in einiger Entfernung vom Schiff geschleppt, um Daten der obersten Ozeanschicht ohne den Einfluss der Schiffsschraube zu bekommen. Ein Lagranges Strömungsexperiment mit Oberflächendriftern wurde außerdem durchgeführt. Die Untersuchungen tragen zu den Teilprojekten L3 und T2 im DFG geförderten Transregio „Energy transfer in Atmosphere and Ocean“ (TRR 181) bei.

2 Participants

Name	Discipline	Institution
Jochumsen, Dr. Kerstin	Chief scientist	IfM HH
Carpenter, Dr. Jeffrey	Glider	HZG
Dräger-Dietel, Dr. Julia	Drifter data analysis	IfM HH
Gillner, Christiane	MSS watch	IOW
Hainbucher, Dagmar	CTD/UCTD processing	IfM HH
Heene, Toralf	Technician, MSS, Catamaran	IOW
Holtermann, Dr. Peter	MSS/Catamaran data analysis	IOW
North, Dr. Ryan	ADCP processing	IfM HH
Mashayekh Poul, Dr. Hossein	Oxygen titration	IfM HH
Raeke, Andreas	Meteorology	DWD
Rochner, Andrea	CTD/LADCP watch	IfM HH
Rotermund, Meike	CTD/LADCP watch	IfM HH
Sass, Martin	MSS watch	IOW
Schultze, Larissa	Glider	HZG
Shilongo, Secilia	observer	MFMR
Siemssen, Jens-Erwin	Artist	Freelance
Specht, Mia	CTD/LADCP watch	IfM HH
Umlauf, Dr. Lars	MSS/Catamaran data analysis	IOW
Wasilewski, Thomas	LADCP processing	IfM HH
Welsch, Andreas	Technician, salinometer	IfM HH
Wett, Simon	CTD/LADCP watch	IfM HH
Wünsche, Anna	CTD/LADCP watch	IfM HH
Zeigermann, Luise	CTD/LADCP watch	IfM HH

DWD Deutscher Wetterdienst, Seeschifffahrtsberatung, Bernhard-Nocht-Straße 76, 20359 Hamburg, Germany, http://www.dwd.de

IfM HH Institut für Meereskunde, Universität Hamburg, Bundesstraße 53, 20146 Hamburg, Germany, http://ifm.uni-hamburg.de

HZG Helmholtz Zentrum Geesthacht, Max-Planck-Str. 1, 21502 Geesthacht, Germany, http://www.hzg.de

IOW Leibniz-Institut für Ostseeforschung, Warnemünde Seestraße 15, 18119 Rostock, Germany, http://www.io-warnemuende.de/

MFMR Ministry of Fisheries and Marine Resources, National Marine Information and Research Center (NatMIRC), Strand Street, Swakopmund, Namibia, http://www.mfmr.gov.na/

3 Research Program

Cruise R/V METEOR 132 aimed at collecting high resolution observations at the upwelling front off Namibia. The goal was to obtain a detailed understanding of the interaction between meso- and submesoscale processes occurring at the front. The cruise was fully in the focus of physical oceanography, targeting energy exchanges between scales, which contributes to the DFG project TRR 181 (Energy transfers in Atmosphere and Ocean) from which the cruise was funded. The major goals of the cruise were: (1) observing mixed layer eddies and instabilities at the upwelling front and assessing their horizontal and vertical structure; (2) evaluating the generation, lifetime and dissipation of submesoscale features found in the working region; (3) quantifying the lateral exchange or tracers and properties across the front.

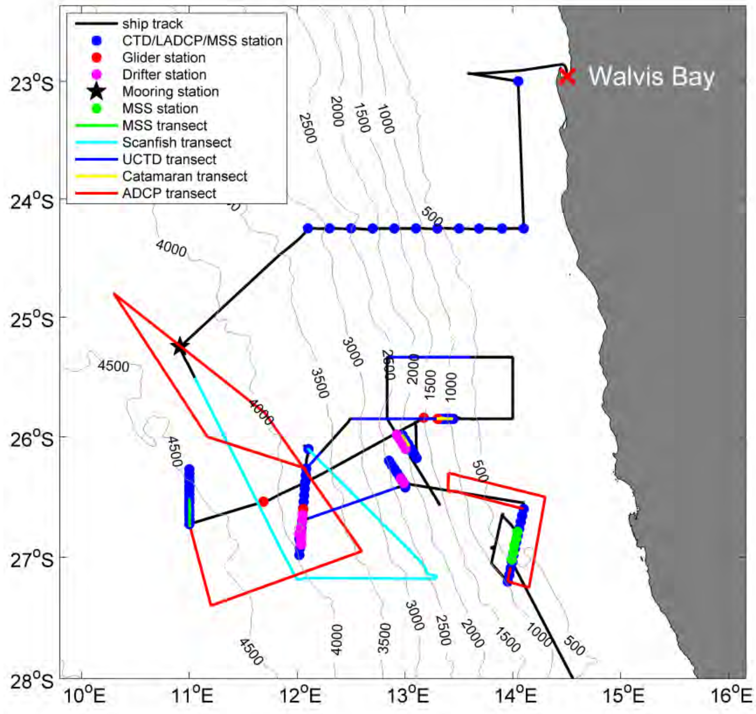

Fig. 3.1 Track chart of R/V METEOR Cruise M132. The cruise started in Walvis Bay and ended in Cape Town (not shown). The working area was the upwelling region off Namibia.

The data collected to obtain the listed goals was obtained from a variety of instruments: The vessels' ADCP was used to derive the mesoscale current field and compared to anomalies in sea surface height as seen in satellite products. In order to locate upwelling filaments, R/V METEOR's thermosalinograph measurements were monitored closely and combined with information from satellite sea surface temperature data. CTDO (conductivity-temperature-depth-oxygen) profiles as well as horizontal current profiles were taken at 121 stations, giving high vertical resolution data within the fronts of filaments and at the upwelling region. Profiles were conducted to a maximum depth of 500 m, as the focus of the cruise was on upper ocean processes. Beyond classical CTD measurements, CTD profiles were also obtained during transits from the moving ship, either with the help of a towed and undulating CTD system (ScanFish) or with an underway CTD system. In addition, microstructure profiling (MSS) was carried out on 63 stations, mostly close to CTD stations at pronounced temperature fronts. To investigate the uppermost region of the water column without contamination from the wake of the ship, current and temperature measurements were conducted from a research catamaran towed 100-150 m behind the ship on selected transects. The measurement program was completed by two autonomous gliders, which passed the temperature fronts several times, thereby obtaining hydrographic and dissipation profiles.

4 Narrative of the Cruise

On 15th November 2016 at 08:00 UTC R/V METEOR departed from Walvis Bay port, heading westward on the Namibian shelf. Underway measurements using the ADCP and thermosalinograph systems installed on R/V METEOR were started at 8:40 UTC. The first station at 22°55.75’ S, 13°05.1’ E was dedicated to a glider recovery, which was deployed during cruise M131. The operation went smoothly and the glider was on deck at 13:30 UTC. The first CTD and MSS station was carried out at 23° S, 14°02.9’ E at 16:15 UTC, which is the position of a long-term mooring operated by IOW. All systems were tested, but no water samples were taken. A first CTD section was conducted during 16th November. Then, R/V METEOR headed towards 25°14.8’ S, 10°54.9’ E, where a deep sea mooring had been deployed during cruise M99 in August 2013. A first recovery attempt in February 2014 during cruise M104 had failed. This time (on 17th November) the mooring again did not respond to acoustic commands and a dredging attempt was unsuccessful. The mooring is therefore considered to be lost.

R/V METEOR continued the cruise southwestward. Along the 130 nm of transit towards an upwelling filament identified in a satellite sea surface temperature (SST) image, underway measurements were complemented by measurements with a Scanfish, which provided hydrographic profiles of the upper 110 m of the ocean. Upon recovery on 20th November the Scanfish data cable was found to be damaged. The instrument was therefore not used during the rest of the cruise. One CTD station was carried out for calibration purpose at the location of the Scanfish recovery. The following days (20th to 22nd November) were dedicated to detailed measurements within the upwelling filament. 37 CTD stations and 21 MSS stations were performed, crossing the filament in north-south direction several times. At the southern boundary of the filament 12 surface drifters (SVP) were deployed in groups of three instruments, arranged in a triangle of 100 m and 200 m side lengths. They will report their position and ocean surface temperature in 30 min intervals during the next several months. In addition, one glider was deployed on 22nd November 8:10 UTC at 26°36.1’ S, 12°3.3’ E.

Late on 22nd November (23:30 UTC) an underway-CTD section was started towards east, where the upwelling front was located. The section was interrupted after only 3 profiles due to a malfunction of the winch. Repair was finished at 4:30 UTC on 23rd November and the measurements continued until 11:10 UTC. Three hours later a glider was deployed at 25°50.4’ S, 13°18.7’ E after two test dives for optimizing the ballast within the device. In the following the research catamaran was deployed and towed behind R/V METEOR with a speed of approx. 2kn. Simultaneously MSS profiles were conducted. The track was crossing the front back and forth during the night until the catamaran was recovered on 24th November 9:10 UTC. The rest of the day was spent with a CTD section in very high horizontal resolution (distance between stations 0.55 nm, 15 stations). Due to strong winds and waves only underway measurements were performed on 25th November, where the temperature distribution further offshore was investigated.

During the morning of 26th November another 12 drifters were deployed at the northern boundary of the filament. In the following, a track across the temperature front was sampled repeatedly with CTD and MSS stations, and later on using the catamaran. Profiling was stopped at 00:40 UTC on 27th November when R/V METEOR headed to the northeast to recover one glider at 25°50.2' S, 13°10.8' E. The device was on board at 04:10 UTC. The calm weather conditions were used to recover the second glider as well. After a transit of 9 hrs the glider position at 26°32.4' S, 11°41.1' E was reached, and it was recovered at 13:50 UTC. Station work with CTD/MSS was continued on 27th and 28th November across the western extension of the filament, a location where the drifters had passed a few days before.

Due to severe weather conditions station work was stopped on 28th November 18:15 UTC and a large scale survey of the mesoscale eddy field was started. Using the ADCP mounted in the hull of the ship, R/V METEOR mapped the currents around the filament for about 2 days. On 30th November a new CTD/MSS section was started at 21:10 UTC at the filament in meridional direction, close to the location of the first drifter deployments. The section was completed on 2nd December, when another 6 drifters were deployed. The transit to the eastern edge of the filament was complemented with underway-CTD measurements. Due to the loss of one probe data acquisition only resumed to 18 UTC. At 22:00 UTC a new CTD/MSS section was started, crossing the northern boundary of the filament. One station was used as a calibration station for the MSS. Along the section the last 7 drifters were deployed on 3rd December from 10:20 UTC to 11:20 UTC.

The voyage continued with a transit to the upwelling front, where satellite images indicated the formation of a new filament. At 17:30 UTC on 3rd December the catamaran was deployed and towed across the front during the night. The device was recovered at 7:00 UTC on 4th December. The following CTD/MSS section had to be canceled after the first station due to strong winds and waves, only MSS measurements continued until the evening (18:15 UTC). The following 19 hours were again used for a detailed survey of the currents and temperature distribution in the region, using R/V METEOR's underway systems. Station work was resumed on 5th December 13:30 UTC at the upwelling front off Lüderitz. After the section had been completed on 6th December the catamaran was deployed at 15:10 UTC at the front and towed across the location of strongest temperature gradient. Meanwhile, MSS profiles were taken. The final CTD/MSS section of cruise M132 was conducted on 7th December at the same locations of the previous section to cover temporal variability of the upwelling front. At 5:00 UCT on 8th December station work was finished and R/V METEOR headed towards Cape Town. Underway measurements were stopped on 8th December 20:15 UTC, when the vessel reached the EEZ of South Africa. Finally, R/V METEOR arrived at the port of Cape Town on 11th December 7:45 UTC.

5 Preliminary Results

(K. Jochumsen, A. Welsch, D. Hainbucher, H. Mashayekh Poul, N. Verch, A. Rochner)

5.1 CTD Measurements and Calibration

5.1.1 CTD System Overview and Performance

Conductivity-temperature-depth (CTD) profiles were obtained with a Sea-Bird Electronics (SBE; USA) 9plus, integrating a pressure sensor with a digiquarz unit. For temperature and conductivity/salinity measurements, a double sensor pack was used. Additionally, a dissolved oxygen sensor was attached to the CTD, as well as a transmissiometer. The instrument distance above the sea floor was derived from a Benthos altimeter working at a frequency of 200 kHz, which was lowered with the CTD. Furthermore, a high precision temperature recorder was installed on top the CTD body, recording the temperature at the times when bottles were closed. All operating devices of the CTD-system are listed in Table 5.1.

Table 5.1. CTD devices used during cruise M132.

Pressure sensor, SBE9plus	0285
SBE3 (primary temperature sensor)	1294
SBE3 (secondary temperature sensor)	5456
SBE4 (primary conductivity sensor)	1329
SBE4 (secondary conductivity sensor)	3960
SBE5 (oxygen sensor)	1761
Pump 1	931
Pump 2	5967
Atimeter (Benthos PSA-916, 200 kHz)	885
Transmissiometer	CST-377DR
RT35	0067

The CTD/O instrument was attached to a metal rosette frame, holding a 12-bottle-carousel water sampling system with 5l Niskin bottles. A configuration with 6 bottles was used to obtain water samples from selected depth levels, as bottles were removed to attach a lowered ADCP system. The secondary sensor pack was attached at the top of the rosette frame, which is used to lower the CTD into the water. In this configuration, the secondary sensors derive undisturbed measurements when the frame is on its way up. In the laboratory, the data from the CTD cast was converted by an SBE 11 plus deckunit (#0791), and recorded with a standard “MS Windows 7” PC, using the Seasave software (V 7.22.5). The conductivity signal of both sensor packs was automatically advanced in time by the deckunit with a setting of 0.073 s, therefore only a minor misalignment of the sensors remained (except for oxygen). The processing and conversion of the raw data was done with the SBE Data Processing program package (V 7.22.5). The CTD-water sampler system was used for 121 casts, which were generally conducted from the surface to 500 m depth, as the scientific focus of the cruise was on upper ocean structures. Station #1627/99 was only for calibrating the MSS profiles and thus reached only 30 m. Produced were final datasets for the up and down casts using the primary and secondary sensor packs, respectively.

5.1.2 Oxygen and Salinity Calibration

Conductivity/Salinity

For the calibration of the conductivity cells the CTD data was compared with salinity measurements from the bottle samples, which were obtained by a Guildline salinometer of type Autosal 8400A (s/n 59.083), provided by the University of Hamburg. Calibration during operation was done using IAPSO standard seawater (Batch P157, K15=0.99985 and Batch P159, K15=0.99988), which was measured at the beginning and end of the salinometer use each day. The salinometer data showed trends below 0.001 in salinity for half a day in operation, which were removed from the measured salinity samples. In total the salinity of 232 sea water samples was measured using the salinometer during the cruise. The two sensors showed a persistent offset from each other, which was removed during the calibration process. The conductivity calibration was performed using a linear fit with respect to conductivity, temperature, and pressure, but only a correction regarding temperature was found to be necessary:

C_corrected_primary = C_observed -2.06408972e-03*T-5.83986768e-02

Oxygen

To calibrate the SBE dissolved oxygen sensor bottle samples were collected and oxygen concentration was measured in the laboratory using the Winkler potentiometric method. Altogether 254 oxygen samples were collected on cruise M132. At the beginning of the cruise 3-6 samples were taken on every station. During high frequent measuring, when distance and time between stations was sparse, 3-4 samples were collected on every third CTD station only. Sampled depths were always different depending on the local oxygen profile of the station. The instrument used for the lab analysis was a Metrohm Titrino Plus 848 unit with a Micro Pt Titrode (s/n 108 06245).

A comparison of the oxygen samples against the values of the CTD (Fig. 5.1) shows that the difference between them is low (<3%) with the exception of some outliers where presumably bubbles were produced during sampling. After removing these outliers a mean difference of 4 µmol/kg and a standard deviation of 1.2881 µmol/kg were calculated. Additionally, oxygen was found to depend on pressure:

O_corrected(mg/l) = O_observed(mg/l) -8.27781119e-05*P+1.98703385e-01

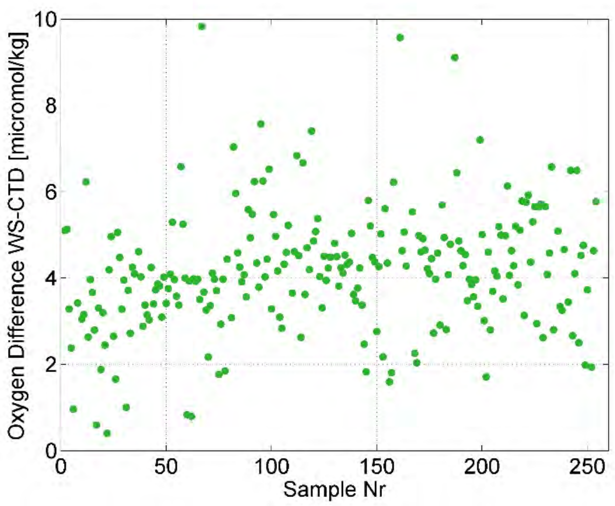

Figure 5.1: Oxygen difference (water samples – CTD [µmol/kg]) for 254 oxygen samples.

5.1.3 First results

The first CTD section conducted during cruise M132 aimed at capturing the upwelling front and the distribution of water masses in the region. The section of potential temperature (Fig. 5.2) shows that the upwelled water masses originate in 200-300 m depth. At the surface temperatures decrease from about 18°C to less than 14°C in the upwelling region. The density of the upper ocean is less on the offshore side of the upwelling front.

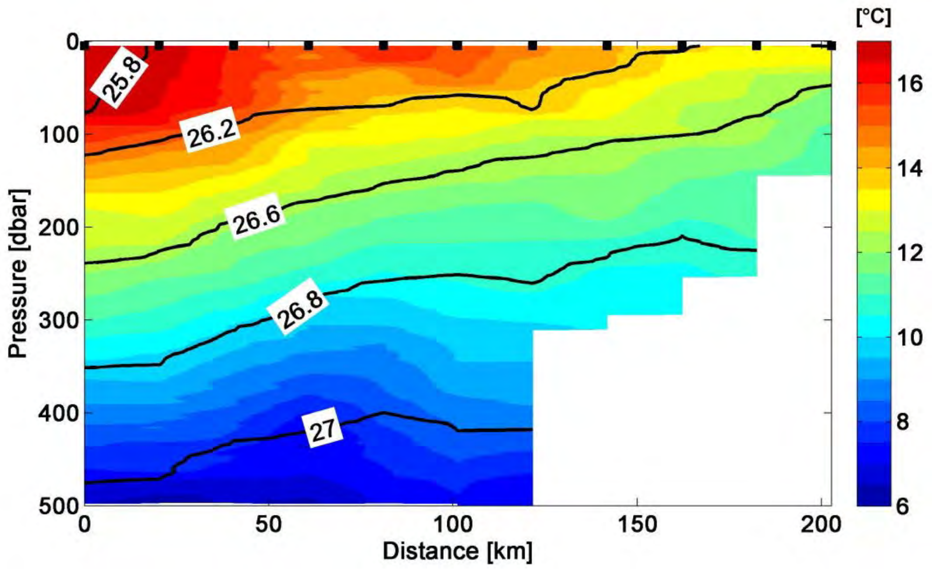

Figure 5.2: Vertical distribution of potential temperature along 24.25°S during cruise M132. Black lines show selected isopycnals. White areas are on the Namibian shelf (shallower than 500 m).

An example of a section crossing a filament in North-South direction is given in Figure 5.3. The filament had been identified in a satellite picture of sea surface temperature (cf. Hösen et al., 2016) and the location of the section was chosen accordingly. While crossing the filament ocean surface temperatures dropped from 18.5°C to 16.5°C in its center. The temperature anomaly measured in the CTD casts was comparable to the anomaly seen in the SST image in the center of the filament (-2.5°C). Outside the filament a warm surface layer covering the upper 50 m of the water column was found, but mixed layers within the filament showed only depths of 20-30 m. Gradients of surface temperature were pronounced on both the northern and southern side of the filament; steeper isotherms however occurred at the southern boundary in this realization. Below the mixed layer the filament was stratified in temperature, although doming of isotherms and isopycnals was seen even at 500 m depth (not shown).

The salinity distribution reveals the core of the filament as a low salinity region when compared to the surroundings (Figure 5.3). Salinity values in the upper 200 m of the filament correspond to salinity found in central water at about 200 m depth. Filaments can therefore be connected to the upwelling. For the central water masses two different sources were determined, distinguishable in oxygen content (Figure 5.4). Contributions from the Indian Ocean show a minimum in oxygen content, while central waters from the South Atlantic feature high oxygen contents.

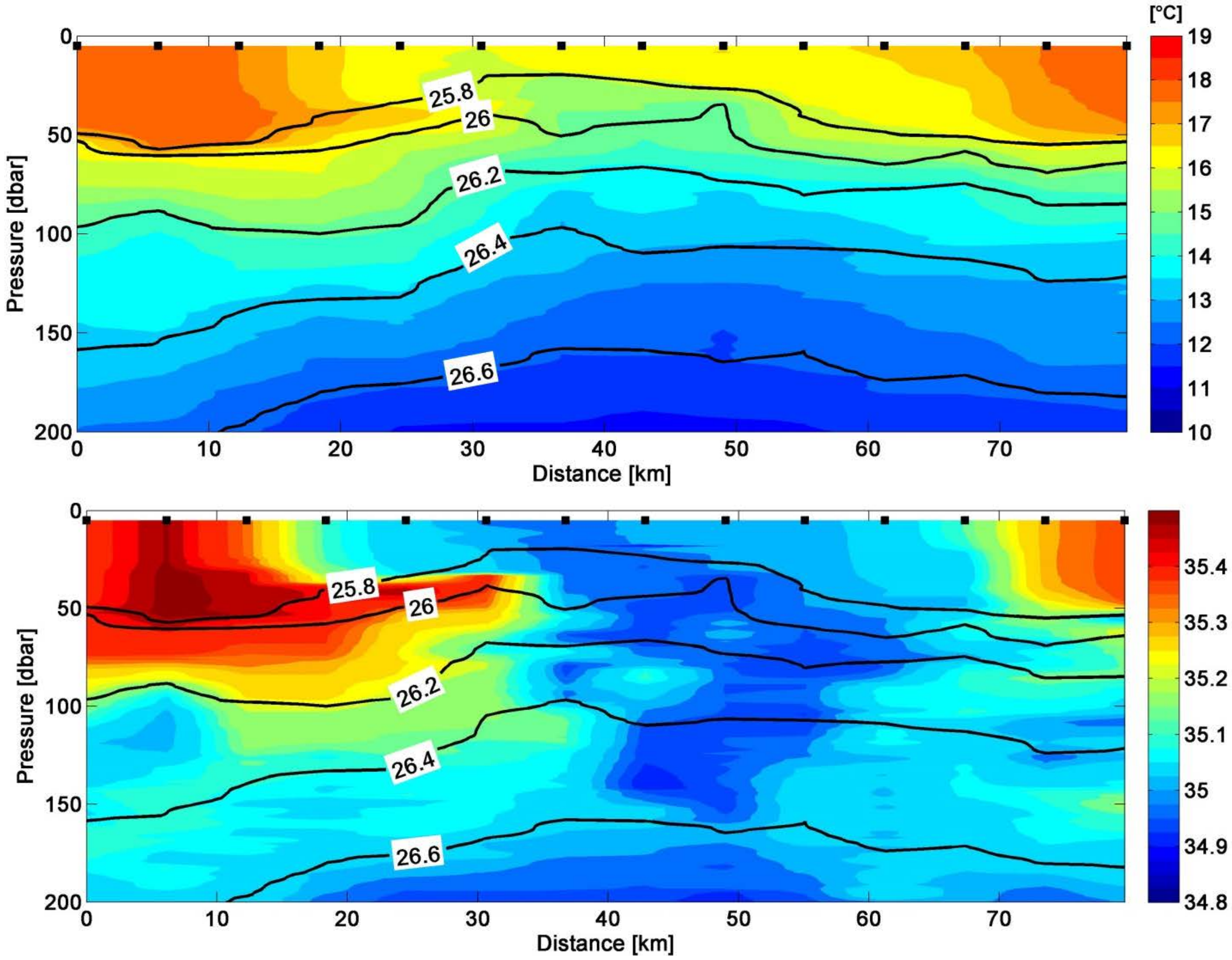

Figure 5.3: Vertical distribution of potential temperature (upper panel) and practical salinity (lower panel) along a section crossing a filament. Black lines show selected isopycnals.

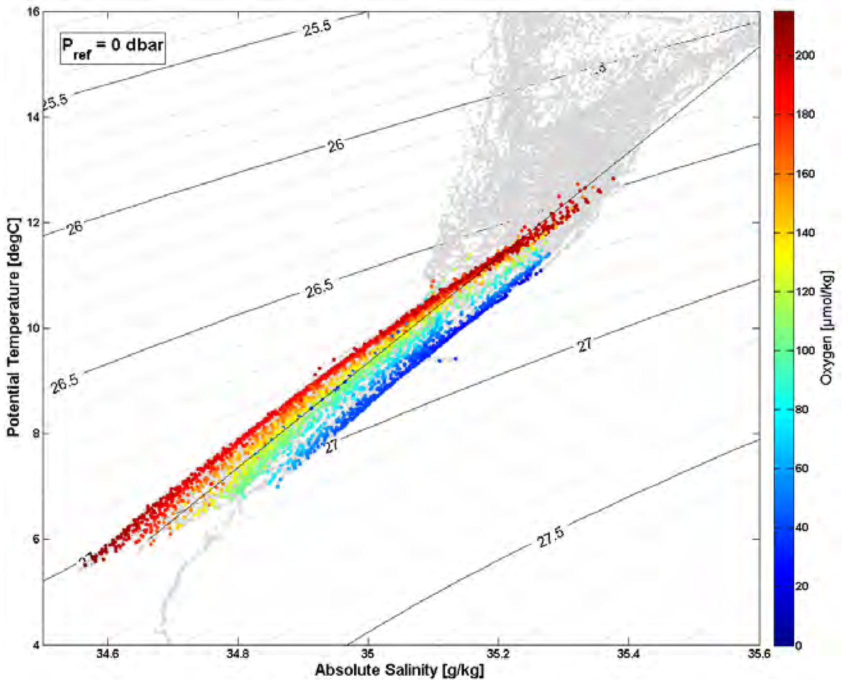

Figure 5.4: Temperature-Salinity diagram of CTD profiles obtained during cruise M132. For central water masses dots were colored according to their oxygen content.

5.2 LADCP Measurements

(K. Jochumsen, T. Wasilewski)

Two Lowered Acoustic Doppler Current Profilers (LADCP) of type Teledyne-RD Instruments (T-RDI) Workhorse Monitor, operating at 300 kHz, were attached to the carousel water sampler. They were operated in a synchronized master-slave configuration in which the downward looking master device (s/n 22763) triggers the upward looking slave device (s/n 22762). Both instruments were used with a ping rate of 1 Hz and a 8 m depth cell size. The power for both devices was supplied from an external pressure housing (s/n 3001). As the LADCPs lack an internal pressure gauge, CTD pressure profiles were incorporated during the LADCP data processing to obtain the exact depth information of the LADCP instruments during the cast. LADCP data were recorded on all CTD casts. The data were processed with the LDEO LADCP software (A. M. Turnherr, 2010).

5.3 Microstructure Profiling

(L. Umlauf, P. Holtermann)

One key instrument of the observational program was a MSS90-L microstructure profilers (s/n 055) from ISW (Germany), equipped with two airfoil shear probes for turbulence measurements, a fast FP07 thermistor, a Seapoint turbidity sensor, and precision CTD sensors from SST (Germany). In total, 800 full-depth profiles were obtained with this instrument during short transects and in the vicinity of fixed stations (see summary in Tab. 5.2), yielding a detailed description of stratification and mixing parameters inside the filaments and fronts we encountered in our study area.

During these microstructure measurements, R/V METEOR cruised slowly (typical speed: 1-2 kn) against wind and waves while microstructure profiles were taken in yo-yo mode from the stern of the ship down to approximately 100-150 m depth. Typically, a series of 5-8 profiles was obtained following CTD measurements at fixed stations. In a few cases, microstructure measurements were also obtained on longer transects to gain a detailed picture of frontal structures. These microstructure transects were often combined with measurements from a towed research catamaran and a towed thermistor chained as described in more detail below.

Table 5.2. Summary of microstructure profiler deployments. Deployment times and positions refer to the start of the deployment according to R/V METEOR's station book. Station names ending with "A" and "B" denote the beginning and end of microstructure transects. The last column indicates whether the MSS was deployed simultaneously with the research catamaran (CATM) or with the towed thermistor chain (THERM). During deployment MSS56, the MSS was attached to the standard CTD for sensor inter-calibration.

MSS ID	Meteor ID	Date	Time (UTC)	Longitude	Latitude	Comment
MSS01	1450	15-Nov-2016	16:53	014°02.8800E	23°00.0102S	
MSS02	1473	20-Nov-2016	19:00	012°02.9400E	26°39.0198S	
MSS03	1475	20-Nov-2016	21:21	012°02.6502E	26°42.2598S	
MSS04	1477	20-Nov-2016	23:24	012°02.3802E	26°45.6000S	
MSS05	1479	21-Nov-2016	1:20	012°02.0700E	26°48.8802S	
MSS06	1481	21-Nov-2016	3:14	012°01.7802E	26°52.1598S	
MSS07	1483	21-Nov-2016	5:01	012°01.5000E	26°55.4598S	

MSS08	1485	21-Nov-2016	6:58	012°01.1802E	26°58.7802S	
MSS09	1491	21-Nov-2016	15:12	012°01.1202E	26°58.7802S	
MSS10	1493	21-Nov-2016	17:15	012°01.4898E	26°55.4700S	
MSS11	1495	21-Nov-2016	19:40	012°01.7802E	26°52.1700S	
MSS12	1497	21-Nov-2016	22:06	012°02.1102E	26°48.8898S	
MSS13	1499	22-Nov-2016	0:28	012°02.4300E	26°45.5802S	
MSS14	1501	22-Nov-2016	2:24	012°02.6598E	26°42.2298S	
MSS15	1503	22-Nov-2016	4:21	012°03.0102E	26°38.9700S	
MSS16	1505	22-Nov-2016	6:37	012°03.2802E	26°35.7102S	
MSS17	1508	22-Nov-2016	10:59	012°03.6102E	26°32.4198S	
MSS18	1510	22-Nov-2016	13:04	012°03.9000E	26°29.1300S	
MSS19	1512	22-Nov-2016	15:08	012°04.1802E	26°25.8000S	
MSS20	1515	22-Nov-2016	17:20	012°04.4898E	26°22.4898S	
MSS21	1517	22-Nov-2016	19:51	012°04.7802E	26°19.1898S	
MSS22	1519	22-Nov-2016	22:22	012°05.1102E	26°15.9000S	
MSS23A	1523	23-Nov-2016	15:27	013°24.6900E	25°50.9598S	CATM
MSS23B	1523	23-Nov-2016	19:10	013°19.3200E	25°50.9502S	CATM
MSS24A	1525	23-Nov-2016	21:37	013°26.1300E	25°50.9502S	CATM
MSS24B	1525	24-Nov-2016	1:28	013°18.5100E	25°50.9400S	CATM
MSS25A	1527	24-Nov-2016	4:42	013°26.6400E	25°51.2598S	CATM
MSS25B	1527	24-Nov-2016	8:42	013°17.6298E	25°50.8902S	CATM
MSS26	1550	26-Nov-2016	9:01	012°55.6002E	25°59.1798S	
MSS27A	1552	26-Nov-2016	11:09	012°58.7100E	25°59.2602S	THERM
MSS27B	1552	26-Nov-2016	13:25	013°00.6900E	26°02.1300S	THERM
MSS28A	1554	26-Nov-2016	15:07	012°58.5900E	25°59.1498S	CATM
MSS28B	1554	26-Nov-2016	18:05	013°02.1198E	26°04.2702S	CATM
MSS29	1556	26-Nov-2016	19:38	013°01.8300E	26°03.7398S	
MSS30	1558	26-Nov-2016	21:11	013°03.3702E	26°05.9898S	
MSS31	1560	26-Nov-2016	22:41	013°04.9398E	26°08.3202S	
MSS32	1562	27-Nov-2016	0:14	013°06.4302E	26°10.5600S	
MSS33A	1579	28-Nov-2016	9:13	010°59.8500E	26°30.9498S	THERM
MSS33B	1579	28-Nov-2016	17:57	011°00.4302E	26°45.0600S	THERM
MSS34	1582	30-Nov-2016	21:51	012°05.1000E	26°15.8898S	
MSS35	1584	30-Nov-2016	23:40	012°04.8402E	26°19.2198S	
MSS36	1586	1-Dec-2016	1:19	012°04.5498E	26°22.4898S	
MSS37	1588	1-Dec-2016	3:05	012°04.1898E	26°25.8300S	
MSS38	1590	1-Dec-2016	5:00	012°03.9198E	26°29.1600S	
MSS39	1592	1-Dec-2016	6:48	012°03.5802E	26°32.4000S	
MSS40	1594	1-Dec-2016	8:46	012°03.2898E	26°35.7000S	
MSS41	1596	1-Dec-2016	10:46	012°03.0000E	26°39.0000S	
MSS42	1598	1-Dec-2016	12:42	012°02.7000E	26°42.3402S	
MSS43	1600	1-Dec-2016	14:34	012°02.3898E	26°45.6300S	
MSS44	1602	1-Dec-2016	16:19	012°02.0898E	26°48.8700S	
MSS45	1604	1-Dec-2016	18:07	012°01.8102E	26°52.2300S	
MSS46	1606	1-Dec-2016	20:15	012°01.5000E	26°55.4898S	
MSS47	1608	1-Dec-2016	22:14	012°01.2198E	26°58.8198S	
MSS48A	1609	2-Dec-2016	1:56	012°03.6600E	26°32.5200S	THERM

MSS48B	1609	2-Dec-2016	10:41	012°02.2500E	26°47.2098S	THERM
MSS49	1614	2-Dec-2016	22:32	012°51.0198E	26°12.0300S	
MSS50	1616	3-Dec-2016	0:09	012°52.5000E	26°14.0400S	
MSS51	1618	3-Dec-2016	1:43	012°54.0102E	26°16.0200S	
MSS52	1620	3-Dec-2016	3:18	012°55.5498E	26°18.0798S	
MSS53	1622	3-Dec-2016	4:51	012°57.0300E	26°19.9998S	
MSS54	1624	3-Dec-2016	6:29	012°58.5198E	26°22.0200S	
MSS55	1626	3-Dec-2016	8:25	013°00.0000E	26°24.0102S	
MSS56	1627	3-Dec-2016	9:19	013°00.1500E	26°25.2402S	CTDCALIB
MSS57	1632	4-Dec-2016	12:06	014°02.5500E	26°47.4000S	
MSS58	1633	4-Dec-2016	13:22	014°01.9500E	26°50.7000S	
MSS59	1634	4-Dec-2016	14:50	014°00.7800E	26°54.1500S	
MSS60	1635	4-Dec-2016	16:15	014°00.3102E	26°57.5502S	
MSS61	1636	4-Dec-2016	17:34	013°59.3700E	27°01.0500S	
MSS62	1639	5-Dec-2016	14:06	014°06.0198E	26°36.1302S	
MSS63	1641	5-Dec-2016	15:46	014°05.0298E	26°39.4698S	
MSS64	1643	5-Dec-2016	17:17	014°04.2702E	26°42.5598S	
MSS65	1645	5-Dec-2016	19:10	014°03.4902E	26°45.8100S	
MSS66	1647	5-Dec-2016	21:05	014°02.6298E	26°49.0500S	
MSS67	1649	5-Dec-2016	22:51	014°01.8198E	26°52.3698S	
MSS68	1651	6-Dec-2016	0:39	014°00.8700E	26°55.5798S	
MSS69	1653	6-Dec-2016	2:37	013°59.9400E	26°58.8600S	
MSS70	1655	6-Dec-2016	4:29	013°59.3100E	27°02.2302S	
MSS71	1657	6-Dec-2016	6:26	013°58.5300E	27°05.4000S	
MSS72	1659	6-Dec-2016	8:51	013°57.6798E	27°08.7498S	
MSS73	1661	6-Dec-2016	10:54	013°56.9502E	27°12.0798S	
MSS74A	1662	6-Dec-2016	15:16	014°04.5702E	26°41.2602S	CATM
MSS74B	1662	7-Dec-2016	5:39	013°58.0302E	27°07.8402S	CATM
MSS75A	1668	7-Dec-2016	14:48	014°02.6598E	26°49.1802S	
MSS75B	1668	7-Dec-2016	22:02	013°59.3400E	27°02.6100S	

5.4 Research Catamaran

(L. Umlauf, T. Heene)

To investigate the uppermost region of the water column without contamination from the wake of the ship, turbulence measurements on longer transects were often accompanied by measurements from a research catamaran that was towed 100-150 m behind the ship, laterally shifted to be outside the ship's wake. During these measurements, the catamaran was towed at a speed of approximately 2 kn. Occasionally, the catamaran was also towed in stand-alone mode (without MSS measurements) at a higher towing speed of 4-5 kn. The catamaran was equipped with a downward-looking 300 kHz broad-band ADCP (#1137) from RDI (USA), using an on-board GPS system to monitor the motion of the catamaran, and correct the velocity measurements accordingly. On some of the transects, in order to investigate the near-surface temperature structure, we also attached a 20-25 m thermistor chain with 13 high-resolution temperature/pressure sensors from RBR (Canada) to the rear end of the catamaran. The sensors used in the thermistor chain are listed in Tab. 5.4. This thermistor chain was sometimes also attached to the starboard crane on the after deck, and towed at approximately 10 m distance besides the ship (corresponding deployments are indicated in Tab. 5.2). All catamaran measurements are compiled in Tab. 5.5.

Table 5.3. Sensors used in the thermistor chain

Sensor Type	Serial No
RBR TR1060	19894
RBR TR1060	19895
RBR TR1060	20669
RBR TR1060	20670
RBR TR1060	20671
RBR TDR2050	16162
RBR soloT	76359
RBR soloT	76360
RBR soloT	76361
RBR TDR2050	23916
RBR soloT	76385
RBR soloT	76386
RBR duet	82701

Table 5.4. Summary of start and end points of the catamaran transects. The last two columns indicate if the towed thermistor chain was attached, and if microstructure measurements were carried out simultaneously.

CAT ID	Meteor ID	Date	Time (UTC)	Longitude	Latitude	Chain	MSS
CAT01A	1523	23-Nov-2016	15:15	013°24.8802E	25°50.9598S	THERM	MSS
CAT01B	1523	23-Nov-2016	19:13	013°19.2798E	25°50.9502S	THERM	MSS
CAT02A	1524	23-Nov-2016	19:32	013°19.6902E	25°50.4600S	THERM	
CAT02B	1524	23-Nov-2016	21:21	013°26.1300E	25°50.9100S	THERM	
CAT03A	1525	23-Nov-2016	21:33	013°26.2398E	25°50.9502S	THERM	MSS
CAT03B	1525	24-Nov-2016	01:28	013°18.5100E	25°50.9400S	THERM	MSS
CAT04A	1526	24-Nov-2016	01:42	013°18.5100E	25°50.7498S	THERM	
CAT04B	1526	24-Nov-2016	04:29	013°26.5998E	25°50.8800S	THERM	
CAT05A	1527	24-Nov-2016	04:42	013°26.6400E	25°51.2598S	THERM	MSS
CAT05B	1527	24-Nov-2016	09:09	013°16.9398E	25°50.8902S	THERM	MSS
CAT06A	1554	26-Nov-2016	15:01	012°58.4298E	25°58.9302S	THERM	MSS
CAT06B	1554	26-Nov-2016	18:24	013°02.3502E	26°04.6200S	THERM	MSS
CAT07A	1630	3-Dec-2016	17:49	014°05.9298E	26°32.9502S		
CAT07B	1630	4-Dec-2016	3:07	013°57.1200E	27°11.4498S		
CAT07C	1630	4-Dec-2016	5:18	013°48.0402E	27°03.0300S		
CAT07D	1630	4-Dec-2016	6:50	013°49.7202E	26°55.5798S		
CAT08A	1662	6-Dec-2016	15:10	014°04.6302E	26°41.0598S	THERM	MSS
CAT08B	1662	7-Dec-2016	6:05	013°57.8400E	27°08.5500S	THERM	MSS

First results

The small-scale variability of filaments and mixed-layer fronts was the central research focus of the group from IOW. As the mixed layer was often only a few tens of meters thick, the research catamaran turned out to be a useful tool to investigate near-surface processes unaffected by disturbances caused by the wake of the ship (see instrument description above).

Using this device, we were able to identify a number of sharp mixed-layer fronts, presumably generated by the straining of large-scale density gradients by mesocale eddies that were typical features in our study area. An example observed during one of the first catamaran transects is shown in Fig. 5.5.

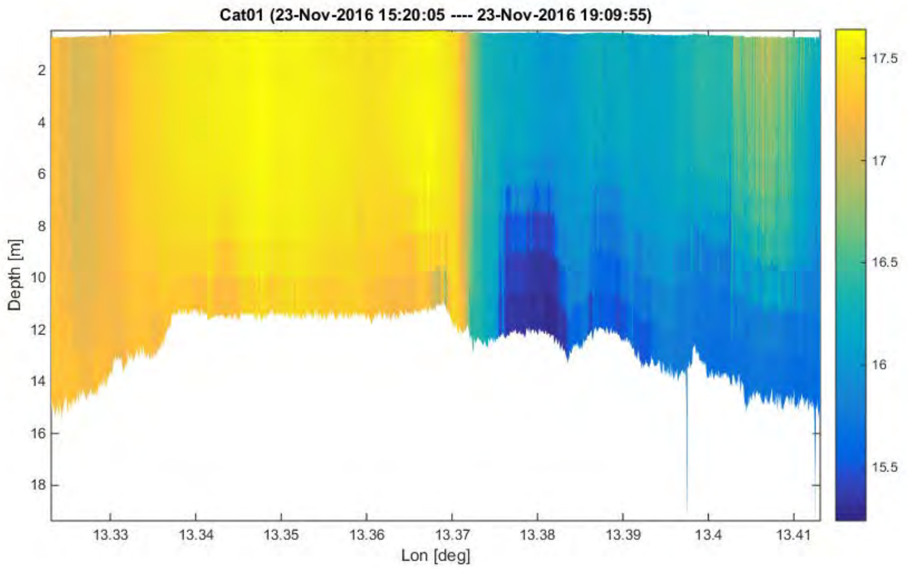

Figure 5.5: Near-surface temperature from a short catamaran transect between positions CAT01A and CAT01B (see Tab. P3). Note the sharp mixed-layer front near the center of the transect.

The temperature in this feature changed by more than 1 °C over a distance of the order of 100 m, resulting in a remarkably strong horizontal density gradient.

Turbulence microstructure measurements, typically conducted in parallel with the catamaran tows, revealed the internal structure of such fronts. Data from a somewhat wider front at the southern end of one of the upwelling filaments investigated during our cruise is shown in Fig. 5.6. The northern side of the front, i.e. the part characterized by cold upwelling waters, exhibited a strongly turbulent surface mixing layer that extended down to approximately 40 m depth, where it was capped by a stable density interface. Inside the frontal transition zone between the cold upwelling and warm ambient waters at the southern end of the transect, strong horizontal density gradients can be identified in Fig. P2. The tendency for restratification induced by such gradients leads to a suppression of turbulence in the mixing layer, which is most evident in a strong reduction of the mixing layer depth to approximately 10 m, i.e. more than four times smaller compared to the central part of the filament that did not exhibit horizontal density gradients (Fig. 5.6).

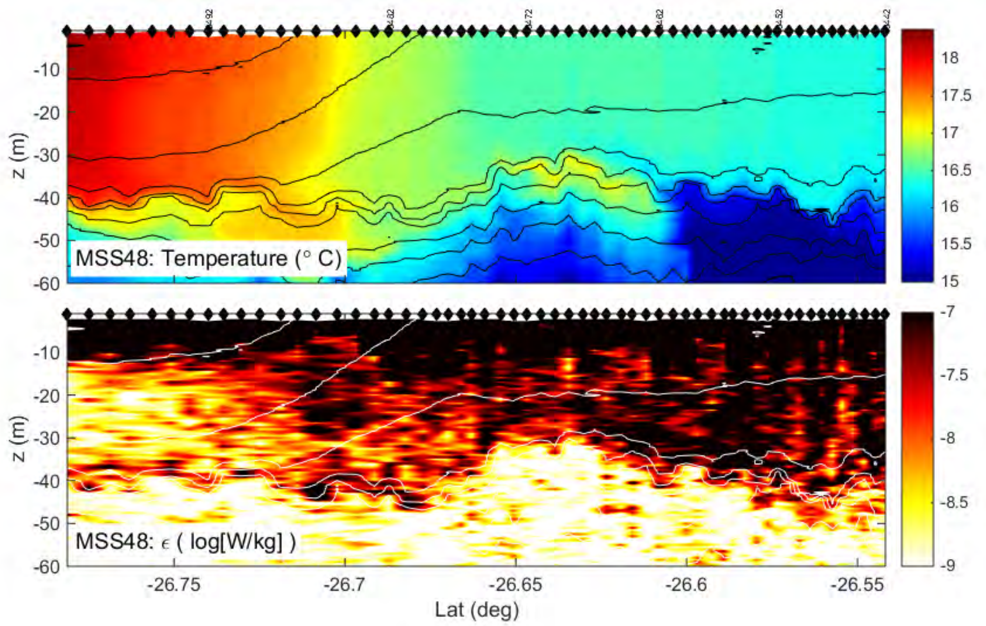

Figure 5.6: Temperature (upper panel) and turbulence dissipation rate during an approximately 10 km long microstructure transect across the flank of an upwelling filament (transect coordinates are given in Tab. P1). Black/white contour lines denote isopycnals at 0.1 kg m^{-3} intervals.

Similar fronts have also been observed by the gliders from the HZG research group, as discussed in more detail below. The processes by which such "sub-mesocale" mixed-layer fronts are generated and destroyed, and the energetics associated with them, are one of the core topics of sub-project T2 of the TRR181, in the framework of which this cruise was carried out.

5.5 Glider

(J. Carpenter, L. Schultze)

The glider operations during M132 were part of a DFG project to study energy transfers primarily within and around the surface mixed layer of the ocean due to the dynamics of submesoscale features (TRR 181, T2). Submesoscales are typically from 100 m up to tens of kilometres, and are recognized by strong horizontal gradients in ocean water properties. This often consists of two fundamental structures: (i) fronts, where there is a sharp change in water properties (e.g., temperature, salinity, density) from one water mass to another, such as colder upwelling waters and warmer basin waters, and (ii) filaments, where the horizontal property gradients are confined to long thin geometries. Our goal was to sample these structures using ocean gliders.

Ocean gliders are autonomous underwater vehicles that can be remotely controlled via an iridium satellite connection. They consist of a hull section that contains most of the scientific instrumentation, and wings to provide lift (see figure below). We deployed two Slocum gliders manufactured by Teledyne-Webb Research. The goals of the present measurement campaign are particularly focused on quantifying the small-scale pathways of energy transfer from the larger scale submesoscales to the smaller turbulence scales. Therefore, both gliders were carrying turbulence microstructure sensor packages mounted to the top of the gliders (Figure 5.7).

Figure 5.7: A Slocum ocean glider together with MicroRider turbulence package (black on top).

Equipment

Two Slocum Ocean Gliders (s/n 204 and 501) manufactured by Webb Teledyne Research were used for the measurements. They are both of the G2-type with ‘Sebastian’ a shallow glider capable of diving to approximately 100 m depth, and ‘Comet’ a deep glider capable of diving as deep as 1000 m. The gliders scientific instrumentation consists of a Seabird pumped CTD, a Wetlabs Ecopuck for the measurement of fluorescence and optical backscatter, as well as standard GPS navigation systems. Both gliders were equipped with MicroRider turbulence packages manufactured by Rockland Scientific Instruments (s/n 111 and 115) having 2 air-foil shear sensors and 2 FP07 micro-temperature sensors. In addition, Comet was carrying an RDI manufactured phased-array ADCP for measuring currents and velocity shear.

Sampling Strategy

The first glider deployed was Comet, on 22 November at 10:00 UTC at the location 26.578°S, 12.043°E. After an initial test dive to 100 m depth the weight was altered by 30 g to fine-tune the ballasting. The glider was set to sample within an upwelling filament to a depth of 250 m (see Figure 5.8). The glider performed approximately 200 profiles (dives plus climbs) over the period until it was recovered on 27 November at 12:00 UTC at the position 26.542°S, 11.689°E.

The second glider, Sebastian, was deployed on 23 November at 15:00 UTC at the location of 25.829°S, 13.313°E. This location corresponded to a strong nearby front between upwelling waters and ocean surface waters (see Figure 5.8). The glider was programmed to dive to a depth of 90 m, and performed a total of approximately 400 profiles (dives and climbs). During the initial test of the ballasting it was noticed that the conductivity cell was reading too high. This was confirmed after the first couple of dives as well, and is discussed in the next section. The path of the glider crossed the upwelling front a total of 4 times before it was recovered on 27 November at 04:00 UTC at the location of 25.847°S, 13.714°E.

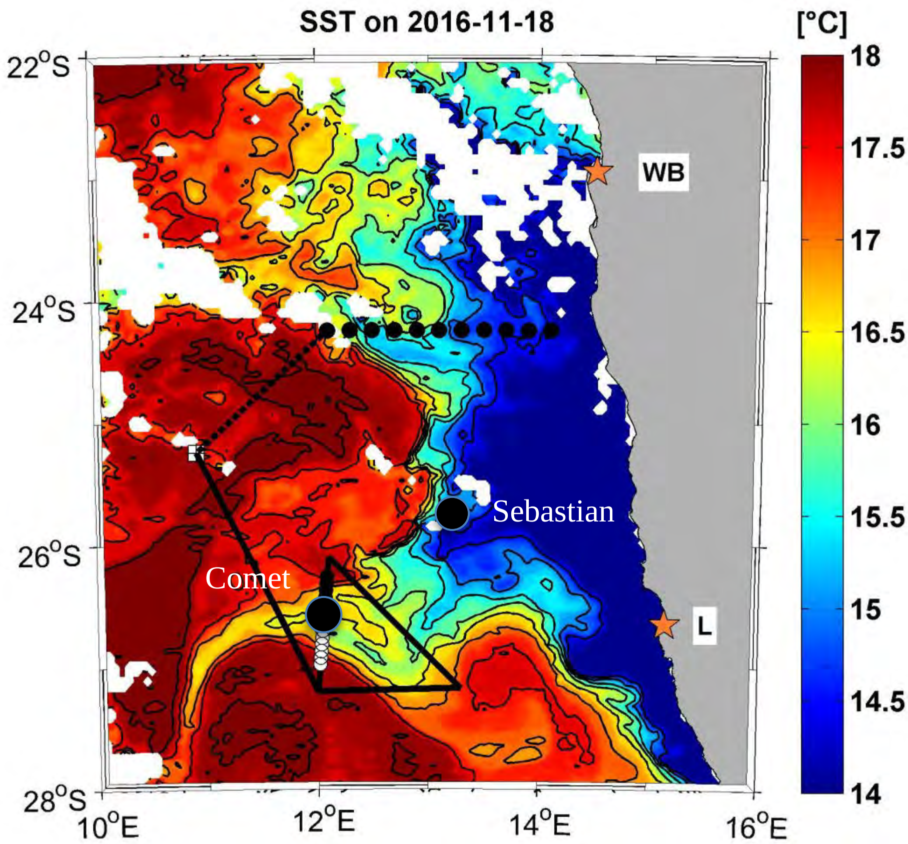

Figure 5.8: Satellite sea surface temperature field with the deployment locations of the gliders Comet and Sebastian. WB: Walvis Bay; L: Lüderitz.

Initial Results

Upon recovery of Comet, it was seen that there were communication problems between the main science processor of the glider and the ADCP device installed. This caused the science processor to slow its recording of all data from the CTD and other devices controlled through this processor. Since the microstructure data has its own processor, it was not affected. This resulted in the irregular and slow logging of data at an approximate rate of 24 Hz, rather than the normal 1 Hz. In addition, no ADCP data was recorded. Our best guess at to the cause of the problem was a faulty connection between the science processor and the ADCP, but more work has to be done in order to determine the exact cause, as well as to produce reliable initial results from this glider data.

The shallow glider, Sebastian, has recorded a time series of temperature and depth that is shown in Figure 5.9. The large changes in temperature (> 1°C) of the surface layer of the ocean demonstrate that the glider has transited across the upwelling front on four occasions. In addition to the temperature, a first estimate of turbulent kinetic energy dissipation rate (in W/kg) is plotted in the bottom panel of the figure. This was calculated from the measurements of the two airfoil shear probes on the MicroRider (s/n 111). It shows generally that enhanced dissipation can always be found in the surface mixed layer, as well as often at reasonable depths below this. The largest rates of dissipation are, in fact, observed as deep as 60 m, and can often be associated with the largest horizontal temperature gradients.

The potential density surfaces have not been plotted for Sebastian due to the calibration problem found with the conductivity cell of the CTD. We will conduct a post-deployment calibration to help determine the appropriate corrections, however.

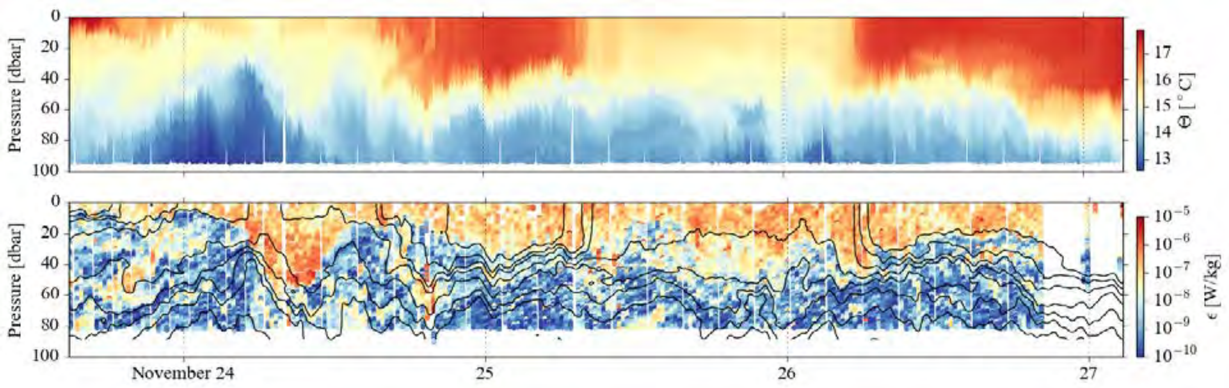

Figure 5.9: Transects in depth and time from the glider 'Sebastian' showing in-situ temperature (upper panel) and initial estimates of the dissipation rate of turbulent kinetic energy (lower panel). The iso-temperature surfaces are also plotted in the bottom panel.

The large gap at the end of the microstructure plot (beginning late on Nov. 26) is due to the sudden failure of the sensors. Upon recovery of Sebastian, it was seen that one of the FP07 micro-temperature sensors was physically broken. This appears to have occurred suddenly to all sensors (including the protected pressure sensor) during the flight of the glider at approximately 60 m depth. The cause of the damage is unknown.

5.6 Underway systems

5.6.1 Underway-CTD

(K. Jochumsen, D. Hainbucher)

Underway measurements of pressure, temperature and conductivity profiles were made with an Oceanscience UCTD system in order to obtain hydrographic data during transits. Due to frequent severe weather conditions the operation of the UCTD system was only possible occasionally; in total 47 casts were conducted. The tow-yo deployment mode was applied, where no spooling on the probe's spindle was carried out (Ullman and Hebert, 2014). However, 6 profiles were lost due to an error in operation (profiles 22-27 not recorded). Two UCTD probes (s/n 192 and s/n 258) were operated in turn, with each probe capturing 2-7 subsequent profiles. Data were logged internally and downloaded to a laptop after recovery of the instrument via Bluetooth. Data processing was performed afterwards, following the procedure described in Ullman and Hebert (2014) and applied in Hainbucher et al. (2015). The average depth obtained using the UCTD was approximately 330 m and varies for each profile due to variations in ship speed.

Unfortunately, the robe was torn at profile 46 (station #1612) and one probe was lost (s/n 258). Cast 47 was a calibration cast of probe s/n 192, where the probe was attached to the CTD system and lowered together (cast #1625/098). An example of UCTD measurements is shown in Figure 5.10, which is a section across the upwelling front at 25°20'S.

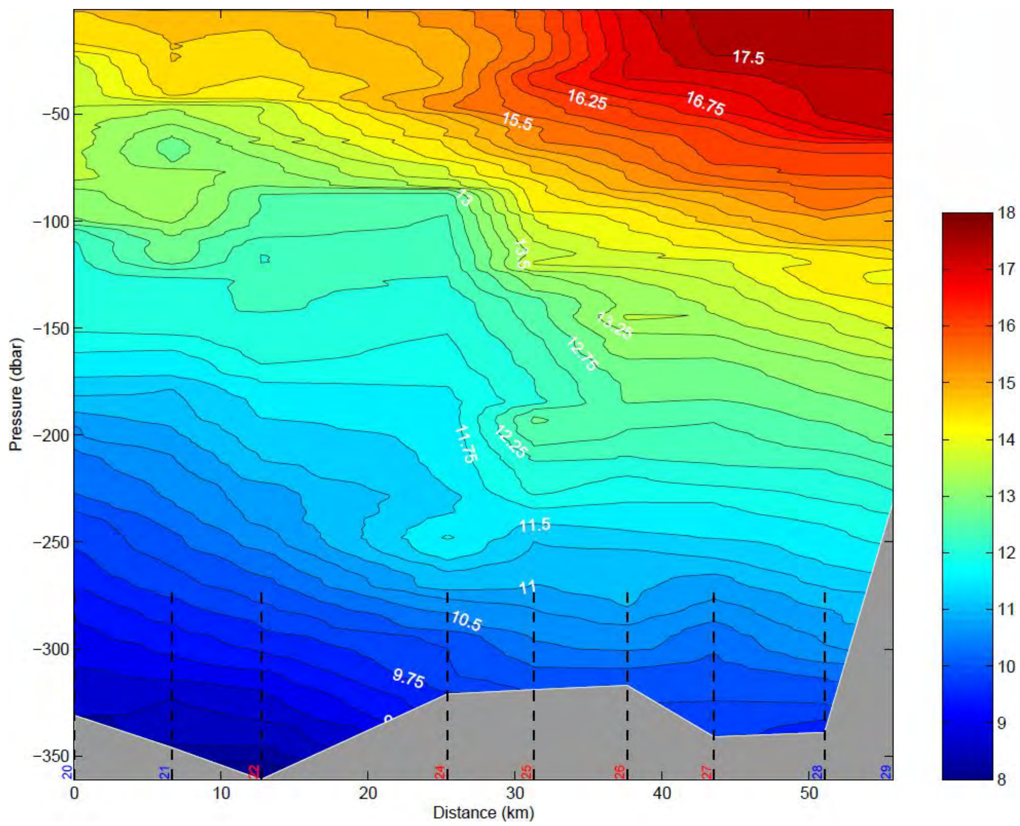

Figure 5.10: UCTD temperature section crossing the upwelling front at 25°20'S. The figure is based on uncalibrated data obtained on 25th of November 2016.

5.6.2 Scanfish

(L. Umlauf, T. Heene)

Beyond classical CTD measurements, CTD profiles were also obtained from the moving ship with the help of a towed and undulating CTD system (ScanFish from Eiva, Denmark) that contained a pumped set of sensors from Seabird for temperature (SBE3, #1456), conductivity (SBE4, #2064), pressure (#76058), and oxygen (SBE43, #157). Also included were sensors for turbidity (FLRTD-3274) and fluorescence (NTURTD-3274) from Wetlabs (USA). Due to irreparable cable damage, however, measurements with this instrument had to be discontinued on 20th November 2016. Near surface temperature distributions from ScanFish data are shown in Figure 5.11. A summary of all ScanFish transects is provided in Tab. 5.3. A calibration cast using the sensors from the Scanfish was performed at CTD station #1593/084.

Table 5.5. Start and endpoints of ScanFish transects.

SCAN ID	Meteor ID	Date	Time (UTC)	Longitude	Latitude
SF01	1463	17-Nov-2016	20:49	011°02.9700E	25°30.3498S
SF02	1463	18-Nov-2016	22:30	012°04.9800E	27°10.2900S
SF03	1463	19-Nov-2016	11:48	013°16.9602E	27°09.1098S
SF04	1463	20-Nov-2016	05:50	012°05.8998E	26°05.8698S

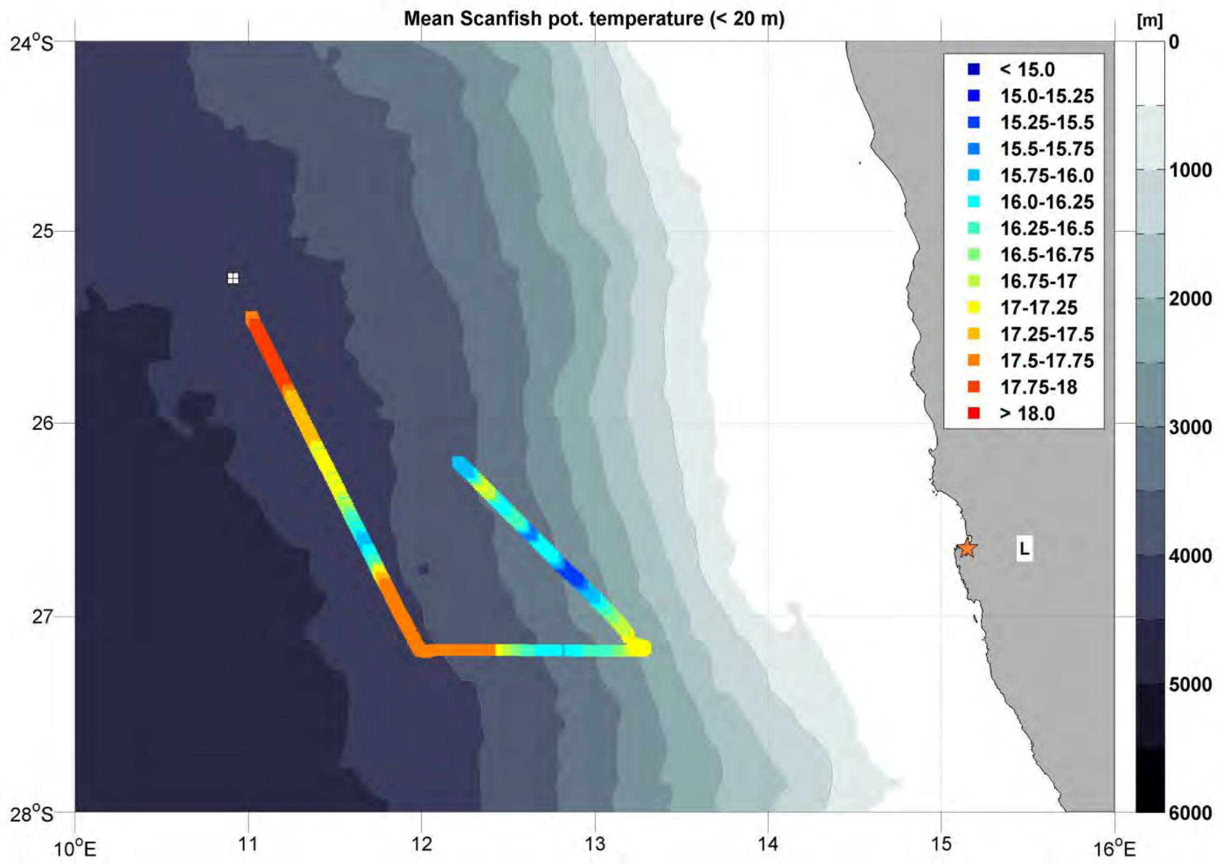

Figure 5.11: Near surface temperature distribution (average of upper 20 m) from ScanFish surveys.

5.6.3 Thermosalinograph

(K. Jochumsen, D. Hainbucher)

Underway temperature and salinity measurements were made with a Seacat SB 21E (SeaBird) installed in the ship's well. Two devices were operated simultaneously, for which water was pumped into the system from about 1.5 m depth. For calibration purposes additional water samples were taken from the tap and their salinity determined using the salinometer. Sensor pack 2 was found to provide noisy data at the beginning of the cruise. After cleaning and flushing on 18th of November the quality of the data improved considerably. However, the salinity difference to the salinometer was found to increase with time and at the end of the cruise it reached approx. 0.04, with higher values obtained from the thermosalinograph. The temporal drift of the primary sensor was even larger (see Figure 5.12), increasing the difference to the salinometer to 0.1.

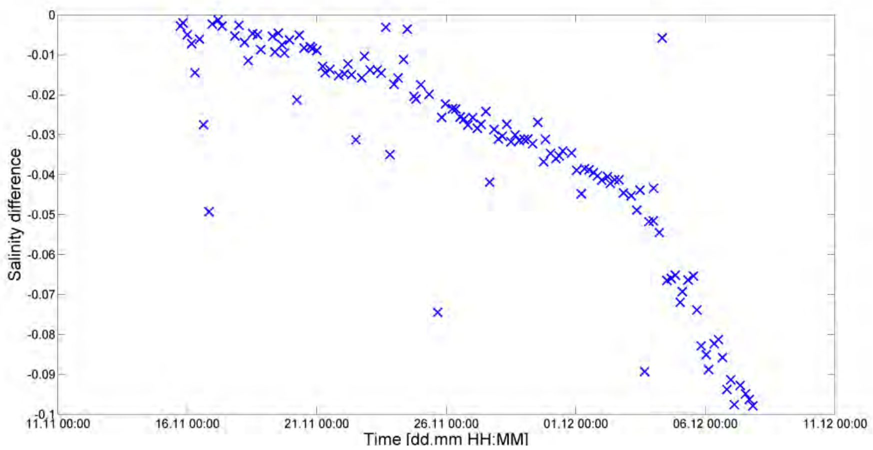

Figure 5.12: Temporal evolution of the salinity difference between the thermosalinograph (sensor 1) and the salinometer during cruise M132.

5.6.4 Vessel-mounted ADCP

(R. North, K. Jochumsen)

Underway current measurements were taken with 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 8 m, the ADCP run in narrowband mode. The instrument was controlled by computers using the conventional VMDAS software under a MS Windows system. Time between ensembles was set to 1 s.

ADCP data was processed using the software package CODAS (version 2013.04.30, see Firing et al., 1995, or http://currents.soest.hawaii.edu/docs/adcp_doc/index.html), developed by the University of Hawaii. The processing corrected for the velocity of the vessel and the misalignment angle.

Days of severe weather conditions were used to map the mesoscale current distribution in the working area (Figure 5.13). A close connection of the current field with sea surface height anomalies (SLA) was apparent, which indicates the presence of eddies. Anti-clockwise currents at positive SLA features support this assumption. The location of the filament found during the cruise is between an SLA dipole at approx. 26.5°S. Here, westward currents dominate the near-surface flow. We therefore conclude that the zonal extension of the filament is influenced by the strength and persistence of the surrounding eddies. Future work includes an analysis of the origin an lifetime of eddies found in the region; they are presumably connected to the Agulhas Retroflection.

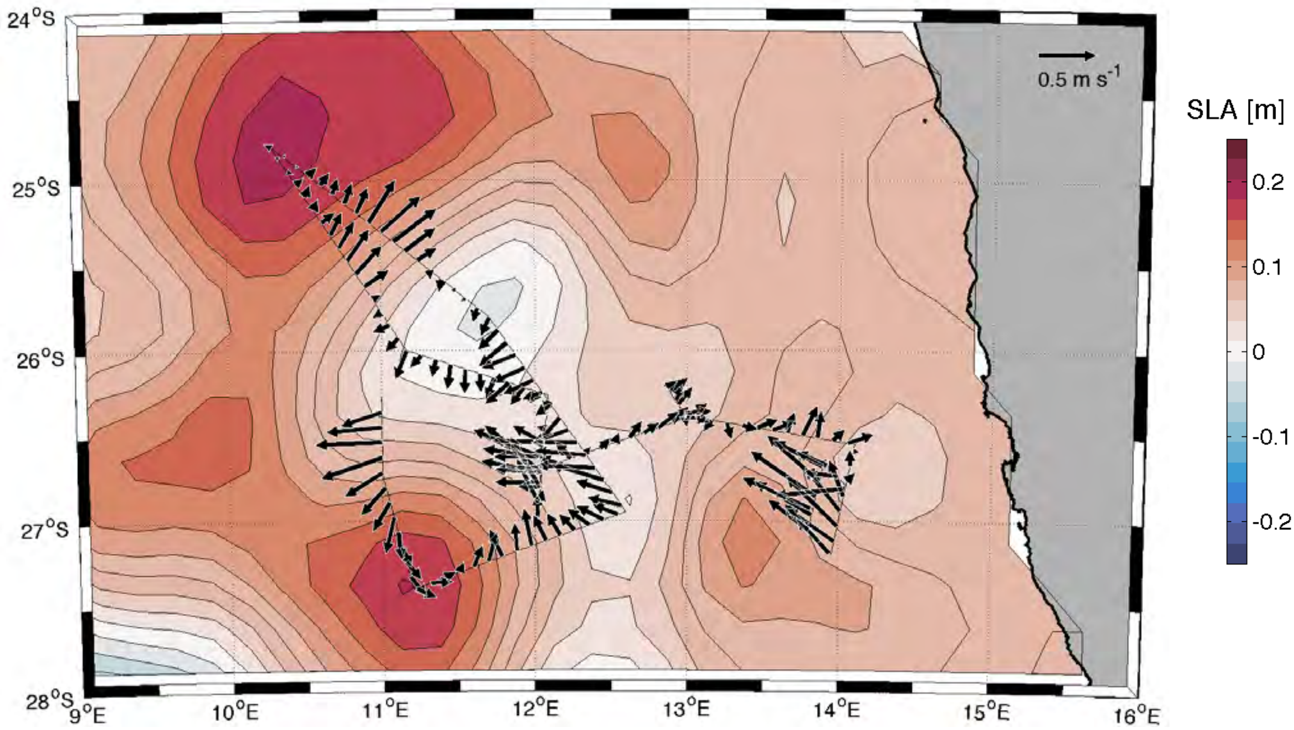

Figure 5.13: Distribution of near-surface currents (at 26 m depth) from an ADCP survey on 28th – 30th November 2016. The colored background shows sea surface height anomalies on 28th November from AVISO.

5.7 Surface drifters

(J. Dräger-Dietel, K. Jochumsen)

A Lagrangian experiment based on surface drifters was initialized during cruise M132, where 37 devices were deployed. The type of drifter was SVP-I-XDGS (MetOcean), featuring Iridium Telemetry, a drogue centered at 15 m, drogue on/off indicator, GPS positioning, and a sea surface temperature sensor. The initial transmission interval was hourly, but shortly after starting the instruments the drifters' transmissions were set to every 30 minutes.

The deployment strategy was focused on capturing submesoscale dynamics at gradients in an upwelling filament. Drifters were deployed in groups of three instruments (triplets), ideally arranged in a triangle with 100 m and 200 m side length. Conditions during the deployment were sometimes rough and occasionally larger or shorter initial distances were obtained. While crossing a front, deployment locations were chosen in distances of 5 km (Figure 5.14). In total, 4 deployment locations were occupied, where 4/4/2/2 triplets were released (Table 5.6). The last deployment included one additional drifter, as altogether 37 devices were purchased for the experiment.

Drifters were found to deliver data as planned, but one device (#300234064527060) failed to obtain position fixes after 15th December and is considered lost. The instrument was either picked up by a vessel and stored inside, or its antenna was damaged.

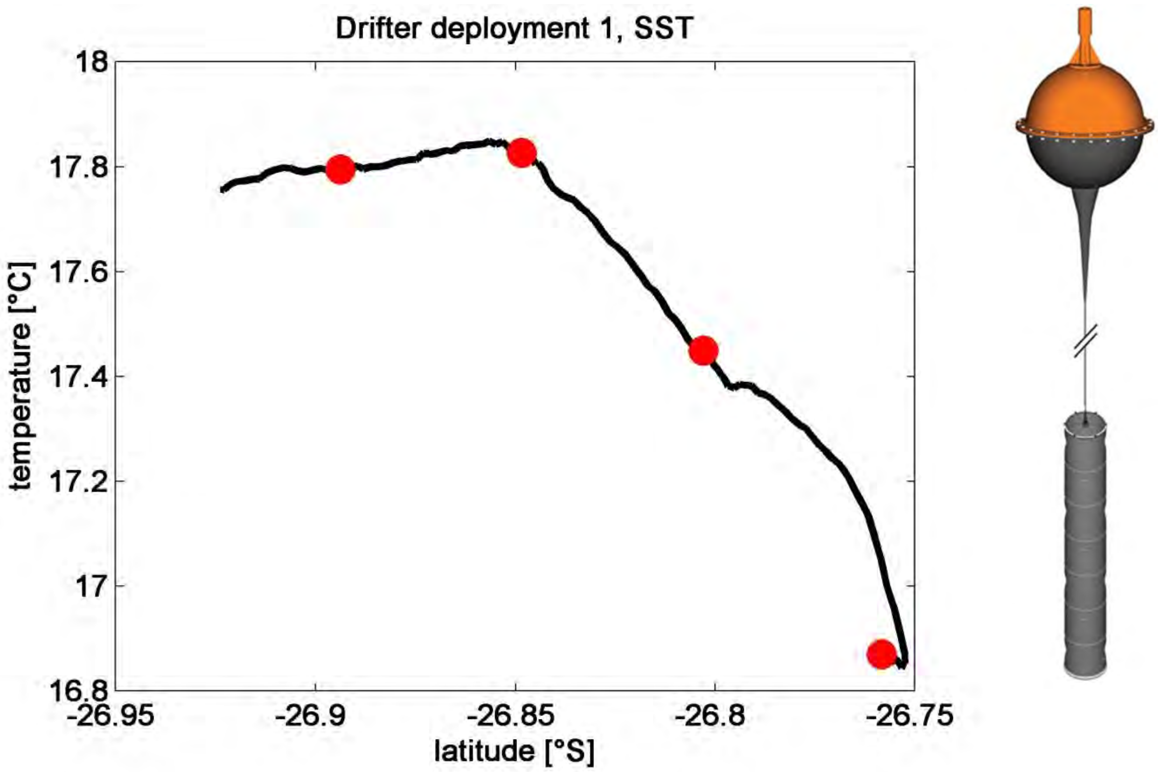

Figure 5.14: Sea surface temperature at drifter deployment location 1. Red dots indicate the deployment positions of triplets. A schematic picture of an SVP drifter is shown on the right side of the figure.

Initial Results

A first analysis of the evolution of pair separation with time for the initial pairs of the first two deployments sowed that the conditions at the northern and southern boundary of the filament differ significantly from each other (Figure 5.15). Drifters deployed at the southern boundary stayed together for several days and followed the filament to the west (not shown), while drifters deployed at the northern boundary started to move away from each other almost immediately. When started, the separation of the southern release occurs much more rapid than at the northern release, as seen in the slopes of the curves in Figure 5.15. A diffusive regime seems to be reached for the second drifter release (green curve) after about 20 days, while the drifters of the southern release still appear to be in a Richardson-like regime. Analyses of these trajectories will be continued within the project TRR 181 for the next years.

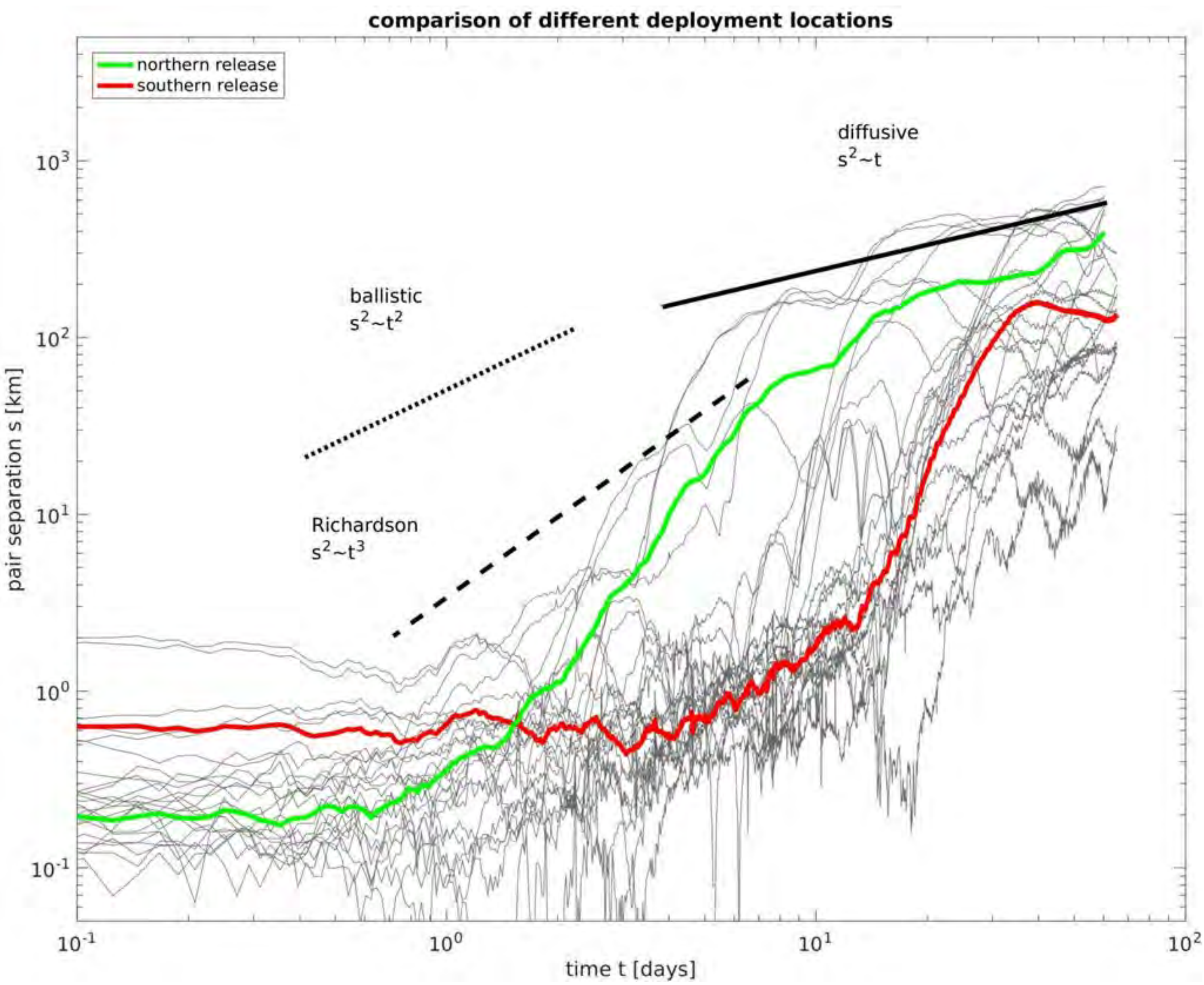

Figure 5.15: Evolution of pair separations with time (grey lines) for the first two deployments. The red and green lines show the average for each deployment. Furthermore, theoretical pair separations of ballistic, diffusive and Richardson regimes are displayed.

Table 5.6. IMEI numbers, dates and deployment positions for the drifter experiment.

		start		deployment		position	
Pos.	**IMEI#**	**date**	**time**	**date**	**time**	**lat (S)**	**long (E)**
1	300234064526070	01/12/16	16:38:00	03/12/16	10:20:20	26°20,8'S	12°57,6'E
2	300234064527070	20/11/16	8:26:00	21/11/16	11:31:05	26°50,9'S	12°02,1'E
3	300234064529060	20/11/16	8:27:00	21/11/16	10:36:50	26°48,2'S	12°02,0'E
4	300234064528040	22/11/16	7:51:00	26/11/16	8:07:07	25°58,7'S	12°55,3'E
5	300234064520050	01/12/16	16:39:30	03/12/16	10:37:14	26°20,7'S	12°57,8'E
6	300234064520070	20/11/16	8:26:30	21/11/16	10:44:22	26°48,2'S	12°02,1'E
7	300234064524060	20/11/16	8:31:00	02/12/16	11:48:30	26°39,0'S	12°03,0'E
8	300234064521070	01/12/16	16:35:00	02/12/16	12:41:00	26°41,8'S	12°02,9'E
9	300234064524070	01/12/16	16:39:00	03/12/16	10:28:27	26°20,9'S	12°57,7'E
10	300234064529040	20/11/16	8:28:30	21/11/16	9:41:47	26°45,4'S	12°02,0'E
11	300234064528070	22/11/16	8:02:00	26/11/16	6:54:40	26°03,6'S	12°58,4'E
12	300234064528050	01/12/16	16:34:30	03/12/16	11:15:11	26°23,2'S	12°59,2'E
13	300234064527060	01/12/16	16:38:30	03/12/16	11:22:36	26°23,2'S	12°59,3'E
14	300234064524020	20/11/16	8:28:00	21/11/16	9:33:44	26°45,6'S	12°02,3'E
15	300234064523060	20/11/16	8:31:30	21/11/16	12:19:50	26°53,6'S	12°02,1'E
16	300234064525070	01/12/16	16:35:30	03/12/16	10:32:52	26°20,8'S	12°57,7'E
17	300234064522030	13/11/16	10:00:00	21/11/16	9:31:09	26°45,5'S	12°02,3'E
18	300234064523040	20/11/16	8:27:00	21/11/16	10:48:10	26°48,1'S	12°02,1'E
19	300234064525030	20/11/16	8:29:00	21/11/16	12:31:15	26°53,6'S	12°02,2'E
20	300234064523020	01/12/16	16:34:00	03/12/16	11:12:05	26°23,1'S	12°59,3'E
21	300234064525020	22/11/16	7:59:30	26/11/16	6:06:27	26°06,0'S	13°00,4'E
22	300234064527030	22/11/16	7:53:00	26/11/16	7:26:37	26°01,2'S	12°57,0'E
23	300234064521000	22/11/16	7:56:00	26/11/16	7:32:58	26°01,2'S	12°57,2'E
24	300234064521010	22/11/16	7:57:00	26/11/16	6:44:21	26°03,7'S	12°58,7'E
25	300234064525000	20/11/16	8:30:30	21/11/16	11:42:20	26°50,9'S	12°02,2'E
26	300234064529000	01/12/16	16:37:00	02/12/16	12:00:46	26°39,1'S	12°03,1'E
27	300234064528010	22/11/16	7:55:00	26/11/16	7:24:00	26°01,3'S	12°57,1'E
28	300234064520010	22/11/16	7:50:00	26/11/16	8:05:20	25°58,8'S	12°55,4'E
29	300234064527020	20/11/16	8:30:00	21/11/16	11:38:20	26°51,0'S	12°02,1'E
30	300234064520030	22/11/16	7:54:30	26/11/16	8:12:22	25°58,7'S	12°55,5'E
31	300234064521020	22/11/16	7:58:00	26/11/16	6:47:52	26°03,7'S	12°58,8'E
32	300234064522010	22/11/16	8:01:00	26/11/16	5:59:40	26°06,0'S	13°00,3'E
33	300234064527050	20/11/16	8:29:30	21/11/16	12:25:50	26°53,7'S	12°02,1'E
34	300234064420990	01/12/16	16:37:30	02/12/16	11:55:10	26°39,1'S	12°03,0'E
35	300234064529420	01/12/16	16:36:30	02/12/16	12:31:53	26°41,7'S	12°02,8'E
36	300234064526050	22/11/16	8:00:30	26/11/16	5:54:43	26°06,0'S	13°00,3'E
37	300234064524430	01/12/16	16:36:00	02/12/16	12:36:00	26°41,8'S	12°02,8'E

6 Ship's Meteorological Station

(A. Raeke, M. Knobelsdorf)

In the morning of the 15th of November 2016 R/V METEOR started expedition M132 from the harbor of Walvis Bay (Namibia). At the beginning of the expedition the cruising area was located on the northeastern fringe of the subtropical high. At near coastal areas weak and variable winds were experienced. On the open sea, a glider of the previous expedition was recovered which was still taking data during the harbor stay. The significant wave height of 2.5 m and the weak wind sea of less than 0.5 m allowed the rubber dinghy to be set out for taking up the glider.

From the 16th of November the subtropical high intensified with the consequence of increasing southerly winds of 6 Bft. In the following days a low moved offshore Namibia, this resulted in a gusty southeasterly wind of strength 7 Bft. On the night to the 18th gust of 45 knots were reported. On the 18th the significant wave height reached 4 to 5 m which hampered the research work until the 19th.

From the 20th the high weakened significantly, the pressure gradient flattened and the wind abated to 3 to 4 Bft. The significant wave height ranged to 2.5 m. On the 21st a planned setting out of the glider with the rubber dinghy was postponed to the 22nd due to the wind shift to the east/ southeast and in combination with a southerly swell a cross sea developed. On the 22nd sea conditions improved and the glider was set out. A little later on the norther fringe of a small scale upper air low a local thunderstorm developed.

On the 23rd good wind and sea conditions allowed the catamaran to be set out. The significant wave height ranged only up to 1.5 m with a wind of strength 4 Bft. In the following days until the 26th the wind increased again to 5 to 6 Bft, at times to 7 Bft. The significant wave height ranged between 2 and 3 m.

On the 27th the subtropical high weakened for a while with winds deceasing to 4 Bft and the significant wave height dropping to 1.5 to 2 m. The conditions were favorable to take out the gliders with the rubber dinghy. The original weather forecasts until the end of the research period showed only a little window for a possible taking out of the gliders on the 3rd.

On the 28th with the high shifting to the east and the trough offshore Namibia the pressure gradient increased again. The wind increased to 5 to 6 Bft, on the 29th to 7 Bft with the significant wave height reaching 3.5 m. The period was used for cross sections. From the 30th until the 3rd the pressure gradient flattened a little with persisting winds of 5 to 6 Bft, at times 7 Bft. The significant sea reached a level of about 2.5 m.

On the 3rd the weakening high temporarily moved to the west while the heat low moved to the east. The wind showed strength 4 to 5 Bft and a significant wave height 1.5 to 2 m. From the 4th the high strengthened again and moved on the 5th to the Cape of Good Hope. The wind freshened to 7 Bft and the significant wave height increased to 3 to 3.5 m. These conditions allowed only cross sections. As the high moved away the pressure gradient decreased and in the remaining days until the 8th the wind reached mostly 5 to 6 Bft. The sea decreased to 2 to 2.5 m.

On transit to Cape Town the weather pattern did not change much. On the 9th/10th a low was located to the south of Cape Town bringing up a swell of 3 m into the cruising area. The wind blew with 5 to 6 Bft from the south to southeast. The air temperature was hovering around 16 to 18 degree Celsius, only local shower occurred. On the 11th of December 2016, R/V METEOR reached the harbor of Cape Town.

7 Station List M132

EXPO CODE	Statn-No.	Gear	Date	Time (UTC)	POSITION				Water depth [m]	Comments
					Latitude		Longitude			
M132	1449	CTD / LADCP	15.11.2016	16:25:00	22° 59.990	S	14° 02.972	E	137	no LADCP, #1
M132	1450	MSS	15.11.2016	16:53:00	23° 00.01	S	14° 02.88	E		MSS Teststation
M132	1451	CTD / LADCP	16.11.2016	1:13:16	24° 14.990	S	14° 06.016	E	152	#2
M132	1452	CTD / LADCP	16.11.2016	2:52:08	24° 15.012	S	13° 54.001	E	260.9	#3
M132	1453	CTD / LADCP	16.11.2016	4:53:30	24° 15.016	S	13° 41.099	E	300	#4
M132	1454	CTD / LADCP	16.11.2016	6:24:00	24° 14.99	S	13° 30.034	E	316.7	#5
M132	1455	CTD / LADCP	16.11.2016	8:18:23	24° 14.993	S	13° 17.954	E	557.2	#6
M132	1456	CTD / LADCP	16.11.2016	10:15:01	24°14.98	S	13° 06.00	E	1011.9	#7
M132	1457	CTD / LADCP	16.11.2016	12:03:14	24° 14.988	S	12° 54.034	E	1540	#8
M132	1458	CTD / LADCP	16.11.2016	13:57:15	24° 14.994	S	12° 41.992	E	2061.3	#9
M132	1459	CTD / LADCP	16.11.2016	15:49:40	24° 14.979	S	12° 29.982	E	2463	#10
M132	1460	CTD / LADCP	16.11.2016	17:31:47	24° 14.975	S	12° 17.965	E	2859	#11
M132	1461	CTD / LADCP	16.11.2016	19:19:02	24° 14.954	S	12° 05.985	E	3140.7	#12
M132	1462	Mooring	17.11.2016	5:12:00	25° 14.77	S	10° 54.84	E	-	no contact via hydrophon
M132	1462	Mooring	17.11.2016	7:00:00	25° 14.37	S	10° 54.54	E	4255	begin dredging
M132	1462	Mooring	17.11.2016	17:25:00	25° 14.92	S	10° 54.39	E	4263.7	end dredging
M132	1463	Scanfish	17.11.2016	20:49:00	25° 30.35	S	11° 02.97	E	4164.9	
M132	1463	Scanfish	20.11.2016	5:50:00	26° 05.87	S	12° 05.90	E	-	
M132	1464	CTD / LADCP	20.11.2016	7:00:42	26° 06.158	S	12° 06.254	E	3661	#13
M132	1465	CTD / LADCP	20.11.2016	10:43:11	26° 15. 92	S	12° 05.075	E	3746.4	#14
M132	1466	CTD / LADCP	20.11.2016	11:51:00	26° 19.202	S	12° 04.799	E	3753.3	#15
M132	1467	CTD / LADCP	20.11.2016	12:54:35	26° 22.518	S	12° 04.477	E	3771	#16
M132	1468	CTD / LADCP	20.11.2016	13:54:16	26° 25.817	S	12° 04.175	E	3784	#17
M132	1469	CTD / LADCP	20.11.2016	14:55:14	26° 29. 08	S	12° 03.889	E	3814	#18
M132	1470	CTD / LADCP	20.11.2016	15:55:40	26° 32.384	S	12° 03.569	E	3836	#19
M132	1471	CTD / LADCP	20.11.2016	15:54:13	26° 35.702	S	12° 03.264	E	3854	#20
M132	1472	CTD / LADCP	20.11.2016	18:02:00	26° 38.995	S	12° 02.97	E	3893.3	#21
M132	1473	MSS	20.11.2016	19:04:00	26°39.0198	S	12° 02.9400	E	4570.2	
M132	1474	CTD / LADCP	20.11.2016	20:23:29	26° 42.294	S	12° 02.668	E	3861.7	#22
M132	1475	MSS	20.11.2016	21:21:00	26°42.2598	S	12° 02.6502	E	4992.1	
M132	1476	CTD / LADCP	20.11.2016	22:57:43	26° 45.590	S	12° 02.378	E	3875.9	#23
M132	1477	MSS	20.11.2016	23:24:00	26°45.600	S	12° 02.3802	E	3867.0	
M132	1478	CTD / LADCP	21.11.2016	0:40:18	26° 48.866	S	12° 02.066	E	4579	#24

M132	1479	MSS	21.11.2016	1:20:00	26° 48.8802	S	12° 02.07	E	3871.6	
M132	1480	CTD / LADCP	21.11.2016	2:37:44	26° 52.160	S	12° 01.794	E	3891	#25
M132	1481	MSS	21.11.2016	3:14:00	26°52.1598	S	12° 01.7802	E	3894.3	
M132	1482	CTD / LADCP	21.11.2016	4:20:57	26° 55.456	S	12° 01.503	E	3920.1	#26
M132	1483	MSS	21.11.2016	5:01:00	26°55.4598	S	12° 01.500	E	3921.3	
M132	1484	CTD / LADCP	21.11.2016	6:09:26	26° 58.768	S	12° 01.181	E	3965	#27
M132	1485	MSS	21.11.2016	6:58:00	26° 58.780	S	12°01.1802	E	3952.9	
M132	1486	Drifter	21.11.2016	9:31:00	26° 46.55	S	12° 2.32	E	3867.5	3x SVP
M132	1487	Drifter	21.11.2016	10:36:00	26° 48.19	S	12° 01.06	E	3875.2	3x SVP
M132	1488	Drifter	21.11.2016	11:31:00	26° 50.87	S	12° 02.06	E	3891.1	3x SVP
M132	1489	Drifter	21.11.2016	12:19:00	26° 53.57	S	12° 02.06	E	4998.8	3x SVP
M132	1490	CTD / LADCP	21.11.2016	14:38:10	26° 58.816	S	12° 01.150	E	3953.9	#28
M132	1491	MSS	21.11.2016	15:12:00	26° 58.7802	S	12°01.1202	E	3957.7	
M132	1492	CTD / LADCP	21.11.2016	16:41:24	26° 55.501	S	12° 01.485	E	3920	#29
M132	1493	MSS	21.11.2016	17:15:00	26°55.470	S	12°01.4898	E	5393.5	
M132	1494	CTD / LADCP	21.11.2016	18:55:00	26° 52.171	S	12° 01.775	E	3898.6	#30
M132	1495	MSS	21.11.2016	19:40:00	26°52.170	S	12°01.7802	E	3895.7	
M132	1496	CTD / LADCP	21.11.2016	21:30:31	26° 48.889	S	12° 02.106	E	3872.8	#31
M132	1497	MSS	21.11.2016	22:06:00	26°48.8898	S	12°02.1102	E	3871.5	
M132	1498	CTD / LADCP	21.11.2016	23:36:15	26° 45.577	S	12°02.403	E	3864.9	#32
M132	1499	MSS	22.11.2016	0:28:00	26°45.5802	S	12°02.430	E	3864.8	
M132	1500	CTD / LADCP	22.11.2016	1:49:08	26° 42.290	S	12° 02.715	E	3860.1	#33
M132	1501	MSS	22.11.2016	2:24:00	26°42.2298	S	12°02.6598	E	3859.3	
M132	1502	CTD / LADCP	22.11.2016	3:47:17	26° 38.999	S	12° 03.023	E	3851.6	#34
M132	1503	MSS	22.11.2016	4:21:00	26°38.970	S	12°03.0102	E	3854.8	
M132	1504	CTD / LADCP	22.11.2016	5:46:50	26° 35.710	S	12° 03.282	E	3866.4	#35
M132	1505	MSS	22.11.2016	6:37:00	26°35.7102	S	12°03.2802	E	3858.1	
M132	1506	Glider	22.11.2016	8:05:00	26° 36.06	S	12° 03.34	E	4984	deployment
M132	1506	Glider	22.11.2016	9:35:59	26° 36.06	S	12° 03.34	E	5057	
M132	1507	CTD / LADCP	22.11.2016	10:20:06	26° 32.386	S	12° 03.6	E	3836	#36
M132	1508	MSS	22.11.2016	10:59:00	26°32.4198	S	12°03.6102	E	3808.9	
M132	1509	CTD / LADCP	22.11.2016	12:36:59	26° 29.121	S	12° 03.889	E	3809.7	#37
M132	1510	MSS	22.11.2016	13:04:00	26°29.130	S	12°03.90	E	3808.9	
M132	1511	CTD / LADCP	22.11.2016	14:33:07	26° 25.796	S	12° 04.176	E	3775.7	#38
M132	1512	MSS	22.11.2016	15:08:00	26°25.80	S	12°04.1802	E	5531.3	
M132	1513	U-CTD	22.11.2016	16:18:00	26° 24.67	S	12° 04.29	E	3770	Test station
M132	1514	CTD / LADCP	22.11.2016	15:45:50	26° 22.467	S	12° 489	E	3771.4	#39
M132	1515	MSS	22.11.2016	17:20:00	26°22.4898	S	12°04.4898	E	5484.5	
M132	1516	CTD / LADCP	22.11.2016	19:00:03	26° 19.183	S	12° 04.775	E	3747.1	#40, PC crash
M132	1517	MSS	22.11.2016	19:51:00	26°19.1898	S	12°04.780	E	3750.7	
M132	1518	CTD / LADCP	22.11.2016	21:39:19	26° 15.942	S	12° 5.052	E	3897.3	#41
M132	1519	MSS	22.11.2016	22:22:00	26°15.900	S	12°05.110	E	3736.3	
M132	1520	U-CTD	22.11.2016	23:30:00	26° 15.24	S	12° 05.76	E	3755	
M132	1520	U-CTD	23.11.2016	0:53:59	26° 07.70	S	12° 13.31	E	3542	abortion, technical problems
M132	1521	U-CTD	23.11.2016	4:38:00	25° 51.01	S	12° 33.09	E	3187.2	
M132	1521	U-CTD	23.11.2016	11:11:59	25° 51.00	S	13° 29.48	E	825.1	

M132	1522	Glider	23.11.2016	12:42:00	25° 51.00	S	13° 18.15	E	1263.6	
M132	1522	Glider	23.11.2016	13:10:00	25° 51.00	S	13° 18.16	E	1268.1	
M132	1523	CAT + MSS	23.11.2016	15:15:00	25° 50.96	S	13° 24.88	E	1001.2	
M132	1523	CAT + MSS	23.11.2016	19:13:59	25° 50.95	S	13° 19.28	E	1219.1	
M132	1524	CAT	23.11.2016	19:32:00	25° 50.46	S	13° 19.69	E	3147.5	
M132	1524	CAT	23.11.2016	21:21:59	25° 50.95	S	13° 19.28	E	945.1	
M132	1525	CAT + MSS	23.11.2016	21:33:00	25° 50.95	S	13° 26.24	E	942.9	
M132	1525	CAT + MSS	23.11.2016	1:28:59	25° 50.94	S	13° 18.51	E	942.9	
M132	1526	CAT	24.11.2016	1:42:00	25° 50.75	S	13° 18.51	E	1247.3	
M132	1526	CAT	24.11.2016	4:29:59	25° 50.88	S	13° 26.6	E	923.9	
M132	1527	CAT + MSS	24.11.2016	4:42:00	25° 51.26	S	13° 26.64	E	3434.2	
M132	1527	MSS	24.11.2016	8:42:00	25° 50.89	S	13° 17.63	E	2028.6	
M132	1527	CAT	24.11.2016	9:09:59	25° 50.89	S	13° 16.94	E	1572.7	Catamaran on deck
M132	1528	CTD / LADCP	24.11.2016	10:33:37	25° 50.998	S	13° 18.273	E	1260	#42, PC crash
M132	1529	CTD / LADCP	24.11.2016	11:31:00	25° 51.000	S	13° 18.947	E	1230.8	#43
M132	1530	CTD / LADCP	24.11.2016	12:26:12	25° 51.004	S	13° 19.568	E	1211	#44
M132	1531	CTD / LADCP	24.11.2016	13:08:00	25° 50.987	S	13° 20.151	E	1184.7	#45
M132	1532	CTD / LADCP	24.11.2016	15:01:28	25° 50.998	S	13° 20.759	E	1159.9	#46
M132	1533	CTD / LADCP	24.11.2016	15:49:15	25° 50.985	S	13° 21.432	E	1130.5	#47
M132	1534	CTD / LADCP	24.11.2016	16:41:05	25° 50.993	S	13° 21.989	E	1108	#48
M132	1535	CTD / LADCP	24.11.2016	17:57:00	25° 50.975	S	13° 22.595	E	1086	#49
M132	1536	CTD / LADCP	24.11.2016	18:55:00	25° 50.958	S	13° 23.168	E	1062.7	#50
M132	1537	CTD / LADCP	24.11.2016	19:43:00	25° 50.972	S	13° 23.848	E	1037.6	#51
M132	1538	CTD / LADCP	24.11.2016	20:35:11	25° 50.955	S	13° 24.453	E	1880.5	#52
M132	1539	CTD / LADCP	24.11.2016	21:22:00	25° 50.946	S	13° 25.048	E	988.4	#53
M132	1540	CTD / LADCP	24.11.2016	22:05:00	25° 50.979	S	13° 25.696	E	961.3	#54
M132	1541	CTD / LADCP	24.11.2016	22:45:00	25° 50.990	S	13° 26.295	E	937.9	#55
M132	1542	CTD / LADCP	24.11.2016	23:27:00	25° 50.978	S	13° 26.907	E	911.9	#56
M132	1543	U-CTD	25.11.2016	8:52:00	25° 20.00	S	13° 36.60	E	494.8	
M132	1543	U-CTD	25.11.2016	13:57:59	25° 20.01	S	12° 51.04	E	2465.6	
M132	1544	U-CTD	25.11.2016	14:12:00	25° 20.78	S	12° 50.00	E	2465.6	
M132	1544	U-CTD	25.11.2016	14:20:59	25° 21.54	S	12° 50.00	E	2473.7	
M132	1545	Drifter	26.11.2016	5:55:00	26° 06.00	S	13° 00.29	E	1964.0	3x SVP
M132	1546	Drifter	26.11.2016	6:44:00	26° 03.71	S	12° 58.71	E	2096.4	3x SVP
M132	1547	Drifter	26.11.2016	7:24:00	26° 01.32	S	12° 57.09	E	2424.6	3x SVP
M132	1548	Drifter	26.11.2016	8:04:00	25° 58.88	S	12° 55.41	E	2245.4	3x SVP
M132	1549	CTD / LADCP	26.11.2016	8:31:00	25° 59.181	S	12° 55.603	E	2215	#57
M132	1550	MSS	26.11.2016	9:01:00	25° 59.18	S	12° 55.60	E	2212.3	
M132	1551	CTD / LADCP	26.11.2016	10:30:45	25° 59.176	S	12° 58.632	E	2095	#58
M132	1552	MSS+THERM	26.11.2016	11:07:00	25° 59.24	S	12° 58.69	E	2086.9	
M132	1552	MSS	26.11.2016	13:25:00	26° 02.13	S	13° 00.69	E	1994.6	
M132	1553	CTD / LADCP	26.11.2016	13:55:40	26° 01.482	S	13° 00.136	E	2030	#59
M132	1554	MSS	26.11.2016	15:07:00	25° 58.93	S	12° 58.43	E	2090.3	
M132	1554	MSS	26.11.2016	18:00:00	25° 58.93	S	12° 58.43	E	1873.1	
M132	1554	CAT	26.11.2016	15:01:00	25° 58.93	S	12° 58.43	E	2088.2	
M132	1554	CAT	26.11.2016	18:24:59	26° 04.62	S	13° 2.35	E	1873.1	
M132	1555	CTD / LADCP	26.11.2016	18:53:51	26° 03.675	S	13° 01.785	E	1910	#60

M132	1556	MSS	26.11.2016	19:38:00	26° 03.74	S	13° 01.83	E	1905.6	
M132	1557	CTD / LADCP	26.11.2016	20:31:43	26° 05.983	S	13° 03.359	E	1820	#61
M132	1558	MSS	26.11.2016	21:00:00	26° 05.99	S	13° 03.37	E	1818.8	
M132	1559	CTD / LADCP	26.11.2016	22:05:57	26° 08.282	S	13° 04.902	E	1775	#62
M132	1560	MSS	26.11.2016	22:41:00	26° 08.32	S	13° 04.94	E	1771.9	
M132	1561	CTD / LADCP	26.11.2016	23:33:00	26° 10.559	S	13° 06.424	E	1740	#63
M132	1562	MSS	27.11.2016	0:14:00	26° 10.56	S	13° 06.43	E	1742.8	
M132	1563	Glider	27.11.2016	3:45:00	25° 50.40	S	13° 10.40	E	1568.7	
M132	1564	Glider	27.11.2016	13:44:00	26° 32.40	S	11° 41.14	E	-	
M132	1565	CTD / LADCP	27.11.2016	17:44:13	26° 43.493	S	10° 59.997	E	4550	#64
M132	1566	CTD / LADCP	27.11.2016	18:57:30	26° 41.376	S	11° 00.034	E	4540	#65
M132	1567	CTD / LADCP	27.11.2016	20:17:09	26° 39.087	S	10° 59.978	E	4540	#66
M132	1568	CTD / LADCP	27.11.2016	21:12:46	26° 37.178	S	10° 59.967	E	4540	#67
M132	1569	CTD / LADCP	27.11.2016	22:12:15	26° 35.087	S	10° 59.930	E	4530	#68
M132	1570	CTD / LADCP	27.11.2016	23:05:42	26° 32.982	S	10° 59.964	E	4520	#69
M132	1571	CTD / LADCP	28.11.2016	0:00:42	26° 30.895	S	10° 59.956	E	4510	#70
M132	1572	CTD / LADCP	28.11.2016	0:53:00	26° 28.793	S	10° 59.965	E	4490	#71
M132	1573	CTD / LADCP	28.11.2016	1:47:00	26° 26.682	S	10° 59.951	E	4480	#72
M132	1574	CTD / LADCP	28.11.2016	2:39:30	26° 24.577	S	10° 59.976	E	4465	#73
M132	1575	CTD / LADCP	28.11.2016	3:35:24	26° 22.489	S	10° 59.969	E	4450	#74
M132	1576	CTD / LADCP	28.11.2016	4:30:07	26° 20.387	S	11° 00.002	E	4430	#75
M132	1577	CTD / LADCP	28.11.2016	5:26:18	26° 18.301	S	10° 59.980	E	4413	#76
M132	1578	CTD / LADCP	28.11.2016	6:40:39	26° 16.188	S	10° 59.959	E	4410	#77
M132	1579	MSS+THERM	28.11.2016	9:13:00	26° 30.95	S	10° 59.85	E	5298.6	
M132	1579	MSS+THERM	28.11.2016	17:57:59	26° 44.79	S	11° 0.37	E	4553.6	
M132	1580	ADCP-Fahrt	28.11.2016	18:14:00	26° 45.95	S	011° 00.70	E	4556.8	
M132	1581	CTD / LADCP	30.11.2016	21:06:00	26° 15.850	S	12° 05.035	E	3720	#78
M132	1582	MSS	30.11.2016	21:51:00	26° 15.89	S	12° 05.10	E	3717.5	
M132	1583	CTD / LADCP	30.11.2016	23:02:26	26° 19.180	S	12° 04.818	E	3740	#79
M132	1584	MSS	30.11.2016	23:30:00	26° 19.22	S	12° 04.84	E	3739.5	
M132	1585	CTD / LADCP	01.12.2016	0:42:50	26° 22.471	S	12° 04.535	E	3760	#80
M132	1586	MSS	01.12.2016	1:19:00	26° 22.49	S	12° 04.55	E	3756.0	
M132	1587	CTD / LADCP	01.12.2016	2:29:47	26° 25.813	S	12° 04.141	E	3760	#81
M132	1588	MSS	01.12.2016	3:05:00	26° 25.83	S	12° 04.19	E	3768.1	
M132	1589	CTD / LADCP	01.12.2016	4:16:53	26° 29.086	S	12° 03.889	E	3800	#82
M132	1590	MSS	01.12.2016	5:00:00	26° 29.16	S	12° 03.92	E	4391.6	
M132	1591	CTD / LADCP	01.12.2016	6:04:02	26° 32.397	S	12° 03.581	E	3820	#83
M132	1592	MSS	01.12.2016	6:48:00	26° 32.40	S	12° 03.58	E	4672.5	
M132	1593	CTD / LADCP	01.12.2016	8:04:44	26° 35.676	S	12° 03.267	E	3840	#84
M132	1594	MSS	01.12.2016	8:46:00	26° 35.70	S	12° 03.29	E	3838	
M132	1595	CTD / LADCP	01.12.2016	10:01:40	26° 38.992	S	12° 02.981	E	3880	#85
M132	1596	MSS	01.12.2016	10:46:00	26° 39.00	S	12° 03.00	E	3843.4	
M132	1597	CTD / LADCP	01.12.2016	12:07:55	26° 42.320	S	12° 02.688	E	3850	#86
M132	1598	MSS	01.12.2016	12:47:00	26° 42.34	S	12° 2.7	E	3850.3	
M132	1599	CTD / LADCP	01.12.2016	13:58:40	26° 45.603	S	12° 02.393	E	3850	#87
M132	1600	MSS	01.12.2016	14:34:00	26° 45.63	S	12° 02.39	E	4193.9	
M132	1601	CTD / LADCP	01.12.2016	15:44:10	26° 48.845	S	12° 02.087	E	3890	#88

M132	1602	MSS	01.12.2016	16:19:00	26° 48.87	S	12° 02.09	E	3864.8	
M132	1603	CTD / LADCP	01.12.2016	17:23:55	26° 52.195	S	12° 01.804	E	3880	#89
M132	1604	MSS	01.12.2016	18:07:00	26° 52.23	S	12° 01.81	E	3884.1	
M132	1605	CTD / LADCP	01.12.2016	19:27:30	26° 55.468	S	12° 01.483	E	3910	#90
M132	1606	MSS	01.12.2016	20:15:00	26° 55.49	S	12° 01.50	E	4620.4	
M132	1607	CTD / LADCP	01.12.2016	21:32:41	26° 50.793	S	12° 01.193	E	3940	#91
M132	1608	MSS	01.12.2016	22:14:00	26° 58.82	S	12° 01.22	E	4718.4	
M132	1609	MSS+THERM	02.12.2016	1:52:00	26° 32.47	S	12° 03.63	E	4990.0	
M132	1610	Drifter	02.12.2016	11:49:00	26° 38.99	S	12° 02.96	E	3846.0	3x SVP
M132	1611	Drifter	02.12.2016	12:32:00	26° 41.73	S	12° 02.77	E	3845.5	3x SVP
M132	1612	U-CTD	02.12.2016	13:16:00	26° 40.68	S	12° 06.37	E	3836.4	
M132	1612	U-CTD	02.12.2016	19:54:00	26° 25.46	S	12° 55.31	E	2256.9	Probe lost
M132	1613	CTD / LADCP	02.12.2016	21:57:00	26° 11.960	S	12° 51.072	E	2348	#92
M132	1614	MSS	02.12.2016	22:32:00	26° 12.03	S	12° 51.02	E	2345.4	
M132	1615	CTD / LADCP	02.12.2016	23:34:37	26° 14.012	S	12° 52.499	E	2320	#93
M132	1616	MSS	03.12.2016	0:09:00	26° 14.04	S	12° 52.50	E	2323.2	
M132	1617	CTD / LADCP	03.12.2016	1:10:18	26° 15.983	S	12° 54.014	E	2305	#94
M132	1618	MSS	03.12.2016	1:43:00	26° 16.02	S	12° 54.01	E	2305.1	
M132	1619	CTD / LADCP	03.12.2016	2:41:09	26° 18.025	S	12° 55.514	E	2265	#95
M132	1620	MSS	03.12.2016	3:18:00	26° 18.08	S	12° 55.55	E	2265.7	
M132	1621	CTD / LADCP	03.12.2016	4:14:42	26° 19.999	S	12° 57.026	E	2212	#96
M132	1622	MSS	03.12.2016	4:51:00	26° 20.00	S	12° 57.03	E	2213.2	
M132	1623	CTD / LADCP	03.12.2016	5:47:50	26° 21.997	S	12° 58.508	E	2165	#97
M132	1624	MSS	03.12.2016	6:29:00	26° 22.02	S	12° 58.52	E	2164.9	
M132	1625	CTD / LADCP	03.12.2016	7:29:51	26° 23.988	S	12° 59.996	E	2125	#98, uCTD Calibration
M132	1626	MSS	03.12.2016	8:25:00	26° 24.01	S	13° 00.00	E	2125.6	
M132	1627	CTD/MSS-Calibration	03.12.2016	9:19:00	26° 25.24	S	13° 00.15	E	2135.9	#99 MSS calibration
M132	1628	Drifter	03.12.2016	10:20:00	26° 20.81	S	12° 57.62	E	2194.4	4x SVP
M132	1629	Drifter	03.12.2016	11:12:00	26° 23.08	S	12° 59.3	E	2145.9	3x SVP
M132	1630	CAT	03.12.2016	17:42:00	26° 32.63	S	14° 06.06	E	384.0	
M132	1630	CAT	03.12.2016	7:04:59	26° 54.91	S	13° 48.98	E	586.0	
M132	1631	CTD / LADCP	04.12.2016	11:25:42	26° 47.339	S	14° 02.624	E	410	#100
M132	1632	MSS	04.12.2016	12:06:00	26° 47.40	S	14° 02.55	E	404.1	
M132	1633	MSS	04.12.2016	13:22:00	26° 50.70	S	14° 01.95	E	407.1	
M132	1634	MSS	04.12.2016	14:50:00	26° 54.15	S	14° 00.78	E	413.4	
M132	1635	MSS	04.12.2016	16:15:00	26° 57.55	S	14° 00.31	E	426.3	
M132	1636	MSS	04.12.2016	17:34:00	27° 01.05	S	13° 59.37	E	456.0	
M132	1637	ADCP-Fahrt	04.12.2016	19:01:00	27° 04.75	S	13° 58.69	E	748.8	
M132	1637	ADCP-Fahrt	05.12.2016	13:30:59	26° 35.93	S	14° 05.99	E	393.6	
M132	1638	CTD / LADCP	05.12.2016	13:33:15	26° 36.013	S	14° 06.015	E	395	#101
M132	1639	MSS	05.12.2016	14:06:00	26° 36.13	S	14° 06.02	E	395.6	
M132	1640	CTD / LADCP	05.12.2016	15:12:03	26° 39.345	S	14° 05.110	E	400	#102
M132	1641	MSS	05.12.2016	15:46:00	26° 39.47	S	14° 05.03	E	391.1	
M132	1642	CTD / LADCP	05.12.2016	16:47:22	26° 42.530	S	14° 04.286	E	397	#103
M132	1643	MSS	05.12.2016	17:17:00	26° 42.56	S	14° 04.27	E	398.5	
M132	1644	CTD / LADCP	05.12.2016	18:29:01	26° 45.791	S	14° 03.527	E	403	#104
M132	1645	MSS	05.12.2016	19:10:00	26° 45.81	S	14° 03.49	E	406.2	

M132	1646	CTD / LADCP	05.12.2016	20:30:00	26° 49.055	S	14° 02.631	E	405	#105
M132	1647	MSS	05.12.2016	21:05:00	26° 49.05	S	14° 02.63	E	405.3	
M132	1648	CTD / LADCP	05.12.2016	22:19:54	26° 52.354	S	14° 01.886	E	410	#106
M132	1649	MSS	05.12.2016	22:51:00	26° 52.37	S	14° 01.82	E	408.9	
M132	1650	CTD / LADCP	06.12.2016	0:05:48	26° 55.609	S	14° 01.032	E	417	#107
M132	1651	MSS	06.12.2016	0:39:00	26° 55.58	S	14° 00.87	E	417.0	
M132	1652	CTD / LADCP	06.12.2016	2:02:40	26° 58.933	S	14° 00.310	E	431	#108
M132	1653	MSS	06.12.2016	2:37:00	26° 58.86	S	13° 59.94	E	433.9	
M132	1654	CTD / LADCP	06.12.2016	3:50:10	27° 02.291	S	13° 59.766	E	467	#109
M132	1655	MSS	06.12.2016	4:29:00	27° 02.23	S	13° 59.31	E	471.5	
M132	1656	CTD / LADCP	06.12.2016	5:42:00	27° 05.48	S	13° 58.80	E	568.1	#110
M132	1657	MSS	06.12.2016	6:26:00	27° 05.40	S	13° 58.53	E	578.5	
M132	1658	CTD / LADCP	06.12.2016	8:05:00	27° 08.73	S	13° 58.03	E	698.8	#111
M132	1659	MSS	06.12.2016	8:51:00	27° 08.75	S	13° 57.68	E	712.5	
M132	1660	CTD / LADCP	06.12.2016	10:19:00	27° 12.09	S	13° 57.21	E	823	#112
M132	1661	MSS	06.12.2016	10:54:00	27° 12.08	S	13° 56.95	E	834.4	
M132	1662	MSS	06.12.2016	15:10:00	26° 41.06	S	14° 04.63	E	834.4	
M132	1662	CAT	06.12.2016	15:10:00	26° 41.26	S	14° 04.57	E	394.4	
M132	1662	CAT	06.12.2016	15:10:00	26° 41.06	S	14° 04.63	E	719.7	
M132	1663	CTD / LADCP	07.12.2016	10:07:18	26° 35.966	S	14° 06.019	E	394.5	#113
M132	1664	CTD / LADCP	07.12.2016	11:09:25	26° 39.278	S	14° 05.181	E	391.2	#114
M132	1665	CTD / LADCP	07.12.2016	12:10:00	26° 42.540	S	14° 04.369	E	401.6	#115
M132	1666	CTD / LADCP	07.12.2016	13:10:37	26° 45.822	S	14° 03.537	E	160.6	#116
M132	1667	CTD / LADCP	07.12.2016	14:13:50	26° 49.074	S	14° 02.708	E	404.9	#117
M132	1668	MSS	07.12.2016	14:48:00	26° 49.18	S	14° 02.66	E	405.2	
M132	1668	MSS	07.12.2016	22:02:59	27° 02.61	S	13° 59.34	E	475.0	
M132	1669	CTD / LADCP	07.12.2016	23:16:30	26° 52.372	S	14° 01.850	E	916.4	#118
M132	1670	CTD / LADCP	08.12.2016	0:22:13	26° 55.645	S	14° 01.106	E	416	#119
M132	1671	CTD / LADCP	08.12.2016	1:28:37	26° 58.882	S	14° 00.305	E	430.7	#120
M132	1672	CTD / LADCP	08.12.2016	2:33:39	27° 02.145	S	13° 59.431	E	466.4	#121

8 Data and Sample Storage and Availability

Scientific data from stations of cruise M132 (CTD, LADCP) and Scanfish transects will be submitted to the World Data Center PANGAEA (www.pangaea.de) in spring 2018. It provides long-term archives and free access to the scientific data. Contact person is K. Jochumsen (kerstin.jochumsen@ uni-hamburg.de).

All meta information (including station map, short cruise report), underway, and bathymetric data was sent to the German Oceanographic Data Centre (DOD), which inventoried the respective cruise summary report. Bathymetric data was furthermore provided to GEOMAR, working group C. Devy, for preparing PANGAEA input. Measurements of the vessel's thermosalinograph system (TSG) and respective salinometer data obtained during the cruise were sent to the Control Station German Research Vessels for quality control and archiving.

Data collected using the catamaran and MSS need extensive processing and are not part of a planned data base submission so far. Contact person for these observations is L. Umlauf (lars.umlauf@io-warnemuende.de).

Drifter data (surface temperature and positions) will presumably be included into the Global Drifter Program (GDP, http://www.aoml.noaa.gov/phod/dac/gdp_objectives.php) during summer 2017. Contact with GDP PIs has been established and the process of transferring the drifter to the program is under discussion.

Glider data will be available via the COSYNA system at HZG (http://codm.hzg.de/codm), when data quality checks are finalized. This is expected to be in 2018. Any earlier data requests can be handled by contacting Jeff Carpenter (jeff.carpenter@hzg.de).

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