Baltic Sea Research Institute Warnemünde

C r u i s e R e p o r t

R/V "Alkor"

Cruise- No. 06AK1001

This report is based on preliminary data

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1. **Cruise No.:** 06AK1001

2. **Dates of the cruise:** from 27.02.2008 to 10.03.2008

3. **Particulars of the research vessel:**

   Name: R/V Alkor
   Nationality: Germany
   Operating Authority: Baltic Sea Research Institute (BSRI) Warnemünde

4. **Geographical area in which ship has operated:**

   Baltic Sea (Bornholm Basin)

5. **Dates and names of ports of call**

   No ports of call

6. **Purpose of the cruise**

   The purpose of this cruise was to collect data for the IOW projects ShIC and ILWAO, in which boundary mixing processes and mixing due to internal waves are studied. Focal area was the Bornholm Basin in the southern Baltic Sea. We investigated highly resolved hydrographic and turbulence parameters on different transects and stations, using a similar methodology at all locations: one or two moored CTD chains with current profilers (ADCPs) were deployed near a cross-slope transect and/or near a number of fixed stations. Then, turbulence measurements were performed with a shear-microstructure profiler (including precision CTD sensors) for a duration of up to several days, either inside a radius of 1 nm around the fixed stations or along the cross-slope transect in the vicinity of the moorings. This approach, providing measurements combining high temporal resolution (from the moorings) and high spatial resolution (from ship-based profiling), was repeated at several locations in the study area.

7. **Crew:**

   Name of master: J. P. Lass
   Number of crew: 11

8. **Research staff:**

   Chief scientist: Umlauf, Lars

   Scientists: Baumann, Carsten
   Freund, Madeleine
   Gräwe, Ulf
   Holtermann, Peter
   Mohrholz, Volker
   Schippman, Bianca
   van Haren, Hans
   van der Lee, Eefke

Engineers: Heene, Toralf
Laan, Martin

9. Co-operating institutions:

The Royal Netherlands Institute for Sea Research (NIOZ)
P.O. Box 59, 1790 AB, Den Burg, The Netherlands

10. Scientific equipment

- 1 x Seabird 911plus CTD unit with rosette
- 2 x MSS90-L microstructure profiler from ISW
- 4 x RDI ADCPs (2x 600 kHz Broad-Band, 2x 300 kHz workhorse)
- 300 kHz vessel mounted ADCP
- 600 kHz towed ADCP
- 23 x SeaCat/MicroCat CTD loggers from Seabird
- 20 x temperature loggers from RBR
- 1 x Eddy-flux bottom lander with acoustic current meter (ADV), acoustic current profiler (ADP), and fast-response temperature and conductivity sensors
- 1 x thermistor-chain lander with 300 kHz ADCP, and approximately 150 high-precision temperature sensors

11. General remarks and preliminary results (ca. 2 pages)

Measurements were taken in the Bornholm Basin (Fig. 1) at the central station S1 (corresponding to station 213 of the official Baltic Sea Monitoring Program), and on the transect T1 on the southern slope of the basin. The locations of these stations and transects are summarized in Tab. 1. The general working mode during this cruise consisted of short-term deployments of different types of moored instrumentation and bottom landers, accompanied by ship-based hydrographic and turbulence measurements in the vicinity of these moorings. The turbulence microstructure profiler was operated 24 hours per day by teams of 3 scientists during 6-hour shifts. Mooring work was only performed during daylight. The operations at S1 had to be interrupted from 28 February (22:30 UTC) until 02 March (10:00 UTC) due to heavy winds, rising up to 7-8 Bft. The measurements on transect T1 were overshadowed by the loss of a mooring at station T1A (Fig. 2), which was presumably destroyed by a trawled fisher net. After extensive search, we were able to recover the releaser, 9 MicroCats CTD loggers, and 9 NIOZ C/T loggers. A 600-kHz ADCP and 2 NIOZ4 C/T loggers were lost. A damage report (in German) is attached.

The moored instrumentation at S1 consisted of a bottom-mounted trawl-resistant 300-kHz ADCP (TRBM-ADCP), a moored CTD/thermistor chain with attached 600-kHz ADCP (TSC2), and a high-resolution bottom lander with approximately 150 densly-spaced (ca. 0.1 m) high-precision temperature sensors and a 300-kHz ADCP (NIOZ–lander), the latter deployed by our partners from NIOZ. The vertical structure of the water column at station S1 was sampled with a shear-microstructure profiler including precision CTD sensors (MSS90-L from ISW), which was continuously operated in free-fall mode during day and night with a repetition rate of approximately 5 minutes, depending on water depth. The times and locations of these deployments are summarized in Tabs. 2 and 3 below.

Following our measurements at station S1, operation was continued on transect T1 (see Fig. 2) on the south-eastern slope of the Bornholm Basin. Moorings and bottom landers were deployed at the positions T1A-T1D shown in Fig. 2 during the times indicated in Tab. 3. Along with the evolving hydrographic conditions at these sites, the whole transect was moved 2 nm towards the deeper part of the basin (from the yellow dashed to the red transect shown in Fig. 2), and moorings and landers were re-deployed several times as summarized in Tab. 3. In addition to the moored instruments mentioned above for station S1, we also deployed a second CTD-chain with attached 600-kHz ADCP (TSC1), and a turbulence bottom lander that was able to measure near-bottom stratification, shear, and the turbulent fluxes of momentum, temperature, and salinity. A summary of all deployments is given in Tabs. 2 and 3 below.

Preliminary results: Scientifically, the data set obtained during this cruise includes the first extensive observations of turbulence and mixing due to internal wave motions in one of the deep basins of the Baltic Sea during winter time. The stratification we observed was dominated by a halocline at approximately 60 m depth, separating a very weakly stratified upper layer from a moderately stratified bottom layer. The internal wave field recorded by the acoustic current profilers revealed the dominance of near-inertial wave motions that strongly increased during the wind event described above. Mixing was enhanced in the surface mixed layer (directly forced by the wind stress), and in a bottom boundary layer of several meters thickness. We also observed increased (by up to two orders of magnitude) dissipation rates near the upper edge of the halocline, where the shear from the near-inertial waves was apparently strong enough to overcome the stabilizing effect of the rather strong stratification. Clear signals of warm-water intrusions could also be identified in this halocline layer that could be associated with the enhanced mixing rates in this region as well. The corresponding data from the high-resolution thermistor chain from our partners from NIOZ, however, have not yet been analyzed in detail.

Strong mixing was also observed in the bottom boundary layer on transect T1 (see Fig. 3), where high dissipation rates coincided with stable stratification. This indicates efficient mixing, and highlights the potential importance of boundary mixing for the overall basin-scale mixing. Simultaneously with the microstructure measurements, we also towed an ADCP down the slope on T1, which allowed us to observe the near-bottom velocity structure with high vertical resolution and very little data loss due to the bottom-blanking effect. These data indicated the presence of shear layers across the halocline, which may be the reason for the turbulent patches observed even in the most strongly stratified parts of the halocline on the slope (see Fig. 3).

All in all, in spite of the loss of one expensive instrument and the data recorded by it, we have gathered an extensive (including more than 1400 microstructure profiles) and unique multi-parameter data set, describing mixing and its relation to the internal wave field that is likely to result in a number of interesting publications.

Appendix: Figures and tables

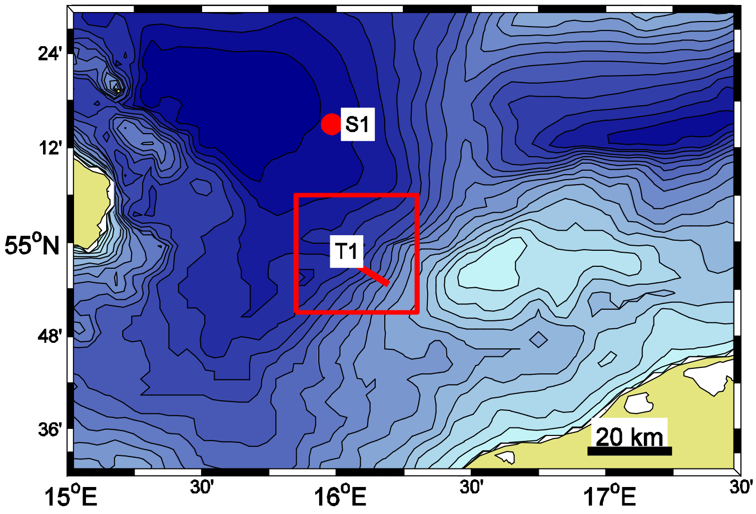

Fig. 1. General study area in the Bornholm Basin with topography at 5 m intervals. Red rectangle marks the area around transect T1 (see Fig. 2).

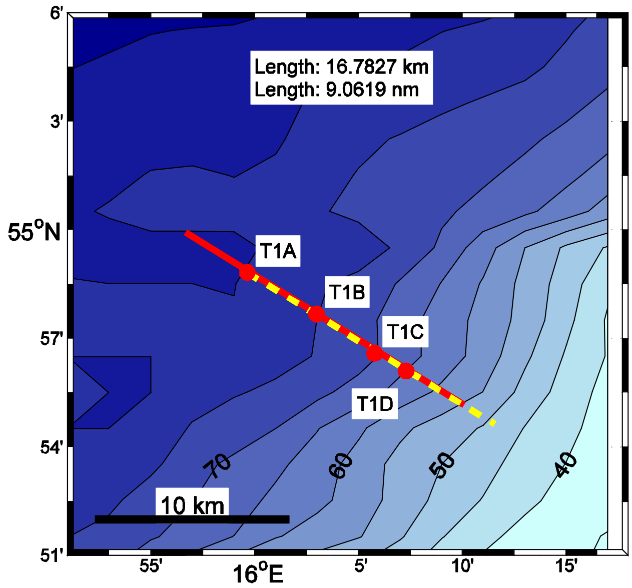

Fig. 2. Study area near transect T1 (see Fig. 1) with topography in meters. Transect T1 was moved from shallower (yellow dashed) to deeper (red) parts of the slope. T1A - T1D denote positions of mooring deployments.

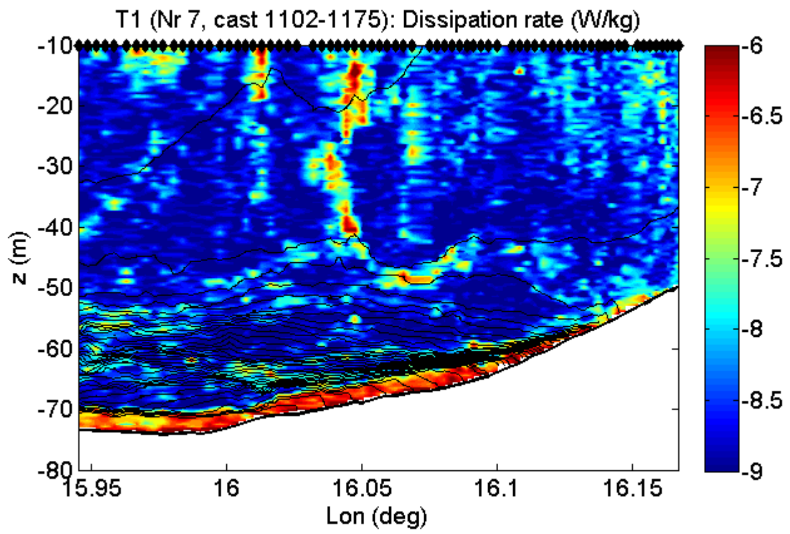

Fig. 3. Transect T1 (see Fig. 2) with density (black contour lines) and decadal logarithm of dissipation rate (colors). Markers on top denote the position of individual microstructure casts.

Tab. 1. Summary of station and transect locations (including moorings points T1A-T1D)

Location	Latitude (N)	Longitude (E)
S1	55°15.0000'	15°59.0000'
T1 (1)	54°58.8200' 54°54.6350'	15°59.6680' 16°11.5610'
T1 (2)	54°59.9280' 54°55.1560'	15°56.6900' 16°10.0740'
T1A	54°58.8200'	15°59.6680'
T1B	54°57.6782'	16°03.0000'
T1C	54°56.5860'	16°05.7840'
T1D	54°56.1060'	16°07.3080'

Tab. 2. Summary of microstructure measurements with MSS90-L profiler.

Location	Start	End	Number of casts
S1 **(within radius of 1 nm)**	28 February 2010 12:28	04 March 2010 06:30	452
T1 **(transect SE to NW)**	04 March 2010 18:35	05 March 2010 21:29	319
T1A **(within radius of 1 nm)**	05 March 2010 21:41	06 March 2010 16:58	177
T1 **(transect SE to NW)**	06 March 2010 20:03	08 March 2010 07:17	382
S1 **(within radius of 1 nm)**	08 March 2010 17:14	09 March 2010 07:41	120

Tab. 3. Dates and positions of moorings deployed at/near the stations and transects shown in Figs. 1 and 2.

Location	Mooring	Latitude (N)	Longitude (E)	Start	End
S1	TRBM	55° 15.0060'	15° 58.7940'	28 February 2010 07:53	09 March 2010 08:23
	TSC2	55° 14.7540'	15° 58.8420'	28 February 2010 09:46	04 March 2010 07:18
	NIOZ	55° 14.9160'	15° 59.2740'	28 February 2010 10:21	2010-03-04 08:30:26
T1	TSC1 (at T1D)	54° 56.0160'	16° 07.2000'	04 March 2010 13:31	07 March 2010 09:46
	ECOR (at T1D)	54° 56.1900'	16° 07.3500'	04 March 2010 14:26	07 March 2010 09:15
	NIOZ (at T1C)	54° 56.7300'	16° 05.8140'	04 March 2010 15:00	07 March 2010 08:08
	TSC2 (at T1A)	54° 58.7640'	15° 59.3700'	04 March 2010 17:08	08 March 2010 11:01 (seacats)
	NIOZ (at T1B)	54° 57.7980'	16° 02.9340'	07 March 2010 11:11	08 March 2010 09:01
	ECOR (at T1B)	54° 57.5580'	16° 02.7180'	07 March 2010 11:29	08 March 2010 08:38