Baltic Sea Research Institute Warnemünde

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

R/V " A.v.Humboldt "

Cruise- No. 44 / 98 / 06

This report is based on preliminary data:

Institut für Ostseeforschung Warnemünde
an der Universität Rostock
Seestraße 15
D-18119 Rostock- Warnemünde
GERMANY
+49-381-5197-0
+49-381-5197 440

1. **Cruise No.:** 44 / 98 / 06

2. **Dates of the cruise:** from 15.04.1998 to 30.04.1998

3. **Particulars of the research vessel:**
Name: A. v. Humboldt
Nationality: Germany
Operating Authority: Baltic Sea Research Institute
Warnemünde (IOW)

4. **Geographical area in which ship has operated:**
Eastern Gotland Basin (57°-57°35')N; (19°32.1-20°27 .9')E

5. **Dates and names of ports of call**
16 – 17 April, 1998; Stralsund- Germany

6. **Purpose of the cruise**
Exchange processes in deep meso-scale mass-field patterns

7. **Crew:**
Name of master: G. Herzig
Number of crew: 10

8. **Research staff:**
Chief scientist: E. Hagen
Scientists: R. Feistel
Ch. Zülicke
H. Piazena/ Univ.-Erlangen
A. Stips/ SAI-JRC-Ispra
J. Reissman
Engineers: S. Weinreben
I. Schuffenhauer
Technicians: W. Hub

9. **Co-operating institutions:**
- Botanical Institute of the University of Erlangen, Staudtstrasse 5, D-91058 Erlangen, Germany

- Space Application Institute of the Joint Research Centre, I-21020 Ispra, Italy

10. **Scientific equipment:** Sea-Bird CTD – probe, Enhanced Dissipation Profiler (EDP), ADCP, and RCM's, Thermosalinograph, Automatic Weather Station, Double-Monochromatic Spectral Radiometer, Secchi-Disk
Deploy of two surface moorings with 5 RCM-7/9 current meters (60m, 50m, 40m, 30m, 20m) at (57°21.27'N, 19°36.65'E), (5 7°25.38'N, 20°20.83'E) and 1 ADCP (57°21.26' N, 19°36.37'E) ab ove the Klints-Bank at 70 m water-depth

11. **General remarks and preliminary result** (ca. 11 pages)

Warnemünde, 12 May, 1998

Because of their depth and central location, the deep basins are probably the most interesting regions for theoretical and experimental investigations in the context of thermodynamics and/ or kinetics of oceanic irreversible processes. There is some observational evidence that much of the diapycnal mixing is actually done before the dense deep water is incorporated into deep waters of the Baltic Proper. Associated processes of detrainment essentially modify dense bottom currents spreading from the Arkona Basin through the Bornholmgat into the Bornholm Basin in order to enter the Eastern Gotland Basin via the Stolpe Furrow.

Our hydrographic activities support running BASYS (***Baltic Sea System Study***)-field campaigns and contribute to the Russian- German field study programme **„Research on the Baltic Sea (RBS)**“, which is partly funded by the Ministry of Science and Technical Politics of the Russian Federation and the Federal Ministry of Education, Scientific Research and Technology of the FRG. The programme ‘**Meso-Scale Dynamics/ MESODYN**’ runs for four years (1996- 1999) above deep Baltic basins. Eddy-resolving CTD-profiles have a station spacing of about 2.5 n.m. to study exchange processes of water properties between different layers in the water column, between coastal zones and central parts of the Baltic as well as between different basins during different seasons. Vertical fluxes through the permanent halocline and within the well-mixed top layer are studied by measurements of the micro-structure using the ‘Enhanced Dissipation Profiler (EDP)’. These activities are part of the EU-funded project ‘**Micro-Structure Technology (MITEC**)’ under the umbrella of MAST-III (1998- 2000). The joint objective lies in a better calibration/ validation of running circulation models by means of suitable parameterizations of processes, which are detected at both the meso- and the micro-scale.

Previous field campaigns have been carried out in the Stolpe Furrow (March, 1996 and June, 1997), in the eastern Gotland Basin (June, 1996 and September, 1997), the Bornholm Basin (September, 1996 and March, 1997), the Arkona Basin (December, 1996). These activities will be continued by two hydrographic surveys in 1998. One of them is planned in co-operation with MITEC for the eastern Gotland Basin (r/v ‘A.v. Humboldt’: November, 1998). The other field campaign will be carried out in the Stolpe Furrow (r/v ‘Prof. A. Penck’: November, 1998). Further field campaigns are still under discussion for 1999. Repeated measurements will be performed at the same positions to describe the seasonal cycle in meso-scale patterns of the mass-field and associated fluxes of energy and matter. Our CTD-campaigns will be completed by records of moored current meters, tracks of both towed CTD’s and ADCP’s, and vertical dissipation profiling above steep topographic slopes. Resulting data sets will be analysed to estimate statistics of baroclinic eddy-like features and associated changes in the net volume transport, especially in layers beneath the permanent halocline.

Before our field campaign, r/v ‘A.v.Humboldt’ had a stay of two days (16-17 April) in Stralsund/ Germany. There was the ‘open ship’ with different poster sessions in the frame of a scientific symposium, which was organized by the Marine Museum Stralsund (‘International Year of the Ocean’). Totally, more than 550 people visited the ship.

The area under investigations is shown in Fig.1 while the hydrographic station grid is plotted in Fig. 2 above rough contours of the bottom topography.

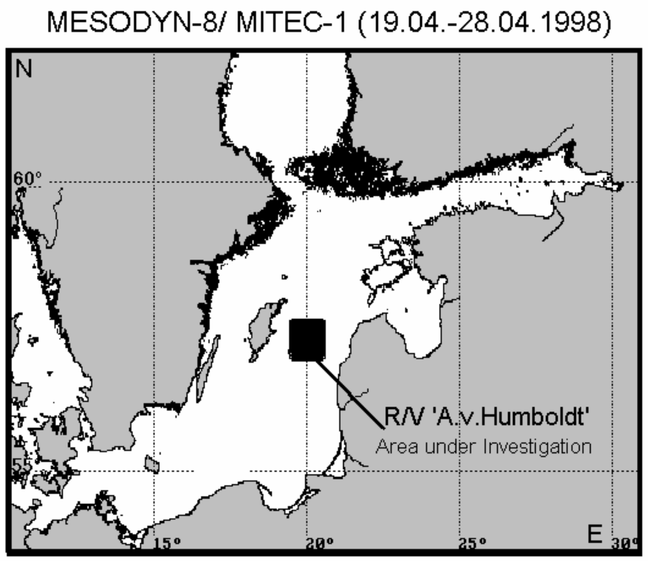

Fig.1 Area under investigation with R/V ‘A.v.Humboldt’ in the Eastern Gotland Basin (EGB) during the campaign MESODYN-8/ MITEC-1 in April, 1998.

This field campaign was carried out on a regular station grid starting with CTD/ EDP-measurements in the northwest corner (station no.1) along zonal transects, which are denoted by (z) in Fig.2. All CTD - profiles have been performed with the SeaBird System from the sea surface down to the near bottom layer. At least two EDP-casts were taken at each station. Depending from the actual wind situation two strategies were used for EDP-measurements covering the 100 dbar top layer. Under weak winds, the first cast started before the CTD-application while the second cast was thereafter with a lag between 10 and 15 minutes.

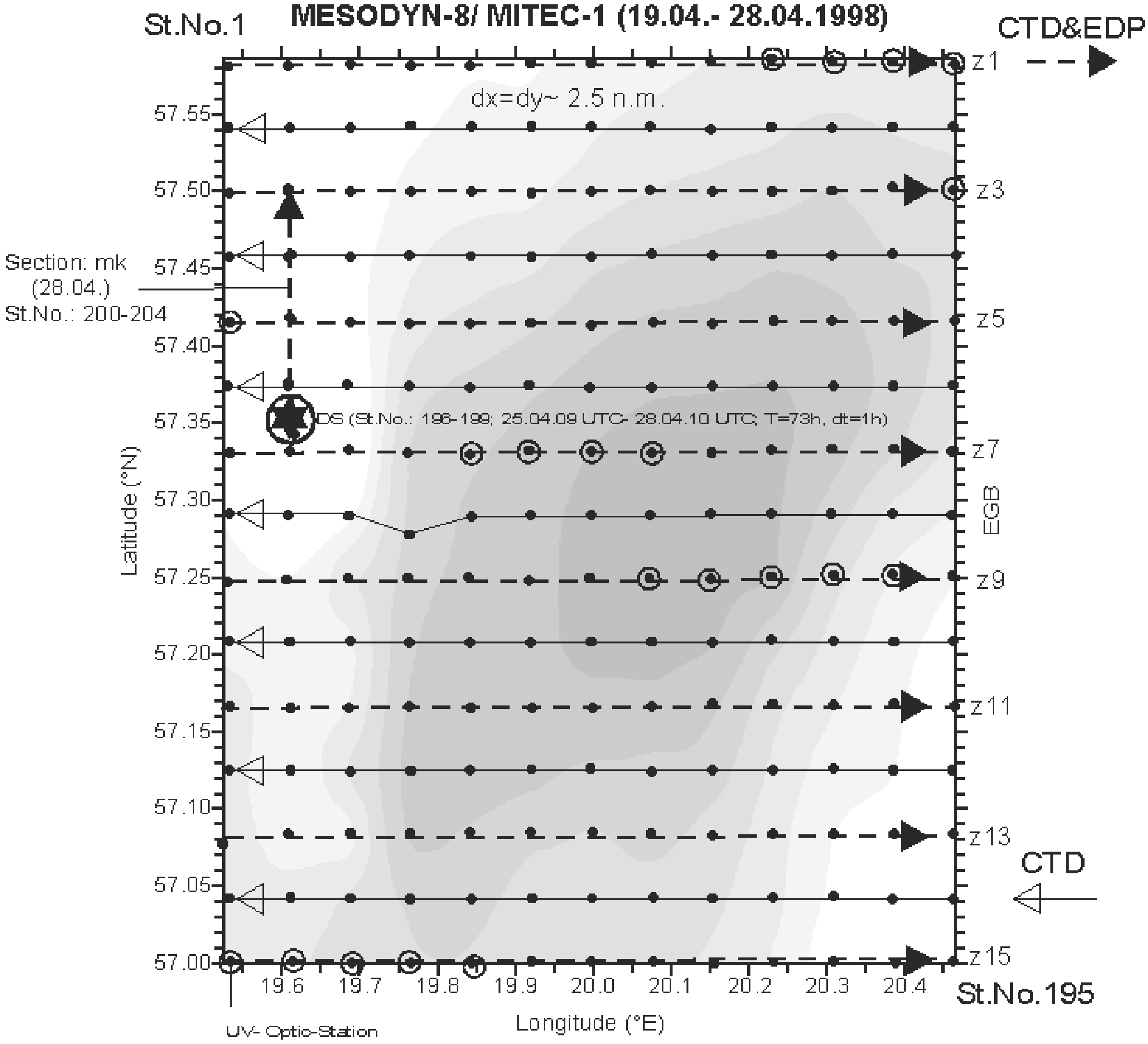

Fig.2 Hydrographic station grid over rough contours of the bottom topography, cf.Fig.3; the anchor station (DS) was performed at 70m water depth above the Klints Bank and accompanied by current meter- and ADCP-records (1 minute sampling interval for 5 inertial cycles) to complete hourly CTD -time series; here, 5 EDP-casts each hour recorded the vertical micro-structure by burst sampling; circled dots show irregularly distributed stations for underwater UV-measurements; zonal sections are denoted by (z) while the short meridional transect is (mk).

During moderate winds up to about 9 m/s, both EDP-casts started with a time lag of about 5 minutes before the CTD-application to avoid a risk for the EDP-probe and its cable when hanging off board. Principally two fast temperature sensors were used simultaneously at the EDP profiler (TE- sensor [thermoelement] and NTC-sensor [thermistor FP07]). Due to time limitations, the EDP-measurements are performed along west-east transects only, that means along each second CTD-section (z1, z3, z5, z7, z9, z11, z13, z15 in Fig.2). The NTC sensor was covered by a protection cap to minimise the risk of destroying both sensors at the same time by one bottom hit at stations shallower than 120 m depth.

A total of 195 CTD-profiles (15 sections x 13 stations) was gathered under uniform environmental conditions with moderate winds between 3 and 9 m/s from the sector NE-SE. CTD-measurements started 19 April 00:00 UTC (station no. 001) and ended 24 April 16:15 UTC, 1998, in the south-east corner (station no. 195). The area under investigation covers the region between (57°- 57°35') N and (19°32.1'- 20°27.9') E with 55.6 km x 64.8 km = 3603 km^2.

To study the energy dissipation of inertial oscillations, we carried out an anchor station for time series. The position of r/v 'A.v.Humboldt' located above the southern part of the Klints Bank (57°21.21'N, 19°36.51'E). Here, the water depth was 71m . Resulting time series cover five inertial cycles during 73 hours. Two ship lengths north, two surface moorings recorded the motion field. There, the water depth was 70m. A string of Aanderraa current meters (RCM-7 at 50m, 40m, 30m, and 20m depth) was deployed while one RCM-9 recorded current, pressure, temperature, salinity, and turbidity at 60m depth (57°21.27'N, 19°36.65'E). Their sampling interval was 1 minute. Furthermore, a 600 MHz-ADCP was moored at 57°21.26'N, 19°36.37'E. Both moorings and the anchored ship formed a small triangle. CTD-time series started for hourly profiles at 25 April 09:00 UTC (station no.196-1) and ended at 28 April 10:00 UTC (station no.199-11). All records of current meters are still under processing and not available at this time.

At the anchor station, five EDP-casts were performed by burst sampling in the first 30 minutes each hour. The profiler was deployed from on board of the ship with the underwater winch staying on deck and the cable being towed via a block (diameter: 30 cm), which was fixed at a crane. The loose in the cable was manually removed. The NTC sensor was again covered by a protection cap. It was not possible to avoid bottom hits with the profiler completely, so it happened about 10 times. The TE sensor tip changed totally its direction, but it was still working. For falling measurements a much larger sensor protection guard must be used in the future. Movements of the anchored vessel caused disturbances in the upper part of the water column and gave several problems during the recovery of the EDP profiler. Anchorage with two anchors to provide a fixed position should be preferred for the next field campaigns, especially with respect to the application of a rising EDP-probe. All EDP profiles were collected under the leadership of the Space Applications Institute (SAI) of the Joint Research Centre in Ispra/ Italy.

At irregularly distributed stations, the penetration depth of solar UV-radiation was measured using a double-monochromatic spectral radiometer with a resolution of 2 nm between wave-lengths of 290 nm and 700 nm. The photo-biological relevance of the scalar UV-radiation should be investigated with respect to the development of the spring bloom of phytoplankton. Such investigations strictly depend from daily conditions of the solar irradiance (cloud coverage,...). Consequently, resulting stations can not show any regular grid. These measurements were carried out by the botanical institute of the Erlangen-University.

After the anchor station, the rest of available time was used for a short meridional transect for CTD and EDP, which is denoted (mk) in Fig.2. This section followed the crest of the Klints Bank (station no.200-204) from south to north. Thereafter, at the position of station 204, both probes were mounted together to calibrate their sensors (temperature, conductivity, pressure).

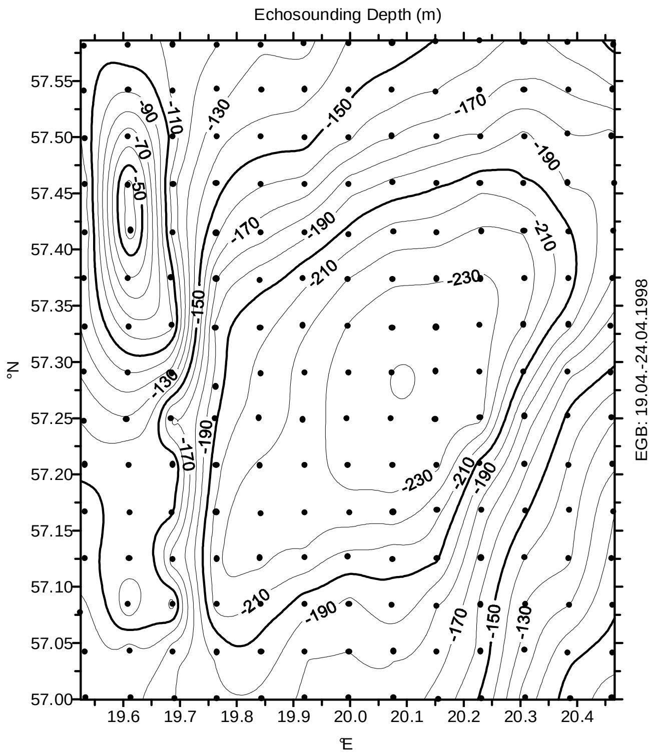

Fig.3 Bathymetric map of the MESODYN-8 area with station positions (dots)

For the CTD, the temperature was controlled by three reversing thermometers at different depths at the stations 008, 040, 072, 109, 142, 188, 196, 197, 198, and 204. The resulting rms error is (+/-) 0.002 K without any statistical correlation with the pressure. An analogous procedure was performed for salinity with the aid of salinometer measurements and for dissolved oxygen (Winkler method) resulting from bottle casts of the same horizons. Values of rms are found to be (+/-) 0.0006 (PSU) and (+/-0.59) ml/l, respectively. Actual echosounding depths are plotted in Fig.3

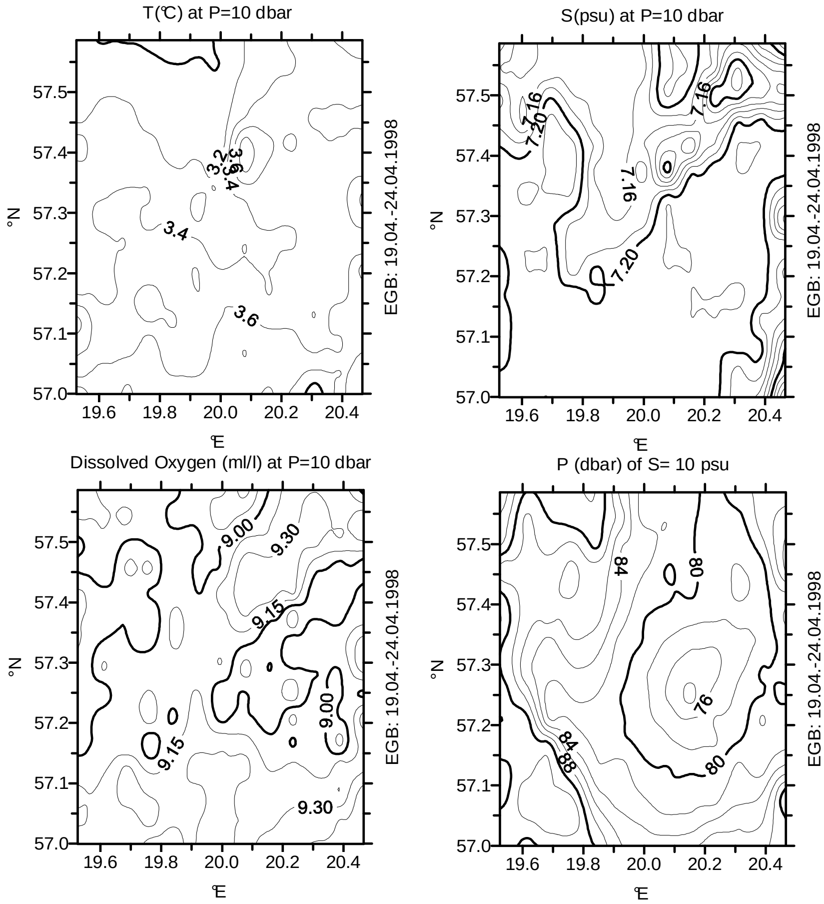

Fig.4 Distribution of temperature, salinity, and dissolved oxygen at the pressure level of 10 dbar in comparison with the topography of the S=10 psu- surface

The weather situation was characterised by a low with core pressures below 990 hPa southern of Iceland and a relatively stable high (>1030 hPa) over central Russia causing moderate winds from NE-SE. Near surface structures of temperature (T), salinity (S), and dissolved oxygen are compared with the pressure level of the S=10 psu- surface in Fig.4.

Water temperatures of the near-surface layer were measured around 3.5°C. It seems to be that a tongue of well oxygenated water with relatively low salinity contents spreads from NE-corner to SW. It could be interpreted as western branch of a cyclonic rotation in the motion field. The S=10 psu- surface roughly indicates the low part of the permanent halocline, which separates properties of the near surface water from those of the deep water. This surface shows a dome-shaped roof, which roughly locates above the deepest part of the basin. Such pattern must be associated with upward directed vertical motions.

In layers beneath the permanent halocline, series of smaller eddy-like features could be detected in different Relative Dynamical Topographies (not shown). Their diameter is about 5-15 km with a ‘wave-length’ of the same order between neighbouring events of the same sign. Peak values of related geostrophic current cores reach +/-16 cm/s. There is also some observational evidence that these features ventilate deep layers and contribute to upward directed fluxes of salinity and (if available) H_2S, especially along the rim of the basin. Only at few stations in the central basin some smell of H_2S occurred in the rosette samples, which were taken for O_2-calibration only.

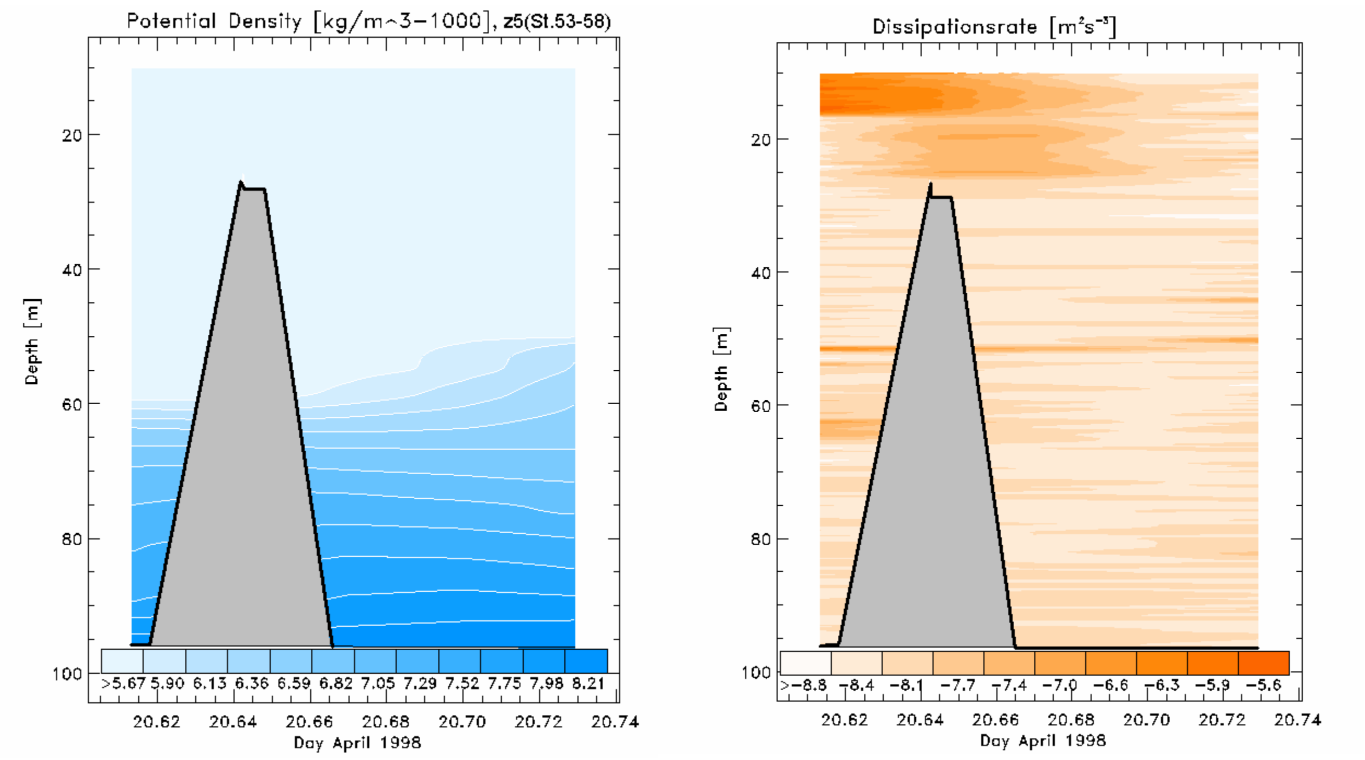

Fig.5 Vertical structures of the potential density and the dissipation-rate in the upper 100 dbar layer along the eastern part of section z5 (Station.no.53-58) enclosing the Klints Bank

Most of the EDP-profiles along zonal sections suggest an intensified production of turbulence just at the top of the pycnocline around 50m depth. Examples are shown in Fig.5 and Fig.6. Associated processes probably relate to downward directed convection caused by the cooling at the sea-surface during winter. Furthermore, there are clear signals of energy dissipation in shallower layers around the Klints Bank, which may be caused be different dynamical processes forced at the sea surface, Fig.5. Resulting time series of the dissipation-rate indicate an enrichment of turbulent energy down to the pressure level of about 20 dbar with cycles of the local inertial period of 14h in Fig.6. Another source is found in the 15m-near bottom layer. Its upper boundary coincides with the top of the pycnocline, which is here also characterised by strong vertical gradients in the temperature.

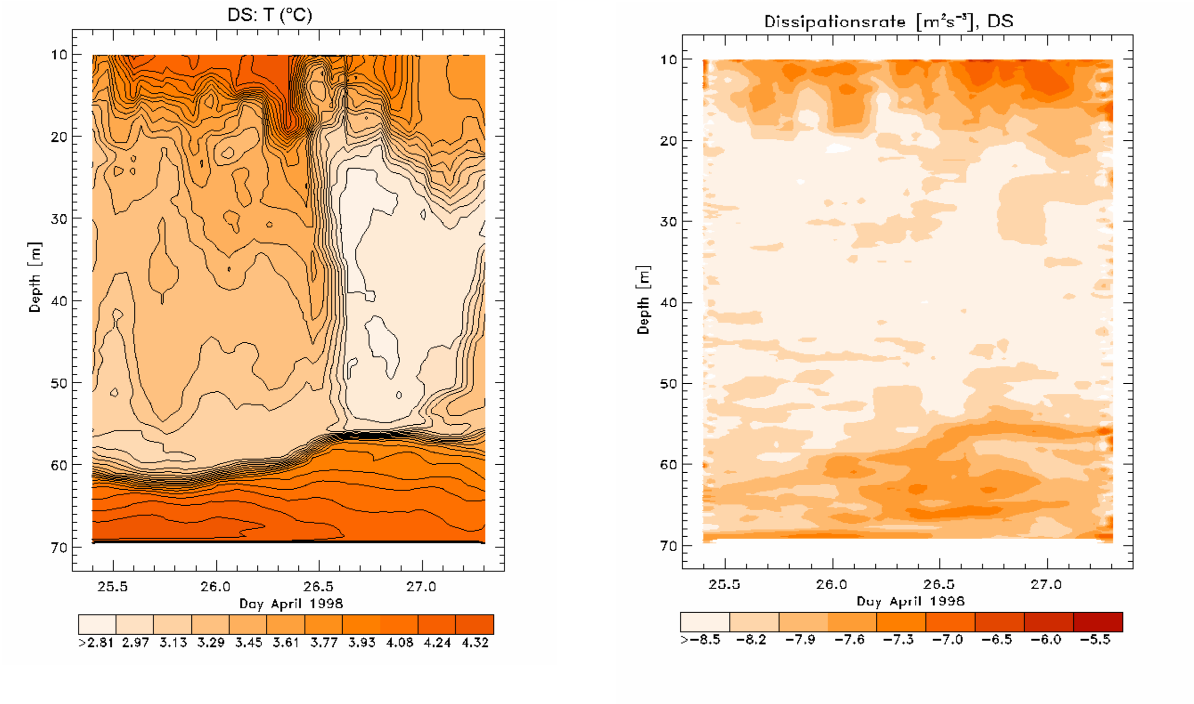

Fig.6 Vertical time series of the temperature (T) and the dissipation-rate (m^2/s^3) at the anchor station (DS); station position is given in Fig.2.

The passage of a relatively cold water lens with temperatures below 3°C was observed in intermediate layers between 20m and 55mdepth during day 26.5-27.5, Fig.6. It is associated with the advection of conditions indicating relatively poor energy dissipation. The temperature fluctuated around 4°C while the salinity was measured between 8.6 and 9.2 psu in deeper layers.

Optical underwater measurements revealed following observations: The detected colour types of water related to coastal waters of type C1-C3 according to JERLOV. Secchi-depths were found to be between 8m and 15m due to spatially patterned structures in the developing phytoplankton bloom. At the anchor station, this depth fluctuated around 8m. For example, the spectral distribution of the attenuation coefficient and that of the 0.1% depth for the scalar up- and downward directed irradiance are plotted in Fig.7 from observations at station (DS). Related data of yellow and/ or other dissolved substances together with phytoplankton from selected bottle-casts will be analysed in laboratories of the Erlangen-University during the next weeks.

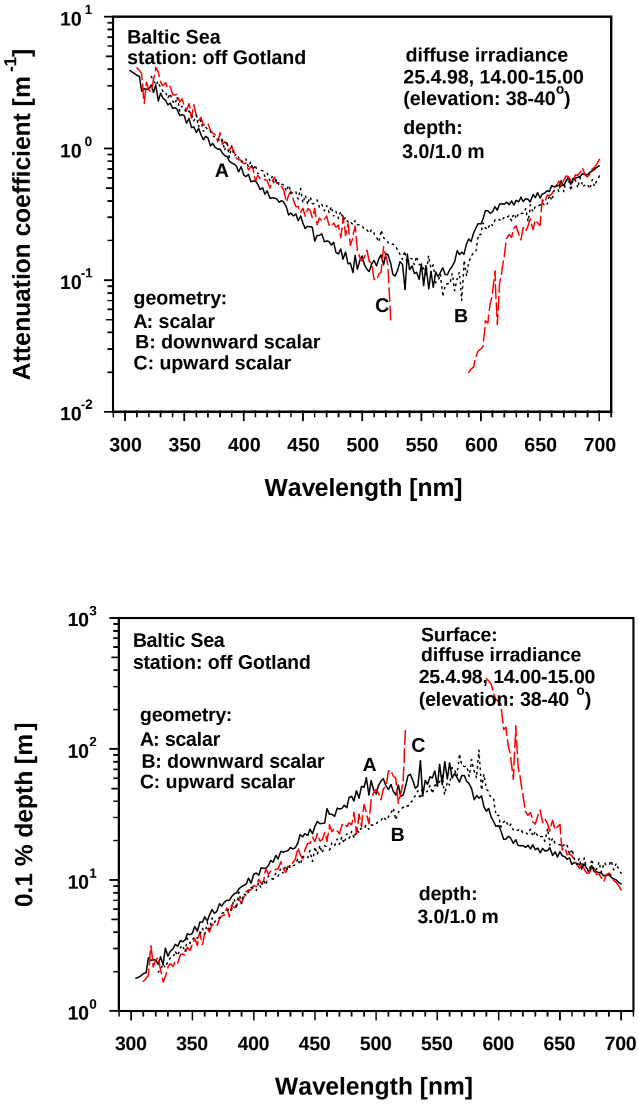

Fig.7 Spectral attenuation coefficient (upper panel) and 0.1%-depth of the irradiance at the anchor station (DS).

E. Hagen
Chief scientist