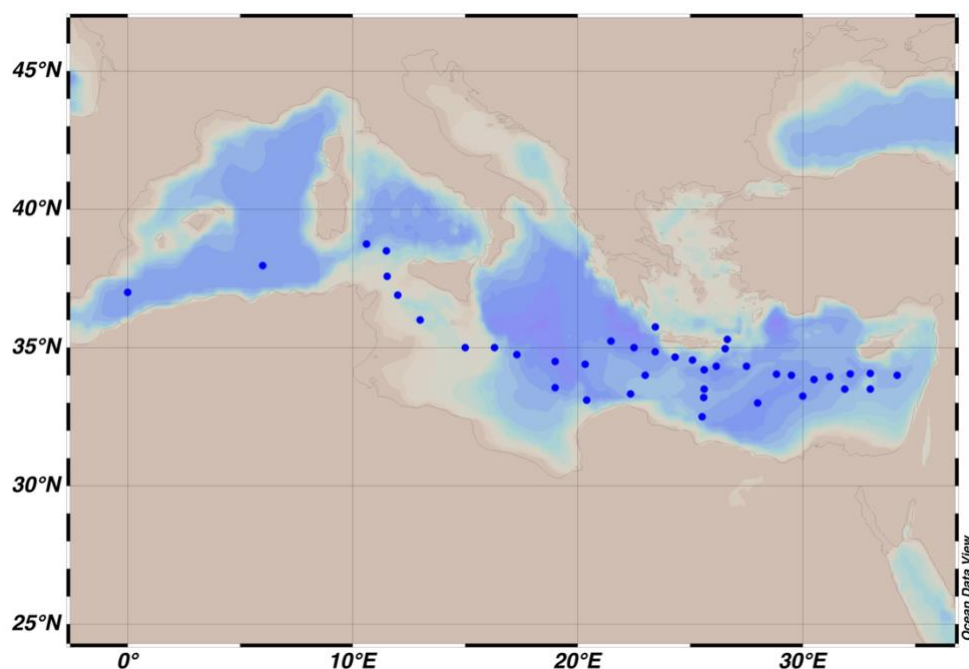


CRUISE REPORT: METEOR 51/2

Created: May 2026



Highlights

Cruise Summary Information

Section Designation	Cruise 51, Leg 2
Expedition Designation (ExpoCode)	06MT20011018
Chief Scientists	Wolfgang Roether; UBrem- Tracer
Dates	18 October – 11 November 2001
Ship	METEOR
Ports of Call	Malaga, Spain –,La Valetta, Malta
Geographic Boundaries	0° 38.75°N 34.2°E 32.5°N
Stations	44
Floats and Drifters Deployed	0
Moorings Deployed and Recovered	1 deployed

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Table of contents for the entirety of METEOR 51 is appended at the end of this cruise report

Report assembled by Savannah Lewis

METEOR-Berichte 03-1

Ostatlantik-Mittelmeer-Schwarzes Meer

Part 2

Cruise No. 51, Leg 2

18 October – 11 November 2001, Malaga – La Valetta



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2003

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2.1 Participants

Table 2.1: Participants of METEOR cruise M51/2

Name	Speciality	Institution
Almus, Ulrike	Zooplankton	UHam-Zool.
Bulsiewicz, Klaus	Tracer measurements	UBrem-Tracer
Christiansen, Bernd, Dr.	Zooplankton	UHam-Zool.
Deponte, Davide	CTD measurements	OGS, Italy
El-Komi, Mohamed, Dr.	Observer Egypt	NIOF, Egypt
Elvers, Dirk	Genetics	UBrem-Zool.
Fahmi, Mamdouh, Dr.	Observer Egypt	NIOF, Egypt
Gertmann, Isaac, Dr.	Nutrient measurements	IOLR, Israel
Halsband-Lenk, Claudia, Dr.	Zooplankton	UHam-Zool.
Herut, Barak, Dr.	Nutrient measurements	IOLR, Israel
Hollermann, Jürgen	Tracer measurements	UBrem-Tracer
Huhn, Oliver	Tracer measurements	UBrem-Tracer
Kahl, Gerd, Dr.	Meteorology	DWD
Klatt, Olaf	Tracer measurements	UBrem-Tracer
Klein, Birgit, Dr.	Tracer measurements	UBrem-Tracer
Koppelman, Rolf, Dr.	Zooplankton	UHam-Zool.
Kress, Nurit, Dr.	Nutrient measurements	IOLR, Israel
Lahajnar, Niko, Dr.	Sediment traps	UHam –IBM
Manca, Beniamino, Dr.	CTD measurements	OGS, Italy
Meligy, Mamdouh, Cdr.	Observer Egypt	Egyptian Navy
Mouloudj, Mohamed, Cdr.	Observer Algeria	Algerian Navy
Neugebohrn, Liesl	Zooplankton	UHam-Zool.
Roether, Wolfgang, Prof. Dr.	Chief Scientist	UBrem-Tracer
Scarazzato, Paolo, Dr.	CTD measurements	OGS, Italy
Schattenhofer, Martha	Tracer measurements	UBrem-Tracer
Streu, Peter	CO2 measurements	IfM-Chemie
Truscheit, Torsten	Meteorology	DWD
Warnken, Carolin	Sediment traps	UHam –IBM
Zimmermann-Timm, Heike, Prof. Dr.	Micro-Biology	Uni-Jena

Table 2.2: Participating Institutions

OGS	Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS), Borgo Grotta Gigante 42/c, 34010 Sgonico/Trieste, Italy
IfM-Chemie	Institut für Meereskunde an der Universität Kiel, Abt. Meereschemie, Düsternbrookerweg 20, 24105 Kiel, Germany
IOLR	Israel Oceanographic & Limnological Res., P.O. Box 8030, Tel Shikmona, Haifa, 31080, Israel
NIOF	National Institute for Oceanography and Fisheries, 101-Kasr El-Einy St., Cairo, Egypt
UBrem-Tracer	Universität Bremen, FB1, Insitut für Umweltphysik, Abt. Ozeanographie, P.O. Box 330440, 28334 Bremen, Germany

UHam-IBM	Universität Hamburg, Institut für Biogeochemie und Meereschemie, Geomatikum, Bundesstr. 55, 20146 Hamburg, Germany
UHam-Zool	Universität Hamburg, Institut für Hydrobiologie und Fischereiwissenschaften, Hydrobiologische Abteilung, Zeiseweg 9, 22765 Hamburg, 22765 Hamburg, Germany
Uni-Jena	Institut für Ökologie, AG Limnologie, Friedrich-Schiller-Universität Jena, Winzerlaerstr. 10, 07745 Jena, Germany

2.2 Research Program

2.2.1 Investigating the Transient of the Thermohaline Circulation of the Eastern Mediterranean

The classical thermohaline circulation of the Eastern Mediterranean, described by G. Wüst among others, was dominated by deep water production in the Adriatic, manifest in quite uniform values of temperature and salinity below about 1200 m depth. However, at the end of the 1980s, the Aegean Sea, which likewise borders the northern rim of the Eastern Mediterranean, was raised in salinity to a degree that dense waters were formed at a considerable rate, which to a large extent replaced or masked the Adriatic-derived deep waters. The last available survey of the „classical“ situation, and the first survey that definitely showed that a big transient was in place, were obtained during the METEOR cruises M5/6 (1987) and M31/1 (1995), respectively (Roether et al., 1996; Klein et al., 1999). Both surveys were part of the international program POEM or POEM-BC (Physical Oceanography of the Eastern Mediterranean – Biology and Chemistry), of which the detection of the big transient was a side-product. These cruises comprised measurements of hydrographic properties, nutrients/oxygen, anthropogenic and natural tracers, and various biological parameters, on a medium-resolution station grid covering the entire Eastern Mediterranean. A further survey (M44/4, 1999) documented an ongoing, comparatively rapid change in the hydrography of the sea. Numerous, areally more restricted cruises by the oceanographic centers of the region, have reported much further detail of the transient. Changes brought about by the transient are present over most of the water column and refer to the distributions of all properties, such as the nutrients, the CO₂ system parameters and biological properties. Biogeochemical rates are likewise affected, for which a reported increase in deep water oxygen consumption rates is an example (Klein et al., 2002).

The phenomenon that dominant deep water production flips between two potential deep water formation areas is of general oceanographic interest. The issue is the role of internal system instability versus changes in atmospheric forcing (a Global Change context). To obtain a conclusive answer, it is necessary to carry out repeated observations of the transient and to hindcast these using dynamical circulation models and ecological models of a suitable design. Due to the limited extension of the Eastern Mediterranean, such an approach is far easier applicable here than in the major ocean basins, but the Mediterranean transient can potentially serve a model function in assessing the role of the ocean in the context of global climate prediction. The M51/2 cruise was aimed at documenting the further development of the transient, using measurements similar to those of the previous cruises.

2.2.2 Structures and Dynamics of Zooplankton and Biogeochemical Fluxes in the Deep Waters

Previous zooplankton investigations in winter 1987 (M5/1) and in summer 1993 (M25/2) southeast of Crete (Ierapetra Basin) documented a high variability in the deep water body of the Levantine Sea which is unusual for a deep-sea environment. Main generators of the significant increase of the zooplankton standing crop in 1993 were large, interzonal copepods. The submergence of the species' standing crops which were composed of dormant developmental stages, points to a direct surface-abyssal-pelagic coupling of processes. Considering the life strategies and food demands of these key species in other seas, it is suggested that the common dominance of microbial loop production in the euphotic zone of the Levantine Sea associated with dominant small copepod species, was changed on short term to a more classical food web structure, with large coarse-filterers as a typical faunal element. One of the dominant copepod species was not even observed in the area prior to 1993. It may have been transported into the Levantine Sea in the course of the enhanced Aegean deep-water inflow since about 1990. One aim of M51/2, the fifth cruise into the Levantine Sea, therefore was to assess the acting temporal and spatial scales of variability, i.e. to discriminate longer term, basin-wide effects from shorter term (interannual, seasonal), sub-basin scale effects. For this purpose, and based on the concomitant oceanographical survey, the structure and dynamics of zooplankton in the water column off Crete were investigated in line with earlier expeditions (M5/1, M25/2, M40/3, M44/4).

The second aim was to estimate the carbon demand of the zooplankton and micronekton faunas. These results together with the findings obtained from the biogeochemical working groups were to answer the question whether changes in the taxonomical and trophical structure in the deep water column modify the vertical flux of particles to the abyssal sea floor.

The following objectives were pursued:

- quantitative sampling of the pelagic faunas to estimate their composition and standing crop,
- determination of the variability of zooplankton on different scales in space and time,
- analyses of ontogenetical and size structures,
- assessment of trophic levels and their analysis by means of diets of selected taxa,
- estimation of the carbon demands of the pelagic deep-sea metazoan faunas and chosen components.

Furthermore, a sediment trap system was deployed in the Ierapetra Deep, with the aim to investigate the variation of fluxes and composition of particles settling to the deep sea in space and time. Detailed analyses of organic compounds will provide information on the sources, transport paths and transport processes of the organic matter. These investigations, carried out in the western Levantine Basin for the first time, are closely linked to the planktological investigations and should contribute to the understanding of externally forced material fluxes and its relevance for deep sea biology.

2.3 Narrative of the Cruise

METEOR sailed in beautiful weather from Malaga, Spain, on 18 October, 8.00 UTC. The scientific crew was complete (23 scientists of the participating groups from Germany, Italy, and Israel, 2 guest scientists, and 2 observers) and all gear had been received in time. Following the usual instruction by the ship and a first information exchange concerning scientific goals and methods to be employed, the setting up of equipment, which had begun in port, was resumed. The first station was occupied early the next day, with two multinet casts to 1000 m and a trial cast of the CTD/Rosette system. The second station, on the following morning, included another multinet cast and two CTD/Rosette casts, of which one served to ensure absence of CFC contamination of the Rosette's water bottles. A few smaller equipment problems were eliminated. The ship left the Algerian waters early on Sunday, October 21, whereupon the Algerian observer, who had joined the ship already during M51/1, was collected by an Algerian navy vessel; a moderate delay was caused by a mix-up of the meeting position. Winds were favourable so that the ship swiftly progressed East, reaching the starting point, between Sardinia and Sicily, of the detailed hydrographic work planned, in the early evening of the same day. The hydrographic work went on uninterrupted up to the afternoon of October 26, providing a coherent section through the Strait of Sicily and along the Eastern Mediterranean up to south of Crete (~ 25°E) with a detour into the deep connection with the Aegean Sea west of Crete (15 stations altogether). Samples were taken for a variety of measurements (hydrographic properties, tracers), and part of the stations included multinet, WP-2 net, and/or Bongo net casts. Very late on this day, the Ierapetra deep (about 34°25'N, 26°05'E, > 4000 m) was reached, whereupon three and a half days of zooplankton catches with the MOCNESS multinet (20 * 1 m² nets) began. This work included several shallow and deep casts. The shallow casts were to sample under representative day and night conditions, while the deep ones reached down to close to the bottom (10 m minimum distance). The wind had caught up somewhat (close to Bft 7), but the work was not really affected. However, strong currents induced considerable side drifts of the net, which required careful manouvering during MOCNESS retrieval. While the MOCNESS work went on, a dinner on deck and party was held on Sunday evening, October 28. On October 30, a sediment trap was deployed and two hydrographic stations were done, whereafter the intense MOCNESS work was completed. METEOR continued northeast into Kasos Strait east of Crete, and then turned southeast and east to complete the west-to-east section of hydrographic and MOCNESS stations. The easternmost position, approximately 34°N, 34°E, off the Libanese coast, was reached during the night of 3 November. From then on, the cruise followed a less regular route meant to fill in information complementary to that from the section obtained previously. Completing several further hydrographic stations, the ship firstly steamed toward the southwestern corner of the Levantine Basin, where another MOCNESS station was run. These stations and subsequent ones along short northward section toward Crete, in part met Egyptian territorial waters. For the stations affected, a sample sharing procedure to meet Egyptian demands was devised, the details of which were worked out in cooperation with the Egyptian observer. The ship then moved due west to the position of a last MOCNESS station, and then southwestward once more. Due to generally favourable weather and absence of technical problems, fortunately, enough time was left to allow us to run a number of further fill-in stations, sampling the southern deep waterway of the Cretan Passage, waters close to the Libyan coast (keeping due distance), and, finally, on approach to the Malta Escarpment, more northerly waters

than had been sampled on the way in (for ship track see Fig. 2.1 and 2.2). The weather during these days was somewhat variable, so that it was necessary to keep track of the ship's progress continually. A good-bye party to celebrate the success of the cruise and the splendid cooperation with the crew was held on November 8. Moreover, seminars were offered to the crew to inform them of scientific and technical aspects of the work, and joint ping-pong and table soccer contests were organized. The work ended in the afternoon of November 10. Hurried packing followed, which was largely completed when the ship called in, as scheduled, at the port of La Valetta, Malta, at 8 am on November 11. Most of the scientific crew left METEOR that day. The final event of cruise was a well attended reception by METEOR in the afternoon of November 13, jointly with the scientific crew of the leg following, and with the German Embassy.

2.4 Preliminary Results

2.4.1 Hydrographic Investigation of the Eastern Mediterranean

2.4.1.1 CTD Observations and Dynamics

(B. Bruno Manca, Davide Deponete, Paolo Scarazzato)

2.4.1.1.1 Data and Methods

CTD data: Along the ship track, shown in Figure 2.1, a total of 44 hydrological stations were occupied. There were 61 CTD casts, of which 48 were down to the bottom, including a few repeated profiles, and 13 were limited to 200 m to collect additional water for analyses of organic compounds in particulate matter. Two stations in the Western Mediterranean essentially reoccupied stations of the previous cruises M31/1 (1995) and M44/4 (1999). The Eastern Mediterranean stations are depicted in Figure 2.2; they form two west-east sections running between 35-36° N and at 33° N. The parameters measured at each station were: temperature, salinity, dissolved oxygen, light transmission, light scattering and fluorescence, obtained using a SBE 911 plus CTD (Conductivity, Temperature and Depth) vertical profiler equipped with the following sensors:

- Paroscientific digiquartz pressure transducer (0÷10000 psia, 0.015 % F.S.);
- Oceanographic thermometer S/N 1709, as primary, and S/N 1717, as secondary (-5 ÷ 35 °C, ± 0.002 °C);
- Electrical conductivity sensor S/N 1487, as primary, and S/N 1489, as secondary (0÷7 Siemens/m, ± 0.001 S/m);
- Beckman polarographic dissolved oxygen sensor S/N 130514, (0÷15 ml/l, ± 0.1 ml/l);
- Chelsea Alphatracka, transmissometer, 25 cm water path (0÷100 %, <0.3 % F.S.);
- Chelsea, Mk III Aquatracka Fluorometer (0-96 µg/l of Chl, ± 3% of reading);
- Sea Tech light scattering S/N 242, (0÷33 mg/l, ± 0.01 F.S.).

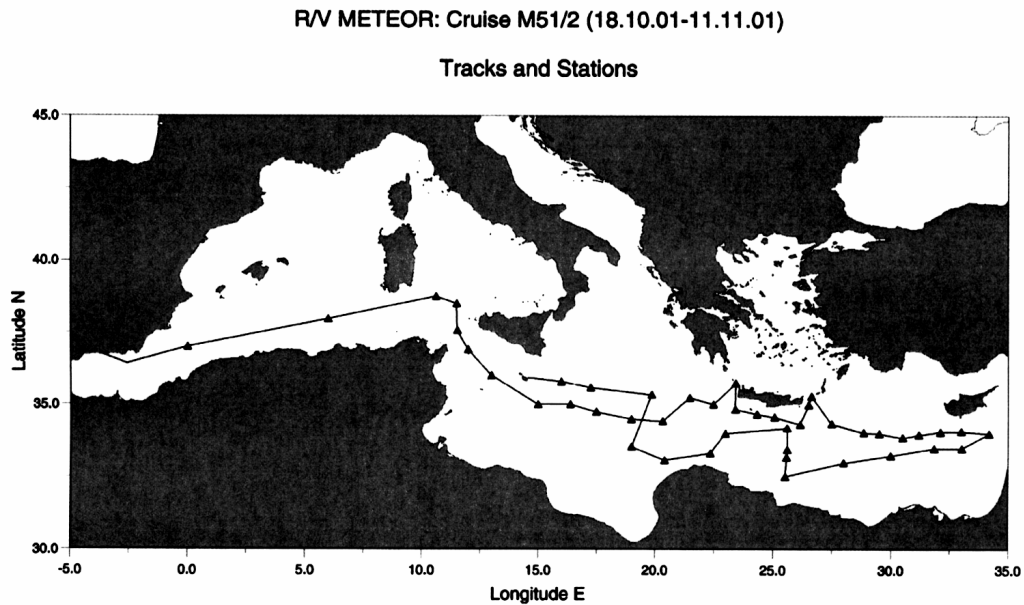


Fig. 2.1: Ship track of METEOR Cruise M51/2.

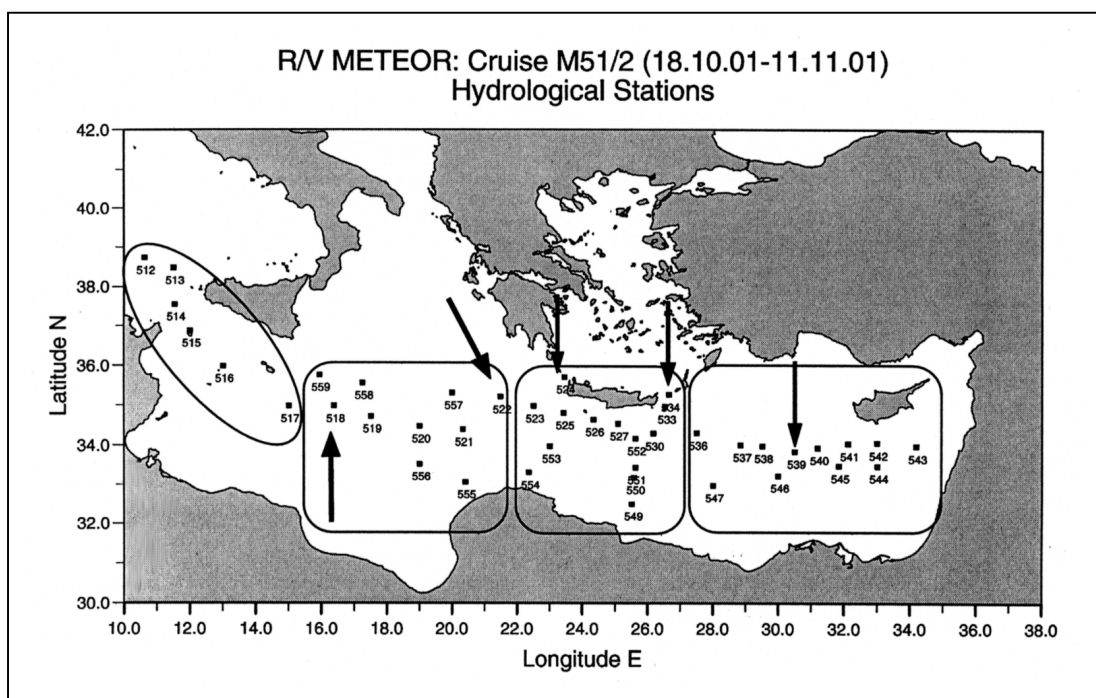


Fig. 2.2: Station map of the hydrological stations occupied in the Eastern Mediterranean during M51/2. Certain areas referred to in Fig. 2.4 are indicated (W: western, C: central and E: eastern part).

A tilt sensor was set to reveal distances of 10 m from the sea bed. A SBE Carousel Water Sampler was used in combination with the CTD to collect water samples at desired depth from 24-Niskin bottles of 10 l. Additional independent measurements of salinity were performed on water samples by 8400A Guildline Autosol bench-salinometer (± 0.001) for calibration purposes. The methods used for collecting and analysis of CTD data were essentially those described in the UNESCO technical papers in marine science no. 54 (UNESCO, 1988). The high resolution vertical profiles were sampled at 24 Hz when the CTD was lowered at a nominal winch-speed of 1 m/s. Data were processed on board and visually inspected to eliminate obvious erroneous values retaining the down cast, exclusively. The up-cast was used to extract data in correspondence of the water samples collected for bio-chemical and tracer measurements. The quality controlled data were subsequently averaged over 1 dbar pressure interval. The analyses of water samples for salinity determination were performed on board after the samples were stabilised at room temperature, while the bath of the salinometer was maintained at 24 °C.

Quality control and calibration: The temperature, conductivity and dissolved oxygen sensors were calibrated by the manufacturer prior to the cruise (date: June 19th 2001). Moreover, the hydrological measurements were quality controlled by checking the discrepancies between different sensors and methods. The differences in temperature and salinity between the primary and secondary sensor were extremely constant during every cast and all through the cruise, i.e., within the instrumental accuracy of ± 0.001 °C for temperature and ± 0.002 for salinity. The two temperature sensors showed identical values, but the data from the two salinity sensors differed. Comparison with the salinity determinations on the water samples confirmed that the salinity output of the primary sensor was correct, which was therefore chosen as the retained data. Temperature data follow the IPTS-68 temperature scale to maintain the compatibility with our previous measurements, and salinity is expressed in psu (UNESCO, 1983).

Dissolved oxygen concentrations, derived from temperature and concurrent data of the polarographic sensor, were computed by using the SEASOFT software package of SBE. They were calibrated by comparison with the data obtained on water samples by N. Kress using the Carpenter-Winkler titration analytical procedures, with a precision of ± 0.3 % (see 5.2.1.3), revealing depth-dependent and time-dependent differences. The CTD data were corrected accordingly. Figure 2.3 shows the CTD-water sample data comparison after the data correction, which indicates an overall rms error of the former of ± 0.062 ml/l.

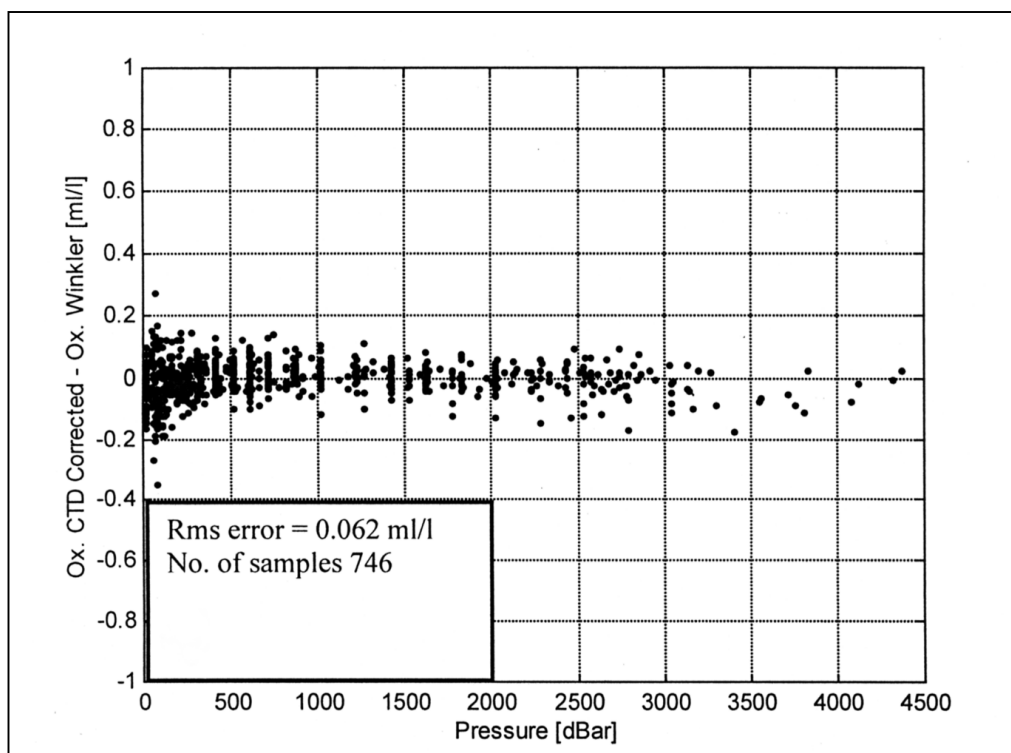


Fig. 2.3: Differences between concurrent dissolved oxygen (ml/l) measurements obtained by the CTD polarographic sensor (corrected, see text) and by Winkler titration vs. pressure. The overall rms error is ± 0.0657 (ml/l).

Periodic maintenance was performed on the transmissometer probe, and its calibration coefficient was repeatedly checked on deck following thorough cleaning of the probe's optics. The data are expressed in %. The light scattering probe was calibrated using NTU Formazin and data are given in mg/l. Cross checks between the profiles of transmittance and light scattering showed that the instruments tracked the expected inverse correlation very well through the water column. The fluorometer remained uncalibrated to fluorometric chlorophyll, so that the data (which are in arbitrary units) largely represent qualitative anomalies of the fluorescence, which are mainly present through the photic layer. The graphs below exclusively use data from the CTD sensors.

ADCP measurements: Current measurements were obtained along the ship track (as far as permission was available) by means of METEOR's ship-mounted Ocean Surveyor 75kHz-ADCP (Acoustic Doppler Current Profiler). The ADCP was connected to a GPS positioning system and a gyro-compass, which allowed to compute accurately the ship velocity that must be subtracted from the measured velocity data. The ADCP worked in the narrow band mode and was set-up in order to obtain one ping every 2 seconds. The system was setup to cover the maximum allowed (theoretical) depth range of about 700 m, i.e., 45 cells of data representative over a bin interval of 16 m. To boost accuracy, the data were averaged over 30 pings, i.e. one minute, yielding a standard deviation of 3.1 cm/s. The horizontal resolution of vertical current profiles is thus 100 - 200 m, depending on the ship's velocity. Good data were retrieved between 25 m (first cell) and about 500-700 m depth.

Air-sea interface parameters: Meteorological data and data from thermo-salinograph were collected from the ship's meteorological station interfaced to the navigation system data acquisition. They were: air temperature (dry), relative humidity, barometric pressure, wind speed

and direction and incident radiation. A CD-ROM with the data registered from the navigation system was also made available on board by the system manager at the end of cruise. It contains the navigation data in combination with the data derived from other measured air-sea interface parameters along the ship track, sub-sampled every 5 minutes. Further parameters were observed/estimated by sight, i.e.: sea state and direction, cloud type and amount, visibility and present weather. These parameters were registered on log-form according to codes and standards, following the user manual published by the World Meteorological Organization. These observations were performed at each hydrological station.

2.4.1.1.2 Results

Water mass properties across the Eastern Mediterranean: Potential temperature versus salinity diagrams are shown in Figure 2.4 a-d for the regions indicated in Fig. 2: (a) the Sicily Strait (Stas. 512-517), (b) the Ionian Sea (518-522; 555-559), (c) the Cretan Passage (523-534; 549-554), and (d) the Levantine Basin (536-547). Core properties of the relevant water masses, i.e., Modified Atlantic Water (MAW), Levantine Intermediate Water (LIW) and Eastern Mediterranean Deep Water (EMDW) are indicated. In the upper waters upward of the $28.4 \text{ kg}\cdot\text{m}^{-3}$ isopycnal, all the diagrams show the relatively fresh MAW, with salinity ranging from $S \cong 37.2$ in the Sicily Straits to $S \cong 38.7$ in the Levantine Basin, where the MAW is overlain by more saline locally formed waters ($S > 39.0$). In the intermediate layer, the LIW core (temperature about $15.0\text{-}17.0^\circ\text{C}$) reaches its salinity maximum of about $S \cong 39.13$ in the Levantine Basin, while both its salinity and temperature decrease on its way west. In the Ionian the LIW splits into two salinity maximum different cores. They may derive from prolonged residence in the eastern Ionian and/or contributions of high salinity waters from the Cretan Sea (South Aegean).

The situation in the deep layer is characterized by the progression of the relatively denser waters (i.e., warmer and saltier) of Aegean origin into the previous regime of colder and less saline EMDW of Adriatic origin. A substantial difference between the western region (Fig. 4a and b) and the eastern region (Fig. 2.4 c and d) emerges in the range $\sigma_\theta > 29.20 \text{ kg}\cdot\text{m}^{-3}$. The latter graphs show a distinct inversion in temperature and salinity below $\sigma_\theta \cong 29.20 \text{ kg}\cdot\text{m}^{-3}$, which is clear evidence of dense Aegean waters. In the Ionian, the inversion is largely restricted to stations close to the Aegean outflow through the western Cretan Arc strait (Fig. 4b). A significant part of the deep outflow through the Sicily Straits into the western Mediterranean (Fig. 2.4a) is composed of waters colder and less saline than LIW, clearly originating from the Adriatic Sea. In fact, in the western Ionian a consistent uplifting of the deep isopycnals ($\sigma_\theta \cong 29.17\text{-}29.19 \text{ kg}\cdot\text{m}^{-3}$) up to the sill depth of the Sicily Strait ($\sim 700\text{-}1000 \text{ m}$) is observed (see Fig. 8c below), allowing dense waters of Adriatic origin to pass over into the western Mediterranean.

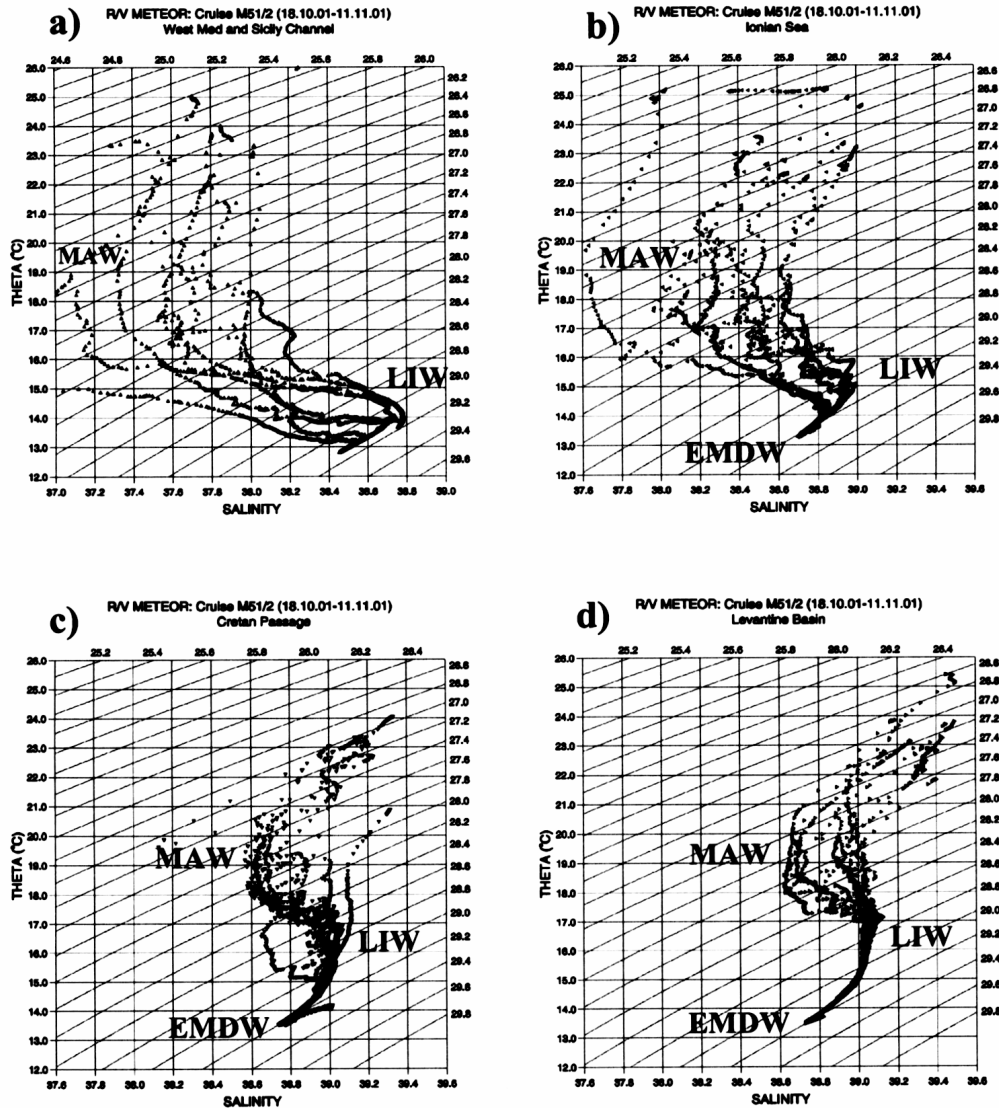


Fig. 2.4: Potential temperature (THETA) versus salinity diagrams plotted as scatter plots of the CTD data, grouping together the stations in four regions as indicated in Fig.2.2; (a) Sicily Strait, (b) Ionian Sea, (c) Cretan passage and (d) Levantine basin. Superimposed are isolines of the potential density excess σ_0 ($\text{kg}\cdot\text{m}^{-3}$, right y-axis). Note the different salinity scale in Fig. 2.4a.

Long-term changes of the water column structure: Comparisons of selected temperature and salinity profiles obtained in some key areas of the eastern Mediterranean during M51/2 (thick lines; stations indicated by arrows in Fig. 2.2) with ones obtained during METEOR cruise M31/1 in 1995 (thin lines), i.e., during an early status of the transient, are shown Fig. 2.5. Evidently, the change in water characteristics affects both the deep and the intermediate-depth waters. The change furthermore decreases in intensity with distance from the Cretan Arc Straits, and in part also changes sign (compare upper and lower panels of Fig. 2.5a). The biggest change occurs in the Cretan Arc straits (Fig. 2.5c), where both temperature and salinity have become distinctly

lower in the previous outflow range of Aegean dense waters (approximately 400 – 800 m). The present outflow/inflow situation across the Cretan Arc will be a subject of future investigation using the ADCP current data.

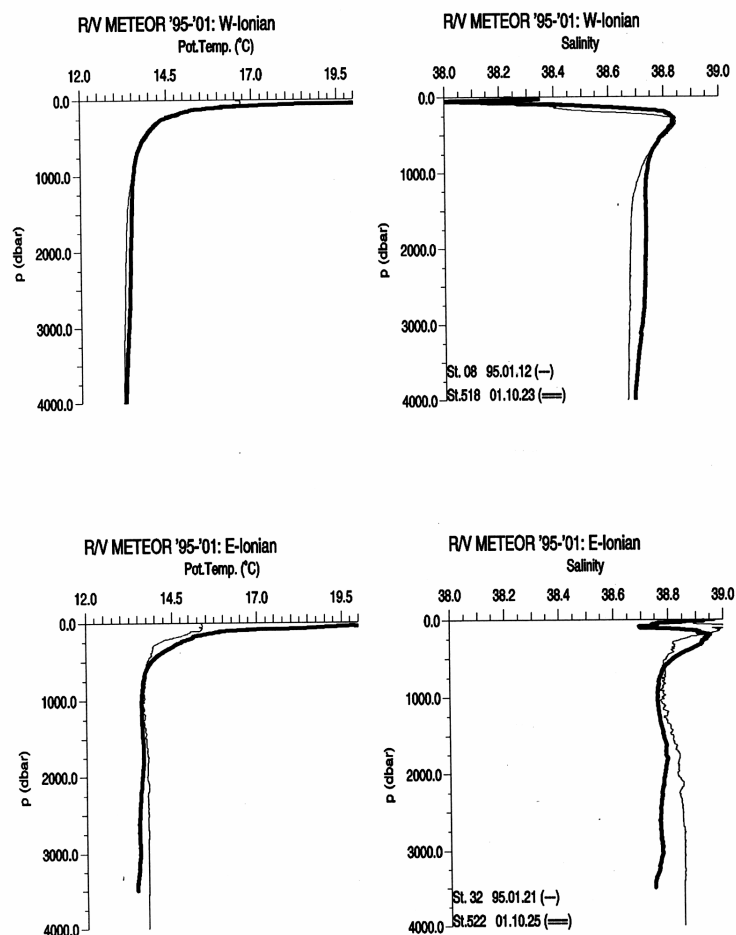


Fig. 2.5: Potential temperature and salinity profiles at selected stations in 1999 (thin lines) and in 2001 (thick lines); (a) in the western Ionian (top row) and in the eastern Ionian (bottom row)

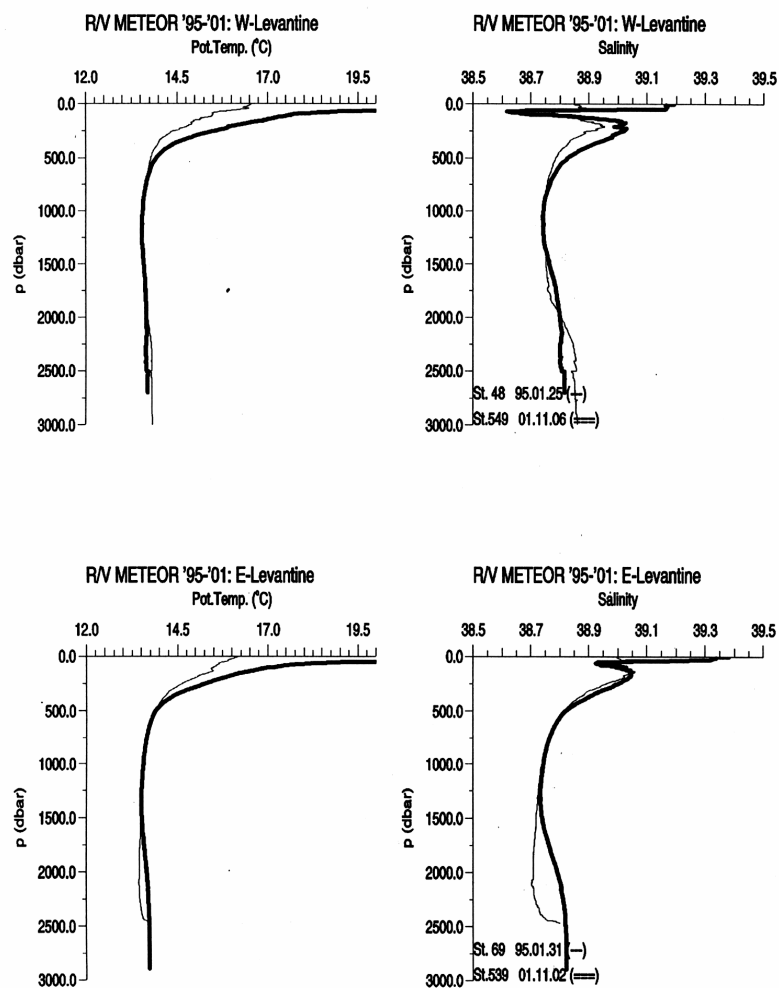


Fig. 2.5 cont.: Potential temperature and salinity profiles at selected stations in 1999 (thin lines) and in 2001 (thick lines); (b) in the western Levantine (top row) and eastern Levantine (bottom row)

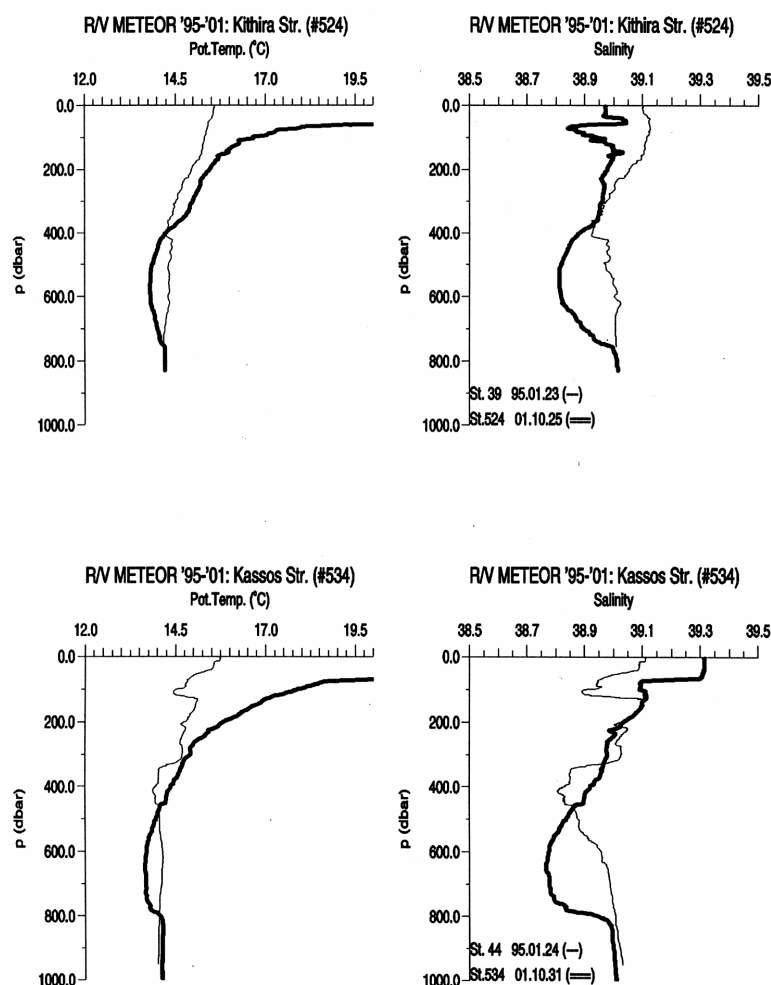


Fig. 2.5 cont.: Potential temperature and salinity profiles at selected stations in 1999 (thin lines) and in 2001 (thick lines); (c) in the Kithira Strait (top row) and Kassos Strait (bottom row)

Dynamical features: Various surface features were monitored during the survey using sea surface temperature (SST) satellite images, prepared at the OGS shore laboratory and transmitted via e-mail. Besides the expected north-south temperature increase (about 9°C), various surface current features described previously (e.g., POEM Group, 1992; Robinson and Malanotte-Rizzoli (eds.), 1993) became apparent. These include the meandering Atlantic-Ionian Stream, which transports MAW eastwards, a strong Cretan Cyclone and the Ierapetra Anticyclone close to the Cretan Arc. Further east, we observed a large cyclonic Rhodes Gyre extending westwards including the West Cyprus Gyre, and prevailing anticyclonic motion in the south, seemingly in a multi-lobe configuration. Both the Adriatic and Black seas surface waters seem to flow into the adjacent basins, i.e. the Ionian and Aegean seas, respectively. The dynamical features were also verified through the ADCP current measurements. Fig. 2.6 as an example shows a stick diagram of horizontal current vectors at mid-basin between 26° and 32°E. Where available, these vectors can be related to the SST images. The mentioned features and further ones, including the mesoscale, will be the subject of future investigation. It is strongly recommended to collect ADCP data also during future surveys.

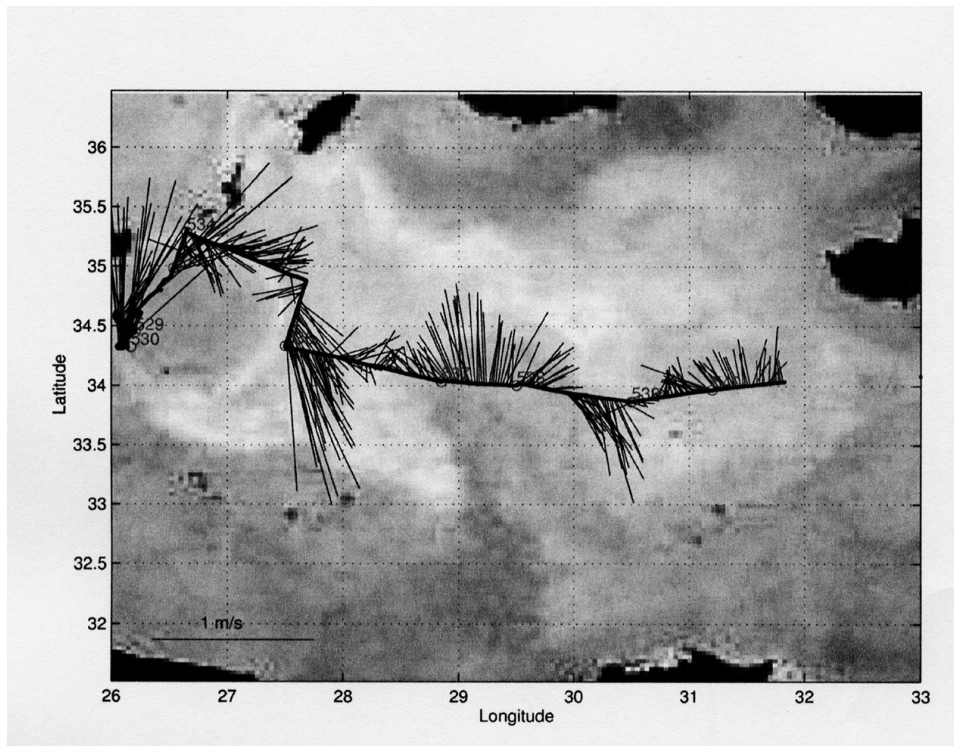


Fig. 2.6: Continuous traces of current vectors (stick diagrams) along the ship track (thick black lines), overimposed to the SST satellite image in the region between the Cretan Passage and west of Cyprus. The island of Rhodes, Asia Minor and the Egyptian coastlines may be also noted.

Vertical sections: Along-basin sections of potential temperature, salinity and potential density are shown in Figures 2.7a, b and c, with water masses marked in the salinity section. Salinity is most indicative of the water mass distribution, whereas temperature and density reflect more the dynamics, in particular in the upper water column (0 - 800m) where a strong thermocline/pycnocline develops. The topography of the density isolines indicates that the majority of the mentioned dynamical features indicated by the satellite SST images extend down into the water column. One recognizes a large anticyclone in correspondence of station 520 (Central Ionian), the strong Cretan Cyclone in correspondence of station 525 (western tip of Crete), the Ierapetra Anticyclone between stations 527 and 536, and a weak expression of the Rhodes Gyre between stations 537 and 539. The salinity section (Fig. 2.7b, top panel) shows a tongue of freshly intruding MAW in the west, extending east in a sub-surface layer into the middle of the Levantine basin, where it is overlain by very saline Levantine Surface Water. The intermediate layer is dominated by westwards spreading of LIW, with a core ($S > 39.05$) in the eastern Levantine between 150 and 250 m depth. The LIW deepens westward to about 200-400 m depth, and enters the eastern Ionian with a salinity of about 38.90. Here a second source of saline water from the Cretan straits, as noted during the 1999 METEOR cruise, seems to raise the salt content in the LIW layer. The LIW reaches the western end of the Ionian, at depths of about 300-600 m with a salinity maximum of 38.80.

Property sections in the deep layer (Fig. 2.7a, b and c, bottom panels) demonstrate the evolution and status of the vertical structure caused by the addition of warmer and more saline dense waters outflowing from the Aegean Sea. The influence of Aegean dense water extends

more strongly into the Eastern Levantine, below 1500 m, where temperature and salinity increased considerably. A clear indication of a westward spreading into the western Ionian of dense waters recently formed in the Aegean is missing (by the way, a general increase of temperature and salinity in the transition and deep layers is noted). On the other hand, there is clear evidence that the core of the old EMDW of Adriatic origin (less saline), which is found below 1000 m in the western Ionian with properties of $\theta \cong 13.50$ °C, $S \cong 38.75$, and $\sigma_\theta \cong 29.19$ kg·m⁻³, appears to be more extended than observed during the 1999 cruise. Moreover, itv seems that a tongue of EMDW ($\theta \cong 13.55$ °C ; $S \cong 38.74$) in the Levantine basin, presumably old deep water uplifted to about 1000 or less, is able to intrude into the Aegean Sea through the Eastern Cretan Arc straits, compensating Aegean outflow in the upper and intermediate layers. Presumably, such EMDW is effective in diminishing the salt content in this critical region of the Eastern Mediterranean.

Financial support was received from CNR/Rome (Italy) with contribution n. 00.00047.PF21 in the framework of the “Accordo di programma tra il CNR e il MURST – Legge 95/95”, project SINAPSI- Ecosistemi Marini, and also by the Ministero per l’Università e la Ricerca Scientifica e Tecnologica (MURST). We acknowledge the Deutsche Forschungsgemeinschaft for supporting our participation in the M51/2 cruise.

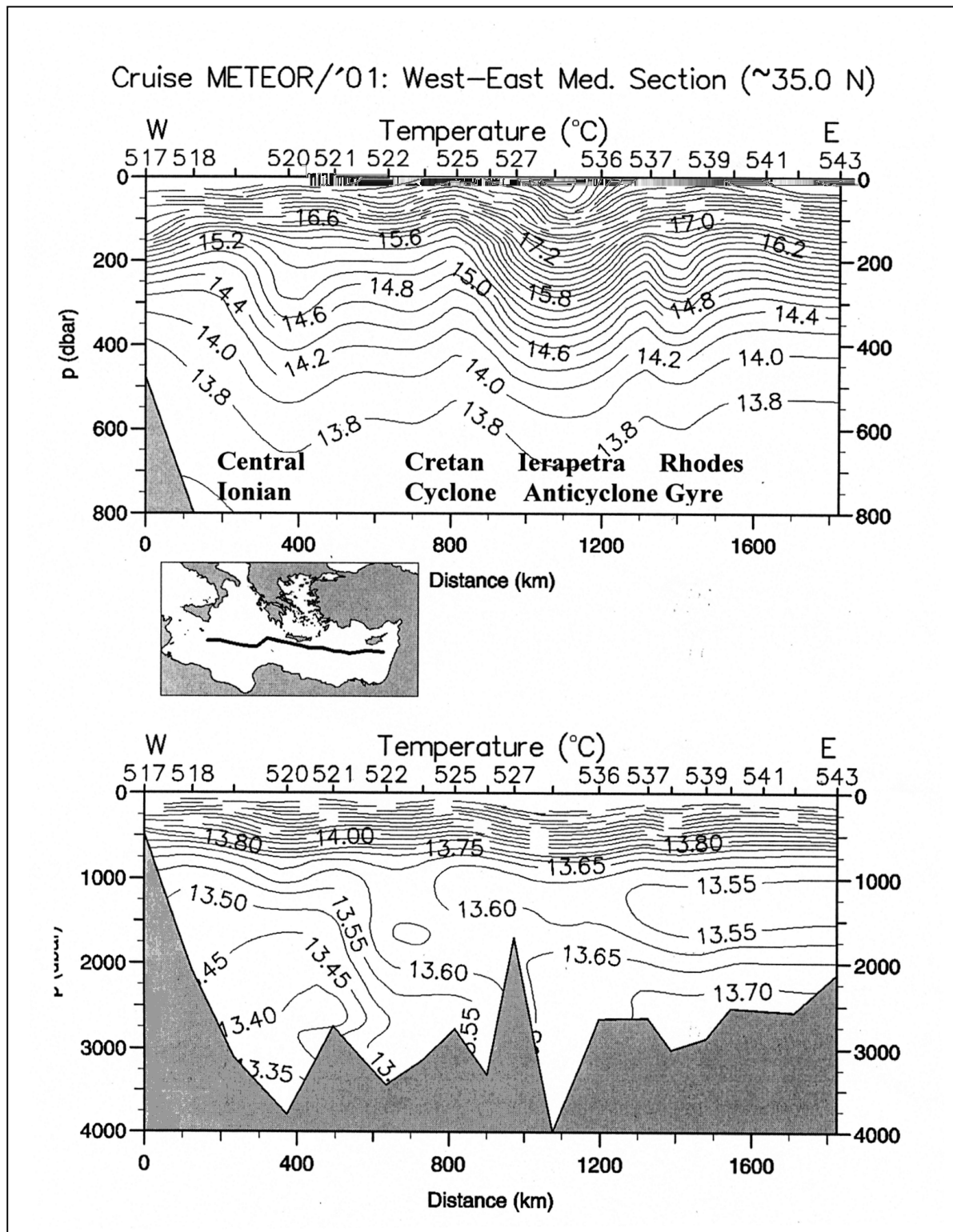


Fig. 2.7: Vertical distributions of potential temperature (a), salinity (b) and potential density (c). Sections are shown for the upper 800 dbar (upper panel) and for the whole water column (lower panel). Station numbers are given at the top, and the section is shown in the insert map.

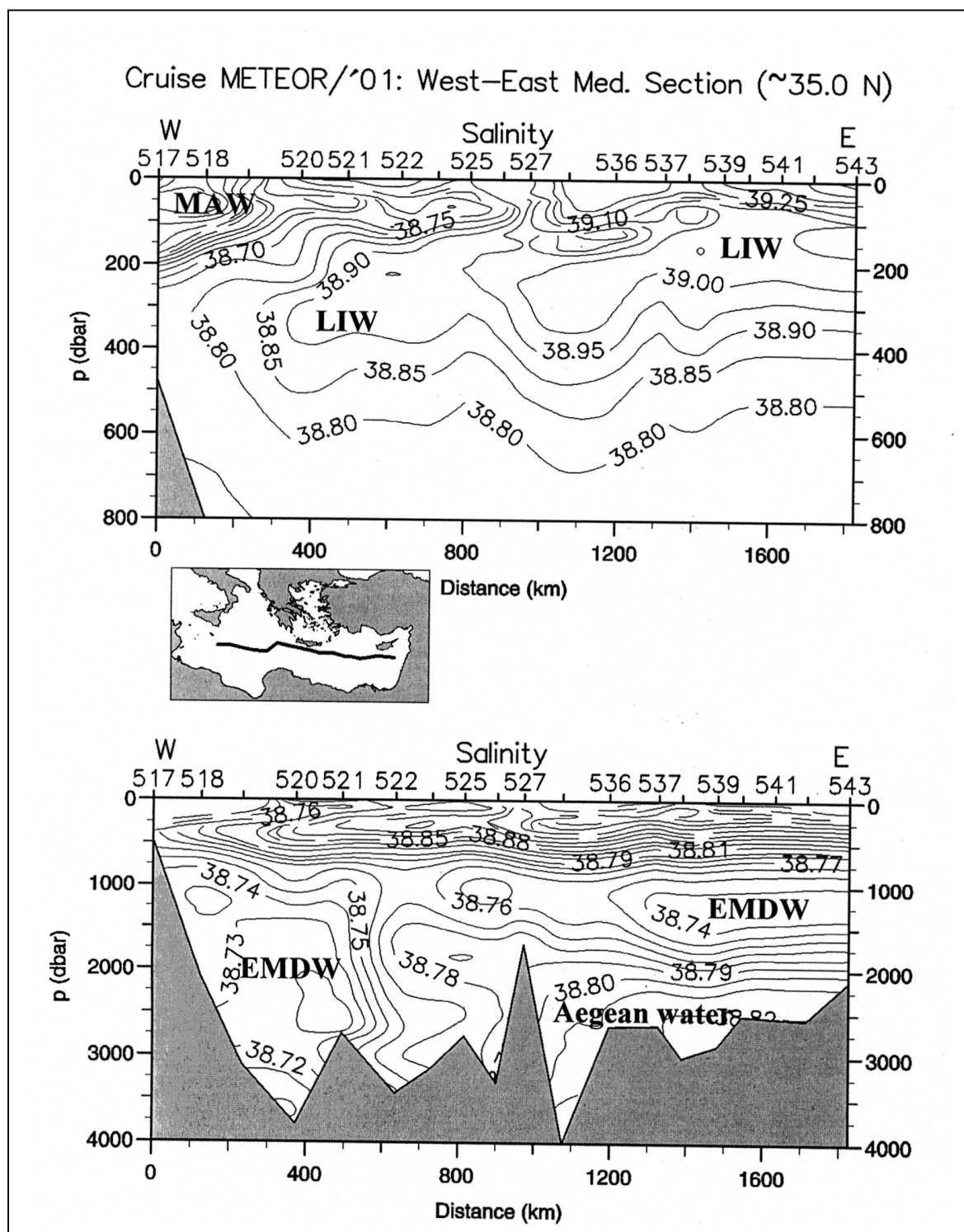


Fig. 2.7: continued

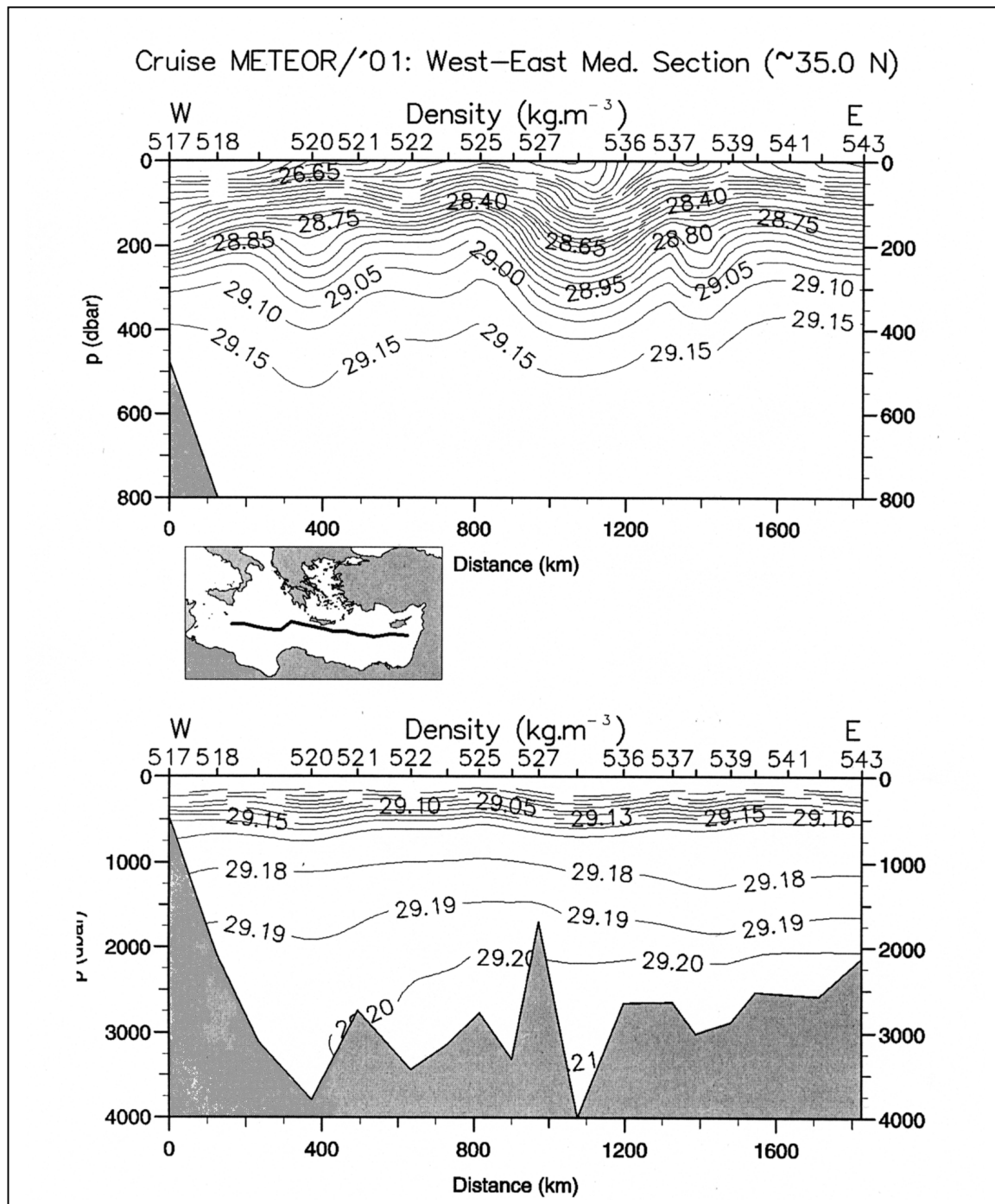


Fig. 2.7: continued

2.4.1.2 Tracer Observations

(Birgit Klein, Wolfgang Roether, Klaus Bulsiewicz, Jürgen Hollermann, Oliver Huhn, Olaf Klatt, Martha Schattenhofer)

Material and Methods: The tracer observations carried out during M51/2 include CFCs (CFC-11, CFC-12 and CFC-113), helium isotopes and tritium. Out of the 49 stations 43 stations were sampled for CFCs and 33 stations for helium and tritium (see table 2.17). Most of the CFC samples have been analysed directly on board using a gas chromatographic technique described by Bulsiewicz et al., 1998. The last two stations, which were close to the arrival port on Malta, had to be sampled 'offline' because the remaining analysis time was insufficient. At these 2 stations a total of 50 samples have been filled into glass ampoules which were flame-sealed after a nitrogen headspace was applied. These samples will be analysed later in the laboratory. Including the 50 off-line samples a total of 795 CFC observations in sea-water could be obtained. Additional to the sea water measurements, air samples have been measured for calibration purposes.

At the 33 stations which were sampled for helium isotopes and tritium, a total of 455 samples was collected each. Helium samples were collected in 40 ml clamped-off copper tubes. Tritium samples were collected in 1 liter glass bottles. The analysis of the helium samples will be performed with a dedicated noble-gas mass spectrometer at the laboratory in Bremen. Tritium will be measured by the helium-ingrowth method (6 months ingrowth after degassing).

Preliminary results: The tracer studies in the Eastern Mediterranean during M51/2 complement previous investigations in 1987 (M5/6), 1995 (M31/1) and 1999 (M44/4). The aim was to follow the development of the Eastern Mediterranean Transient. The time dependant nature of the CFCs uptake at the sea surface make them an especially useful tool to study ventilation of the water column. During M51/2 a zonal section was repeated once again running from Sicily towards Cyprus. Fig. 2.8 shows the temporal evolution of CFC12 along this section between 1999 and 2001. The most noticeable changes appear in the tracer minimum layer around 1000 m depth. Evidently the evolution in this depth range is determined by different processes in the Ionian and the Levantine Basin. In the western half of the Ionian Basin (Stas. 518-520) the tracer minimum is just barely noticeably in 2001, it has been eroded considerably compared to the earlier survey. The tracer minimum in the Levantine Basin, in contrast, remains relatively unchanged. It is eroded at its base by the still continuing spreading, of Aegean Deep Water in this basin and is slightly displaced upwards due to its spreading but the core of the minimum retains its concentration value. In the western half of the Ionian Basin the erosion of the tracer minimum core is accompanied by a significant increase in salinity at depths between 500-1500 m, and by a similar impressive increase in oxygen ($\Delta O_2 = +10 \mu\text{mol/kg}$). The density in this depth range varies between $29.16\text{--}29.17 \text{ kg/m}^3$, which is close to the density of the Adriatic dense water. The dense water discharged presently from the Adriatic through the Strait of Otranto has densities around 29.17 kg/m^3 , it is not dense enough to sink to the bottom and thus is spreading in mentioned depth horizon.

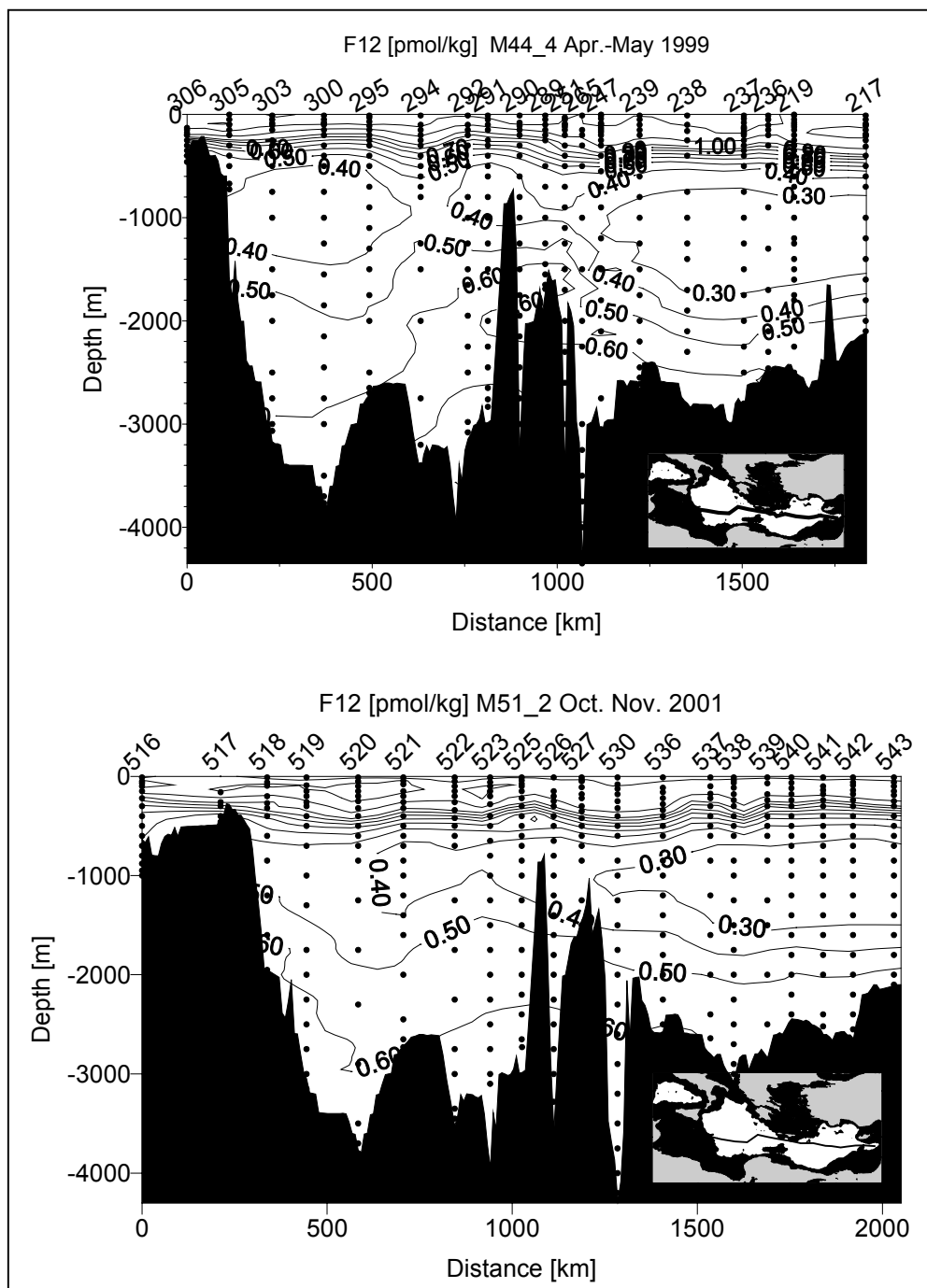


Fig. 2.8: Comparison of a zonal section of F12 [pmol/kg] sampled in 1999 (upper panel) and in 2001 (lower panel).

The comparison of the two surveys also gives the impression that the tracer minimum layer is extending further westward from the Levantine Basin. However, this could be related to changes in the dynamical flow fields, as St. 251-239 during the M44 cruise were positioned in the Iera-Petra anticyclone, depressing the isolines.

The CFC section showed clearly that the evolution of the Eastern Mediterranean Trantient developed differently in the Ionian and Levantine Basin, as is evident from the vertical profiles at selected stations displayed in Figs. 2.9 – 2.11.

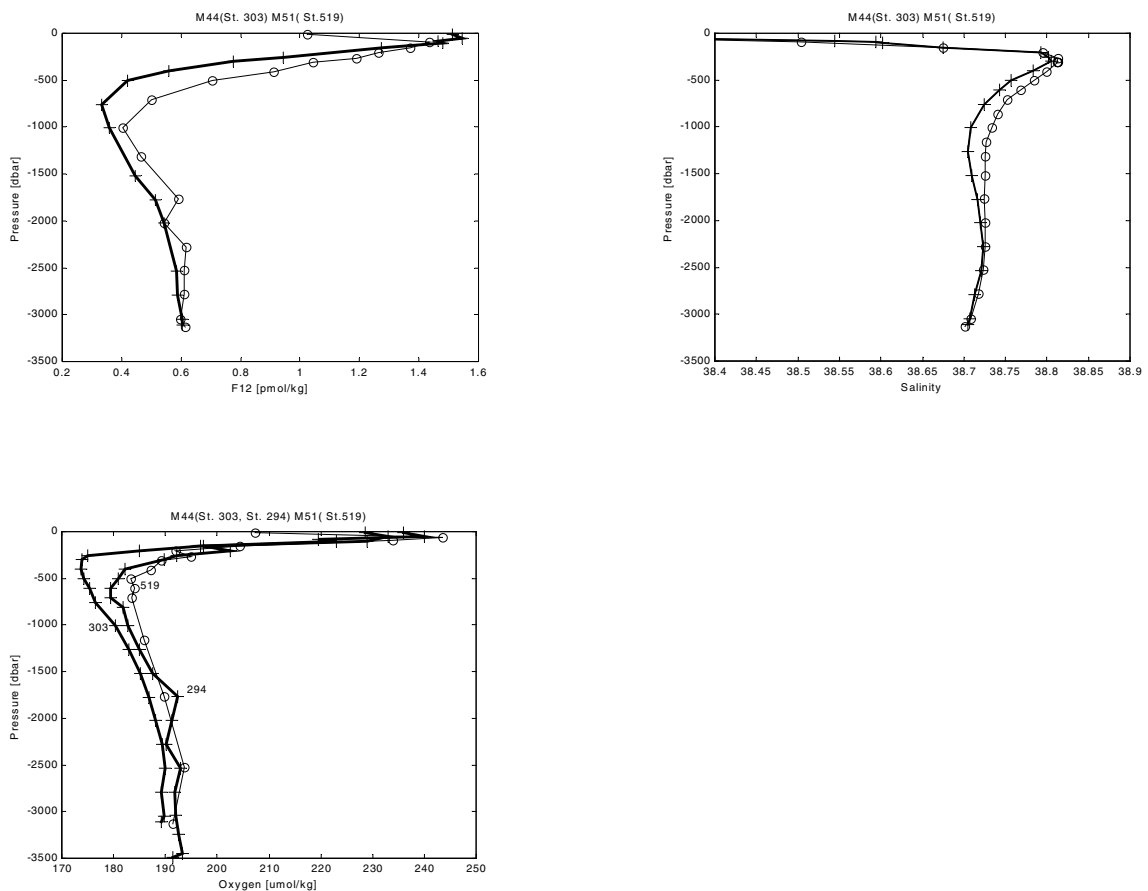


Fig. 2.9: Comparison of vertical profiles in the western Ionian Basin from 1999 and 2001 a) F12, b) salinity and c) oxygen. 1999 profiles are given by crosses, 2001 profiles are depicted by circles. For the oxygen distributions the zonal gradient of oxygen in the Ionian Basin in 1999 from west (St. 303) to east (St. 294), is given for comparison.

Fig. 2.9 displays the situation in the western part of the Ionian Basin. The CFC profiles (Fig. 2.9a) indicate ventilation of the former tracer minimum layer around 800m depth and below by ADW. The increase in F-12 is also evident above the tracer minimum between 200-500, accompanied by a moderate increase in salinity and a particularly strong increase in oxygen. This part of the water column is occupied by LIW/CIW. Evidently the ventilation in the intermediate water range increased considerably since 1999. Only at the westernmost stations in the Ionian an increase of CFCs and salinity at depth larger than 2000 m can be noted. The CFC-section (Fig. 2.8) showed at stations 518-519 strongly upward sloping CFC-12 isolines along the bottom of the continental slope. The increase of CFC-12 below 2000m (Fig. 2.9a) is accompanied by an increase in oxygen and salinity (Fig. 2.9 b and c). The increase of CFC-12 and of oxygen both point to the arrival of a more ventilated water mass. The density in the depth range below 2000 m increases slightly between the two surveys, at the bottom the change amounts to an increase from 29.193 to 29.194 kg/m³. At this density the only source for this ventilated and salty water mass can be of Aegean origin. The oxygen increase that is noted with the arrival of the Aegean waters at the western slope is at first puzzling, since in the Aegean deep water a strong oxygen consumption was noted related to its larger load of liable organic material (Klein et al., 2002),

transforming it from an oxygen rich water mass in 1995 to a much less oxygenated water mass in 1999. An explanation for the oxygen increase is portrayed in Fig. 2.9.c.

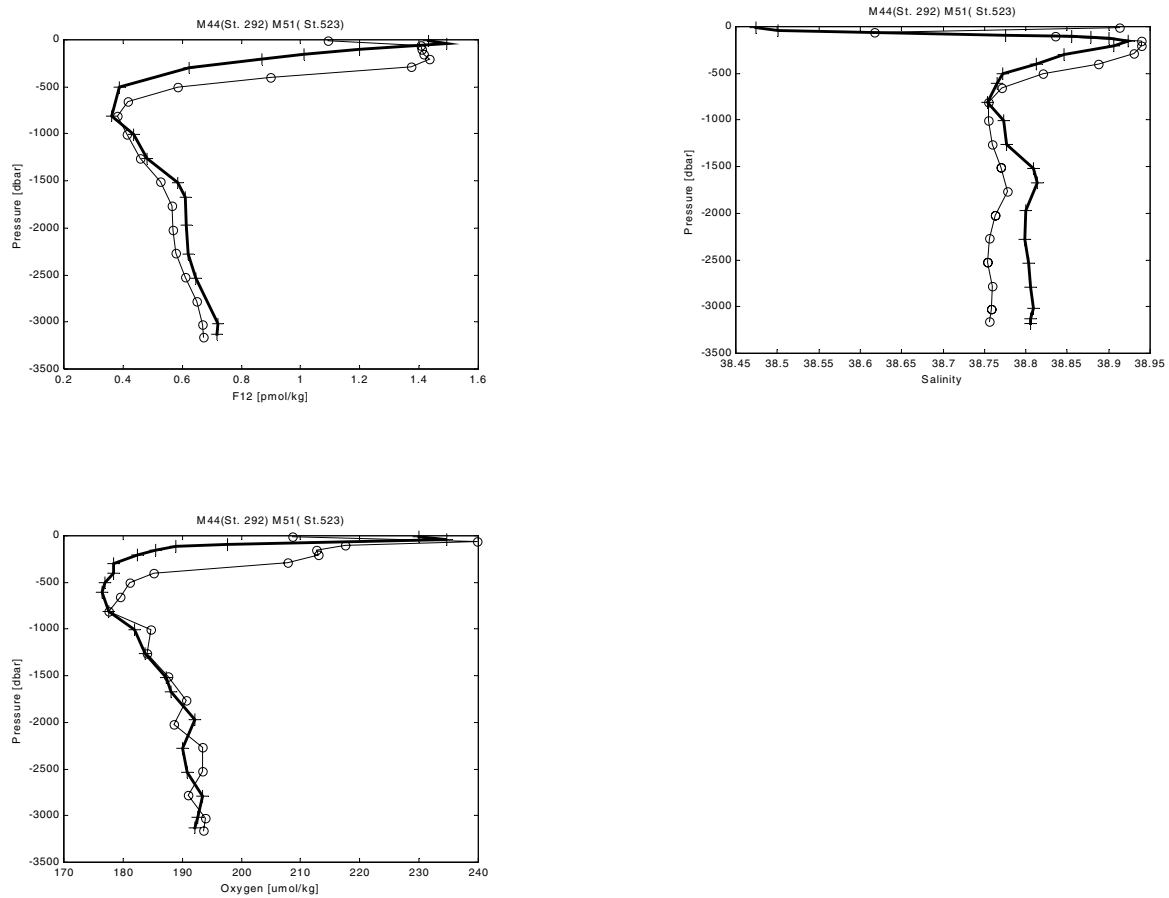


Fig. 2.10: Comparison of vertical profiles in the eastern Ionian Basin from 1999 and 2001 a) F12, b) salinity and c) oxygen. 1999 profiles are given by crosses, 2001 profiles are depicted by circles.

In 1999 a small zonal gradient of oxygen still existed in the Ionian basin with oxygen concentrations being 3-4 $\mu\text{mol/kg}$ higher in the eastern part of the basin than in the west. These water masses from the eastern part of the Ionian, which are strongly influenced by the Aegean deep, water are moving anticyclonically in the deep Ionian and are in 2001 arriving at the western slope. The 2001 oxygen profile measured at the western slope thus corresponds to a profile from the eastern Ionian in 1999. An anticyclonic motion of the Aegean deep water is in agreement with current meter data from the Maltese escarpment which show northward flow in the bottom layer.

A different situation is met in the central and eastern Ionian Basin, as well as in the Cretan Passage (Fig. 2.10). As in the western Ionian, a strong ventilation of the intermediate layers can be noted (Fig. 2.10a and c). Closer to the source of CIW the increase in salinity (Fig. 2.10) is

more pronounced. The main difference is noted in the temporal evolution below 2000m depth. F-12 and salinity clearly show a decrease, while oxygen remains at a similar level. The decrease in salinity and F-12 is related to the removal of the Aegean influenced deep waters and an eastward inflow of deep water more influenced by the Adriatic source, being less saline and less well ventilated.

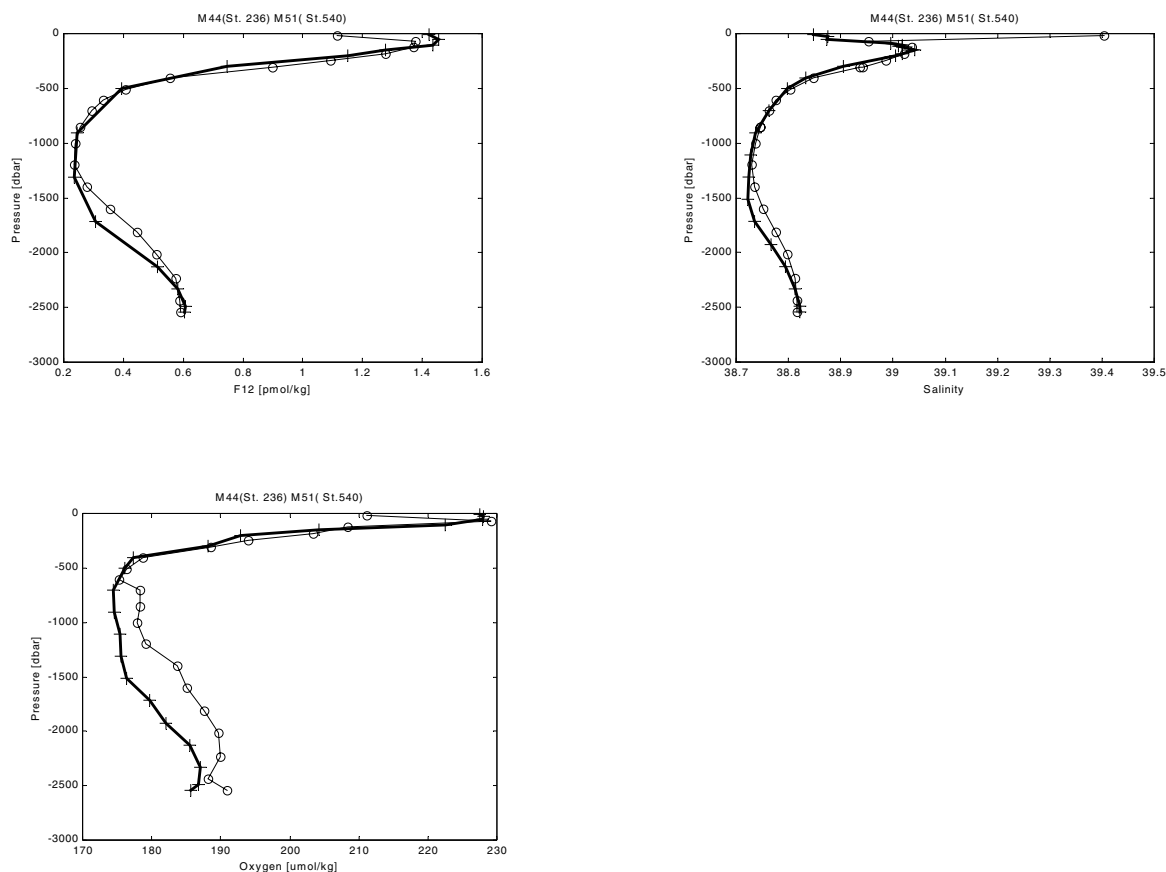


Fig. 2.11: Comparison of vertical profiles in the eastern Levantine Basin from 1999 and 2001 a) F12, b) salinity and c) oxygen. 1999 profiles are given by crosses, 2001 profiles are depicted by circles.

In the eastern Levantine Basin (Fig. 2.11) the advance of the Aegean deep waters can be observed at depth between 1500-2200m depth through increasing values of CFC-12, salinity and oxygen. In the layer closest to the bottom no changes in CFC-12 and salinity can be detected and the oxygen increase becomes smaller. Compared to the Ionian Basin and the Cretan Passage another difference is noted in the intermediate layer above 500m. Contrary to the other basin, no increased ventilation can be detected for the intermediate water range. This is probably an indication that the discharge of CIW is primarily towards the Ionian Basin through the western Cretan Arc Straits.

2.4.1.3 Nutrients, Oxygen, Biogeochemical Parameters, and Stable Isotopes; Dry Atmospheric Input of Nitrogen and Phosphorus

(Nurit Kress, Barak Herut, Isaac Gertman)

2.4.1.3.1 Nutrients, Oxygen Biogeochemical Parameters and Stable Isotopes

The aims of our research in the eastern Mediterranean during the METEOR 51/2 cruise were as follows:

1. To provide an additional 'snapshot' (following the studies in 1987, 1995 and 1999) of the influence of the changed thermohaline circulation on the distribution of dissolved oxygen and nutrients in the eastern Mediterranean and on the chemical characterization of the water masses as well as to compare among the basins.
2. To determine the particulate C and N concentrations in the intermediate (ca. 300 m) and transition levels (ca. 850 m) across the eastern Mediterranean in order to analyze spatial changes in the C/N composition and their relationship to the dissolved N/P ratios in the deep water mass.
3. To determine the concentration of biogenic silica across the eastern Mediterranean and together with silicic acid and chlorophyll *a* concentrations try to establish its' importance and cycling in this oligotrophic area.
4. To study the distribution of $\delta^{18}\text{O}$ and δD across the eastern Mediterranean in order to obtain more information on the sources of the water masses and their dispersion, and to evaluate the spatial variations in $\delta^{18}\text{O}$ and δD in the LSW to use them as a possible indicator of the location of LIW formation.

Sampling and Methods: Water samples were collected at 42 stations with a SeaBird Rosette equipped with twenty-four 10 liters Niskin bottles. Water for dissolved oxygen and nutrients was sampled at 11-24 depths, from 10 meters above the sea bottom to the surface, the number of samples depending on the station's water depth. Water samples for dissolved oxygen were sampled after the sampling for tracers and pickled. Duplicate samples for nutrient analysis were collected in 15-ml acid washed plastic scintillation vials and immediately frozen. Dissolved oxygen was measured at sea using the Carpenter-Winkler titration procedure (Carpenter, 1965) and a Radiometer automatic titrator (TTT80), equipped with a dual platinum electrode, in the dead-stop end point mode. The precision was 0.3%. Nutrients were shipped to IOLR - Haifa and are determined using a segmented flow Technicon AutoAnalyser II (AA-II) system by the methods described by Krom et al. (1991) and Kress and Herut (2001). The precision for nitrate+nitrite, phosphate and silicic acid is 0.02, 0.003 and 0.06 μM , respectively. The limit of detection (2 times the standard deviation of the blank) for the procedures is 0.075 μM for nitrate+nitrite, 0.008 μM for phosphate and 0.03 μM for silicic acid.

Water for chlorophyll *a* and biogenic silica was collected at 16 stations across the eastern Mediterranean at 5-7 water depths in the photic zone. Water samples for chlorophyll *a* were filtered through GF/F filters, the filters were folded into aluminum foil and frozen. Water samples for biogenic silica were filtered through polycarbonate filters (0.2 and/or 0.8 μm), the filters were then folded into aluminum foil and frozen. The frozen filters were shipped to IOLR – Haifa. Chlorophyll *a* will be determined in the laboratory by the fluorimetric method of Holm-

Hansen et. al. (1967) while biogenic silica will be determined as silicic acid after dissolution in Na_2CO_3 .

Water for particulate C and N was collected at two depths at 25 stations across the eastern Mediterranean. Water samples were filtered through pre-combusted, pre-weighted GF/F filters, after filtration through a 63 μm sieve. The filters were then frozen in plastic petri dish. The frozen filters were shipped to IOLR. Filters will be sub-sampled for analysis of total organic C and N by a CHN analyzer.

Water for $\delta^{18}\text{O}$ and δD determination were collected at 42 stations across the Mediterranean at 4-7 water depths. The samples were kept in the refrigerator, and were shipped to Israel. The determination of $\delta^{18}\text{O}$ and δD in the water samples will be carried out at the Geological Survey of Israel. $\delta^{18}\text{O}$ will be measured using the isoprep-18, CO_2 - H_2O equilibration bench, which allows a rapid sample preparation for automated analysis of the $^{18}\text{O}/^{16}\text{O}$ ratio. Hydrogen isotopic composition will be determined using a VG mass spectrometer after reacting the water samples with Zn.

Preliminary results: The depth distribution of dissolved oxygen across the eastern Mediterranean (22 stations – 2200 km), from the Sicily channel (station 514) to the eastern Levantine (station 543) are shown in Fig. 2.12. The upper layer was quite homogeneous in dissolved oxygen across the eastern Mediterranean. The seasonal layer of maximum oxygen appeared at 50-100 m in association with the modified Atlantic water (Kress and Herut, 2001). There were clear indications of the main oceanographic features (POEM group, 1992): A large anticyclone located in the mid-Ionian at station 520, the Pelops anticyclone at station 523, doming of the Cretan cyclone at the western tip of Crete (station 525); and the large anticyclone at the western part of the Levantine basin (Ierapetra anticyclone, (stations 530, 536). The influence of physical forcing on the depth distribution of oxygen was pronounced between 100 to 500 m. The Ierapetra Anticyclone was pronounced even at the surface, as shown by the maximum oxygen at ca. 130 m depth, deeper than in the other stations along the transect.

In the intermediate layer (150 – 500 m) the dissolved oxygen isolines were essentially leveled from the Ionian to the Levantine, neglecting the influence of the physical features. For example, the 190 μM dissolved oxygen isoline was located at ca. 300 m in the Ionian and in the Levantine. This is in contrast with the sloping down of the isolines from the Ionian to the Levantine found in 1999 (Kress et al., 2002). In the transition layer (500-1500 m) a minimum in dissolved oxygen (O_2 min) was found across the whole W-E transect. Minimal concentrations were similar in the Ionian and the Levantine but the O_2 min layer got thicker and deepened eastwards. In the Levantine this layer was located between 400-1400 m, with minimum concentration of 180 μM , while in the western Ionian the O_2 min layer was between 350-800 m, with similar dissolved oxygen concentration. In the bottom layer (below 1500 m), the dissolved oxygen concentration in the Ionian was higher than in the Levantine at the same water levels. Maximal concentrations of 195 and 190 μM were found in the bottom layer of the western Ionian and the Levantine, respectively. Similar depth distribution were found during the 1999 survey with slight changes in the concentrations (Kress et al., 2001)

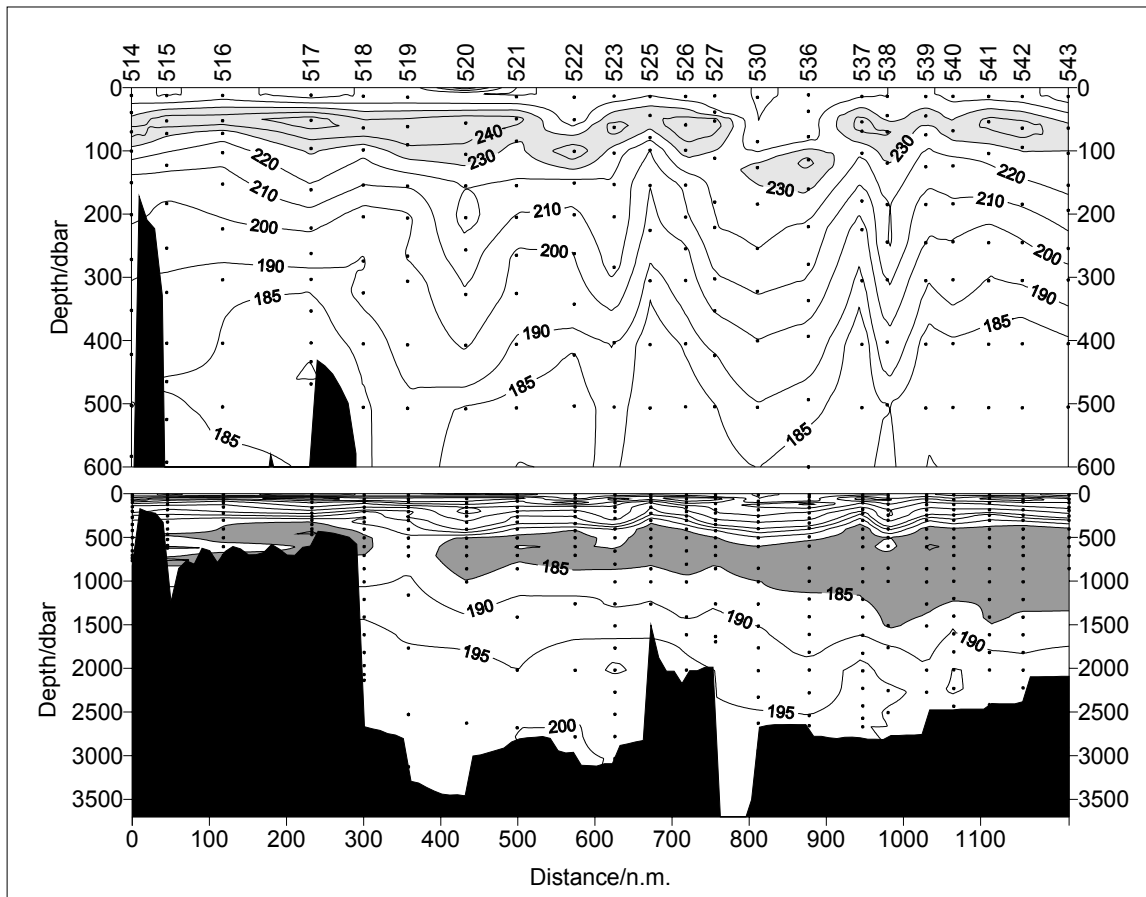


Fig. 2.12: Depth cross section of dissolved oxygen, in μM , along the eastern Mediterranean during October-November 2001 (M51/2). For station positions see Fig. 2.2.

Comparison of depth profiles of the same stations occupied during this and the 1999 cruises is shown in Fig. 2.13. In the upper layer there are differences resulting from seasonal variability. Below 500 m depth, the concentrations found during this survey were essentially equal to those found in 1999 at the stations in the eastern Ionian, the Cretan Arc and the western Levantine. In the Sicily channel, western Ionian and the eastern Levantine the concentrations below 500 m depth were higher in this survey than in 1999. This may indicate further spreading of the EMDW of Aegean origin towards the east in the Levantine and the west in the Ionian.

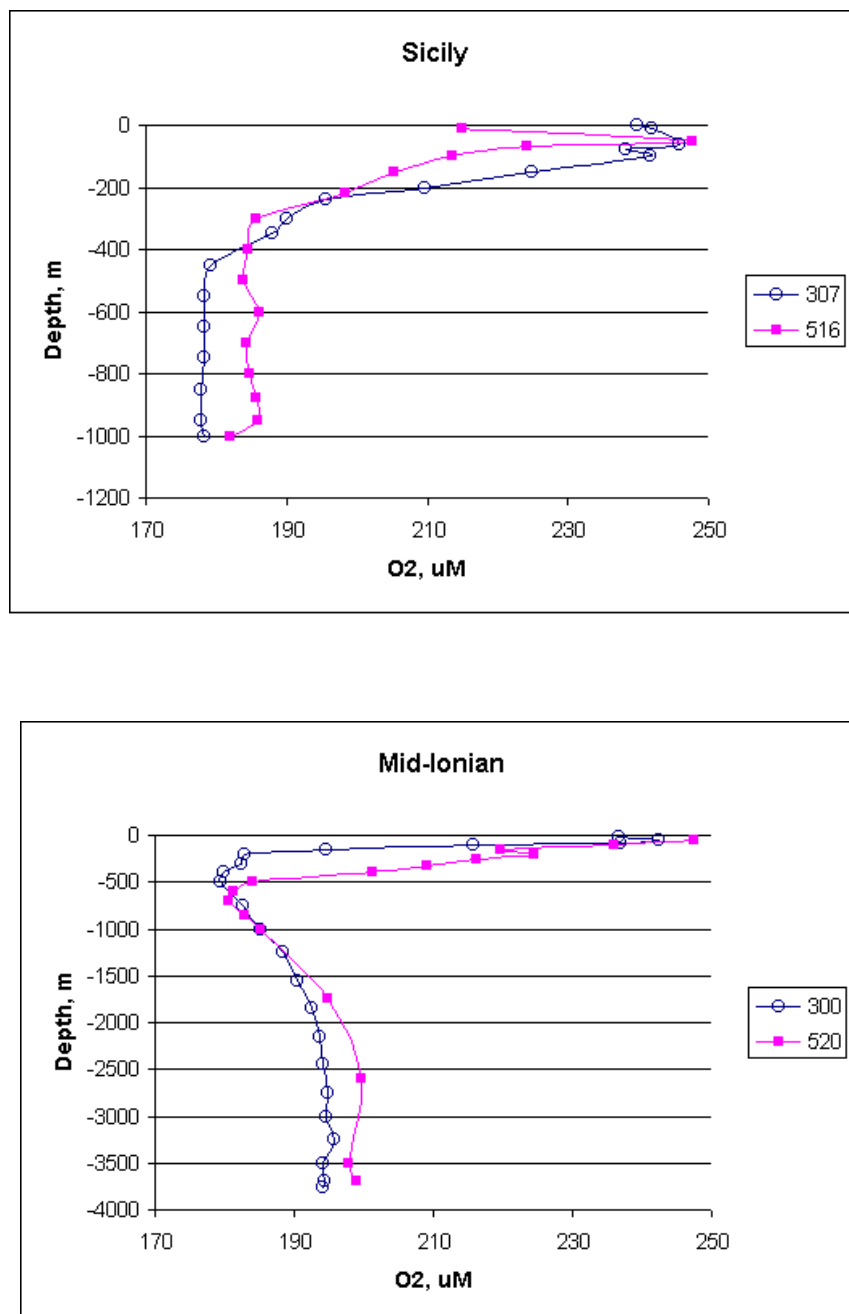


Fig. 2.13: Comparison of dissolved oxygen depth profiles at stations sampled in 1999 (307, 300, 292, 290, 239, 230) and during this cruise (516, 520, 523, 526, 536, 545) in different areas of the eastern Mediterranean.

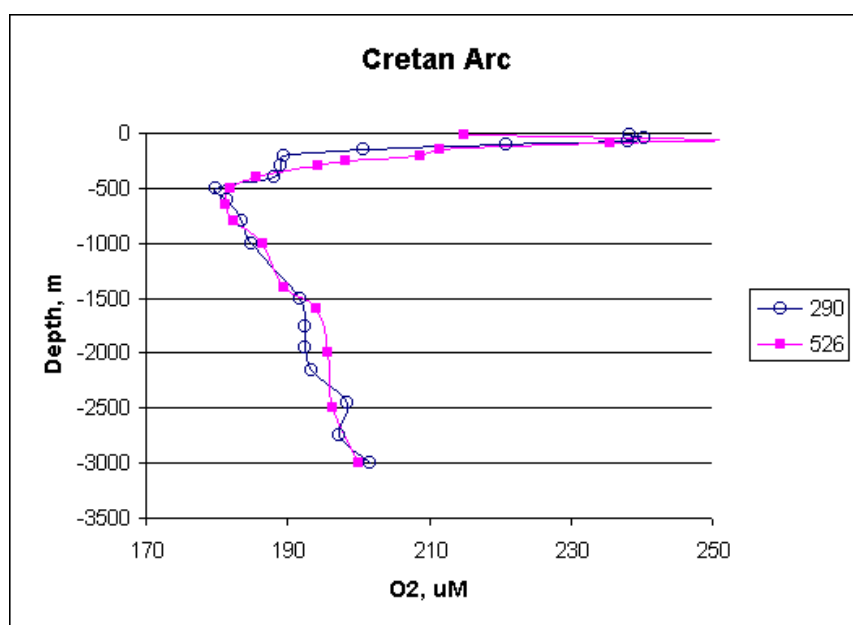
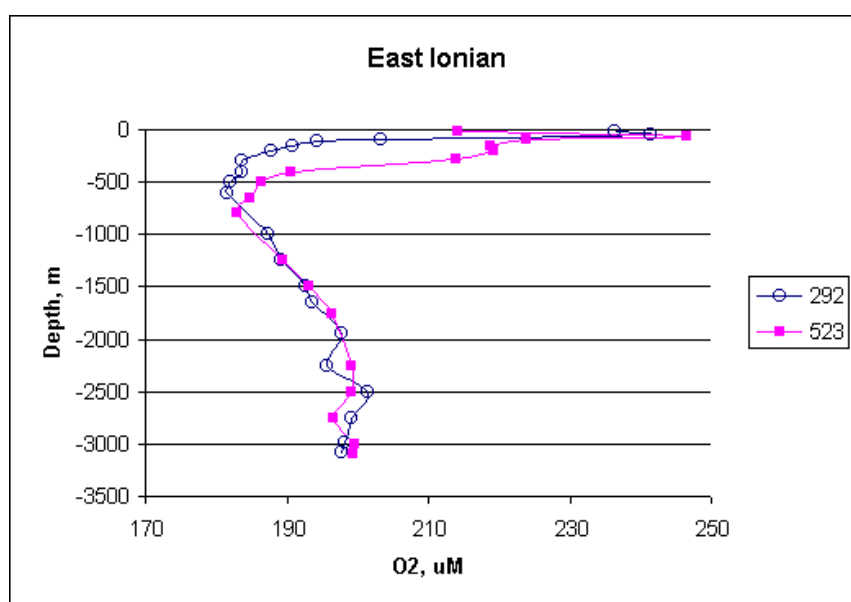


Fig.2.13 continued

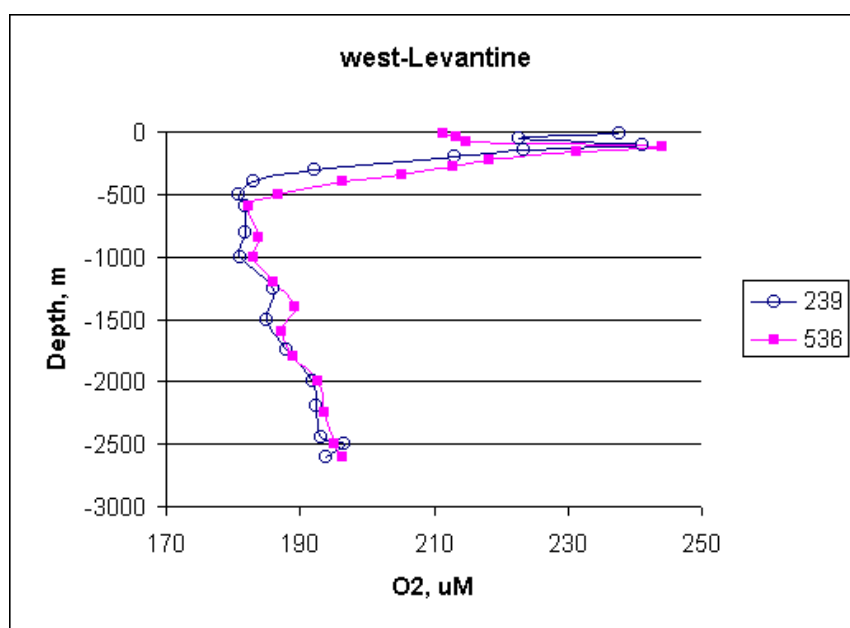
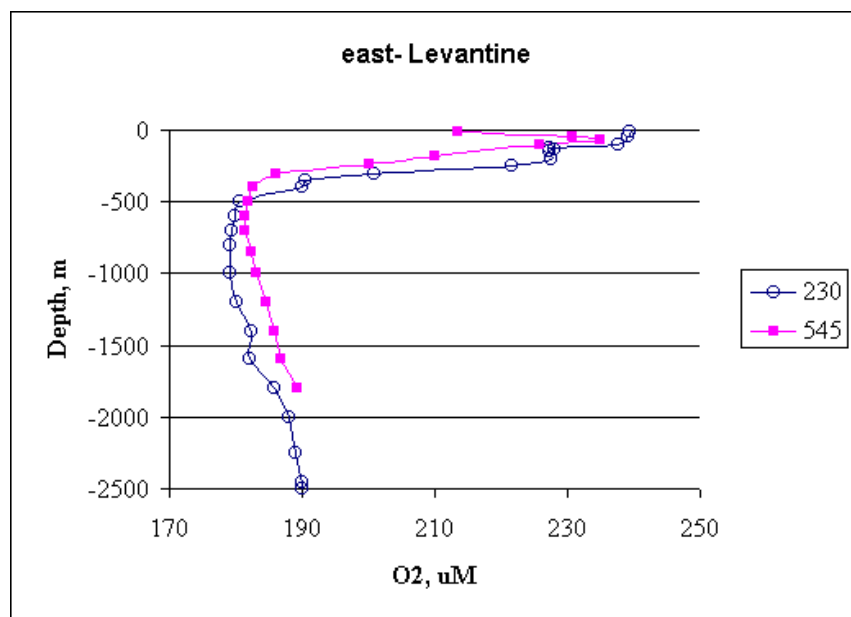


Fig. 2.13 continued

2.4.1.3.2 Dry Atmospheric Input of Nitrogen and Phosphorous

Atmospheric deposition is an important route through which many elements are delivered to surface seawater. The Mediterranean has one of the highest fluxes of atmospheric dust to the sea surface (Guerzoni *et al.*, 1999 and references therein; Herut *et al.*, 2001). Its eastern basin is a very oligotrophic sea with low levels of nutrients even in the deep water (Kress and Herut, 2001). Thus, in this particular basin, the atmospheric deposition may play a particularly important role in the supply of bioavailable nutrients to surface waters. Indeed, recent studies have suggested that significant input of nutrients to the Mediterranean basin at present is via the atmosphere (Martin *et al.*, 1989; Guerzoni *et al.*, 1999). Although it has been previously shown that phosphate is leached from dry fallout into nutrient-depleted surface waters (Lepple, 1975; Graham and Duce, 1979; Herut *et al.*, 1999a,b), almost no studies have examined both N and P leachability in surface seawater from particles collected at sea. In this study we aim to provide estimates of seawater leachable (bioavailable) inorganic nitrogen (IN) and phosphorus (IP) from dry aerosols and their flux into the area during the cruise. This information will help assessing the atmospheric exogenous bioavailable nutrient inputs to the photic zone.

Sampling and analysis: Collection of total suspended particles (aerosols) on Whatman 41 filters (20 x 25 cm) by a high volume sampler located on the upper deck. The collection was at a flow rate of $42 \text{ m}^3 \text{ h}^{-1}$ for approximately 48 hours, but varied between filters. Detailed information on the collection periods and locations is given in table below. In the laboratory at IOLR filters will be dried in a desiccator for 24 hours before being re-weighed, and the amount of trapped aerosol determined. We will conduct leaching experiments to evaluate the amount of seawater leachable inorganic nitrate, ammonium and phosphate from the filters. Sub-samples of one cm^2 of dust filter and blanks will be shaken in centrifuge vials with filtered SE Mediterranean surface seawater for 30 hours. Analysis of nutrients will be performed as described for the water samples (see above).

Table 2.3: Sampling of total suspended particles in air

		Sampling Time – local					Mean Flow Rate		Total Air Flow	
		From		To		Elapsed Time		Filter Weight		Total Air Flow
Filter #	Filter	Date	Time	Date	Time					
	Type	start	start	End	end	Reading	m3/min	Before (g)	m³	
256	Whatman41	18/10/01	11:21	19/10/01	23:00	25.65	0.685	4.1348	1054	
257	Whatman41	19/10/01	22:08	20/10/01	17:09	18.99	0.544	4.1260	620	dust event
258	Whatman41	20/10/01	17:15	22/10/01	8:22	35.40	0.596	4.2200	1266	dust event, 3.7 hrs stop
259	Whatman41	22/10/01	8:30	24/10/01	0:04	63.57	0.577	4.2503	2200	
260	Whatman41	24/10/01	0:10	25/10/01	20:17	44.12	0.710	4.0666	1879	
261	Whatman41	25/10/01	20:25	26/10/01	20:48	24.38	0.650	4.1440	951	strong winds
262	Whatman41	26/10/01	20:55	29/10/01	15:49	66.90	0.624	4.2040	2506	
263	Whatman41	29/10/01	15:54	01/11/01	8:08	62.73	0.603	4.2344	2268	1.5 hrs stop
264	Whatman41	01/11/01	11:24	02/11/01	23:16	35.87	0.703	4.1430	1512	
265	Whatman41	02/11/01	23:21	04/11/01	12:50	37.48	0.647	4.0650	1454	
266	Whatman41	04/11/01	12:59	05/11/01	8:13	19.23	0.478	4.2250	552	rain during the night
267	Whatman41	05/11/01	8:28	06/11/01	8:10					
268	Whatman41	06/11/01	8:25	08/11/01	6:39	42.93	0.727	4.2180	1872	3.3 hrs stop
269	Whatman41	08/11/01	9:32	09/11/01	19:15	32.05	0.661	4.2020	1271	1.67 hr stop

2.4.1.4 Add-on Sampling

2.4.1.4.1 Stable Isotopes

(Birgit Klein)

Water samples have been collected from the rosette at 15 stations to be analysed for ¹³C and ¹⁸O in the Geology Department of the University of Bremen. The sampling stations are distributed over the entire Eastern Mediterranean and cover all important water masses in the water column. Water samples were placed into 30 ml glas bottles and 0.5 ml of HgCl₂ were added to the ¹³C samples. All samples were sealed at the top with paraffin and stored immediately in a refrigerated room at 4 °C. All together 237 samples have been taken of each species. The samples will be measured mass spectrometrically in the Geology department of the University after the cruise.

The analysis of ¹³C and ¹⁸O is performed in the context of palaeontological investigations. Present day correlation of ¹³C and ¹⁸O with salinity and temperature, as well as the variability of these parameters in different water masses, will be required knowledge in paleo-reconstructions of the Eastern Mediterranean climate which are based on the composition of foraminiferes. The interpretation of the stable isotope distributions will also benefit from the CO₂ data and oxygen and nutrient distributions measured during the cruise.

A big thanks goes to our egyptian cruise member Prof. Mamdouh Famy who helped with the sampling and the preparation of the samples.

2.4.1.4.2 CO₂-Parameters

(Peter Streu)

Samples were taken during the whole cruise on 15 stations. The samples were taken from the rosette, distributed over the whole water column from up to 19 depths (270 samples total). Samples were fixed with 100µl HgCl₂ and are to be analysed for total CO₂ and alkalinity in the home lab (Institut für Meereskunde, Kiel).

Table 2.4: CO₂ Samples

Station	Number of samples
511/2	18
512/3	18
516/6	12
518/9	18
520/11	19
523/32	16
526/28	19
536/22	18
538/20	18
540/18	19
542/16	19
543/15	19
544/47	19
549/14	19
557/58	19

2.4.1.4.3 Hydrochemical Studies in the Egyptian Mediterranean Waters

(Mamdouh A. Fahmi)

Within the M51/2 programme, water samples were collected from different water levels, at each station within the Egyptian territorial waters, by using Rosette water sampler. Water samples were kept frozen immediately after collection until analysis. The chemical analysis of water samples will be performed in the laboratories of the National Institute of Oceanography and Fisheries, Alexandria, Egypt. Nutrient salts ammonium, nitrite, nitrate, total nitrogen, reactive and total phosphorus and reactive silicate will be investigated. The mechanism responsible for the distribution pattern of different nutrients in the deep waters and their relation with the overlying waters will be discussed. Hydrographical conditions of seawater temperature, salinity and dissolved oxygen will be used for interpretation.

2.4.2 Pelagic Ecology

2.4.2.1 Spatial Changes in Bacteria and Autotrophic Phytoplankton

(Heike Zimmermann-Timm)

Protozoan diversity and abundance in the water column will be examined from a transect consisting of 16 different stations in the Mediterranean Sea (Tab. 1). At each station a depth profile of 15 – 24 samples was taken with a CTD - rosette (Tab. 1). 250 ml of each sample were fixed in 4 % glutaraldehyd. Samples for the determination of the picoplankton will be stained with the fluorochrome, 4'6-diamidinio-2-phenylindole (DAPI), according to Porter and Feig (1980) and counted under an epifluorescence microscope.

Table 2.5a: Microbial food web sampling with the CTD / Rosette.

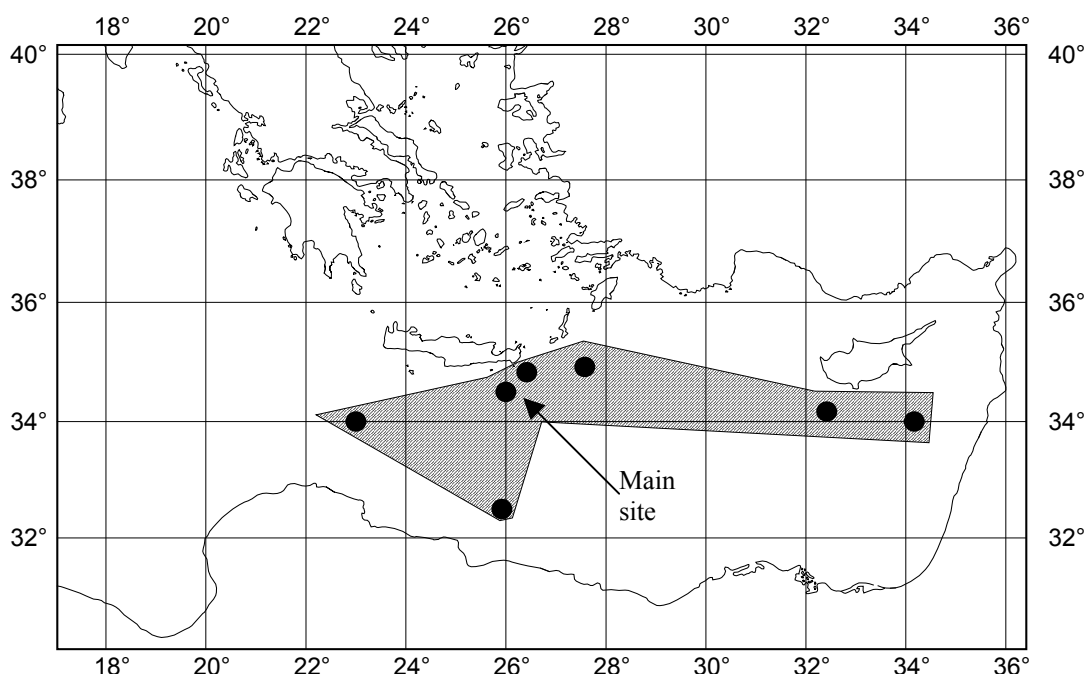
Station No.	Date	Time (UTC)	GPS Latitude (°N)	GPS Longitude (°E)	Water depth [m]	Sampled Depths [m]
511	20.10.01	09:42 - 10:34	38.00000	6.00000	2804	10, 50, 70, 150, 270, 300, 400, 500, 600, 700, 900, 1000, 1200, 1400, 1700, 2000, 2300, 2600, 2700, 2800
512	21.10.01	19:04 - 20:50	38.71670	10.61670	2420	10, 40, 150, 220, 300, 400, 500, 600, 700, 800, 900, 1000, 1200, 1400, 1600, 1850, 2100, 2300, 2400
515	22.10.01	12:05 - 14:00	36.90000	12.00000	1016	10, 50, 70, 100, 150, 220, 300, 400, 500, 600, 700, 800, 880, 950, 1000
518	23.10.01	13:30 - 16:30	35.00583	16.37866	2140	10, 60, 95, 150, 200, 270, 320, 400, 500, 600, 600, 850, 1000, 1200, 1400, 1600, 1800, 1950, 2050, 2100
520	24.10.01	06:11 - 08:45	34.50000	19.00000	3793	10, 50, 100, 150, 200, 250, 320 400, 500, 600, 700, 850, 1000, 1250, 1500, 1750, 2000, 2300, 2600, 2900, 3200, 3500, 3700, 3800
521	24.10.01	16:11 - 17:03	34.32583	20.41950	2741	10, 45, 80, 150, 200, 260, 320, 400, 500, 600, 700, 850, 1000, 1200, 1400, 1600, 1800, 2000, 2200, 2450, 2650, 2730

Table 2.5b: Microbial food web sampling with the CTD / Rosette.

Station No.	Date	Time (UTC)	GPS Latitude (°N)	GPS Longitude (°E)	Water depth [m]	Sampled Depths [m]
523	25.10.01	10:40 - 13:01	35.00000	22.33333	3140	10, 60, 100, 150, 200, 280, 400, 500, 650, 800, 1000, 1250, 1500, 1750, 2000, 2250, 2500, 2750, 3000, 3100
525	26.10.01	02:03 - 04:04	34.83333	23.41667	2771	10, 40, 75, 100, 150, 220, 300, 400, 500, 600, 700, 850, 1000, 1250, 1500, 1750, 2000, 2200, 2400, 2700, 2817
527	26.10.01	15:53 - 17:31	34.55283	25.08650	1675	10, 35, 50, 110, 180, 220, 300, 350, 420, 500, 600, 700, 850, 1000, 1250, 1500, 1620, 1680
530	30.10.01	15:57 - 17:23	34.48333	26.16667	4300	10, 80, 125, 180, 250, 320, 400, 500, 600, 850, 1000, 1250, 1500, 1750, 2000, 2300, 2600, 2900, 3200, 3500, 3750, 4000, 4200, 4270
536	01.11.01	06:00 - 07:50	34.33333	27.50000	2650	10, 40, 89, 115, 160, 220, 280, 340, 400, 500, 600, 850, 1000, 1200, 1400, 1600, 1800, 2000, 2250, 2500, 2610
537	01.11.01	13:48 - 15:40	34.03333	28.85000	2640	10, 50, 65, 100, 175, 220, 300, 400, 500, 600, 850, 1000, 1200, 1400, 1600, 1800, 2000, 2200, 2400, 2550, 2640
539	02.11.01	02:37 - 04:40	33.86670	30.50000	2937	10, 40, 70, 120, 180, 240, 300, 400, 500, 600, 850, 1000, 1250, 1500, 1750, 2000, 2250, 2500, 2760, 2866
541	02.11.01	16:36 - 19:21	34.06500	32.12000	2547	10, 50, 100, 140, 180, 240, 300, 400, 500, 600, 700, 850, 1000, 1200, 1400, 1600, 1800, 2000, 2200, 2400, 2520
542	03.11.01	05:45 - 07:35	34.08333	33.00000	2569	10, 60, 90, 140, 180, 240, 300, 400, 500, 600, 700, 850, 1000, 1200, 1400, 1600, 1800, 2000, 2200, 2400, 2550
543	03.11.01	20:36 - 22:06	34.00000	34.20130	2124	10, 60, 100, 150, 190, 250, 300, 400, 500, 600, 700, 850, 1000, 1200, 1400, 1600, 1800, 2000, 2106

2.4.2.2 Deep-Sea Zooplankton

(Rolf Koppelman, Ulrike Almus, Bernd Christiansen, Claudia Halsband-Lenk, Liesel Neugebohrn, Heike Zimmermann-Timm)



Source: GEBCO.

Fig. 2.14: Areas of plankton tracks. The gray area denotes the region where the plankton nets were to be trawled, solid points indicate the approximate center of a station.

Sampling: Pelagic metazoans were collected south of Crete at the main site of biological sampling and at some reference stations (see Fig. 2.1) at the positions for hydrographic investigations. Standard devices for the quantitative collection of zooplankton was a 1m²-Double-MOCNESS (Wiebe et al. 1985) equipped with 20 nets of 0.333 mm mesh size. The net can be opened and closed sequentially. The water column was traversed by stratified oblique tows (Table 2.6), with sampling intervals increasing with depth, from 50 m in the top 450 m to a maximum spacing of 250 m at depths greater than 2250 m (Table 2.7). The filtered volume was calculated by a flowmeter (Table 2.8). To investigate diel vertical migrations the hauls from the upper 1000 m were performed during day and night. The device carries CTD-probes. To assess the small mesozooplankton living at the sampling depths of the sediment traps, discrete layers were fished horizontally with nets of 0.100 mm mesh.

Prior to the preservation of the fresh material, subsamples (Table 2.9) were taken with regard to the determination of CN, lipids, stable isotopes ($\delta^{15}\text{N}$, $\delta^{13}\text{C}$) and metabolic activity (ETSA). Two hauls were exclusively taken for the analysis of stable nitrogen isotopes (see also 2.4.2.6.1). One half of the samples from 450 m to the surface from haul MOC-D-16 was given to an Egyptian observer (Mohamed M. El-Komi).

Table 2.6: MOCNESS Haul Data.

Haul	Date	Time = UTC		Coordinates				max.	Sampling depth	Remarks
		Sampling time		Start		End		Water		
		Start	End	Latitude N	Longitude E	Latitude N	Longitude E	depth		
MOC-D-01	26.10.01	21:07	1:30	34°22.45'	25°55.73'	34°25.15'	26°05.95'	4285 m	0-1250 m	Night sample
MOC-D-02	27.10.01	3:20	12:47	34°19.91'	26°08.47'	34°36.66'	26°00.80'	4241 m	70 mab-1250 m	
MOC-D-03	27.10.01	15:02	0:45	34°18.81'	26°08.49'	34°32.87'	26°04.03'	4270 m	4200-1250 m	
MOC-D-04	28.10.01	2:37	7:15	34°18.88'	26°08.34'	34°27.77'	26°04.28'	4264 m	0-1250 m	Day sample
MOC-D-05	28.10.01	8:48	13:10	34°19.34'	26°08.28'	34°27.73'	26°05.20'	4263 m	0-1250 m	Day sample
MOC-D-06	28.10.01	14:28	18:52	34°19.33'	26°08.25'	34°27.93'	26°11.60'	4261 m	0-1250 m	Night sample
MOC-D-07	28.10.01	20:37	7:05	34°19.52'	26°03.04'	34°38.29'	26°11.41'	4261 m	10 mab-1250 m	
MOC-D-08	29.10.01	9:40	21:03	34°18.97'	26°05.66'	34°36.23'	26°11.27'	4285 m	10 mab-1250 m	
MOC-D-09	29.10.01	23:34	8:25	34°18.62'	26°03.58'	34°35.50'	26°12.84'	4285 m	0-4250	
MOC-D-10	30.10.01	20:36	5:18	34°18.80'	26°03.51'	34°35.56'	26°11.87'	4285 m	0-4250	
MOC-D-11	31.10.01	8:21	12:24	34°48.24'	26°24.28'	34°54.51'	26°30.57'	2086 m	0-1850	
MOC-D-12	31.10.01	22:33	1:09	34°55.11'	27°35.07'	34°53.09'	27°40.61'	1571 m	0-1250 m	
MOC-D-13	02.11.01	14:56	16:15	34°00.65'	32°03.22'	34°03.79'	32°06.42'	2537 m	0-450 m	
MOC-D-14	02.11.01	18:30	1:23	34°04.04'	32°07.29'	34°04.19'	32°24.29'	2660 m	10 mab-450 m	
MOC-D-15	03.11.01	14:21	18:41	34°00.00'	34°00.44'	34°00.03'	34°11.35'	2121 m	0-1850 m	
MOC-D-16	06.11.01	3:17	7:58	32°36.12'	25°59.14'	32°34.52'	25°49.30'	2784 m	0-1850 m	
MOC-D-17	07.11.01	17:14	22:01	34°00.02'	22°59.72'	34°04.78'	22°30.08'	2394 m	0-1850 m	

Table 2.7: MOCNESS hauls: sampled depth intervals. mab = meters above bottom. * = 0.1 mm net.

Net	Haul MOC-								
	D-01	D-02	D-03	D-04	D-05	D-06	D-07	D-08	D-09
L1	0-1250	0-4200	0-4200	0-1250	0-1250	0-1250	0-10 mab	0-10 mab	0-4250
L2	1250*	4200*	4200*	1250*	1250*	1250*	10 mab*	10 mab*	4250-3500
L3	1250	4200	4200	1250	1250	1250	10 mab	10 mab	3500-3000
L4	1250-1050	4200-4000	4200-4000	1250-1050	1250-1050	1250-1050	10 mab-4000	10 mab-4300	3000-2500
L5	1050-900	4000-3750	4000-3750	1050-900	1050-900	1050-900	4000-3750	4300-3750	2500-2000
L6	900-750	3750-3500	3750-3500	900-750	900-750	900-750	3750-3500	3750-3500	2000-1500
L7	750-600	3500-3250	3500-3250	750-600	750-600	750-600	3500-3250	3500-3250	1500-1000
L8	600-450	3250-3000	3250-3000	600-450	600-450	600-450	3250-3000	3250-3000	1000-500
L9	450-400*	3000-2750*	3000-2750*	450-400*	450-400*	450-400*	3000-2750*	3000-2750*	500-250
L10	400-0	2750-0	2750-0	400-0	400-0	400-0	2750-0	2750-0	250-0
R1	0-1250-450	0-4200-3000	0-4200-3000	0-1250-450	0-1250-450	0-1250-450	0-10 mab-2500	0-10 mab-2500	0-4250
R2	450-400	3000-2750	3000-2750	450-400	450-400	450-400	2500	3000-2750	4250-3500
R3	400-350	2750-2500	2750-2500	400-350	400-350	400-350	2500-2250	2750-2500	3500-3000
R4	350-300	2500-2250	2500-2250	350-300	350-300	350-300	2250-2050	2500-2250	3000-2500
R5	300-250	2250-2050	2250-2050	300-250	300-250	300-250	2050-1850	2250-2050	2500-2000
R6	250-200	2050-1850	2050-1850	250-200	250-200	failed	1850-1650	2050-1850	2000-1500
R7	200-150	1850-1650	1850-1650	200-150	200-150	200-150	1650-1450	1850-1650	1500-1000
R8	150-100	1650-1450	1650-1450	150-100	150-100	150-100	1450-1250	1650-1450	1000-500
R9	100-50	1450-1250	1450-1250	100-50	100-50	100-50	1250-0	1450-1250	500-250
R10	50-0	1250-0	1250-0	50-0	50-0	50-0	failed	1250-0	250-0

Table 2.7: cont.

Net	Haul MOC-							
	D-10	D-11	D-12	D-13	D-14	D-15	D-16	D-17
L1	0-4250	0-1850	0-1250	0-450	0-10 mab	0-1850	0-1850	0-1850
L2	4250-3500	1850-1650	1250-1050	450-400	10 mab	1850-1650	1850-1650	1850-1650
L3	3500-3000	1650-1450	1050-900	400-350	10-50 mab	1650-1450	1650-1450	1650-1450
L4	3000-2500	1450-1250	900-750	350-300	50 mab	1450-1250	1450-1250	1450-1250
L5	2500-2000	1250-1050	750-600	300-250	50-100 mab	1250-1050	1250-1050	1250-1050
L6	2000-1500	1050-900	600-450	250-200	100 mab-2500	1050-900	1050-900	1050-900
L7	1500-1000	900-750	450-150	200-150	2500-2250	900-750	900-750	900-750
L8	1000-500	750-600	150-100	150-100	2250-2050	750-600	750-600	750-600
L9	500-250	600-450	100-50	100-50	2050-1850	600-450	600-450	600-450
L10	250-0	450-0	50-0	50-0	1850-0	450-0	450-0	450-0
R1	0-4250	0-1850-420	0-1250-450	0-450	0-10 mab-1850	0-1850-450	0-1850-450	0-1850-450
R2	4250-3500	420-400	450-400	450-400	1850-1650	450-400	450-400	450-400
R3	3500-3000	400-350	400-350	400-350	1650-1450	400-350	400-350	400-350
R4	3000-2500	350-300	350-300	350-300	1450-1250	350-300	350-300	350-300
R5	2500-2000	300-250	300-250	300-250	1250-1050	300-250	300-250	300-250
R6	2000-1500	250-200	250-200	250-200	1050-900	250-200	250-200	250-200
R7	1500-1000	200-150	200-150	200-150	900-750	200-150	200-150	200-150
R8	1000-500	150-100	150-100	150-100	750-600	150-100	150-100	150-100
R9	500-250	100-50	100-50	100-50	600-450	100-50	100-50	100-50
R10	250-0	50-0	50-0	50-0	450-0	50-0	50-0	50-0

Table 2.8: MOCNESS hauls: filtered volume in m³

Net	Haul MOC-																
	D-01	D-02	D-03	D-04	D-05	D-06	D-07	D-08	D-09	D-10	D-11	D-12	D-13	D-14	D-15	D-16	D-17
L1	4437	7977	9025	4334	2856	3865	11578	14562	9973	9207	5153	3190	1923	7507	4647	4302	5682
L2	808	1497	1524	1289	1284	1313	1536	1479	2546	2679	479	464	249	1561	577	720	1110
L3	791	1563	1589	1324	1341	1356	1595	1581	1553	1726	625	391	244	446	845	674	1086
L4	1433	897	1111	919	1023	1127	1395	230	1619	1639	685	477	208	1590	890	798	871
L5	834	987	923	817	504	719	943	2249	1950	1729	938	595	227	608	707	979	1041
L6	672	1024	844	746	544	1047	665	655	1719	1623	480	591	244	562	680	563	1004
L7	787	1024	815	731	840	691	691	576	1753	2014	622	1348	251	964	898	735	818
L8	1021	844	883	755	633	913	868	711	2069	1975	394	196	273	869	697	779	635
L9	301	860	730	665	506	166	946	734	932	859	512	209	258	766	610	799	564
L10	4064	8499	9571	2551	2966	2050	8685	9150	913	677	2770	186	303	5959	2144	3211	1960
R1	10783	15813	16714	10915	9025	11031	20217	22043	9973	9207	9888	5708	1923	14873	10551	10349	12811
R2	301	860	730	665	506	166	858	734	2546	2679	318	198	249	690	195	524	180
R3	896	804	747	271	520	162	653	803	1553	1726	226	191	244	727	246	366	221
R4	455	856	704	301	875	317	611	844	1619	1639	272	236	208	618	239	243	257
R5	410	678	590	389	229	484	618	794	1950	1729	332	248	227	702	226	326	225
R6	379	671	762	364	407	300	597	844	1719	1623	624	237	244	540	307	445	209
R7	420	533	743	308	354	244	507	632	1753	2014	393	238	251	446	295	337	229
R8	441	1036	771	365	302	173	622	804	2069	1975	248	196	273	479	233	335	203
R9	353	572	676	361	279	89	5077	703	932	859	169	209	258	455	201	297	194
R10	710	3349	4578	192	failed	281	failed	3726	913	677	188	186	303	1302	202	338	242

Table 2.9: MOCNESS hauls: planned analyses. BT = Biomass and Taxonomy. S = Stable isotopes. E = Electron transport system activity (ETSA). A = Species specific Analyses. C = Further BioChemistry. EO = handled over to an Egyptian Observer.

Net	Haul MOC-																
	D-01	D-02	D-03	D-04	D-05	D-06	D-07	D-08	D-09	D-10	D-11	D-12	D-13	D-14	D-15	D-16	D-17
L1	C	C	C	C	C	C	C	C	C	A	C	C	C	C	C	C	C
L2	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	S	S	BT	BT	BT	BT	BT	BT	BT
L3	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	S	S	BT	BT	BT	BT	BT	BT	BT
L4	BT	BT	BT	BT	BT	BT	BT	BT	S	S	BT	BT	BT	BT	BT	BT	BT
L5	BT	BT	BT	BT	BT	BT	BT	BT	S	S	BT	BT	BT	BT	BT	BT	BT
L6	BT	BT	BT	BT	BT	BT	BT	BT	S	S	BT	C	BT	BT	BT	BT	BT
L7	BT	BT	BT	BT	BT	BT	BT	BT	S	S	BT	S	BT	BT	BT	BT	BT
L8	BT	BT	BT	BT	BT	BT	BT	BT	S	S	BT	S	BT	BT	BT	BT	BT
L9	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	S	S	BT	S	BT	BT	BT	BT	BT
L10	A	A	C	A	A	C	C	C	S	S	A	S	BT	C	C	C	C
R1	C	C	C	C	C	C	C	C	C	C	C	A	C	C	C	1/1EO	C
R2	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	½BT, ¼E, ¼C	S	S	BT	BT	S	BT	BT	½BT, ½EO	BT
R3	BT	BT	BT	BT	BT	BT	BT	BT	S	S	BT	BT	S	BT	BT	½BT, ½EO	BT
R4	BT	BT	BT	BT	BT	BT	BT	BT	S	S	BT	BT	S	BT	BT	½BT, ½EO	BT
R5	BT	BT	BT	BT	BT	BT	BT	BT	S	S	BT	BT	S	BT	BT	½BT, ½EO	BT
R6	BT	BT	BT	BT	BT	BT	BT	BT	S	S	BT	BT	S	BT	BT	½BT, ½EO	BT
R7	BT	BT	BT	BT	BT	BT	BT	BT	S	S	BT	BT	S	BT	½BT, ½S	½BT, ½EO	BT
R8	BT	BT	BT	BT	BT	BT	BT	BT	S	S	BT	BT	S	BT	½BT, ½S	½BT, ½EO	BT
R9	BT	BT	BT	BT	BT	BT	A	BT	S	S	BT	BT	S	BT	½BT, ½S	½BT, ½EO	BT
R10	BT	A	C	BT	Failed	BT	failed	C	S	S	BT	BT	S	C	½BT, ½S	½BT, ½EO	BT

Biochemical analyses: At the main station, south of Crete, the potential oxygen consumption of the mesozooplankton of the sieve fraction smaller than 5 mm was measured at defined depths in the water column for 0.100 and 0.333 mm samples (Tables 2.7 and 2.9). Moreover, the oxygen demand of single taxa and groups from integrated samples was measured (Tables 2.9 and 2.10). The data was obtained using the ETSA (electron transport system activity). The ETS analysis was done following the method of Packard (1971), modified by Kenner and Ahmed (1975). The enzymatic activity will be recalculated for *in-situ* temperature using the Arrhenius equation assuming an activation energy of 13.2 kcal mol⁻¹ for bathypelagic zooplankton (Packard et al. 1975) to determine the oxygen consumption in µlO₂d⁻¹g wet wg⁻¹. A respiration/ETS ratio of 0.5 will be used to adjust the potential oxygen consumption measured by the ETS method to respiration. The ratio found by King and Packard (1975a) was modified by Hernández-León and Gómez (1996) for the Kenner and Ahmed (1975) version of the ETS assay. Since the respiration/ETS ratio has been shown to be insensitive to hydrostatic pressure (King and Packard 1975b), the above ratio derived from upper ocean zooplankton will be also applied to deep-living zooplankton.

The fatty acid composition of the some euphausiid species (see Table 2.10) will be determined to get some information about the sources of their diet.

Table 2.10: Haul and bucket number from which species/groups were taken for biochemical investigations.

Taxa/Group	ETSA	Stable isotopes	Fatty acids
Thysanopoda aequalis	D7R9, D2LR10	D7R9, D2LR10	different buckets
Nematoscellis megalops	D7R9, D2LR10	D7R9, D2LR10	different buckets
Stylocheiron longicornis	D4L10, D7R9, D12R1	D7R9, D5L10	different buckets
<i>Haloptilus</i> spp.	2 * D4L10	2 * D1L10	
Lucicutia longiserrata	D2LR10, D7R9, D10L1	D7R9, D2LR10	
Eucalanus monachus	D2LR10, D7R9, D10L1	D7R9, D2L10	
Chaetognatha	2 * D11L10	2 * D11L1/L10	

2.4.2.3 Plankton Sampling for Molecular Population Genetic Studies

(Dirk Elvers)

The aim of the study is to investigate the degree of genetic variability of selected mesozooplankton species (Copepoda, Chaetognatha, Euphausiacea) within and between different regions with focus on the influence of geographic barriers, different life strategies and hydrographic conditions. For this purpose altogether 30 stations from the western to the eastern mediterranean basin were sampled (Table 2.11) using a multiple closing net and a bongo net. A comparison with samples of the northern Red Sea taken during the M44/2 cruise is intended.

Multiple Closing Net: 17 vertical plankton hauls with 5 depth intervals (mainly 1000-600m, 600-300m, 300-100m, 100-50m, 50-0m) were carried out at 14 stations using a multiple closing net (Fa. HYDROBIOS Kiel) with a 0,25 sqm opening and 100 µm meshsize. Winch W3 with a descend and ascend speed of 0,5m/s was used.

Bongo Plankton Net: 23 vertical plankton hauls of the upper 200m of the water column were performed with a "bongo" double plankton net (Fa. HYDROBIOS Kiel) with an opening of 0.68 m² and 200 µm meshsize. The sampling volume was measured with a flowmeter. All bongo net hauls were carried out parallel to deep CTD casts using winch W4.

Sample Preservation: Plankton catches of all stations were concentrated using a 55µm mesh, transferred to 250 ml Kautex bottles and preserved in 100% undegraded ethanol to allow further genetic analysis. The Kautex bottles were sealed with parafilm and stored in the dark at roomtemperature. At 7 stations aliquots of the plankton samples were preserved in buffered 4% formaline (sodium tetraborate) solution to serve as taxonomic references.

Genetic Analysis: The following genetic analysis will be carried out at the University of Bremen. The use of mitochondrial and nuclear DNA-markers is intended:

Mitochondrial: 16S rRNA and Cytochrome Oxidase Subunit I (COX I)

Nuclear: Internal Transcribed Spacer 1 (ITS 1)

Table 2.11: Plankton Sampling for Population Genetics

Station	Net type	Meshsize [µm]	Date	Time (UTC)	Max. Depth	Net number	Depth interval	Sampled volume [m ²]	Fixation
510	Multiple closing net	100	19.10.01	03:25	2666	1	300-100m	50	Ethanol 100%
		100	19.10.01	03:32	2666	2	100-50m	13	
		100	19.10.01	03:34	2666	3	50-0m	13	
		100	19.10.01	08:24	2666	1	600-300	75	
		100	19.10.01	08:51	2666	2	300-100	50	
		100	19.10.01	08:59	2666	3	100-50	13	
		100	19.10.01	09:01	2666	4	50-0	13	
510	Bongo net	200	19.10.01	05:15	2666	1	1000-0m		Ethanol 100%
		200	19.10.01	05:15	2666	2	1000-0m		
511	Multiple closing net	100	20.10.01	12:39	2807	1	1000-600	100	Ethanol 100%
		100	20.10.01	12:54	2807	2	600-300	75	
		100	20.10.01	13:05	2807	3	300-100	50	
		100	20.10.01	13:12	2807	4	100-50	13	
		100	20.10.01	12:15	2807	5	50-0	13	
		100	20.10.01	18:40	2807	1	1000-600	100	
		100	20.10.01	18:53	2807	2	600-300	75	
		100	20.10.01	19:04	2807	3	300-100	50	
		100	20.10.01	19:12	2807	4	100-50	13	
		100	20.10.01	19:14	2807	5	50-0	13	
515	Multiple closing net	100	22.10.01	12:45	624	1	600-300	100	Ethanol 100%
		100	22.10.01	12:56	624	2	300-200	75	
		100	22.10.01	13:00	624	3	200-100	50	
		100	22.10.01	13:03	624	4	100-50	13	
		100	22.10.01	13:05	624	5	50-0	13	
518	Multiple closing net	100	23.10.01	14:10	2095	1	1000-600	100	Ethanol 100%
		100	23.10.01	14:24	2095	2	600-300	75	
		100	23.10.01	14:38	2095	3	300-100	50	
		100	23.10.01	14:45	2095	4	100-50	13	
		100	23.10.01	14:47	2095	5	50-0	13	

520	Bongo net	200 200	24.10.01 24.10.01	07:05 07:05	3707 3707	1 2	200-0 200-0		Ethanol 100%
521	Multiple closing net	100 100 100 100 100	24.10.01 24.10.01 24.10.01 24.10.01 24.10.01	15:25 15:45 15:50 15:59 16:00	2687 2687 2687 2687 2687	1 2 3 4 5	1000-600 600-300 300-100 100-50 50-0	100 75 50 13 13	Ethanol 100%
523	Multiple closing net	100 100 100 100 100	25.10.01 25.10.01 25.10.01 25.10.01 25.10.01	10:01 10:14 10:24 10:31 10:32	3070 3070 3070 3070 3070	1 2 3 4 5	1000-600 600-300 300-100 100-50 50-0	100 75 50 13 13	Ethanol 100%
523	Bongo net	200	25.10.01	08:00	3070	1	200-0		Ethanol 100%
527	Multiple closing net	100 100 100 100 100	26.10.01 26.10.01 26.10.01 26.10.01 26.10.01	15:08 15:23 15:35 15:41 15:43	1674 1674 1674 1674 1674	1 2 3 4 5	1000-600 600-300 300-100 100-50 50-0	100 75 50 13 13	Ethanol 100%
527	Bongo net	200 200	26.10.01 26.10.01	16:00 16:00	1674 1674	1 2	200-0 200-0	60 60	Ethanol 100%
530	Bongo net	200	30.10.01	16:05	4187	1	200-0	86	Ethanol 100%
533	Bongo net	200	31.10.01		2522	1	200-0	135	Ethanol 100%
536	Multiple closing net	100 100 100 100 100	01.11.01 01.11.01 01.11.01 01.11.01 01.11.01	05:01 05:14 05:24 05:31 05:33	2587 2587 2587 2587 2587	1 2 3 4 5	1000-600 600-300 300-100 100-50 50-0	100 75 50 13 13	Ethanol 100%
536	Bongo net	200	01.11.01	06:13	2599	1	200-0	125	Ethanol 100%
537	Bongo net	200	01.11.01	14:08		1	200-0	67	Ethanol 100%
538	Multiple closing net	100 100 100 100 100	01.11.01 01.11.01 01.11.01 01.11.01 01.11.01	19:36 19:50 20:00 20:06 20:08	2951 2951 2951 2951 2951	1 2 3 4 5	1000-600 600-300 300-100 100-50 50-0	100 75 50 13 13	Ethanol 100%
539	Bongo net	200	02.11.01	03:15		1	200-0	57	Ethanol 100%
540	Multiple closing net	100 100 100 100 100	02.11.01 02.11.01 02.11.01 02.11.01 02.11.01	08:37 08:52 09:02 09:08 09:10	2452 2452 2452 2452 2452	1 2 3 4 5	1000-600 600-300 300-100 100-50 50-0	100 75 50 13 13	Ethanol 100%
540	Bongo net	200	02.11.01	10:50	2452	1	200-0	62	Ethanol 100%
542	Multiple closing net	100 100 100 100 100	03.11.01 03.11.01 03.11.01 03.11.01 03.11.01	05:00 05:14 05:24 05:31 05:33	2521 2521 2521 2521 2521	1 2 3 4 5	1000-600 600-300 300-100 100-50 50-0	100 75 50 13 13	Ethanol 100%
542	Bongo net	200	03.11.01	06:01	2521	1	200-0	68	Ethanol 100%

542	Multiple closing net	100	03.11.01	07:58	2523	1	250-200	13	Ethanol 100%
		100	03.11.01	07:59	2523	2	200-150	13	
		100	03.11.01	08:01	2523	3	150-100	13	
		100	03.11.01	08:02	2523	4	100-50	13	
		100	03.11.01	08:03	2523	5	50-0	13	
543	Multiple closing net	100	03.11.01	19:50	2094	1	1000-600	100	Ethanol 100%
		100	03.11.01	20:03	2094	2	600-300	75	
		100	03.11.01	06:13	2094	3	300-100	50	
		100	03.11.01	20:20	2094	4	100-50	13	
		100	03.11.01	20:22	2094	5	50-0	13	
543	Bongo net	200	03.11.01	20:55	2094	1	200-0	72	Ethanol 100%
544	Multiple closing net	100	04.11.01	05:03	2086	1	1000-600	100	Ethanol 100%
		100	04.11.01	05:17	2086	2	600-300	75	
		100	04.11.01	05:27	2086	3	300-100	50	
		100	04.11.01	05:34	2086	4	100-50	13	
		100	04.11.01	05:36	2086	5	50-0	13	
544	Bongo net	200	04.11.01	06:00	2085	1	200-0	63	Ethanol 100%
545	Bongo net	200	04.11.01	14:15	2097	1	200-0	75	Ethanol 100%
549	Multiple closing net	100	06.11.01	10:31	2643	1	1000-600	100	Ethanol 100%
		100	06.11.01	10:44	2643	2	600-300	75	
		100	06.11.01	10:56	2643	3	300-100	50	
		100	06.11.01	11:04	2643	4	100-50	13	
		100	06.11.01	11:06	2643	5	50-0	13	
551	Bongo net	200	06.11.01	21:30	2442	1	200-0	82	Ethanol 100%
552	Bongo net	200	07.11.01	02:30		1	200-0	62	Ethanol 100%
553	Bongo net	200	07.11.01	15:30	2385	1	200-0	63	Ethanol 100%
553f	Bongo net	200	07.11.01	15:30	2385	1	200-0	63	Formaline 4%
554	Bongo net	200	08.11.01	03:15	2213	1	200-0	49	Ethanol 100%
554f	Bongo net	200	08.11.01	03:15	2213	2	200-0	49	Formaline 4%
555	Bongo net	200	08.11.01	14:00	2744	1	200-0	65	Ethanol 100%
555f	Bongo net	200	08.11.01	14:00	2744	2	200-0	65	Formaline 4%
556	Bongo net	200	08.11.01	23:25	3040	1	200-0	67	Ethanol 100%
556f	Bongo net	200	08.11.01	23:25	3040	2	200-0	67	Formaline 4%
557	Bongo net	200	09.11.01	11:30	2936	1	200-0	53	Ethanol 100%
557f	Bongo net	200	09.11.01	11:30	2936	2	200-0	53	Formaline 4%
558	Bongo net	200	10.11.01	00:45	3923	1	200-0	51	Ethanol 100%
558f	Bongo net	200	10.11.01	00:45	3923	2	200-0	51	Formaline 4%
559	Bongo net	200	10.11.01	08:40	3572	1	200-0	64	Ethanol 100%
559f	Bongo net	200	10.11.01	08:40	3572	2	200-0	64	Formaline 4%

2.4.2.4 Reproduction of Calanoid Copepods

(Claudia Halsband-Lenk)

At 10 stations, vertical net tows were performed with a WP-2 net (333 µm mesh size) or a Bongo net (200 µm mesh size), respectively, over the upper 200 m of the water column (Tab. 2.12). Adult females of different free-spawning species were sorted out under a binocular immediately after capture and incubated individually in multiwells (CORNING®) for 24 hours in 50 µm pre-screened seawater from the respective station. Incubation temperature was 16°C. After 8 h and 24 h the wells were checked for eggs and in case that spawning had been taken place the eggs were pipetted to new incubation chambers to let them hatch separate from the female. The females were preserved in 4% buffered formalin after the incubation period for further identification to species level at the home institute (IHF Hamburg).

Tab. 2.12: List of stations where egg production (EP) and hatching (H) measurements were conducted

Station-No.	Date	Latitude	Longitude	UTC	Device	Experiment
M51/2-516	22.10.01	36°48.4'N	12°06.1'E	14:30	WP-2	EP
M51/2-518	23.10.01	35°00.3'N	16°22.8'E	15:00	WP-2	EP, H
M51/2-521	24.10.01	34°24.9'N	20°19.7'E	16:30	WP-2	EP, H
M51/2-523	25.10.01	35°00.2'N	22°30.1'E	08:00	Bongo	EP
M51/2-533	30.10.01	34°59.2'N	26°32.6'E	13:15	Bongo	EP
M51/2-536	31.10.01	34°19.6'N	27°30.0'E	06:00	Bongo	EP
M51/2-537	01.11.01	34°02.3'N	28°51.0'E	14:00	Bongo	EP, H
M51/2-540	02.11.01	33°57.7'N	31°11.8'E	10:30	Bongo	EP, H
M51/2-542	03.11.01	34°05.0'N	32°59.9'E	06:00	Bongo	EP
M51/2-544	04.11.01	33°29.8'N	33°00.9'E	06:00	Bongo	EP
M51/2-552	07.11.01	34°11.5'N	25°37.2'E	02:30	Bongo	EP

Preliminary results: In the experiments, 147 adult females were examined, mainly belonging to the genera *Acartia*, *Candacia*, *Euchaeta* and *Temora*. At any station only few females spawned during the incubation period of 24 h. This might indicate either strong food limitation and thus long intervals between spawning events (> 24 h), or that the seasonal spawning cycle was almost completed and adults prepared for overwintering. Females that spawned produced between 2 and 65 eggs per clutch. Hatching success was determined for 12 clutches of eggs of the species *Acartia*, *Candacia*, *Euchaeta* and *Temora* and one clutch produced by a female of the family Pontellidae. The percentage of viable eggs usually was high, ranging between 50 and 100 %.

2.4.2.5 Sediment Traps and Suspended Particulate Matter (SPM)

(Niko Lahajnar, Carolin Warnken)

A mooring system MID-2 (Mediterranean Ierapetra Deep) was deployed in the Ierapetra Deep off Crete (34°26.50' N, 026°11.40' E) for the second time after spring 1999 (Cruise M 44). The system consisted of two PARFLUX MARK 7G-21 and one newly built PARFLUX 78G-21 sediment traps. It was intended to deploy the system at the same position as in 1999; however, the exact position at the slope was slightly missed due to strong currents so that the anchor hit the seafloor at 3600 m water depth instead of 3750 m (see Fig. 2). The mooring was designed to collect settling particles from 550, 1530, and 2560 m water depth. The sampling period started from

November 5th 2001 with 21 weekly intervals and will stop on April 1st 2002 (Tab. 2.13). Initial filling of the sampling cups was filtered (0.7 µm GF/F) sea water with 35 g l⁻¹ NaCl and 3.3 g l⁻¹ HgCl₂ added in order to avoid organic matter decomposition during deployment. It is intended to recover the mooring in April 2002 during M 53/1.

The principal goal of the sediment trap experiment is to investigate the variation of externally forced material fluxes settling to the deep eastern Mediterranean Sea in space and time. Detailed analyses of bulk composition and organic compounds will provide information on the sources, alteration, transport paths as well as transport processes of the organic matter. These investigations are closely linked to the planktological investigations. Moreover, the sediment trap experiment will allow to quantify the carbon flux to the deep Mediterranean Sea and thus will elucidate its relevance for the deep sea biology.

Tab. 2.13: Rotation schedule for MID-2.

Cup Number	Sampling Start [Date and Time]	Sampling End [Date and Time]	Sampling interval [hours]
1	05.11.01 00:00	12.11.01 00:00	168
2	12.11.01 00:00	19.11.01 00:00	168
3	19.11.01 00:00	26.11.01 00:00	168
4	26.11.01 00:00	03.12.01 00:00	168
5	03.12.01 00:00	10.12.01 00:00	168
6	10.12.01 00:00	17.12.01 00:00	168
7	17.12.01 00:00	24.12.01 00:00	168
8	24.12.01 00:00	31.12.01 00:00	168
9	31.12.01 00:00	07.01.02 00:00	168
10	07.01.02 00:00	14.01.02 00:00	168
11	14.01.02 00:00	21.01.02 00:00	168
12	21.01.02 00:00	28.01.02 00:00	168
13	28.01.02 00:00	04.02.02 00:00	168
14	04.02.02 00:00	11.02.02 00:00	168
15	11.02.02 00:00	18.02.02 00:00	168
16	18.02.02 00:00	25.02.02 00:00	168
17	25.02.02 00:00	04.03.02 00:00	168
18	04.03.02 00:00	11.03.02 00:00	168
19	11.03.02 00:00	18.03.02 00:00	168
20	18.03.02 00:00	25.03.02 00:00	168
21	25.03.02 00:00	01.04.02 00:00	168

Mooring-I.D.: MID-2		Deployment Date:		30.10.01
Release Code:		Enable: 1 C Release: 1 A		Start: 11:00 UTC
Radio Frequency:		156.425 MHz, Channel 68		Topfloat under water: 13:49 UTC
Deployment Position:		34°26.50' N, 026°11.40' E		
Buoyancy speed:		Deployment: - 176 m/min		
Mooring Diagram		Mooring Description		Deployment
m.a.b.	m.b.s.			Time out [UTC]
3080 m	520 m	3 Ball Radio Float + Flasher		11:21
3077 m	523 m	G-6600-3 Triple Float		11:21
3075 m	525 m	G-6600-3 Triple Float		11:21
3073 m	527 m	G-6600-3 Triple Float		11:21
		20 m Nylon Rope		
3050 m	550 m	Mark 7G-21 Sediment Trap MID 2 - Shallow		11:23
		450 m Wire Rope		
		500 m Wire Rope		
2095 m	1505 m	G-6600-3 Triple Float		11:51
2093 m	1507 m	G-6600-3 Triple Float		11:51
		20 m Nylon Rope		
2070 m	1530 m	Mark 7G-21 Sediment Trap MID 2 - Middle		11:52
		500 m Wire Rope		
		500 m Wire Rope		End of wire was missing!
1065 m	2535 m	G-6600-3 Triple Float		12:21
1063 m	2537 m	G-6600-3 Triple Float		12:21
1040 m	2560 m	Mark 78G-21 Sediment Trap MID 2 - Deep		12:24
		500 m Wire Rope		new trap version! new timer version! new motor version! 500 ml cups
		500 m Wire Rope		
35 m	3565 m	G-6600-3 Triple Float		13:31
28 m	3572 m	Benthos Release 865 A, 9 V		13:31
		20 m Nylon Rope		N. Lahajnar Armed: C. Warnken D. Elvers
0 m	3600 m	Anchor (3 Railroad Wheels)		13:32

Fig. 2.15: Mooring system information MID-2

Samples of suspended particulate matter (SPM) were taken from various depths throughout the entire eastern Mediterranean Sea (Tab. 2.14). Samples were filtered through polycarbonate (0.45 µm) and GF/F (0.7 µm) filters, respectively. All samples were dried at 40° C for 72 hours.

In addition to satellite imagery these data provide a powerful tool to quantify primary production as not only the sea surface is covered but also deeper layers of the photic zone are taken into account. Especially in these deeper layers of the photic zone considerable primary production takes place. By establishing a link between primary productivity and sinking particles in sediment traps the export production can be quantified. Moreover, biogeochemical analyses of the composition of SPM will be compared with the organic matter in the sediment traps. Thus, degradation pathways and transport processes of particulate organic matter through the water column will provide new insights into the flux of organic matter to the deep eastern Mediterranean Sea. These results will be compared to the chemical composition of sea floor sediments (taken during M 44/4 in 1999). Therefore, the fate of organic matter from its production to its final burial can be investigated and is a major step in understanding the biogeochemistry of the eastern Mediterranean.

Tab. 2.14: Filtration of SPM during M 51/2

Station	Depth [m]	Volume/Depth [l]	Volume/Station [l]	Station	Depth [m]	Volume/Depth [l]	Volume/Station [l]		
511	5.6	30	30	540	5.6	48	250		
512	5.6	32	32		35	90			
515	5.6	76	178		110	112			
	20	46		542	5.6	62	268		
	70	56			45	94			
518	5.6	60	246		115	112		543	5.6
	25	82		35	73				
	100	104		100	114				
521	5.6	53	230	544	5.6	76	268		
	30	77			45	78			
	90	100			115	114			
523	5.6	44	148.5	546	5.6	98	98		
	20	56.5		547	5.6	50	50		
	90	48		549	5.6	58	242		
527	5.6	45	45		78				
	40	114	105		106				
	529	5.6	57	279	552	5.6	84	84	
110		113	553		5.6	90	90		
200		109	555		5.6	88	88		
533	5.6	81	81	556	5.6	68	68		
536	5.6	62	252	557	5.6	72	72		
	50	96		558	5.6	90	90		
	100	94		559	5.6	50	50		
538	5.6	67	256	Total volume M 51/2: 3947 liter					
	45	91							
	100	98							

2.4.2.6 Trophic Interactions in the Water Column

2.4.2.6.1 Stable Isotopic Composition

(Rolf Koppelman, Heike Zimmermann-Timm)

Stable isotope tracing is becoming an increasingly important tool in studies of aquatic food webs (Peterson and Fry, 1987; Preston, 1992) in limnic as well as marine ecosystems (e.g. Hobson et al., 1995; Hoch et al., 1996; Montoya et al., 1990; Yoshii et al., 1999 and studies cited therein). Since the $\delta^{15}\text{N}$ values of animals reflect their diets, the isotopic signature of an organism provides integrated information about its feeding habits over longer time periods.

First results obtained during the cruise M44/4 indicates that the $\delta^{15}\text{N}$ values of zooplankton were markedly lower in the Levantine Sea compared to some oceanic areas, e.g. the Arabian Sea with zooplankton surface values from 9.5 to 13.5 ‰. Data from the upper 250 m in the Levantine Sea (2-4 ‰) suggest that N_2 from the atmosphere was used as a nitrogen source for primary production. Moreover, a loop system seemed to be active by which isotopically light NH_4^+ is recycled and used by phytoplankton. Analyses of abundance and stable isotope composition of diazotroph cyanophyceae, phytoplankton, protozoans and dominant micro- and mesozooplankton species are planned to enlarge our knowledge of trophic interactions in the epipelagic zone.

Method: Measurements of nitrogen isotope ratios ($\delta^{15}\text{N}$) will be done in a Carlo Erba NA-2500 Analyzer, from which the evolved N_2 was passed in a continuous flow of helium through a ConFlo II – Interface to a Finnigan MAT 252 isotope mass spectrometer. The analytical error of this method is ≤ 0.1 ‰. Stable isotope values are expressed in δ -notations as parts per thousand (‰), where R is the ratio of $^{15}\text{N}/^{14}\text{N}$ and the standard is atmospheric nitrogen:

$$\delta^{15}\text{N} [\text{‰}] = ((R_{\text{sample}}/R_{\text{standard}}) - 1) * 1000.$$

Microbial investigations: For tropical studies surface and near bottom samples were taken at 4 different stations with a CTD - rosette (Tab. 2.15). The plankton was fractionated by sieves and filters of different pore size (Tab. 2.16) and the different fractions were frozen. Beside this material was also fixed for further microscopical studies. The samples will be analysed for stable carbon and nitrogen isotopes.

Mesozooplankton investigations: Two hauls were taken over the whole water column south off Crete and some additional samples at the other sites were obtained to investigate the stable isotopic composition of mesozooplankton (Tables 2.6 and 2.9). Fresh material from the hauls was immediately fractionated into five size classes (<0.5, 0.5-1, 1-2, 2-5, and >5 mm) and rinsed with filtered freshwater. The material was then freeze-dried and pulverized for further analysis. Additionally, some single taxa and groups (Table 2.10) were taken for the analysis of stable carbon and nitrogen isotopes.

Table 2.15: Stable Isotope Sampling with the CTD / Rosette.

Station No.	Date	Time (UTC)	GPS Latitude (°N)	GPS Longitude (°E)	Water depth [m]	Sampled Depths [m]
525	26.10.01	02:03 - 04:04	34.83333	23.41667	2741	10, 40, 75, 100, 150, 220, 1750, 2000, 2200, 2400, 2700, 2817
530	30.10.01	15:57 - 17:23	34.48333	26.16667	4300	10, 80, 125, 180, 250, 320, 3200, 3500, 3750, 4000, 4200, 4270
541	02.11.01	16:36 - 19:21	34.06500	32.12000	2547	10, 50, 100, 140, 180, 240, 1600, 1800, 2000, 2200, 2400, 2520
543	03.11.01	20:36 - 22:06	34.00000	34.20130	2124	10, 60, 100, 150, 190, 250, 1200, 1400, 1600, 1800, 2000, 2106

Table 2.16: Fractionation of the Plankton Samples for Stable Isotope Analysis (n.d. = not determined)

Size fraction	Organisms
> 44 µm	Metazoa (f.e. copepods)
15 – 44 µm	Ciliates, some flagellates and phytoplankton
5 – 15 µm	Flagellates and phytoplankton
3 – 5 µm	Flagellates and phytoplankton
1 – 3 µm	Flagellates, autotrophic picoplankton and bacteria
0,2 – 1 µm	Bacteria
< 0,2 µm	n.d.

2.4.2.6.2. Protozooplankton and Their Importance in the Pelagic Food Web

(Heike Zimmermann-Timm)

Introduction: Planktonic protozoans are an important part of the microbial food web (Pomeroy, 1974, Azam et al., 1983). They are the intermediate organisms that link phyto- and bacterioplankton with higher trophic levels (Verity, 1991), and they are important sources of remineralised nutrients (Caron, 1991). However, the information about the microbial community and their importance in the pelagic food web in oligotrophic warm marine environments with high water temperature and high rates of irradiation is very scarce (Gocke and Koppe, 1994, Hausmann et al., 1994, Hausmann et al., 1999, Lenz et al., 1994, Zimmermann-Timm and Weikert, 2000).

The main objectives during METEOR cruise 51/2 were:

- Protozoan diversity in the water column and comparison of these data with other protozoan data from the Mediterranean Sea
- Comparison of protozoan communities in defined water masses at different stations.
- The protozoan community will be compared with different abiotic and biotic parameters such as temperature [°C], salinity [PSU], oxygen [mg l⁻¹], chlorophyll *a* [µg l⁻¹], bacteria [cells ml⁻¹] and autotrophic picoplankton (APP; cells ml⁻¹).
- Protozoan grazing on microbial food web components

- Interactions between planktonic protozoans and metazoans

Material and Methods: A) Protozoan diversity and abundance in the water column will be examined at 16 different station in the Mediterranean Sea (Tab. 2.5). At each station a depth - profile of 15 – 24 samples (Tab. 2.5) was taken with the CTD - rosette. 250 ml of each sample were fixed in 4 % glutaraldehyde, 250 ml with BOUIN's fixative and about 200 ml were used for live examinations.

Protozoan diversity:

- Live observations: A few μ l water were given on a slide. An Olympus microscope (BH – 2) with phase contrast and Normarski optics allowed the investigations of specimens on board of the ship. Especially flagellates were determined and quantified in this way.
- Observations of fixed samples: To determine the different species the „Quantitative Protargol Technique (QPS)“ will be used (Skibbe, 1994).
- Samples for the determination of the flagellate abundance, fixed with glutaraldehyd, will be stained with the fluorochrome, 4'6-diamidinio-2-phenylindole (DAPI), according to Porter and Feig (1980) and counted under an epifluorescence microscope.

B) Interactions between planktonic protozoans and metazoans in the food web: To study the growth rates, grazing impact, and energy fluxes from the picoplankton to the metazoans, the size fractionation technique (Arndt, 1990, Landry 1994, Zimmermann 1996, Zimmermann-Timm and Weikert 2000) was used at four different stations (525, 530, 541, 543, see Tab. 2.5). To separate the species at the higher trophic levels in the plankton, the water was filtered through 44 μ m and 15 μ m sieves. Filtered and unfiltered water (UF) as well as water enriched with zooplankton (3 x 1 l > 44 μ m and unfiltered water, ZP) was placed in 1 l glass bottles (Fig. 2.16). All procedures were performed on triplicate samples. The bottles were exposed on a rotating wheel under ambient conditions. Abundance and biomass of the autotrophic picoplankton (APP), bacteria, algae and protozoa were determined at the beginning of the experiments and after incubation periods of 12, 24 and 48 h. The protozoa were separated into several groups: nanoflagellates (NF), flagellates < 20 μ m; large heterotrophic flagellates (LF), flagellates > 20 μ m; ciliates < 20 μ m (NC) and ciliates > 20 μ m (LC). Metazoans were counted at the start and at the end of the experiment. The phytoplankton and ciliates will be identified in the lab as described above. The abundance of bacteria, APP (autotrophic picoplankton) and NF will be determined after staining with DAPI on black membrane filters under the epifluorescence microscope (Porter and Feig, 1980). Metazoans will be determined under an inverted microscope. The size of the bacteria, APP and NF will be measured using an image analysis system and their volume will be calculated using appropriate formulas (Padisak and Adrian, 1999). Crustacean abundance will be converted to biomass according to known relationships between body length and dry weight. The number of cells and their biovolume will be used to calculate the amount of carbon using the following conversion factors: for bacteria 15 fg C cell⁻¹ (Simon and Tilzer, 1987), HF 220 fg C mm⁻³ (Børshiem and Bratbak, 1987), ciliates 110 fg C mm⁻³ (Turley et al., 1986) and metazoans (Cushing et al., 1958). For a rough calculation of total phytoplankton, chlorophyll *a* values will be converted to C, assuming a C : Chlorophyll *a* ratio of 25 : 1 (Bell and Kuparinen, 1984). Protozoa production will be estimated from the mean cell concentration and the calculated size specific growth rates. The production of metazooplankton will be derived from the calculated community ingestion rates, assuming a growth efficiency of 25 % (Bosselmann and Riemann, 1986). To determine the food supply of the protozoa, their ingestion rates were calculated,

assuming that 200 % of the body weight per day must be ingested by individuals in the size class from 5 to $50 \times 10^3 \text{ mm}^{-3}$, when their production efficiency is 50 %. An ingestion rate greater than 300 % of the body weight is assumed for smaller individuals, and 150 % for larger ones (Laybourn – Parry, 1984).

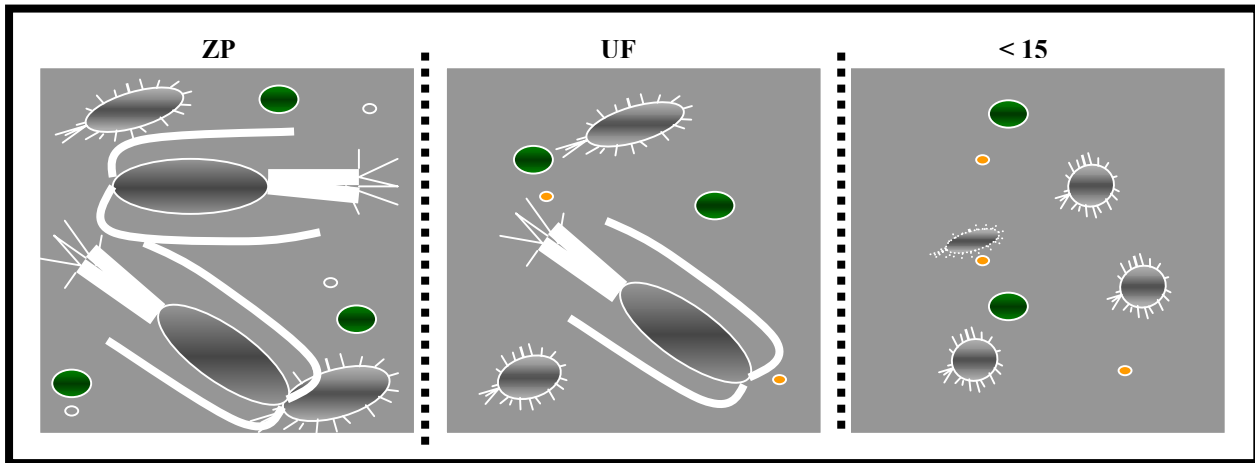


Fig. 2.16: Size-fractionation-technique was done with experiments over 12, 24 and 48 h. To separate the species at the higher trophic levels in the plankton, the water was filtered through $44 \mu\text{m}$ and $15 \mu\text{m}$ sieves. Filtered and unfiltered water (UF) as well as water enriched with zooplankton ($3 \times 1 \text{ l} > 44 \mu\text{m}$ and unfiltered water, ZP) was placed in 1 l glass bottles. The fraction $< 15 \mu\text{m}$ included bacteria, algae and protozoa, the UF – fraction included bacteria, algae, protozoa and some metazoa and the ZP-fraction included bacteria, algae, protozoa and many metazoa.

First results: About 22 different flagellate species were found using the live observation technique. Most of these flagellates were suspended in the pelagic environment, only a few organisms were attached to algae or small particles. Exact determinations of the ciliates will be done later, using the protargol technique, in the laboratory. It is visible, that the protozoan community was represented by auto-, hetero- and mixotrophic species. Comparing these results with the those from the M 44 / 4 cruise in spring it is visible that the number of the species *Mesodinium rubrum* is reduced. Numbers and abundances of species decreased from the western to the eastern part and with increasing depth. But at depths below 4000 m, comparable to our results from 1999 (Zimmermann-Timm & Weikert, 2000), high protozoan numbers were found in the sediment – water - area. Detailed results about the number of the organisms, the species composition and the importance of protozoans will follow later, after further analysis in the lab.

2.4.2.7 Zooplankton Sampling During Cruise M51/2

(Mohamed El-Komi)

The issue was the sampling of plankton in different water depths of the Mediterranean Sea. At the five Egyptian Waters sampling sites, zooplankton samples were obtained using the Bango Net (with mesh size 200 μ) from 200 m depth to the surface. Another zooplankton sample was collected by using MOCNESS (multi opening closing net for environmental sensing system) in one area in the Egyptian Waters. This sample was taken from different depths up to 450 m below the sea surface. The collected samples were fixed in 5% formalin solution. These samples will be investigated in the laboratory at the National Institute of Oceanography and Fisheries, Alexandria, Egypt. The investigation will be focused on species composition and species abundance. These data will be processed to cover the regional distribution of different important mesoplankton species in the oceanic region off the Egyptian Waters along the south eastern of the Mediterranean Sea.

The distribution of the mesoplankton is affected by the movement of the water masses and the ecological conditions of the seawater. The characters of the seawater in the sampling sites will be taken in consideration to interpretate the distribution, species composition and diversity of zooplankton communities in the oceanic region.

2.5 Ship's Meteorological Station

(Gerd Kahl, Torsten Truscheit)

When METEOR left Malaga on 18 October, 2001, a storm center of 970 hPa dominated much of the Northeastern Atlantic, its cold front having just passed our port of departure. Another frontal trough had just passed the Azores and was swinging east, too. The ship made her way accompanied by moderate southwesterly winds until the frontal trough caught up with her during October 20. In the afternoon winds peaked South 6 Bft and there was a little rain, too. Thus far, there seems to be nothing worth mentioning, but by the next morning when winds had veered to Northwest, peaking 6 Bft later in the day, a special result could be seen on all decks. The southerly winds had brought sand and particles of lesser size with them to deposit them on the ship. When METEOR passed the Straits of Sicily on October 22, working near the island of Pantelleria, winds were down to moderate westerlies again. While differences in sea level pressure were weak in the western Mediterranean, a high of 1020 hPa was lying over the Cyrenaika, extending into the Ionian Sea during the next days. East of it, the Etesian winds developed over the Levant, and strong northeasterly winds that occurred when the ship was working in the Straits of Antikithera gave way to northwesterly gales of 7 Bft when METEOR worked in the area south of Crete. A typical synoptic situation for the Etesian winds to blow was that of October 27: A high of 1035 hPa reaches from the Carpathian Mountains to the region north of the Black Sea and on to the northern part of the Caspian Sea. A wedge is extended to the Asian part of Turkey. This results in the sea level pressure to drop in the southern Aegean and along the Mediterranean coast of the Asian part of Turkey, whereas Egypt is less affected. So the scene is set for the strong to gale force winds in the Aegean and the Levant that are called Etesians by the Greek and Meltemi by the Turks. These winds finally abated on October 29, and when the ship visited the Straits of Kasos during November 1, winds were light and variable.

Conditions continued to be that favourable at the research vessel's position when the most easterly station was reached on November 3. However, in the southern part of the Aegean and in the area southwest of Crete lows of 1010 hPa were developing, the low in the southern Aegean reaching the status of a gale center during November 4 when central pressure was down to 1000 hPa. Then it filled again, moving southeast and passing the ship early on November 6. Southwesterly winds of about 6 Bft had been blowing all through November 5, thunder and lightning accompanying the passage of a frontal trough, but now northwesterly gales of 7 Bft were to be reported. Winds calmed down during the day. Meanwhile, further west a new low of 1015 hPa had developed over the Gulf of Lions because cold air masses had reached the area in the wake of a gale center that had made its way from Iceland through the Skaw to the Baltic States and further east. METEOR was likely to meet this low on her way further west as well as another low that was forecast to develop over the Gulf of Lions on November 8. These developments were not too intense, but they would prove to be able to cause strong winds from westerly directions during passing of their frontal troughs. METEOR called at La Valetta, Malta, on November 11.

2.6 Station List M51/2

Table 2.17: Station list M51/2

Station	Pr.	Latitude	Longitude	Date	Work
510	1	36 59.92 N	000 00.25 E	19 10 2001	Multinet
510	2	36 59.75 N	000 00.53 E	19 10 2001	Bongonet
510	3	36 59.76 N	000 00.70 E	19 10 2001	CTD/Rosette
510	4	36 59.64 N	000 00.62 E	19 10 2001	Multinet
511	1	37 59.68 N	005 59.67 E	20 10 2001	CTD/Rosette
511	2	37 59.77 N	005 59.78 E	20 10 2001	Multinet
511	3	37 59.75 N	005 59.75 E	20 10 2001	CTD/Rosette (Tracer, Nut, Bio)
511	4	37 59.68 N	005 59.42 E	20 10 2001	Multinet
511	5	37 59.69 N	005 59.02 E	20 10 2001	CTD/Rosette (Tracer)
512	1	38 45.17 N	010 37.00 E	21 10 2001	CTD/Rosette (Tracer, Nut, Bio)
513	1	38 29.93 N	011 30.03 E	22 10 2001	CTD/Rosette (Tracer, Nut, Bio)
514	1	37 34.05 N	011 31.96 E	22 10 2001	CTD/Rosette (Tracer, Nut, Bio)
515	1	36 54.14 N	012 00.00 E	22 10 2001	CTD/Rosette (Bio)
515	2	36 54.20 N	012 00.21 E	22 10 2001	Multinet
515	3	36 54.14 N	011 59.97 E	22 10 2001	CTD/Rosette (Tracer, Nut, Bio); parallel Plankton net
516	1	36 00.15 N	013 00.08 E	22 10 2001	CTD/Rosette (Tracer, Nut, Bio)
517	1	35 00.01 N	015 00.06 E	23 10 2001	CTD/Rosette (Tracer, Nut, Bio)
518	1	35 00.19 N	016 22.76 E	23 10 2001	CTD/Rosette (Bio)
518	2	35 00.26 N	016 22.80 E	23 10 2001	Multinet
518	3	35 00.31 N	016 22.75 E	23 10 2001	CTD/Rosette (Tracer, Nut, Bio); parallel plankton net
519	1	34 44.62 N	017 30.10 E	23 10 2001	CTD/Rosette (Tracer, Nut, Bio)

520	1	34 29.99 N	018 59.97 E	24 10 2001	CTD/Rosette (Tracer, Nut, Bio); parallel bongo net
521	1	34 24.93 N	020 19.81 E	24 10 2001	CTD/Rosette (Bio)
521	2	34 24.89 N	020 19.68 E	24 10 2001	Multinet
521	3	34 25.13 N	020 19.56 E	24 10 2001	CTD/Rosette (Tracer, Nut, Bio); parallel bongo net
522	1	35 13.92 N	021 28.88 E	25 10 2001	CTD/Rosette (Tracer, Nut, Bio)
523	1	35 00.15 N	022 30.17 E	25 10 2001	CTD/Rosette (Bio); parallel bongo net
523	2	35 00.07 N	022 29.92 E	25 10 2001	CTD/Rosette
523	3	34 59.99 N	022 29.92 E	25 10 2001	Multinet
523	4	35 00.12 n	022 29.81 E	25 10 2001	CTD/Rosette (Tracer, Nut, Bio)
524	1	35 43.78 N	023 26.53 E	25 10 2001	CTD/Rosette (Tracer, Nut)
525	1	34 50.00 N	023 25.21 E	26 10 2001	CTD/Rosette (Tracer, Nut, Bio)
526	1	34 40.00 N	024 20.02 E	26 10 2001	CTD/Rosette (Tracer, Nut, Bio)
527	1	34 33.84 N	025 05.20 E	26 10 2001	CTD/Rosette (Bio)
527	2	34 33.86 N	025 05.15 E	26 10 2001	Multinet
527	3	34 33.78 N	025 05.16 E	26 10 2001	CTD/Rosette (Tracer, Nut, Bio); parallel bongo net
528	1	34 26.45 N	025 55.73 E	26 10 2001	Mocness cast
528	2	34 19.78 N	026 08.54 E	26 10 2001	Mocness cast
528	3	34 18.81 N	026 08.49 E	27 10 2001	Mocness cast
528	4	34 18.85 N	026 08.36 E	28 10 2001	Mocness cast
528	5	34 19.32 N	026 08.28 E	28 10 2001	Mocness cast
528	6	34 19.22 N	026 08.26 E	28 10 2001	Mocness cast
528	7	34 19.46 N	026 03.01 E	28 10 2001	Mocness cast
528	8	34 18.91 N	026 05.67 E	29 10 2001	Mocness cast
528	9	34 18.59 N	026 03.56 E	29 10 2001	Mocness cast
529	1	34 19.90 N	026 06.44 E	30 10 2001	Mooring deployment
529	2	34 26.59 N	026 12.36 E	30 10 2001	CTD/Rosette (Bio)
530	1	34 19.17 N	026 10.00 E	30 10 2001	CTD/Rosette (Tracer, Nut, Bio); parallel bongo net
531	1	34 18.70 N	026 03.51 E	30 10 2001	Mocness cast
532	1	34 48.16 N	026 24.28 E	31 10 2001	Mocness cast
533	1	34 58.94 N	026 32.27 E	31 10 2001	CTD/Rosette (Tracer, Nut, Bio); parallel bongo net
534	1	35 17.08 N	026 39.02 E	31 10 2001	CTD/Rosette (Tracer, Nut)
535	1	34 55.06 N	027 34.92 E	31 10 2001	Mocness cast
536	1	34 19.86 N	027 30.06 E	01 11 2001	CTD/Rosette (Bio)
536	2	34 19.38 N	027 30.18 E	01 11 2001	Multinet
536	3	34 19.95 N	027 30.00 E	01 11 2001	CTD/Rosette (Tracer, Nut, Bio); parallel bongo net

537	1	34 02.02 N	028 51.05 E	01 11 2001	CTD/Rosette (Tracer, Nut, Bio); parallel bongo net
538	1	34 00.03 N	029 30.05 E	01 11 2001	CTD/Rosette (Bio)
538	2	34 00.30 N	029 30.11 E	01 11 2001	Multinet
538	3	34 00.42 N	029 30.67 E	01 11 2001	CTD/Rosette (Tracer, Nut, Bio)
539	1	33 51.94 N	030 30.06 E	02 11 2001	CTD/Rosette (Tracer, Nut, Bio); parallel bongo net
540	1	33 57.70 N	031 12.12 E	02 11 2001	CTD/Rosette (Bio)
540	2	33 57.62 N	031 12.00 E	02 11 2001	Multinet
540	3	33 57.72 N	031 11.91 E	02 11 2001	CTD/Rosette (Tracer, Nut, Bio); parallel bongo net
541	1	34 03.64 N	032 03.22 E	02 11 2001	Mocness cast
541	2	34 03.89 N	032 07.28 E	02 11 2001	CTD/Rosette (Tracer, Nut, Bio)
541	3	34 04.00 N	032 07.30 E	02 11 2001	Mocness cast
542	1	34 04.97 N	032 59.97 E	03 11 2001	CTD/Rosette (Bio)
542	2	34 04.98 N	032 59.92 E	03 11 2001	Multinet
542	3	34 04.99 N	032 59.80 E	03 11 2001	CTD/Rosette (Tracer); parallel bongo net
542	4	34 05.00 N	032 59.86 E	03 11 2001	Multinet
542	5	34 04.82 N	032 59.85 E	03 11 2001	CTD/Rosette (Tracer, Nut, Bio)
543	1	34 00.01 N	034 00.33 E	03 11 2001	Mocness cast
543	2	34 00.00 N	034 11.49 E	03 11 2001	CTD/Rosette
543	3	34 00.10 N	034 11.53 E	03 11 2001	Multinet
543	4	34 00.20 N	034 12.08 E	03 11 2001	CTD/Rosette (Tracer, Nut, Bio); parallel bongo net
544	1	33 29.97 N	033 00.04 E	04 11 2001	CTD/Rosette (Bio)
544	2	33 29.99 N	033 00.22 E	04 11 2001	Multinet
544	3	33 29.82 N	033 00.62 E	04 11 2001	CTD/Rosette (Tracer, Nut); parallel bongo net
545	1	33 29.96 N	031 50.34 E	04 11 2001	CTD/Rosette (Tracer, Nut, Bio); parallel bongo net
546	1	33 14.92 N	029 59.84 E	04 11 2001	CTD/Rosette (Tracer, Nut, Bio); parallel bongo net
547	1	33 00.04 N	028 00.23 E	05 11 2001	CTD/Rosette; parallel bongo net
547	2	33 00.04 N	028 00.17 E	05 11 2001	CTD/Rosette (Tracer, Nut, Bio)
548	1	32 30.12 N	025 59.16 E	06 11 2001	Mocness cast
549	1	32 30.96 N	025 31.91 E	06 11 2001	CTD/Rosette (Bio)
549	2	32 30.99 N	025 31.71 E	06 11 2001	Multinet
549	3	32 31.33 N	025 31.40 E	06 11 2001	CTD/Rosette (Tracer, Nut); parallel bongo net
549	4	32 31.50 N	025 30.67 E	06 11 2001	Bongo net
550	1	33 12.07 N	025 35.06 E	06 11 2001	CTD/Rosette (Tracer);

					parallel bongo net
551	1	33 27.39 N	025 37.21 E	06 11 2001	CTD/Rosette (Tracer, Nut); parallel bongo net
552	1	34 11.46 N	025 37.16 E	07 11 2001	CTD/Rosette (Tracer, Nut, Bio); parallel bongo net
553	1	34 00.00 N	022 59.93 E	07 11 2001	CTD/Rosette (Tracer, Nut, Bio); parallel bongo net
553	2	34 00.01 N	022 59.95 E	07 11 2001	Mocness cast
554	1	33 19.90 N	022 21.11 E	08 11 2001	CTD/Rosette (Tracer, Nut); parallel bongo net
555	1	33 05.35 N	020 24.07 E	08 11 2001	CTD/Rosette (Tracer, Nut, Bio); parallel bongo net
556	1	33 33.09 N	019 00.15 E	09 11 2001	CTD/Rosette (Tracer, Nut, Bio); parallel bongo net
557	1	35 19.89 N	019 51.95 E	09 11 2001	CTD/Rosette (Tracer, Nut, Bio); parallel bongo net
558	1	35 34.87 N	017 14.91 E	10 11 2001	CTD/Rosette (Tracer, Nut, Bio); parallel bongo net
559	1	35 47.07 N	016 00.07 E	10 11 2001	CTD/Rosette (Tracer, Nut, Bio); parallel bongo net

2.7 Concluding Remarks

Due to fortunate circumstances, the cruise was successful to a degree that the participants had not dared to expect when they embarked. This situation applies to all participating groups. The assistance and technical support in our work by master Martin Kull, the chief engineer, the officers and electronic engineers and the entire ship's crew was highly efficient and always pleasant, which deserved and met praise by all members of the scientific crew, as did the hospitality during leisure time, and also the cooking - except for a growing desire for pasta by the Italian colleagues.

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Cruise No. 51

12 September – 28 December 2001



Christoph Hemleben, Kaj Hoernle, Bo Barker Jørgensen and Wolfgang Roether

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Abstract

METEOR cruise M51 started on September 12, 2001 at Warnemünde (Germany) and ended on December 28, 2001 at Istanbul (Turkey) comprising stops at Malaga (Spain), Valletta (Malta), Rhodes (Greece) and Istanbul (Turkey). The scientific programs of at least 27 different working groups used several approved but also new methods to characterize the earth-system. The scientific objectives focused on the volcanology of the East Atlantic Ocean and Alboran Sea, the hydrography and planktology of the Eastern Mediterranean Sea, the paleoceanography and the sapropel formation of the Levantine and Aegean seas, and the climate history and biochemistry of the Black Sea. The scientific programs used a multi-proxy approach to study processes of the present and past Earth's system. Cruise M51 was divided into four legs to obtain insitu measurements and samples from the water column and the sea floor for general biological, microbiological, micropaleontological, geochemical, volcanological and sedimentological studies.

This report summarizes the main goals of the various working groups, provides complete lists of all stations and equipment employed on each leg, and presents the preliminary results obtained during the cruise. The cruise was funded by the *Deutsche Forschungsgemeinschaft* (German Research Foundation).

Zusammenfassung

Die METEOR-Reise 51 startete am 12. September 2002 in Warnemünde (Deutschland) und endete am 28. Dezember 2001 in Istanbul (Türkei) mit Zwischenaufenthalten in Malaga (Spanien), Valletta (Malta), Rhodos-Reede (Griechenland) und Istanbul (Türkei). Das wissenschaftliche Programm der mindestens 27 Gruppen benutzte zahlreiche erprobte, aber auch neue Methoden, um das System Erde zu charakterisieren. Die verschiedenen Unterprogramme waren auf vulkanologische und sedimentologische Fragen im östlichen Atlantik (M und Kanaren) und der Alboran See gerichtet. Im östlichen Mittelmeer, der Ägäis, dem Marmara Meer und dem Schwarzen Meer standen hydrographische, mikrobiologische geochemische und sedimentologische Untersuchungen im Vordergrund. Ein besonderer Schwerpunkt waren Untersuchungen und Probennahme zur Paläoozeanographie und Klimageschichte des östlichen Mittelmeeres, der Ägäis und des Schwarzen Meeres. Dieser Bericht fasst die Ziele und Durchführungen (Methoden), sowie erste Resultate zusammen, inklusiv einer Stationsliste, die während der vier verschiedenen Reiseabschnitte gewonnen wurden. Die Reise 51 wurde von der *Deutsche Forschungsgemeinschaft* (German Research Foundation) finanziell unterstützt.

Research Objectives

Cruise M51 was divided into four legs (Fig.1) It started on September 12, 2001 at Warnemünde and ended on December 28, 2001 at Istanbul. The following table lists the chief scientists and leg dates. Master of R/V METEOR cruise 51 was M. Kull.

Table 1: Legs and chief scientists of R/V METEOR cruise M 51.

Leg	Ports	Period	Chief scientist
M 51/1	12.09.01-15.10.01	Warnemünde-Malaga (Spain)	Prof. Dr. K. A. Hoernle
M 51/2	18.10.01-11.11.01	Malaga (Spain) – Valletta (Malta)	Prof. Dr. W. Roether
M 51/3	14.11.01-10.12.01	Valletta (Malta)-Istanbul (Turkey)	Prof. Dr. C. Hemleben
M 51/4	13.12.01-28.12.01	Istanbul-Istanbul (Turkey)	Prof. Dr. B.B. Jørgensen

Leg 1

The causes for the existence of a volcanic belt extending ca 1.700 km between 23°N and 38°N in the eastern north Atlantic as well as the reasons for the volcanism in the Alboran Sea (western Mediterranean) are a subject of ongoing debate. Proposed geodynamical models include 1) a plume swarm, 2) a single mega-plume, 3) subduction, 4) delamination/ detachment of lithosphere and 5) rifting. Recent geochemical studies and age dating indicate at least two independent active hot spot systems (mantle plumes) in the eastern north Atlantic, which can be retraced to ca 70 million years (Ma) B.P.. In contrast, the volcanism in the Alboran region is probably associated with Miocene subduction of oceanic lithosphere or delamination/ detachment of subcrustal lithosphere. The aim of this research project was to test these models based on a temporal and spatial reconstruction of the volcanism in the working areas by using major- and trace element as well as Sr-Nd-Pb-O isotope and laser- $^{40}\text{Ar}/^{39}\text{Ar}$ - age data. This will also serve as a contribution for the understanding of the causes of the drying down of the Mediterranean Sea roughly between 5-6 million years ago (Messinian Salinity Crisis). The long-term objective is the reconstruction of the Cenozoic mantle dynamics in the eastern north Atlantic and in the western Mediterranean.

In addition to these investigations the sediment facies distribution in the Cabo de Gata area and epibenthic organisms from dredged samples were studied.

Leg 2

During METEOR cruise M51/2 highly precise measurements of the distribution of CFCs (CFC-11, CFC-12, CFC-113), tritium and helium isotopes/neon were carried out along a west/east transect in the eastern Mediterranean Sea. This tracer study is closely connected to the hydrographic program including measurements of nutrient, oxygen and CO₂ concentrations. The circulation and formation of water masses in the eastern Mediterranean Sea is recently characterized by a transient phase. Main objectives of the oceanographic investigations were to assess the adaptation in a new state of equilibrium and to quantify the impact of these changes on the biochemical characteristics.

On the background of the oceanographic changes in the Levantine Sea, the biological program studied the abundance, variability and structure of the zooplankton communities. For the first time it will be possible to compare the impact of oceanographic and biological changes on the flux rates within the bathypelagic (>1000 m) and abyssopelagic (>2000 m) zooplankton, and to the deep-sea floor. In addition, carbon fluxes to the deep-sea have been studied by means

of sediment traps. The data will be compared with the turnover rates of the zooplankton. The intensity of the degradation of organic matter in the water column has been investigated and compared to the data obtained during 1999 (M44/4).

Leg 3

During METEOR cruise M51/3 several long sediment cores were obtained from the Ionian Sea, Levantine Sea, Aegean Sea, and Sea of Marmara. The investigations focus on the reconstruction of abrupt climatic fluctuations during selected time intervals (e.g., Holocene, Eemian) of the last 150 kyr and their impact on the different marine ecosystems in the eastern Mediterranean Sea during glacial and interglacial boundary conditions. The paleoceanographic onshore studies include the reconstruction of temporal and spatial gradients of surface water temperature, productivity, nutrient distribution, and deep water ventilation. For the paleoceanographic studies different proxies will be applied comprising geochemical (stable isotopes, alkenones, lignin), micropaleontological (foraminifera, coccoliths, siliceous plankton) and sedimentological (e.g., clay mineralogy) investigations.

In addition to the paleoceanographic investigations, the bacterial communities have been studied in the water column, the sediment surface, and selected sapropel layers to document the differences to results obtained during cruise M40/4 in 1998. Furthermore, the distribution pattern of calcareous dinoflagellates in the water column and in the sediment have been investigated. The bathymetric distribution of selected macrobenthic communities (e.g., Scleractinia) have been studied off Rhodes to obtain ecological information for the paleo-ecological and paleoceanographic interpretation of fossil faunas from Plio-Pleistocene land sections.

Leg 4

The Holocene sedimentary sequences of the Black Sea which were deposited predominately under anoxic conditions provide a unique opportunity to study biogeochemical budgets in relation to the Holocene climate evolution with highest temporal resolution. This specific sedimentary environment resulted in thinly laminated sediments that contain mainly annual layers for the last ca. 7500 years. The expected high resolution paleoclimate records provide the potential to study Holocene climate variations on up to interannual/decadal time-scales. Through comparisons with other high resolution records both from the continent (e.g., Greenland ice-cores and lake sediments/tree-rings from Europe) and the marine realm (e.g., Arabian Sea, eastern Mediterranean Sea, and Red Sea), we aim to detect global or at least hemispheric climate signals (e.g., ENSO and NAO) in order to contribute to a better understanding of their long-term variability. On the other hand, as the type-locality for TOC-rich deposits in the geological past, the Black Sea provides an ideal area to study biogeochemical cycles. Through the planned multi-disciplinary approach combining solid and liquid phase analyses on high-resolution sediment profiles and in the water column with modeling, contribute to the understanding of biogeochemical processes leading to the development of specific element signals during sediment formation under oxic and anoxic conditions.

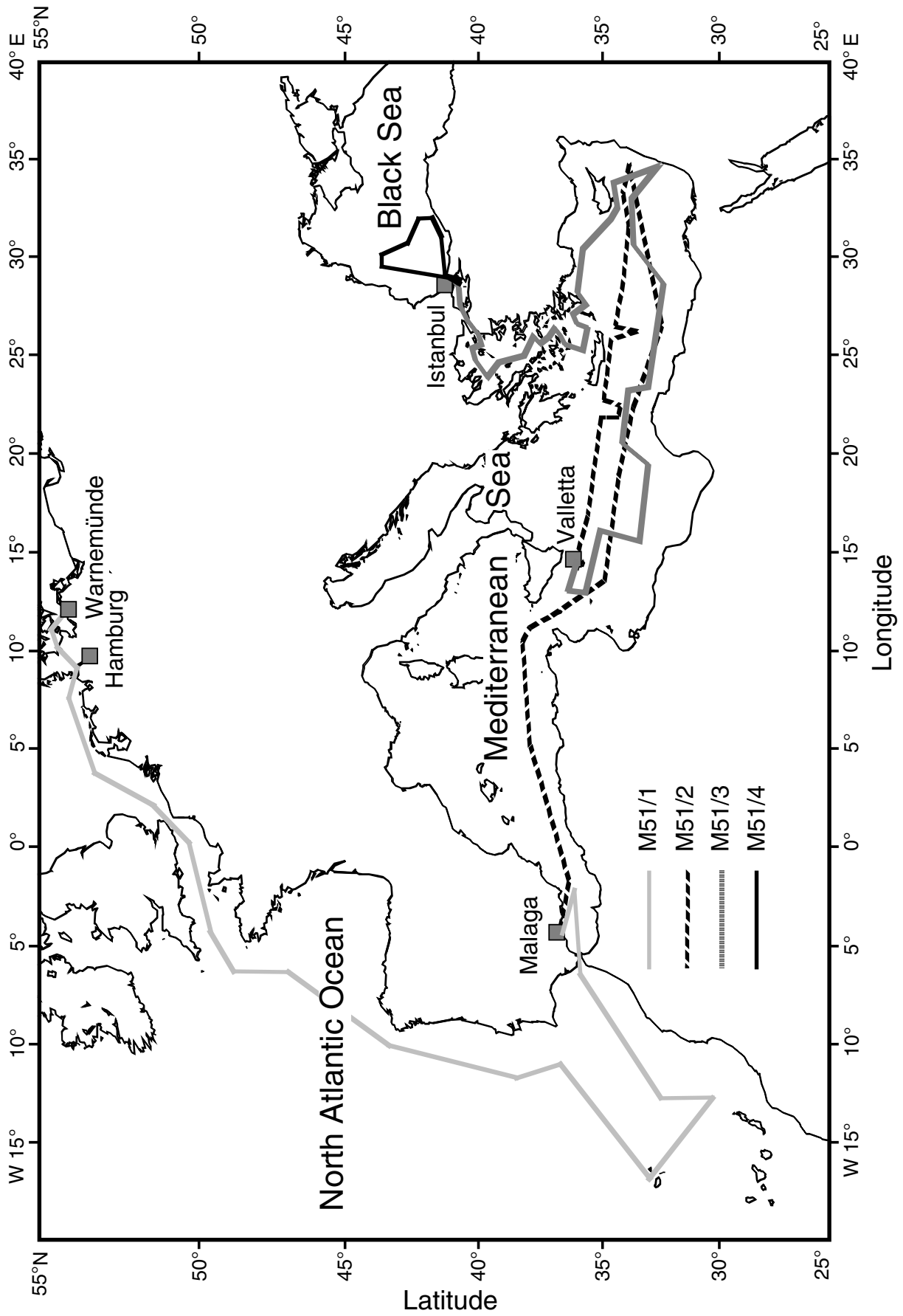


Fig. 1: M51 Cruise track

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