1. INTRODUCTION

The time series station ESTOC (European Station for Time-series in the Canary Islands, Estación Europea de Series Temporales Oceánicas de Canarias) started its operation in 1994. Since this report is the first in a series of annual reports, some background information will be provided in this introduction.

Both the WOCE and JGOFS Science Plans included requirements for establishing time series stations using research vessels. Two such stations existed, one at Bermuda and one at Hawaii, both in the interior of the respective oceans.The Canary Islands region appeared to be an appropriate location for a time series station in an eastern boundary current regime for several reasons.

The archipelago is situated in the eastern part of the North Atlantic subtropical gyre, and it is surrounded by deep water. Several Spanish marine science institutions exist on the islands which were prepared to contribute to the operations. In addition, two German institutions were willing to get involved: the Marine Physics Department of the Institut für Meereskunde at Kiel University which has a long record of physical oceanographic observations in the subtropical eastern North Atlantic, and the Geosciences Department of Bremen University with its long-standing experience in the research on particle flux in the ocean. The main goals for the ESTOC station work were specified as follows:

- to investigate the long-term changes of stratification and circulation on seasonal and interannual time scales in the southwestern approaches to Europe, with the aim of extending the data base which can be used for improving models of the eastern boundary circulation,

- to investigate the biogeochemical cycles in this region, with the aim to better understand the processes controlling the flux of carbon and associated elements in the ocean on seasonal and interannual time scales,

- to provide a focus for ocean studies by European and other research groups in the Canary Islands region,

- to strengthen the oceanographic research capabilities in the Canary Islands region and to improve the scientific interaction between the local institutions and other European ocean research institutions, particularly in Spain and Germany,

- to use the time series data as a contribution to the World Ocean Circulation Experiment (WOCE), and

- to use the time series data as a contribution to the Joint Global Ocean Flux Study (JGOFS).

The station is positioned at 29º10'N, 15º30'W, about 60 nautical miles to the north of the islands of Gran Canaria and Tenerife. It is the aim to occupy the station with a research vessel once each month for standard observations, including measurements of physical, chemical and biological properties and water sampling. These observations are complemented by measurements with moored instruments.

In order to obtain an improved understanding of the processes governing the region and thereby to gain information on the representativeness of the time series data, repeated process studies are carried out. These interdisciplinary experiments with research vessels combine hydrographic measurements, chemical and biological sampling, productivity experiments and drifting surface-tethered particle trap observations. The cruises are also used to exchange ESTOC moorings and to carry out the standard observations when appropriate. As a further contribution to the process studies, XBT lines were established between Gran Canaria and the station and also between Gran Canaria and the African coast.

The ESTOC work was initiated by a group of four scientists in Spain and Germany who are the editors of this report and who also constitute the international ESTOC Committee at present. The ESTOC Scientific Committee has the following tasks:

- to coordinate the scientific programmes,
- to ensure high data quality and appropriate data dissemination,
- to relate the observations to WOCE and JGOFS and other programmes,
- to coordinate meetings and the publication of documents, and
- to encourage the joint evaluation and publication of obtained data.

Monthly measurements started in February 1994, using the research vessel "Taliarte" (a rebuilt fisheries vessel) which is operated by the ICCM in Telde, Gran Canaria. In the monthly station observations the team of the ICCM collaborates with the IEO Tenerife and several groups from the University of Las Palmas. The German groups are occasionally participating in the monthly station observations, and provide input to this part of the programme mostly with respect to methods and calibration.

The repeated interdisciplinary process studies are carried out on German and later probably also on Spanish research vessels once or twice per year, combining groups from the ESTOC partner institutions, from the University of Las Palmas and from other institutions in several countries.

The funding for the German contribution to ESTOC is provided by the Ministry of Science and Technology (BMBF, Fkz.: 03F0108D), Bonn, as part of the German JGOFS programme. The Spanish institutions obtain their funding from local and national government sources.

The following report summarizes the observations and the data collected during the first year of station operations with the Spanish research vessel "Taliarte", during the first process study cruise with the German research vessel "Poseidon", and with the ship of opportunity "Esperanza del Mar" for the XBT sections.

2. CRUISE SUMMARIES AND DEPLOYMENT INFORMATION

2.1. Regular Station Observations

2.1.1. Monthly Observations

The position of the ESTOC station is shown in Figure 1. It is occupied regularly each month for two days. The list of cruises during this initial year is presented in Table 1. The measurements are carried out by groups varying from cruise to cruise, with different people from the participating institutions (see Table 3). The journey from Las Palmas to the ESTOC position takes about 8 hours, the depth of the station is 3600m and the work on station lasted approximately 9 hours during this first year.

The present report presents a summary of the station activities during the first year of operation. Starting in February 1994, the station was occupied eleven times during 1994 using the BO "Taliarte" and once the FS "Poseidon" (Table 1). During this first year the sampling was performed with Niskin bottles of 5 litres capacity fitted with calibrated reversing thermometers. Each bottle carried three thermometers, and was mounted on stainless-steel hydrowire (Taliarte) or on a General Oceanics rosette (Poseidon).

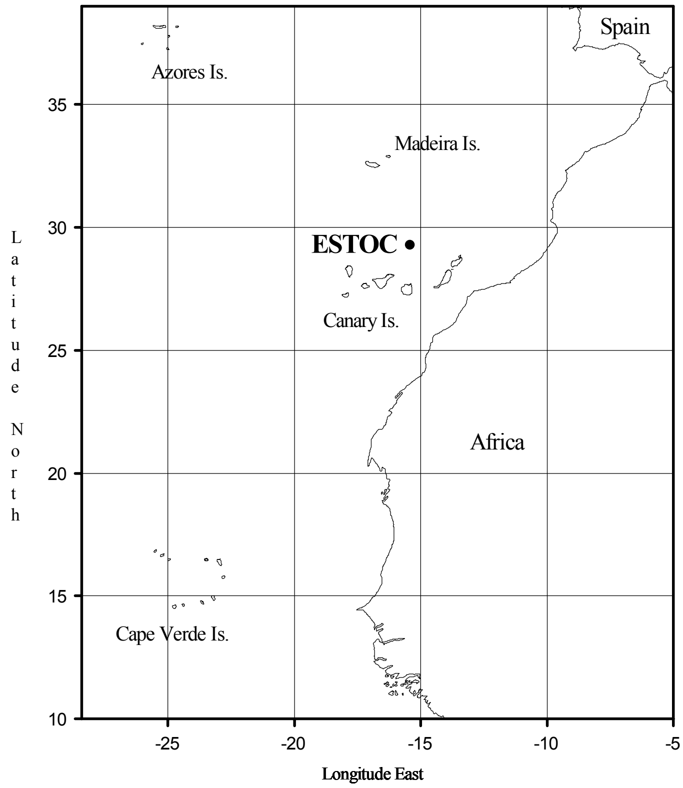

Figure 1. Map of the eastern Subtropical Atlantic, showing the position of the ESTOC station.

Table 1. Summary of ESTOC cruises, 1994

ESTOC	Ship	Depart	Return
0294	Taliarte	09.02.94	10.02.94
0394	Taliarte	29.03.94	30.02.94
0494	Taliarte	27.04.94	28.04.94
0594	Taliarte	27.05.94	28.05.94
0694	Taliarte	21.06.94	22.06.94
0794	Taliarte	12.07.94	13.07.94
0894	Taliarte	30.08.94	31.08.94
0994	Poseidon	25.09.94	08.10.94
1094	Taliarte	24.10.94	25.10.94
1194	Taliarte	16.11.94	17.11.94
1294	Taliarte	15.12.94	16.12.94
0195	Taliarte	25.01.95	26.01.95

Table 2. Basic parameters of the ESTOC station measured in 1994.

ESTOC parameters	0194	0294	0394	0494	0594	0694	0794	0894	0994	1094	1194	1294	0195
salinity	▒	------	------	------	------	------	------	------	------	------	------	-----	------
temperature	▒	------	------	------	------	------	------	------	------	------	------	------	------
CTD	▒	▒	------	------	▒	▒	▒	▒	------	▒	▒	▒	▒
XBT	▒	▒	▒	▒	------	------	▒	▒	▒	▒	▒	▒	▒
oxygen	▒	------	------	------	------	------	------	------	------	------	------	------	------
nitrates+nitrites	▒	------	------	------	------	------	------	------	------	------	------	------	------
phosphates	▒	------	------	------	------	------	------	------	------	------	------	------	------
silicates	▒	-----	------	------	------	------	------	------	------	------	------	------	------
metals	▒	▒	▒	▒	▒	▒	▒	▒	------	------	------	------	------
chlorophyll a	▒	------	------	------	------	------	------	------	------	------	------	------	------
other pigments	▒	------	------	------	------	------	------	------	------	------	------	------	------

Table 3. Personnel involved in the monthly ESTOC cruises.

Names	ESTOC	2	3	4	5	6	7	8	9	10	11	12
O. LLinás , I.	ICCM	▓										
M.J. Rueda , I.	ICCM	▒	▓	▓	▓	▓	▓	▓		▓	▓	▓
R. Molina, I.	IEO	▒										
F. Lopez-Laatzen, I.	IEO	▒			▒		▒		▥	▒	▒	
R. Santana, PhD stud.	ICCM		▒	▒	▒	▒	▒	▒	▥	▒	▒	▒
E. Delgado, PhD stud.	ICCM	▒	▒	▒	▒	▒	▒	▒	▥	▒	▒	▒
C. Rodriguez, PhD stud.	ICCM	▒		▒				▒	▥			
S. Ramos, Tech.	ICCM	▒	▒	▒	▒	▒	▒	▒	▥	▒	▒	▒
J. Betancor, Tech.	ICCM		▒		▒	▒	▒					
J. M. Rodríguez, Tech.	IEO			▒	▒	▒		▒				
C. García-Ramos, Tech.	IEO			▒		▒		▒		▒	▒	
J. Escánez, Tech.	IEO						▒		▥			
C. Haag, I.	IFMK					▒			▥			
B. Vanderbiest, Stud.	ICCM							▒	▥			
D. Martinez, Stud.	ICCM									▒	▒	▒

▥ Poseidon Cruise (see cruise report in Appendix D)

2.1.2. Moorings

During the FS "Poseidon" cruise 202, a current meter mooring (see Figure 1 in Appendix D) was deployed on 22.09.1994 at 29º10.09'N and 15º40.25'W at a water depth of 3620m. The mooring was equipped with 7 Aanderaa current meters at 270, 500, 800, 1200, 1600, 2500, and 3500m depth. An upward looking ADCP was installed at 200m depth.

The particle trap mooring had already been deployed on FS "Meteor" cruise M20 on 25.11.1991 and was subsequently exchanged according to the schedule outlined in Table 4. The moorings carried up to three particle traps, current meters and a particle camera. The instruments and deployment depths are shown in Figure 1 in the Appendix B.

Table 4. Moored particle traps at the ESTOC station: Depths and collection periods. No data are available from the 1 km trap of CI 3 because of loss of the flotation buoy.

Mooring	Trap depth (m)		Total collection period		Deployment (Days)	Sample interval (Days)
	1 km	3km	Start	End		
CI 1	1006	3084	25.11.1991	25.09.1992	305	15
CI 2	1036	3067	01.10.1992	09.04.1993	190	10
CI 3	1026	3086	12.04.1993	07.06.1994	430	21
CI 4	923	3070	09.06.1994	02.09.1994	86	8

2.2. Related Process Studies

2.2.1. "Poseidon" Cruise 202

Poseidon left Bremerhaven on 01.09.1994 and arrived in Las Palmas on 08.10.1994. The cruise was split into 3 legs, with the first two legs being mainly dedicated to mooring work. During the third leg hydrographic observations including biogeochemical sampling were performed around the Canary Islands.

In the beginning of the first leg three sound source moorings were recovered on positions N2 (43°02'N, 14°01'W), G (36°42'N, 11°59'W) and A (35°21'N, 12°49'W). On 10.09.1994 the mooring 346 (36°40'N, 15°49'W), equipped with two RAFOS floats for test purposes, was recovered. "Poseidon" called port in Funchal, Madeira, in the morning of 12.09.1994 for the exchange of mooring equipment and the embarkation of scientific personnel.

The second leg started on the 15.09.1994. The JGOFS mooring L1 (33°09'N, 21°59'W) with sediment traps was recovered the next day, and the mooring 276-13 on position KIEL276 (33°00'N, 22°00'W) on the 17./18.09.1994. Two days later mooring 364 (33°19'N 24°52'W) was retrieved. The ESTOC position was reached on 22.09.1994. The ESTOC current meter mooring 367 (29°11'N, 15°40'W) was deployed at a water depth of 3600 m. As on most of the mooring positions a CTD cast was taken in the vicinity of the mooring. On the 23.09.1994 "Poseidon" called port at Santa Cruz de Tenerife where the scientific crew was exchanged.

The third leg started on 25.09.1994 for station work around the Canary Islands. CTD casts were obtained on 63 stations (see cruise track in Appendix C). The CTD was either equipped with an oxygen sensor (24 stations) or a fluorometer and a lowered ADCP (39 stations). Both the ADCP and the fluorometer were only capable of a depth of 3000m. A surface-tethered particle trap was deployed 3 times (stations 769, 792, 815) close to the ESTOC station. The trap was always drifting for 3 to 4 days before it was recovered. Dilution experiments were carried out on stations 771, 788, 815, 796 and 822 in 30m depth to determine phytoplankton growth and grazing rates.

Two XBT sections were carried out, a meridional one along 15º3.0´W with 10 XBT profiles and a zonal section along 29º7.0´N with 15 XBT profiles. Close to the ESTOC station a Bongo net was lowered once to a depth level of 200m. On 07.10.1994 the station work was finished, and FS "Poseidon" called port at Las Palmas, Gran Canaria, on 08.10.1994.

The cruise track and the station list are attached as Appendix C.

3. SAMPLING PROCEDURES AND ANALYTICAL METHODS

3.1. CTD

3.1.1. Neil Brown CTD-O_2

A Neil Brown CTD-O_2 instrument was used during the FS „Poseidon" cruise 202. The CTD was either equipped with an oxygen sensor (24 stations) or a fluorometer and a lowered ADCP (39 stations), which both could only be used down to a depth of 3000m. All CTD profiles reached the bottom, unless the profile depth is noted explicitly in the station list (Appendix D).

On each station water samples were obtained with a GO multisampler (21 x 10l) if possible from the following 20 pressure levels: 2 x bottom, 3000 dbar, 2500 dbar, 2000 dbar, 1500 dbar, 1300 dbar, 1200 dbar, 1100 dbar, 1000 dbar, 800 dbar, 600 dbar, 400 dbar, 200 dbar, 150 dbar, 100 dbar, 75 dbar, 50 dbar, 25 dbar, 10 dbar and the pressure level of maximum chlorophyll content.

After the cruise the CTD-O_2 temperature, pressure, conductivity and oxygen calibrations were checked. The temperature and pressure sensors showed a stable or smoothly drifting behaviour. While slight changes were found for conductivity which could be handled in the calibration procedures, no satisfying calibration was possible for dissolved oxygen. No specific calibration was carried out for fluorometer data.

For the calibration of the pressure and temperature sensors, the results of the pre-cruise and post-cruise sensor calibration were used. They were obtained in the IFMK laboratory in November 1993 and January 1995. It is assumed that the temperature sensor responds to temperature changes only. The pressure sensor was calibrated for both the static response to changing pressure in loading and unloading mode at three different temperatures and for the dynamic response to fast temperature changes (MÜLLER ET AL., 1994).

For the calibration of the conductivity sensor the salinity values of the water samples were converted to in-situ conductivities by using the associated calibrated temperature and pressure values. The vertical scale for applying calibrations to the CTD-O_2 downcasts was smaller than the vertical response scale of the CTD-O_2 probe mounted below a 24 bottle rosette of 0.5 dbar.

To calculate calibration coefficients for the oxygen sensor, the oxygen values from the water samples and the low pass filtered temperature, salinity and pressure values from the CTD downcast were used (OWENS AND MILLARD, 1985). Potential density served as a reference level. Unfortunatly, it was not possible to obtain a satisfying calibration because the new type of sensor was not equipped with an internal temperature sensor, which turned out to be absolutly neccessary.

3.1.2. SIS autonomous CTD

During this first year, a self-contained CTD SIS for a maximum depth of 1000m was purchased and then used at the station; it was in operation three times, namely on ESTOC 0394, 0494 and 0594; several calibration problems were encountered that made it impossible to use the CTD during the remaining months of 1994.

3.2. ADCP

3.2.1. Vesselmounted ADCP

Due to problems with the input of the ship's gyro information and also with the positions delivered from the scientific GPS receiver, no vesselmounted ADCP data were obtained.

3.2.2. Lowered ADCP

The LADCP data were processed following the procedures of FISCHER AND VISBECK (1993). Due to problems with the GPS-data the profiles could not be corrected for shipdrift. The profiles were thus referenced to their mean to get some relative profiles (see Figures D10 and D11).

3.3. Discrete Water Column Measurements

3.3.1. Cast Order

The cast order of the monthly station work was as follows:

cast 1:

deep sampling I: from 600 to 3000 m, taking samples at the 600, 800, 1000, 1100, 1200, 1300, 1500, 2000, 2500, 2800 and 3000m levels (depending on the available length of wire on the winch).

cast 2:

surface sampling II: from 0 to 400m, taking samples at the 0, 10, 25, 50, 75, 100, 150, 200, 300 and 400m levels.

cast 3:

chlorophyll sampling III: duplicates from 0 to 200m were taken to have the volume of water necessary to obtain a significant filtered sample; the sampling was done at the 0, 10, 25, 50, 75, 100, 150 and 200m levels.

For sampling types I and II samples of oxygen, metals, salinity and nutrients were taken. In the sampling of type III only chlorophyll was measured.

3.3.2. Water Sampling

Samples were collected immediately after the bottles were on board. The sampling sequence was as follows:

1.) Oxygen (duplicated at each level) was fixed at once, then was kept for further analysis at the laboratory.
2.) Metals (starting with ESTOC 0994): Metal samples were frozen at -20°C inside a plastic container.
3.) Nutrients (triplicate sampling): Nutrient samples were frozen immediately at -20°C.
4.) Salinity (duplicate sampling): Salinity samples were kept in boxes to protect them from light.
5.) Pigments: The pigment samples were filtered and the filters were frozen subsequently at -20°C.

All samples were taken using the procedures established in the WOCE Operations Manual, WHP Office Report WHPO 91-1/WOCE Report No.68/91.

3.3.3. Salinity

The salinity samples were taken from 5 l Niskin bottles at the depths established in the station protocol.

Samples were measured with a salinometer, model Autosal 8400a, whose measurement range was between 0.005-42 (psu), with an accuracy of ±0.003, according to the manufacturer. It was calibrated following the manufacturer´s information and standarizing it with IAPSO Standard Seawater. Salinity values were calculated as practical salinity according to Unesco (1978, 1984).

3.3.4. Dissolved Oxygen

The water samples used to analyse oxygen were gathered from the Niskin bottles placed either on the rossette or on the stainless steel hydrowire if single bottles were used. In both cases, the oxygen samples were the first ones to be obtained from the sampling bottles, following the customary protocol described in the WOCE Operations Manual. BOD bottles were used and always duplicated. The samples were fixed inmediately for subsequent analysis in the laboratory.

The chemical determination of the dissolved oxygen carried out by ICCM up to ESTOC 1294 was based on the methodology proposed by WINKLER (1888) and modified by STRICKLAND AND PARSONS (1972). Results are expressed as milliliters of oxygen per liter of sea water. The samples were collected in duplicate in 300 ml BOD Bottles, and a 50 ml subsample volume was removed for titration. From ESTOC 1294 onwards, the samples were analysed using the method described in the WOCE Operations Manual, WHP Office Report No. 68/91; bottles with 125 ml volume were used and the final titration point was detected using a Metrohm 665 Dosimat Oxygen Auto-Titrator Analyser.

The oxygen determination carried out by the Instituto Español de Oceanografía achieved for ESTOC 0494, 0694, 0794, 0894, 0994, 1094, 1194 and 0195 used bottles of 125 ml volume and applied the method described in the WOCE Operations Manual, WHP Office Report No. 68/91.

3.3.5. Nutrients

Nutrients were taken in triplicate in polypropylene bottles which were previously cleaned and washed with HCl acid and were completely dry, according to the instructions of the following manuals: WOCE Operations Manual. WHP Office Report WHPI 91.1., WOCE Report No.68/91. Samples were immediately frozen at -20°C, analysing them as soon as possible after arrival at the laboratory. Freezing the samples is a common practice. It does not or only in a non-significant way affect the nitrate+nitrite and the phosphate

values (by a slight decrease) and is not noticeable in the silicate values (KREMLING AND WENCK,1986; MCDONALD AND MCLUNGHLIN, 1982).
The nutrient determination were performed with a segmented continuous-flow autoanalyser, a Skalar® San Plus System (ICCM) and 4 channels Technicon® AA II Auto Analyzer (IEO).

Nitrate+Nitrite: The automated procedure for the determination of nitrate and nitrite is based on the cadmium reduction method; the sample is passed through a column containing granulated copper-cadmium to reduce the nitrate to nitrite (WOOD ET AL.,1967), using ammonium chloride as pH controller and complexer of the cadmium cations formed (STRICKLAND and PARSONS, 1972). The optimal column preparation conditions are described by several authors (NYDAHL, 1976; GARSIDE, 1993).

Phosphate: Orthophosphate concentration is understood as the concentration of reactive phosphate (RILEY AND SKIRPOW,1975) and according to KOROLEFF (1983a) is a synonym of "dissolved inorganic phosphate". The automated procedure for the determination of phosphate is based on the following reaction: ammonium molybdate and potassium antimony tartrate react in an acidic medium with diluted solution of phosphate to form an antimony-phospho-molybdate complex. This complex is reduced to an intensely blue-coloured complex, ascorbic acid. The complex is measured at 880nm. The basic methodology for this anion determination is given by MURPHY and RILEY (1962); the used methodology is the one adapted by STRICKLAND AND PARSONS (1972).

Silicate: The determination of the soluble silicon compounds in natural waters is based on the formation of the yellow coloured silicomolybdic acid; the sample is acidified and mixed with an ammonium molybdate solution forming molybdosilicic acid. This acid is reduced with ascorbic acid to a blue dye, which is measured at 810nm. Oxalic acid is added to avoid phosphate interference. The used method is described in KOROLEFF (1983b).

3.3.6. Aluminium

This parameter became part of the regular sampling of the ESTOC station from ESTOC 0994 onwards; the investigators responsible of taking these measurements are members of the Chemistry Department of the ULPGC. The sampling is carried out from the Niskin bottles, being the second samples taken in the collection order; the samples are kept in polypropylen bottles previously cleaned, washed with HCl and dried, and wrapped in plastic bags (each bottle individually) to avoid any contact with other ship materials. The samples are taken with gloves and each bottle is rinsed at least three times with water from the respective level, being subsequently frozen at -20ºC to be transferred to the laboratory, where they are analysed according to the method following HERNÁNDEZ-BRITO ET AL., (1994a).

The method is based on complexation of aluminum with 1,2-dihydroxyanthraquinone-3-suplhonic acid (DASA) and measurement of the reduction current of this complex using high speed cathodic stripping voltametry (HSCSV). Samples were prepared in Teflon cups of polarographic cell, containing 10 ml of water, $2 \cdot 10^{-6}$ M DASA and 0.01 M BES. The adsorption potential (-0.9 V/Ag/AgCl) was applied to the working electrode, while the solution was stirred. After 40s accumulation time, the stirring was stopped and 5s were allowed for the solution to become quiescent. The scanning was started at -0.9 V and terminated at -1.4 V. The scanning is made using staircase modulation with a scan rate of 30 V/s and a pulse height of 5 mV. The DASA-Al peak appears at ca. -1.25 V. A standard addition procedure is used to quantify the aluminium concentration of the sample.

The electrochemical system used has been designed to measure the instantaneous currents at short times with a low noise level (HERNANDEZ-BRITO ET AL., 1994b). Thus, the analytical time required for each sample is substantially reduced. A PAR-303A electrochemical cell with hanging mercury drop electrode (HMDE) was connected to a locally produced computer-controlled potentiostat.

The detection limit was 1.7 nM for 40s adsorption time. It was calculated as 3 times the standard deviation of seven repeated determinations. The standard deviation was less than 3% for a 19 nM Al concentration.

3.3.7. Phytoplankton pigments

Pigments were measured during 1994 using spectrophotometric analysis, following the methodology described by PARSONS ET AL. (1984), and the determination was achieved applying the JEFFREY AND HUMPHREY (1975) equations. A spectrophotometer HP 8452 with cells of 1cm light path was used.

Intercalibration between GFF and GFC filters

Samples were filtered onto Whatman glass microfibre filters type GF/C. This kind of filter was used in order to reference the measurements to previous measurements carried out with these filters. Once both types of filters were calibrated at the ESTOC station, we were in the position to compare the measurements taken at ESTOC with a wide collection of historical measurements taken in the Canaries and Saharian Bank areas. The amount of filtered water was 4 litres and the filters were frozen at -20°C.

Starting in 1995, the pigments have been measured at ESTOC using fluorometry, performing the calibration with the spectrophotometric method and taking duplicate samples. The calibration results of the different methods will be presented in the next ESTOC report.

3.3.8. Dilution experiments

Dilution experiments are based on growth rate determinations of phytoplantkon in different dilutions of seawater over 24 h. Phytoplankton growth and microzooplankton grazing rates are determined by regressing the growth rates in the different dilutions against the dilution factor. For details see LANDRY AND HASSETT (1982) and NEUER AND COWLES (1994). During FS "P0SEIDON" cruise 202/1c, 5 dilution experiments were carried out in the ESTOC region with water taken in a depth of 30m and incubated on board the ship under a neutral density screen to simulate the ambient light regime at depth. The seawater was prescreened through a 100µm screen to exclude larger zooplankton. Ammoniumchloride was added in a final concentration of 0.05µMol to compensate for nutrient limitation effects in the higher dilutions.

3.3.9. Calibrations

The ICCM laboratory has maintained a programme of calibration and monitoring which is supposed to ensure a high quality of the nutrient determination using an autoanaliser AII Technicon as well as a Skalar San Plus System.

In addition comparisons with external groups were performed. Both laboratories (ICCM and IEO-Canary islands) have joined the QUASIMEME Quality Assurance and Laboratory Performance Studies (LPS) Programmes.

The QUASIMEME LPS has the support of the Helsinki Commission (HELCOM), the Oslo and Paris Commissions (OSPAR), the Mediterranean Pollution Monitoring and Research Programme (MEDPOL), the Arctic Monitoring and Assessment Programme (AMAP), the International Council for the Exploration of the Sea (ICES) and the European Cooperation for Accredited Laboratories (EAL). The LPSs follow the IUPAC/ISO/AOAC international protocol for laboratory testing and are managed by the Project Office at the Scottish Agriculture, Environment and Fisheries Department (SOAEFD), Marine Laboratory, Aberdeen.

Interlaboratory calibration

In order to ensure the appropriate quality of observation and analysis with two different groups (ICCM, IEO) being involved in the monthly regular programme at the ESTOC station a comparison and intercalibration of procedures and analytical methods was started during 1994.

- **Oxygen**

Samples were taken by both groups on five cruises, corresponding to 82 samples whose results are shown in Table 5.

- **Phosphates**

The intercalibration was done on eight cruises, providing a total of 140 samples, previously frozen at -20ºC; the results are shown in Table 5.

- **Nitrates and Nitrites**

The intercalibration was made on six cruises, providing 111 samples altogether, frozen at -20ºC; the results also shown in Table 5.

Table 5. Results from the intercalibration between IEO and ICCM. Regression model. (IEO value)=a (ICCM values) + b; r = correlation coefficient; r^2 = determination coefficient.

Parameters	number of samples	r^2	r	a	b
oxygen	82	0.914	0.956	1.013	0.053
phosphate	140	0.958	0.979	0.970	0.002
nitrate+nitrite	111	0.969	0.984	0.942	0.565

3.4. Moorings

3.4.1. Selfcontained ADCP

The current meter mooring was recovered in 1995 and the results will appear in the 1995 ESTOC data report.

3.4.2. Aanderaa Current Meters

The current meter mooring was recovered in 1995 and the results will appear in the 1995 ESTOC data report.

3.4.3. Particle Traps

Particle flux was determined at the ESTOC Station using 20 cup particle traps of the Kiel type (AQUATEC, sampling area 0.5 m^2) in four mooring deployments with varying length and sampling intervals (CI 1-4, Table 1). The sampling cups of the particle traps were poisoned prior and after deployment with mercury chloride in a 40 psu density gradient (Suprapur NaCl). The fraction > 1mm was not further analysed and mainly contained pteropod shells, insignificant amounts of amorphous aggregates and occasionally fish rests. Samples were omitted if during sample preparation fish remains were detected.

The size-fraction < 1mm was analysed according to FISCHER AND WEFER (1991). Briefly, the freeze-dried samples were weighed to determine total flux; carbonate and organic carbon were determined from non-acidified and acidified samples analysed in a CHN-analyser (HEREAUS) and biogenic opal was determined by the automated wet-leaching method (MÜLLER AND SCHNEIDER, 1993). The lithogenic fraction was calculated as: Lith = Total flux - (opal flux + carbonate flux + 2 Corg flux). Samples were not corrected for dissolution loss, which for biogenic opal was estimated previously to amount to 1-7% on an annual basis (FISCHER ET AL., 1996a). However, as dissolution processes occur rapidly within the cups they will affect all samples equally (FISCHER ET AL., 1996a).

3.4.4. Influx Current Meters

Influx current meters were supplied by G. Krause (AWI, Bremerhaven) and were equipped with an Aanderaa rotor and pressure, temperature and conductivity sensors. In addition, these instruments carry optical sensors to determine chlorophyll fluorescence (fluorometer), turbidity (backscattering) and Gelbstoff (fluorometer). The sampling interval of the optical sensors is 1h with 10 burst intervals averaged each lasting 1s.

3.4.5. Particle Camera

For direct optical measurement of abundance, concentration and size distribution of marine particles, a high-resolution camera system (ParCa) was designed. Imaging a sample volume of up to 37 l, smallest particles with diameters of 50 µm can be counted. The images provide information on particle size, shape and abundance either during profiling through the water column or while moored in a certain depth over time. The camera system was deployed in the CI mooring during mooring interval CI4 (see Appendix B; RATMEYER AND WEFER, 1996).

3.5. Drifting Particle Collector

The drifting particle trap consisted of four 1.10m long cylinders inserted into a metal frame. On top of all four cylinders a ca. 20cm long baffle was fixed to minimize turbulence at the cylinder mouth. The surface buoy carried an ARGOS transmitter, a radio transmitter and a xenon flash. The trap was positioned at 160m depth and an Aanderaa current meter was placed 10m below the trap (Figure 2 in Appendix B). Particles were collected with 250ml sample bottles screwed into the collection funnels below the cylinders. The sample bottles were filled with a density gradient solution made up with Suprapur NaCl and formalin (final concentration 2 %). The deployment time ranged from three to four days.

Before analysis of the samples in the laboratory, zooplankton swimmers that had entered the trap actively were removed using a binocular. The samples were then dried and analysed in a CHN analyser with and without decalcification with a few drops of 1 N HCL. The carbon content of the decalcified and the untreated samples were used to calculate carbonate and organic carbon values, and organic matter was obtained by doubling the organic carbon content. Opal and lithogenic matter was calculated by subtracting carbonate and organic matter from the total weight of the sample (FISCHER AND WEFER, 1991).

3.6. Remote Sensing

The images were processed at the ICCM.

The satellite images enclosed result from the AVHRR-2 sensor that is mounted on the satellites of the NOAA series (SCHWALB, 1978). This sensor has five spectral bands centered at 0.63, 0.91, 3.74, 10.8 and 12.0µm and gathers the irradiance (energy per surface unit per spherical angle unit in the direction of the observation). These platforms orbit at an approximate height of 850km above the earth surface (orbit period of 101 minutes) in a heliosynchronic mode. The diurnal pass through our study area is between 14.00 and 16.00 hours local time. The instantaneous vision field of 1.3 mradians is equivalent to 1.1km per pixel in the nadir, corresponding to a total width of 53°, equivalent to 2750km; from these images, the part corresponding to the study window limited by 30°N, 20°W and 20°N 10°W is selected, always removing the sunglint portion that occurs during these passes in the western part of the images.

Acquisition and Processing: Images are used from the AVHRR sensor which are coincident in time with the oceanographic cruises (previous and following week) in the image catalogues (quicklooks) provided by the tracking and receiving station of Maspalomas in Gran Canaria or in the global coverage files (GAC) of the NOAA in Washington. Only those images that have a cloud coverage below 30% are selected; when necessary, the images were also obtained from ESA in geophysical parameters format SHARP 2A (ARINO ET AL., 1994).

Using a set of routines written at ICCM, data are deduced from the brightness values (reflectivity in channels 1 and 2, brightness temperatures in channels 3, 4 and 5) and corrected according to the response factor of each detector (LAURITSON ET AL.,1979). A cloud removal algorithm is used to calculate the sea surface temperature, based in reflectivity thresholds and in channel intercomparison (MCCLAIN ET AL., 1985). The sea surface temperature is obtained using the algorithm (split window) for mean latitudes of CASTAGNÉ ET AL. (1986), modified to account for the solar elevation effect by MAY ET AL. (1992).

To achieve a final representation in a Lambert conformal conic projection, a combined model of orbital parameters and ground control points is applied.

First, the pass slant is corrected using a linear model followed by a bilinear interpolation based on nine control points. The RMS error of the obtained projection is always lower than one pixel. The radiometric sensibility is assumed to be 0.5ºC and the spatial resolution is approximately 1.1 km per pixel.

3.7. XBT

- The ICCM had a long-term cooperation for more than 10 years with the “Instituto Social de la Marina”, taking advantage of the activity of the B/H „Esperanza del Mar“ (hospital ship) rendering regular support to the Spanish fishing fleet which operates in the area off Northwest Africa. Starting in 1994, this activity has become part of ESTOC. Several areas have been sampled with Sippican XBT7 probes, of which two sections are shown in Appendix A, Figure 1. Sections were made to the north and south of the Canary Islands. The data were taken in April-May 1994.

- In addition to the usual sampling performed on the B/H „Esperanza del Mar“, a section is now made at each journey from Gran Canaria to the ESTOC station; data from that section will be analysed and presented in the next ESTOC reports.

- During the FS „Poseidon“ cruise 202, two XBT sections were carried out, a meridional one along 15º 3.0' W with 19 profiles and a zonal one along 29º 7.0' N with 15 profiles. Since T5 probes were used, the XBT profiles were reaching a depth level of 1800 m. No further temperature or depth corrections were carried out.

4. RESULTS

4.1. Regular Station Observations

The observations from the first year indicate that the changes of property distributions at the ESTOC site represent processes related to the gyre flow, to mesoscale eddies and meddies (Mediterranean Water lenses), and to episodic athmosphere-ocean fluxes and biogeochemical variation in the water column. A strong seasonal variability is found.

4.1.1. Monthly Observations

The vertical distributions of the observed parameters are shown in Appendix A. The originally planned cruise for January 1994 could not be carried out because of poor weather conditions; therefore, a complete annual cycle is achieved by adding the data from January 1995.

The monthly observations indicate the seasonal cycle which is well represented and has values within the range obtained in earlier studies near the Canary Islands (DE LEÓN AND BRAUN, 1973), and in the historical values described for the area in the various publications (LEVITUS, 1984 and 1986; KAMYKOWSKI AND ZENTARA, 1986 and 1991; FUKUMORI ET AL., 1991; LEVITUS ET AL., 1993).

It is expected that the observed variability of the Mediterranean Water (MW) and the Antarctic Intermediate Water (AIW) can partly be explained as a consequence of changes at the larger scale, but this will require long-term observations.

The influence of the coastal upwelling did not seem to produce a variation in the characteristics of surface waters at the station. The properties correspond to waters of Type 1 (LLINÁS ET AL., 1990; VAN CAMP ET AL., 1991; LLINÁS ET AL., 1994). The station will be used to pursue calibration studies and to validate sensors and satellite imagery algorithms, despite the existence of a considarable cloud coverage.

The aluminium distributions in the surface waters of the Eastern Central Atlantic waters have a particularly great potential for identifying physical and biogeochemical processes. Concentrations vary widely from a few nM (MEASURES, 1995) in upwelling eutrophic waters to more than 40nM in oceanic surface oligotrophic waters (HYDES, 1983). Water masses like the North Atlantic Central Water (NACW), the South Atlantic Central Water (SACW), the Mediterranean Waters (MW) or the Antarctic Intermediate Water (AIW) also show specific aluminium concentrations. Besides, aluminium can indicate the transport or resuspension of sediments in the near-bottom layer (MORAN AND MOORE, 1991) or dust inputs in the shallow waters (MEARING AND DUCE, 1987). The ESTOC station is a well suited location to establish the link between these processes and the aluminium distribution in the water column.

4.1.2. Moorings

4.1.2.1. Current Meter Mooring

The current meter mooring was lanched on 22.09.1994 and has been recovered in 1995. The results will be presented in the 1995 ESTOC data report.

4.1.2.2. Sediment Trap Mooring

Current speeds

Current meter data (RCM8, AANDERAA and INFLUX current meters, KRAUSE AND OHM, unpubl. manuscript) from depths 20m below the sediment traps are available for CI 1-4 (upper traps) as well as for CI3 and CI4 (lower traps). At depths around 1000m, velocities ranged from 1 to 11cm s^{-1}, with directions varying between 10° and 170°. Slightly higher velocities were recorded for the lower depths, with maxima of 15cm s^{-1} in November 1993 and oscillating directions from NNE to SSW.

Episodic flux events

Short-term (few hours to few days) peaks of pigment fluorescence and backscattering were observed with the INFLUX current meter in late winter to early spring 1993 in 900m depth. These peaks coincided with the late winter to early spring particle flux maximum recorded with the traps (FISCHER ET AL., 1996b).

Particle concentrations from particle camera

In order to compare high-resolution data on particle concentration and flux through time, ParCa was also deployed on a sediment-trap mooring at 995 m depth in the Canarian Basin between June and Setember 1994. First results show similar trends in sediment-trap derived fluxes of particulate matter from 2.8 to 67.2 mg m^{-2} d^{-1} and equivalent spherical volumes of particles with diameters>0.5 mm from 0.98 to 4.13 mm^3 l^{-1}.

Seasonality of deep-sea particle flux

As a complete record of particle flux during the mooring period is available only from the traps located at 3km depth. We will first present these results; later on we will compare these flux data with those obtained at 1km depth.

Particle flux at 3km depth was highly seasonal, with the largest amount of particles collected at the end of February and beginning of March (Figure 2). In comparison with the CZCS data record, flux peaks generally lagged about one to two months after the onset of high phytoplankton biomass observed in surface waters. Total flux in late winter ranged from 118 mg m^{-2} d^{-1} to a maximum of 188 mg m^{-2} d^{-1} (Figure 2a). During winter 1993, three distinct flux maxima were measured, one already in January. During the remaining months, particle flux was highly variable with occasional peaks in late spring, summer and fall. The fluxes remained, however, below the high values recorded during late winter and ranged between 49 mg m^{-2} d^{-1} and a maximum of 88 mg m^{-2} d^{-1}(August 1994, Figure 2a). The sedimentation of organic carbon, carbonate, biogenic opal and lithogenic material followed the total particulate flux pattern (Figure 2b, c, d, e). These biogenic and lithogenic flux components peaked during the late winter as well as during summer-fall sedimentation maxima.

Comparison of particle flux at different depths

Peak fluxes of total particulate matter determined at 1km depth (Figure 3) were for the most part coincident with those found at 3km depth (Figure 2), albeit lower in magnitude.While the late winter sedimentation event in 1993 amounted to about 70 % of the flux determined with the deep trap, the maximum flux in spring of 1992 reached only about one fourth of the flux recorded in 3km depth during the same interval. Most sampling intervals with peak fluxes coincided in time. A time lag between upper and lower traps could, however, be observed for the following peaks: (1) in the summer of 1992 (b and b' in Figures 2 and 3, time-lag about one month), (2) in the spring of 1993 (a and a', time-lag about 10 days) and (3) in the summer of 1994 (b and b', time-lag about one month) (NEUER ET AL., in press).

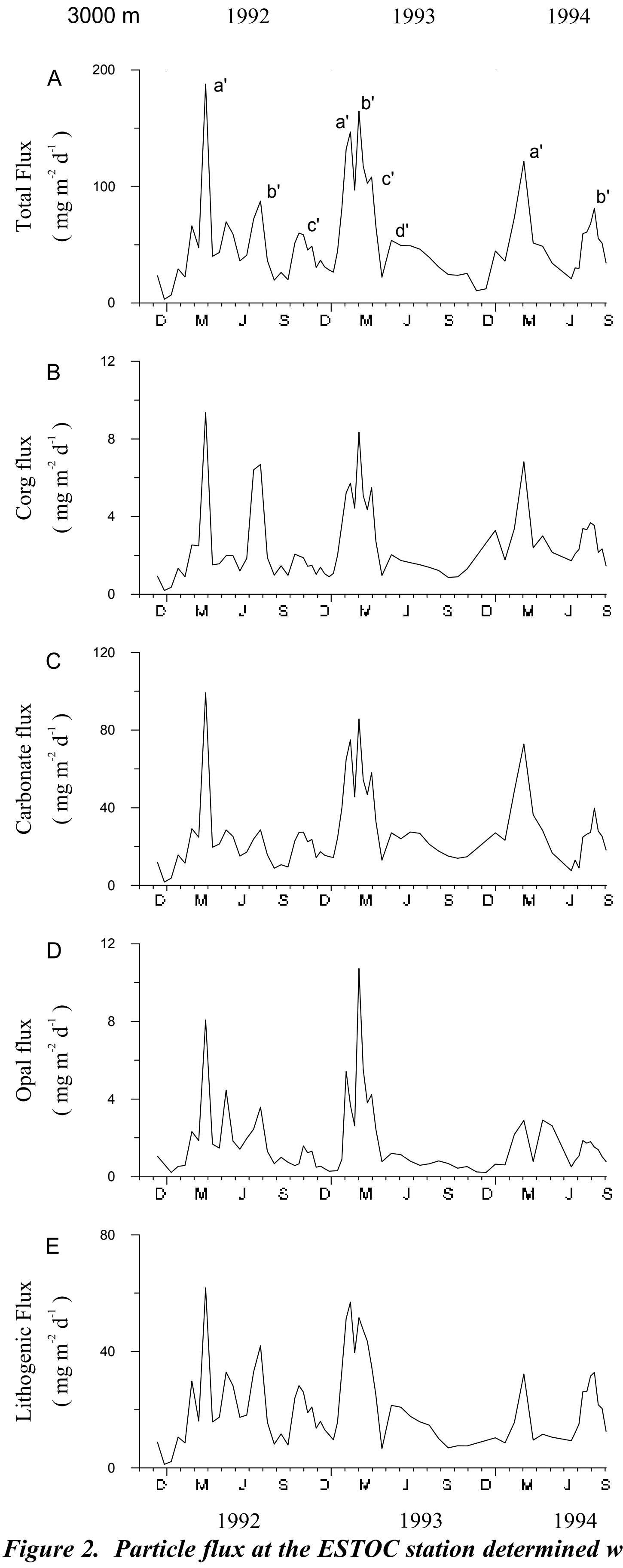

Figure 2. Particle flux at the ESTOC station determined with particle traps at 3 km depth. a. total particulates; b. organic carbon; c. carbonate; d. opal; e. lithogenic matter.

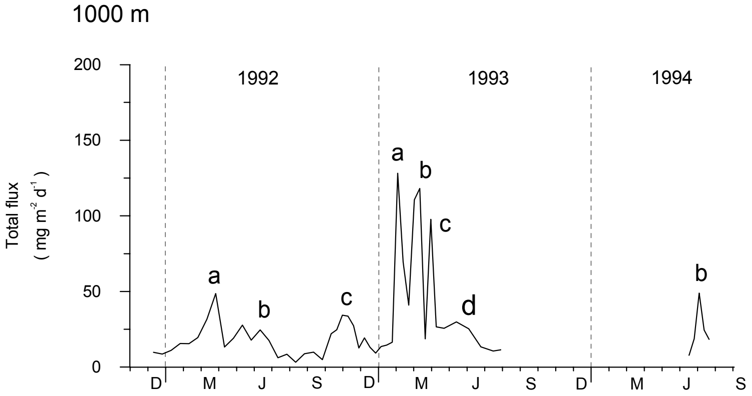

Figure 3. Total particulate flux at the ESTOC station determined with the 1 km depth particle trap.

4.2. Related Regional Studies

4.2.1. "Poseidon" Cruise 202

4.2.1.1. CTD Station Work

Below the surface layer, which was about 40m deep, pure North Atlantic Central Water (NACW) was observed on all CTD stations in a depth range between 100m and 700m (Fig. D2-D9). The NACW is characterized by a fixed temperature/salinity relationship. At a depth level of about 800m, we found Antartic Intermediate Water (AAIW), which enters the area from the south and is characterized by a salinity minimum. The lowest salinity values were observed at the eastern CTD stations between the Canary Islands and the African coast. In this area, the AAIW reached a depth level of more than 1100 m. The highest salinity values of the AAIW were observed at the western CTD stations north of the Canary Islands. The Mediterranean Water (MW), which enters the area from the north, is characterized by a high temperature and salinity. The MW signal was much stronger north of the Canary Islands than in the south. Especially at the stations south and east of Gran Canaria the influence of MW was hardly seen. The MW was observed in a depth level of about 1200 m, but at the CTD stations between the Canary Islands and the African coast the MW was found at the bottom in about 1400-1500 m. Within the upper 1000 m the isotherms and isohalines were oriented from the northeast to the southwest with decreasing temperatures and salinities towards the African coast.

A „Meddy" (Mediterranean Eddy) was observed at 29º08' N, 15º00' W (stations 792 and 830) in a depth range between 900 m and 1500 m with temperatures and salinities of more than 11ºC and 36.3 psu, respectively. The Meddy was shaped like a disk with a diameter of about 35 km. Since a Meddy had been observed in August 1994 at the ESTOC station, which is about 20 nm further west, this Meddy had probably moved towards the east with about 1.5 cm/s.

Some CTD stations just north of Gran Canaria showed cold and fresh water intrusions of AAIW within the warm and salty MW. The AAIW moves northward and probably crosses the sill at the bottom between Gran Canaria and Fuerteventura.

Results from LADCP

The velocities of the LADCP measurements were referenced to the mean value of each profile due to problems with the scientific GPS receiver. The shear profiles are shown in Figure D10-D11 in Appendix D.

Results from dilution experiments

Significant results were obtained from the stations 788, 815 and 822. The specific growth rate of the phytoplankton on station 788 and 815 was smaller than one doubling per day (0.69 d^{-1}).

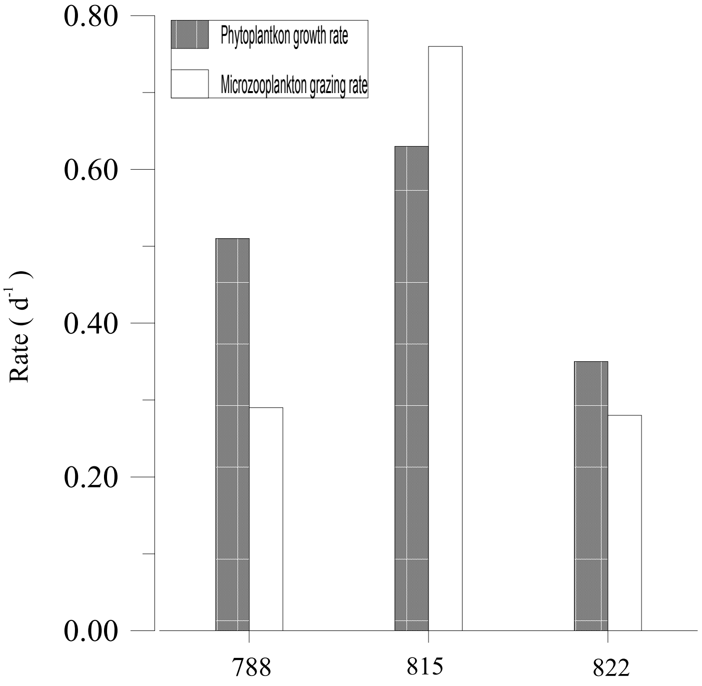

Figure 4. Phytoplankton growth and microzooplankton grazing rates determined with the dilution experiments on "Poseidon" 202.

On station 822, the growth rate was even lower with only half a doubling per day. With the exception of station 815, microzooplankton grazing rates were smaller than phytoplankton growth rates.

4.2.1.2. Underway Measurements

- Due to problems with the input of the ships gyro information and with the positions delivered from the scientific GPS receiver, no vesselmounted ADCP data were obtained.

- As explained before a Meddy was observed at the CTD station 792 in a depth range between 900 m and 1500 m with temperatures and salinities of more than 11ºC and 36.3 psu, respectively. To survey this meddy two XBT sections were carried out, a meridional one along 15º3.0'W with 19 XBT profiles and a zonal one along 29º7.0'N with 15 XBT profiles. Since T5 probes were used, the XBT profiles were reaching a depth level of 1800 m.

4.2.1.3. Drifting Particle Collectors

During the 3 deployment periods on "Poseidon" cruise 202/1c, the traps drifted to the northwest for 6 to 25 nautical miles, in addition to moving in inertial circles with periods close to one day.

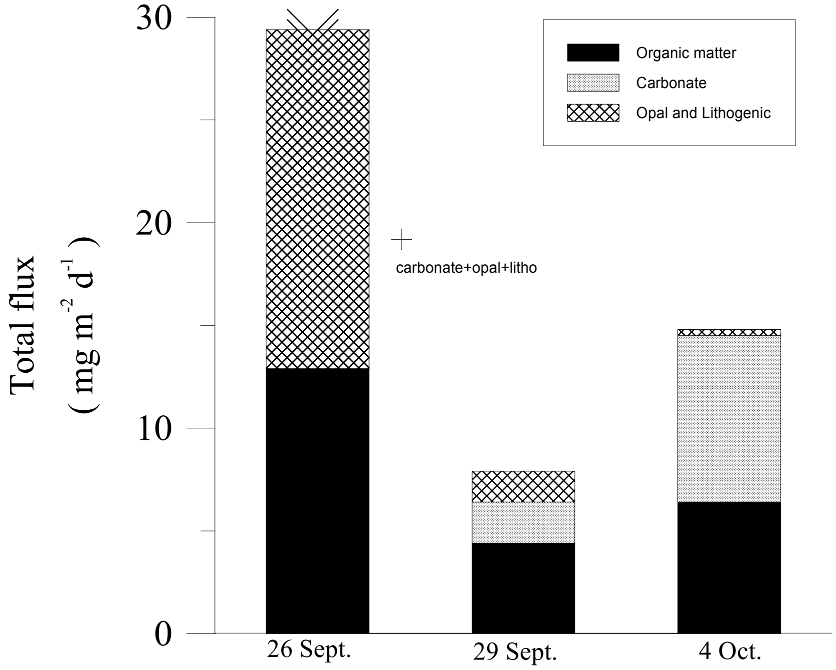

Figure 5. Flux rates obtained with drifting during the three deployment periods on "Poseidon" 202.

Fluxes varied by a factor of 2-3 and the contribution of carbonate to total flux also changed.

4.2.2. XBT Sections

Taking advantage of the cruises of the hospital ship "Esperanza del Mar" which provides medical and logistic support to the Spanish fishing fleet off Africa, two

XBT-7 sections were performed during the Spring of 1994 (Figure A1 in Appendix A). The first led from Gran Canaria towards the south along the 15º15´W meridian, and the second went from the north of Lanzarote towards the African coast in an approximately northeastern direction (Figures A2 and A3 in Appendix A).

4.2.3. Remote Sensing

The satellite observations of selected surface ocean properties provide a synoptic view of the ocean.

Such observations help to identify specific features in the neighbourhood of ESTOC. The shipboard observations of parameters which can also be measured from a satellite can also be used for calibrating the satellite sensor an to validate the reomote sensing data. The observational program at the ESTOC station had been designed to also allow this comparison. Unfortunately the new SeaWIFS satellite was delayed.

In Image 1, four scenes of a surface temperature distribution typical for the area can be seen, including a characteristic cloud cover of the area of the ESTOC station. Image 2 shows the scenes corresponding to the period 27 and 28.04.1994 when a high-intensity Saharan dust intrusion was observed (28.04.1994) in comparison to the image of the previous day. This gives an impression of the speed at which the event is generated. The same image (bottom scene) shows a three-days mean where the persistence of the cloud distributions and the characteristic surface temperature structures, both at the African coast and near the Canary Islands, can be recognized.

5. REFERENCES

BRAUN, J.G. (1980): Estudios de producción en aguas de las Islas Canarias, Hidrografía, nutrientes y producción primaria. Boletín Oficial de Oceanografía, 285, 5(4), 149-154.

CARPENTER, J.H. (1965): The accuracy of the Winkler method for dissolved oxygen analysis. Limnol. and Oceanogr., 10, 135-140.

CARPENTER, J.H. (1965): The Chesapeake Bay Institute. Technique for the Winkler oxygen method. Limnol. and Oceanogr.,10, 141-143.

CASTAGNÉ, N., P. LE BORGNE, J. LE VORUCH AND J.P. ORLY (1986): Operational measurements of sea surface temperature at CMS Lanion from NOAA-7 AVHRR data. International Journal of Remote Sensing, 5, 855-860.

CULBERSON, C.H. (1994): Dissolved oxygen. In WOCE Operations Manual. Volume 3: The Observational Program. Section 3.1: WOCE Hydrographic Program. Part 3.1.3: WHP Operations and Methods. WHP Office Report WHPO 91-1/ WOCE Report No. 68/91.

DE LEÓN, A.R. AND J.G. BRAUN (1973): Ciclo anual de la producción primaria y su relación con los nutrientes en aguas canarias. Boletín del Instituto Español de Oceanografía, 167.

FISCHER, G. AND G. WEFER (1991): Sampling, preparation and analysis of marine particulate matter. In: The Analysis and Characterisation of Marine Particles . D.C. Hurd and D.W. Spencer (eds.), Geophysical Monographs, 391-397.

FISCHER, G., B. DONNER, V. RATMEYER, R. DAVENPORT AND G. WEFER (1996a): Distinct year-to-year particle flux variations off Cap Blanc during 1988-1991: Relation to δ^{18}O-deduced sea-surface temperatures and trade winds. Journal of Marine Research, 54: 73-98.

FISCHER, G., S. NEUER, G. WEFER AND G. KRAUSE (1996b): Short-term sedimentation pulses recorded with a fluorescence sensor and sediment traps at 900-m depth in the Canary basin. Limnol. and Oceanogr., 41, 1354-1359.

FISCHER, J. AND M. VISBECK (1993): Deep velocity profiling with self-contained ADCPs. J. Atmos. Oceanic Technol., 764-773.

FUKUMORI, I. , F. MARTELL AND C. WUNSCH (1991): The hydrography of the North Atlantic in the early 1980's. An Atlas. Prog. Oceanogr., 27 (1-2), 1-110.

GRASSHOFF, K. (1976): Methods of seawater analysis. Verlag Chemie, Weinheim, 317 pp.

GRASSHOFF, K, M. EHRHARDT AND K. KREMLING (1983): Methods of seawater analysis. K. Grasshoff, M. Ehrhardt and K. Kremling (eds), Verlag Chemie, Weinheim, 419 pp.

Guildline Instruments (1981): Tecnical Manual for "autosal" Laboratory Salinometer. Model 8400.

HERNÁNDEZ-BRITO, J.J., M.D. GELADO-CABALLERO, J. PÉREZ-PEÑA AND J.A. HERRERA-MELIÁN (1994a): Fast determination of Aluminium reactive to 1,2-dihydroxyanthraquinone-3-sulfonic acid in sea-water. Analyst, 119, 1593-1597.

HERNÁNDEZ-BRITO, J.J., P. CARDONA-CASTELLANO, V. SIRUELA-MATOS AND J.A. PÉREZ-PEÑA (1994b): High-speed computerized polarographic system for cathodic stripping voltammetry in seawater. Electroanal., 6, 1141-49.

HYDES, D.J. (1983): Distribution of aluminium in waters of the North East Atlantic 25°N to 35°N. Geochim. et Cosmochim. Acta, 47, 967-973.

KAMYKOWSKI, D. AND S.J. ZENTARA (1986): Predicting plant nutrient concentrations from temperature and sigma-t in the upper Kilometer of the world ocean. Deep-Sea Research, 33(1), 89-105.

KAMYKOWSKI, D. AND S.J. ZENTARA (1991): Spatio-temporal and process-oriented views of nitrite in the world ocean as recorded in the historical data set. Deep-Sea Research, 38 (4A), 445-464.

KIRKWOOD, D.S. (1989): Simultaneous determination of selected nutrients in sea water - ICES. CM, 1989/C:29 Hydrographic committee. Ref.: Marine Environmental Quality Committee.

KOROLEFF, F. (1983a): Determination of dissolved inorganic phosphate. In Methods of Seawater Analysis. K. Grasshoff, A. Ehrhardt and K. Kremling (eds), Verlag Chemie, 126-129.

KOROLEFF, F. (1983b): Determination of dissolved inorganic silicate. In Methods of Seawater Analysis. K. Grasshoff, A. Ehrhardt and K. Kremling (eds), Verlag Chemie, 175-180.

KREMLING, K. AND A. WENCK (1986): On the storage of dissolved inorganic phosphate, nitrate and reactive silicate in Atlantic Ocean water samples. Meeresforsch, 31, 69-74.

LANDRY, M.R. AND R.P. HASSETT (1982): Estimating the grazing impact of marine micro-zooplankton. Marine Biology, 67: 283-288.

LAURITSON, L., G.J. NELSON AND F.W. PORTO (1979): Data extraction and calibration of TIROS-N/NOAA radiometers. NOAA Tech. Memo. NESS 107.

LEVITUS, S. (1984): Annual Cycle of temperature and heat storage in the World Ocean. J. Phys. Oceanogr., 14, 727-746.

LEVITUS, S. (1986): Annual Cycle of Salinity and Salt storage in the World Ocean. J. Phys. Oceanogr., 16(2), 322-343.

LEVITUS, S., M.E. CONKRIGHT, J.L. REID, R.G. NAJJAR AND A. MANTYLA (1993): Distribution of nitrate, phosphate and silicate in the world oceans. Prog. Oceanogr., 31, 245-273.

LLINÁS, O. (1990): Aportaciones de la cuantificación de algunos fenómenos oceanográficos de interés en Canarias. III Reunión Científica del grupo de trabajo en Teledetección, October 1989, AET, pp. 327-336.

LLINÁS, O., M.J. RUEDA AND E. PÉREZ-MARTELL (1993): Variabilidad de parámetros oceanográficos en aguas de Canarias. Boletín del Instituto Español de Oceanografía, 9(1), 89-100.

LLINÁS, O. (1994a): Características termohalinas y nutrientes en aguas de las plataformas insulares canarias a finales de primavera. Bol. Inst. Esp. Oceanogr., 10(2), pp. 177-189.

LLINÁS, O., A. RODRIGUEZ DE LEÓN, G. SIEDLER AND G. WEFER (1994b): The ESTOC Time Series Started Operation. International WOCE Newsletter, 17, 20.

MARING, H.B. AND R.A. DUCE (1987): The impact of atmospheric aerosols on trace metal chemistry in open ocean surface seawater, 1. Aluminum. Earth Planet. Sci. Lett., 84: 381-392.

MCCLAIN, C.R., W.E ESAIAS, G. FELDMAN, J. ELROD AND D. ENDRES (1990): Physical and Biological Processes in the North Atlantic during the First GARP Global Experiment. Journal of Geophysical Research, 95, C10, 18027-18048.

MCDONALD, R.W. AND F.A. MCLAUGHLIN (1982): The effect of starege by freeging of disolute inorganic phosphate, nitrate and reactive silicate for samples from coastal and internal water. Water Research, 16, 95-104.

MEASURES, C.I. AND J.M. EDMOND (1988): Aluminium as a tracer of the deep outflow from the Mediterranean. J. Geophys. Res., 93, 591-595.

MEASURES, C.I. AND J.M. EDMOND (1990): Aluminium in the South Atlantic: steady state distributions of a short residende time element. J. of Geophys. Res., 95, 5331-5340.

MORAN, S.B. AND R.M. MOORE (1991): The potential source of dissolved aluminum from resuspended sediments to the North Atlantic Deep Waters. Geochimica et Cosmochimica Acta, 55, 2745-2751.

MÜLLER, P. AND R. SCHNEIDER (1993): An automated leaching method for the determination of opal in sediments and particulate matter. Deep-Sea Research, 40, 425-444.

MÜLLER, T.J., J. HOLFORT, F. DELAHOYDE AND R. WILLIAMS (1994): MKIIIB CTD: Improving its System Output. Deep Sea Research, 42, 2113-2126.

MURPHY, J. AND J.P. RILEY (1962): A modified single solution method for the determination of phosphate in natural waters. Anal. Chim. Acta, 27, 31-36.

NEUER, S. AND T. COWLES (1994): Protist herbivory in the Oregon upwelling system. Marine Ecology Progress Series, 113, 147-162.

NEUER, S., V. RATMEYER, R. DAVENPORT, G. FISCHER AND G. WEFER (in press): Deep-water particle flux in the Canary Islands region: Seasonal trends in relation to long-term satellite derived pigment data and lateral sources. Deep-Sea Research.

OWENS, W.B. AND R.C. MILLARD, JR. (1985): A new algorithm for CTD oxygen calibration. Journal of Physical Oceanography, 15, 621-631.

RATMEYER, V. AND G. WEFER (1996): A high resolution Camera System: System design and results from profiles and 3 months deployment. J. Mar. Res., 54, 586-603.

RILEY, J.P. AND J.P. SKIRROW (1975): The Micronutrient Element. Chemical Oceanography, 2, 245-297.

SKALAR ANALITICAL (1993). Manual San Plus Analizer. Water Analysis. Publication no. 0660193.

STRICKLAND, J.D.H AND PARSONS (1972): A practical handbook of seawater analysis. Fisheries Research Board of Canada, 167 pp.

TREGUER, P. AND P. LE CORRE (1975): Manuel d'Analyse des sels nutritifs dans l'eau de mer. (Utilisation de l'Auto Analyzer Technicon AA II) - 2ème. édition. 112 pp. Université de Bretagne Occidentale.

UNESCO (1978): Technical Papers in Marine Science, 28, 35pp.

UNESCO (1981): Tenth report of the joint panel on oceanographic tables and standards. Technical Papers in Marine Science, No.36, Unesco,Paris.

UNESCO (1984): La escala de salinidades practicas de 1978 y la ecuacion internacional de estado del agua de mar de 1980. Documentos tecnicos de la Unesco sobre Ciencias del Mar, no. 36.

VAN CAMP, L., L. NYKJAER, E. MITTELSTAEDT AND P. SCHLITTENHARDT (1991): Upwelling and boundary circulation off NW Africa as depicted by infrared and visible satellite observations. Prog. Oceanogr., 26, 357-402.

WINKLER, L.W. (1888): Die Bestimmung des in Wasser gelö-sten Sauerstoffes. Berichte der Deutschen Chemischen Gesellschaft, 21, 2843-2855.

WOCE OPERATIONS MANUAL (1994): WHP office report. whpi 91.1. WOCE report no. 68/91.

WOODS, E.D., F.A.J. ARMSTRONG AND F.A. RICHARDS (1967): Determination of nitrate in seawater by cadmium-cooper reduction to nitrate. J. Mar. Biol. Ass. U.K., 47, 31-43.

6. ESTOC PRESENTATIONS AND PUBLICATIONS

Talks and poster presentations

- AGU/ASLO, San Diego, U.S.A., Feb.21-25, 1994
  - *Fischer, G., S. Neuer, G. Krause and G. Wefer*: Deep-water chlorophyll and particle flux recorded north of Gran Canaria.

- JGOFS meeting, Oldenburg, May 2, 1994
  - *Neuer, S. and C. Haag*: Outline and aim of the ESTOC programme.

- First Meeting of the ESTOC-Project, Telde, Gran Canaria, 13-14.10.1994
  - *Llinás, O.*: Introduction to ESTOC, Relationship to WOCE and JGOFS
  - *Siedler, G.*: Introduction to ESTOC, Relationship to WOCE and JGOFS
  - *Wefer, G.*: Introduction to ESTOC, Relationship to WOCE and JGOFS
  - *González.-Muñoz, A.*: Short- term variations of the upwelling in the NW Africa (20ºN-26ºN)
  - *Davenport, R.*: Application of remote sensing ocean pigment data to the Canary Region
  - *Gnade, O.*: Ocean Surface dynamics of the Canary Current region as observed by ERS-1 altimetry
  - *Pérez-Marrero, J.*: Infrared observations of upwelling phenomena in relation to other data

Knoll, M.: Preliminary results of the Poseidon Cruise 202/1c
Zenk, W.: Circulation patterns in the deep and bottom waters of the Eastern North Atlantic
Rodriguez, I.: A prognostic upwelling model off NW Africa
Neuer, S.: Particle flux recorded at the ESTOC Site using moored sediment traps from 1991 till 1993
de Armas, D.: Data management for ESTOC (EDAM)

- JGOFS- Workshop, Universität Bremen, 5.-6.12.1994
  Siedler, G.: Stand der Arbeiten bei ESTOC
  Neuer, S.: Partikelsedimentation an der ESTOC-Station: Saisonalität und biologische componenten.

7. Acknowledgments

Working with the small research vessel “Taliarte” on the windward side of the Canary Islands often proves to be difficult because of rough seas. We want to acknowledge the high motivation and excellent work under such conditions performed by captain Fco. Medina and his crew, and by the chief scientist M. J. Rueda and her scientific staff onboard. We also want to acknowledge the most valuable assistance of captain Andresen and his crew on the “Poseidon”.

The work was funded as part of the German JGOFS programme by the Ministry of Science and Technology (BMBF, Fkz.: 03F0108D) in Bonn, by the Excmo. Cabildo Insular de Gran Canaria and the D.G. de Universidades e Investigación del Gobierno de Canarias, and by the Instituto Social de La Marina, sponsor of the B/H „Esperanza del Mar“. Thanks are also given to S. Ramos, J. Betancor and A. Álamo for their valuable help and support to the project.

8. Data availability and distribution

The data reports will be published annually in the ICCM report series, combining the data sets from the standard station observations and from the special process studies. It is the understanding that in the future the data sets will be made available to other users through the ICCM web server two years after the year of observation, unless the ESTOC Comittee decides that special restrictions apply.