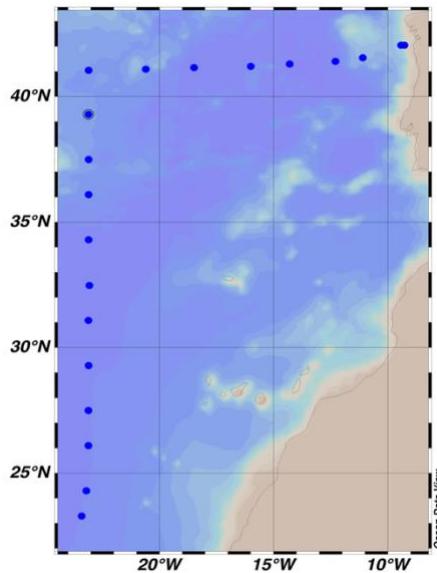


## CRUISE REPORT: Biomass - IV

(Created: December 2025)



## Highlights

## **Cruise Summary Information**

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Report assembled by Savannah Lewis by concatenating information from the following two articles:

[https://doi.org/10.1016/S0924-7963\(97\)00108-5](https://doi.org/10.1016/S0924-7963(97)00108-5)

[https://doi.org/10.1016/0198-0149\(92\)90093-9](https://doi.org/10.1016/0198-0149(92)90093-9)

**Links to Selected Topics**

Shaded sections are not relevant to this cruise or were not available when this report was compiled.

<b>Cruise Summary Information</b>		<b>Hydrographic Measurements</b>	
Description of Scientific Program		<b>CTD Data:</b>	
Geographic Boundaries		Acquisition	
Cruise Track (Figure): PI CCHDO		Processing	
Description of Stations		Calibration	
Description of Parameters Sampled		Temperature	Pressure
Bottle Depth Distribution (figure)		Conductivity	Oxygen
Deployments		<b>Bottle Data</b>	
Moorings Deployed or Recovered		Salinity	
Programs and Principal Investigators		Oxygen	
Scientific Personnel		Nutrients	
Problems and Goals Not Achieved		Total CO <sub>2</sub>	
		CFCs and SF <sub>6</sub>	
		Total Alkalinity	
		pH	
<b>Underway Data Information</b>		Lowered Acoustic Doppler Current Profiler	
Navigation Bathymetry			
Acoustic Doppler Current Profiler			
Thermosalinograph			
XBT and/or XCTD			
pCO <sub>2</sub>		<b>Acknowledgements</b>	
Atmospheric Chemistry Data			
Meteorological Observations			

## **Summary:**

During the "ANA" cruise in November 1988, Western North Atlantic Water (WNAW) was found linked to the Azores Current (AC) at 23° W, where according to various authors Eastern North Atlantic Water (ENAW) forms a boundary with WNAW east of the Mid-Atlantic Ridge (MAR). This boundary changes position during the year.

The vein of Mediterranean Water (MW) moving towards the MAR seems to be connected with the AC, and restricts the penetration of ENAW of subpolar origin (ENAWP).

A subsurface front has been found along 42° N, separating ENAW of subtropical origin (ENAWT) that moves northeastwards generating a cyclonic eddy that is confined between the lower limit of surface layer and approximately isopycnal 27.06, and modified ENAWP that moves southwards forming various anticyclonic eddies.

## **Methods**

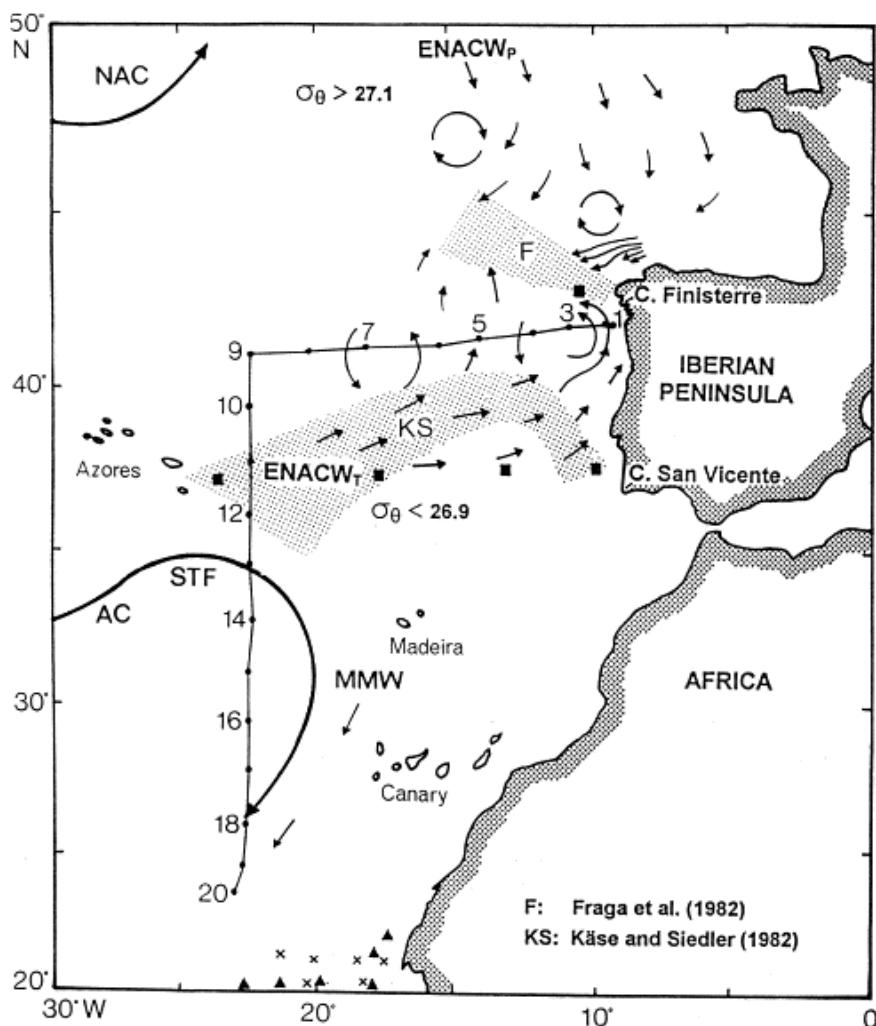
During the "ANA" cruise of the "Biomass-IV" expedition on R/V "Professor Siedlecki" in November 1988, 20 stations were occupied between 42°53'N - 9°28.5'W and 23°29'N - 23°40.1'W. Nine stations lay on a perpendicular section to the NW coast of Galicia (Spain); the other eleven stations lay on a meridional section perpendicular to the first. The positions of stations are shown in Fig. 1.

During the 'ANA' cruise of the 'Biomass-IV' expedition on R/V 'Professor Siedlecki' in November 1988, 20 stations were sampled between 42°53'N-9°28.5'W and 23°29'N-23°40.1'W. Nine stations lay on a perpendicular section towards the NW coast of Galicia (Spain); the other 11 stations lay on 22°W nominal longitude. The positions of stations are shown in Fig. 1.

Salinity, temperature and pressure were measured with a 'Neil Brown' CTD model SN-01/1132 at each station. Bottle samples for salinity, nutrients, pH and alkalinity determinations were collected from surface to 1100 m depth. Salinity was measured with an induction salinometer (Plessey Environmental Systems Model 6230N) to an accuracy of 0.005. Oxygen samples were measured using an automated and potentiometric titration as a slight modification of the original Winkler method. The standard error for five replications was less than  $2 \mu\text{mol kg}^{-1}$ . The apparent oxygen utilisation (AOU) defined by the deficit of oxygen concentration with regard to the saturation concentration at atmospheric pressure is used to describe the oxygen distributions. Nutrients were determined by colorimetric methods, using a Technicon Autoanalyser AAII. For silicate, a modified version of the method by Hansen and Grasshoff (1983) was used, in which  $\beta$ -silicomolybdenic acid is reduced with ascorbic acid. Nitrate was determined after reduction to nitrite in a Cd-Cu column. The standard deviation for duplicates was  $0.07 \mu\text{mol kg}^{-1}$  for silicate,  $0.06 \mu\text{mol}$

$\text{kg}^{-1}$  for nitrate and  $0.01 \mu\text{mol kg}^{-1}$  for phosphate. This is equivalent to 0.3%, 0.5% and 0.8% (full scale) reproducibility, respectively.

A Ross Orion 81-04 electrode calibrated with 7.413 NBS buffer, was used to determine pH. The temperature was also measured by means of a Pt-100 probe. pH values were normalised to  $15^\circ\text{C}$  to avoid the temperature effect over pH (Pérez and Fraga, 1987a). Automatic titration was used to measure alkalinity to a final pH of 4.44 with HCl (Pérez and Fraga, 1987b). The precision was  $2 \mu\text{mol kg}^{-1}$  (0.1%) for alkalinity and 0.005 for pH. In order to correct for the drift and bias during the cruise due to slight changes in the reference electrodes, routine and daily measurements of both variables for a large container (25 l) were made. Dissolved inorganic carbon (DIC) and partial pressure of  $\text{CO}_2$  ( $\text{pCO}_2$ ) were estimated from pH15 and alkalinity using the equations of the carbonate system (Dickson, 1981) and the constants determined by Mehrbach et al. (1973) and Weiss (1974). We use Mehrbach's constants because they are determined in natural sea water and reproduce very well the experimental temperature effect on  $\text{pCO}_2$  (Takahashi et al., 1993; Millero et al., 1994). In addition, the NBS scale was used in the TTO cruise, whose data are here compared with ANA data. In any case, the use of the new set of constants (Roy et al., 1993; Lee and Millero, 1995) give only a positive difference of  $1.4 \pm 0.15 \mu\text{mol kg}^{-1}$  in the DIC calculations which is lower than the precision of the analytical determination. The total propagation error of alkalinity and pH15 over DIC and  $\text{pCO}_2$  was  $4 \mu\text{mol kg}^{-1}$  and  $6 \mu\text{atm}$  respectively (Millero, 1995; Ríos and Rosón, 1996). The normalised DIC (NDIC) defined by  $\text{NDIC} = \text{DIC} \cdot 35/\text{S}$  was used to describe the carbonic variability.



**Fig. 1.** The location of stations of ANA cruise (•) and the TTO (■), ATLOR II (▲), ATLOR VII (×) stations used to validate the model. The circulation scheme of NACW varieties according to Ríos et al. (1992) is also superimposed. The main hydrographic features are also represented: NAC (North Atlantic Current), F (Subsurface Front between ENACWP and ENACWT; Fraga et al., 1982), AC (Azores Current), STF (Subtropical Front) and KS (Frontal Band; Käse and Siedler, 1982). The displacement of East North Atlantic Central Water of subtropical (ENACWT) and subpolar (ENACWP) origin, and the Madeira Mode Water (MMW) are given.

## References:

Dickson, Andrew G. "An exact definition of total alkalinity and a procedure for the estimation of alkalinity and total inorganic carbon from titration data." *Deep Sea Research Part A. Oceanographic Research Papers* 28.6 (1981): 609-623.

Fraga, Fernando, C. Mouriño, and Mario Manríquez. "Las masas de agua en la costa de Galicia: junio-octubre." (1982).

Hansen and Grasshoff, K . "Automated chemical analysis." *Methods of seawater analysis* (1976): 263-297.

Klein, Birgit, and Gerold Siedler. "On the origin of the Azores Current." *Journal of Geophysical Research:*

*Oceans* 94.C5 (1989): 6159-6168.

Mehrbach, Carl, et al. "Measurement of the apparent dissociation constants of carbonic acid in seawater at atmospheric pressure 1." *Limnology and oceanography* 18.6 (1973): 897-907.

Millero, Frank J and Lee, Kitack.. "Thermodynamic studies of the carbonate system in seawater" *Deep-Sea Research Part I* Volume 42, Issue: 11-12 (1995): 2035-2061.

Millero, Frank J. "Thermodynamics of the carbon dioxide system in the oceans." *Geochimica et Cosmochimica Acta* 59.4 (1995): 661-677.

Millero, Frank J., et al. "The internal consistency of CO<sub>2</sub> measurements in the equatorial Pacific." *Marine Chemistry* 44.2-4 (1993): 269-280.

Perez, Fiz F., and Fernando Fraga. "The pH measurements in seawater on the NBS scale." *Marine Chemistry* 21.4 (1987a): 315-327.

Perez, Fiz F., and Fernando Fraga. "A precise and rapid analytical procedure for alkalinity determination." *Marine Chemistry* 21.2 (1987b): 169-182.

Ríos, Aida F., Fiz F. Pérez, and Fernando Fraga. "Water masses in the upper and middle North Atlantic Ocean east of the Azores." *Deep Sea Research Part A. Oceanographic Research Papers* 39.3-4 (1992): 645-658.

Roy, Rabindra N., et al. "The dissociation constants of carbonic acid in seawater at salinities 5 to 45 and temperatures 0 to 45 C." *Marine Chemistry* 44.2-4 (1993): 249-267.

Takahashi, Taro, et al. "Seasonal variation of CO<sub>2</sub> and nutrients in the high-latitude surface oceans: A comparative study." *Global Biogeochemical Cycles* 7.4 (1993): 843-878.

Weiss, R\_F. "Carbon dioxide in water and seawater: the solubility of a non-ideal gas." *Marine chemistry* 2.3 (1974): 203-215.