POLYMODE NEWS

No. 76 May 30, 1980

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NOTES from the Editor

This issue is entirely given over to abstracts of papers presented at the recent POLYMODE Scientific Assembly. The abstracts show significant activity and progress. As you go through them, I think you will be impressed by their scientific content.

The results summarized in these abstracts will ultimately appear as papers in the regular scientific literature. POLYMODE News was established to provide an avenue for informal communications between investigators. Now, in the final stages of the experiment, the need for informal communication is much reduced. Consequently, we don't expect that POLYMODE News will carry further articles based on these abstracts. If you are interested in further details of the material in these abstracts, please contact the author directly.

As we approach the end of POLYMODE, it looks as though we will have two more issues. The next issue will contain the final round of articles. If the number of contributions is greater than we now anticipate, we may have two more issues of scientific articles. The final issue will include an index to all articles that have appeared in POLYMODE News and abstracts of the final MODE Contribution papers.

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The TELEX number for the USSR POLYMODE Office is changed (as of 24 May 1980) to: 411 968; answer back is OKEAN-SU.

-- F.W.

POLYMODE OFFICE NOTES

To the POLYMODE Community,

I am giving up the post of POLYMODE Executive Manager as of 1 July 1980. As POLYMODE winds down, the scientific effort has attained a momentum which will insure the successful completion of the program early next year, without the need for active coordination and management.

I would like to sincerely thank all of you with whom I have worked in POLYMODE for the last four and a half years for your help and patience. For me, it has been a fun, interesting, and productive period. To the extent that the Executive Office has been able to help in planning and carrying out the program, it has been due to the cooperation we have gotten from the participants.

There are, of course, a number of POLYMODE activities that will take place in the months to come. Carol Ramey will be handling logistic support and planning as she has so ably in the past.

I look forward to working with all of you in the future.

Bob Heinmiller

Robert Heinmiller
POLYMODE Executive Office
Building 54-1418
Massachusetts Institute of Technology
Cambridge MA 02139
(617) 253-7828

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The POLYMODE* News is produced at the Woods Hole Oceanographic Institution. It is edited by Ferris Webster and Catherine Herrity.

Material of interest for this newsletter may be sent to Catherine Herrity at the Woods Hole Oceanographic Institution, Woods Hole, MA, 02543, Telephone (617) 548-1400, ext. 2550, TWX 710-346-6601; or to Ferris Webster at NOAA/RD, 6010 Executive Blvd, Rockville, MD, 20852, Telephone (301) 443-8344.

*POLYMODE is derived from the names of the USSR POLYGON experiments and the Mid-Ocean Dynamics Experiment (MODE).

LOCAL DYNAMICS EXPERIMENT RESULTS

SOME ASPECTS OF SALINITY VARIABILITY IN THE LDE

Curtis C. Ebbesmeyer
Evans-Hamilton, Inc.

Abstract:

Standard deviations of salinity (σ_s) were computed on 300 potential density surfaces for the LDE density data. Vertical profiles of the LDE σ_s were contrasted with those from the historical and MODE data sets. The general shapes of the profiles are similar. Salinity anomalies associated with two small-scale eddies (S1 and D1) were superimposed on the vertical profiles of σ_s. The S1 and D1 salinity anomalies exceeded the historical value of σ_s and were equivalent to 3-4 x σ_s of the MODE and LDE data. Maps of salinity on selected density levels were shown and contrasted with maps of dynamic height.

FIRST RESULTS FROM THE LOCAL DYNAMICS EXPERIMENT MOORED CURRENT METER ARRAY

W. Brechner Owens
Woods Hole Oceanographic Institution

Abstract:

Statistical analyses of the LDE moored current measurements indicate that the LDE region is a transition between the "mid-ocean" and recirculation region. In the upper 1 km, mean velocities are to the southwest, consistent with Worthington's description of the mean circulation. The abyssal means are to the east, towards shallower depths, which are not consistent with both other direct current measurements and Worthington's description. The eddy kinetic energy (EKE) has trebled compared to the MODE region. The vertical structure of EKE is independent of frequency in comparison to the MODE results. Comparison with other longitudes indicates that the rapid change in structure of EKE as one enters the recirculation region may be ubiquitous.

Preliminary vorticity balances show at 600 m depth signatures of two-dimensional turbulence. The thickness of a layer (representative of planetary vortex stretching) and relative vorticity each appear to be independently acting as passive scalars with local rates of change being balanced by advection.

INTERCOMPARISON OF SMALL-SCALE FEATURES IN THE LDE

James C. McWilliams
National Center for Atmospheric Research

Abstract:

Three distinct small-scale features, observed during the 1978 LDE, are described in a common framework: temperature anomalies on pressure surfaces, vertical and horizontal scales, maximum currents, Rossby numbers, property anomalies (salinity and dissolved oxygen) on potential density surfaces, and propagation characteristics.

HORIZONTAL STRUCTURE OF NEAR-SURFACE CURRENTS

Lloyd Regier
Scripps Institution of Oceanography

Abstract:

The horizontal structure of currents at depths from 20 to 90 m was obtained using a Doppler acoustic profiling current meter and was compared to the current field obtained from the geostrophic shear relative to 3000 dbar. The structures thus derived were in general agreement with regard to form and magnitude, but the agreement was substantially better in LDE surveys 3, 4, and 5 where the current mean studies were substantially larger than in earlier surveys. There was little vertical difference in horizontal structure seen in the depth range studies although a substantial shear of $\sim 3 \times 10^{-3}$/sec existed. Ageostrophic currents exhibited no tendency for an Ekman spiral, but the analysis is as yet incomplete.

LDE PROFILER OVERVIEW

Brady Elliott
Applied Physics Laboratory
University of Washington

Abstract:

The profiler data can be subdivided into profiles taken in the subthermocline eddy D1 and those taken in the LDE region. Profiles through D1 clearly show D1 to be confined between 1000-3000 dbar with a

velocity maximum at about 1700 dbar. When compared to the background the profiles show D1 to be embedded in a larger-scale flow. In the LDE region during the first part of the cruise (6-11 June 1979), bottom velocities are large (∿13 cm/sec) to the southwest. Profiles show the flow to be primarily barotropic and first-baroclinic. Later in the cruise (12-18 June) bottom velocities in the same region are much smaller (∿3 cm/sec) and to the east. Profiles indicate the flow to be primarily barotropic.

FLOAT RESULTS

A TIME-LAPSE FILM OF SOFAR FLOATS IN THE LOCAL DYNAMICS EXPERIMENT

H. Thomas Rossby
University of Rhode Island

Abstract:

A computer-generated time-lapse film illustrating the movement of the LDE SOFAR floats was shown in color. It was indicated how color can be used to identify specific floats, or groups of floats (for example, according to depth). It can also be used to display water temperature along the float track, or vertical velocity past the float from the time rate of change of temperature (see abstract by Kuh Kim).

The film shows the rapid dispersal of the shallow floats (700 m) compared to the sustained coherent motion of the deep floats (1300 m). Temperature differences between neighboring shallow floats are at least qualitatively consistent with simple geostrophic motion (thermal wind). Vertical motion has evident horizontal coherence, as well as vertical coherence between shallow and deep floats nearby.

The computer program, with which the film was prepared, allows for simple "conversational" interaction between the observer and the data set.

ON THE STRUCTURE AND ORIGIN OF A SMALL LENS OF WATER TRAPPED IN THE MAIN THERMOCLINE

H. Thomas Rossby
University of Rhode Island

Abstract:

The existence of a very small, but energetic lens of water was revealed by the rapid orbital motion of one of the shallow (750 m) floats in the LDE. STDs taken at the time of recovery of the float revealed: 1) a weak but distinctive thermostad (1°/87m) about 160 m thick; 2) a negative salinity anomaly of 0.09°/$_{oo}$; and 3) a negative oxygen anomaly of 0.6 ml/l. Subsequently, it was learned that one of the LDE CTD casts, which by good fortune had been taken in this lens of water two months earlier, revealed remarkably similar temperature and salinity structure between ∿600 and 900 m.

Isopycnal analysis of water mass types of the σ_θ = 27.1 surface, corresponding to the center of the lens, indicates that the entrapped water originates from the low-oxygen tongue that extends westward from Africa along 20°N. The low thermostad suggests that the lens may have formed in the Eastern Atlantic. The lifetime of this lens is estimated to be at least several years (2.5?), but precise determination depends upon its place of genesis, migration path, and rate, all of which are unknown.

The discovery of lenses such as this, far from their parent water mass, identify them as a specific, possibly active, mechanism for the large-scale redistribution of salt, oxygen, and other tracers. It is of considerable importance to obtain a measure of their contribution to the total flux of these properties, for if significant, they could alter present views of the large-scale circulation as inferred from box models or diagnostic computations using the observed distributions of oceanic tracers.

VERTICAL VELOCITIES FROM FLOATS AND SOME OF THEIR USES

Kuh Kim
University of Rhode Island

Abstract:

In the absence of mixing, heat is conserved so that

$$\underbrace{\left(\frac{\partial}{\partial t} + u\frac{\partial}{\partial x} + v\frac{\partial}{\partial y}\right)}_{\frac{D_f}{Dt}}\theta + w\frac{\partial\theta}{\partial z} = 0 \quad (\theta;\ \text{potential temperature}) .$$

Since floats are isobaric devices, the change of θ as seen by floats is equal to $\frac{D_f}{Dt}\theta$, from which vertical velocities can be estimated as $w = -\frac{D_f}{Dt}\theta / \frac{\partial\theta}{\partial z}$. For practical purposes the instantaneous vertical gradient, $\frac{\partial\theta}{\partial z}$, may be replaced by a mean gradient.

During days 3714-3744 (25 July-24 August, 1978) the estimated vertical velocities show a coherent pattern horizontally and between the two float levels (700 db and 1300 db) as well with the range of $-4 \sim 0$ m/day at both levels. A prime use of the vertical velocity field is to estimate vertical stretching of vorticity and energy conversion, $\rho'gw$. Statistics of the daily change of kinetic energy following floats and the energy conversion subsampled every ten days are:

	700 db	1300 db
No. of samples	173	221
$\rho_o \frac{D_f}{Dt}\frac{1}{2}(u^2+v^2)$ (ergs/day)	.84 ± 54.04	.33 ± 11.33
$-\rho'gw$ (ergs/day)	−.24 ± .94	−.01 ± .20

This preliminary result indicates that ageostrophic pressure work (geostrophic pressure does not work!) is a dominant energy transfer process compared with $\rho'gw$. For limited data it is shown that eddy energetics are strongly barotropic in contrast with the case of linear baroclinic Rossby waves for which the pressure work and $\rho'gw$ are equally important.

DYNAMICAL AND STATISTICAL INFERENCES FROM THE LDE SOFAR FLOAT DATA SET

James C. Price
Woods Hole Oceanographic Institution

Abstract:

A striking feature of the 1300 m LDE SOFAR float data set is an energetic northeast to southwest oscillation which was strongest during the first half of the experiment (described in several POLYMODE News notes by Price and by Rossby). Potential vorticity balance for this motion was achieved by planetary vorticity change and topographically induced stretching acting in phase to balance changes in relative vorticity (±3% of f). This motion had a wavelength of 390 km, a wave vector which pointed northwest, and a period of 55 days. These scales match the dispersion relation for a barotropic planetary wave over the LDE topography.

XBT & DENSITY RESULTS

TRACERS OBSERVED DURING APRIL 1977, PRE-POLYMODE CRUISE

Curtis C. Ebbesmeyer
Evans-Hamilton, Inc.

Bruce Taft
University of Washington

James C. McWilliams
National Center for Atmospheric Research

Abstract:

During April 1977, a three-week cruise was conducted approximately along 70°W between ∿23-33°N. The cruise was undertaken in order to perfect techniques used in 1978 during the LDE density work. Tracers observed included conductivity, temperature, pressure, oxygen, and nephels from a vertical profiling system. Also observed were nitrate, silicate, and phosphate determined from discrete samples. The observed variables were interpolated to selected potential density surfaces. Major features observed include a sharp thermal front in the main thermocline near 30-31°N, a salinity front beneath the main pycnocline on $\sigma_\theta = 27.37$ near 26°N, and several small intense salinity anomalies.

T-7 XBT CALIBRATION: XBT-CTD INTERCOMPARISONS

Robert Heinmiller
Massachusetts Institute of Technology

Curtis C. Ebbesmeyer
Evans-Hamilton, Inc.

Bruce Taft
University of Washington

Abstract:

The results of five previous independent T-7 XBT comparisons with four different CTD profilers were reviewed (by Flierl and Robinson, McDowell, Fedorov, and two by Seaver and Kuleshov) and the results of two additional comparisons carried out during the LDE were presented.

The mean curves of depth error (XBT-CTD) as a function of depth for six of the studies (all except Fedorov) are compared and shown to be statistically similar. The overall results, comprising a total of 261 XBT-CTD intercomparisons, indicate the existence of a systematic difference between depths as measured by the T-7 XBT and the profilers.

THE SIGNATURE OF THERMOCLINE EDDIES IN THE SEA SURFACE TEMPERATURE AND SALINITY FIELDS

Eric J. Lindstrom
University of Washington

Abstract:

Average temperature and salinity in the upper 10 m were computed for the intensive LDE hydrographic surveys. Survey means of these quantities were subtracted to obtain anomaly maps. Temperature anomalies ranged from -1.0°C to +1.5°C while salinity anomalies ranged from $-0.50°/_{oo}$ to $+0.20°/_{oo}$. Maximum warm anomalies are associated with northeasterly flow in the western part of the array during late May and early June and with northwesterly flow in the eastern part of the array during July. The largest cold anomalies occur during strong southwesterly flow during mid-June. Extreme fresh anomalies are coincident with the deep expression of upper thermocline cold core feature S2 at the times it was mapped on the LDE array (2 large-scale surveys and 2 fine-scale surveys from 21 June to 4 July). Anomalously fresh water extends to 30-40 m depth.

ORIGIN OF MESOSCALE EDDIES USING AN ISOPYCNAL SALINITY/OXYGEN ANALYSIS

Scott McDowell
University of Rhode Island

Abstract:

Dissolved oxygen can be treated as a quasi-conservative tracer along potential density surfaces in the intermediate and deep waters of the North Atlantic. Hydrographic data collected during the IGY illustrate the variability of salinity and oxygen throughout the central ocean and adjacent seas. An isopycnal salinity/oxygen analysis was used to determine the origin of three anomalous eddies discovered during the POLYMODE experiment.

The core of the deepest feature had a negative salinity anomaly of $0.04°/_{oo}$ and a positive oxygen anomaly of 0.3 ml/l. This water can be formed by combining Labrador and Sargasso waters along $\sigma_\theta = 27.74$, which explains its large volume in the region to the northeast of Bermuda. The mid-thermocline lens, centered at 750 db, had a negative salinity anomaly of $0.09°/_{oo}$, as well as a negative oxygen anomaly of 0.6 ml/l. Water having similar characteristics at $\sigma_\theta = 27.06$ is found along 20°N in the low-oxygen tongue extending west from Africa. The third eddy had T/S characteristics identical to nearby stations but had an oxygen deficiency of 0.2 ml/l at $\sigma_\theta = 26.80$. Water having these properties is common in the region bounded by 20° to 30°N and 30° to 60°W.

WATER MASS ADVECTION BY MESOSCALE EDDIES

Colin Y. Shen
University of Washington

Abstract:

MODE density data are analyzed for evidence of water advection by mesoscale eddies. The salt anomaly on the potential density surface is used as the tracer for water mass. Correlation calculation shows that near 1500 dbar, the salt anomaly is negatively correlated ($\sim$-0.7) with the pressure fluctuation of the isopycnal surface and positively correlated ($\sim$0.5) with the density gradient across the isopycnal. Near the surface and in the thermocline, little salt

and pressure correlation is found. There is, however, some negative correlation between the salt and the density gradient in the thermocline.

The salt anomaly maps constructed by the objective analysis technique (Bretherton et al., 1976) are next examined at three depths, 150, 750, and 2000 dbar, and compared with the streamfunction maps (McWilliams, 1977) of the MODE mesoscale eddy field. Near the surface at 150 dbar, some evidences of westward movement of the salt anomaly with eddy field are found. In the thermocline at 750 dbar, both westward movement with the eddies and advection of the anomaly by eddy currents are observed. Below the thermocline near 2000 dbar, no appreciable movement of the anomaly and the eddy field is seen except for some advection of positive anomaly by a NE to SW jet across the MODE area.

The water advection by eddies is further examined using the potential vorticity maps made by McWilliams (1976). At 150 dbar, evidence of westward movement of water mass with eddies are again found. (The water mass is now identified by the closed potential vorticity contour lines.) At 750 dbar, the maps show the formation and the advection of closed potential vorticity contours by an anticyclonic eddy. At 2000 dbar, the maps show the formation and the advection of closed potential vorticity contours by the NE to SW jet.

A simple finite-amplitude Rossby wave model is discussed to show the relationship between the closed potential vorticity contour lines and the instantaneous streamlines of the wave and to point out the possibility of westward propagation of the closed potential vorticity region with the wave. Finally, a general criterion for the formation of the closed region is presented, i.e., the particle speed must equal the phase speed of the wave.

References

Bretherton, F.P., R.E. Davis and C.B. Fandry (1976) A technique for objective analysis and design of oceanographic experiments applied to MODE-73. Deep-Sea Res., *23*, 559-582.

McWilliams, J.C. (1976) Maps from the Mid-Ocean Dynamics Experiment: Part II. Potential vorticity and its conservation. J. Phys. Oceanogr., *6*, 828-846.

McWilliams, J.C. (1977) Atlas of the Mid-Ocean Dynamics Experiment (MODE-I). V. Lee and C. Wunsch, eds. MIT, Cambridge, 274 pp.

THEORETICAL & MODELING RESULTS

THEORETICAL ASPECTS OF ISOLATED EDDIES

James C. McWilliams
National Center for Atmospheric Research

Abstract:

A progress report is made on several theoretical calculations related to intense, isolated eddies: namely, numerical studies of the inviscid propagation (as a function of the numerical resolution), frictional decay, and resistance to perturbations for barotropic modons. This work has been done in collaboration with Drs. G. Flierl, V. Larichev, and G. Reznik.

REMARKS ON A COMPARISON OF LONG-TERM CURRENT METER MOORING DATA WITH EDDY-RESOLVING NUMERICAL MODELS

William R. Holland
National Center for Atmospheric Research

Abstract:

Schmitz and Holland are comparing data from the North Atlantic current meter moorings with numerical model results. Geographical distributions of deep eddy kinetic energy suggest that for basins scaled to North Atlantic dimensions, using observed wind-stress amplitude, the models reproduce quite well the amplitude and meridional structure

of the eddy energy levels. Some interesting questions regarding downstream (zonal) decay of eddy energy levels have arisen. It is also clear that the flat-bottom numerical experiments cannot deal with regions of rough topography. These results have suggested to us the next generation of numerical experimentation necessary to explore the role of eddies in the North Atlantic general circulation; this work is underway.

REGIONAL FORECAST MODELING

Allan Robinson
Harvard University

Abstract:

The quasigeostrophic dynamical open ocean model forecasts values interior to a region upon whose boundary normal flow and vorticity on the inflow are specified. The statistical model interpolates and extrapolates in space/time in terms of mixed space time correlation functions (objective analysis). Combined with real time observations, a "best estimate" of the physical fields now and in the future is obtained by combining three fields -- dynamical forecast, statistical forecast, and interpolated observations -- with weights determined by minimizing a pre-selected error norm. The barotropic model has been used for dynamical simulation studies (Robinson and Haidvogel, 1980, preprint) and is presently being used for statistical forecasting and optimal updating studies. The baroclinic model has been successfully implemented with open boundary conditions and is undergoing studies of computational error sources prior to baroclinic simulations. The Harvard model is being intercompared with a similar model developed at the Shirshov Institute of Oceanology. The model will be used for physical/dynamical interpretation and analysis of the composite POLYMODE data set including feasibility studies for practical forecasting.

Reference

Robinson, A.R. and D.B. Haidvogel (1980) Dynamical forecast experiments with a barotropic open ocean model. J. Phys. Oceanogr. (accepted).

FORM-DRAG INSTABILITIES

Glenn Flierl
Massachusetts Institute of Technology

Abstract:

Standing Rossby waves generated by flow over topography can be unstable in a manner similar to free traveling waves. However, the perturbations with the largest growth rate have an unusual form: one component corresponds to a zonal flow perturbation (very large scale) while the other components have the topographic length scale. This instability, which occurs when the mean flow is faster than the phase speed of a free wave with the topographic wavenumber, is caused by a change in mean flow inducing an altered wave state which generates a form drag that reinforces the change in the mean flow.

In a baroclinic flow with no motion at the bottom, wavy topography can cause instability at mean flow speeds which are subcritical for normal baroclinic instability. The energy is still derived from the available potential energy but the release is catalyzed by the topography.

EDDY HEAT FLUX PARAMETERIZATION IN HOMOGENEOUS QUASIGEOSTROPHIC TURBULENCE

Dale B. Haidvogel
Woods Hole Oceanographic Institution

Abstract:

Statistically steady states consistent with a horizontally uniform time-averaged temperature gradient in a two-layer quasigeostrophic model on a beta-plane are described. Based on the result that the flow statistics are nearly independent of the size of the doubly periodic domain, it is argued that this homogeneous flow is physically realizable. The eddy heat flux and eddy energy levels in these simulations are shown to depend strongly on two physical nondimensional parameters, representing the supercriticality of the flow and the strength of surface drag effect, and much less sensitivity on the computational details of the model. The parametric dependence of eddy heat flux in this system is noted to depart significantly from the parameterization schemes of Green and Stone.

DIRECT ATMOSPHERIC FORCING OF EDDIES

Peter Müller
Harvard University

Claude Frankignoul
Massachusetts Institute of Technology

Abstract:

To assess the role of direct stochastic wind forcing on generating mid-ocean mesoscale eddies, we calculate analytically the response of a simple ocean model to a realistic model windstress spectrum and compare the results with observations. The ocean model is a continuously stratified β-plane ocean of infinite horizontal extent and constant depth. All transfer and dissipation processes are parameterized by a linear scale-independent friction law (Rayleigh damping). The model predicts qualitatively the amplitudes and space and time scales of the observed eddy field on mid-ocean regions far removed from strong currents. Observed coherences and seasonal modulations provide direct evidence of forcing at high frequencies where motions have little energy. Evidence at the more energetic low frequencies will be difficult to establish because the expected coherences are small.

OTHER RESULTS

50°W MOORED ARRAY

Ross Hendry
Atlantic Oceanographic Laboratory
Bedford Institution of Oceanography

Abstract:

A preliminary look at ∿600 days of moored current meter data from 4000 m depth south of the Gulf Stream at 50°W (near 38°N latitude) shows eddy kinetic energies of ∿75 μg/gm and an eastward mean flow of ∿2 cm/sec, suggesting a two-fold decrease of eddy KE from results of Array II at 55°W and a zonal continuation of the deep pattern of mean flows observed in Array II. There are suggestions of variability on very long time scales (>6 months) with significant energy accompanying the faster eddy time scale variations.

MID-OCEANIC EDDY IN THE NORTHEASTERN ATLANTIC: LAGRANGIAN AND HYDROLOGICAL CHARACTERISTICS FROM OBSERVATIONS

Jean-Claude Gascard
Muséum National D'Histoire Naturelle, Paris

Abstract:

Two papers on the Tourbillon Experiment ["Tourbillon" means "eddy"; the Tourbillon Experiment is a part of the AFEX 79-80 (Anglo-French Experiment)] have recently been published in POLYMODE News No. 73. Alain Colin de Verdière wrote a cruise report, and Pierre Tillier wrote a description of the expendable mid-range SOFAR floats and shipborne receiver used with great success during the September-October 1979 cruise.

After several preliminary and exploratory cruises in the northeast Atlantic occurring in May with N/O Jean Charcot (Brest, CNEXO), June with N/O Cirolana (Lowestoft, MAFF; see report in POLYMODE News No. 74), and in August with N/O Maria Paolina (La Spezia, SACLANT), making use of XBTs/CTDs and surface drifters, the site (200 km square) was defined for the intensive experiment around 47°N-15°W.

Two surface drifters and ten subsurface SOFAR floats were launched in this area, approximately between the surface and 2650 m. Their drift was observed for 50 days. Simultaneously, a grid of 40 CTDs (0-4000 m) spaced 25 km apart over this area was repeated 4 times at ten-day intervals.

We can summarize these preliminary results as follows:

Hydrology

Within the upper 2500 m, water masses and mode waters characterizing this region were:

·two different water masses were separated by the main thermocline:

- upper layer (800 m thick) was made up of North Atlantic central waters which were a mixture of eastern (11°C) and western

(18°C) subtropical mode waters. The seasonal thermocline extended through this layer up to 100 m below the surface. The upper 30 to 40 m were well mixed (mixed layer);

- lower layer (1000 m thick) was made of upper North Atlantic deep water which was a mixture of Mediterranean and deep Labrador mode waters respectively characterized by a T/S maximum and a T/S minimum; and

·four different mode waters:

within the upper layer	--the northeast Atlantic central mode waters (11°C, 35.5°/$_{oo}$);
within the upper layer	--the subarctic mode water, also called by Wust the North Atlantic Intermediate water;
within the main thermocline (200 m thick)	--the Mediterranean mode water overflowing at Gibraltar straits;
within the lower layer	--the deep Labrador mode water formed in winter in the central Labrador Sea.

Lagrangian Motions

All the floats and buoys from surface down to 2650 m depth indicated an anticyclonic eddy. During the 50-day experiment the eddy drifted at about 2 cm/sec in a WNW direction. The trajectories were quite coherent with respect to layers:

·upper layer -- two surface drifters (drogued at 100 m depth) and surface float within the mixed layer and a deep float (865 m depth) drifted at 10-15 cm/sec along a quasicircular trajectory (80 km in diameter) in about four weeks;

·lower layer -- four floats between 900 and 1600 m drifted at 5 cm/sec along a quasicircular trajectory (60 km in diameter) in about six weeks.

One float at about 750 m depth was situated within the core of the eddy characterized by the mode water (10-11°C; 35.4-35.5°/$_{oo}$), a large quantity of which has been observed northward as reported by Dickson and Gurbutt (POLYMODE News No. 74). During the first three weeks this float drifted at 15 cm/sec along an anticyclonic curve (20 km in diameter) in about one week.

Within the main thermocline, Mediterranean mode water and subarctic water were situated at the eddy periphery. There was much mixing between these two mode waters associated with the eddy.

This eddy mixing process was predicted in this region by Stommel, Meincke and Zenk (POLYMODE News No. 22) from OWS Juliett observations. From historical data (Helland-Hansen, 1930; IGY 1957-58 Dietrich Atlas) up to more recent observations (Miloc 65; 1976-77 surface drifters, observations by Madelain Kerut; many XBT sections by English scientists; and the Tourbillon Experiment), we can also certify that such eddies frequently occur in the northeast Atlantic European Basin.

CONTRIBUTORS

Dr. Curtis Ebbesmeyer
Evans-Hamilton, Inc.
6306 21st Avenue NE
Seattle WA 98115
(206) 525-5268

Dr. Brady Elliott
Applied Physics Laboratory
University of Washington
1013 NE 40th Street
Seattle WA 98105
(206) 543-1365

Dr. Glenn Flierl
Building 54-1422
Massachusetts Institute of Technology
Cambridge MA 02139
(617) 253-4692

Dr. Claude Frankignoul
Building 54-1516
Massachusetts Institute of Technology
Cambridge MA 02139
(617) 253-2258

Dr. Jean-Claude Gascard
Laboratoire Oceanographie Physique
Museum National D'Histoire Naturelle
43 Rue Cuvier
75231 Paris Cedex 05 FRANCE

Dr. Dale B. Haidvogel
Woods Hole Oceanographic Institution
Woods Hole MA 02543
(617) 548-1400, ext. 2800

Mr. Robert Heinmiller
POLYMODE Executive Office
Building 54-1418
Massachusetts Institute of Technology
Cambridge MA 02139
(617) 253-7828

Dr. Ross Hendry
Bedford Institute of Oceanography
P. O. Box 1006
Dartmouth, Nova Scotia
B2Y 4A2 CANADA
(902) 426-3846, ext. 3142

Dr. William R. Holland
National Center for Atmospheric Research
P. O. Box 3000
Boulder CO 80307
(303) 494-5151, ext. 668

Dr. Kuh Kim
Graduate School of Oceanography
University of Rhode Island
Kingston RI 02881
(401) 792-6124

Dr. Eric J. Lindstrom
Department of Oceanography WB-10
University of Washington
Seattle WA 98195
(206) 543-7129

Mr. Scott E. McDowell
Graduate School of Oceanography
University of Rhode Island
Kingston RI 02881
(401) 792-6124

Dr. James C. McWilliams
National Center for Atmospheric Research
P. O. Box 3000
Boulder CO 80307
(303) 494-5151, ext. 696

Dr. Peter Müller
Pierce Hall
Harvard University
Cambridge MA 02138
(617) 495-4128

Dr. W. Brechner Owens
Woods Hole Oceanographic Institution
Woods Hole MA 02543
(617) 548-1400, ext. 2811

Dr. James F. Price
Woods Hole Oceanographic Institution
Woods Hole MA 02543
(617) 548-1400, ext. 2526

Dr. Lloyd Regier A-030
Scripps Institution of Oceanography
La Jolla CA 92093
(714) 452-4607

Dr. Allan R. Robinson
Pierce Hall
Harvard University
Cambridge MA 02138
(617) 495-2819

Dr. H. Thomas Rossby
Graduate School of Oceanography
University of Rhode Island
Kingston RI 02881
(401) 792-6124

Dr. Colin Shen
Department of Oceanography WB-10
University of Washington
Seattle WA 98195
(206) 543-7129

Dr. Bruce A. Taft
Department of Oceanography WB-10
University of Washington
Seattle WA 98195
(206) 543-7129