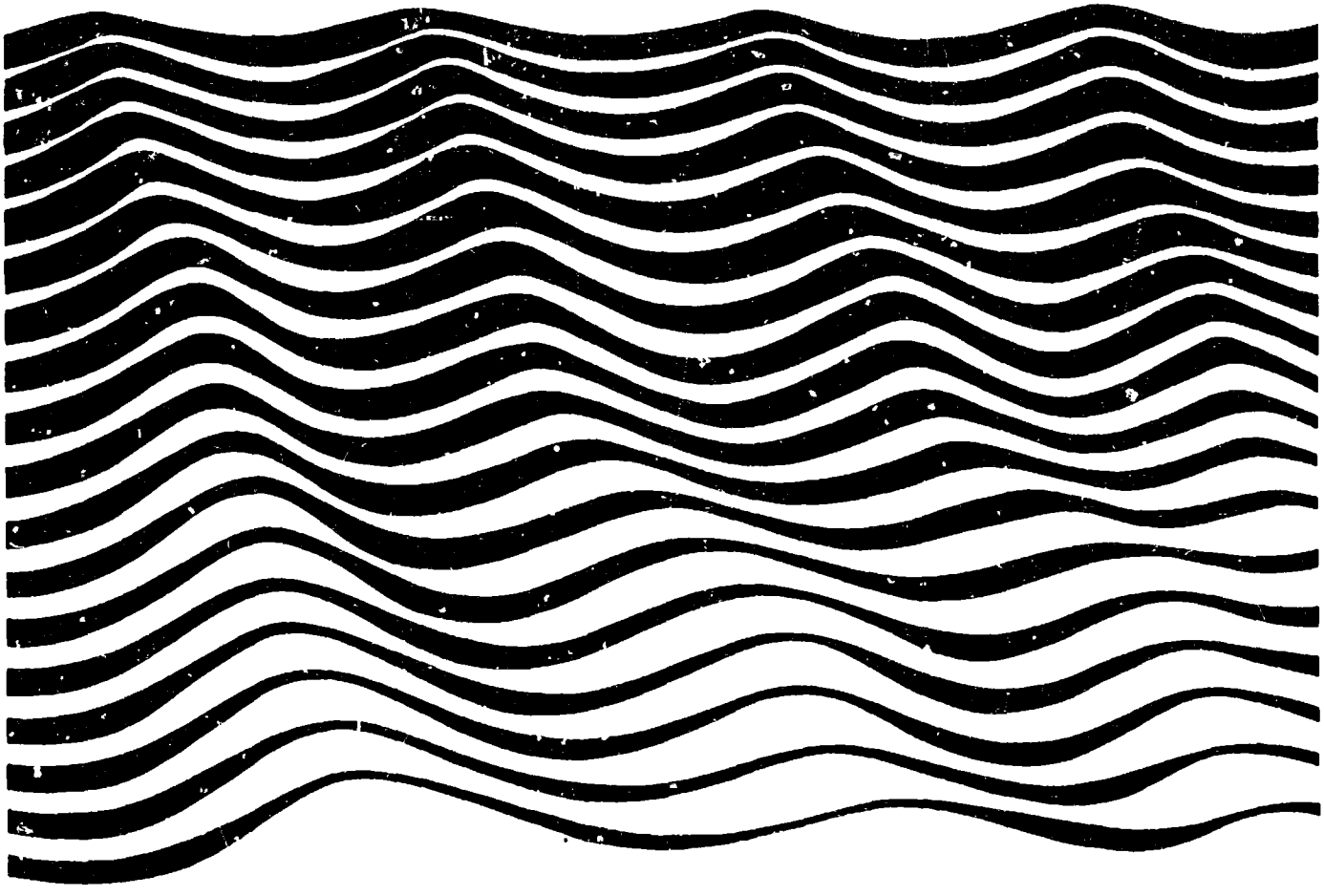
Unesco reports
in marine science 44

Physical oceanography of the Eastern Mediterranean (POEM): Initial Results

Unesco/IOC First POEM
Scientific Workshop,

Erdemli, Turkey,
16-20 June 1986



Unesco, 1987

UNESCO REPORTS IN MARINE SCIENCE

No.		Year
1	Marine ecosystem modelling in the Eastern Mediterranean Report of a Unesco workshop held in Alexandria, Egypt, December 1974 English only	1977
2	Marine ecosystem modelling in the Mediterranean Report of the Second Unesco Workshop on Marine Ecosystem Modelling English only	1977
4	Syllabus for training marine technicians Report of an IOC/Unesco workshop held in Miami, Florida, 22-26 May 1978 Available in English, French, Russian and Spanish	1979
5	Marine science syllabus for secondary schools Report of an IOC workshop held at United World College of the Atlantic, United Kingdom, 5-9 June 1978 Available in Arabic, English, French, Russian and Spanish	1979
6	Organization of marine biological reference collections in the Mediterranean Arab countries Expert meeting held in Tunis, 20-23 September 1978 Available in Arabic, English and French	1979
8	The mangrove ecosystem: Human uses and management implications Report of a Unesco regional seminar held in Dacca, Bangladesh, December 1978 English only	1979
9	The mangrove ecosystem: scientific aspects and human impact Report of the seminar organized by Unesco at Cali, Colombia, 27 November-1 December 1978 Available in English and Spanish	1979
10	Development of marine science and technology in Africa Working Group of Experts sponsored by ECA and Unesco, Addis Ababa, 5-9 May 1980 Available in English and French	1980
14	Marine science and technology in Africa: present state and future development Synthesis of Unesco/ECA survey missions to African coastal states, 1980 Available in English and French	1981
15	Fishery science teaching at the university level Report of a Unesco/FAO workshop on university curricula in fishery science, Paris, May 1980 Available in Arabic, English, French, Russian and Spanish	1981
16	Marine and coastal processes in the Pacific: ecological aspects of coastal zone management Report of a Unesco seminar held at Motupore Island Research Centre, University of Papua New Guinea, 14-17 July 1980 English only	1981
18	Coral reef management in Asia and the Pacific: some research and training priorities Report of a Unesco workshop held in Manila, Philippines 21-22 May 1981 English only	1982
19	Mareas rojas en el Plancton del Pacífico Oriental Informe del Segundo Taller del Programa de Plancton del Pacífico Oriental, Instituto del Mar, Callao, Perú 19-20 de noviembre de 1981 Spanish only	1982
20	Quantitative analysis and simulation of Mediterranean coastal ecosystems: The Gulf of Naples, a case study Report of a workshop on ecosystem modelling Ischia, Naples, Italy, 28 March to 10 April 1981 Organized by the United Nations, Educational, Scientific and Cultural Organization (Unesco) and the Stazione Zoologica, Naples English only	1983
21	Comparing coral reef survey methods A regional Unesco/UNEP workshop, Phuket Marine Biological Centre, Thailand, December 1982 English only	1983
22	Guidelines for marine biological reference collections Prepared in response to a recommendation by a meeting of experts from the Mediterranean Arab countries Available in English, French and Arabic	1983
23	Coral reefs, seagrass beds and mangroves: their interaction in the coastal zones of the Caribbean Report of a workshop held at West Indies Laboratory, St. Croix, U.S. Virgin Islands, May, 1982 English only	1983
24	Coastal ecosystems of Latin America and the Caribbean The objectives, priorities and activities of Unesco's COMAR project for the Latin America and Caribbean region Caracas, Venezuela, 15-19 November 1982 Available in English and Spanish	1983
25	Ocean engineering teaching at the university level Recommended guidelines from the Unesco/IOC/ECOR workshop on advanced university curricula in ocean engineering and related fields, Paris, October 1982 Available in English, French, Spanish, Russian, Arabic and Chinese	1983
26	Global survey and analysis of post-graduate curricula in ocean engineering English only	1984
27	Productivity and processes in island marine ecosystems. Recommendations and scientific papers from the Unesco/IOC sessions on marine science co-operation in the Pacific, at the XVth Pacific Science Congress, Dunedin, New Zealand, February 1983 English only	1984
28	Oceanographic modelling of the Kuwait Action Plan (KAP) Region. Report of simposium/workshop; University of Petroleum and Minerals, Dhahran, Kingdom of Saudi Arabia 15-18 October 1983 English only	1984
29	Eutrophication in coastal marine areas and lagoons: a case study of 'Lac de Tunis' Report prepared by Dr M. Kelly and Dr M. Naguib English only	1984
30	Physical oceanography of the Eastern Mediterranean: an overview and research plan Report of a workshop held in Lerici, La Spezia (Italy), September 1983 English only	1984
31	MABAHISS/John Murray 50th anniversary: Marine science of the North West Indian Ocean and adjacent waters Report of a symposium on the occasion of the 50th anniversary of the MABAHISS/John Murray Expedition (1933/34), University of Alexandria, Egypt, 3 to 7 September 1983 English only	1985
32	L'estuaire et la mangrove du Sine Saloum Résultats d'un Atelier régional Unesco-COMAR tenu à Dakar (Sénégal) du 28 février au 5 mars 1983 French only	1985
33	Coral taxonomy Results and recommendations of a regional Unesco (COMAR)/UNEP Workshop with advanced training Phuket Marine Biological Centre Thailand, 10-26 February 1984 English only	1985
34	Bibliography on costal lagoons and salt marshes along the Southern Mediterranean coast (Algeria, Egypt, Libya, Morocco, Tunisia) Available in Arabic, English and French	1985
35	Physical oceanography of the Eastern Mediterranean (POEM): A Research Programme. Reports of the Organizing Committee Meeting, Paris, August 1984, and the Scientific Workshop, Lucerne, October 1984 English only	1985
36	Méthodologie d'étude des lagunes côtières. Résultats d'un atelier régional réuni à Abidjan du 6 au 11 mai 1985 French only	1986
37	Principles of Geological Mapping of Marine Sediments (with special reference to the African continental margin) Available in English and Russian	1986
38	Marine Sciences in CMEA countries Programme and results of co-operation Available in English and Russian	1986
39	Development of marine sciences in Arab Universities Meeting of Experts held at the Marine Science Station Aqaba, Jordan 1-5 December 1985 Available in Arabic, English, French	1986

Cont'd on inside of back cover

Unesco reports
in marine science 44

Physical oceanography of the Eastern Mediterranean (POEM): Initial Results

Unesco/IOC First POEM
Scientific Workshop,
Institute of Marine Sciences,
Middle East Technical University,

Erdemli, Turkey,
16-20 June 1986

Unesco, 1987

ISSN 0253-0112

Published in 1987
by the United Nations Educational,
Scientific and Cultural Organization,
7, place de Fontenoy, 75700 Paris.
Printed in Unesco's workshops.

PREFACE

Unesco Reports in Marine Science are designed to serve specific programme needs and to report on developments in projects conducted by the Unesco Division of Marine Sciences, including those involving collaboration between the Division and the Intergovernmental Oceanographic Commission.

Designed to serve as a complement to the Unesco Technical Papers in Marine Science, the Reports are distributed automatically to various institutions and governmental authorities. Individuals may, at their request, receive copies of specific titles, but cannot be included on the automatic distribution list. Both the Reports and the Technical Papers series are free of charge.

Requests for copies of specific titles or for additions of institutions or authorities to the mailing list should be addressed, on letterhead stationery if possible, to:

Marine Information Centre
Division of Marine Sciences
Unesco
Place de Fontenoy
75700 Paris
France

ABSTRACT

This report presents the results of the First Scientific Workshop of P.O.E.M. (Physical Oceanography of the Eastern Mediterranean) held in Erdemli, Turkey, 16-20 June 1986. It summarizes the present status and knowledge of the water masses and hydrography; general circulation; mesoscale processes and dynamics; air-sea interface fluxes in the Eastern Mediterranean. It reviews the relevant POEM work in progress and the POEM results to date, and outlines future POEM work and plans. Two POEM general surveys of the Eastern Mediterranean have been carried out insofar, POEM-0-85 in October-November 1985 and POEM-1-86 in March-April 1986. Further general surveys are planned for November 1986 (POEM-2-86); March-April 1987 (POEM-3-87); August-September 1987 (POEM-4-87), the latter one to be coordinated with the METEOR expedition devoted primarily to measurements of transient tracers. The data set obtained with the sequence of these surveys will provide the first complete phenomenology of the Eastern Mediterranean and of its inter-annual as well as seasonal variability. Further POEM work focusses on the modelling component, which involves an extensive study of both the general circulation on the basin scale and of the mesoscale processes and related eddy field.

RESUME ANALYTIQUE

Ce rapport présente les résultats de la première réunion de travail scientifique sur l'océanographie physique de la Méditerranée orientale (POEM), qui a eu lieu à Erdemli (Turquie) du 16 au 20 juin 1986. Il récapitule l'état actuel des connaissances en ce qui concerne les masses hydriques et l'hydrographie, la circulation générale, la dynamique et les processus à moyenne échelle ainsi que les flux à l'interface air-mer en Méditerranée orientale. On y passe en revue les activités en cours dans ce domaine et les résultats obtenus jusqu'à présent dans le cadre de ces recherches, et on y expose les grandes lignes des activités ultérieures et les plans en matière de POEM. Deux études générales portant sur la Méditerranée orientale ont été menées jusqu'à présent, POEM-0-85 en octobre-novembre 1985 et POEM-1-86 en mars-avril 1986. D'autres études de caractère général sont prévues pour novembre 1986 (POEM-2-86), mars-avril 1987 (POEM-3-87) et août-septembre 1987 (POEM-4-87), cette dernière étude devant être conduite en liaison avec l'expédition METEOR, consacrée principalement aux mesures des traceurs transitoires. L'ensemble de données obtenu grâce à cette série d'études constituera le premier inventaire complet des phénomènes propres à la Méditerranée orientale ainsi que de leur variabilité interannuelle et saisonnière. D'autres recherches de POEM sont axées sur l'élément modélisation, qui comprend une étude approfondie à la fois de la circulation générale à l'échelle du bassin, et des processus à moyenne échelle ainsi que du champ tourbillonnaire connexe.

RESUMEN

En el presente informe figuran los resultados de la Primera Reunión de Trabajo Científica sobre POEM (Oceanografía Física del Mediterráneo Oriental) que tuvo lugar en Erdemli, Turquía, del 16 al 20 de junio de 1986. Se resumen el estado actual y los conocimientos de las masas de agua y la hidrografía; la circulación general; los procesos en escala media y la dinámica; y los flujos de interfaz aire-mar en el Mediterráneo Oriental. Se analizan los trabajos en curso sobre POEM y los resultados obtenidos hasta la fecha en esta materia, y se describen los trabajos y planes futuros con relación a POEM. Hasta ahora se han llevado a cabo dos estudios generales POEM sobre el Mediterráneo Oriental, el POEM-0-85 en octubre-noviembre de 1985 y el POEM-1-86 en marzo-abril de 1986. Existen planes para realizar otros estudios generales en noviembre de 1986 (POEM-2-86); marzo-abril de 1987 (POEM-3-87), y agosto-septiembre de 1987 (POEM-4-87), este último en coordinación con la expedición METEOR que se dedicará principalmente a mediciones de trazadores transitorios. El conjunto de datos que se obtenga con esta serie de estudios proporcionará la primera fenomenología completa del Mediterráneo Oriental y de su variabilidad interanual y estacional. Otros trabajos sobre POEM se centran en el componente de modelación, que entraña un estudio extenso sobre la circulación general en la escala de la cuenca y sobre los procesos en escala media y campo turbulento relacionado.

РЕЗЮМЕ

В настоящем докладе приводятся результаты первого научного семинара ПОЭМ (Физическая океанография восточной части Средиземного моря), проходившего в Эрдемли, Турция, 16-20 июня 1986 г. В докладе обобщается текущее состояние и имеющиеся данные по водным массам и гидрографии; общей циркуляции; мезомасштабным процессам и динамике; поверхностным течениям в восточной части Средиземного моря; в докладе дается обзор соответствующей работы ПОЭМ, находящейся в стадии осуществления, и результатов ПОЭМ, полученных к настоящему времени, а также определяются предстоящие мероприятия и планы ПОЭМ. На сегодняшний день подготовлено два общих обзора ПОЭМ по восточной части Средиземного моря: ПОЭМ-0-85 в октябре-ноябре 1985 г. и ПОЭМ-1-86 в марте-апреле 1986 года. Новые общие обзоры планируется провести в ноябре 1986 года (ПОЭМ-2-86); в марте-апреле 1987 г. (ПОЭМ-3-87); в августе-сентябре 1987 г. (ПОЭМ-4-87), причем последний из них будет проведен в координации с экспедицией научно-исследовательского судна "Метеор", которая прежде всего будет посвящена измерениям переносимых индикаторов. Наборы данных, полученные в результате серии таких обзоров, позволят впервые получить полное представление о явлениях в восточной части Средиземного моря, а также о его годичных и сезонных изменениях. Дальнейшая работа в рамках ПОЭМ будет сосредоточена на мероприятиях по моделированию, которые предусматривают проведение глубокого исследования как общей циркуляции в масштабах всего бассейна, так и мезомасштабных процессов и соответствующего вихревого поля.

خلاصة

يعرض هذا التقرير نتائج حلقة العمل العلمية الأولى عن الأوقيانوغرافيا الفيزيائية لشرق البحر المتوسط (بويم - P.O.E.M.) التى عقدت فى اردملى بتركيا من ١٦ الى ٢٠ يونيو / حزيران ١٩٨٦ . ويلخص الوضع الحالى والمعرفة الحالية للكتل المائية والهيدروغرافيا ، ودوران المياه العام ، والعمليات والديناميات متوسطة النطاق ، والتدفقات الناجمة عن التفاعل بين الجو والبحر شرق البحر المتوسط . ويستعرض نشاط بويم الجارى والنتائج التى توصلت اليها بويم حتى الآن ، كما يرسم الخطوط العريضة لنشاط بويم وخططها فى المستقبل . وحتى الآن أجرت بويم عمليتى مسح عام لشرق البحر المتوسط ، بويم - ٠ - ٨٥ فى أكتوبر / تشرين الأول ونوفمبر / تشرين الثانى ١٩٨٥ ، وبويم - ١ - ٨٦ فى مارس / آذار - أبريل / نيسان ١٩٨٦ . ومن المتوقع اجراء عمليات مسح عام أخرى فى نوفمبر / تشرين الثانى ١٩٨٦ (بويم - ٢ - ٨٦) ، وفى مارس / آذار - أبريل / نيسان ١٩٨٧ (بويم - ٣ - ٨٧) . وفى أغسطس / آب - سبتمبر / أيلول ١٩٨٧ (بويم - ٤ - ٨٧) ، على أن تتسق العملية الأخيرة مع بعثة ميتيور المخصصة أساسا لقياس العناصر الاستشفافية السريعة الزوال . وستتيح مجموعة البيانات المستخلصة من تقاطع عمليات المسح هذه تحديد أول وصف علمى للظاهرات فى شرق البحر المتوسط وتحديد تغيراته السنوية والموسمية على حد سواء . ويركز نشاط آخر لبويم على العنصر النموذجى الذى يشمل دراسة ضافية لدوران المياه العام فى نطاق الحوض وللعمليات متوسطة النطاق ولمجال الدوامات ذات الصلة بالمنطقة .

摘　　要

本报告介绍了１９８６年6月１６至２０日在土耳其埃尔代姆利举办的东地中海物理海洋现象（P.O.E.M）第一期科学研究会的成果。它对东地中海的水团和水文现象，大环境，中间级变化过程和动态以及大气海洋分界面流动等的现状和对它们的了解作了概括的叙述。它评述了在东地中海物理海洋现象正在进行的有关工作和至今所取得的成果，并规划了东地中海物理海洋现象今后的工作和方案。迄今为止，已对东地中海水域进行了两次东地中海物理海洋现象综合考察，即１９８５年１０—１１月的POEM－０－85和1986年3－4月的POEM－１－８６。进一步的综合考察分别订于1986年11月（POEM－２－８６）；１９８７年３—４月（POEM－３－８７）和１９８７年８－９月（POEM－４－８７）进行，最后一项综合考察将与以瞬时描绘器测量为主要目的的METEOR考察协同进行。从这一系列考察获取的一整套数据，将对东地中海及其各年间和各季节的差异的综合现象第一次做出完整的描述。有关东地中海物理海洋现象的进一步工作，将着重于模拟分潮方面，这涉及到一项不仅有关海盆级大环流而且有关中间级变化过程及与其相关的涡流水域的广泛研究。

TABLE OF CONTENTS

FOREWORD

The Erdemli Workshop, the first major scientific meeting after the commencement of POEM, gathered together scientists from Egypt, Greece, Israel, Italy, Lebanon, Tunisia, Turkey, the United States, and Yugoslavia. It was planned and conducted as a working scientific meeting reviewing substantial ideas, analyzing data and planning research. The participants recognized the importance of the scientific opportunity and the results of their work are summarized in the present report and its companion volumes.* On behalf of P.O.E.M. scientists, we express gratitude to Dr. Dale Krause and Dr. Selim Morcos of Unesco Division of Marine Sciences, Dr. Mario Ruivo and Dr. Makram Gerges of the Intergovernmental Oceanographic Commission (IOC) of Unesco for their help and support in making this workshop possible. We thank the U.S. National Science Foundation for the support of the U.S. participants. It is a very special pleasure to thank Prof. M. Gonlubol, President of the Middle East Technical UIniversity (METU) and Prof. U. Unluata, Director of the Institute of Marine Sciences of METU for the excellent organization that facilitated our scientific accomplishments and for most comfortable accommodations.

Co-chairpersons of POEM Steering Committee

A.R. Robinson

P. Malanotte-Rizzoli

*Two volumes will be published at Harvard: "Proceedings of a UNESCO/IOC Workshop on Physical Oceanography of the Eastern Mediterranean, first P.O.E.M. Workshop, Middle East Technical University, Institute of Marine Sciences, Erdemli, Turkey.
Part I. Phenomenology and Dynamics of the Circulation of Eastern Mediterranean.
Part II. Climatology of the Eastern Mediterranean, the wind field, water masses and general circulation."
These two volumes will include the complete text of the invited lectures and contributed papers.

1. INTRODUCTION

The POEM research program was developed in the period 1982-1984 via a general scientific discussion meeting (Cannes), a major focussed scientific workshop (Lerici), an Organizing Committee Meeting (Paris) and a scientific discussion meeting (Lucerne), at which the international scientific community interested in Mediterranean research and problems unanimously endorsed the scientific basis of POEM and encouraged its implementation. (The Cannes and Lerici Reports appear as Unesco Reports in Marine Science #30 and Paris and Lucerne appear in Unesco Report in Marine Science #35). In early 1985 POEM received strong statements of endorsement and support from both the Unesco Division of Marine Sciences and the Intergovernmental Oceanographic Commission facilitating effective scientific collaboration and the interfacing of POEM with national needs and international agencies. A Steering Committee was established and POEM is now in the active phase. The first general surveys of the Eastern Mediterranean were successfully carried out in October-November 1985 (POEM-ϕ-85) and March-April 1986 (POEM-1-86). The accomplishments of a coordinated, intercalibrated, quality data set with adequate sampling over most of the Eastern Mediterranean Basin will constitute a substantial contribution to ocean science and serve as a definitive step forward for POEM.

The Erdemli Workshop is the first major scientific meeting after the commencement of the POEM scientific program. The general goals of POEM are:

1) To achieve a definitive, shared and intercalibrated set of physical data.

2) To construct a relevant, valid and verified physical model - a shared community model of the general circulation and its variability.

The model will be applicable to biological, chemical and environmental and climate studies.

The objectives of the POEM Workshop held in Erdemli, Turkey, June 16-20, 1986, under the sponsorship of UNESCO and IOC are the following:

Objectives of the Workshop:

(a) Review, overview and critically synthesize knowledge of the Eastern Mediterranean and produce a useful review volume.

(b) Scientifically and technically analyze POEM results of data and POEM overall scientific plans.

(c) Detailed planning of specifics of POEM for the next year.

(d) Establish scientific communications and active cooperation on individual and group basis.

2. OPENING

The meeting was opened by three introductory addresses:

- President M. Gonlubol welcomed the participants on behalf of the Middle East Technical University and wished the workshop and POEM every success.

- Dr. S. Morcos representing UNESCO and IOC explained the general Mediterranean programs of these organizations, the history of POEM and the role of UNESCO and IOC in its support.

- Prof. A.R. Robinson placed POEM science and the workshop in a general oceanographic context and expressed thanks to the authorities on behalf of the participating scientists for this unique opportunity to advance Eastern Mediterranean Science.

The full text of the opening addresses appears as Appendix II.

3. ARRANGEMENTS OF THE MEETING

Prof. A.R. Robinson was elected Chairman of the Workshop.

Profs. U. Unluata and P. Malanotte-Rizzoli were elected vice-chairpersons.

Prof. P. Malanotte-Rizzoli was also appointed Rapporteur of the workshop.

Dr. S. Morcos acted as representative of UNESCO and IOC.

Dr. M. Gerges acted as Technical Secretary.

The overall agenda and the detailed program and timetable of the Workshop appear as Appendices I and III.

4. SCIENTIFIC CONDUCT OF THE MEETING

The workshop opened with in-depth reviews of four topics that had been commissioned prior to the workshop which appear in the companion volumes I and II of the Workshop Proceedings, which are in the process of being published by Harvard University.

These papers were discussed following their presentation:

- Water Masses and Hydrography — Dr. A. Hecht
- Air-Sea Interface Fluxes — Dr. N. Pinardi
- General Circulation — Prof. P. Malanotte-Rizzoli
- Mesoscale Processes and Dynamics — Prof. A.R. Robinson

The next phase consisted of 29 contributed scientific papers. These rich sources of Mediterranean knowledge are summarized by the abstracts and some extended papers. A major accomplishment of the workshop occurred during the working group meetings which occupied two entire days (Appendix III). The three working groups were:

(a) Water Masses and Hydrography

(b) General Circulation

(c) Internal Dynamical Processes, Models and Experiments.

An additional special Methodology Session was held which stimulated special questions and answers on many levels (Appendix IV). The working group composition appears as Appendix V. Coordination was maintained by short intermittent plenary sessions. The list of participants appears as Appendix VI. The abstracts of scientific presentations appear as Appendix VII and the full text of some of the extended papers appear in the Proceedings volume no. II.

5. WORKING GROUP REPORT AND SPECIFIC RECOMMENDATIONS

5.1 WORKING GROUP A "WATER MASSES AND HYDROGRAPHY"

A. Hecht and A. Michelato

1. The working group has prepared a minimum bibliography required for summarizing the present data knowledge on the phenomenological aspect of the Eastern Mediterranean Sea. This bibliography follows the working group recommendations.
2. The working group reviewed the phenomenological description of the Eastern Mediterranean Sea and reached the conclusion that the knowledge concerning the distribution, variability and budget of water masses leaves much to be desired. We feel that in the two previous POEM extensive cruises there is already information to redress the situation and future POEM extensive cruises will augment this data base. However during future extensive cruises the capability of additional tracers should be explored and in particular transient radioactive nucleides appear to be a desirable tool.
3. Additional information which seems to be lacking consists of the balance between wind driven and thermohaline circulations.
4. The working group made a series of detailed recommendations regarding the common utilization of the data acquired during the POEM cruises (see paragraph below).
5. Lack of data along the southernmost Levantine, and the Central and South Ionian Sea.

Common utilization of acquired data.

The use of data acquired during POEM can be enhanced by:

(a) Bilateral agreements between countries that acquire data of common interest. This can be accomplished directly between the interested parties.

(b) Access to data for a scientist who does not possess data to be shared.

(i) As a training opportunity

(ii) For cooperative work

This will require a statement from institutions willing to accept visitors stating the type of visitors they are willing to accept; it will require the visitors application to the institute and the final approval of the institute. We recommend that most institutes issue a statement specifying the conditions under which they are willing to accept visitors.

(c) The utilization of the entire data base by the entire community starts with an extremely well prepared and detailed workshop:

(i) Identification of the institution which will host such a workshop

(ii) Test runs of data transfer

(iii) Determination of topics for analysis

(iv) Determination of necessary programs

(v) Determination of necessary facilities

(vi) Test runs of local and imported programs

BIBLIOGRAPHY: WORKING GROUP A

Theocharis, A. (1983) Deep water formation and circulation in the Aegean Sea. Unpublished manuscript, presented in NATO-ASI, Lerici, Italy.

Miller, A.R. (1972) Deep convection in the Aegean Sea. In: La formation des eaux oceaniques profandes. Paris. Colloques Interactionaux du CNRS no. 215, pp. 155-163.

Carter, D.B. (1956) The water balance of the Mediterranean and Black Seas. Publication in climatology. Jersey, Drexd, Institute of Technology Laboratory of Climatology, Centertown, New Jersey, pp. 123-175.

Bunker, A.F., Charnock, H., and Goldsmith, R.A. (1982) A note on the heat balance of the Mediterranean and the Red Sea. J. Mar. Res. 40 (supp.) 73:84.

Ovchinnikov, I.M. (1966) Circulation in the surface and intermediate layers of the Mediterranean. Oceanology, 6, 48-58.

Ovchinnikov, I.M., and Plakhin, Ye. A. (1984). Formation of deep water masses in the Mediterranean Sea. Oceanology, 5, 40-47.

Hopkins, T.S. (1978) Physical processes in the Mediterranean basins. In: Estuarine transport processes, Bjorn Kjerfve (ed). The Bell and Baruch Library in Marine Science, n. 7, pp. 269-310.

Lacombe, H., and Tchernia, P. (1973) Hydrography of the Mediterranean. In: Consultation on the protection of living resources and fisheries from pollution in the Mediterranean. Rome, 19-23 Feb. 1974, 12 p..

Morcos, S.A. (1972) Sources of Mediterranean intermediate water in the Levantine Sea. In: Studies in Physical Oceanography, A Tribute to Georg Wust on his 80th birthday, A.L. Gordon (ed.). Gordon and Brooch, 2, 232 pp.

Buljan, M, and Zore-Armanda, M. (1976) Oceanographic properties of the Adriatic Sea. In: Oceanogr. Mar. Biol. Ann. Rev., Harold Barnes (ed). 14, Aberdeen University Press, pp. 11-98.

Franco, P., Jeftic, L., Malanotte Rizzoli, P., Michelato, A., and Orlic, M. (1982) Descriptive model of the Northern Adriatic. Oceanologica Acta, 5(3): 379-389.

Hendershott, M.C., and Rizzoli, P. (1976). The winter circulation of the Adriatic Sea. Deep Sea Res., 23: 353-370.

Zore Armanda, M. (1963) Le masses d'eau de la mer Adriatique. Acta Adriatica, 10(3): 5-89.

Zore Armanda, M. (1969) Water exchanges betweeen the Adriatic and the Eastern Mediterranean. Deep Sea Res., 16: 71-178.

Garzoli, S, and Maillard, G. (1979) Winter circulation in the Sicily and the Sardinia straits region. Deep Sea Res., 26A: 933-954.

SACLANTCEN Conference proceedings on the straits of Sicily 1972. Sicily straits.

Lascaratos, A. (1983) Hydrology of the Aegean Sea. Unpublished manuscript, presented in NATO-ASI, Lerici, Italy.

Pollack, M.S. (1951) The sources of the deep water of the Eastern Mediterranean Sea. J. Mar. Res., 10: 128-152.

Bethoux, J.P. (1979) Budgets of the Mediterranean Sea. Their dependence on the local climate and on the characteristics of the Atlantic waters. Oceanol. Acta, 2, 2, 157-163.

Bethoux, J.P. (1980) Mean water fluxes across sections in the Mediterranean Sea evaluated on the basis of water and salt budgets and observed salinities. Oceanol. Acta, 3, 1, 79-88.

Cortecci, G., Noto, P., and Tonarelli, B. (1979) Tritium and oxygen profiler in the Eastern Mediterranean. Tellus, 31, 179-183.

5.2 WORKING GROUP B: GENERAL CIRCULATION MODELLING:

Paola Malanotte-Rizzoli, Chairperson

5.2.1 Outline

1. Priority scientific problems

   Specific scientific questions of priority that should be addressed by general circulation modelling and data analysis. A consensus on priority questions is needed.

2. Review of past work and relevant bibliography
3. Modelling carried out to date and underway
   a. Appropriate types of models
   b. How these should address the questions posed in (1.)
4. Short term and intermediate successive steps in modelling required to thoroughly address the questions in (1.). Feedback to (3.a.), (3.b.).
5. Relationship of circulation modelling to
   a. The use of the data of POEM-0-85 and POEM-1-86.
   b. Problems of initialization, dynamical interpolation, and updating (including inverse methods, etc.)
6. a. Recommendations derived from the model requirements for the future general surveys of POEM
   b. Parameterization and tuning of models and consistency checks of dynamical assumptions on the basis of available POEM data
7. Recommendations for future work and hierarchy of models to be used in conjunction

Definition of general circulation for Eastern Mediterranean modelling

Considering that:

(a) Even in a basin of limited size like the Eastern Mediterranean it will be very difficult to obtain synoptic data with meso-scale resolution basin-wide and that we shall have to use information collected over many eddy turn-over times,

(b) That the general circulation will reflect the forcing trends (atmospheric forcing, strait flows, etc.) much more than the meso-scale eddy field

The following working definition is adopted:

The general circulation is a circulation pattern not resolving the mesoscale but resolving the variability of the external forcing, that is at least the seasonal variability in time and a spatial variability of the size of local sub-basin gyres

Time Scale	of relevance	at about 1 month
Space Scale		at about 1° latitude x 1° longitude

Priority scientific problems: detailed discussion

(a) Intercomparison of the main forcing mechanisms:

- wind forcing
- thermohaline forcing
- source/sink flow through straits
- (tidal forcing)

(b) Role played by topography, irregular coastlines, major islands

(c) Identification of the basic time and space scales for the variability of the general circulation (the ω-k spectrum)

(d) On the basis of (c.), construction of the mean and eddy fields both from the POEM (and historical, if any) data and from numerical experiments. Related energy and vorticity analysis.

(e) Data analysis of general POEM surveys as well as available historical data sets and satellite imagery

Intercomparison of:

- core method analysis
- isopycnal analysis
- geostrophic computations
- objective analysis for general circulation

Comparison of the above methods with analyzed satellite images and inverse theory results, both for POEM surveys as well as available historical data.

(f) Estimates of atmospheric variability and atmospheric and oceanic budgets in box models from POEM general surveys and related general meteorological fields

(g) Relationship between the observed property distribution (T,S,O_2 tracers) and the actual circulation patterns obtained both by data analysis and numerical simulations. Estimates of residence times of different water masses.

(h) Methodology of approach to numerical modelling

(i) Use of different type of models in a

- hierarchy mode

(from the simplest to the most sophisticated)

- coupling mode

(diagnostic models for deep layers coupled with multi-layer General Circulation Models (GCM); embedding of local eddy resolving models into GCM: coupling of surface mixed layer models with GCM, etc.)

(ii) Design of simple benchmark experiments with only one or few driving mechanisms/internal discontinuities to first understand, rather than predict, internal dynamical processes.

Intercomparison of the different available models on the benchmark experiments.

(iii) Parameterization of important phenomena for the modelling of the Eastern Mediterranean

- deep convection
- vertical mixing
- meso-scale processes for coarse resolution GCM

(iv) Initialization of, and assimilation into, the available GCM of POEM general survey data.

Use of the GCM as dynamical interpolator in regions of missing data and for survey planning and design

(v) Use of inverse methods:

- comparison of inverses with GCM results
- use of the inverse fields as data for initialization of dynamical models
- parameter tuning of the GCM on the basis of inverse theory results
- test of the validity of assumed model dynamics through inverse theory

(vi) Modelling of convection processes with steady diffusive models and/or convection-diffusion models.

Analytical and numerical modelling

(vii) Study of property distributions along isopycnal surfaces and/or in different vertical layers with diffusion and/or advection/diffusion models.

Analytical and numerical modelling

5.2.2 General Recommendations of Working Group B

1. It is essential that the data of POEM general surveys form a composite, shared data set to be analyzed as a whole jointly by the scientists of each country, after completion of the analysis of the local data belonging to each country. A possible approach to achieve this indispensable goal, should be the organization of a workshop with specific objectives:
   (a) Each institute should take to the workshop all the local data sets available at the time of the workshop, already analyzed by the institute's own scientists.
   (b) The local data sets would be combined into one set for the entire Eastern Mediterranean and reanalyzed during the workshop using the technique and methodologies recommended by each working group.
2. The responsibility of the air-sea interaction effort during POEM and related scientific problems should be assigned to Dr. Navarra and Dr. Latif who will work in close collaboration.

5.2.3 Specific Recommendations for Modelling

The short and intermediate scale planning for modelling bears upon the use of the models already available and already being used for Eastern Mediterranean circulation modelling.

A specific plan for short and intermediate mesoscale has been designed during the workshop and proposed for each model suitable for the general circulation. A set of single benchmark experiments has been discussed during the workshop for intercomparison of the diagnostic reduced gravity, multilevel model and two active layers with active thermodynamics and inverse theory to be carried out and the results to be shared by the end of 1987. However, the long-term goal of POEM must be born in mind i.e. providing a GCM to the POEM community capable of realistically simulating the 3-dimensional circulation

pattern and property distribution of the entire Eastern Mediterranean without and with mesoscale resolution. This model will be necessary for the use of the biological community as well as for monitoring of pollution and waste disposals and problems in coastal areas. To achieve this goal it is recommended that the apprenticeship to the use of the Primitive Equation General Circulation Model (PEGCM) starts now. In fact the experience accumulated in the past shows that it will take a considerable amount of time to fully learn how to use the PEGCM for efficient simulations and we need to be ready for this purpose by the end of the POEM field plan.

5.2.4 Recommendations of the General Circulation Modelling Group for the next POEM General Surveys

1. Adriatic network should be carried out only by Yugoslavians and R/V Lo Bianco.
2. The Italian research vessel should focus on the Ionian Sea carrying out a network of stations with GC resolution on the Ionian Sea waters allowed by international rules. (Aegean is less crucial if we have the measurements in the Straits.)
3. Current meter measurements throughout POEM general surveys should be carried out in the Straits using NOAA current meters to be distributed by IOC (Sicily-Otranto-Greek Straits).
4. One anchored buoy to be positioned in central location of presumed intermediate water formation during the next surveys.

5. Inquire into the possibility of having

(a) a total of 10-12 drifting buoys to be deployed by the research vessels of each country in strategic positions to be closer during the general surveys. Price of one, $20,000. It is recommended that IOC provide technical advice and backstopping. The ARGOS system, upon payment from each country, could provide the system for buoy tracking.

(b) Inquire at a national level on the possibility of using national ferries as ships of opportunity for XBT's provided by each country.

5.3 WORKING GROUP C: INTERNAL DYNAMICAL PROCESSES, MODELS AND EXPERIMENTS:

Allan Robinson and Unit Unluata, Co-chairpersons
Nadia Pinardi and Temel Oguz, Rapporteurs

5.3.1 Outline

Although it is obvious that there is overlapping between the working groups, our aim is to concentrate in the study and definition of the mesoscale variability in the Eastern Mediterranean.

Our tasks are:

(i) Review of present knowledge

(ii) Synthesis of POEM-0-85

(iii) Mesoscale processes, local dynamics, water-mass formation processes, dispersion and mixing

(iv) Identification of important present questions

(v) Experiment planning

(vi) Modelling planning

(vii) Draft recommendations on future work

We start by trying to delineate our understanding of the mesoscale phenomena contained in the latest available data sets in the Eastern Levantine Basin. We agreed on putting equal emphasis on formation, stirring, dispersion and mixing of intermediate waters as well as internal nonlinear dynamical processes. We have discussed Israeli and Turkish data both from POEM cruises and other recent synoptic data sets.

The Israeli data collected at very high resolution (more or less 10 km) show a pervasive field of mesoscale eddies with space scales ranging from 50 km to 100 km in diameter.

The Turkish data (March 1976) shows also a field of eddies with intense jets, filaments and meandering currents along the coasts. The variability seems to be both transient and stationary: the mesoscale eddy field seems to mask the "traditional general circulation" pattern, even at the "gyre" scales.

One of our goals in the future will be to concentrate in the quantitative description of the space and time scales of this variability: eddy, seasonal and interim time scales have to be ascertained from both data analysis and dynamical data assimilation estimates of the flow.

It is agreed that one of the tasks of this group is to develop a detailed guideline for the application of Objective Analysis techniques to the specific data sets available in the Eastern Mediterranean basin.

5.3.2 General Recommendations

1. Define the kinematics of the regions in the Eastern, North, and South Levantine basin. We have defined the "coarse" characteristics of the general circulation of the basin and of the mesoscale regional variability in the Easternmost part of the basin.

   The Asia Minor Current (A.M.C.) appears as a meandering current with an intense eddy field surrounding it. The Rhodes gyre seems to be a persistent feature with intense oscillations of its border jets. The Southern Levantine basin, in the region of Cyprus, shows a field of intense mesoscale eddies which, especially in winter and transition seasons, mask the transport of the broad A.M.C. of this region. The fields look similar to the intense filaments, jets, and eddies found in the California Current System.

   On the basis of the above "coarse" definition of the kinematics of these two regions, we recommend to carry out the quantitative identification of the time and space scales of the variability.

2. Define the energy sources of the variability and ascertain the intense nonlinear processes inherent in the above kinematical picture.
3. Identify the source regions of L.I.W. formation and study the mesoscale processes involved. The Rhodes gyre should be studied in detail and other interesting regions should be identified, re-examining presently available historical data sets in both North and south Levantine basin. Find the stability characteristics and the meandering pattern of the Rhodes gyre.

5.3.3 Recommendations for Future Field Work

1. High resolution surveys (~10 km of spacing) are timely: they will define the time and space scales of the eddy variability, enucleate the nonlinear dynamical processes proper of the Eastern Mediterranean basin mesoscale fields, and identify the process of LIW formation.

Two regions have been identified for the high resolution mesoscale studies:

(a) Asia Minor Current monitoring of meanders and eddies.

(i) Phase of definition of the meandering current features.

- Coarse survey to determine the shape of the meandering pattern and identify eddies (N-S sections seems to be fine).
- Fine resolution sections across the axis of the meandering current and eddies to define the shape of the currents in horizontal and vertical.

It is advised to use the following strategy for the objective analysis of this region:

- From the high resolution surveys, the structure of the meandering current will be defined so that it will be possible to subtract the instantaneous current pattern from the data or a "feature" model of the meanders. Analyze the residual field with optimal interpolation.
- The correlation function should be determined from the high resolution survey. It is recommended the strategy of subsampling the data to find the parameters of the analytical correlation function.

(ii) Phase of determination of energy sources for meander, eddies. Monitor of the Cilician basin transport and "coarse" resolution CTD surveys in this region.

(iii) Fine scale survey around the Rhodes Gyre. It is advised to have a high resolution survey in a 150 x 150 km^2 region in the context of a collaboration between U.S. and Turkey.

(b) Asia Minor Current extension and regional studies

(i) Phase of definition of the scales of the pattern. It is advised to have a fine resolution (~10 km) survey in the mesoscale region with XBT and sparse CTD.

Phase of the regional dynamics experiment.

- Coarse mapping survey.
- Initialization of the quasi-geostrophic model.
- Application of the Energy Vorticity Analysis (EVA) and determination of intense energy conversion subregions.
- New high resolution survey to the regions of intense nonlinear processes.

2. Current meters, floats, telephone cables, codar, etc. to obtain absolute velocity measurements.
3. Calibration of the Sea Surface Temperatures obtained from satellite to monitor the eddy variability on long and short time scales in the Asia Minor Current.

6. WORKSHOP RECOMMENDATIONS

6.1 The Meeting (Dr. S. Morcos)

Recognizing the great need for cooperation between institutions and scientists to study oceanography of the Eastern Mediterranean.

Realizing the deficiency in our knowledge of the Oceanography of the Eastern Mediterranean particularly the southernmost part of the Levantine and Ionian Seas.

Requests Unesco and the IOC to continue their efforts in approaching the European Economic Community (EEC), United Nations Development Program (UNDP) and other funding bodies to support a regional project or projects to facilitate cooperation, mutual work and training among institutions and scientists in marine science, particularly in physical oceanography and productivity studies in the Eastern Mediterranean.

6.2 General Scientific Recommendations

6.2.1 Establish Standing Working Groups

(a) Water Properties and Budgets

(i) Volumetric census of existing data for Eastern Mediterranean; quality control and rate estimates

(ii) Volumetric census: POEM data and rate estimates

(iii) Assess Western Mediterranean problem

U. Unluata, Chair, A.H. El-Gindy, A. Hecht

(b) Modelling

(i) Coordinate modelling at Harvard Center and other institutes

(ii) Guide model intercomparisons and community model development

A.R. Robinson and P. Malanotte-Rizzoli, Co-chair

C. Koutitas, S. Piacsek, T. Oguz, M. Gerges, N. Pinardi

(c) Air-Sea Interactions

(i) Flux estimation including parameters

(ii) Flux maps throughout POEM

(iii) Developed coupled model

A. Navarra, Chair, M. Latif, S. Piacsek

(d) Sea Surface Temperatures from Satellites

Report on proposed program by September 1986

N. Pinardi, Chair, P. LaViolette, O. Ozsoy

Italian Representative not yet named

6.2.2 Workshop on Data Management

Prepare composite data set, analyze cooperated workshop, prepare joint publications

A.R. Robinson and P. Malanotte-Rizzoli, Chair

A. Michelato, A. Hecht, A. Theocharis, M. Gacic, S. Morcos, U. Unluata

6.2.3 Ad Hoc Groups for Technical and Program Development

(a) XBT's from Eastern Mediterranean Ferries of Opportunity

M. Gerges, Chair

National Steering Committee Members or alternatives

Letter report to Steering committee by September 1986

(b) Sea level investigation

Assess program development and funding possibilities as MEDALPEX did in Western Mediterranean

M. Gacic, Chair, S. Morcos

Letter report to Steering committee by September 1986

(c) Absolute velocity measurements of deep water

Assess availability of instrumentation and possible collaborations, releases, Current Meter moorings, surface drifters, deep floats.

A. Michelato, Chair, P. LaViolette, A. Robinson

6.2.4 The POEM Scientific Workshop recommends that the Steering Committee considers at its next meeting whether or not it is scientifically desirable to add additional studies related to deep water formation processes in the Aegean Sea to the POEM scientific program.

6.2.5 Future coverage of areas and processes

- Moored current meter arrays

  (a) NOAA/IOC current meter arrays in Straits of Sicily, Otranto, Kithira, Antikithira, Kassos, Karpatos, and Rhodos Straits, in the Cilician Basin and in the southern Levantine Basin

- Water Masses and General Circulation:

  (a) Additional Standard Parameters for POEM Surveys

  (b) Adriatic Surveys to be conducted by Yugoslavian and Ancona Laboratory (Italy)

  (c) Italian effort to cover deep Ionian

  (d) Explore possibility of anchored meteorological buoy in Levantine water

  (e) Modelling

      (i) Start intercomparison problems

      (ii) Initiate simultaneously Primitive Equations modelling

- Mesoscale Dynamics and Processes

  The next step involves the evaluation of:

  i) Definitive structure; space and time scales

  ii) Energy conversion and production studies

  iii) Mesoscale processes and Levantine Intermediate Water formation experiments

  (a) Asia Minor Current Variability Study

      (i) Fine mesoscale measurements across meanders and eddies

      (ii) Standard section in Turkey Cyprus Gap

      (iii) Telephone cable for integrated transports

(b) Southern Levantine Mesoscale Variability

(i) Fine Mesoscale Resolution study in subregion of mapped mesoscale

(ii) Dynamical study of nonlinear processes and energy conversions via Energetics and Vorticity Analysis and accurate measurements

(c) Rhode Gyre experiment on mesoscale processes and Levantine Intermediate Water formation region, high resolution survey in March

Objective Analysis Techniques

Mesoscale and General Circulation Maps

7. CLOSURE OF THE MEETING

At the final plenary session the set of general recommendations was adopted unanimously.

Appendix I

First POEM Scientific Workshop
Erdemli, Turkey, 16-20 June 1986

AGENDA

1. OPENING
2. ARRANGEMENTS
   - 2.1 ELECTION OF CHAIRMAN AND VICE-CHAIRMAN
   - 2.2 DESIGNATION OF RAPPORTEUR
   - 2.3 CONSIDERATION OF AGENDA
   - 2.4 TIMETABLE AND CONDUCT OF WORKSHOP
3. REVIEW OF THE PRESENT STATE OF KNOWLEDGE (INVITED LECTURES)
   - 3.1 WATER MASSES AND HYDROGRAPHY
   - 3.2 GENERAL CIRCULATION
   - 3.3 MESO-SCALE PROCESSES AND DYNAMICS
   - 3.4 AIR-SEA INTERFACE FLUXES
4. SCIENTIFIC PRESENTATIONS (CONTRIBUTED PAPERS)
5. RELEVANT WORK IN PROGRESS
6. POEM RESULTS TO DATE
7. FUTURE WORK AND PLANS
8. RECOMMENDATIONS OF THE WORKING GROUPS
9. ADOPTION OF REPORT AND RECOMMENDATIONS
10. CLOSURE

Appendix II

First POEM Scientific Workshop
Erdemli, Turkey, 16-20 June 1986

OPENING ADDRESSES

Prof. Mehmet Gonlubol, President, Middle East Technical University, Turkey

Dear Co-chairpersons of the POEM Steering Committee, UNESCO and IOC Representative, and the Committee Members and Scientists of POEM

It is with great pleasure that I welcome you to Erdemli Workshop. The Middle East Technical University is honoured to be the host and thus contribute to the scientific cooperation and communication among POEM scientists.

POEM is already moving towards being a successful program, thanks to this large scale cooperation. I am therefore reassured that we will leave the workshop with increased contentment, albeit with many new perspectives of scientific inquiry.

The Eastern Mediterranean is known to be the ground for many oceanographic puzzles. After the sixties, calls for coordinated oceanographic investigations in this sea have frequently been made. For our part, we have recognized the size of collaboration required. We are finally happy to see that systematic investigations are planned under POEM. The extent and quality of your work will set a cornerstone in the exposition of the Mediterranean Sea. Being a professor of international law who is closely involved in many aspects of the Law of the Sea, I have had full support for the programme. From the very beginning, I have instructed Unluata to make sure that this Institute becomes a full participant in POEM activities.

The first two POEM cruises have now been carried out successfully. The data set obtained so far is unsurpassed in quality and coverage as compared to earlier surveys. These first steps have taught us a great deal in terms of cooperation and knowledge to be gained.

The Institute of Marine Sciences, METU has contributed significantly to the initial POEM cruises. Great detail has been captured by these surveys. The fresh information acquired is already rewarding and promising for the future. It is natural that the more we learn, the more appropriate scientific questions we will pose in this continuing study.

We extend many thanks to the Unesco and IOC for their continued support of POEM in general, and of this workshop in particular. It is also largely due to their earlier support that this Institute could be developed to its present state.

The use of modern methodologies of oceanography in carrying out the scientific objectives of POEM is a valuable asset of the programme. Technological transfer between participating institutions is expected to have a direct bearing on regional scientific development. We look forward to this cooperation and exchange.

I am happy to open the first POEM Scientific Workshop with best wishes for its success.

Dr. Selim Morcos, Unesco and IOC Representative

Your Excellency, the President of the Middle East Technical University, Ladies and Gentlemen, and Colleagues,

It gives me great pleasure to address you on behalf of Unesco and the Intergovernmental Oceanographic Commission (IOC), in this Opening Session of the Scientific Workshop on the Physical Oceanography of the Eastern Mediterranean (POEM). I am particularly happy to welcome you here in Erdemli, in the Institute of Marine Sciences of the Middle East Technical University, which we, in Unesco, regard as one of our best achievements in the context of our cooperation with the University and the United Nations Development Programme (UNDP). I would like to mention here that, a few years ago, there was no marine science station along the Turkish coast east of Izmir. Subsequently, a project financed by the University and UNDP, and executed by Unesco in cooperation with the University, resulted in the establishment in 1977 of the present oceanographic institution, which can be considered as one of the best in the Eastern Mediterranean. This workshop is the first scientific gathering in this Institute. Let us extend on this occasion our hearty congratulations to the Middle East Technical University on its achievement in the field of marine sciences.

The Middle East Technical University is, in fact, only one example of several projects carried out by Unesco in the Eastern Mediterranean during the last decade. Among these, I should like to mention in particular the National Centre for Marine Research in Athens; the National Oceanographic Data Centre and the National Marine Biological Reference Collection Centre of the Institute of Oceanography and Fisheries in Alexandria; the Marine Pollution Unit of the University of Alexandria; the Marine Research Centre in Beirut; the Marine Research Centre in Tripoli and the Marine Biology Research Centre of Al-Fateh University in Tajoorah, Libya. These projects and others, brought

to fruition through the national efforts of the member states of the Eastern Mediterranean, with or without outside assistance, have made it possible to launch cooperative programmes such as POEM and convene specialized meetings such as this workshop which, I hope, will successfully meet our expectations.

This workshop represents a step towards the development of cooperative studies on particular phenomena related to the physical oceanography of the Eastern Mediterranean. The Mediterranean has a long history of international cooperation in marine sciences. One may recall that the International Commission for the Scientific Exploration of the Mediterranean Sea (ICSEM) is the oldest body to be created in the Mediterranean and comes only second to the International Council for the Exploration of the Sea (ICES) which is mainly concerned with the North European waters and the North Atlantic Ocean. One should also recall the Cooperative Investigations in the Mediterranean (CIM) which were initiated in 1968 by IOC, ICSEM and the General Fisheries Council for the Mediterranean (GFCM) of FAO. These cooperative investigations which covered the whole Mediterranean, were however more successful in the Western Mediterranean. One of the earliest examples of cooperation in physical oceanography is MEDOC, the multiple ship survey of 1969/1970 in the North Western Mediterranean to study the deep winter-time convection. In an Ad Hoc meeting held in Paris in December 1985 by IOC and UNEP, six cooperative scientific programmes in physical oceanography were identified in the Mediterranean, east and west. These are: POEM, the Italo-Yugoslavian Cooperative Project in the Adriatic Sea (ASCOP), ALPEX/MEDALPEX, MED MODEL, the Western Mediterranean Circulation Experiment (WMCE) and the Gibraltar Experiment. This demonstrates clearly the intensive investigations going on in the Western Mediterranean, compared with the modest efforts made in the Eastern Mediterranean, as well as the need to mobilize scientists, and policy

and decision-makers in our member states.

For those of you who are attending a POEM meeting for the first time, the origin of the POEM Programme can be traced back to the Round Table Discussion which took place within the framework of the Physical Oceanography Committee of ICSEM in Cannes in December 1982. The actual planning of the programme took about two years during which time four meetings were held: in Lerici, Italy, September, 1983; in Paris, August 1984; in Lucerne, October 1984, and in Paris, June 1985. However, these efforts culminated in intensive field investigations in October/December 1985 and in March/April 1986. More details on the activities carried out within the framework of this programme will be given by Professors Allan Robinson and Paola Malanotte-Rizzoli the Co-Chairpersons of the POEM Steering Committee.

I will content myself, here, with emphasizing a few facts about why the Unesco Division of Marine Sciences and IOC have supported this programme wholeheartedly. It is a known fact that our knowledge of the Eastern Mediterranean lags behind that of the Western Mediterranean. The efforts made on the national level in many of the Member States of the Eastern Mediterranean, are now mature enough to manifest themselves in some sort of successful cooperative programme, which lies within the spirit of the U.N. drive towards Technical Cooperation between Developing Countries (TCDC). In fact, Unesco and later the IOC have adopted a favourable attitude towards the POEM Programme ever since the Round Table Discussion in Cannes in December 1982. This was mainly based on the fact that the programme came as a response to a genuine desire of the scientific community and was of potential benefit to the Member States concerned, facts which we give a high recognition. This appreciation and endorsement of the programme by Unesco and IOC has been expressed in terms of support to the following specific activities:

1. Meetings: Eight meetings in three years, September 1983 to September 1986, took or will take place with substantial contribution from Unesco and IOC.
2. Publications: Two Unesco Reports in Marine Science (Nos. 30 and 35) and two Newsletters (Nos. 1 and 2) were produced and disseminated world-wide during that period.

The above activities were carried out with substantial resources from Unesco and IOC, including the staff time and travel required to accomplish these activities. We look forward to a time when the POEM Programme is strong enough to enter a new phase based mainly on the cooperative efforts of the scientific institutions involved, and on diversified financial resources - national, regional and international, as the case may be.

This workshop is an important event which will contribute to the scientific knowledge of the Eastern Mediterranean. It demonstrates that physical oceanography which, for many decades, was considered a weak point in marine science activities in the Eastern Mediterranean, is now becoming a stronger and more mature discipline. It should be pointed out that many of the communications to be presented in this workshop, emanate particularly from the work carried out within and outside the POEM Programme, a fact which predicts a potential growth in our knowledge of the physical oceanography of the Eastern Mediterranean over the next few years.

I would like to express my sincere appreciation to the Middle East Technical University and its Institute of Marine Sciences, for hosting this meeting and providing us with all the necessary facilities. Also, I wish to express my thanks to all those of you who worked hard to make this meeting a successful gathering. These expressions of appreciation and greetings are shared by my colleagues back in Paris, and particularly by Dr. Dale C. Krause, Director of the Unesco Division of Marine Sciences and Dr. Mario Ruivo,

Secretary of the Intergovernmental Oceanographic Commission.

Finally, it gives me great pleasure to convey to you the greetings and best wishes of the Director General of Unesco, Mr. Amadou Mahtar M'Bow. Greetings are also proffered from the Chairman of the Intergovernmental Oceanographic Commission (IOC), Mr. I. Ronquillo.

Thank you.

Prof. A.R. Robinson, Co-chairperson of POEM

Mr. President, colleagues,

The Eastern Mediterranean presents scientifically challenging, important and interesting problems. It is timely to attack these problems and their solutions are of practical consequence.

Why is it timely? Generally, ocean science has advanced rapidly over the last two decades. In the major ocean basins, new instrumental sampling techniques and concepts have revealed the true kinematic structure of ocean phenomena. Variability in space and time, eddies fronts - "Internal deep sea" weather phenomena - have been discovered and attempts have been made to describe and quantify the general circulation. Hand in hand new and profound theories are being constructed.

We now know what to expect and how to approach definite measurements effectively and how to model them. Thus the Eastern Mediterranean, not very well known physically, can be researched and brought relatively quickly to a new stage of physical knowledge. But it takes substantial commitment and resources. During the 1970's the world's oceanographers learned it was necessary to work together for progress.

Why is it important? Knowledge of physical processes, principles and circulation is the basis for understanding transport and dispersion of material - thus affecting our ability to understand biological and chemical processes. Fisheries, productivity studies, environmental management are indicated. The currents associated with the "internal weather of the sea" affect all marine operations including resource exploration and exploitation. Moreover, the sea and the atmosphere are coupled and interact to cause

climatic fluctuations - which can be of economic significance. We need to determine the Mediterranean influence qualitatively and its consequences quantitatively.

Eastern Mediterranean physical oceanography is a miniature cosmos of global physical oceanography. The ocean is driven by winds and by density differences due to the heating, cooling evaporation and precipitation. All of these forces act on the Eastern basin, isolated by the Straits of Sicily. Intermediate and deep convection occur here, heavy water being formed locally. Not so with the Atlantic and Pacific. Only elsewhere is the polar ocean where heavy salty water is formed by ice formation-the analogy here is evaporation. Thus the Eastern Mediterranean is for global oceanographers a "laboratory basin" for general circulation processes. This provides the basis for our working together with regional scientists towards common goals of understanding.

This has resulted in POEM - the program internationally cooperative coordinating both experimental and modelling studies of the Eastern Mediterranean.

The scientific basis for POEM was set by an international workshop in Lerici, Italy in 1983. During the intervening three years the scientific goals and program were established. Now we have begun our work and are at an exciting and critical juncture. Two coordinated experimental data sets have been obtained, models have been set up. If we can have a productive week of discussion for analysis and planning, we will accomplish a scientifically significant step forward, setting the stage for a mature and successful POEM project.

The overall goals of POEM are ambitious and feasible.

1) To achieve a definitive, shared and intercalibrated set of physical data.

2) To construct a relevant, valid and verified physical model - a shared community model of the general circulation and its variability.

The model will be applicable to biological, chemical and environmental and climate studies.

The goals of the workshop are well defined and focussed:

- A review, overview and critical synthesis of knowledge of the Eastern Mediterranean in four areas, and the production of a useful review volume.
- To scientifically and technically analyze POEM results of data and POEM overall scientific plans. Detailed planning of specifics of POEM for the next year.
- To establish scientific communications and active cooperation on an individual and group basis.

We the POEM scientists are seriously grateful to our sponsors, and on behalf of all our colleagues and my co-chairperson Paola Malanotte-Rizzoli, we thank them: the Unesco Division of Marine Sciences, the Intergovernmental Oceanographic Commission and sponsors of the national programmes of oceanography, for myself, in the US, the National Science Foundation.

We are particularly thankful to our Turkish hosts from the Middle Eastern Technical University. We are grateful for the opportunity to pursue together our scientific discoveries.

Appendix III

First POEM Scientific Workshop
Erdemli, Turkey 16-20 June 1986

PROGRAM AND TIME TABLE

Monday, June 16

10:00 am Opening of the Workshop U. Unluata, Chairman

Professor Mehmet Gonlubol, President of the Middle East Technical University

Dr. Selim Morcos, Representative of UNESCO and IOC

Professor Allan Robinson, Co-chairman POEM

11:30 Chairman, S. Morcos

"Water Masses and Hydrography" A. Hecht

12:15 pm "Air-Sea Interface Fluxes" N. Pinardi

2:30 Chairman, M. Gerges

"General Circulation" P. Rizzoli

3:15 "Mesoscale Processes and Dynamics" A. Robinson

4:30 Institute Presentations P. Rizzoli, Chairman

E. Ozsoy

"Meso-scale Hydrographic Characteristics in the Northeastern Mediterranean- November 1985"
E. Ozsoy, M.A. Latif, U. Unluata

"Sea surface expression of mesoscale eddies in the Northeastern Mediterranean, November 1985"
E. Ozsoy, C. Saydam, J. Salihoglu, U. Unluata

"Meso-Scale Circulation Features in the Northeastern Mediterranean- November 1985"
E. Ozsoy, T. Oguz, U. Unluata

5:30 M. Gacic

"The exchange of water between South Adriatic and Eastern Mediterranean"
M. Gacic

Tuesday, June 17

9:00 am Institute Presentations P. Rizzoli, Chairman

	M. Gerges	Institute Presentation (Egypt)
	A. El-Gindy	"The dynamic structure and its seasonal evolution in the Eastern Mediterranean" S.H. Sharaf El-Din, A.H. El-Gindy
	I. Maiyza	"On the peculiar hydrographic character of the Eastern Mediterranean in the warm and cold winters" I.A. Maiyra
9:30	A. Michelato	Institute Presentation (Italy)
		"Current measurements in the Strait of Otranto" A. Michelato
	G. Manzella	"The Janus Experiment in the Strait Sicily G. Manzella
	A. Artegiani	"Observations of the water masses of the middle Adriatic Sea during POEM-0-85 and POEM-1-86" A. Artegiani, E. Paschini
11:00	Institute Presentations A. Robinson, Chairman	
	S. Brenner	Institute Presentation (Israel)
		"Observations of a quasistationary meso-scale eddy in the northeastern Levantine Basin" S. Brenner, Z. Rosentroub, Y. Bishop
2:30	Working Groups in session	
4:30	Plenary Session of Methodology, A. Robinson, Chairman	

Wednesday, June 18

9:00 am Scientific Presentations, U. Unluata, Chairman

U. Unluata	"On the distribution of the Atlantic waters in the Levantine" U. Unluata, E. Ozsoy, M.A. Latif
A. Hecht	"Climatology and dynamics of the Eastern Mediterranean" A. Hecht, N. Pinardi, A.R. Robinson

	N. Pinardi	"Non-linear meso-scale processes in the Eastern Mediterranean basin" N. Pinardi, A.R. Robinson, A. Hecht
		"Surface fluxes and air-sea interactions" A. Navarra
	E. Tziperman	"Applications of linear inverse methods to Eastern Mediterranean data" E. Tziperman, A. Hecht
	H. Nelken	"Tracer tongues in a diffusive fluid" H. Nelken
	N. Pinardi	"Observations of eddy variability during POEM-O-85". I. Satellite sea surface temperature analysis. G. Vivanti, F. Parmiggiani, N. Pinardi
11:00	Scientific Presentations, G. Koutitas, Chairman	
	A. Bergamasco	"The general circulation of the Eastern Mediterranean: Wind versus thermohaline driving" A. Bergamasco, P. Malanotte-Rizzoli
	I. Maiyza	"On the anomalous atmospheric circulation features over the Eastern Mediterranean" I.A. Maiyza
		"On the steric sea level of the Eastern Mediterranean Sea" I.A. Maiyza, F.M. Eid
	A. El-Gindy	"The time variations of monthly means of sea surface temperature and meteorological parameters in the Eastern Mediterranean" A. El-Gindy, A.A. Hamed
		"Hydrographic characteristics and circulation of the Eastern Mediterranean waters" M.A. Said
		"Estimation of the vertical current velocity in the Eastern Mediterranean" M.A. Said
	M. Abboud-Abisaab	Institute Presentation (Lebanon)
2:30	Working Group Reports, A. Robinson, Chairman	
) :00	Working Groups in session	

Thursday, June 19

9:00 am Scientific Presentations A. Michelato, Chairman

C. Koutitas Institute Presentation (Greece)

Abstracts of the following papers;
"Distribution of Levantine Intermediate Water in the Northwest Levantine and Southeast Aegean"
A. Theocharis, D. Georgopoulos, G. Zodiatis, S. Christianides

"Water Masses in the Ionian Sea"
D. Georgopoulos, A. Theocharis, G. Zodiatis

"Observations on vertical processes in the Northwest Levantine Basin"
A. Theocharis, D. Georgopoulos, G. Zodiatis

"Summary Meteorological Report POEM-1-86" (February - March 1986)
S. Christianides

"Numerical modelling of wind and tidal induced circulation in semienclosed coastal and pelagic basins"
C. Koutitas

"Residual flows at Kassos Strait"
E.J. Papageorgiou

E. Ozsoy "Mesoscale Circulation Studies Based on Surveys of 1968 and 1983"
E. Ozsoy, M.A. Latif, T. Oguz, C. Saydam

10:00 Working Groups in session

2:30 Working Group Reports A. Robinson, Chairman

3:00 Working Groups in session

Friday, June 20

9:00 am Recommendations of the Working Groups
P. Rizzoli, Chairman

11:00 Report Preparation

2:30 Report Preparation

4:30 Adoption of Report and Closure
A. Robinson, Chairman

Appendix IV

FIRST POEM SCIENTIFIC WORKSHOP
Erdemli, Turkey, 16-20 June 1986

METHODOLOGY SESSION: DISCUSSION QUESTIONS

Tuesday, June 17, 1986

A.R. Robinson, Chairman

-Evaluation and comparison of method and isopycnal analysis to detect water mass movement. (El-Gindy)

-Methods of synthesizing data into a set of "synoptic" observations. Relative weights, importance, reliablity, accuracy, of various types of observations (CTD, current meter, etc.).
Question of temporal synthesis (i.e. what is an appropriate "time window" for synoptic data set?). (Brenner)

-Satellite data: Their importance for the progress of oceanography (AVHRR(IR) and altimetric?). Synoptic coverage. (Sammari)

-Vertical profiling of section. (Bingel)

-a) Methods/models for evaluation of coefficients in flux formula
-b) Renewal time estimates (Latif)

-Timing of cruises. Why Spring and Fall?

-Mesoscale dynamical modelling. Streamfunction field maps: statistical optimal analysis

-Dynamical computations versus/numerical modelling techniques for the study of general circulation

-Practicability of remotely sensed data in the study of sea surface features

-Measurements-models coupling

-Calibration of General Circulation Model wind stress and heat fluxes vs. ship observations and climatological fluxes

-Assimilation of new POEM data in a new "running mean" or updated climatology; blending technique of XBT/CTD with satellite Sea Surface Temperatures and climatology

-Use of variational inverse techniques and diagnostic models in the general circulation

-Strategy adopted for experimental network design on the basis of the ODPS

-A discussion on choosing parameters used in prespecified correlation function (objective analysis)

-A short description of Energetics and Vorticity Analysis (by giving a test case if possible)

-Data processing techniques and products that should be commonly adopted

-Possibilities of measuring deep currents/to be used in assimilation

-Discussion on fronts - time scale structure and sampling requirements

-The Harvard Model: specification of incoming Potential Vorticity computation of the barotropic velocity signal

Appendix V

First POEM Scientific Workshop
Erdemli, Turkey, 16-20 June 1986

PARTICIPANTS IN THE WORKING GROUPS

WORKING GROUP A: "Water Masses and Hydrography"

Co-Chairmen - A. Hecht and A. Michelato

Rapporteurs - A.H. El-Gindy and A. Michelato

Working Group Members - M. Abboud-Abisaab, A. Akyarli, A. Artegiani, A.H. El-Gindy, A. Hecht, I. Maiyza, A. Michelato, S. Morcos, S. Sammari, C. Saydam

WORKING GROUP B: "General Circulation"

Chairperson - P. Malanotte-Rizzoli

Rapporteurs - E. Ozsoy and M. Gacic
M. Latif for coverage of Air-Sea Interactions

Working Group Members - A. Bergamasco, M. Gacic, M. Gerges, M. Latif, P. Malanotte-Rizzoli, G. Manzella, H. Nelken, E. Ozsoy, I. Salihoglu, A. Theocharis, I. Unsal, E. Tziperman, C. Koutitas

WORKING GROUP C: "Internal Dynamical Processes, Models and Experiments"

Co-chairmen - A. Robinson and U. Unluata

Rapporteurs - N. Pinardi and T. Oguz
N. Pinardi for coverage of Air-Sea Interactions

Working Group Members - O. Basturk, S. Brenner, C. Koutitas, T. Oguz, E. Papageorgiou, N. Pinardi, A. Robinson, E. Tziperman, U. Unluata

Appendix VI

First POEM Scientific Workshop
Erdemli, Turkey, 16-20 June, 1986

LIST OF PARTICIPANTS

M. Abboud-Abisaab
Marine Research Centre
P.O. B ox 123
Jounieh
LEBANON
Phone: 9-934763
Cable: CENERES BEIRUT

A. Akyarli
University of Dokuz Eylul
Institute of Marine Sciences
and Technology
P.O. Box 478
Izmir
TURKEY
Phone: 254338
Telex: 52889 DBTE TR

S.N. Alavi
Middle East Technical University
Institute of Marine Sciences
P.O. Box 28
Erdemli, ICEL
TURKEY
Phone: 7585-1842
Telex: 67796 DMS TR

A. Artegiani
Istituto di Ricerche sulla Pesch Marittima
C.N.R.
Molo Mandracchio
I 60100 Ancona
ITALY
Phone: 71-55313
Telex: 560070 AGEMOR I

O. Basturk
Middle East Technical University
Institute of Marine Sciences
P.O. Box 28
Erdemli, ICEL
TURKEY
Phone: 7585-1842
Telex: 67796 DMS TR

A. Bergamasco
Istituto per lo Studio della
Dinamica delli Grandi Masse
Ca' apadopoli 1364
San Polo
I-30125 Venezia
ITALY
Phone: 041-705060
Telex:

Middle East Technical University
Institute of Marine Sciences
P.O. Box 28
Erdemli, ICEL
TURKEY
Phone: 7585-1842
Telex: 67796 DMS TR

S. Brenner
Israel Oceanographic and
Limnological Research Ltd.
Tel Shikmona
P.O. Box 8030
31080 Haifa
ISRAEL
Phone: 04-515202
Telex: 46400 BXHA IL

A.H. El-Gindy
Oceanography Department
Faculty of Science
University of Alexandria
Moharram Bey
Alexandria
EGYPT
Phone: 71960
Telex: 54467 UNIVY UN

M. Gacic
Institute of Oceanography & Fisheries
P.O. Box 114
Kt Marjana
Split 58 000
YUGOSLAVIA
Phone: 058-46688
Telex: 26477 URBS YU

M. Gerges, Acting Executive Scientist
Intergovernmental Oceanographic
Commission (IOC), UNESCO
1 rue Miollis
75015 Paris
FRANCE
Phone: 4568.41.54
Telex: 204461 F

Present Address:
Oceans and Coastal Areas
Programme Activity Centre (OCA/PAC)
UNEP
P.O. Box 47074
Nairobi, KENYA
Phone: 2452-333930 Ext. 6972
Telex: 25164 UNEPRS KE

M. Gonlubol
President
Middle East Technical University
Ankara
TURKEY
Phone: 237100/50
Telex: 42761 ODTU TR

A. Hecht
Israel Oceanographic and
Limnological Research Ltd.
Tel Shikmona
P.O. Box 8030
Haifa 31080
ISRAEL
Phone: 04-515202
Telex: 46400 BXHA IL

C. Koutitas
Aristotelio University of Thessanoliki
School of Engineering
Department of Civil Engineering
Thessanolica
GREECE
Phone: 031-992683
Telex: 224135 IOKE GR

M.A. Latif
Middle East Technical University
Institute of Marine Sciences
P.O. Box 28
Erdemli, ICEL
TURKEY
Phone: 7585-1842
Telex: 65596 DMS TR

I. Maiyza
Institute of Oceanography and Fisheries
Mediterranean Branch
Kayet Bey
Alexandria
EGYPT
Phone: 203-801553
Telex: 93069 ASTR UN

P. Malanotte-Rizzoli Vice-Chairman/General Rapporteur
POEM Co-chairperson
Massachusetts Institute of Technology
Department of Earth, Atmospheric, and
  Planetary Sciences
Building 54-1422
Cambridge, MA 02139
U.S.A.
Phone: 617-253-24541
        617-868-7240 (home)
Telex: 921473 MITCAM
Telemail: P.RIZZOLI

A. Maley
Institute of Biology
University of Lyublyana, MRIC
66320 Piran, YLA 65
YUGOSLAVIA
Phone: (?6)73740

G. Manzella
Istituto per lo Studio della Dinamica
  delle Grandi Masse
CNR c/o ENEA CREA
P.O. Box 316
13100 La Spezia
ITALY
Phone: 187-536309
Telex: 271268 CNRSP I

A. Michelato
Osservatorio Geofisico
Sperimental (OGS)
P.O. Box 2011
34016 Trieste
ITALY
Phone: (40) 2140221
        (40) 567575 (home)
Telex: (843) 460329 OGS

S. Morcos, Representative of UNESCO and IOC
Division of Marine Sciences
UNESCO
7 Place de Fontenoy
75700 Paris
FRANCE
Phone: 568-39-65
Telex: 204461 Paris

H. Nelken
Massachusetts Institute of Technology
Department of Earth, Atmospheric, and
  Planetary Sciences
Building 54-1417
Cambridge, MA 02139
U.S.A.
Phone: 617-253-5934
Telex: 921473 MITCAM

T. Oguz
Middle East Technical University
Institute of Marine Sciences
P.O. Box 28
Erdemli, ICEL
TURKEY
Phone: 7585-1842
Telex: 67796 DMS TR

E. Ozsoy
Middle East Technical University
Institute of Marine Sciences
P.O. Box 28
Erdemli, ICEL
TURKEY
Phone: 7585-1842
Telex: 67796 DMS TR

S.A. Piacsek
SACLANTCEN
Via S. Bartolomeo 400
19026 La Spezia
ITALY
Phone: (39)-187-540-323

N. Pinardi
I.M.G.A.-C.N.R.
University of Modena
Via Campi 213/a
Modena
ITALY
Phone: 59-362388
51-394549 (home)
Telex: 583251 PISIMO I

A. Robinson,
Chairman
Harvard University
Department of Earth & Planetary Sciences
Pierce Hall, Room 100C
Cambridge, MA 02138
U.S.A.
Phone: 617-495-2819
Telex: 257550 HAR UR
Telemail: A.ROBINSON

I. Salihoglu
Middle East Technical University
Institute of Marine Sciences
P.O. Box 28
Erdemli, ICEL
TURKEY
Phone: 7585-1842
Telex: 67796 DMS TR

S. Sammari
Presently:
IFREMER
P.O. Box 330
83507 La Seyne-sur-Mer
FRANCE
Phone: 94.94.18.36 Ext. 1245
Telex: 400205 F
Home Address:
Faculte des Sciences de Tunis
Departement des Sciences Naturelles
Le Belvedere, Tunis

C. Saydam
Middle East Technical University
Institute of Marine Sciences
P.O. Box 28
Erdemli, ICEL
TURKEY
Phone: 7585-1842
Telex: 67796 DMS TR

E. Tziperman
Massachusetts Institute of Technology
Department of Earth, Atmospheric, and
Planetary Sciences
Building 54-1314
Cambridge, MA 02139
U.S.A.
Phone: 617-628-6063
Telex:

U. Unluata, Vice-Chairman
Middle East Technical University
Institute of Marine Sciences
P.O. Box 28
Erdemli, ICEL
TURKEY
Phone: 7585-1842
Telex: 67796 DMS TR

M. Unsal
Middle East Technical University
Institute of Marine Sciences
P.O. B ox 28
Erdemli, ICEL
TURKEY
Phone: 7585-1842
Telex: 67796 DMS TR

APPENDIX VII

ABSTRACTS OF SCIENTIFIC PRESENTATIONS

WATER MASSES OBSERVATIONS IN THE MIDDLE ADRIATIC SEA DURING POEM-0-85 AND POEM-1-86

A. Artegiani and E. Paschini

Institute of Research and Marine Fishery, C.K.R., Ancona, Italy

First analyses of the data collected in the middle Adriatic Sea during the cruises POEM-0-85 (November 1985) and POEM-1-86 (May 1986) are presented.

A mass of water with a temperature around 13°C and density 29.15 was present in the Italian side of the section of Vieste. The central area of the section was almost occupied by a mass of water with high salinity (S_{max} = 38.82) and a temperature of approximately 14.2°C.

This two mass of water are not so clearly present in the section of Pescara. In this section, instead, is present in the bottom layer an "old" mass of water (T=10.9°C S=38.49 $\sigma_{1\_}$ 29.55 and AOU 1.8 cm^3/l).

During the winter time this mass of water was renewed. In fact during the POEM-1-86 cruise we found in the two Pomo pits a new mass of water, originated in the north Adriatic sea, characterised by a salinity less than 38.3, temperature less than 10°C and ΔOU less than 0.48 cm^3/l.

A mass of water well defined, with a minimum of salinity of 38.09 and temperature 10.17°C, is present along the Italian coast.

In the central part of the section of Vieste is present a mass of water with a salinity maximum OF 38.77 and a temperature of approximately 14.2°C like in the previous cruise.

THE GENERAL CIRCULATION OF THE EASTERN MEDITERRANEAN: WIND VERSUS THERMOHALINE DRIVING

Andrea Bergamasco, Paola Malanotte-Rizzoli

Laboratorio per lo Studio della Dinamica delli Grandi Masse, Venice, Italy

The wind versus thermohaline driven general cieculation in the Eastern Mediterranean is studied through multi-level general ciruclation model, with coarse (no eddy resolving) resolution but with basic sets. First, the wind-driven circulation is studied using the model in its barotropic version with the real bottom topography. Various steady wind are used to compare the winter versus summer steady circulation. The final experiement is run for more than one year using the annual cycle of observed climatological wind stresses (monthly averages). Second, the thermohaline circulation is studied using the model in its 3-level version (surface Atlantic, intermediate Levantine, deep bottom water). Climatological averages and temperature and salinity are used to initialize the mode. Again, the model is driven with average surface fluxes for the winter and summer seasons to compare the two steady situations. Then the model is driven through the one year cycle using the time series of monthly averages of surface fluxes (latent and sensible heat; ri diative heat; evaporation).

OBSERVATIONS OF A QUASISTATIONARY MESO-SCALE EDDY IN THE NORTHEASTERN LEVANTINE BASIN

S. Brenner, Z. Rosentroub, and Y. Bishop

Israel Oceanographic & Limnological Research, 31080 Haifa, Israel

During POEM-O-85 and in previous cruises conducted by IOLR, indications of a warm core eddy were found in the vicinity of stations 299 and 300 (located at 34N, 34.5E and 34E respectively). From the data available on the one half degree resolution observational grid, the eddy appeared to be roughly circular with a radius of 50 km and most intense at depths ranging from 200 to 550 m. A warm core eddy was observed at this location as early as December 1982. It has been remarkably persistent since October 1983 and appears to have maintained its present intensity since May 1984.

In order to gain additional insight into the processes that are driving this eddy, during POEM-1-86 we increased the resolution of our data by adding four additional stations in the northeastern corner of our track. These stations, designated as 299 A, B, C, and D, were spaced at one quarter degree intervals and located as follows: A was due north of 299, B was due west of A, C was due south of B (thus half way between 299 and 300), and D was due south of C. These stations were occupied on 6-7 April 1986. Measurements were made with a CTD down to 1000 m. In addition, at station B an attempt was made to measure currents by lowering an Aanderaa current meter to 600 m. After correcting for the drift of the ship, it was found that the currents at this point were very weak (typically less than 2-3 cm/s) thus indicating that this station was very close to the center of the eddy.

A preliminary analysis of the data (including cross sections and plan views of temperature, salinity, and dynamic heights) reveals the following characteristics of the eddy:

1. Temperature: at depths of 200-500 m, the temperature at the center is 0.9 C warmer than at the edges. This corresponds to a depression of 100-150 m in the isotherms. Between 200 m and the surface the center is roughly 0.3 C cooler than the edges, corresponding to an elevation of 60 m in the isotherms.
2. Salinity: in the warm core region, especially below 300 m, the salinity is less than at the edges by an much as 0.1-0.15. Above 200 m the salinity is fairly uniform.
3. Currents: based on dynamic height calculations relative to 1500 dbar, the circulation is anticyclonic at all levels with maximum geostrophic velocities of 25 cm/s occurring at depths of 200-300 m. The corresponding gradient velocities were found to be as high as 43 cm/s.

SUMMARY OF THE WEATHER SITUATION OVER THE AREAS AEGEAN, IONIAN, NW LEVANTINE DURING MARCH - APRIL 1986

Savas Christianides

National Centre for Marine Research
Aghios Kosmas, GR-16604 Helliniko, Greece

In general the last winter can be characterized as a mild winter, milder than the average, and without any particular intense phenomena. November and December 1985 were months with temperature values 2-3°C higher than the 30 years average. The sea level air pressure field was not far from the usual situation of the month, during November, while during December the whole pressure field was 2-3 mbs higher than the 30 years average value. No significant fluctuations of the mean air temperature and air pressure were registered during January and February 1986 though the tendencies were positive.

THE TIME VARIATIONS OF MONTHLY MEANS OF SEA SURFACE TEMPERATURE AND METEOROLOGICAL PARAMETERS IN THE EASTERN MEDITERRANEAN

A.A.H. El-Gindy* and A.A. Hamed**

*Faculty of Science, Alexandria University, Alexandria, Egypt
**Hydrometeorological Office, Egyptian Navy, Alexandria, Egypt

This paper is an effort towards a better understanding of the variability of the hydrometeorological factors in the Eastern Mediterranean which is not yet well known. The monthly mean time series of several parameters; sea-surface temperature, air temperature, dewpoint temperature, the difference between air and sea-surface temperatures, atmospheric pressure and evaporation, during the period 1961-1967 are investigated. Three marine zones are considered in the area: the South East of Sicily, the South West of Crete Island, North of Egypt and at the coastal meteorological Station Ras El-Tin (Alexandria, Egypt). The preliminary inspection of the time series indicates more smooth records of the air and the sea-surface temperatures and the most disturbed records belong to the atmospheric pressure, which becomes smoother towards the east. The spectral analyses of the different parameters, at the different considered series in the area, manifest the dominance of the seasonal cycle with a significant peak at 12 months period. The spectral density distribution for the different parameters at the different places are identical at low frequencies (less than 2 c.p.y.) but they are somewhat different in the higher frequencies due to local factors. The low frequencies are mostly related to large scale variations which have similar effects on the whole area. However, the atmospheric pressure has a significant spatial evolution. In the Ionian Sea (SE of Sicily) the energy density is nearly similar for high and low frequencies with no significant peaks, while going to the east, the energy density increases in the low frequencies and decreases in

the high frequencies. This evolution is due to the fact that the Ionian Sea has stronger depressions activity.

The coherences between the different sites, for the same parameter, were found to be significant at the oscillation with less than 5 c.p.y. Higher coherence existed at the low frequencies and the coherence decreases with increasing the distance between the two positions. The atmospheric pressure shows, again the least coherence.

The amplitudes and phases of the general monthly averages for the different parameters in the three marine areas, are determined.

The relation between the monthly mean sea-surface and air temperatures were found to be linear with quite high significant correlation coefficients. The equations relating these two factors are nearly identical at the Area South East of Sicily and North of Egypt. The equations were calculated in two separate periods: one from April to August, when the air temperature is higher than that of the sea-surface, and the other during the rest of the year, when air temperature is less than that of the sea-surface temperature. These equations could be used to calculate the monthly mean sea-surface temperature with accuracy of about + 0.7°C.

THE EXCHANGE OF WATER BETWEEN SOUTH ADRIATIC AND EASTERN MEDITERRANEAN

Miroslav Gacic

Institute of Oceanography and Fisheries, Split, Yugoslavia

The South Adriatic is considered as a site for the dense water formation and main origin of the deep water for the Eastern Mediterranean. The surface layer cyclonic circulation occupies the entire basin and it is a quasi-permanent feature. The inflow of Mediterranean water along the eastern coast of the South Adriatic and the outflow along the western coast is subject to strong seasonal changes. During the winter time the inflow prevails while during the summer time the outflow is prevailing. Vertically three layers can be distinguished during the summer while during the winter only two layers are present. South Adriatic water spreads in the bottom layer over the Otranto Sill especially during winter. This water exchange is also subject to strong multiannual changes so that there are situations when the Adriatic Sea and the Ionian Sea are completely decoupled. The south Adriatic water is mostly formed in the center of the South Adriatic cyclonic gyre. Formation events are connected to the cold air outbreaks during bura events in winter time. Certain volume of that water is also formed along the South Adriatic shelf. Some results give the evidence that the curl in the bura wind field can generate downward water motions in the shelf area of the South Adriatic. The typical length scale of convective cells in the center of the South Adriatic gyre is about 20 miles and time scale of several days. During the active convection period the water column of about 100 meters is completely vertically mixed. According to some recent results outflow of the south Adriatic water in the bottom layer can reach the value of about 1.8×10^{3} m^3/s. Generally the typical horizontal length scale in the Adriatic Sea is smaller

than for the Eastern Mediterranean and first internal Rossby radius of deformation can be as small as 5 km.

WATER MASSES IN THE IONIAN SEA

D. Georgopoulos, A. Theocharis, and G. Zodiatis

National Centre for Marine Research, Aghios Kosmas,
GR-16604 Helliniko, Greece

In the NE Ionian sea three water masses can be distinguished: (1) the near surface, with characteristics similar to the North Atlantic Water, (2) the transformated Levantine Intermediate Water, and (3) traces from the Deep Water of the Eastern Mediterranean. The transformation of the Levantine Intermediate Water is due to the spreading and mixing processes which occur along its route from the Levantine to the Ionian. In the vicinity of Otranto strait, large mixing process takes place. The product of the mixing, that corresponds to the dense Adriatic water with the winter Levantine water, in the Ionian, is considered Deep Water of the eastern Mediterranean.

CLIMATOLOGY AND DYNAMICS OF THE EASTERN LEVANTINE BASIN

A. Hecht, N. Pinardi, A.R. Robinson

Harvard University, Cambridge, MA 02138, U.S.A.

Seventeen cruises carried out over a period of six years in the Eastern Levantine Basin have been analyzed. The seasonal and interannual variability of the water properties and the kinematics of the circulation of this region is identified and described. We use Empirical Orthogonal Functions to describe the vertical variabiltiy for the dynamic height profiles and to construct absolute geostrophic steamfunctions fields for each cruise. Optimal interpolation techniques were applied to the analyzed data set and sensitivity experiments were carried out for different horizontal correlation functions. The regional climatological Brunt-Vaisala for the determination of the local dynamical baroclinic modes and the local Rossby radius of deformation of which is approximately 12 km. We discovered a very intense meso-scale eddy field associated with scales of motion ranging from one to several local Rossby radii of deformation.

NUMERICAL MODELLING OF WIND AND TIDAL INDUCED CIRCULATION IN SEMIENCLOSED COASTAL AND PELAGIC BASINS

Dr. Christopher Koutitas

School of Engineering, Aristotle University, Thessaloniki, Greece

A short presentation of the types of mathematical models in use during the last 10-15 years in Greek universities for coastal circulation in relation to coastal environment pollution problems is given.

The formulation of the depth varying model with boundary conditions and turbulent parametrisation is subsequently presented. Its numerical solution procedure is outlined. Comments on the depth averaged or layered models follow.

A series of applications to a fictitious coastal basin, and a real one illustrate the behaviour of the various models.

The extension of modelling to the open sea is demonstrated by an application to the Aegean sea. Climatologic data of summer wind field and stratification are used to the model and the steady state circulation is compared to the observed circulation patterns (qualitative evaluation of the model). A final preliminary application is done concerning the tidal circulation in Aegean Sea.

THE JANUS EXPERIMENT IN THE STRAIT OF SICILY

Giuseppe Manzella

Instituto Grandi Masse, CNR, La Spezia, Italy

Time series of 4 months duration were collected in the Strait of Sicily from 3 moorings, each with 4 current meters, during the period November 1985-March 1986. Together with current data, sea-level was simultaneously measured at coastal and island stations as well as meteorological data. During the deployment and retrieval of the current meters, a network of hydrographic stations was also carried out densely covering the region of the strait. A preliminary analysis of the data shows a high variability of the Atlantic water in the surface layer, where the standard deviation is of the same source of the mean value. The Levantine Intermediate Water seems to be more stable, even though the flow show complex horizontal patterns most probably due to the important influence of topography. A comparison is made between evaluated geostrophic velocities and current data which poses some interesting questions about the nature of the flow.

ON THE ANOMALOUS ATMOSPHERIC CIRCULATION FEATURES OVER THE EASTERN MEDITERRANEAN SEA

Ibrahim A. Maiyza

Institute of Oceanography & Fisheries, Alexandria, Egypt

The atmospheric circulation features over the Eastern Mediterranean Sea in the anomalous cold and warm periods in relation with the anomalous air and water temperature were studied using the surface water and air temperature and the daily Synoptic charts. This study lead to a classification of the four winter and four summer anomalous pressure types governing the anomalous air and water temperature in the investigated area.

In general two types of air masses: (1) the continental tropical and (2) continental arctic, determine the weather conditions in the Eastern Mediterranean Sea, causing the positive or negative temperature anomaly, when each of them prevails over the investigated area. Sometimes each of them invades over different parts of the area causing the occurrrence of temperature anomaly of different sign in different parts of the region. In the warm year too, a small area of negative temperature anomaly is observed. This occurs when a small depression lies over the sea near the coast (especially in the northern Levantine Sea).

ON THE PECULIAR HYDROGRAPHIC CHARACTER OF THE EASTERN MEDITERRANEAN SEA IN WARM AND COLD WINTERS

Ibrahim A. Maiyza

Institute of Oceanography & Fisheries, Alexandria, Egypt

The variations of the water masses were investigated on monthly basis for each year (between 1955-1978), with particular attention given to the distinct warm and cold years.

The water temperature, salinity and density (σt) varied from one year to another in the same month and position, on the sea surface and at deeper levels.

The vertical convection in the cold winters was stronger than that in the warm ones, especially in the upper 300 m.

The water salinity in the warm years was higher by up to 0.2 than that in the cold years. This is explained as due to evaporation.

The Aegean Sea may be considered as a secondary source of the Intermediate water mass.

To the east of Crete Island, in the northern Levantine basin, forms the deep water mass. This conclusion agrees and solve the contrast between the results of Nielsen (1912), Pollack (1951) and Wust (1961).

ON THE STERIC SEA LEVEL OF THE EASTERN MEDITERRANEAN SEA

Ibrahim A. Mayza* and Fahmy M. Eid**

*Institute of Oceanography & Fisheries, Alexandria, Egypt
**Department of Oceanography, Alexandria University, Alexandria, Egypt

The steric fluctuation is defined in terms of the seasonal fluctuation in specific volume. Intensive study of the seasonal and annual variations of the steric sea level of the Eastern Mediterranean Sea was made on the basis of comparison of the variation of water density in the anomalous warm and cold years, which makes it possible to estimate the maximum magnitude of the annual variation in the sea level due to the steric effect.

The hydrographic material in the anomalous warm and cold years was taken from the work of Maiyza (1984).

Formulation

Pattulo et al. (1955) equation was used to estimate the steric departures from the mean sea level (MSL):

$$Z\alpha = g^{-1} \int_{Pa}^{Po} \Delta\alpha_Z \, dP \qquad (1)$$

Where:

$\Delta\alpha_Z$ is the departure in specific volume due to small T & S given by:

$$\Delta\alpha = \alpha(\overline{T},\overline{S},\overline{P}) - \left(\frac{\partial\alpha}{\partial T}\right) \Delta T + \left(\frac{\partial\alpha}{\partial T}\right) \Delta S \ldots$$

ΔS & ΔT: are the difference between the annual mean salinity and temperature and their respective monthly means,

Pa : is the atmospheric pressure,

Po : is the pressure to which the integration has been carried, presumably the pressure at which all seasonal effects vanish.

g : acceleration of gravity.

For practical estimation of the steric level equation (1) was transformed by Galerkin (1961) as:

$$h = 0.1\ \Delta h\ \Delta\alpha Z \qquad (2)$$

h : steric level in cm; Δh: the depth of the studied layer.

For the computation of the differences in steric departures between the anomalous warm and cold years, equation (2) can be written in the form:

$$\Delta h_s = \sum_{i=1}^{n} 0.1\ \Delta h_i\ \alpha h_i$$

where:

$$\Delta\alpha_i = \alpha_i\ (w) - \alpha_i\ (c)$$

α_i : the difference in specific volume in the layer i between anomalous warm (w) and cold (c) years.

Results

The steric departures in the Eastern Mediterranean Sea were higher in the warm years than those in the cold ones except in the center of the Ionian Sea and the north of the Levantine Sea in winter and the Strait of Sicily and the southern part of the Levantine Sea in summer. The thickness of the layer in which the steric variations take place was 200-1000 m. The magnitude of the differences of the steric departures in summer is larger (16 cm) than that in winter (12 cm).

The effect of temperature on the steric departures in the upper 50 m layer was more than that of salinity, but at deeper levels the reverse is true.

From the seasonal point of view, the steric level in summer is higher than that in winter (12 cm) in the warm years. In the cold ones the vibration of the steric departures is smaller (about 4 cm).

Conclusion

The steric departures of sea level between anomalous warm and cold years in the Eastern Mediterranean Sea were calculated. This study proved that the effect of water density on sea level may reach 50% of the seasonal observed values of sea level. The layer thickness of the steric variation reach 1000 m, and this may be related to the presence of the formation of the Mediterranean deep waters.

References

Galerkin, L.E. (1961), Problems of the sea level seasonal vibration - Okeanologia, 6: 1105-1115 (in Russian).

Lisitzin, E. and Pattullo, J.G. (1961), The principal factors influencing the seasonal oscillation of sea level - J. Geophys. Res., 66: 845-852.

Maiyza, I.A. (1984), The long term variations of water temperature in the Eastern part of the Mediterranean Sea - Ph.D. Thesis, Moscow State University, U.S.S.R., 144 p. (in Russian).

Pattullo, J.G. et al. (1955), The seasonal oscillations in sea level - J. Mar. Res., 14: 88-161.

Pattullo, J.G., (1963), Seasonal changes in sea level - The Sea, vol. 2, M.N. Hill, ed., New York, Interscience, pp. 485-496.

CURRENT METER OBSERVATONS IN THE STRAIT OF OTRANTO DURING POEM-0-85

Antonio Michelato

Osservatorio Geofisico Sperimentale, Trieste, Italy

Two current-meter mooring were maintained in the Strait of Otranto from 20 October to 2 November 1985 during POEM-0-85 cruise.

A preliminary analysis of the data has shown that the Italian continental shelf was the seat of a quasi-permanent southward flow, with average velocities of 9.5 and 5.8 cm/s at 58 m depth and near the bottom respectively.

In the central part of the strait a two-layer circulation was observed. In the surface layer the net drift was to the north with an average velocity of 5.2 cm/s, whilst in the deeper layers (573 and 874 m) the flow was southeastward with average velocities of 1.4 and 7.1 cm/s respectively.

Current intensification and inertial oscillations were experienced during the passage of meteorological perturbations. Short periods of flow reversal were also observed; they were caused by strong winds and/or wind-induced setups of Adriatic mean sea level.

SURFACE FLUXES AND AIR-SEA INTERACTIONS

Antonio Navarra

University of Modena, Modena, Italy

Estimates of the transfers of sensible heat, moisture and momentum are important forcing functions for the ocean circulation. Though a proper flux description is thought to be crucial to the stimulation of the general circulation. Meso-scale features may be heavily affected too. The POEM Experiment provides a unique opportunity for studying the impact of these atmospheric parameters in a particularly data-rich context. In order to properly introduce the topic, a brief description of the climatology of the Mediterranean region will be given with emphasis on the surface/low level winds characteristic. The existing data produced by the operational centers will be reviewed and to some extent compared. Climatological data sets of wind stresses will also be reviewed.

After the data survey, the attention will focus on the theories of the surface layer profiles that enable us to calculate the fluxes at the surface. The classical Prandtl formulation of bulk aerodynamical laws and the similarity (Monin-Obukhov) theory will be discussed. Some peculiarity of the formulation of the roughness length over sea and over land will be pointed out. A brief overview of the status of recent developments in the field will be given. The implementation of these parameterizations in actual coupled models will then be analyzed and some indication for future development of the interface physical parameterization will be attempted.

TRACER TONGUES IN A DIFFUSIVE FLUID

Haim Nelken

Massachusetts Intitute of Technology, Cambridge, MA 02139, U.S.A.

Observed tongue-like shapes of tracer concentration were used in the past to infer the sense of the general circulation, e.g. Wust's core layer method, and are a common tool today in the general circulation analysis. In this work the hypotheses that the tongues can appear in an environment with no advection at all is examined. A completely diffusive fluid is assumed where the density depends on the temperature and salinity only, each with a given source function. A simple and unstable vertical density profile is created causing strong vertical mixing by convective overturning. From this well mixed water column, tongues of high/low salinity and temperature can diffuse horizontally. Thus localized tongues of property distributions can be accounted for by strong vertical mixing followed by horizontal and vertical diffusion, with no advection. Diffusive spreading is therefore a possible explanation of the 300 m salinity maximum in the Eastern Mediterranean, usually referred to as the Mediterranean Intermediate Water. Here it is argued that due to "Deep Water Formation" processes the saline fluid sinks and then diffuses simply with only minor contribution from advection.

NON-LINEAR MESO-SCALE PROCESSES IN THE EASTERN LEVANTINE BASIN

N. Pinardi, A.R. Robinson and A. Hecht

Harvard University, Cambridge, MA 02138, U.S.A.

Interesting meso-scale processes such as the formation of internal rossby radius of deformation eddies and jet enhancing phenomena modified by local driving mechanisms were observed and investigated for the first time in the Eastern Levantine Basin. We used a CTD data set composed of 17 cruises, each of them centered at 33.5 N, 33.5 E covering a 300 x 300 km squared region. This data was collected during 6 years (1979-1984) by the Israeli R.V SHIKMONA. Here we examine only a subset of the entire data base. For this investigation we adapted and tuned the methodology of data assimilation for meso-scale eddy fields in open ocean regions to the environment of the Eastern Mediterranean area. We studied the vertical structure of the single cruises through an Empirical Orthogonal Functions analysis and the dynamical model decomposition of the climatological N squared (2) profile for the region. We produced geostrophic streamfunctions and we dynamically interpolated the data fields with the Havard Open Ocean Boundary Model. Local wind forcing, topographic effects and free non-linear evolution of the meso-scale eddy fields are intercompared. The data shows very different horizontal and vertical structures between mid-summer and winter-spring time conditions but with patterns persisting over two or three months in each season.

MESO-SCALE HYDROGRAPHIC CHARACTERISTICS IN THE NORTHEASTERN MEDITERRANEAN - NOVEMBER 1985

E. Ozsoy, M.A. Latif and U. Unluata

Institute of Marine Sciences, METU, Erdemli, Icel, Turkey

A meso-scale survey of high resolution has been carried out in the northeastern quarter (north of 34 deg. N and east of 28 deg. E) of the Levantine Sea by the R/V BILIM during 1-12 November 985. A total of 54 deep stations with spacings of 1/2 degree latitude and longtitude were occupied during the survey. Hydrographic casts at the stations were down to a maximum depth of 1000 m with vertical resolution using a Seabird Model SBE9 CTD profiler equipped with an oxygen sensor. The volume of data has been edited and processed such that original data failing consistency checks are eliminated. The remaining data have been despiked and filtered. Derived quantities such as mixed layer depth, heat and salt storage in the mixed layer and in the upper layers and salt volumes in the subsurface salinity minimum and maximum layers. Turner double-diffusive stability index and Brunt-Vaisala frequency are calculated from the data. Overall hydrographic features and a summary of important results are presented.

In general, a mixed layer of 20-50 m thickness is found at the surface. Immediately below the mixed layer, an abrupt drop in salinity marks waters of Atlantic origin. At intermediate depths, a maximum in the salinity profiles indicates the presence of Levantine Intermediate Water (LIW). These characteristics are similar to those found by Wust (1961) and Miller et. al. (1970).

The LIW core (maximum salinity: 39.1) is found maximally to the south of Antalya and NW of Cyprus where is seems to be trapped in anticyclonic eddies.

Just further to the south and also within the cyclonic eddy located near Rhodes, upwelling is indicated by the upward lifting of isohalines (isopycnals) by several hundreds of meters. In fact, below a thin surface layer, temperature and salinity are more or less uniform since the LIW core and minimum salinity waters are destroyed by upwelling. A secondary center of high density is located to the east of Cyprus. The minimum salinity water (minimum 38.3) below the mixed layer (at 40-50 m dept) is found most abundantly to the SW of Cyprus and is partially advected towards the Gulf of Antalya. In the west of Cyprus, the zones of minimum salinity subsurface water and LIW are separated by a front which extends in an E-W direction. Near this front, interleaving is observed in the salinity profiles.

References

Miller, A.R., Tchernia, P., and Charnock, H. (1970), Mediterranean Sea Atlas of Temperature, Salinity, Oxygen Profiles and Data from Cruises of R.V. Atlantis and R.V. Chain, WHOI Atlas Series 3, Woods Hole, Mass., WHOI.

Wust, G. (1961) On the Vertical Circulation of the Mediterranean Sea, J. Geophys. Res., 66: 3261-3271.

MESO-SCALE CIRCULATION STUDIES BASED ON SURVEYS OF 1968 AND 1983

E. Ozsoy, M.A. Latif, T. Oguz, and C. Saydam

Middle East Technical University, Institute of Marine Sciences
P.O. Box 28, Erdemli, ICEL, Turkey

Recent hydrographic coverage of meso-scale sampling resolution in two independent sureys of 1968 (NATO) and 1983 (METU) in the northeastern Mediterranean, is utilized to give preliminary descriptions of meso-scale features. Objectively analysed scream function maps at different depths indicate a series of gyres (≈ 100 km diameter each) are ordered along the analysis region. In both cases persistent cyclonic and anticyclonic gyres were found to the SE of Rhodes and South of the Gulf of Iskenderun respectively. Hydrographic property distributions conform with the circulation features. A prominent upwelling and radial distribution of LIW is found near the SE Rhodes gyre. Strong downwelling is seen near the edges of the Gulf of Iskenderun eddy.

For both experiments, the available potential energy density for the whole region was about 20 times larger than the baroclinic part of the knetic energy. Vertical modal decompositions show the first few modes to be the most important.

MESO-SCALE CIRCULATION FEATURES IN THE NORTHEASTERN MEDITERRANEAN - NOVEMBER 1985

E. Ozsoy, T. Oguz and U. Unluata

Institute of Marine Sciences, METU, Erdemli, Icel, Turkey

Density profiles at 54 deep stations in the northeastern Mediterranean (north of 34°N and east of 28°E) have been analyzed. The original data were obtained with a Seabird Model SBE9 CTD profiler on board the R/V BILIM. The maximum depth of the casts was 1000 m, with vertical resolution of less than 1 m, 24 Hz Sampling Upcasts were used in the analyses since only upcasts are available at a majority of the stations.

The original data were edited such that data failing consistency checks were eliminated, and the valid profile data were despiked and filtered. The density profiles were then used to calculate geostrophic streamfunction at standard depths assuming a level of no motion at 900 m. Objective analysis techniques (Bretherton et. al., 1976) were used to construct maps of optimally interpolated streamfunction estimates and relative estimation error.

At the surface, an intense cyclonic eddy is found SE of the Island of Rhodes in the general area that had been reported earlier by Ozturgut (1975), Anati (1984) and Ovchinnikov (1984). Breakup eddies from this main circulation extend towards the Gulf of Antalya and further to the south. Another cyclonic eddy is detected at the NE tip of the Island of Cyprus. On the other hand, anticyclonic eddies are found in the Cicilian channel and its exit to the Gulf of Antalya. Considerable vertical structure is displayed by the analyses made at different depth. Jet-like features at the surface coincide with frontal zones west of Cyprus and near the shelf edge at the Gulf of Iskenderun.

At the westernmost cyclonic eddy centers, upwelling is observed. Intermediate depth salinity maximum (LIW) is found at the center of the anticyclonic eddy located ot the NW of Cyprus. The advection of the subsurface salinity is strongly correlated with the circulation patterns.

References

Anati, D.A. (1984), A Dome of Cold Water in the Levantine Basin, Deep-Sea Res., 31 (10): 1251-1257.

Bretherton, F.P., Davis, R.E. and C.B. Fandry (1976), A Technique for Objective Analysis and Design of Oceanographic Experiments Applied to MODE-73, Deep-Sea Res., 2: 559-582.

Ovchinnikov, I.M. (1984), The Formation of Intermediate Water in the Mediterranean, Oceanology, 24 (2): 168-173.

Ozturgut, E. (1975), The Sources and Spreading of the Levantine Intermediate Water in the Eastern Mediterranean, SACLANT ASW Research Center Memorandum SM-92, La Spezia, Italy, pp. 45.

SEA SURFACE EXPRESSION OF MESO-SCALE EDDIES IN THE NORTHEASTERN MEDITERRANEAN - NOVEMBER 1985

E. Ozsoy, C. Saydam, I. Salihoglu and U. Unluata

Institute of Marine Sciences, METU, Erdemli, Icel, Turkey

The northeastern corner of the Mediterranean (north of 34°N and east of 28°E) was surveyed by the R.V/BILIM during 1-12 Nov. 1985. Hydrographic casts were made at 54 deep stations using a Seabird model SBE9 CTD profiler. Along the ship course between these stations, the CTD instrument was immersed in an on-board overflow tank through which sea water was pumped at constant rate. The surface temperature, salinity and density were sampled continuously in real-time with an averaging period of 1 minute for each recording. In addition, water samples were collected for the analysis of nutrients. The samples were then analyzed with an on board Technician II autoanalyzer with single channel colorimeter for the determination of phosphate concentration. The ship position was also monitored continuously using mainly satellite navigation, or dead reckoning when fixes were not available.

In processing the large volume of sea surface data, the original time series were first transposed to ship position coordinates making use of the available fixes. Positioning data with obvious error were either corrected or eliminated based on checks for maximum calculated ship speed and total distance travelled. Ship positions between consecutive fixes were interpolated. Then the surface data along the ship course were projected onto straight paths connecting stations and filtered to eliminate noise or originating from ship roll and wake, interference of microscales and other sampling errors. Contours of temperature, salinity, density and phosphate concentration were then passed manually through intercepts determined from

the processed data.

In the surface temperature distribution, a series of eddies are identified with cold centers to the SE of Rhodes Island (19°C.) in Antalya Bay (21°C) and at the NE tip of the Island of Cyprus (21°C) and warm centers (23°C) to the NW of Cyprus. The SE Rhodes eddy is the most intense among these, with two associated breakup eddies located S of the Gulf of Anatalya. Similar eddies were also found by Ozturgut (1976), Anati (1984) and Ovchinnikov (1984) at different times. Frontal crossings with gradients occasionally exceeding 1°C/10 km and displaying meanders are identified at the edges of some of these eddies. Part of the frontal zone extends parallel to the coast and separates coastal and open sea water masses. The observed surface features are closely correlated with the deeper circulation. In the westernmost eddy center considerable upwelling occurs as manifested by the deep station profiles, increased surface turbidity and visual sightings of seabirds, squids and dolphins. Light penetration measurements indicate higher extinction coefficients (0.2-0.5 m^{-1}) the upwelling zone SE of Rhodes as compared to other regions such as the warm core eddy located NW of Cyprus (0.05-0.1-1).

Features that are typical of oceanic fronts (Bowman and Esaias, 1978) are also identified as follows: Along the frontal zones, salinity is reduced through frontal mixing with the underlying minimum salinity waters. A significant increase in phosphate concentration occurs near the fronts, although it is uniformly distributed elsewhere and only increases with depth. Strong interleaving is observed in the T-S diagrams near the fronts.

References

Anati, D.A. (1984), A Dome of Cold Water in the Levantine Basin, Deep-Sea Res. 31 (10): 1251-1257.

Bowman, M.J. and W.E. Esaias (eds.) (1978), Oceanic Fronts in Coastal Processes, Spring-Verlag, Berlin.

Ovchinnikov, I.M. (1984), The Formation of Intermediate Water in the Mediterranean, Oceanology, 24 (2): 168-173.

Ozturgut, E. (1976), The Sources and Spreading of the Levantine Intermediate Water in the Mediterranean, SACLANT ASW Research Center Memorandum SM-92, La Spezia, Italy, pp.45.

RESIDUAL FLOWS AT KASSOS STRAIT

E.J. Papageorgiou

National Center for Marine Research

GR-16604, Hellinikon, Greece

ABSTRACT

Water flow characteristics in the Crete-Kassos Strait are studied. The data were collected in spring 1986 using Aanderaa recording current meters (model RCM-4S) from three depths at two stations.

Residual water circulation patterns show that there is an inflow of water to the Aegian basin from the upper layer (50 m depth) and the deep layer (700 m depth). In the intermediate layer (700 m depth) there is a water flow towards west/southwest.

HYDROGRAPHIC CHARACTERISTICS AND CIRCULATION OF THE EASTERN MEDITERRANEAN WATERS

M.A. Said

Institute of Oceanography & Fisheries, Alexandria, Egypt

Classical observations carried out during March 1977 have been analyzed in order to explain the large variability of the water masses and of the surface curculation occurring in the eastern Mediterranean Sea. Three water masses were identified: (1) the near-surface water mass of Atlantic origin between 0-150 m depth, (2) the intermediate water mass between 200-600 m and (3) the deep water mass between 800-3000 m.

The horizontal distribution of the water characteristics at the surface, 50 m and 100 m levels are approximately the same. The outstanding features of the surface layer salinity in the Levantine sea is the presence of a wide area covered with salinity higher than 39.00. The Levantine Intermediate Water, characterized by the maximum salinity, forms in the central, the northern and the south-eastern parts of the Levantine basin where at these areas the winter convection reaches the depth of maximum salinity. The water temperature and salinity slightly decrease with increasing depth to reach the values 13.60°C and 38.70 respectively near the bottom.

ESTIMATION OF THE VERTICAL CURRENT VELOCITY IN THE EASTERN MEDITERRANEAN

M.A. Said

Institute of Oceanography and Fisheries

Alexandria, Egypt

This paper deals with a simple model of calculating the vertical velocity component of sea currents. The vertical components of the current velocities in the Eastern Mediterranean Sea were calculated using the equation of continuity at different levels during summer and winter seasons. The values of the vertical velocities at these levels were of order of 10^{-4} cm/sec. The maximum values ($5\text{-}10 \times 10^{-4}$ cm/sec) were observed at a depth of 300 m and were usually situated in the near-shore zone.

Areas of water rising coincide with the center of the Levantine cyclonic gyre. Sinking is found in the Libyan Sea and the borders of the cyclonic gyres.

THE DYNAMIC STRUCTURE AND ITS SEASONAL EVOLUTION IN THE EASTERN MEDITERRANEAN

S.H. Sharaf El-Din and A.H. El-Gindy

Faculty of Science, University of Alexandria, Alexandria, Egypt

The objective of this paper is to discuss the following problems:

1. The horizontal geostrophic circulation and its seasonal variations in the Eastern Mediterranean (from the Eastern Sicilian Straits to the eastern side of the Levantine basin). The dynamic topography at the sea-surface and at 250 db surface are taken relatie to 1000 db.
2. Calculation of absolute geostrophic current in the Ionian Sea, using data of May 1969, by the B-spiral method.
3. The vertical structure of currents obtained by both the geostrophic method and direct mesurements, at vertical sections near the Eastern Sicilian Straits and north of the Ionian Sea, and at some positions in Cretean and Levantine Seas.
4. The study of the water exchange systems through Otranto Strait, Sicilian Straits, Cretean Sea Straits and between Ionian and Levantine basins.

In this analysis, the hydrographic data taken in period from 1947 to 1972 (about 5 0 cruises in the four seasons) were used. The vertical stability of the water column at the different stations were examined and the temperature (or salinity) was corrected, on the basis of the surroundings sampling, whenever a vertical instability was detected.

The result shows that the surface current in the north of the Ionian Sea has a cyclonic eddy in all seasons, but in Autumn no data were available. In the south of the Ionian Sea, an anticyclonic gyre was found in Spring and Summer and no data were available in Winter and Autumn.

The Levantine Sea has a cyclonic eddy in the north, all year around, while in south an anticyclonic motion is observed in all seasons except in Autumn when an anticyclonic gyre was found in the central Levantine between two cyclonic eddies in the south and the north. The cyclonic motion in the south Levantine in Autumn is a favourable condition for Levantine water formation.

In the Aegean Sea, a cyclonic eddy exists in the Kio basin, while in the Cretean Sea, an anticyclonic gyre, found in Spring, is reversed to become cyclonic in Summer.

The intermediate water circulation, indicated by geostrophic current at 250 decibars and maximum salinity distribution, agrees with the previous studies, with a cyclonic eddy in the Levantine basin, a westward flow to the Ionian Sea, and an inflow to the Adriatic Sea and the Sicilian Straits. The systems of water exchange through Otranto and Sicilian Straits, deduced from our results, agree with that previously given by other authors, while the exchange through the different Cretean Sea Straits with the Ionian and Levantine Seas is variable in the different seasons.

OBSERVATIONS ON VERTICAL PROCESSES IN THE NW LEVANTINE BASIN

A. Theocharis, D. Georgopoulos, and G. Zodiatis

National Centre for Marine Research, Aghios Kosmas
GR- 16604 Helliniko, Greece

Two events of vertical processes below 400 dbars have been observed in limited areas of the NW Levantine basin. The processes seems to extend below 1000 dbars and the features might be characterized as remainders of formation processes occurred some time ago.

DISTRIBUTION OF THE LEVANTINE INTERMEDIATE WATER IN THE NW LEVANTINE AND SE AEGEAN

A. Theocharis, D. Georgopoulos, G. Zodiatis, and S. Christianides

National Center for Marine Research, Aghios Kosmas, GR- 16604 Helliniko, Greece

During March-April 1986 the LIW has been identified over the areas of NW Levantine and SE Aegean. The T-S characteristics of the core layer were 15.5°C and 39.0. Differences in the structure and the characteristics of the LIW layer have been observed between the two areas of investigation. The communication between them through the eastern side of Kassos strait seems to be good within the LIW layer (0-500 dbars).

APPLICATIONS OF LINEAR INVERSE METHODS TO EASTERN MEDITERRANEAN DATA

Eli Tziperman and Artur Hecht

Massachusetts Institute of Technology, Cambridge, MA 02139, U.S.A.

A finite difference multi-level inverse model is applied to quasi-synoptic data from the Eastern Mediterranean. The emphasis of the analysis is on second order physics, the main purpose is to find whether one can calculate diffusion coefficients and vertical velocities from the data. The data consist of 27 CTD in a horizontal grid, with 1/2 degree spacing in latitude and longitude. It is part of an extensive data set collected by IOLR off the coast of Israel. The models' grid follows the stations locations horizontally and has high vertical resolution--30 levels with variable vertical spacing. The thermal wind relation and the continuity equation are used to express the 3-dimensional velocity field as a combintion of known relative velocities, given in terms of the density field, and unknown reference velocities. There are three unknown reference velocities and possibly an additional unknown diffusion coefficient at each station loation. Advection-Diffusion equation for the salinity and temperature fields are evaluated at several levels for each station. Thus giving a set of equations for the diffusion coefficients and reference velocities. Additional constraints are derived from the condition of no normal velocity into the bottom. Results and maps of the velocity field are shown at various depths.

ON THE DISTRIBUTION OF THE ATLANTIC WATERS IN THE LEVANTINE

U. Unluata, E. Ozsoy, and M.A. Latif

Institute of Marine Sciences, METU, Erdemli, Icel, Turkey

Distribution and circulation of the North Atlantic Water (NAW) in the Levantine Basin of the Eastern Mediterranean is examined in the light of both the past and recent data. Particular attention is given to the circulation of the NAW in the Northern Levantine and the recent data obtained during the November, 1985 cruise of R/V BILIM is utilized for this purpose.

It is found that the meso-scale eddies that are aligned along the Turkish coast, and the semi-permanent gyre located at the western end of the region play a crucial role on the fate of NAW. The sub-surface salinity minimum, which is the signature of NAW in summer-fall is completely or nearly lost at the inner edges of the cyclonic eddies- yre. This is attributed to intense upwelling of the saline waters below the salinity minimum. NAW penetrates primarily from the region to the west Cyprus and appears to meander and breakup into lenses at the northernmost reaches of the Levantine. Only a very diluted amount of NAW in the northeastern Levantine reaches Aegean through the strait between Turkey and Rhodes.

OBSERVATIONS OF EDDY VARIABILITY DURING POEM-0-85 SATELLITE SEA SURFACE TEMPERATURE ANALYSIS

G. Vivanti, F. Parmiggiani, and N. Pinardi

J.M.G.A.-CNR, Modena, Italy

Polar-orbiting satellite (NOAA-9) AVHRR data have been analyzed in order to produce sea surface temperatures for the whole region of the Eastern Mediterranean during the Intensive Field Period surveys of POEM-0-85.

Split-window algorithms have been used to retrieve Sea Surface Temperatures (SST). In order to identify the thermal frontal structures, coloured SST maps have been produced above cloud-free regions of the Eastern Levantine Basin. The informations are given at 1 Km resolution so that eddy resolving models of the Eastern Mediterranean Circulation could use directly the satellite surface data. Qualitatively, the pictures show a strong surface eddy activity in the whole Eastern basin and a few upwelling centers are also noticeable.

UNESCO REPORTS IN MARINE SCIENCE

No.	Year
40 Human induced damage to coral reefs Results of a regional Unesco (COMAR) workshop with advanced training Dipoegoro University, Jepara and National Institute of Oceanology Jakarta, Indonesia May 1985 English only	1986
41 Caribbean coastal marine productivity Results of a Planning Workshop at Discovery Bay Marine Laboratory, University of the West Indies Jamaica, November, 1985 English only	1986
42 The application of digital remote sensing techniques in coral reef, oceanographic and estuarine studies. Report on a regional Unesco/COMAR/GBRMPA Workshop Townsville, Australia August 1985 English only	1986
43 Quaternary coastal geology of West Africa and South America. Papers prepared for the INQUA-ASEQUA Symposium in Dakar, April 1986 Available in English and French	1987

Cont'd on inside of back cover

UNESCO REPORTS IN MARINE SCIENCE

Title of numbers which are out of stock

No.	Year
3 Benthic ecology and sedimentation of the south Atlantic continental platform Report of the seminar organized by Unesco in Montevideo, Uruguay, 9-12 May 1978	1979
7 Coastal ecosystems of the Southern Mediterranean; lagoons, deltas and salt marshes, Report of a meeting of experts, Tunis, 25-27 September 1978	1979
11 Programa de Plancton para el Pacífico Oriental Informe final del Seminario-Taller realizado en el Instituto del Mar del Perú, El Callao, Perú, 8-11 de septiembre de 1980	1981
12 Geología y geoquímica del margen continental del Atlántico Sudoccidental Informe final del Taller de Trabajo organizado por la Unesco en Montevideo Uruguay, 2-4 de diciembre de 1980	1981
13 Seminario Latinoamericano sobre Enseñanza de la Oceanografía Informe final del Seminario organizado por la Unesco en São Paulo, Brasil, 17-20 de noviembre de 1978	1981
17 The coastal ecosystems of West Africa: coastal lagoons, estuaries and mangroves A workshop report, Dakar, 11-15 June 1979	1981