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Joint Meeting of the Task Team on Implications
of Climatic Changes in the Mediterranean and
the Co-ordinators of Task Teams for the Caribbean,
South-East Pacific, South Pacific, East Asian Seas
and South Asian Seas Regions

Split, 3-8 October 1988

# REPORT OF THE MEETING

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## Background

1. In spite of uncertainties surrounding predicted climatic changes, greenhouse gases seem to have accumulated in the atmosphere to such a level that the changes may have started already and their continuation may now be inevitable.

2. The environmental problems associated with the potential impact of expected climatic changes may prove to be among the major environmental problems facing the marine environment and adjacent coastal areas in the near future. Therefore, in six regions covered by the UNEP Regional Seas Programme (Mediterranean, Caribbean, South Pacific, South Asian Seas, South-East Pacific and East Asian Seas), Task Teams have been established and charged with the preparation of studies on the possible impact of climatic changes on the ecological systems as well as on the socio-economic structures and activities.

3. The intended objectives of the studies were:

(a) to examine the possible effects of the sea level changes on the coastal ecosystems (deltas, estuaries, wetlands, coastal plains, coral reefs, mangroves, lagoons, etc.);

(b) to examine the possible effects of temperature elevations on the terrestrial and aquatic ecosystems, including the possible effects on economically important species;

(c) to examine the possible effects of climatic, physiographic and ecological changes on the socio-economic structures and activities; and

(d) to determine areas or systems which appear to be most vulnerable to the above changes.

4. The regional studies were intended to cover the marine environment and adjacent coastal areas influenced by or influencing the marine environment.

5. The studies were expected to be based on:

(a) the best available existing knowledge and insight into the problems relevant to the subject of the study;

(b) assumptions accepted at the UNEP/ICSU/WMO International Conference in Villach, 9-15 October 1985, i.e. increased temperature of 1.5-4.5$^{\circ}$ C and sea level rise of 20-140 cm before the end of the 21st century (for the purpose of these studies temperature elevation of 1.5$^{\circ}$ C and sea level rise of 20 cm by the year 2025 were accepted, with the understanding that these estimates may have to be revised on the basis of new scientific evidence); and

(c) several detailed case studies, which would constitute the substantive annexes of the studies.

6. In order to review the results of the studies prepared by the Task Teams, a joint meeting of the Mediterranean Task Team and of the co-ordinators of the other five Task Teams was organized in Split (3-8 October 1988) by the Co-ordinating Unit for the Mediterranean Action Plan, in co-operation with the Oceans and Coastal Areas Programme Activity Centre of UNEP. The list of participants, all attending in their personal capacity, is attached to this report (Annex I).

7. The meeting was hosted by the Priority Actions Programme Regional Activity Centre of the Mediterranean Action Plan.

8. This document contains the report of the meeting.

Agenda item 1: Opening of the meeting

9. Mr. A. Pavasovic, Director of the Priority Actions Programme Regional Activity Centre, welcomed the participants on behalf of the Centre and briefly reviewed the activities of the Centre, emphasizing those related to the subject of the meeting.

10. Mr. V. Simoncic, Deputy Director of the Department of Planning and Environmental Protection at the Committee for Building, Housing, Public Works and Environment of SR Croatia (Yugoslavia), and Mr. D. Krstulovic, representative of the Split municipal authorities, greeted and welcomed the participants. Both of them expressed the keen interest of national and local authorities in the deliberations of the meeting and their satisfaction with the fact that Yugoslavia, and Split in particular, had been selected as the venue of the meeting.

11. Mr. S. Keckes, Director of the Oceans and Coastal Areas Programme Activity Centre, welcomed the participants on behalf of the Executive Director of UNEP and emphasized the great importance attached by UNEP to the work carried out by the Task Teams. Since the environmental problems associated with the potential impact of expected climatic changes may prove to be in the near future among the major environmental problems facing mankind, UNEP, as the organization co-ordinating the response of the United Nations systems to environmental problems, obviously could not neglect the issue. UNEP's strategy is based on a three-pronged approach:

(a) Improved knowledge about the causes and the expected course of the climatic change. Although this approach is recognized as one of the bases of UNEP's strategy, UNEP is not and does not intend to be in the forefront of support to scientific research and monitoring which is expected to lead to a better understanding of the problem. The leading role in this field belongs to scientists and scientific programmes, such as the World Climate Programme and the International Geosphere-Biosphere Programme, both supported but not led by UNEP.

(b) Analysis of the potential impact of expected climatic changes on ecosystems and on socio-economic structures and activities. The impact analyses are at present in the very centre of UNEP's strategy aiming at identification of problems which may be expected from the predicted climatic changes in various parts of the world. The lack of adequate data and uncertainties concerning the predicted magnitude of climatic changes, in particular of regional and site-specific changes, seriously hamper the development of these analyses. Therefore they are intended to be developed through an open-ended iterative process, taking advantage of the new data and improved accuracy in prediction of climatic changes.

(c) Development of policy options and management measures which may avoid or mitigate the negative consequences of expected climatic changes. In spite of uncertainties surrounding the issue of climatic changes, the consideration of policy options and the design of management measures cannot wait until all the answers have been obtained. Attention should concentrate, however, on areas which are best known or which require urgent action. The adoption of the Montreal Protocol on control of some greenhouse gases is an example of UNEP's successful approach in this field.

12. In his closing remarks, Mr. S. Keckes invited the meeting:

- to review critically the impact studies prepared by the Task Teams;
- to identify the gaps in present knowledge; and
- to formulate recommendations for future activities which may improve the assessment of impacts of expected climatic changes and assist in development of policy options and management measures for mitigation of the expected impacts.

Agenda item 2: Organization of the meeting

13. Mr. L. Jeftic, Senior Marine Scientist of the Co-ordinating Unit for the Mediterranean Action Plan and Co-ordinator of the Mediterranean Task Team, was proposed and elected as the Chairman of the meeting.

14. The meeting decided to work in plenary sessions only.

15. A small drafting group was elected to prepare the draft recommendations for the meeting's consideration and eventual adoption.

Agenda item 3: Adoption of the agenda

16. The agenda of the meeting, proposed by the secretariat, was adopted with slight adjustments (Annex II).

17. Agenda items 4-10 reflect the oral presentation of communications, supported by documents available to the meeting (Annex III).

18. The summaries of the presentations, as prepared by their authors, and including references to major comments offered during the discussions which followed each presentation, are contained in paragraphs 19-149 of this report.

Agenda item 4: Implications of climatic changes in the Mediterranean region

Future climate of the Mediterranean Basin with particular emphasis on changes in precipitation (T.M.L. Wigley)

19. Global and hemispheric mean temperature changes show an overall warming of about 0.5° C over the past 100 years. These changes have not been continuous nor have they been spatially uniform. For example, over 1947-86, while the Southern Hemisphere warmed substantially, the Northern Hemisphere mean temperature changed little. Over this period the North Atlantic, Europe and the Mediterranean Basin area cooled. As the global climate has warmed, greenhouse gas concentrations have increased. To model the greenhouse effect, one must take into account both the climate sensitivity (expressed as the equilibrium global-mean temperature change due to a $CO_2$ doubling; value thought to be in the range 1.5-4.5° C) and the delaying effect due to oceanic thermal inertia. Between pre-industrial times and today, the greenhouse gas forcing has been equal in magnitude to increasing the sun's output by about 1 per cent. The implied warming over the past 100 years lies in the range 0.4-1.1° C. The observed warming is compatible with this model prediction, but this does not prove conclusively that the models are correct.

20. Predicting future climatic change can be considered as a global-mean problem and at the regional level. Future greenhouse gas concentrations will probably lead to a doubling of the effective carbon dioxide level by 2030. The corresponding global-mean warming by 2030 (i.e. 1985-2030) is expected to lie in the range 0.5-2.0° C, a considerable acceleration over past changes even if the lower limit is considered. Regional changes in all climatic variables will occur. These details can, in principle, be estimated using General Circulation Models (GCMs). However, current models cannot simulate the regional details of today's climate reliably. Projections using these models must therefore be treated cautiously. When results from four independent models are reviewed they show the following:

(a) Warming of about 3.5° C in all seasons by about 2050. This value is probably close to an upper limit, because the models considered all have high climate sensitivity. The lower limit would be around 1.2° C.

(b) Very few clear indications of precipitation changes. However, the data suggest increased winter precipitation in the north and decreased winter precipitation in the south, which could mean drying of the southern portion of the Mediterranean Basin relative to the north.

21. Physical arguments and information about current climatic conditions can be used to supplement and improve on GCM output. Qualitatively, the indications are equivocal and further analysis of past data is required in order to quantify relationships between broad-scale and regional-scale variables.

22. An increase in global-mean (eustatic) sea level will almost certainly accompany a global warming. Over the past 100 years global-mean sea level is thought to have increased by 10-15 cm, with some evidence of a faster rate of increase since 1930. However, there are considerable difficulties in interpreting the tide gauge data on which the above estimate is based, and there is still a small probability that global-mean sea level has not changed over the past 100 years. This uncertainty is consistent with our uncertainty regarding the causes of past sea level change. Thermal expansion of the oceans has probably caused a 2-5 cm rise and the melting of small mountain glaciers has probably added another 3-5 cm. The contribution from the large ice sheets of Greenland and Antarctica is unknown. Changes in these ice masses could have either increased or decreased the sea level. By differencing, using the 10-15 cm best estimate of total rise, it appears that they have contributed a small positive amount. Future sea level rises have most recently been estimated at the UNEP meeting in Norwich, September 1987. The best estimate of change between 1985 and 2030 is 14-22 cm, most of which comes from thermal expansion and the melting of small mountain glaciers. A rise anywhere in the range 0-50 cm is, however, possible.

23. There is a significant rise commitment, however; similar to the warming commitment which results from oceanic thermal inertia. For example, if greenhouse gas concentrations stopped increasing in the year 2030, sea level would continue to rise, probably at a similar rate for many decades. Since the warming would continue, mountain glaciers would continue to melt, and thermal expansion of the oceans would continue for many centuries.

Isopleth maps on mean monthly and annual data of the GISS-GCM programme for the Mediterranean (summary prepared by T.M.L. Wigley on the basis of the paper submitted by W. Bach)

24. The characteristics of a number of Global Circulation Models (GCMs) are summarized. Changes in temperature, precipitation and evaporation/evapotranspiration as projected by the Goddard Institute for Space Studies (GISS) GCM are presented for January and July and for the annual mean. The first two variables are given in more details in the paper by T.M.L. Wigley on a seasonal basis. T.M.L. Wigley also gives results from three other GCMs. T.M.L. Wigley pointed out that, of all available models, the GISS model is probably the least reliable, although no individual model results can be accepted as reliable projections at the regional scale.

Predictions of relative coastal sea level change in the Mediterranean based on archaeological, historical and tide gauge data (N. Flemming)

25. The presentation included an analysis of all known archaeological sites in the Mediterranean giving accurate estimates of relative sea level change and an empirical correlation between archaeological data and tide gauge data for the area of the Aegean and Ionian coasts of Greece. The apparent rate of earth movement decreases with longer periods of observation because there are periods of cessation or reversal of direction. Thus it is not reliable to try and extrapolate from short tide-guage records to predict local movements for periods of 50-100 years in the future; nor is it reliable to interpolate from archaeological records of 1000-2000 years back to 50-100 years.

26. The predicted possible rise of eustatic sea level in the next 50 years is at a rate of 3-20 mm/year. Vertical earth movements in the Mediterranean commonly occur at a rate of 1-5 mm/year averaged over thousands of years, and 3-20 mm/year averaged over 15-20 years. It follows that in the future the economic cost of protecting or abandoning structures or land on the Mediterranean coast will depend strongly upon the local land movement. Where land is subsiding, the net relative change will be approximately twice that of the global eustatic rise of sea level; where land is rising, the relative change will be significantly reduced. It is therefore practical to try and construct a regional map of the Mediterranean coast showing the areas which are rising or subsiding in mm/year.

27. There are several geological methods for identifying palaeo-shorelines, but most of these are only accurate to 1 or 2 metres of vertical resolution, and over time-scales of many thousands of years. For timescales of a few hundred to 2000 years, coring of alluvial sediments and observations of solution notches are useful, provided that the latter can be dated. However, the most widely distributed data set consists of observations of coastal archaeological sites, providing estimates or rates of vertical change at 335 locations. Photographic evidence was shown to illustrate the types of structures which indicate previous sea levels from various archaeological periods, ranging from 1400 AD to 10,000 BP. As explained above, the rates of change indicated from these sites will be an under-estimate of the most probable rate of change in the next 50 years at some locations. The data also show that there is extreme variability between the rates and directions of change for sites which are separated by only a few tens of km in the more tectonically active areas of the Mediterranean.

28. During the last 100 years there have been tide gauges installed at 56 different sites for varying lengths of time over 15 years. Only 30 tide gauges are currently operated producing published data, of which 15 are in Greece, 5 in Yugoslavia, and 3 in Israel. Long tide gauge records of several decades provide the best basis for forecasting local vertical earth movements, but it is not possible to extrapolate the prediction laterally because of variations in tectonic character and alluvial compaction and subsidence. The tide gauges therefore provide a method for calibrating the archaeological data, and for deriving the frequency characteristics of the spectrum of vertical earth movements. However, the archaeological data give by far the most detailed picture of the regional distribution of rates of each movement.

<u>Impact of a future rise in sea level on the coastal lowlands of the Mediterranean (S. Jelgersma and G. Sestini)</u>

29. Nearly all the Mediterranean coastal lowlands and their shorelines are at present experiencing damage from erosion and inundation during storms. Various processes contribute to this situation. In the deltaic basins (like the Po and the Nile) surface lowering is due to tectonic subsidence and compaction of soft sediments. Together with a slight rise in sea level this has produced a relative rise in sea level.

30. More important are man's economic and social activities that interfere with the natural processes and lead to shoreline erosion. Also, the construction of dams and reservoirs in rivers has reduced considerably the sediment supply to beaches and deltas. Locally the withdrawal of groundwater has caused a land subsidence of several cm/year.

31. The economy of some countries is highly dependent on their coastal environment. The coastal lowlands house important harbours, industries and cities, rich agricultural land and beach resorts. A future rise in sea level is likely to accelerate erosion and inundation. It is recommended that organizational and legal instruments, to control coastal development, land reclamation and groundwater exploitation, be developed; lowlands be analyzed and zoned in high, medium and low risk categories, in order to appropriately site new developments.

<u>Change in vegetation and land-use by the year 2050; a prospective study (H.N. Le Houérou)</u>

32. In the present prospective study a mean annual temperature increase of the order of magnitude of $3^{o}$ C was assumed. Presently available models do not provide any reliable estimate on the seasonal change in temperature. Whether the change occurs mainly in winter or in summer, or is spread evenly over the whole year, will obviously have quite different and significant impacts on natural vegetation as well as on the nature and patterns of crop cultivation.

33. The model scenarios available in late 1987 do not provide any reliable information on changes in rainfall. According to some, the rainfall would slightly increase in the Mediterranean while according to others it would decrease. Such changes would, no doubt, have significant impacts, depending on the magnitude of the change and its seasonal distribution. Therefore it was assumed that there will be no significant change, either in the amount of mean annual rainfall or in its seasonal distribution pattern.

34. As a consequence of these assumptions mean annual potential evapotranspiration would increase by 180-220 mm, and would be evenly spread over all seasons, resulting in an increase of about 17 mm/month. The impact on natural vegetation and crops would be slight, but it could be significant in areas where climatic or soil conditions are marginal. One may also expect a slight shift in vegetation belts due to increasing aridity and an expansion of desertification at the margins of the Sahara and Near-Eastern deserts. This will happen anyway, as a result of exponential demographic growth, irrespective of climatic change; the climatic change will only exacerbate the phenomenon.

35. Change in winter temperature would have a very significant impact in areas where this factor is limiting to plant growth. It would, for instance, increase the areas of cultivation of cold-sensitive crops such as olive, citruses, winter cereals, vegetables. There would be a slight upward and northward shift in vegetation belts.

36. The economic impact may be quite significant. For instance, if citruses could be grown over sizeable areas in southern Europe it would probably close the market for the import of these products from Northern Africa and the Near East, which in turn would probably shift large areas of irrigated land to more tropical crops that could not be grown in Europe, such as banana.

37. The change in vegetation and crop patterns induced by the rise in temperature will be moderate when compared with the change induced by exponential population growth in the south and east of the Mediterranean Basin. The twelve developing countries of the eastern and southern Mediterranean (including Iran and Iraq) had a total population of around 30 million people at the beginning of this century, they reached almost 100 million by 1950, rising to 185 million in 1975, and numbering 275 million today. By the year 2000 they will reach a figure of 400 million, irrespective of any possible corrective means that might be taken to curb the population growth. If the present growth remains unabated for the next generation the total population of these areas may reach the figure of 1.95 billion by the year 2050. Any forseeable change in temperature would then have an almost negligible impact on the environment when compared to the impact of this demographic explosion. The human population growth and its consequences on vegetation, soil, water, erosion and sedimentation will thus exacerbate the present situation of biorhexy in the south of the Basin. Man is thus becoming a major geological agent in this part of the world.

Implications of climatic change on land degradation in the Mediterranean (A.C. Imeson and I.M. Emmer)

38. The impact of climatic change on land degradation in the Mediteranean region will be most serious in areas where soils have an inherently high erodibility, in regions already under environmental stress and in drier regions. Forested areas will also be adversely affected by the increased frequency of fire. Direct impacts on degradation resulting from changes in the magnitude and distribution of precipitation could be extremely important but no information is available concerning precipitation changes. An increased temperature, by influencing the mineralisation of organic matter and the form of organic soil material, the water balance, the salt balance and the soil temperature will impart to the soil an increased susceptibility to physical degradation. The processes responsible for this and the implications for erosion are discussed in detail. Special attention is given to the effect of organic matter on soil stability and infiltration in areas having silty and sandy soils. Also predictable are the poor physical properties likely to be caused by an increase in the area affected by clay dispersion. Gully erosion and piping could spread into areas that develop slightly drier conditions as a result of quantitatively small changes in the chemical composition of the soil solution.

39. To assess the impact of climatic change, relationships should be established between climatic parameters and "climate sensitive" processes. Threshold conditions should be identified by laboratory experiments and by field investigation along climatic gradients. Two examples of attempts to do this are described for areas in Israel and Spain.

40. The site-specific impact that climatic change will have on erosion will mean that the general trends towards degradation will not always occur, nor will they always have the same impact. Local studies will have to be made to establish exactly how site specific factors determine the impact of general trends.

Physical oceanography aspects and changes in circulation and stratification (M. Gacic, A. Lascaratos, A. Hecht and T. Hopkins)

41. To understand the response of the sea in the Eastern Mediterranean to predicted climatic changes it is necessary to have a detailed description of both, the forcing functions and responses over the entire subtidal frequency range. The forcing variable at shorter time scales, like atmospheric pressure and wind variations at the synoptic scale, will both be influenced by changes in climate. Therefore, the sea response on those time scales will also be affected. It is very likely that there will be a general northward shift of the atmospheric circulation pattern, which will influence the path and frequency of passage of midlatitude cyclones over some parts of the Mediterranean area. It is still not clear whether there will be any important changes in the wind regime which is now mostly related to the passage of atmospheric disturbances. The wind affects not only sea level changes but it is also very important in generating the processes of vertical convection and deep water formation.

42. Sea level slope between connected basins dictates water exchange between them, if it is not due exclusively to differences in the atmospheric pressure between the two areas. Studies of sea level response to atmospheric forcing are, therefore, important from the point of view of the barotropic water exchange between connected basins. It has been shown that mean flow is mostly driven by the density differences between adjacent water bodies. In contrast, shorter period fluctuations (2-10 days) are barotropic and are generated by sea level slope along the strait.

43. Attention is first focused on temporal variation of sea level over periods from two days to several weeks but less than the seasonal time scale, i.e. scales in which it is expected that the influence of atmospheric forcing will prevail. An EOF analysis of both, the sea level and atmospheric pressure, resulted in the separation of lower frequency oscillations of planetary wave time scale expressed by the first mode from the higher frequency synoptic time scale variability included in the second mode. The first mode is related to the in-phase sea level and atmospheric pressure variations over the entire area, while the second mode represents variations for which the Adriatic Sea is out of phase with respect to both the Ionian and Aegean Seas. These first two modes represent a regionally coherent signal subtracting more than 90 per cent of the total variance from both the sea level and atmospheric pressure data. The majority of the variance of the sea level slope between the Adriatic and the Ionian Seas is generated by atmospheric forcing at the synoptic time scale. Therefore, if the sea level slope is not exclusively induced by atmospheric pressure forcing through isostatic responses, appreciable variations in water exchange between the two basins can be expected on those time scales. The sea level slope related to variations at planetary wave time scales and longer is very small, since the typical length scale of the forcing function is much larger than the northeastern Mediterranean.

44. At time scales longer than synoptic and planetary, both sea level and atmospheric pressure spectra display important energy content. Energy is present on seasonal, annual and inter-annual time scales. The relative importance of those parts of the spectrum is different for each of those signals. For example, in the Eastern Mediterranean, the annual variability of the sea level is very important compared to the other parts of the spectrum. As an example, evidence is presented of large regional changes in surface salinity on time scales of a few years in the Aegean and Adriatic Seas. The salinity changes in the Aegean Sea were shown to be closely related to mean sea level variation in the area.

45. The MC (Marine Climate) cruises are a series of twenty Israeli oceanographic cruises carried out over a period of five years. Each of these cruises occupied the same 30 stations situated at $0.5^{\circ}$ intervals on a regular grid in a rectangular domain defined by the latitudes of $32^{\circ}00'$ and $34^{\circ}30'$N and the longitudes of $32^{\circ}30'$ and $34^{\circ}30'$E.

46. The investigation of the MC series shows the seasonal development of the local water masses: the Levantine Surface Waters (LSW), the Levantine Intermediate Waters (LIW) and the intrusion and spread of the Atlantic Waters (AW). These water masses are defined by their particular salinity signal but do not seem to have a characteristic temperature signal. Thus for an investigation of the temporal variation of these water masses the repeatability of the salinity measurements is of critical importance. In the MC series the repeatability of the salinity was determined by a comparison of the results obtained in waters deeper than 1000 decibars and were shown to be of the order of $\pm$ 0.01. The 9 cruises following December 1982 show a distinct discontinuous upward jump in both the lower limit as well as the upper limit of the LIW layer. Moreover, on the same 9 cruises, the subsurface salinity maximum indicated the LIW as higher than on the previous cruises. These changes may or may not be a result of climatic variations in the Eastern Levantine Basin but such changes are bound to occur if a climatic change occurs. Therefore, they could be a very sensitive means of identifying and monitoring climatic variations, indicating the importance of continuing the monitoring of the temporal variations of the Eastern Mediterranean principal water masses.

47. A simple method is presented for estimating the thermohaline driven exchanges through straits. The primary assumption is that the exchange is determined by the pressure force at the depth of the sill created by the differing weights of the water columns on either side of the sill, and by the continuity requirement that the net transport equals the internal volume flux. This renders the exchanges insensitive to the particular bottom topography or dynamical complications within the strait and capable of being estimated from single or averages of density profiles on either side of the strait. The method is applicable at time scales greater than days, and thus facilitates the resolution of seasonal variability in thermohaline circulations and the monitoring of inter-annual trends. The seasonal balance of exchanges for the Tyrrhenian Sea are computed to provide an example of the interdependence of exchanges in basins with multiple openings and to demonstrate the fact that Mediterranean thermohaline circulations are driven from below, even though they have an origin in a surface atmospheric exchange process. A cursory example is also given of the consequences of atmospheric warming on the Mediterranean circulation. It is shown that the vigour of the thermohaline circulation would decline in proportion to a decline in deep water production.

48. As a conclusion, it was suggested that some insight into possible effects of climatic changes should come from detailed studies of shorter period inter-annual fluctuations of the El Nino type.

Hydrological aspects and impact on water table resources (summary prepared by G. Kullenberg on the basis of the paper submitted by G. Lindh)

49. The study deals with the impact of the expected climatic change on hydrology and water resources. It recapitulates the global changes problem, the role of $CO_2$ and other greenhouse gases, the expected effects on sea level, and proceeds to discuss in some detail the socio-economic consequences of climatic changes. These include the effects of sea level rise on coastal erosion, salinity in estuaries and aquifers, inundation, flooding and storm drainage and the submergence of coastal wetlands. The erosion problem is evaluated using the concept of an equilibrium profile. The very significant problem of salt water intrusion in coastal regions is discussed using the classical hydrostatic approach and the prognostic formulation of water and salt continuity and longitudinal momentum equation.

50. The influences on the hydrological cycle is considered from the perspective of general circulation models, pointing out their shortcomings, e.g. with respect to resolution, vegetation, soil moisture. The impact on water resources is evaluated on the basis of knowledge of the hydrological processes, and of the influence of climatic change. The importance of the water balance equation is stressed, including precipitation, runoff, and evapotranspiration. A review of available models suggests that the water balance formulation provides a practical method for assessing the actual problem. In this way the impacts of global climatic changes on runoff and soil moisture on limited size catchment basins have been evaluated. The final section of the paper gives examples of consequences of changes in runoff and sea level for urban areas, including the effects on drainage systems and on flood frequencies.

Implications of climatic changes on the socio-economic activities in the Mediterranean coastal zone (A. Baric and F. Gasparovic)

51. Socio-economic structures and activities are closely dependent upon the existing climatic conditions. Any change of climatic conditions affects both, the natural environment and the way people live and act. It is assumed that the impact on the socio-economic structures and activities will primarily be local, with possible important common characteristics for small and large areas or regions. The assessment of local and regional impacts presents great difficulties due to inadequate understanding and knowledge of the local conditions. In the integrated planning component (Blue Plan and Priority Actions Programme) of the Mediterranean Action Plan, impressive amounts of data have been gathered relating to Mediterranean coastal zones, and were used in assessing the impact of climatic changes.

52. At present approximately 133 million people (representing 37 per cent of total population of the Mediterranean countries) live in the littoral zone (which represents only 17 per cent of the total area of these countries). Sixty one per cent of them live in urban zones. According to the results of five Blue Plan scenarios, in the year 2025 there will be between 200 and 220 million inhabitants living in the coastal zone. Seventy five per cent of the population of coastal zones will be located in cities.

53. The changes of climatic conditions will have a limited impact on the distribution and dynamics of the population of the littoral zones. The natural growth of the population will not be affected by climatic changes and will continue to follow the present general trends of population growth in the individual countries, i.e. decrease of natural population growth in the northern Mediterranean countries, and a strong increase of population size in the countries on the southern and eastern coasts of the Mediterranean. The mechanical population growth caused by the present process of littoralization will probably not change, although it could accelerate in the south due to the natural spreading of the deserts.

54. Approximately 5 per cent of the population living in coastal zones would be indirectly affected by the impacts of climatic changes and sea level rise. A part of this percentage (10-20 per cent) will be directly affected by sea level rise.

55. About 54 per cent of the total Mediterranean coastline is rocky, the rest consists of low sedimentary shores. The total area covered by cities and settlements represents 1.11 per cent of the total area of the Mediterranean administrative regions. The rise of sea level will affect the parts of the coast that are alluvial and low-lying.

56. The climatic changes will affect both, the natural and the man-made environment, and various human activities (agriculture, forestry, fisheries, aquaculture, tourism, transport, etc).

57. To mitigate the adverse effects it would be necessary to increase expenditures for:

- the protection of the low coastal areas from sea level rise;
- the protection of freshwater resources;
- the (re)-construction of waste water disposal systems; and
- the production of food and other agricultural products.

58. The expenditures for the alleviation of climatic impact could be met, without major problems, by countries with higher national income. However, countries with lower national income (developing countries) may have great difficulty in covering the cost of counteracting the negative impacts of climatic changes.

Implications of climatic changes on the Nile Delta (G. Sestini)

59. The nature and extent of climatic change impact would depend not only on the present level of population and of economic activity, but also and largely on the degree of coastal development during the next 2-3 decades. Intensified land-use in the coastal zone is inevitable, due to the continued growth of population, and the consequent need to augment food production through the further extension of land reclamation and of lagoonal fishing. Additional factors contributing to intensified land-use will be the need to house people and to provide employment. The new industrial and agricultural developments will place an increasing stress on water supplies.

60. It is considered that a sea level rise of 10-20 cm in the next 2-3 decades will be of little consequence generally, except for aggravating local problems of coastal dynamics. The coast will continue to retreat due to the lack of Nile sediment supply. Local relative sea level rises of over 30-50 cm would however have more serious effects, requiring extensive measures of protection.

61. Flooding of coastal lowlands is not to be expected. In theory, a sea level rise (or relative rise, to include the effects of land subsidence) of 100 cm, could submerge the lowlands to within 30 km of the coast or more, affecting 12-15 per cent of Egypt's arable land, 8 million people, and 10-15 per cent of the gross national product. The cultivated lands, however, are already bordered by dykes, and more protection works are likely to be constructed along with new reclamation, or water preservation schemes. The impact of sea level rise will be mainly a burden on financial resources to carry out protection (especially adjustments to harbour infrastructures) and re-deployment.

62. The main effects of higher temperatures will be on rates of evaporation, on the chemistry of the coastal lakes and lagoons, and especially on the salinity of soils. In general, the higher temperatures and the higher $CO_2$ concentrations would favour agriculture (maybe with some shift in crops) and fishing. Negative impacts would come from a changed, or more erratic water supply, from increased evapotranspiration and soil salinity, possibly also from an increase in pests and weeds. Further expansion in the use of fertilizers and insecticides would have serious impacts on the pollution of coastal zone waters.

63. Socio-economic structures will be affected more by the expected sharp population increase, by social policies, and by economic trends, both internal and external, than by climatic changes. Further urbanization will magnify the problems of food and water availability.

Preliminary report on the GRID Mediterranean case studies (Summary prepared by H. Croze on the basis of the paper submitted by O. Simonet)

64. Geographic Information Systems (GIS) are powerful tools for integrating geo-referenced data from diverse sources to address interdisciplinary topics. It was suggested that the GIS technology of UNEP's GRID (the Global Resource Information Database) with appropriate scientific input, would be useful for describing, quantifying and modelling climatic change impacts on coastal areas. Examples of two major impact types were given: changes in crop potential due to temperature increase (using a model from Uganda); and area-specific impacts on population and cropland in the Nile Delta due to sea level rise. Quantitative estimates were given, ranging from 7 per cent of Egypt's population and 6 per cent of her cropland affected by a 0.5 m rise in sea level, to 19 per cent and 29 per cent respectively at 3 m rise. Caution was urged in the selection of the baseline datum for such studies.

Implications of future climatic changes for the Inner Thermaikos Gulf (D. Georgas and C. Perissoratis)

65. An attempt was made to evaluate the possible impact of climatic changes, in a qualitative rather than quantitative way, on the environment of the Inner Thermaikos Gulf (Greece).

66. According to the given scenarios, impacts would be first sensed in the years 2030-40, when a $1^{o}$-$2^{o}$ C rise in the average temperature is expected and might be accompanied by a 20-30 cm rise of mean sea level. However, later impacts of a $2^{o}$-$3^{o}$ C temperature rise and of a 0.5-1.0 m gradual sea level rise could be catastrophic, unless timely preventive action is taken.

67. The coastal environment of the semi-enclosed embayment of the Inner Thermaikos Gulf would have to accept the excessive water masses which would first gradually flood the intertidal zone and then part of the unprotected lowland of the northwestern developing industrial coastal zone. As a consequence, properties and low-lying industries might be damaged. Sea surges would also cause significant damage along the whole coastline, as waves would easily overtop the present sea barriers that front the reclaimed agricultural land and the city of Thessaloniki (1.000.000 inhabitants). The coast at the eastern tourist area might gradually disappear due to high erosion.

68. The low-lying Mikra airport would be seriously threatened if no preventive action is taken. The sea walls built for the port and other offshore port constructions would have to be re-adjusted to meet future conditions.

69. Temperature rise might establish stratification of the seawater masses, especially during the summer months, which will affect the sediment depositional regime in and out of the bays, causing a blocking of navigation channels. Stratification would negatively affect the primary producers of the eutrophic zone, which might initially benefit from the warmer environment but would be adversely affected by oxygen depletion. Peak summer temperatures might lead to anaerobic conditions of the heavily polluted Thessaloniki Bay.

70. There may be a northward shift of climatic zone, and thus autumn and spring might be shortened in length. Additionally, increased variability and patchiness of the rainfall might extend summer aridity. The scattered rainfall may totally disappear during the warm season and might be transferred to winter.

71. The seasonal reduction of the Axios and Aliakmon river flows, due to the reduced temporal rainfall, would cause problems for the irrigation regime in the agricultural plain and for the hydroelectric power stations along the Aliakmon river.

72. Due to increased aridity the ground water table would be critically lowered, leading to the salinization of ground water. Consequently, seawater would progressively intrude the watertable landward, causing deterioration of the quality of the phreatic and intermediate ground water.

73. Reduction of rainfall during the hot summer period might cause a deficiency of soil moisture, thus degrading soil structure and agricultural fertility in the Thessaloniki plain. Moreover, the reduced run-off could cause seasonal salt-accumulation in the topsoil of several reclaimed lowlands. As a result, a better drainage of the plain would be required.

74. Salinization of irrigation water would have negative consequence on sensitive grain yield. Consequently, new varieties of crops would have to be introduced and adapted to the new natural setting. On the other hand, fast growing plant cycles, due to the $CO_2$ emission and the temperature rise, might increase fertilizer consumption, as the needs in $NO_3$ would be higher. Generally, marine and land weeds may expect to benefit from these conditions. Flora and fauna of the wetlands would be forced to gradual adaptation to induced conditions which might be crucial for the sensitive species which exhibit reduced tolerance to high salinities. As bioclimatic zonation would gradually shift northwards, several species might migrate to the north, and insect populations might increase. Finally, there would be an increasing risk of agricultural pests, bacteria and diseases, especially in the swamps.

75. From the above mentioned data and estimates it is obvious that if the scenario of the future climatic changes becomes reality, large scale radical consequences could affect the greater Thessaloniki area. These enormous changes would require equally remarkable and daring

future steps. Such a step might be the damming and isolation of Thessaloniki Bay and its use as a "buffer zone" in order to diminish or remove the impact of a sea level rise on the low-lying coastal area. The construction of the barrier across the 4.5 km wide Axios delta and M. Envolo Cape (max. depth of 27 m) would be within the capabilities of tomorrow's technology. The suggested damming of the Thessaloniki Bay and its transformation into a controlled lagoon, with essential navigational outlets, would not negatively affect the marine environment of the greater Thermaikos Gulf, as seawater circulation and sewage output regime would remain almost unaffected.

Implications of climatic changes on the Po Delta and Venice Lagoon (G. Sestini)

76. The impact of climatic changes on the northwestern Adriatic lowlands, in the next decades, must be judged in the perspective of the environmental problems that exist there at present. They have resulted not from recent climatic oscillations nor from the, so far, small rate of sea level rise, but from coastal development activities during the last 50 years, that have been carried out with little consideration of the natural processes and their responses. These have included land reclamation, the intense urbanization of the coast, the building of deep harbours and of coastal defence structures, a decrease of the lagoons' surface, enhanced land subsidence caused by water extraction, the derangement of rivers' water and solid discharges, and the pollution of surface waters and the sea.

77. Since the late 1950s, many parts of the shoreline have been retreating, while the lagoons have experienced increasingly higher tide and storm surge levels. Today, the entire coast is in a state of physical instability because of subsidence and sediment starvation, and must be classified as high risk zone in regard to the impacts of sea level rise.

78. In general, climatic changes will occur gradually but will not be specifically manifest ($0.5^{o}$-$1^{o}$ C temperature increase, 15-20 cm sea level rise) until about three decades from now. Hot dry summers and exceptional events of rainfall and floods, marine storms, tidal surges, and of water stagnation and eutrophication could however increase in frequency.

79. It is considered that a sea level rise of 10-20 cm will be of little consequence generally, and would not cause flooding, but would aggravate beach erosion and the periodic high water levels in the Venice lagoon. Flooding, greater tidal currents and generally more estuarine conditions in the lagoons, would accelerate the degradation of the tidal flats and reed beds, diminishing their value for wildlife and fish breeding.

80. The main threats of additional sea level rise (over 40-50 cm after 2030) would be the serious degradation of the city of Venice and of other towns in the lagoons and on the coast, the impairment of the harbour related activities, and a substantial decline of the beach resorts. The average temperature rise of $3^{o}$ C would produce a milder winter climate, possibly with greater rainfall, but this would also alter the river regimes, as lesser snow cover will develop over the Alps and Apennines in winter.

81. As regards the extensive agriculture in the reclaimed subzero level lands, it might be more economical to turn them back, at least in parts, to their original lagoonal state, in favour of fishing, which is at present a more efficient and remunerative activity than cereal growing.

82. In the Po Delta and elsewhere, lagoons and marshes could act as buffer zones between the open seas and higher land, and in parts as nature reserves. Industrial and other activities in the areas below 1 m could probably be moved gradually inland without excessive disruption.

83. Little change is expected to occur in the settlement and economic patterns of the hinterland (elevations between 3 and 5 m) during the next few decades, because of low population growth. Main factors of regional organization, especially for agriculture and urban development, would continue to be the availability and quality of water resources. Means to control industrial, urban and agricultural pollution must be found soon, and new approaches to beach recreation investigated, to minimize the impact on summer tourism.

Implications of climatic changes on the Gulf of Lyon (J.J. Corre)

84. Fortunately, the unattractiveness of the coast in previous centuries resulted in most of the large urban centers of the Gulf of Lyon (Perpignan, Narbonne, Béziers, Montpellier, Nîmes, Arles) to be built away from the shore so that they are protected from any serious impact of a foreseeable rise of sea level.

85. On the other hand, the coast with its tourist and harbour installations is particularly vulnerable, due to the narrowness of the strip of sand for most of its length, the low altitude of the dunes and coastal ridges, their levelling for construction purposes and their decayed condition due to abandonment during the development phase.

86. At present, the major risk derives from the increase in frequency and seriousness of storms which is linked to the genesis of cyclonic circulations. Fortunately, the great storm of 1982 acted as an alarm signal to public authorities. A number of actions and control measures were launched, both experimental and definitive, in order to reinforce the existing policy for response to critical situations. The aim of these actions and measures is threefold: to control longshore drift and beach erosion, to help to bring back and retain the sand on the beach and on the dune (network of semi-permeable barriers, nets, planting schemes etc.), and to create an obstacle to storms while at the same time maintaining a wide enough strip of usable beach (artificial dunes, dykes for the bottom of the beach, etc.).

Implications of climatic changes on the Ebro Delta (M.G. Marino)

87. From 1960 onwards the Ebro Delta has undergone remarkable modifications: its growth has almost stopped, while the front and south lobes are subject to quick erosion, due to the damming of the Ebro river, which has reduced the sediment load to the mouth by more than 98 per cent, and to man induced changes in the river mouth.

88. The temperature increase of 1.5$^{o}$ C and the sea level rise in the range of 20 cm over a 30-50 year period would have much lower effects on the system than the anthropic modifications. Nevertheless, these changes would increase the present erosion processes and lead to more frequent flooding of the wetlands, increasing their salinity and destroying the present flora and the nesting grounds for migratory birds.

89. Also, due to the retreat of the coastline, the bays would gradually become closed and become restricted lagoons, un-connected to the sea. This would have dramatic effects on the area's marine productivity.

90. Agriculture would not be affected, apart from an increase in energy required for pumping and from new conflicting demands for irrigation water.

91. The protection of the lagoons and the wetlands of the front lobe and the adequate planning of water allocation should be reassessed in view of the estimated impact of climatic changes.

Implications of climatic changes on the Garaet el Ichkeul and Lac de Bizerte, Tunisia (G.E. Hollis)

92. This case study examines the impact of a temperature elevation of 1.5$^{o}$ C and a sea level rise of 20 cm by the year 2025 on the wetland National Park at Ichkeul, the Lake of Bizerte and the nearby coast of N. Tunisia. The aim is to assess the likely changes to natural systems and the consequent socio-economic impacts.

93. The area is in the process of adjusting to a long period of apparently accelerating change. Post-Pleistocene fluctuations, the entry of sea water through the cutting of a sea canal in 1895, deforestation, channelization and agricultural improvement, have all had demonstrable effects on the Ichkeul-Bizerte lakes. A scheme to construct at least three dams on the rivers flowing into Ichkeul between 1983 and 2000 could dramatically change the hydrology and ecology

of the National Park. A management scheme involving a sluice and reservoir releases may offset most of the deleterious impacts. The National Park is so important that it is protected under three international conventions.

94. It is suggested that there may be slightly more soil erosion in the headward valleys, but the sediment will be trapped there with a major reduction in the sediment yields in the larger rivers, reservoirs and the downstream lakes. The reduction of sediment flowing out to sea, because of the climatic changes and the effects of reservoirs trapping sediment, may accelerate coastal erosion.

95. The combined effects of the dam scheme and the rise in temperature will turn the Ichkeul National Park into a saline sebha. It is likely to loose all of its food plants for over-wintering and breeding waterfowl. Some groups of birds, notably flamingos and waders, may benefit marginally. The nationally important fishery will disappear from Ichkeul as will its considerable value for grazing. Some freshwater species and some marsh plants may survive in isolated remnants in the rivers and river mouths.

96. The actual evapotranspiration in the region will increase by around 10 per cent when mean air temperature rises by 1.5$^{o}$ C. This will result in, at least, a 10 per cent decline in riverflow. The salinity of the latter will also increase. Potential evapotranspiration and open water evaporation will rise by at least 12 per cent. The demand for irrigation water will rise by at least 12 per cent when reservoirs are depleted by reduced river flow and increased evaporation. The average storage in the reservoirs will fall by up to 26 per cent and they will be nearly empty for up to 19 per cent of the time. An expected 25 per cent filling of the reservoirs with sediment will seriously increase the water supply problems, with mean storage falling to around 60 per cent of the projected levels under present conditions.

97. The 20 cm sea level rise, by itself, is not likely to have a significant impact on either the Lake of Bizerte or Garaet El Ichkeul.

98. Forests are likely to suffer from the increased temperature and aridity. The coastal plantations will suffer from salinization and, probably, remobilized sand dunes. There may be some shifts in the limits of present natural vegetation types. Agriculture is likely to change towards even more intensive irrigation in some areas and a greater reliance on grazing generally. The largest impact on infrastructure will be foundation problems for roads and buildings arising from saline groundwater and swelling clays. Sewage flooding may follow the sea level rise because of inadequate slopes on sewers. Sea flooding is not likely to be a major problem.

99. Overall, existing environmental problems are likely to be exacerbated; agriculture will suffer; inland and lagoon fisheries may have already disappeared through the impact of the dam scheme; sea fisheries may benefit slightly, industry will be largely unaffected; water resources will decline in both quantity and quality; transport will be unaffected save for shipping which may benefit slightly; settlements will suffer through their foundations and sewers; the quality of urban life may decline through an accelerated influx of farmers abandoning the countryside; geomorphological systems will change only marginally; and the hydrology and ecology of the Ichkeul wetland will change dramatically through both the dam scheme and the temperature change because the conservation management measures are not likely to be equal to the developing problems.

<u>Bibliography on effects of climatic change and related topics (L. Jeftic and A. Davakis)</u>

100. The bibliography contains nearly 1400 bibliographic references on climatic change and related topics.

101. The bibliography was prepared by extensive manual literature searching through abstracts and lists of references, periodicals, monographs, reprints of papers and "grey" literature in the Co-ordinating Unit for the Mediterranean Action Plan and other libraries, including Yale

University, Woods Hole Oceanographic Institution, Dalhousie University and others. For on-line(computerized) literature searching the facilities and services of the National Documentation Centre of the National Hellenic Research Foundation were used.

102. Data bases accessed were: AFSA, BIOSIS, COMPENDEX, DELFT HYDRAULICS, ENVIRONLINE, GEOREF, NTIS, OCEANIC, POLLUTION ABSTRACTS, SCIENCE CITATION INDEX, SOCIAL SCIENCE INDEX and U.S. DEPT. OF ENERGY (DOE) DATA BASE (accessed via Yale University).

103. The criteria for selection of citations was to include as broad a range of relevant topics as possible, while limiting the time-span to post-1983 period. Several pre-1983 publications have been exceptionally included because of particular interest or specific reference to the Mediterranean area.

104. Micro-CDS/ISIS developed by UNESCO has been used for the compilation and maintenance of this data base. The data base is searchable and citations retrievable by (a) author, (b) corporate body, (c) title, (d) document number, (e) any word in title, and (f) key work/descriptor. The "climatic change" descriptor has been assigned to all entries and can retrieve the full body of entries. Other key words describing selected entries are: ozone, ozone depletion, greenhouse effect, sea level, coasts. Geographic descriptors have been assigned to Mediterranean area-related references only.

105. The present edition of the bibliography includes:

- Bibliography by author: Full bibliographic citation, indexed by author/corporate body followed by date of publication. Unpublished manuscripts are so cited at the end of the entry.

- Geographic area bibliography: MEDITERRANEAN

106. The present edition is planned to be updated by the Co-ordinating Unit for the Mediterranean Action Plan with information expected to be received from potential users, and issued in early 1989 with a subject index. The new edition is planned to be available also on diskette, together with the relevant software.

## General discussion and recommendations relevant to the Mediterranean

107. A global mean eustatic rise in sea level of around 20 cm by 2025 would not, in itself, have a significant impact on the Mediterranean coasts, except in local situations (e.g. lagoons). However, local sea level changes could be up to five times this amount because of land subsidence and other factors. The negative effects of this impact will be greatest in low lying areas, deltas and coastal cities which are particularly vulnerable to climatic change. This vulnerability is increased by adverse socio-economic conditions, the effects of which will be superimposed upon those of climatic change. Governments should be aware of the increasing risk of catastrophic situations during the coming decades.

108. There are still some uncertainties concerning climatic change in the Mediterranean and it will be at least 5-10 years before better assessments of the problem are available. It is generally believed that in connection with an increase in temperature of 1.5$^{o}$ C by 2025, potential evapotranspiration will increase throughout the Mediterranean. There are also indications that there could be a decrease in precipitation in the southern part of the Mediterranean and an increase in the northern part.

109. A 1.5$^{o}$ C increase in temperature would result in an increase of land degradation, a deterioration of water resources, a decline in agricultural production and damage to natural terrestrial and aquatic ecosystems. It could also alter marine circulation, both in the Mediterranean and the Atlantic, and thus affect marine productivity and the pattern of dispersal of pollutants.

110. The future impacts of non-climatic factors on the society (e.g. population increases, present development plans) may far exceed the direct impacts of a change in climate. Non-climatic factors will cause continuous increases in society's vulnerability to climatic stress in the Mediterranean, particularly in the southern part. Both, non-climatic effects and changes in climate, will increase the probability of catastrophic impact events, and bring forward the date of their occurrence.

111. To develop a strategy for responding to the impacts of the change, it is essential to identify those parts of the Mediterranean coastal regions where understanding of these impacts is still inadequate.

112. More attention needs to be given to the conservation of soil, groundwater and wetland resources in the Mediterranean because they contribute substantially to environmental stability. The overall adverse effects of large dam schemes and groundwater abstraction on the downstream human settlements and ecosystems, and on the Mediterranean Sea itself, have not been adequately considered in past planning. Future plans for large dams should be scrutinized more closely in the perspective of climatic change.

113. Taking into account the presentations relevant to the potential impact of climatic changes on the Mediterranean Basin and the discussions reflected above (paragraphs 19-112), the meeting recommended:

(a) the development of a specific model (scenario) of climatic changes in the Mediterranean;

(b) analysis of:

- the relations between local to regional scale weather and climate and larger scale features of the general circulation;
- the frequency, patterns and mechanisms of cyclogenesis;
- the trends in precipitation, potential evapotranspiration, etc; and
- the frequencies of extreme events (high temperatures, high and low precipitation, storms and storm surges, etc.) and how these frequencies relate to mean climatic conditions in order to help in predicting future changes in extreme event probabilities;

(c) the study of trends in sea level by satellite imagery, additional tide level gauges and archaeological methods;

(d) a comprehensive and quantitative review of the impact of climate change:

- on the hydrology and water resources (including water quality) of the rivers feeding the Mediterranean Sea;
- on the water (fresh/salt and Mediterranean/Atlantic) balance of the Mediterranean Sea; and
- on the exploitation and future management of water resources in the Mediterranean Basin; and

(e) field studies on the effects of climatic change on degradation of soils.

<u>Agenda item 5: Impact of sea level rise on society: a management approach (P.C. Schröder)</u>

114. Sea level rise is inevitable. The extent will be site-specific and dependent on other factors, such as subsidence (all causes: tectonic; extraction of oil, gas or water; down-warping under water weight, etc.), and erosion.

115. Coasts, rivers, infrastructure, ports, shipping, water resources and environment will be affected. Responses need to be generated, implemented and checked. Staff must be trained, technologies mastered, and administrative, organizational and enforcement structures have to be built up.

116. The impact area has to be delineated, defined and precisely determined. The method of approach to generating the response has to be determined. Alternatives have to be formulated.

117. Responses typically are preventive, reactive or mitigating, depending on numerous factors, including the economic ability of the country concerned to shoulder the burden of the cost, and the political will to do so. Once measures have been adopted, enforcement needs to be in place.

118. Time horizons may be misleading. For physical structures (dykes, bridges, etc.) the life span may be up to one hundred years. In some countries, such as Egypt, Bangladesh, Indonesia, Thailand, etc. a sea level rise (relative and absolute) of a few centimeters may aggravate an existing problem. Both timely action and realization of future requirements is essential.

119. For the approach the first requirement is a realistic sea level rise scenario. Secondly, determination of the physical impact on the inshore area is needed. Thirdly, social and economic values have to be assessed, i.e. magnitude of existing investment has to be related to magnitude of investment in protective measures. The range is wide: in some developed countries the risk factor of coastal defense safety failure is set at 1 in 10,000. In other countries this ratio is no more than 1 in 20. Preventive and reactive planning depends on this factor.

120. Several tools are required for the determination of the impact. Thorough knowledge of coastal behaviour under varying conditions is essential. The coastal genesis project in the Netherlands provides the essential insight in this matter, both in terms of hindcasting and forecasting.

121. So-called laboratory cases are needed. A maximally protected nation, such as the Netherlands, provides significant information on many aspects of sea level rise and related phenomena. On the other hand, the rapidly rising level of the Caspian Sea, for instance, would show how an unprotected coast responds.

122. Value assessment of the area impacted and the area to be protected should be as thorough as the engineering evaluations of the coastal defenses. Methods specifically designed for this do not exist as yet, although a number of methods are useful. One of these is the ocean Sector model developed by Pontecorvo.

123. Coastal areas are generally fertile and productive. The global changes now detected are both long term and world wide. Regional interpretations are needed. Site specific data must be generated for input in both regional and global models. Site-specificity is of the essence.

124. Technologies permitting affected countries to exercise their national prerogatives are fundamental to the success of effective responses. Such technologies need to be transferred, so that policy options can be generated within the contexts of national planning and priorities.

## Agenda item 6: Implications of climatic changes in the Caribbean region (G. Maul)

125. A summary of the Caribbean Task Team's study was given by its chairman, and an attempt to assign levels of vulnerability to the region's ecosystems and socio-economic structures was presented.

126. Table 1 is a synthesis designed to assess climate impact *per se*, and does not attempt to place into context climatic changes with respect to other pressures on the marine environment, nor is it designed to be site-specific where many impact levels will be quite different from those on a regional scale. Given these caveats, climatic changes are expected to have a low to

moderate negative net effect, but an effect that will increase the vulnerability of society to other environmental change. In comparison with the more developed Mediterranean socio-economic structures, such as extensive irrigation projects on major rivers, the Wider Caribbean region will probably experience more changes as development matures. In contradistinction, the tropical and subtropical Gulf of Mexico/Caribbean Sea system will probably experience a lower temperature and sea level change by 2025 than more temperate semi-enclosed seas; regional planning should take note of that prediction.

Table 1

Implications of Climatic Changes in the Wider Caribbean Region
(L-Low vulnerability; M-Moderate vulnerability; H-High vulnerability
SLR-sea level rise of 20 cm; T-temperature rise of 1.5$^{o}$ C)

| Terms of reference | SLR | T |
|---|---|---|
| Ecosystems | Level of Vulnerability | |
| Deltas | H | L |
| Estuaries | M | M |
| Wetlands | M | M |
| Coastal Plains | M | L |
| Coral Reefs | M | M |
| Mangroves | M | L |
| Seagrass Beds | M | M |
| Fisheries | L | M |
| Agriculture | L | L |
| Forests | L | M |
| Socio-Economic | Level of Vulnerability | |
| Coastal Zones | L | M |
| Tourism | M | L |
| Settlements & Structures | M | L |
| Public Health | L | M |
| Tropical Storms | L | H |

127. Table 1 is offered as a mechanism to stimulate debate, and to synthesize in all too brief a form a neat simple solution to a complex problem. The levels of vulnerability reflect only the WMO/ICSU/UNEP (1985) climate scenario, and must be considered as issues that exacerbate other problems such as population pressure, pollution, subsidence, coastal erosion, construction, etc.

<u>Agenda item 7: Implications of climatic changes in the South-East Pacific (J. Escobar and S. Avaria)</u>

128. Long term impacts of climatic changes in the South East Pacific Region are inferred from those that occur during "El Nino" events. There are some reasons to believe that El Nino may reflect the conditions resulting from regional climatic changes even though the phenomenon does not occur over a long time scale. The event reaches abnormal proportions off the coastal areas of the countries of the region with positive temperature anomalies from 2$^{o}$ to 3$^{o}$ C above mean

surface temperature and sea level increases ranging from 40 to 50 cms, as recorded in the 1982-1983 event. A case study related to the 1982-1983 event is presented in the report. Figures on El Nino events greatly surpass the 1985 Villach meeting's assumptions (1.5° C sea surface temperature and 20 cms sea level relative rises by the year 2025).

129. The increase in salinity in estuaries will be one of the most significant physical effects of climatic changes in the South-East Pacific. Climatic changes will also disrupt several important regional pelagic fisheries due to a disorganization of schools, changes in the distribution of species and failures in the reproduction and survival of eggs and larvae. The most dramatic biological consequence of a climatic change connected with El Nino was its effect on the anchovy fishery, which in 1970 reached catch levels up to 13 million metric tons in Peru and Chile, then fell to levels of two million tons in 1973. The reduction in anchoveta yields created a biological vacuum in the ecosystem, as reflected in biomass increases of sardine and jack mackerel. Due to close relationships existing between pelagic fish and guano-birds population numbers of the latter have been affected by the climatic changes associated with the El Nino event. The populations of some 30 million birds in 1950 had been reduced to 6 million by the 1972-1973 El Nino, and only 300.000 birds were left after the 1982-1983 event. The event was also responsible for the death of seals and loss of nearly a whole year class.

130. Increases in temperature could cause adverse effects on South-East Pacific coral reefs. They are characterized by the limited diversity of species (8-10 per coral reef) located in shallow protected waters. Regional distribution patterns are influenced by the inflow of cold water originating in the Peruvian current, drainage of a great many rivers and the range of tidal waves. Paleobiological data suggest that during the Pliocene and the Quartenary periods sea level changes and temperature increases were beneficial to the development and overall distribution of coral reefs. A 1.5°C temperature increase could cause adverse effects on coral reefs. During El Nino whitening of reefs, due to loss of zooxanthellae, was recorded. Unusually high temperature and extremely low salinity were responsible for high death rates of the mangrove-associated fauna. Some fishery resources, mainly molluscs and crustaceans showed high production yields during El Nino events. In the case of prairies a sea level rise would enlarge the area under the influence of flooding, thereby affecting composition and distribution patterns of coastal vegetation; halophytic species will show higher growth-rates and wider distribution.

131. Extreme droughts and high rainfall, attributable to climatic changes associated with El Nino and resulting in rivers overflowing, erosion of wetland areas and piling up of sediments, have severe economic and social impacts throughout the South-East Pacific region. The damage sustained by the agricultural sector in terms of crop losses, yield decreases, delays in sowing and soil salinity is substantial. The cattle sector is affected by loss of stock and drying up of pastures. Physical infrastructural damage, including damage to airports, roads, bridges, and railroads, results in heavily increased operational costs.

132. Climatic changes cause impairment of health and nutrition, and increasing morbidity: malaria reaches epidemic proportions and large numbers of urban and rural dwellings are destroyed and/or damaged. According to some estimates, the 1982-1983 El Nino event caused losses of approximately US$ 3.480 million (US$ 2.000 million sustained by Peru; and US$ 640 million by Ecuador). The surface affected by the climatic changes represented 12-15 per cent of the countries' total surface, and some 950.000 people suffered heavy material losses. Flooding affected some 830.000 people.

Agenda item 8: Implications of climatic changes in the South-Pacific region (J.C. Pernetta)

133. Excluding the countries of the Pacific rim and those of the South East Asian Seas region such as the Philippines, the Pacific Basin includes 25 independent micro-states, dependencies and territories of major powers such as the United States, France, United Kingdom, Australia and New Zealand.

134. For most of these 25 countries the land area is insignificant in global terms (just over half a million square kilometers); 85 per cent of this area is contained within the boundaries of Papua New Guinea.

135. In contrast the areas of the exclusive economic zones are considerable and for most Pacific countries land forms less than 0.001 per cent of the area within the exclusive economic zones. Most countries of the region depend upon marine resource exploitation both for subsistence and commercial use.

136. Islands vary from low lying atolls at or below 4 m above sea level to high volcanic islands with steep profile; island relief is important in terms of both coastal inundation and rainfall/run-off patterns hence the impacts of climatic change will differ in islands of differing relief.

137. Population levels are high for most of the smaller states (up to 386 people per square kilometer). Again the absolute numbers of people are small in global terms. Some of the smallest micro-states in the world both in terms of land area and population are found in the Pacific Basin.

138. Any change in sea level is likely to have profound effects upon the economic viability of these micro-states, both through land loss, and loss of exclusive economic rights at the periphery of their existing national boundaries. Both impacts will be highly significant economically, and on the basis of estimated impacts it is believed that five countries of the region may be so badly impacted as to become economically non-viable, under worst case scenarios they may cease to exist altogether.

139. Whilst it might be concluded on the basis of population size that in a global context the potential loss of Pacific micro-states constitutes an insignificant component of changes resulting from climate and sea level change such a view takes no account of the loss of human cultural diversity. Melanesia contains one third of the worlds languages and loss of human cultural groupings within the Pacific through amalgamation and incorporation into neighbouring states would represent a significant loss of the human heritage.

140. Severe regional problems of social and cultural disruption can be predicted as populations move from eroding, waterless atolls and coral islands, first to neighbouring high islands and then to neighbouring rim countries. It is imperative that the problem of "ecological refugees" be addressed at a regional level, particularly as the neighbouring rim countries (Australia and New Zealand) can be expected to be the most likely target destinations for such refugees.

141. Economically all countries would be adversely affected by changing climatic patterns causing alterations to existing agricultural systems of production. Climatic changes will result in increased costs to the economy through generation and consumption of more electricity, whilst freshwater availability will change with consequences for human settlement.

Agenda item 9: Implications of climatic changes in the East Asian Seas region (L.M. Chou)

142. The Task Team co-ordinator was appointed only in mid September 1988, and potential members of the Team are currently being identified. Therefore, no substantive report for the East Asian Seas region was available for the meeting.

143. Countries within this region are characterized by extensive coastlines. About 75 per cent of the combined population of these countries together with development are concentrated in the coastal zone. With the exception of the Philippines and the eastern part of Indonesia the countries of the region are located on the shallow Sunda shelf where effective mixing of the entire water column brings up nutrients from the sea floor. Major coastal ecosystems of the region are highly productive and their living resources diverse. Over-exploitation of these resources where they occur is well known but greater environmental awareness has resulted in improved management steps being taken by many countries.

144. Climatic changes are likely to have a major influence on agriculture (e.g. rice, the major crop, is grown largely in low-lying areas). Tourism is an important industry relying increasingly on coastal environment. These and other considerations, which include increasing population growth, water resources and energy production, will be included in the study planned to be prepared by the Task Team.

145. A suggestion was made to look into ocean current patterns concerning the flow of water from the Pacific Ocean to the Indian Ocean through the region as it may have an important bearing on the movement of pollutants originating from the region. The meeting was informed that there are other on-going projects studying the oceanographic characteristics of the region, relevant to the work of the Task Team, and that results from these projects would be incorporated into the regional report.

Agenda item 10: Implications of climatic changes in the South Asian Seas region (G.S. Quraishee)

146. The region comprises the countries of India, Pakistan, Bangladesh, Sri Lanka and Maldives.

147. The experts from the region, together with invited foreign experts, met in the first meeting of the Task Team from 28 to 30 June 1988. The meeting developed strategies for carrying out studies on the implication of climatic changes. The region being densely populated, this influence was to be borne in mind in all investigations. Various phenomena in the region likely to be intensified by climatic changes were identified, such as: variability in the southwest monsoon and associated precipitation pattern; intensification of cyclones, their frequency and path; intensification of storm surges with the rise in sea level and changes in the air-sea interaction; changes in circulation and in marine productivity.

148. It was noted that the Maldives already face problems of land loss and depletion of fresh water resources. The Task Team considered that due to the very specific nature and conditions the Maldives should be treated through a completely separate case study.

149. The Task Team proposed to tackle its terms of reference in two ways: the generalities to be handled by foreign experts, the specifics through case studies by local and foreign experts. It is planned to hold national workshops to finalize the country reports and a regional workshop to consolidate the final regional report. Some twenty topics for specific case studies and experts/organizations to undertake them were identified by the Task Team.

Agenda item 11: Conclusions and recommendations

Background scenarios

150. Climatic changes have occurred in the past and have caused considerable, often radical, changes in terrestrial and marine ecosystems.

151. As a result of increasing concentrations of greenhouse gases it is now believed that, in the first half of the next century, a rise of global mean temperature could occur which is greater than any in man's brief history.

152. The uncertainties surrounding the global and in particular regional climatic changes are still great. At least 10 to 20 years are required to clarify some of the unknowns. Climatologists generally expect that increasing concentrations of carbon dioxide, methane, nitrous oxide and several other gases will cause the earth to warm by a few degrees in the next century, and it seems that in the coming decades, one of the most important issues which may face coastal areas is likely to be a rise in the sea level.

153. Sea level changes in response to global warming have a greater lag than temperature changes, thus, sea level is likely to continue to rise to 2100 and beyond, even if climate were to be stabilised before that date.

154. The expected changes in surface temperature, and sea level are not the only, and in many places not even the main, phenomena which will affect the ecological systems and human societies supported by them. Changes in amounts and pattern of precipitation, prevailing winds and ocean circulation will be equally important.

Impacts

155. The rise in sea level could inundate lowland areas, erode beaches, exacerbate flooding and increase the salinity of rivers, estuaries, lagoons and aquifers. However, many of the most adverse consequences can be avoided if society takes timely anticipatory measures. Although for some purposes it may be more prudent to wait to see how much the sea rises, there is consensus that we cannot wait until all the answers have been obtained, and adequate measures must be taken now.

156. A global mean eustatic rise in sea level of around 20 cm by 2025 would not, in itself, have a significant impact, except locally (e.g. atolls, lagoons). However, local sea level changes could be up to five times this amount because of land subsidence, sediment compaction and other factors.

157. In many cases, the future impacts on society, as well as on terrestrial and marine ecosystems, of non-climatic factors (e.g. population increases, present development plans) may far exceed the direct impacts of a change in climate or sea level. Nevertheless, changes in climate will be of paramount importance because non-climatic factors will cause continuous increases in society's vulnerability to climatic stress and, eventually, some climate-related event (such as a drought-induced water deficit, flood or storm surges, severe harvest failure or a succession of failures due to reduced rainfall and/or increased heat stress, etc.) may have or trigger a catastrophic impact. Both, non-climatic effects and changes in climate, will increase the probability of such catastrophic impact events, and bring forward the date of their occurrence.

158. It is particularly difficult to forecast the effects of climatic change on agriculture, beyond concluding that some irrigation systems will suffer increasing stress, soil degradation may reduce yields in rain-fed systems, and area-specific potentials for crops may shift.

159. An attempt was made during the meeting to generalize the vulnerability of coastal and marine ecosystems, and human activities with respect to expected climatic changes. The results of this attempt (Table 2) should be interpreted with extreme caution because many site specific conditions may have an over-riding importance. The levels of vulnerability indicated in the table should not be taken as having direct correlation with the actual severity of impact due to climatic changes.

Response considerations

160. The evolutionary rates of socio-economic changes are usually faster than those of climate. Consequently, it is difficult to relate these two different dynamic systems with the objective of analysing their interactions.

161. Due to the coastal dynamics of erosion and deposition, the relatively short life-time on geological and climatological time scales of most human installations, engineering solutions (such as large dykes and walls) are not likely to represent a realistic long-term solution to the problem of rising sea level, except in very special cases. Social adaptation and land-use change will be the most appropriate responses to sea level rise.

162. More attention needs to be given to the conservation of soil, groundwater, wetlands, mangroves and coral reefs because they contribute substantially to the resilience of the environment which will be under impact of climatic changes.

Table 2

Relative levels of vulnerability (H-high, M-moderate, L-low, 0-not vulnerable, na-not applicable) to temperature and sea level rise on marine and coastal ecosystems, and socio-economic structures and activities in the analysed regions. These best estimates should be interpreted with extreme caution, since site-specific conditions may have over-riding importance. Vulnerability should not be interpreted as an impact rating. Assumptions: gradual mean sea level increase of 20 cm (SLR) and mean temperature increase of 1.5$^{0}$ C (T) by the year 2025; no significant changes in precipitation or insolation levels.

| | MED | | CAR | | S/PCF | | EAS | | SAS | | SE/PCF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SLR | T | SLR | T | SLR | T | SLR | T | SLR | T | SLR | T |
| **Ecosystems (types)** | | | | | | | | | | | | |
| Deltas | M | L | H | L | L | L | H | M | H | M | H | L |
| Estuaries | L | L | M | M | M | 0 | H | M | H | M | H | L |
| Wetlands | M | H | M | M | M | 0 | H | M | M | M | H | L |
| Coastal plains | L | L | M | L | M | 0 | H | L | M | M | H | L |
| Coral reefs | na | na | L | M | L | M | L | L | H | L | L | H |
| Mangroves | na | na | M | L | H | L | M | L | H | M | L | L |
| Seagrass beds | 0 | 0 | M | M | 0 | M | M | L | M | M | L | L |
| Lagoons | H | M | M | M | L | M | M | L | M | M | L | L |
| Beaches and intertidal zones | L | 0 | H | L | M | L | M | L | H | L | M | L |
| Human settlements/infrastr. | M | L | M | L | H | H | H | L | H | L | L | M |
| Rivers and coastal lakes | L | H | L | L | M | L | H | L | M | M | M | M |
| Forests | 0 | M | L | M | na | na | M | L | L | M | L | L |
| **Ecosystems (components)** | | | | | | | | | | | | |
| Soil | L | H | L | M | L | 0 | H | H | L | M | L | L |
| Water | L | H | M | M | H | 0 | H | M | M | M | M | L |
| Terrestrial fauna | 0 | L | L | L | 0 | L | L | L | L | L | L | L |
| Terrestrial flora | L | M | L | L | L | L | L | L | L | L | L | L |
| Marine fauna | 0 | 0 | L | M | L | L | L | L | H | M | L | L |
| Marine flora | 0 | 0 | L | M | L | L | L | L | H | M | L | L |
| Cultural heritage | L | L | M | L | H | 0 | M | L | L | L | L | L |
| Quality of urban life | L | M | M | M | M | H | M | M | H | M | M | M |
| Health | L | M | L | M | L | H | L | M | M | H | H | H |
| **Activities** | | | | | | | | | | | | |
| Tourism | M | L | M | L | L | L | M | L | H | L | L | M |
| Development of human settl. | L | M | M | L | L | L | H | L | H | L | H | L |
| Forestry | 0 | M | L | M | 0 | L | L | L | M | L | M | M |
| Agriculture | L | M | L | L | H | L | L | L | H | M | L | L |
| Fisheries | L | L | L | M | 0 | 0 | M | M | L | L | M | H |
| Industrial development | 0 | L | L | L | 0 | 0 | L | L | H | L | L | L |
| Transport | L | 0 | L | L | H | 0 | L | L | M | L | L | L |
| Coastal zone management | M | M | M | L | M | 0 | H | M | H | L | H | L |
| Water resource management | L | H | M | M | M | 0 | M | L | H | M | H | L |
| Transbound. human migration | L | M | L | M | H | L | M | L | H | M | L | L |

163. Coastal human settlements are likely to be specially vulnerable to a sea level rise. Because the problem of liquid waste disposal from such settlements will tend to be exacerbated, consideration of possible changes in sea level should be part of the design of whatever new disposal facilities are now being planned.

Methodological considerations

164. There is a major need to develop a methodology for handling the complex interactions between the systems being considered and for the identification of the different main categories of impact (primary, secondary, reversible, irreversible, synergistic, antagonistic) and techniques of assessments. To handle the vast amount of data that will become available, geographic information system technology may be useful since it could contribute to the better understanding of the nature, magnitude and distribution of impact phenomena. Effective responses to the projected climatic change must involve cross-sectoral and multi-disciplinary approaches to widely drawn definitions.

165. In order to develop strategies for responding to the potential impacts of climatic change, it is essential to identify major gaps in knowledge and deficiencies in the present data bases. In order to formulate early response options, it will be necessary to substitute "best guesses" for those components of present models and climate scenarios which are at present not well defined.

166. The limited understanding of the global water balance is one of the major gaps in our knowledge, particularly associated with hydrological cycle, with the continental ice sheets and with water exchange between the atmosphere and the ocean. The uncertainties are indirectly associated with the ocean water circulation and the processes on the ocean/atmosphere interface.

167. Another gap in our knowledge, is how the transitions, particularly in a regional context, from one climate regime to another will occur, i.e. whether the changes in temperature, rainfall, atmospheric and ocean circulation, etc., will be gradual or occur in abrupt, stepwise progression. Without knowledge of this, problems of arid or semi arid regions cannot be addressed realistically. Answers to these questions may not be available within the next 10 to 15 years because the models will not be able to predict regional changes, with any degree of certainty within this time.

168. A major problem is one of differing scales; the impact analyses of natural processes, for example, must reconcile the approach of biologists whose studies are often undertaken in terms of square metres with the climatological grid of 100 $km^2$. The same problem exists in hydrology, where studies on small watersheds and run-off plots cannot be easily used for large river basins.

169. Studies of the frequencies of extreme events (high temperatures, high and low precipitation events, storms and storm surges, etc.) and how these frequencies relate to mean climatic conditions, are required in order to help predict changes in extreme event probabilities.

170. Attention should be given to identifying and obtaining data that can be used for climatic impact assessment. The value of long-term data series is stressed. Monitoring programmes collecting such data should be maintained and/or extended. Emphasis should be given to monitoring the effects of climatic changes both for practical reasons and because they may provide clearer evidence of climatic change than the direct measurement of meteorological variables.

Follow-up

171. The continuing work of the six Task Teams, established and supported in the framework of the UNEP Regional Seas Programme, is considered important and, therefore, it is recommended:

- to expand and refocus, if necessary, the work of the Task Teams in order to enable the preparation or completion of regional reports on impact assessments, as envisaged according to the original terms of reference (see paragraphs 3-5);

- to use the assessments for the formulation of regional, national and site-specific policy options and management measures by the relevant governments; and

- to enhance the co-operation between the Task Teams in order to benefit from their broader global perspective and from experience gained in dealing with similar issues and problems.

172. Specific activities envisaged for the future work of the Task Teams include:

Mediterranean

(a) finalize and publish the edited versions of the background papers, including the case studies, presented at this meeting;

(b) prepare a consolidated regional report and present it to the Contracting Parties to the Barcelona Convention;

(c) prepare a popular version of the consolidated regional report for distribution to the general public, environmental managers and policy makers;

(d) offer the Contracting Parties the organization of national workshops based on existing case studies and urge them to foster the formulation of policy options and management measures;

(e) prepare additional case studies for areas and sites identified as being highly vulnerable to the impact of expected climatic change (e.g. cities, islands);

(f) improve the existing regional climate scenarios and models and reassess the overall impact of expected climatic change on the Mediterranean Basin.

Wider Caribbean

(a) finalize and publish the edited versions of the background papers and the executive summary of the draft report;

(b) present the final report to the Contracting Parties of the Cartagena Convention and to the IOC Sub-Commision for the Caribbean Sea and Adjacent Regions;

(c) prepare a popular version of the executive summary for distribution to the general public, managers and policy makers;

(d) prepare case studies (see Annex IV of this report) for subject areas which are considered of highest priority;

(e) improve the existing regional climate scenarios and reassess the expected impact based on the case studies and participation in the World Climate Research Programme;

(f) prepare teaching materials, train teachers and disseminate student-friendly materials on implications of climatic changes.

South Pacific

(a) continue examination, in more detail, of the impacts identified during the preliminary reviews of coastal ecosystems, agricultural production, social impacts, site-specific local climates;

(b) identify and detail where possible additional impacts not covered in the preliminary reviews;

(c) raise the awareness of regional governments and administrations of potential problems resulting from climatic and sea level change within the region, and assist in the identification of alternative policy/planning options;

(d) ensure that the potential consequences of global climatic change and sea level rise are taken into consideration in planning future developments in the countries of the region;

(e) prepare reviews of existing information concerning (i) coral reef responses (growth rates in particular) to rising sea level and increased temperature, and (ii) atoll and raised coral island aquifers;

(f) initiate discussions at a governmental level of the possible consequences of global climate change and sea level rise in the Pacific Basin;

(g) identify the requirements of governments and administrations in the region in terms of future work programmes, information flow and planning assistance;

(h) prepare and publish a booklet on the implications of climatic change and sea level rise for Pacific Island states for wide distribution in the region in early 1989;

(i) organize an inter-governmental meeting in mid-1989 at which the results of the present case studies will be presented; government views on future course of action and the modalities of future operation of the regional Task Team will be determined by the meeting.

Recognizing the similarity of certain potential problems in the East Asian Seas, South Asian Seas, South-East Pacific and Wider Caribbean region with those in the Pacific Basin, it is expected that members of the Task Teams from these regions will attend the Pacific meeting in 1989 and that the South Pacific Task Team members will participate in other regional meetings, as appropriate. In particular, it was suggested that Pacific Task Team members could assist in the proposed Maldives case study since the Maldives situation is identical to that of the 5 countries identified in the South Pacific study as being most susceptible to climatic change and sea level rise.

East Asian Seas

(a) create widespread awareness of the problem among the general public (through popular publications and the mass media) and policy makers and scientific community (through national and regional workshops);

(b) publish the edited versions of the regional report, including the papers prepared for and presented at this meeting and at workshops prepared and convened by the Task Team;

(c) identify additional specific critical areas considered most sensitive to climatic change impacts, for in-depth study that will fill information gaps and result in formulation of acceptable mitigating solutions;

(d) continue monitoring and assessing climatic change effects in the light of new data obtained from other on-going joint projects within the region.

South Asian Seas

(a) prepare a consolidated regional report and present it in a regional workshop involving experts, managers and policy makers;

(b) prepare and convene national workshops in each country of the region and prepare country reports;

(c) prepare a popular version of the consolidated regional report for distribution to general public, managers and policy makers;

(d) request UNEP for early action on the Maldives study.

South-East Pacific

(a) prepare a consolidated regional report with versions suitable for (i) governments, policy makers and managers, as well as (ii) the general public, schools and students.

(b) present the regional report to the Contracting Parties to the Lima Convention;

(c) provide the scientific basis for the preparation of a draft regional protocol concerning technical co-operations to combat the negative environmental effects of climatic changes in the South-East Pacific;

(d) prepare a regional map of areas and cities highly vulnerable to sea level rises based on the El Nino records and of other sites expected to be affected by climatic changes;

(e) provide the scientific basis for a regional contingency plan against sea level rise using the El Nino experience as a guide;

(f) prepare a programme for monitoring impacts of climatic changes, specifying: areas and sites to be monitored; parameters to be measured; techniques and methods to be used; impact receptors; and training needs;

(g) offer the Contracting Parties to the Lima Convention the organization of national and regional workshops as well as other meetings regarding regional climatic changes.

Agenda item 12: Other business

173. Mr. S. Keckes expressed UNEP's satisfaction with the results presented at the meeting, commended the Task Teams for their work, and invited all co-ordinators of the Task Teams to submit to the Oceans and Coastal Areas Programme Activity Centre of UNEP, as soon as possible, their detailed proposals for follow-up activities during the biennium 1989-1990, based on recommendations indicated in paragraph 172 of this report. The proposals should be accompanied by cost estimates for each proposed activity. On the basis of the received proposals, and taking into account the available financial resources, decisions will be taken on which of the proposed activities may be supported by UNEP, as well as on the level of the support.

174. On the invitation of the Chairman, Mr. A.T. Brough, Acting Assistant Executive Director of UNEP, expressed his interest in the meeting and satisfaction with its outcome. He reiterated that UNEP places great importance on assisting governments in developing strategies and policies for coping with climatic change and sea level rise, and assured the meeting of UNEP's commitment to supporting the work of the Task Teams in achieving this aim.

Agenda item 13: Adoption of the report

175. The meeting considered the draft of its report, prepared by the Secretariat, and adopted it with changes deemed necessary. The report, as adopted by the meeting, is reproduced in this document.

Agenda item 14: Closure of the meeting

176. The Chairman of the meeting expressed his appreciation for the excellent spirit of co-operation demonstrated by the meeting's participants, thanked the host institution for the support provided to the meeting, and closed the meeting.

# ANNEX I

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# ANNEX II

## AGENDA

1. Opening of the meeting

2. Organization of the meeting

3. Adoption of the agenda

4. Implications of climatic changes in the Mediterranean region

    4.1 Future climate of the Mediterranean Basin with particular emphasis on changes in precipitation

    4.2 Isopleth maps on mean monthly and annual data of the GISS-GCM programme for the Mediterranean

    4.3 Predictions of relative coastal sea level change in the Mediterranean based on archaeological, historical and tide gauge data

    4.4 Impact of a future rise in sea-level on the coastal lowlands of the Mediterranean

    4.5 Change in vegetation and land-use by the year 2050; a prospective study

    4.6 Implications of climatic change for land degradation in the Mediterranean

    4.7 Physical oceanography aspects and changes in circulation and stratification

    4.8 Hydrological aspects and impact on fresh water resources

    4.9 Effects of the sea-level rise on coastal ecosystems, including those under special protection, as well as on threatened and migratory species

    4.10 Implications of climatic changes on the socio-economic activities in the Mediterranean coastal zone

    4.11 Implications of climatic changes on the Nile Delta

    4.12 Preliminary report on the GRID Mediterranean case studies

    4.13 Implications of climatic changes on the Inner Thermaikos Gulf

    4.14 Implications of climatic changes on the Po Delta and Venice Lagoon

    4.15 Implications of climatic changes on the Gulf of Lyon

4.16 Implications of climatic changes on the Ebro Delta

4.17 Implications of climatic changes on the Garaet el Ichkeul and Lac de Bizerte

4.18 Bibliography on effects of climatic change and related topics

4.19 General discussion and recommendations relevant to the Mediterranean

5. Impact of sea level rise on society: a management approach

6. Implications of climatic changes in the Caribbean region

7. Implications of climatic changes in the South-East Pacific region

8. Implications of climatic changes in the South Pacific region

9. Implications of climatic changes in the East Asian Seas region

10. Implications of climatic changes in the South Asian Seas region

11. Conclusions and recommendations

12. Other business

13. Adoption of the report of the meeting

14. Closure of the meeting

# ANNEX III

## LIST OF DOCUMENTS

<u>Working documents</u>

| | |
|---|---|
| UNEP(OCA)/WG.2/1 | Provisional agenda and timetable |
| UNEP(OCA)/WG.2/2 | Implications of climatic changes on the Garaet el Ichkeul and Lac de Bizerte, Tunisia (by G.E. Hollis) |
| UNEP(OCA)/WG.2/3 | Implications of climatic changes on the Ebro Delta (by M.G. Marino) |
| UNEP(OCA)/WG.2/4 F | Implications des changements climatiques dans le Golfe du Lion (par J.J. Corre) |
| UNEP(OCA)/WG.2/4 E | Implications of climatic changes on the Gulf of Lyon (condensed translation of the French version) (by J.J. Corre) |
| UNEP(OCA)/WG.2/5 | Effects of the sea-level rise on coastal ecosystems including those under special protection and threatened and migratory species (by D. Elder and A. Jeudy de Grissac) |
| UNEP(OCA)/WG.2/6 | Future climate of the Mediterranean Basin, with particular emphasis on changes in precipitation (by T.M.L. Wigley) |
| UNEP(OCA)/WG.2/7 | Implications of climatic change on land degradation in the Mediterranean (A.C. Imeson and I.M. Emmer) |
| UNEP(OCA)/WG.2/8 | Preliminary report on the GRID Mediterranean case studies (by O. Simonett) |
| UNEP(OCA)/WG.2/8 Add.1 | GRID Nile delta case study: results (by O. Simonett) |
| UNEP(OCA)/WG.2/9 | Implications of future climatic changes on the Inner Thermaikos Gulf (by D. Georgas and C. Perissoratis) |
| UNEP(OCA)/WG.2/10 | Impact of a future rise in sea level on the coastal lowlands of the Mediterranean (by S. Jelgersma and G. Sestini) |
| UNEP(OCA)/WG.2/11 | Implications of climatic changes on the Po Delta and Venice Lagoon (by G. Sestini) |
| UNEP(OCA)/WG.2/12 | Implications of climatic changes on the socio-economic activities in the Mediterranean coastal zone (by A. Baric and F. Gasparovic) |

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| UNEP(OCA)/WG.2/13 | Predictions of relative coastal sea-level change in the Mediterranean based on archaeological, historical and tide gauge data (by N. Flemming) |
| UNEP(OCA)/WG.2/14 | Implications of climatic changes on the Nile Delta (by G. Sestini) |
| UNEP(OCA)/WG.2/15 | Change in vegetation and land-use by the year 2050; a prospective study (by H.N. Le Houérou) |
| UNEP(OCA)/WG.2/16 | Physical oceanography aspects and changes in circulation and stratification (by T. Hopkins, M. Gacic and A. Laskaratos) |
| UNEP(OCA)/WG.2/17 | Isopleth maps on mean monthly and annual data of the GISS-GCM programme for the Mediterranean (by W. Bach) |
| UNEP(OCA)/WG.2/18 | Bibliography on effects of climatic change and related topics (by UNEP/MEDU) |
| UNEP(OCA)/WG.2/19 | The impact of sea-level rise on society: a management approach (by P. C. Schröder) |
| UNEP(OCA)/WG.2/20 | Interim report on Potential impacts of greenhouse gas generated climatic change and projected sea-level rise on Pacific Island States of the SPREP region (by the Task Team of the Association of South Pacific Environmental Institutions) |
| UNEP(OCA)/WG.2/21 | Implications of climatic changes in the Wider Caribbean region (by the Task Team of the Caribbean Environment Programme) |
| UNEP(OCA)/WG.2/22 | Implications of climatic changes in the South-East Pacific region (by the IOC/CPPS/UNEP Task Team) |
| UNEP(OCA)/WG.2/23 | Implications of climatic changes in the South Asian Seas region (by the IOC/UNEP Task Team) |
| UNEP(OCA)/WG.2/23 Add.1 | Report of the Co-ordinator of the Task Team for South Asian Seas region |
| UNEP(OCA)/WG.2/24 | Hydrological and water resources impact of climate change (G. Lindh) |
| UNEP(OCA)/WG.2/25 | Report of the meeting |

Information documents

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| UNEP(OCA)/WG.2/INF.1 | Provisional list of documents |
| UNEP(OCA)/WG.2/INF.2 | Provisional list of participants |

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| UNEP(OCA)/WG.2/INF.4 | UNEP/ICSU/WHO: Report of the International Conference on the assessment of the role of carbon dioxide and of other greenhouse gases in climate variations and associated impacts (Villach, 9-15 October 1985). WMO, 1986. |
| UNEP(OCA)/WG.2/INF.5 | WHO/UNEP/UNESCO: Interaction of the oceans with greenhouse gases and atmospheric aerosols. UNEP Regional Seas Reports and Studies No. 94. UNEP, 1988. |
| UNEP(OCA)/WG.2/INF.6 | UNEP/WMO: Developing policies for responding to climatic change (Summary of the discussions and recommendations of the workshops held in Villach, 28 September - 2 October 1987, and Bellagio, 9-13 November 1987). WMO, 1988. |
| UNEP(OCA)/WG.2/INF.7 | The changing atmosphere: Implications for global security (Statement of the Conference, Toronto, 27-30 June 1988). Government of Canada, 1988. |
| UNEP(OCA)/WG.2/INF.8 | Climate impact assessment (R. W. Kates, J. H. Ausubel and M. Berberian, eds.) (SCOPE 27). J. Wiley and Sons, 1985. |
| UNEP(OCA)/WG.2/INF.9 | The greenhouse effect, climatic change, and ecosystems (B. Bolin, B. R. Doos, J. Jäger and R. A. Warrick, eds.) (SCOPE 29). J. Wiley and Sons, 1986. |
| UNEP(OCA)/WG.2/INF.10 | Impact of sea level rise on society (H. G. Wind, ed.) A.A. Balkema, Rotterdam, 1987. |
| UNEP(OCA)/WG.2/INF.11 | Effects of changes in statospheric ozone and global climate. Vol. 4: Sea level rise. EPA, Washington, 1986. |

# ANNEX IV

## CARIBBEAN CASE STUDIES

Coastal erosion is an on-going problem along most coastlines which will be exacerbated by climatic changes and higher sea level, changed riverine sediment discharge, and wind-wave climatology. A regional assessment of the problem will be undertaken to identify several sites (small island, large island, continental), followed by detailed, generic case studies, that emphasize the physical, ecological and socio-economic aspects of erosion, and the relative importance of climatic changes as compared to other on-going processes.

Groundwater/Petroleum extraction in coastal areas increases the rate of relative sea level rise due to enhanced subsidence. A reconnaissance to sites most likely to be affected (Galveston, Texas, Lake Maricaibo, Venezuela; Port-au-Prince, Haiti; Puerto Cortes, Honduras; French Guinana) must be conducted, priorities established, local contributors identified, and a unified regional report on the relative importance of climatic changes to the problem must be made that emphasizes quantitative impacts.

Tropical storm, frequency/intensity is expected to be strongly affected by climatic changes; the best guess is that both frequency and intensity will increase. A detailed numerical model based assessment is necessary because many other factors besides increased sea surface temperature influence storm activity, and because these storms provide a significant fraction of fresh water to many Caribbean nations/territories. Evidence for climatic change induced storm formation, intensity, frequency and fate must be gleaned from careful analysis of the historical record.

Wind stress and ocean transport of the North Atlantic's Gulf Stream System is hypothesized to be significantly controlled by variability in the Wider Caribbean region. Since the Gulf Stream forms in the Cayman Sea and since it transports approximately half of all the heat from the tropics to temperate Atlantic latitudes, better understanding of Gulf Stream heat and mass transport is crucial to understanding the earth's climate. A significant international programme of research (including numerical modelling, satellite observations, hydrography and coastal sea level/weather observations) will be a very significant UNEP/IOC contribution to the WCRP.

Riverine discharge, quantity/quality is known to be of vital significance to the fisheries, pollution, erosion, circulation and safety problems confronting many semi-enclosed seas throughout the world; the Caribbean is no exception. A vigorous interdisciplinary programme to assess the range of problems and the role of climatic change as compared to other variables (precipitation, land reclamation, dams, irrigation, deltaic processes, agricultural run-off, etc.) is necessary. This case study should address all four major rivers in the Wider Caribbean region, and must address the combined impact of the smaller ones.

# ANNEX V

## ACTIVITIES OF IOC RELEVANT TO THE WORK OF THE TASK TEAMS

The IOC intends to:

continue to develop the ocean observing systems of temperature, sea-level, and other parameters on global and regional basis and is prepared to take into account needs identified through the regional studies;

assimilate and provide data on oceanographic conditions relevant for climate studies;

study impacts of increased sea surface temperature and sea level elevations on currents (storm surges, cyclones); and

attempt evaluations of rates of changes of sea level and temperature on basis of new data time series.

The IOC strongly emphasizes that the global ocean climate research programme components (TOGA, WOCE) must be implemented, and the ongoing El Nino related studies continued.

Note: The information contained in this annex was received from IOC for inclusion in the meeting's report.