REGIONAL COORDINATING UNIT
EAST ASIAN SEAS ACTION PLAN

UNEP UNITED NATIONS ENVIRONMENT PROGRAMME

IMPLICATIONS OF EXPECTED CLIMATE CHANGES IN THE EAST ASIAN SEAS REGION : AN OVERVIEW

Edited by L.M. Chou

RCU/EAS TECHNICAL REPORTS SERIES NO. 2

UNEP
Bangkok, 1994

Note: This document was originally prepared under project FP/5102-82-05 as a contribution of the Oceans and Coastal Areas Programme Activity Centre (OCA/PAC) to the Global Climate Change Programme of the United Nations Environment Programme (UNEP) with the cooperation of the Association of Southeast Asian Marine Scientists (ASEAMS). Its publication under the RCU/EAS Technical Report Series is a contribution to the development od the Action Plan for the Protection and Management of the Marine Coastal Environment in the East Asian Seas region.

The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of UNEP concerning the legal status of any State, Territory, city or area, or its authorities, or concerning the delimitation of its frontiers or boundaries. The document contains the views expressed by the authors acting in their individual capacities and do not necessarily represent the views of UNEP or ASEAMS.

For bibliographic purposes this document may be cited as:

Chou, L.M. (editor), Implications of expected climate changes in the East Asian Seas region: an overview. RCU/EAS Technical Report Series No. 2. UNEP, 1994

REGIONAL COORDINATING UNIT
EAST ASIAN SEAS ACTION PLAN

UNEP UNITED NATIONS ENVIRONMENT PROGRAMME

IMPLICATIONS OF EXPECTED CLIMATE CHANGES IN THE EAST ASIAN SEAS REGION : AN OVERVIEW

Edited by L.M. Chou

RCU/EAS TECHNICAL REPORTS SERIES NO. 2

UNEP
Bangkok, 1994

PREFACE

In spite of uncertainties surrounding the predicted climate 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.

The environmental problems associated with the potential impact of expected climate changes may prove to be among the major environmental problems facing the marine environment and adjacent coastal areas in the near future. Therefore, in line with the Decision of the Fourteenth Session of the UNEP Governing Council on "Global climate change"[1], the Oceans and Coastal Areas Programme Activity Centre (OCA/PAC) of UNEP launched and supported a number of activities designed to assess the potential impact of climate changes and to assist the Governments in identification and implementation of suitable response measures which may mitigate the negative consequences of the impact.

In 1987, Task Teams on Implications of Climate Change were established for six regions covered by the UNEP Regional Seas Programme (Mediterranean, Wider Caribbean, South Pacific, East Asian Seas, South Asian Seas and South-East Pacific). The Task Team for the East Asian Seas region was jointly sponsored by UNEP and the Association of South East Asian Marine Scientists (ASEAMS) with ASEAMS co-ordinating the work of the Task Team.

The initial objective of the Task Teams was to prepare regional overviews and site specific case studies on the possible impact of predicted climate changes on the ecological systems, as well as on the socio-economic structures and activities of their respective regions. The overviews and case studies were expected:

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

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

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

- to determine areas or systems which appear to be most vulnerable to the above.

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

The regional studies prepared by the Task Teams were planned to be presented to intergovernmental meetings convened in the framework of the relevant Regional Seas Action Plans, in order to draw the countries' attention to the problems associated with expected climate change and to prompt their involvement in development of policy options and response measures suitable for their region.

The site specific case studies developed by the Task Teams were planned to be presented to national seminars.

---

[1]/ Decision UNEP/GC.14/20

Once the initial objective (impact studies) of the Task Teams is achieved, they concentrate on providing assistance to national authorities in defining specific policy options and suitable response measures.

The East Asian Seas Regional Task Team on the Implications of Climate Change comprised scientists from within the region. At its two meetings in May and November of 1989, team members discussed their findings which led to this report. Emphasis was focused on the 5 countries of the region which participate in the Regional Seas Programme (Indonesia, Malaysia, Philippines, Singapore and Thailand) although other countries within the region have been considered in some of the chapters. The team worked to a scenario of a mean global atmospheric temperature rise of 1.5°C and corresponding sea level rise of 20cm by the year 2025. Case studies in this report appear either as individual chapters or are incorporated within chapters.

The publication was prepared by Prof. L.M. Chou on the basis of the work carried out by the UNEP/ASEAMS Task Team on Implications of Climate Change in the East Asian Seas region. The Task Team comprised L.M. Chou (Team Coordinator), J.G. de la Alas, E.C.F. Bird, A.L. Chong, S.C. Lee, S. Panich, J.N. Paw, K.C. Sieh, S. Sudara, H.D. Tjia, H. Uktolseya, P.P. Wong, H.T. Yap.

EXECUTIVE SUMMARY

The five countries in the East Asian Seas Region have an extensive combined coastline of 99,092 km encompassing a combined land area of 295,063,000 hectares. The present population of 312.7 million is projected to increase to 491.5 million by the year 2025. Approximately 75% of the current population live in coastal villages and towns and the rate of coastal development is rapid. Dependence on coastal and marine resources is high, judging from the present rates of habitat destruction and loss.

The region's coastal zone is heavily utilized to support a broad range of socio-economic activities, including industry, transport and commerce, recreation and farming. Coastal aquaculture development is extensive and growing within the region.

Existing records of temperature and rainfall in the coastal areas of peninsular Malaysia since 1930, and East Malaysia (since 1953), show an upward trend in temperature, but no definite trend in rainfall. The data show an average rate of increase per 100 years of 1.7°C in daily mean temperature. The 112-year record of rainfall in Singapore did not reveal any clear trend. However, with the expected further rise in air temperature by 2025, rainfall is also expected to increase.

Statistical tests on apparent increases in wind speed, rainfall and pressure gradients between South China and Southeast Asia showed that the changes were not significant and there is insufficient evidence at present to suggest a change in monsoon and typhoon activity in connection with CO_2 doubling although this is expected to result in an increase in extreme events.

Global warming will cause changes in the physical characteristics of the seas in the region. Present sea surface temperatures of 20°C to 28°C during the colder months at higher latitudes in the East Asian Seas and of 27°C to 29°C for the warmer months in same areas and throughout the year in equatorial areas, are all expected to increase by 1°C. This will be caused by increased long wave energy re-radiated downwards by the atmosphere. However, it can be anticipated that there will be a lag in the response of the surface layers and much longer lag time in the response of the bottom layers. Enhanced evaporation and increased precipitation will affect salinity. Vertical stability of the already stable surface waters of the tropics will increase further, thus inhibiting vertical mixing which has implications for the biological productivity of the marine environment.

The expected increase in atmospheric temperature is predicted to be greater in the high latitudes (4-6°C) than in the tropics (0-2°C). As a result, the warming of the tropical oceans will be less than at higher latitudes resulting in a decrease in the north-south temperature gradient in the oceans, which in turn, will act to diminish the magnitude of the thermohaline circulation. The implications of these changes on the intensity of the Kuroshio current cannot be determined at this stage. Similarly, the impact of such change on other current systems within the East Asian Seas remains uncertain.

Present knowledge of coral reef dynamics indicates that modern day reefs can cope with a sea-level rise of 5mm/yr. Sea-level rise may provide the necessary environmental conditions for reefs to optimize structure and orientation. Many reefs in the region appear to have attained their maximum limits of growth. Reef flats, being relatively shallow, are subject to greater stress factors and thus support less coral growth. A sea-level rise will reduce the frequency of reef flats to aerial exposure and may promote growth on this zone. These assumptions however, have been made without considering erosional factors caused by increased rainfall which will blanket suitable substrata as well as sessile organisms with sediment. Lowered salinity will also be detrimental to species unable to tolerate large salinity fluctuations. A sudden increase in water temperature may also cause corals to bleach, resulting in mass mortality.

Seagrass and macroalgae can be expected to shift their distribution landward in response to sea-level rise provided that the newly submerged shore areas are suitable for the primary settlement of spores or seedlings. Seagrasses in particular, are frequently exposed at ebb tide and have become adapted to ambient air temperature and rainfall. However, increased air temperature and increased precipitation may exceed their environmental thresholds and result in a reduction of these resources, which would in turn affect certain economically important fish and shrimp species.

Mangroves can theoretically migrate landwards in response to sea-level rise as long as freshwater supply remains adequate. Salinity is of critical importance as the fluctuating regimes of tidal inundation and freshwater dilution influence the characteristic zonation patterns from the seaward to the landward side of these communities. The change in salinity patterns through increased rainfall will affect non-tolerant species and determine the survival or death of affected ecozones. Mangrove species are also expected to be stressed by elevated temperatures.

Direct as well as indirect influences on marine productivity can be expected from climate change. Small-scale temperature increases could result in higher productivity by enhancing the growth of many species. Increased precipitation, if frequent and intense, can however lead to decreased salinity in shallow coastal areas much to the detriment of species inhabiting them. The increased level of nutrients washed out to sea can have a positive effect, encouraging growth of primary producers, as well as a negative effect where enhanced blooms of algae may be detrimental to other marine organisms and mariculture operations. Heavy amounts of sediment washed out to sea will reduce light penetration which is damaging to coastal reefs and marine plants.

Enhanced coastal erosion, through the alteration of coastal topography, may cause large changes in nearshore current patterns. This, coupled with salt water intrusion into the estuarine areas, may have adverse effects on breeding and nursery grounds and the migratory patterns of some economically important species.

Fisheries production would be affected through the change in distribution patterns caused by changes in nearshore currents. Even though the subtidal area would be expanded, allowing more shallow areas for fishery operations, the production would depend on the location. Techniques in mariculture which are now operating along coastlines may change. An example is the greater use of cage or raft culture, due to the unavailability of land since dense human settlements already occupy coastlines. The East Asian Seas is a very productive area. Sea-level rise may bring about some changes in species composition in highly productive areas, affecting economically important species, and thus techniques for fishing would also change.

The effect of climate change on tropical forests will be severe, due to existing situations like the nutrient-poor soils and the alarming rate of deforestation in this region. It has been shown in the past (e.g. the 1982-1983 drought) that tropical forests in this area are not immune to climatic extremes and can be severely affected. CO_2 fertilization has not been proven and may not benefit the forests, as it may alter the balance of the forest ecosystem. The agriculture sector will stand to benefit from climate change through CO_2 fertilization, which may increase the yield by 10-50%, as long as moisture is adequate.

A case study in northern Thailand showed that crop yield (rice) depended on available rainfall in July and August, the "drought periods". The means for conserving water during these months was therefore important, especially because evapotranspiration increased in these months of elevated temperatures. Suggestions for increasing available moisture include bundling and strategic irrigation, both of which would be adequate for the provision of water at the critical period, and allow farmers to enjoy the benefits of CO_2 fertilization. In order to cope with expected increasing drought or "stress periods", new drought tolerant varieties of rice may need to be developed. Switching to other crops may not be feasible because crop types are restricted by market forces, and by domestic and international demands.

The effects of temperature increase are complicated by agricultural practice, increased rainfall and higher evapotranspiration. These can be studied using crop models currently being developed, but preliminary results show a mixture of benefits and losses from climate change. It is noted that certain beneficial measures could result from climatic change, such as use of better irrigation systems to offset the loss of water while taking advantage of the higher CO_2 which increases growth rate. Past records show that agricultural practice in this region is very adaptable to extreme climate events such as droughts and floods, and that it is highly possible to plan for mitigation measures in advance.

It is concluded that impacts on agriculture and forestry from sea-level rise will result mainly from salinity intrusion inland rather than from the actual loss of land.

The impact of sea-level rise is considered to be more direct on coastal geomorphology than elevated temperature. Terrestrial flooding or inundation is the first obvious impact. The extent of flooding is dependent on the coastal gradient and shoreline configuration. Another important aspect is the tidal range, where land affected by a rising sea-level within a small tidal range would be subject to more frequent tidal and wave action than is the case of environments with a wide tidal range.

Coupled with changes in nearshore current patterns, coastal erosion and deposition rates will increase and result in changes to coastal geomorphology. This will be further aggravated by the loss of natural ecosystems which, if unable to tolerate the changed conditions, will lose their coastal protection capability.

Coastal erosion will occur more on soft coasts. Thus, sandy beaches, deltas and cliffs formed from soft materials are more susceptible to erosion from a rise in sea-level. For sandy shores, the resulting retreat from a rising sea-level can be predicted to some extent by the Bruun Rule, although there are limitations and difficulties in the application of this rule. Coral reefs, mangroves and sandy beaches are identified as most vulnerable to sea-level rise. Coastal stretches which require further investigation are classified under five types of coasts: deltas, coral reefs, beach ridges, barriers and spits, lagoons and artificial coastlines.