Vol. 18: 1–3, 2001 | CLIMATE RESEARCH Clim Res | Published October 18

Impact of climate change on the coastal zone: discussion and conclusions

J. Sündermann[1,*], S. Beddig[2], J. Huthnance[3], C. N. K. Mooers[4]

[1]Institut für Meereskunde, Troplowitzstraße 7, 22529 Hamburg, Germany
[2]Zentrum für Meeres-und Klimaforschung, Universität Hamburg, Bundesstraße 55, 20146 Hamburg, Germany
[3]Proudman Oceanographic Laboratory, Bidston Observatory, Birkenhead, CH43 7RA, United Kingdom
[4]OPRC/AMP, University of Miami, 4600 Rickenbacker Causeway, Miami, Florida 33149-1098, USA

At the conclusion of 4 full days of lecture and poster presentations, the participants conducted a 1 h discussion. There were participants from the various scientific disciplines, from the universities and governmental research institutions and administrations and from European and North American countries, such that the following summary can be considered to be representative of current opinion on the theme of the Symposium.

In order to stimulate and to structure the discussion, four questions were posed at the outset:

(1) What do we know?
(2) What lessons have been learned?
(3) What are the major research deficits?
(4) How should scientists participate in the political debate?

Although the discussion was not conducted formally according to this scheme, contributions have been classified according to these questions.

What do we know? Long-term observations (ca 100 yr) show significant fluctuations of physical, chemical and biological variables on time scales from days to decades. In general, the magnitude of the synoptic (days) and seasonal (months) signals exceeds those of the low frequency variability (>1 yr). Nevertheless, there is strong evidence of interannual and interdecadal variability, which have been largely ignored in the coastal zone up to now.

The causes for these fluctuations are not fully understood. For the northwest European shelf, observations indicate the following:

- a rise in mean sea level of 20 to 30 cm century^{-1} (Fig. 1)
- an increase in significant wave heights of 7 to 10 cm century^{-1}
- a retreat of endangered coastlines by 1 to 2 m yr^{-1}
- an increase in mean wind speeds (ca 1 m s^{-1} century^{-1}) and in the frequency of storm surges, without an increase in extremes
- a species shift toward marine organisms with an affinity for higher temperatures.

Model development has made great progress, particularly for the physical part of the system. Present circulation, tidal surges, wave and dispersion models have a useful level of forecasting skill. This is not yet the case for the climatological scale. In particular, with the exception of anthropogenic eutrophication and pollution of the shelf seas, it is still not possible to clearly separate long-term natural and anthropogenic variability in marine systems. Model calculations result in a probable but not definitively proven global warming of 2 to 4°C century^{-1} due to the anthropogenic greenhouse effect. We must acknowledge the uncertainties of any predictions on the impacts of climate change. Coastal zones are generally very sensitive to any external forcing, so climate changes are therefore likely to have the greatest impact and be experienced first in the coastal zone, whereas spatio-temporal buffering in the oceans may delay evidence of climate change for decades or even centuries.

What lessons have been learned? From results presented at the conference, some optimistic conclusions can be deduced. We are beginning to understand the regional aspects of variability and their impacts. Regional climate model downscaling is promising. New observing system technologies have the potential to bring fundamental changes in our ability to monitor. New analysis methodologies can provide new levels of information and understanding.

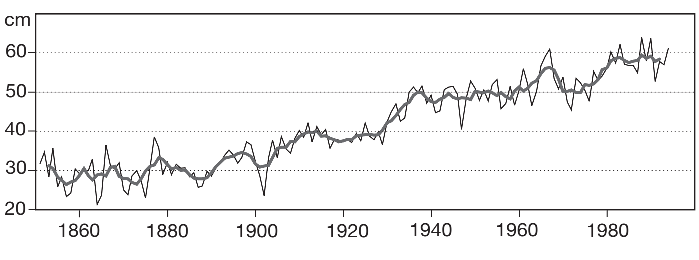

Fig. 1. Sea level rise at Den Helder/Netherlands (annual and 5 yr mean values) from 1850 to 1990 (Sündermann et al. 2001, p 19)

*E-mail: suendermann@ifm.uni-hamburg.de

Interdisciplinary communication and case studies of simple systems should be strengthened. Estuaries are important areas, where many organisms are at the borders of their range. Changes here are not likely to be linear but rather stepwise. We should look for these and draw attention to the fact that small changes in climate can cause tremendous changes in the ecology of coastal areas.

Estuaries are the most variable systems that we have, but on the other hand we're looking at very slow changes with respect to climate. If we look after the physics and the chemistry of the system the biology will take care of itself. However, when humans put constraints on the system, it cannot react as well. The debate at the moment is not whether change is occurring but whether it is anthropogenic. Anthropogenic changes should be identified and evaluated in a societal discussion. Agreement on a long-term protection strategy should be achieved and then transformed into adequate practical measures. With respect to natural changes, after recognizing and understanding them, humankind should react in an intelligent, defensive way. This includes retreating from the coastline if its maintenance is not feasible (i.e. soft engineering). Corresponding strategies must consider geopolitical perspectives.

What are the major research deficits? There are too few data sets and methods appropriate for making good prognoses, even with regard to physical aspects. Effects on the geological/ecological level are more uncertain than physical aspects, and the economic and sociological effects are even more uncertain. There is a need to develop an observation strategy to detect the effects of climate change on the coastal zone in a timely manner. Because of high variability in the system we might not always have the right instruments in the right place. Long time series of marine variables at representative locations are especially needed. At the same time, the scientific basis for monitoring needs to be improved in order to achieve better data sets, despite the difficulties in getting funding for monitoring. Therefore the Global Ocean Observing System (GOOS) and especially its regional component 'EuroGOOS' should be strongly supported. Improved methods and reference data should clarify whether linear, exponential or stepwise changes in temperature and sea level can be expected.

With regard to physical and biological modelling, the interaction must be fostered; in particular physicists need to get more input from biologists. To facilitate sediment transport prediction, observations need to be refocused on obtaining the statistical distribution of key parameters rather than a single estimate, and models need to link bottom turbulence and benthic biology.

Regions that show particularly sensitive reactions on the individual or ecosystem level should be identified, e.g. Arctic regions, deserts and coastal zones, together with gradients, bioindicators and key species. Only complex sensitivity analyses can show the reaction potential and enable effective protection measures.

Case studies are needed to see what we should do as precautions to decrease the sensitivity of coastal areas, i.e. eliminating sewage etc. With the help of such studies, complex interactions should be clarified, e.g. by analysing physical/chemical and biological/ecological processes, identifying patterns and developing models, and testing integrative approaches to ecological and socio-economic problems, drawing on the knowledge and methods of sustainable development. The ongoing transfer of results from basic research to societal applications begs an engineering science approach.

New tools are needed to detect single factors in complex systems. The question of how a system can collapse (e.g. because of extreme events) should be studied. The ecological importance of storms (i.e.

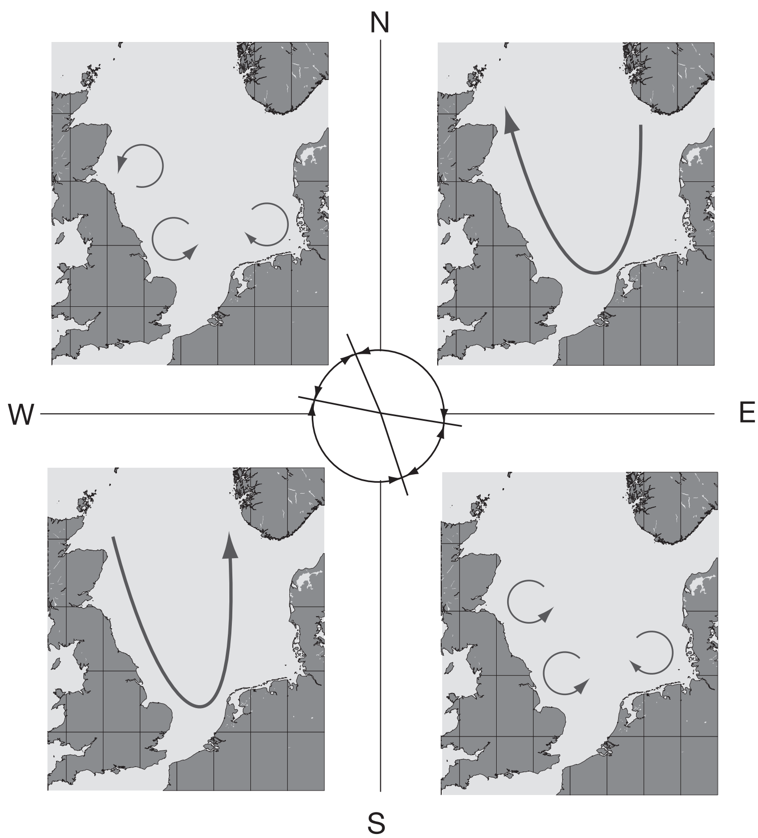

Fig. 2. Circulation states of the North Sea depending on prevailing mean wind directions (Backhaus 1993, p 40)

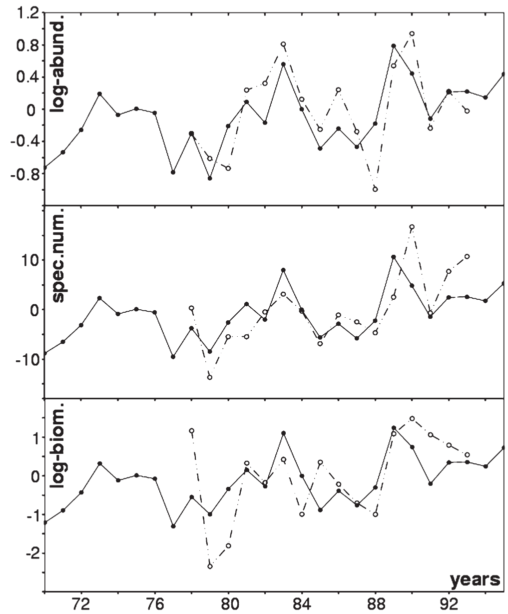

Fig. 3. Dependence of benthic organisms in the North Sea on climate in the North Atlantic. Estimated (solid line) and observed (dashed line) anomalies of log abundance (top), species number (middle) and log biomass (bottom) in the second quarter. Estimations derived from NAO index in the preceding winter (Kröncke et al. 1998, p 33)

extreme versus average conditions) has to be considered.

We should broaden the focus and not only look at the estuaries but rather at the whole shelf, e.g. the way that changes in wind direction can change the circulation regime (Fig. 2). There is an essential need to incorporate consideration of ocean and open ocean processes into the Integrated Coastal Zone Management (ICZM) paradigm (Fig. 3); climate and ocean models need to be downscaled.

There is a need for optimal coastal ocean and estuarine system design for climate detection criteria, as well as for characterization of natural climate variability.

In order to know what is the nature of the fluctuations observed, it is important to have long time series of e.g. storminess, rainfall and temperature data. In this respect, further research is needed on historical records of the last 500 yr or even older, using records that are continuous and uniform. Research on historical sources leading back into the 18th century and overlapping the century of historical instrumental measurements, can supply us with methods of translating the historical evidence (proxy data) into quantified historical climate data.

How should scientists participate in the political debate? Scientists should actively take part in the political debate. They should give politicians the necessary information in the right form, i.e. concisely. Scientists should produce scenarios for policymakers, but should present alternatives from which they can choose.

Scientists must be clear about their uncertainties. Public disagreements by individual scientists arguing from entrenchend positions can undermine credibility. Likewise there are dangers in constantly seeking more funding for topical issues when the science concerned cannot usefully impact on such topics within the timeframe concerned.

Pressure on politicians works better via the public. But public understanding needs to increase. Scientists should therefore become actively involved in informing the public. Scientists should impact the educational process at all levels. ECSA should set up a web site for the public and politicians that will inform them of the changes documented. It should interface with engineers, ICZM and policymakers.

We must be cautious about making recommendations to politicians, since we do not really know very much about the course of change, e.g. in estuaries during the past 20 000 yr. We need to put the role of humans into the greater geological perspective. That means that we should react defensively to natural fluctuations of the system (i.e. soft engineering). Human encroachments should give nature time and opportunity to establish a condition of stability.

LITERATURE CITED

Backhaus JO (1993) Das ‘Wetter’ im Meer: Nord- und Ostsee. In: Schellnhuber HJ, Sterr H (eds) Klimaänderung und Küste — Einblick ins Treibhaus. Springer Verlag, Berlin, p 37–49

Kröncke I, Dippner JW, Heyen H, Zeiss B (1998) Long-term changes in macrofaunal communities off Norderney (East Frisia, Germany) in relation to climate variability. Mar Ecol Prog Ser 167:25–36

Sündermann J, Beddig S, Radach G, Schlünzen H (2001) Die Nordsee — Gefährdung und Forschungsbedarf. Zentrum für Meeres- und Klimaforschung, Hamburg