Coral (*Agaricia agaricites*), fire corals (*Millepora* spp.), and some sponges (*Callyspongia plicifera* and *Aplysina archeri*) and gorgonians (*e.g. Iciligorgia schrammi*), were damaged. A large coral-head was hit by a trap (Fig. 5) at 15 metres depth and a deep groove about 25 cm long and 3 cm wide resulted. Within two days of removal of the trap, regeneration had commenced. However, some Algae grew on the exposed septae and prevented further coral regeneration.

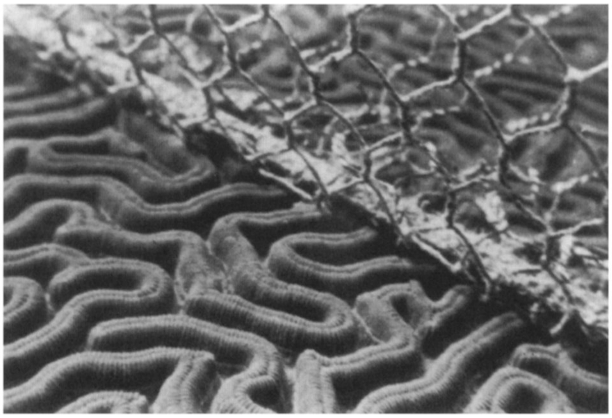

FIG. 5. *A fish-trap set on a Brain Coral,* Diploria labyrinthiformes *(x 2/3).*

Another Brain Coral, *Meandrina meandrites*, which had only been damaged superficially, recovered completely. Growth of Algae also occurred in cases where Leaf and Star corals were injured, and again prevented complete recovery. Gorgonians recovered completely from damage within a month. No macroscopic organisms were found on or near the wounds to inhibit regeneration. Complete deterioration of a vase sponge was observed after it had been severely damaged by a trap at 20 metres' depth.

It was very hard to set a trap neatly in the slope zone (20–30 m, Fig. 2), because of the steepness of the reef's slope; the traps tended to tumble downslope, leaving a track of demolition through slow-growing corals. For this reason further trap trials were abandoned.

## *Discussion*

Major objectives of the research were firstly to deal with technical fishery problems and secondly to study the impact on the fish resources. No quantitative measurements were performed on coral regeneration, though the qualitative results are worth reporting. Data were restricted to opportunistic observations on damage caused during fishing trials. Additional experimental damage was not justifiable in the marine reserve. This report deals with very realistic coral injuries.

The results emphasize the need for trap-fishery regulations which conform to the principles of coral-reef conservation. The preliminary results of the trap-fishery research show that restricted trap-fishery activities may be allowed in the Bonaire Marine Park, but only in certain zones, namely the *Acropora cervicornis* (or Staghorn Coral) zone and on the sand-platform between two reefs. The latter zone would demand much more effort to be expended in hauling traps (Knaap, 1982).

It is obvious that fishermen who are not in possession of winches will prefer fishing in the shallow zone. From the reef-conservation point of view, that choice may be justified because *A. cervicornis* regenerates completely, while species of other coral genera (*Diploria*, *Montastrea*, *Agaricia*, *Millepora*, etc.), either regenerate too slowly to hold their own or lack means of preventing the growth of Algae and the settling of other coral-destroying organisms (boring mussels, boring sponges, and certain tubeworms).

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# Air Pollution Modelling Applications in Hungary:
## An Example of Short-term Collaboration between Switzerland and Hungary

### INTRODUCTION: SUMMARY OF OBJECTIVES

It has often been stated that environmental degradation in Central and Eastern Europe has reached alarming proportions; one major cause is the uncontrolled release into the atmosphere of numerous acidic compounds and heavy-metals by industries which employ outdated production technology. It is therefore of importance, in the new economic and political context of Central Europe, that every effort be made to improve the environmental situation of those countries. In particular, access to modelling techniques which allow regional atmospheric conditions to be simulated, incorporating air pollution transport and dispersion, would help greatly in environmental policy planning and development.

This research proposal was therefore aimed at transferring modelling expertise that had been developed in Switzerland, to scientists working in the Hungarian Meteorological Service and the Department of Meteorology at the Eötvös Loránd University, Budapest. The transfer of expertise and modelling tools is aimed at improving the evaluation and prediction capabilities for the study of some important trace-compounds in Hungary. At a later stage, the collaborative effort between Switzerland and Hungary, funded by other means, should allow the estimation of the relative contributions of domestic and transboundary pollution to observed concentrations of trace-compounds in Hungary.

The project schedule was initially planned to have three phases, *i.e.*:

Phase 1: Analysis of the relevant methods and modelling facilities in Switzerland.

Phase 2: Preparation of data for the implementation of the relevant models in Hungary.

Phase 3: Model implementation, including derivation of climatological results of transport of atmospheric trace-compounds.

The model used throughout the project is the DREAMS Modelling System (*D*ifferential equation *RE*gional Atmospheric *M*odelling *S*ystem). DREAMS-1 is a three-dimensional atmospheric model which makes use of the finite difference technique to solve a series of time-dependent equations for processes acting typically on a regional scale. The model was originally developed in the early 'eighties to investigate organized cloud convection over a maritime area, such as the Rayleigh–Bénard type of convection that is frequently observed as cold air-masses move over a warmer ocean surface. It has also been used to investigate some aspects of cloud and radiation interactions, as well as the dynamic and thermodynamic influence of a water surface on the regional atmosphere. At a later stage of its development, DREAMS-1 has been used in complex terrain to study air pollution on a local scale, through coupling with DREAMS-2. The size of the model domain is essentially limited by the computer resources on which the model code is implemented. For a supercomputer such as the CRAY-2 or equivalent, the enormous memory-capacity allows a generous domain size; DREAMS-1 has been run with up to 2 million grid-points on such a machine.

On less-advanced machines, the model code can generally run with a 32,000-points' grid mesh distributed in the three cartesian directions, thus allowing a balance to be found between domain size and computing time. Typical grid interval is 1,000 m and up in the horizontal and vertical levels can be unevenly distributed, allowing higher resolution of the lower levels of the Atmospheric Boundary Layer (ABL). In general, the first model level is located at 50 m above the reference level, with subsequent even spacing of between 100 and 250 m. The DREAMS-2 model code contains schemes allowing the study of the physical behaviour of pollution with both the Eulerian and the Lagrangian techniques; it is used at present for the study of passive pollutants and employs the dynamic and thermodynamic data generated by DREAMS-1 to compute the characteristics of pollutant transport and dispersion. A number of papers related to this coupled model system have been published in the peer-reviewed literature — *see* the list of 'Selected Publications Relevant ...' at the end of this comunication.

## Description of the Project Schedule

### *Summer 1992: Switzerland*

The Author hosted the visit of three Hungarian specialists: Dr Laszlo Bozo and Dr Sandor Szalai from the Hungarian Meteorological Service in Budapest, and Dr Tamas Weidinger from the Department of Meteorology at the University of Budapest. They spent two weeks in Switzerland, from June 22 through July 4. The principal aim of this visit was to undergo training on the DREAMS modelling system which was provided by the Author in Bern and Lausanne, and by colleagues in Lausanne. A secondary objective was to visit other Swiss groups involved in air-quality research, and also the facilities of the Swiss National Computing Center (Centro Svizzero di Calcolo Scientifico–CSCS) in Lugano-Manno where the DREAMS models are installed and where some of the advanced post-processing and graphics are being developed and implemented.

After reviewing the methodological aspects, the model structure, the parameterization requirements and schemes, and the scope of applications, discussions focused on possible ways of adapting the methodology to Hungarian conditions (orography, resolution of the Hungarian emission inventories of various pollutants, wind, and precipitation fields, etc.). The first tests were made in Switzerland and were followed by others made on a particular test area in Hungary which was of interest to our colleagues from Budapest.

The first week of this part of the project's implementation was therefore devoted to the training, demonstration, and test phases, of the DREAMS models, The second week was devoted to visitation of various Swiss institutions working in related fields. These included:

- Institute of Geography, University of Bern (Professor H. Wanner, leader of the POLLUMET Program), for discussions on aspects of air pollution studies in Switzerland.
- Department of Geography, ETH-Zürich (Professor A. Ohmura and Dr H. Blatter), for discussions on new efforts to model global climate change and its regional impacts.
- Swiss Meteorological Institute, Payerne (Mr P. Jeannet), to visit the environment/aerology section of the Institute.
- Swiss Meteorological Institute, Locarno-Monti (Dr P. Ambrosetti), to visit the instrument development section of the Institute.
- Centro Svizzero di Calcolo Scientifico, Lugano-Manno (Dr R. Gruber), to visit the supercomputing facilities and discuss matters related to advanced modelling and graphics techniques.

A visit was also organized to the Joint Research Center of the European Community in Ispra (Italy), to confer with Professor M. M. Verstraete with whom we collaborate in matters of model/data intercomparisons using remote-sensing techniques.

*Winter and Spring 1993*

Following their visit to Switzerland, the Hungarian experts transferred the DREAMS modelling system to Budapest. The porting, installation, and testing, of the model codes has gone ahead well; this is due in part to the good computing infrastructure which is available at the Hungarian Meteorological Service headquarters and the Eötvös Loránd University, Budapest (VAX and CONVEX machines), which are capable of handling complex models and have good FORTRAN compilers that are essential to the execution of DREAMS. In addition, the Hungarians have begun to collect and prepare the data needed for specific applications to Hungarian conditions. This part of the project includes preparation of the geographical, meteorological, and chemical, data in the formats required by the model; determination of any other initial conditions, including the necessary temporal and spatial characteristics (number of grid-points and characteristic time-intervals to be modelled, etc.). These features are determined by the capabilities and limits of the models, and the availability of emission data in Hungary.

The first tests of the model system to a real situation have been conducted for the region of Sopron, west of Budapest. Here, the topography is moderately complex, with a series of hills and valleys which channel the air-flow and the pollution emitted by industry in the Sopron area. At the time of the compilation of this report, the Hungarian specialists have already simulated a number of typical weather situations in the region, and the model results have been judged satisfactory. Study of the behaviour of air pollution embedded in these flows will be undertaken in the near future with DREAMS-2 (the air-pollution module of DREAMS).

During the recent visit to Hungary by the Author (in April 1993), new simulations were demonstrated in the region of Lake Balaton, where conflicting industrial and environmental interests occur near the north shore of the Lake. Here, wind patterns for typical synoptic episodes have been simulated in an attempt to describe the different vertical wind-profiles as a function of prevailing wind direction and land surface characteristics; a correct description of wind-flow characteristics is essential for accurately simulating air pollution behaviour. Other test cases which will be simulated will be in the region of Budapest, in order to have a synthetic understanding of flow and air quality in the vicinity of the capital.

Dr Tamas Weidinger, Lecturer at the Eötvös Loránd University, Budapest, has used the DREAMS model code as a didactic tool for his students. The model system was used to illustrate the practical aspects of modelling, *i.e.* the 'translation' of mathematical equations through numerical methods into a form which can be executed on a computer. This is believed to be the first time that such a modelling system has been made available, in the field of atmospheric physics, for higher-education purposes in Hungary.

It is planned to pursue the joint collaboration in future, and in time to publish joint papers. A workshop may also eventually be organized, perhaps in collaboration with other Eastern European countries and Austria.

As a concluding remark, this project has shown that, with a relatively modest financial contribution from Switzerland, an interesting joint collaboration has developed which provided Hungarian colleagues with the basis for longer-term research in the Central European region. The transfer of modelling techniques for simulating regional air quality, and their adaptation to local conditions in Hungary, will no doubt prove to be of use to environmental and industrial decision-makers in this important period of economic transition.

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## Selected Publications Relevant to the DREAMS Modelling System (in chronological order)

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