increasing dependence of the science and engineering workforce on those students when they graduate, and the possibility that many of them will return to their more prosperous homelands to become the spearhead of further competition to US industry. The modern equivalent, some would say, of capitalists selling rope to their hangmen.

The world will not change because a few academics are worried that the way it is moving may damage their institutions. Still, there is nothing inevitable about the direction of events, and academics and their friends are not wholly excluded from debates about policy in most countries. Here are some suggestions for constructive action.

First, at every opportunity, remind economists and their allies in government that markets do only one thing very well, namely, allocate resources by setting prices. Markets are not automatically applicable to all social problems, and they may be fatally destructive where values are at issue and quality matters more than price.

Second, welcome the opportunity to be useful. It is not a crime to concede that society has a right to a reckoning of the value of its academic institutions and to expect that some of their intellectual power should address today's problems. As Derek Bok points out in his essay,

there is little evidence to support a direct connection between research and the economic prosperity of the country in which it takes place. In the United States, the connection has already been oversold. The argument needs to be refined and moderated to prevent universities from becoming swamped by disappointments.

Finally, academics need first to understand themselves, and then to persuade others that their greatest social contribution, by far, lies in the preservation of the values that make their institutions worth supporting in the first place. Those values are important underpinnings of democratic societies, as well as being essential for high-quality teaching and research. □

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■ Robert M. Rosenzweig is one of 14 contributors to *Research and Higher Education: The United Kingdom and the United States*, edited by T. G. Whiston and R. L. Geiger. The book considers the 'national systems'; research environments, teaching and research interactions, and graduate education and research training; and prospects for academic research in relation to governments, industry and society. Published by Open University Press, £35.

Mixed reactions

Mark Varney

ECos Estuarine Contaminant Simulator. *Plymsolve*, 32 Looe Street, Plymouth PL4 0EA, UK: 1991. Licence £560 or £280 (educational and research). Other rates and details on application.

ESTUARIES, with their high productivity and frequent proximity to cities, are the purview of marine scientists, teachers, environmentalists and all those involved in aquaculture, water monitoring and pollution control. Many of these groups now use computer software tools to provide a better understanding of data, to assess and predict impacts and risks and to assist in writing reports. These tools are valuable provided that their limitations are acknowledged; they will certainly never obviate the need for field studies. ECoS, a menu-driven estuarine contaminant simulator, is the latest addition to these aids and is intended for specialists and nonspecialists alike.

A main concern of estuarine science is to calculate the transport of contaminants from rivers through estuaries and into oceans. Direct measurements of the hydrodynamics, water flow and concentrations of contaminant involved in the transport are difficult and expensive to

make — hence the need to model and predict fluxes and distributions.

Obviously, modelling any estuary is immensely difficult — tides, the weather, intertidal and mudflat zones, waves, hydraulics, dredged channels and shipping all influence the movement of water. ECoS contains a segmented physical mixing model that can account for the transport and dispersal of contaminants by river flow and tides, water solubility, degradation, disequilibria, air-sea exchange, partitioning onto suspended particles and sediment interactions. The attraction of the simulator is that it can be built up without any knowledge of the underlying physics or hydrodynamics.

The software is written as a flexible 'shell' that can be tailored to both real and hypothetical estuaries. The shape of the estuary can be represented algebraically or as a series of cross-sectional 'segment' areas constructed from 'boxes'. One can define exactly how and where in the estuary the contaminants are introduced, react and are lost, and the program can then be run to establish the distributions of dissolved and absorbed contaminants at a later stage, as well as calculating their residence times in the estuary. Parameters can be freely altered so that their effects on the distributions can be observed. The program can be run and re-run with slight modifications to the 'forcing' functions,

allowing the importance of other chemical processes to be examined interactively. Simulations can be saved and replayed, with the addition of new data if necessary. In this way, large libraries of data and results can be collected.

What are the program's limitations? Measuring fluxes in estuaries is difficult because of the variability caused by external factors. ECoS therefore needs to be calibrated to validate the physical-exchange equations, requiring exacting surveys, usually of the salinity gradient as the best available tracer representing the mixing processes.

ECoS, like most models, uses the averages of measurements throughout tidal cycles. So 'double high waters' and 'young flood stands', which may have significant and asymmetric effects on sediment transport, cannot be modelled. ECoS also assumes that each 'segment' in the model is well mixed. The model cannot represent side-to-side exchange processes such as wind-driven effects on the mean circulation, which in any case are difficult to measure accurately, as are freshwater flows independently of tidal influences. These inaccuracies can lead to large error in flux estimates. And tidal range, river discharge and wind can affect fluxes for up to hundreds of tidal cycles, influences that must be considered when assessing the general applicability of a particular result. Further, with ECoS one cannot model layering such as that of salt wedges or the freshwater-saltwater interface, except by the difficult procedure of increasing the number of 'boxes' where the concentration gradient is highest. Nor does the program treat the problem of 'embayment' — instead, boxes have to be added to the side of the main estuarine box set.

The program is easy to install and use, although it is notably slow and not readily compatible with some other programs, particularly those that are memory-intensive or use a mathematics coprocessor. A code from the hard disk is used as a password to protect the program from illegal copying (I would have preferred the use of the 'dongle').

ECoS is not an ideal representation of an estuary. Two-dimensional models usually provide better descriptions but are more difficult to write, require greater computing power, and are often specific to a particular location and cannot be readily modified. ECoS is useful because it can help determine if it is worth developing better models. It will prove to be valuable for quick exploratory analysis and for indicating where it would be fruitful to collect more data. □

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