The science of sea dumping

SIR—In their letter on the science of sea dumping (*Nature* 11 July, p.100), Alan Reddish and Steve Cousins state that "scientific modelling should clearly specify the model in terms of the underlying theoretical assumptions". We agree, which is why the forthcoming Nuclear Energy Agency (NEA) report on the review of the continued suitability of the north-east Atlantic dump site[1] contains over 60 pages of description of the models developed by the Ministry of Agriculture, Fisheries and Food (MAFF) and the National Radiological Protection Board (NRPB) to assess the radiological impact of sea dumping of radioactive waste on both humans and marine organisms.

Clearly, Professor Holliday and his team[2] could not include all this detail in their report and there was no need since it is to be published elsewhere. However, the full description was provided to them, to the NEA expert group for the dump site review and to the panel of scientists carrying out the London Dumping Convention review.

Reddish and Cousins also express concern about experimental validation of models, but they fail to realize the difficulties involved and the extent to which field measurements have in any case been used. Direct validation of the whole suite of models is simply not possible because of the large time and space scales involved and the very low radionuclide concentrations. What can be done is to validate those parts of the models that have most effect on predicted radiological impact.

Studies of model sensitivity show clearly that it is the interactions between radionuclides and suspended and seabed sediments that most influence doses. This part of the model has been validated[1], using data on naturally occurring radionuclides in the ocean. Data from the earlier dumping site in the English Channel cannot be used for direct validation because the site is coastal while the models deal with dumping in the deep ocean and because monitoring has failed to detect any radioactivity that can be traced to this site. Irish Sea data are also coastal and so could not be used for direct validation, but they can be, and were, used in fixing some model parameters, particularly the factors by which coastal water organisms concentrate radionuclides.

One method of telling whether the results of a particular modelling proach are robust is to tackle the problem in a conceptually different way. The basic model used to estimate dose to man was first of all to predict the distribution of radionuclides in space and time, using an oceanographic model and then to calculate the expected concentrations of radionuclides in sea foods by the application factors.

The concentration factors anticipate the concentration of radionuclides in surface and mid-water marine organisms, relative to the ambient water, as a result of the accumulation of radionuclides from all sources including the ingestion of food. The values used are, for the most part, derived from direct observations. The sea foods eaten by man are all taken in coastal and surface waters to depths of up to 1,500 m.

No sustained food chains from the deep sea (> 4 km) to man are known but, as a safety measure, calculations were also made of the dose to man that could arise if fish living at the dump site itself, close to the bottom, were directly consumed by man. All these calculations indicate very low expected dose rates to man at daily consumption rates of considerable quantities of sea food.

The conceptually-different approach used in the sensitivity analysis was to estimate the dose to man that might arise if, by some chance, contaminated organisms within the dump site were consumed by organisms from outside the area, resulting in radionuclides eventually being transferred to man at concentrations that would not be predictable from the ambient water concentrations, and over a much shorter time scale.

The results of making a number of calculations, based on various ideas as to how such a transfer of radionuclides could in theory be effected, led to the conclusion that even if such occurrences do take place, the resulting dose to man would still be exceedingly low.

There is often a common misconception as to what, exactly, models are attempting to achieve. In this case it is an attempt to estimate the dose to man, and the impact on the deep-sea fauna, as a consequence of disposing packaged radioactive waste into the deep sea. The models used do not aim to represent in detail all known geochemical, oceanographic and biological processes. What they do attempt is a distillation of the major processes and parameters that would be primarily concerned in estimating the dose to man and, by the application of sensitivity analyses model-to-model comparisons, and a verification of major parameters by environmental observation, produce sufficient information for decisions to be made.

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1. *NEA Review of the Continued Suitability of the Dumping Site for Radioactive Waste in the North East Atlantic* (Nuclear Energy Agency, OECD, Paris, in the press).
2. F.G.T. Holliday *Report of the Independent Review of Disposal of Radioactive Waste in the Northeast Atlantic* (HMSO, London, 1984).

Pain and animals

SIR—R. Sharpe's letter (*Nature* 25 July, p. 290) contains a sentence beginning "Since it is impossible to devise a method of measuring pain in animals it follows that...". If this premise was true, it would indeed follow that regulations against cruelty to animals would depend on doubtful subjective judgements. The problem is not how to assess an animal grossly disturbed by some acute injury which no humane human would allow to continue. Veterinarians and scientists are faced with the much more difficult problem of judging animals with a chronic disorder such as arthritis.

A number of groups have proposed solutions and in particular the International Association for the Study of Pain has published its obligatory guidelines (*Pain* **16**, 109–110; 1983). They require a two-stage investigation. First the animal in question is compared with normal animals by measuring quantitatively its behaviour such as movement, grooming, sleep etc. and by measuring its physiology such as EEG, hormone levels, autonomic state and so on. The animal is then treated with a relevant analgesic procedure and its behaviour and physiology are again measured. The first measure describes the abnormality of the animal in objective terms and the second measures the degree of abnormality attributable to pain. It is as crucial for animals as for babies that we should use every available skill to measure their pain in spite of the fact that we cannot speak to them.

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Improving crops

SIR—Close to this town lives a tribe of Indians who practise a clearly defined method for improving their crops, particularly maize. Every family plants its own seed, avoiding contamination with alien germplasm. When they find an outstanding example, they do not use it for food or seed; they give it as a present to a friend, who is not supposed to eat it or use it in any other way, but to plant it. The whole action is treated as a religious ceremony or social convention, presumably part of a system ensuring the tribe's continuity. The exchange involves a large part of the community, and is made in all directions.

The obvious objective is to increase the frequency of favourable genes with additive actions, by selecting within a mildly inbred population, in which new forms with desirable characteristics are introduced periodically.

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