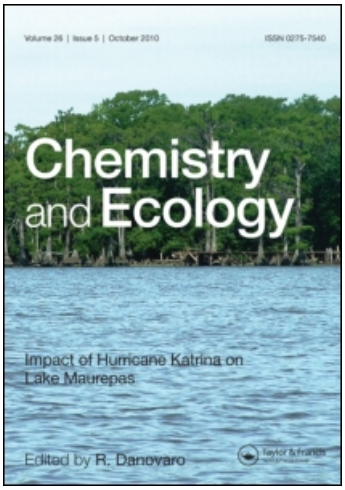

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THE DECLINING INFLUENCE OF SCIENCE ON MARINE ENVIRONMENTAL POLICY

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Differences between the scientific and environmental policy communities regarding marine environmental protection strategies are discussed in the context of the nature and extent of scientific influence on marine environmental policy. Public perceptions of the nature and severity of marine pollution frequently differ from scientific assessments. The thesis of this paper is that the increasing influence of public perception on marine environmental protection policy is leading to the adoption of simplistic and unnecessarily extreme approaches to marine pollution prevention and to a reduced reliance on science. This trend is illustrated by some recent international developments and some suggestions are made towards enhancing the influence of science on marine protection policy.

KEY WORDS: marine pollution, marine policy, scientific assessment, assimilative capacity

INTRODUCTION

The influence of science on marine policy development and the role of science in providing advice on effective methods for marine environmental management appears to be declining. This paper provides a personal perspective on some strategic initiatives in the field of marine environmental protection. This perspective has been gained from involvement in the environmental protection activities of a number of international organizations. The views I express here do not necessarily reflect the views of the Government of Canada for which I work.

HISTORICAL FRAMEWORK

Many of the marine environmental protection initiatives with which we are commonly familiar stem from the 1972 Stockholm Conference on the Human Environment. This Conference, and its 26 General Principles, constitutes a major benchmark in the field of environmental protection. It reflected society's recognition of the growing importance of environmental considerations in the face of continued global development. The conference made relatively few recommendations, but these were both succinct and sensible with the objective of promoting:

- development in a manner that avoids prejudicing environmental amenities for future generations;
- avoidance of serious/irreversible damage to the environment;
- avoidance of measures that transfer damage from marine to other environments;
- concerted international action for environmental protection and conservation.

In the 20 years that have elapsed since this Conference, the need to consider the consequences of action to improve the protection of a single sector of the environment, such as the ocean, on other environmental sectors is a concept that is becoming forgotten. Similarly, the emphasis on 'defined damage' as distinct from mere perturbation has become blurred.

The Stockholm Conference also defined the role of science and technology as follows:

> *'Science and technology, as part of their contribution to economic and social development, must be applied to the identification, avoidance and control of environmental risks and the solution of environmental problems and for the common good of mankind'.*

The Stockholm Conference provided the impetus to the formulation of the London Convention 1972, which came into force in 1975. At this time, the Oslo Convention provided a basis for the multilateral regulation of sea dumping in the northeast Atlantic. Soon afterwards, the Paris Convention was brought into force to provide a basis for the regulation of land-derived discharges and atmospheric inputs to the Northeast Atlantic area. All these Conventions, and several more recent regional conventions, are similar in the sense that they restrict activities by specifying the limits of permissibility – partly through the use of 'black' and 'grey' lists. Black lists specify substances that are proscribed from disposal in the sea except, for example, as trace contaminants. Grey lists contain substances that require special measures to ensure that their disposal does not cause undue harm. These Conventions all specify how the suitability of substances for disposal, and the procedures for disposal, may be assessed to minimize adverse effects on the marine environment.

Common to the black lists of most Conventions are oil, organohalogen compounds, mercury and cadmium. These assignments reflect several of the substances of concern in the early 1970s. Oil, largely because of the several large tanker spills and accidents, was perceived as a wholly deleterious contaminant. Later, this view was to change (GESAMP, 1989; ICES, 1985; GESAMP, 1993), but the contemporary perception of oil as always damaging, whether in large or small amounts, resulted in its assignment to black lists. Mercury and cadmium were also perceived as seriously damaging to the marine environment. The assignment of these substances was primarily a reflection of the Japanese Minimata and 'Itai Itai' disease incidents. Similarly, and far more justifiably in the context of the limited information then available, synthetic halogenated organic preparations were also regarded as damaging. Accordingly, these substances are also common assignments to black lists.

These assignments are attributable to contemporary perceptions rather than to comprehensive scientifically-based evaluations of hazard. Indeed, in retrospect, it is difficult to justify, on scientific grounds, the assignments of mercury and cadmium when, clearly, the natural mobilization of these elements is relatively large and the ocean has a substantial assimilative capacity for both. The same can be said of oil in the sense that there exists significant seepage to the ocean from natural sources and low levels of oil occur wholly naturally. Thus, rather than the Conventions providing a basis for prior assessments of the potential for adverse effects caused by anthropogenic releases of these substances, their Contracting Parties were left with no option but to avoid ocean disposal except to the extent that the relevant 'trace contaminants' provisions would allow. Not surprisingly, in the 2-decade history of the Conventions, these 'trace contaminants' provisions have not yet been quantitatively defined in any rigorous scientific manner and remain as arbitrarily-assigned values.

Another common element of early agreements dealing with marine environmental protection was the adoption of the GESAMP definition of 'pollution':

'Pollution means the introduction by man, directly or indirectly, of substances and energy into the marine environment (including estuaries) [resulting] [which results]* in such deleterious effects as harm to living resources, hazards to human health, hindrance to marine activities including fishing, impairment of quality of use of sea water and reduction of amenities.'*

[* Both forms are in current use: 'which results in' by Unesco and FAO; and 'resulting in' by UNEP, WMO, IAEA, IMO and WHO.]

TWO DECADES OF DEVELOPMENT (1972–1992)

There has been a wide variety of initiatives on marine pollution prevention since the Stockholm Conference of 1972. Many of these led to the second major benchmark statement, known as 'Agenda 21', arising from the United Nations Conference on the Environment and Development (UNCED) held in 1992. Unfortunately, while the Agenda 21 statement on 'Protection of the Oceans ...' (Chapter 17) is far more detailed than relevant parts of the Stockholm Declaration of 1972, it lacks the clarity and coherence of the earlier declaration. This, in large part, is due to the conflicting social philosophies regarding environmental protection, including the stress on the application of the so-called 'precautionary principle' in the absence of a clear understanding of what role this should play in the scientific arena.

I cannot be exhaustive about the many initiatives taken in regard to improving the international framework for marine environmental protection since 1972. Here, I merely attempt to identify some of the issues responsible for a transfer of emphasis from scientifically-based approaches to those favouring public perception.

THE DISTINCTION BETWEEN CONTAMINATION AND POLLUTION

During the last 20 years there has been an increasing tendency for the words 'pollution' and 'contamination' to be used interchangeably. This is contrary to international definitions of these terms in which 'pollution' infers adverse effects and 'contamination' signifies perturbation by anthropogenic activity but **without** implication that such perturbation is necessarily deleterious, viz:

'Contamination is used to describe the situation which exists where either the concentration of a natural substance (e.g., a metal) is clearly above normal, or the concentration of a purely man-made substance (e.g., DDT) is readily detectable, but where no judgement is passed as to the existence of pollution (i.e., adverse effects).' (ICES, 1989)

The GESAMP definition has been criticized on a number of occasions (e.g., Tomczak, 1984). Members of GESAMP have, on two occasions, brought GESAMP's attention to both substantive and presentational flaws in its current definition of pollution. Despite these criticisms, GESAMP has chosen not to adopt any revisions. Consequently, it is interesting that, within the forum of the London Convention 1972, a proposal was made recently for a definition that overcomes most of the deficiencies. This proposed draft definition is as follows:

'Marine pollution means the occurrence of deleterious effects or hazards to human health, harm to living resources and to marine ecosystems, damage to amenities or interference with other legitimate uses of the sea, when those effects are caused, or are likely to be caused, by [the] [man's] introduction, directly or indirectly, into the marine environment of [substances or energy] [wastes and other matter].'

In this definition, pollution becomes equated with adverse effects rather than 'the introduction of substances' which is a substantial improvement and more clearly reflects the meaning of pollution.

ENVIRONMENTAL CAPACITY AND PRECAUTION

The concept of 'environmental capacity' was formally expressed in Principle 6 of the Stockholm Conference:

'The discharge of toxic substances or of other substances and the release of heat, in such quantities or concentrations as to exceed the capacity of the environment to render them harmless, must be halted in order to ensure that serious or irreversible damage is not inflicted upon ecosystems.'

This was later expounded in some detail by GESAMP (GESAMP, 1986) and is intrinsically based on discrimination between 'contamination' and 'pollution'. Clearly, the boundary between these two regimes requires a definition of 'acceptability' and this needs to be judged on social, economic and political, as well as scientific, grounds. However, irrespective of where this boundary is drawn, the concept of acceptable change remains valid. In practice, all prior approvals for the introduction of material to the ocean, or for physical manipulation of the marine environment, made on the basis that adverse effects are limited, reflect implicit acceptance of the concept of environmental, or assimilative, capacity.

This concept, has, however, been criticized on the grounds that it places unwarranted faith in the reliability of scientific measurements of marine conditions and effects (e.g., Jackson and Taylor, 1992). These criticisms, particularly the claim that it constitutes a license to pollute, have been eloquently disputed by Pravdic (1985) and, later, as a response to Jackson and Taylor, by Portmann and Pravdic (1992). As pointed out by these authors, and by GESAMP (1986), any use of environmental capacity should consider, and allow for, scientific uncertainty as a means of ensuring that the capacity is not approached. A lack of appreciation of the process of quantifying and considering uncertainties in scientific evaluations appears to be at the heart of the increased promotion of the 'precautionary principle'.

One of the major criticisms of those advocating the adoption of the precautionary principle is that science has failed to predict and therefore to prevent potentially catastrophic environmental change (Jackson and Taylor, 1992). Stratospheric ozone depletion and the effects of DDT on reproductive success in birds have frequently been cited as examples. This argument is the most persuasive of the entire arsenal of criticisms of the assimilative capacity concept. In this context, Garrett (1992) has referred to two types of scientific 'unknowns': 'known unknowns' for which science can be directed towards defining and reducing uncertainties; and 'unknown unknowns' which involve the presently-unknown revelations of future science that may identify new processes and interactions that could result in drastic revisions of current predictions. Garrett argues that a key management question is how to maximize the

chances of discovering 'unknown unknowns' without impairing work on the 'known unknowns' which limit the accuracy of present predictions. However, when one examines the examples cited as failures of scientific prediction, the problems stem predominantly from shortsightedness in the application of current knowledge, rather than from fundamental gaps in scientific understanding. For example, in the case of DDT, prior testing did not adequately extend to effects on higher trophic organism reproduction. Thus, I would argue that, rather than 'unknown unknowns' having been at the heart of historical failures in predictability, it has been the failure to ensure comprehensive evaluations of the effects of substances being, or potentially to be, released into the environment that has been responsible.

The roots of the precautionary principle are far from clear. However, it has been linked during international negotiations with the *Vorsorgeprinzip* (literal translation: 'the principle of foresight') first formally enunciated in 1986 (FRG, 1986). This latter document, entitled 'Guidelines on Anticipatory Environmental Protection', is a well-reasoned, logical and scientifically-based expression of the concept of precaution and, in this form, I have no problem with the concept. The following passage from the document provides some insight into its approach:

> *'Environmental protection initially entails averting danger. The State must intervene with protection measures if it is possible to recognize that the input of substances is capable of threatening man and the environment. The State must also act if impairment of the natural balance, threat to natural resources or damage to material property is imminent. Protection from environmental burdens of this nature has always been an indispensable constituent of environmental policy. However, not every input of substances poses a threat. The assumption of a risk situation is dependent on the nature and scope of any possible damage as well as on the probability of its occurrence. Active measures will be taken if general experience or scientific findings indicate with sufficient probability that damage will be caused; any remote possibility that damage will be caused is not sufficient.*
>
> *Furthermore, not every imminent pollution of air, water or soil and not every impending material threat to plants and animals can be categorized as a risk. Only 'considerable' burdens are of significance in assuming the existence of a risk. Consequently, measures must be taken based on the principle of averting dangers to prevent their occurrence as far as humanly possible.'*

While the lineage of the 'precautionary principle' is unclear, it seems evident that the manner in which it is now being used departs substantially from the firm foundation, and scientific consistency, of the *Vorsorgeprinzip*. Take, for example, the form in which the 'principle of precautionary action' has been adopted within the Ministerial Declaration of the Second International Conference on the North Sea held in London in November, 1987 (London Conference, 1987):

> *'Accepting that, in order to protect the North Sea from possible damaging effects of the most dangerous substances, a precautionary approach is necessary which may require action to control inputs of such substances* ***even before a causal link is established by absolutely clear scientific evidence.***
>
> [The Governments] *therefore agree to: accept the principle of safeguarding the marine ecosystem of the North Sea by reducing* ***polluting*** *emissions of substances that are persistent, toxic and liable to bioaccumulate at source by the use of the best available technology and other appropriate measures. This applies especially*

when there is reason to assume that certain damage or harmful effects on the living resources of the sea are likely to be caused by such substances, ***even where there is no scientific evidence to prove a causal link between emissions and effects*** *('the principle of precautionary action').* [Boldface – my emphasis]

The Paris Commission, the Governing Council of the United Nations Environment Programme and the Nordic Council's International Conference on Pollution of the Seas all adopted statements of a similar nature during 1989. While the meaning and intent of these statements are unclear to those that are not parties to the agreements concerned, it is evident that within contemporary international negotiations they are frequently being interpreted by some parties to these agreements as a requirement to proceed towards 'zero discharge' for all materials except uncontaminated natural substances. On an *a priori* basis, this is neither scientifically nor socially justified. Statements of the type quoted above are clearly philosophically flawed. The use of the word 'polluting' in the second paragraph may appear logical if it correlates with adverse effects but, if that is the case, what relevance has the application of best available technology if it does not succeed in reducing emissions to the extent required to prevent marine pollution? The opportunity for the injection of perception rather than science in the last clause of the second paragraph is likely to lead to differing priority assignments among States. It will undoubtedly lead to the wastage of resources and re-direction of effort to issues of little significance rather than the concentration of resources on substantive problems or threats.

As a statement of **management** philosophy for the prevention of marine pollution, the 'precautionary principle' is entirely legitimate. However, except in the form of the *Vorsorgeprinzip*, it has no particular bearing or relevance to scientific methods of assessment. Accordingly, I was disappointed to see such a reputable scientific journal as the *New Scientist* recently carry a paper entitled 'How science fails the environment' (Wynne and Mayer, 1993) by advocates of the application of the precautionary principle to science. A formal response to this paper was later published in the same journal under the title 'The perils of green pessimism' (Milne, 1993). The *New Scientist* subsequently issued a *Newsletter* specifically devoted to individual responses to the two articles. While these have gone some way to balancing the arguments within the scientific community, I am concerned about the way these debates may be perceived by non-scientists. The publication of the paper by Wynne and Mayer would have been entirely appropriate in a policy context as a means of stimulating healthy debate about environmental management philosophies but it was inappropriate for a scientific journal. Those unfamiliar with the scientific methods of dealing with environmental issues would, I am sure, be persuaded that the publication of such a paper in a scientific journal gives credence to the scientific nature of the so-called precautionary principle. The rather strong disagreement with the scientific credibility and relevance of the precautionary view as set out by Milne and in several of the letters in the *New Scientist Newsletter* is unlikely to counter such a perception gained by non-scientists. Indeed, the response by Milne elicited as much criticism by correspondents to the *Newsletter* for exceeding his brief as did the original paper for expounding a view not shared by scientists. This makes the entire episode doubly unfortunate.

The core of this debate centres around the scientific relevance of the precautionary principle. It proposes the adoption of extreme measures based on perception, rather than scientific evaluation, of hazards and risks. It is an idealistic statement of principle whose immediate application would be likely to cause far more serious economic and social problems than it solves. The original *Vorsorgeprinzip* fully accepted the legitimacy of scientific evaluations of hazard, consequences and risk. Proponents of

the precautionary principle blame the concept of assimilative capacity for the current state of marine degradation. In reality, they should be blaming the lack of application of the concept with its associated requirement for prior scientific evaluation of hazards, consequences and risks.

All sectors of the environment have the ability to deal with finite amounts of newly-introduced substances whether these be wholly artificial substances or naturally-occurring elements, isotopes and compounds, in the same way that the sea has some finite capacity for fishing without ecological collapse. The illustration used by GESAMP as a simplistic explanation of the environmental capacity concept was that there were clearly no significant consequences associated with the release of a drop of mercuric chloride to the deep ocean – thus, it argued, the **concept** is a valid one. The practical use of capacity, however, necessitates an ability to define its limits with a sufficient margin of safety to accommodate uncertainties and heterogeneities. Indeed, this is at the core of the debate. Science can introduce enough conservatism, or pessimism, in the estimation of capacity for specific substances to accommodate such factors – it would remain to be determined, however, whether such conservatively-defined capacities were sufficiently large to offer practical uses to society for the disposal of particular waste materials. Accordingly, I can see no fundamental flaws in the scientific approach to marine environmental protection that prevailed until the recent pressure for the adoption of 'more precautionary approaches' and abandonment of the 'assimilative capacity' concept. This, however, is not the road being chosen within the development of international mechanisms for pollution prevention because it is regarded as contravening the precautionary approach.

FORECLOSURE OF MARINE DISPOSAL OPTIONS

The current trend in the refinement of international pollution prevention agreements is towards the foreclosure of options. Nowhere is this more evident than within the London Convention 1972. In the last decade, decisions have been taken to proceed with the prohibition of industrial waste dumping and to ban high-temperature incineration of 'noxious' (i.e. organohalogen-containing) wastes at sea. These decisions are based on the assumption that land-based methods for the destruction of such materials are inherently and universally safer. Irrespective of whether this view is correct, the decision to foreclose the marine incineration option has been preferred over reinforcement of existing requirements for the conduct of prior comparative assessments among options for the handling, storage and disposal of such materials so that the least damaging option could be identified. Why is this? First and foremost it reflects a conviction that direct releases of any toxic, persistent and bioaccumulative substances to the ocean should be prevented. The most obvious motive behind such a position is that, if society is forced to deal with its waste problems on its own territory, it will accord higher priority to the devotion of resources required for their resolution. This may well be a valid philosophical argument but it does not involve scientific considerations. This argument is, however, substantially weakened when one observes that, in some countries, material that would have been suitable for sea incineration is now being incinerated in coastal locations often under offshore wind conditions. This does not reflect progress in the dealing with the issue but merely one of concentrating and localizing the risks to members of the public.

Another example concerns the future of low-level radioactive waste disposal at sea. In the period 1946 to 1982, sea disposal of packaged radioactive waste was

practised by a number of countries, latterly under the provisions of the London Convention 1972 and pursuant to the subordinate 'Definitions and Recommendations' of the International Atomic Energy Agency (IAEA, 1986). In 1992, a non-binding moratorium on low-level radioactive waste dumping at sea was agreed to, while a scientific evaluation of the safety of the practice was conducted by an independent Panel of Experts. This Panel submitted its report to the London Convention in 1985. Its main conclusions were as follows:

- The present and future risk to individuals from past ocean dumping of radioactive wastes at the North-east Atlantic dumpsite is extremely small;
- Notwithstanding the very small risk to individuals, the aggregate exposure to the global population from long-lived components of the dumped waste imply that the total casualties resulting from past dumping may be up to about 1,000 spread over the next 10,000 years or so;
- The incremental dose from past sea dumping to individual marine organisms on the sea floor at the dumpsite or nearby will be significantly less than the dose that the organisms receive from naturally occurring radioactivity and hence it is not expected to cause any detectable effects on populations of organisms.

The Panel's overall conclusion was:

'No scientific or technical grounds could be found to treat the option of sea dumping differently from other available options when applying internationally accepted principles of radioprotection to radioactive waste disposal.'

This means essentially that there are no reasons to exclude the option of sea disposal from the balanced prior evaluation of all options for radioactive waste disposal in order to determine, on human health and environmental protection grounds, which option offers the least detriment. No prejudice to the selection of the final option is meant or implied by this statement because it is fully recognised that social, economic and political considerations will also have an influence on the final decision.

Somewhat surprisingly, in 1985, in response to the Expert Panel report, the London Convention chose to extend the moratorium on sea dumping and to commence a further review *inter alia* of the '*wider political, legal, economic and social aspects of radioactive waste dumping at sea, comparisons among options, and whether it can be proven that dumping of radioactive wastes ... at sea will not harm human life and/or cause significant damage to the marine environment.*' The conclusion of the scientific component of this latest review (IMO, 1993) was:

'The Panel concluded that the radiobiological impacts of a given radiation exposure are independent of the source of the radionuclides that give rise to that radiation exposure. To protect human health and the environment, therefore, the same internationally accepted principles of radiological protection apply equally to the scientific and technical assessment of all radioactive waste disposal options.'

This provides no more justification for *a priori* foreclosure of the option than did the results of the earlier Panel. Various arguments in favour of a ban were, however, advanced by the new Panel from political, socio-economic and legal perspectives. On the basis of the second Panel report, the 16th Consultative Meeting of the Convention, in November, 1993, adopted a resolution to amend the Annexes to the Convention to prohibit sea dumping of low-level radioactive waste. This decision was made despite the provisions of Article XV of the Convention, which imposes

a requirement for amendments to the Annexes to be based on scientific and technical considerations, and the fact that no such grounds to warrant foreclosure had been identified in either review. Because there does not yet exist a quantitative definition of *de minimis* for radionuclides, national authorities will have to decide which materials are, and which are not, radioactive for the purposes of the Convention. This may result in further variance among decisions made by Contracting Parties.

These various initiatives within the London Convention reflect an unambiguous trend towards the foreclosure of the sea dumping option for a variety of materials without scientific justification.

Another reflection of differences between policy-makers and the scientific community concerns the relative priority assignments among marine contaminants. As part of the preparative process for UNCED, GESAMP was asked to provide advice on the such priorities based on the 1990 review of the State of the Marine Environment (GESAMP, 1990). The summary table from the document prepared by GESAMP for the United Nations Conference on Environment and Development (UNCED, 1991) is reproduced here as Table I. It shows cases in which improved

Table I Priority Contaminants from Land-based Sources
This table comprises a list of contaminants from land-based sources that constitute the greatest real or perceived threat to the marine environment. Assignments under the heading of 'Status of Science and Management' relate only to routine operations in the civil sector. They do **not** relate to catastrophic accidents.

Substance	Status of Science and Management	Known/Suspected Target/Effects
Sewage	Science Adequate Inadequate Management	Human Health Pathogens Eutrophication
Nutrients	Science Limited Conservative Management Possible	Eutrophication Harmful Algal Blooms
Synthetic Organics	Science Limited Conservative Management Possible	Human Health Animal Health
Sediment	Science Limited Conservative Management Possible	Destruction of Amenities (Habitats/Organisms) Decreased Productivity
Litter	Science Adequate Management Deficient	Animal Life Destruction of Amenities
Metals	Science Adequate Management Deficient	Human Health Animal Health
Radionuclides	Science Adequate Management Adequate	Human Health Animal Health
Oil/Hydrocarbons	Science Generally Adequate* Management Deficient	Animal Health Destruction of Amenities Decreased Productivity
PAHs	Science Limited Management Deficient	Human Health Animal Health Foodstuff Taint

* Excepting land-based sources of oil and associated nearshore effects.
Source: UNCED (1991)

scientific understanding is required but also indicates substances for which conservative management is possible using current knowledge. It also indicates substances for which management deficiencies are primarily responsible for contemporary damage in the marine environment and/or significant threats to human health. GESAMP regards sewage, nutrients, synthetic organics and sediment as the most important classes of marine contaminations. This does not accord with widespread public perception that heavy metals, radionuclides and oil are more serious marine contaminants than sewage, nutrients or sediment. These differences are a remarkable confirmation of the difference between scientifically-defined and publicly-perceived risks, as outlined, for example, by Allman (1985).

SOME POSITIVE SIGNS?

Within the marine scientific community itself, strenuous efforts are being made to convey the scientific aspects of the issue to a wider audience. The Advisory Committee on Marine Pollution (ACMP) of ICES has consistently provided high quality scientific advice to the European Regulatory Commissions (Oslo, Paris and Helsinki). The ACMP, comprising largely co-opted experts in a wide range of disciplines, has not only dealt with requests from the Commissions and the North Sea Task Force but also tried to convey its views on the broader issue of marine environmental protection through the medium of its annual reports, especially during the years 1984–1992 (see, for example, ICES, 1986; 1987). In the latter part of this period, it also made great efforts to ensure that the new Quality Status Report (QSR) for the North Sea would be scientifically well-founded, well structured and informative. Unfortunately, in 1992, during the final stages of the preparation of the QSR, the ACMP was disbanded by ICES and replaced with a new advisory committee comprising national representatives. The reasons for this decision appear to be political rather than scientific but it remains to be seen whether the new committee – The Advisory Committee on the Marine Environment (ACME) – can achieve the high standards of quality in scientific advice consistently maintained by ACMP.

GESAMP has, over a similar period, also provided sound scientific advice in relation to a number of questions raised by its sponsoring United Nations agencies on topics such as: reviews of potential harmful substances; the hazards of harmful substances carried by ships; river and atmospheric inputs to the world ocean; the long-term consequences of low-level contamination of the ocean; the application of quantitative structure activity relationships for assigning priorities among hazardous chemicals; assessing the significance of carcinogens as marine pollutants; coastal modelling procedures for the conversion of radiological exemption rules for radionuclides into *de minimis* values; and air-sea exchange of chemicals in the context of climate change.

GESAMP has also carried out two global reviews of the 'State of the Marine Environment', most recently in 1990. The 1990 review stands as the most comprehensive scientific statement about marine pollution and was used as a benchmark for the UNCED process (UNCED, 1991). More recently, GESAMP has prepared two documents summarizing its views on a suitable framework for marine environmental protection. The first of these (GESAMP, 1991) exemplifies the broad multi-sectoral approach to pollution prevention and marine environmental management. The second (GESAMP, 1992) evaluates the manner in which society deals with radioactive and non-radioactive materials and concludes that the current

approach to the regulation of practices involving the production, use and disposal of radioactive materials is entirely consistent with the GESAMP framework for marine environmental protection.

Thus, ACMP and GESAMP have expended considerable effort to provide information on the scientific perspectives of marine environmental protection and to apply science to the solution of existing problems in this field. GESAMP will no doubt continue its work in this direction but it is too early to predict the line that will be taken by ICES/ACME. The fact that ACME, as its first meeting, was unwilling to accept a clear distinction between the concepts of pollution and contamination does not bode well for the scientific credibility of this latter organization.

A further sign of scientific progress comes from a rather unlikely source – the London Convention 1972. This is in the form of the Waste Assessment Framework (WAF) designed and adopted under the auspices of the Scientific Group of the Convention. This procedure is well thought out, logical and pragmatic. Furthermore, it is consistent with the positions adopted by the late ACMP and GESAMP on marine environmental management. The application of the WAF will still require the setting of certain characteristics of substances in potential wastes to determine the extent to which further evaluations of their potential harm are warranted. In this sense, the WAF does not totally overcome the long-standing problem of the definition of the terms 'trace contaminants' and 'significant amounts' in the annexes to the Convention. However, it does place the setting of levels of no concern and the limits of acceptability for contaminants in a clear and logical scientific context. This represents substantial progress.

IMPLICATIONS FOR SCIENCE

There appears to be a gulf between those devising mechanisms for improved marine environmental protection and the scientific community. The former appear to be devising moralistic terminology such as the 'precautionary principle' to justify extreme actions, such as the foreclosure of marine disposal options in the absence of scientific justification. The scientific community, on the other hand, bases its advice wholly on scientific considerations and fully recognizes that final decisions are made in the context of a broader range of considerations than the purely scientific. What is unfortunate is that decisions frequently involve the selection or rejection of a disposal option which has not been comprehensively evaluated from scientific perspectives. This can lead to the selection of options involving both unforeseen and adverse consequences.

Take for example, a not too hypothetical decision to discontinue the disposal of sewage sludge at sea based on social and political considerations and scientific evaluations of the adverse consequences of continued dumping at sea. Such a decision may well enhance the protection of the sea and its resources but what of the social and economic consequences? Has this decision been made in the full knowledge of the costs, practicality and adverse consequences of other disposal options? Sewage is hardly a material whose generation can be prevented and, therefore, other options for its disposal have to be devised. If a decision to foreclose the marine disposal option is made, purportedly in the interests of marine environmental protection, should not the consequent effects on the land environment be evaluated before an alternative option is selected? Surely, the answer should be 'Yes'! Here lies one of the major deficiencies of current environmental protection initiatives – the general

absence of multi-sectoral perspectives. There clearly exists crosstalk among individual sectors of the environment such as marine, atmosphere and terrigenous domains. Action taken in relation to one sector inevitably has ramifications for others. The disposal of some long-lived substance in a land repository involves the potential for its eventual transport to the marine environment. Similarly, injection of material into the ocean has potential impact on the land environment and its inhabitants through marine transport or the recovery of marine resources such as fish. In the case of marine disposal, such transfers and their potential effects should be, and generally are, taken into account in a prior scientific assessment of consequences. I am less convinced that, with the notable exception of radioactive materials, prior consideration of the consequences of disposal options in other environmental sectors takes full account of marine pathways of transport, exposure and effects. This is one of the messages that both GESAMP and ACMP have tried to convey but with limited success.

This deficiency is exacerbated further by the tendency for many nations to segregate their administration of individual industrial sectors from their overall environmental protection initiatives that are usually concentrated in a single ministry. The interests of the sectoral ministries are those of development and promotion of an industry albeit with concomitant checks and balances that may involve certain environmental protection features. However, these seldom transcend the particular environmental compartment that is of primary relevance to the industry concerned (e.g., marine in the case of sea fisheries, land in the case of mining and forestry). The long-term interests of overall environmental protection warrant far greater devotion to the achievement of multi-sectoral perspectives on such issues.

HOW CAN SCIENTISTS RESPOND TO THIS TREND?

What can scientists do to overcome contemporary suspicions of science and its role in environmental protection? The most important thing is the maintenance of scientific integrity. Collectively we should resist, as much as possible, the incorporation of non-scientific criteria in scientific evaluations and debates. The encroachment of such extraneous ideas into the scientific domain may seem innocuous in the immediate context but they may have significant ramifications in other areas and sectors of science. We all, I am sure, want to avoid the devaluation of environmental science to a level where it is regarded as 'poor science' by other disciplines.

The second thing is to 'think big!' We should ensure that scientific evaluation of the potential for adverse effects of substances released into the environment is as wide-ranging as possible. If there have been serious scientific failings historically, in large part they are due to the approach to testing and assessment having been too narrow. Time taken to consider a variety of hypothetical pathways and exposures and their effects is usually well-rewarded by the acquisition of additional insight and the identification of additional uncertainties that need quantification. Equally, we should adopt a broad-minded perspective in examination of what might appear to be rather limited issues. When, for example, assessing the consequences of some practice on the marine environment, time taken to consider the various alternative options that might be considered, if the marine option is ruled out, can be very rewarding. This does not need to be done exhaustively, but some salutary comments on the need for the assessments of the environmental, social and economic consequences of alternative options can constitute valuable guidance to management.

We also have to be more pragmatic in our delivery of advice. In the current economic climate, the response 'we need more research' when asked to provide a scientific opinion of an issue cuts no ice. Indeed, this never constitutes a viable response unless accompanied by a statement outlining the limitations of current scientific understanding and the degrees of uncertainty that prevented a more insightful response. Accordingly, the modern environmental scientist has to become more accustomed to providing qualified, pragmatic and practical answers to questions with most of the qualifications comprising a set of assumptions and a set of uncertainties based on current scientific understanding. Often, a conservative (i.e., pessimistic) assessment in which the worst-case consequences are considered, can form the basis of an adequate response for management purposes.

Finally, I am convinced that there is a need for us to marshall our forces in a coherent manner when topics of multi-national interest are involved. Take, for example, the issue of environmental quality guidelines. A number of countries are developing guidelines for the presence of contaminants in marine matrices (i.e., water, sediments, biota). Such development should be approached in a holistic manner, bearing in mind the development and application of similar guidelines to other sectors of the environment. They should also strive for uniformity of application in different national jurisdictions. This is not a plea for uniform guideline values – merely a plea that a common conceptual approach be adopted. I question why we have not accomplished more at the international level in coordinating the sound scientific development of guidelines for marine sediments for example. Fortunately, the further development of elements of the Waste Assessment Framework within the London Convention 1972 should expedite multilateral cooperation in this field.

CONCLUSIONS

There appears to be a trend towards reduced scientific influence on international mechanisms for improved marine environmental protection. This reflects the increasing influence of public perceptions which has led to the adoption of simplistic and unnecessarily extreme approaches towards preventing pollution such as the drive towards 'zero discharge' and the foreclosure of marine waste disposal options. The fact that these strategies are being adopted with very limited assessment of the adverse effects on other sectors of the environment emphasizes the continued preoccupation with sectoral approaches. The comprehensive long-term protection of the environment, including the marine sector, requires the adoption of broader, multi-sectoral perspectives for the setting of priorities and formulation of action for the prevention of pollution. (GESAMP, 1991).

Science should lead the way to this broader appreciation of the subject and in educating policy-makers who are preoccupied with sectoral issues. This can only be done if scientists themselves adopt a broader perspective and point out the dangers involved in the selection of simplistic and short-sighted strategies to the solution of perceived problems. An attempt to forestall political acceptance of extreme attitudes based on non-scientific perception has been made under the 'Heidelberg Appeal' (Appendix 1) that has been signed by several Nobel Laureates and other distinguished scientists.

If we collectively fail to reverse the trend towards the discounting of science in the development of environmental protection measures, we will be both failing in

our professional responsibilities and risking a further decline in the influence of science on the development and implementation of marine protection measures.

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APPENDIX 1

HEIDELBERG APPEAL TO HEADS OF STATES AND GOVERNMENTS

On the closure of the Rio Summit, the following Appeal was signed by 425 members of the scientific and intellectual community. The subject matter raised by the Heidelberg Appeal and the fruitful debate it has engendered are prompting the involvement of a number of scientists and intellectuals. The values embraced by the Appeal remain a topic of ongoing interest.

We want to make our full contribution to the preservation of our common heritage, the Earth.

We are however worried, at the dawn of the twenty-first century, at the emergence of an irrational ideology which is opposed to scientific and industrial progress and, impedes economic and social development.

We contend that a Natural State, sometimes idealized by movements with a tendency to look toward the past, does not exist and has probably never existed since man's first appearance in the biosphere, insofar as humanity has always progressed by increasingly harnessing Nature to its needs and not the reverse.

We fully subscribe to the objectives of a scientific ecology for a universe whose resources must be taken stock of, monitored and preserved.

But we herewith demand that this stock-taking, monitoring and preservation be founded on scientific criteria and not on irrational pre-conceptions.

We stress that many essential human activities are carried out either by manipulating hazardous substances or in their proximity, and that progress and development have always involved increasing control over hostile forces, to the benefit of mankind.

We therefore consider that scientific ecology is no more than an extension of this continual progress toward the improved life of future generations.

We intend to assert science's responsibility and duties toward society as a whole.

We do however forewarn the authorities in charge of our planet's destiny against decisions which are supported by pseudo-scientific arguments or false and non relevant data.

We draw everybody's attention to the absolute necessity of helping poor countries attain a level of sustainable development which matches that of the rest of the planet, protecting them from troubles and dangers stemming from developed nations, and avoiding their entanglement in a web of unrealistic obligations which would compromise both their independence and their dignity.

The greatest evils which stalk our Earth are ignorance and oppression, and not Science, Technology and Industry whose instruments, when adequately managed, are indispensable tools of a future shaped by Humanity, by itself and for itself, overcoming major problems like overpopulation, starvation and worldwide diseases.