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Deliberating precaution (and the precautionary principle) in the United Kingdom

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Abstract

The precautionary principle is about making decisions in the presence of uncertainty and *before* there is 'sufficient scientific evidence'. Paradoxically, implementation of the precautionary principle often depends upon existing scientific knowledge and 'evidence'. In order to investigate this puzzle I undertake two environmentally related case studies, one into radioactive waste disposal, the other into endocrine disrupting chemicals. These show how scientific evidence is defined and used in precautionary deliberations. Through these, I demonstrate that science does not provide an 'objective truth' from which indisputable courses of policy action can be determined. I argue that the precautionary principle fills the vacuum created by a science that promises certainty but which continually fails to deliver on that promise.

In practice, interpretations of the precautionary principle depend on the 'institutional' contexts in which deliberations take place, and on the interests of the organisations involved. As I illustrate, the 'career trajectories' of 'environmental problems' are also relevant. This is important since different environmental 'issues' have different 'careers' and hence present different opportunities for precaution.

Ultimately, this thesis highlights the need to go beyond science when attempting to understand and implement the precautionary principle in environmental policy. I argue that its implementation involves creating frameworks of deliberation that are more sympathetic to precautionary courses of action, and that moral, context specific issues are at stake. The challenge for policy is not just one of making decisions based on uncertainty, but of understanding the very formation of environmental problems.

In reaching these conclusions, I hope to have made a useful contribution to environmental debate and to theoretical understandings of science and precaution in contemporary policy.

Acknowledgements

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Chapter One

Introduction

What is the precautionary principle? How has it evolved? How can it be implemented? These are some of the very basic questions that gave rise to this thesis and subsequently to many more questions.

In 1995 the Centre for Science Studies at Lancaster University set up an Economic and Social Research Council (ESRC) CASE award in collaboration with Friends of the Earth and advertised a PhD studentship entitled 'The evolution and application of the precautionary principle for sustainable development'. I applied and was offered the opportunity to undertake this research. A CASE award entails working with a collaborative organisation which has been involved in determining the thesis project and which is therefore interested in the research outcomes. For the student this includes additional remuneration on top of the basic ESRC award plus access to materials and resources at the organisation's discretion. My collaboration with Friends of the Earth has been very successful, with many of the staff at Friends of the Earth giving freely of their time, experience, knowledge and materials. In return I hope I have produced something that will be of value to them in their future work.

I was attracted to this PhD project in the first instance partly because of its close association with Friends of the Earth and partly because of an intuitive belief in the precautionary principle. The precautionary principle is a principle that suggests that action should be taken to protect the environment before there is sufficient scientific evidence to prove a link between cause and effect.[1] At the time of starting my research I was incredibly naive about what I would be able to achieve with regard to the precautionary principle. I expected to be able to create a list of implementation rules with which to judge whether the precautionary principle had been adopted properly, and I naively assumed that this list could to applied to all environmental problem areas. Through my research I have come to realise that the precautionary principle is nothing in itself. It is not an absolute reference point but is, rather, a rhetoric and a vocabulary which is given meaning and is made on the ground each time it is invoked.

Friends of the Earth also had a wish list of what I could produce for them. They wanted something tangible that would help them with their campaigning, and something 'academic' that would lend weight and authority to their interpretation of the precautionary principle. Their view is typical of the environmental movement at large. The shared position is that the precautionary principle should be invoked in connection with all environmental controversies. Whilst Friends of the Earth and other environmental NGOs have some idea as to what this would mean in specific cases they have a tendency to reify the notion of the precautionary principle. For example, in relation to radioactive waste management Friends of the Earth state:

> 'Retrievability and reversibility are fundamental aspects of the precautionary principle, which is central to sustainable development. ... Taking a precautionary approach to making financial provisions for nuclear waste management also implies ensuring that future generations will be able to make decisions on a timely basis.'[2]

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[1] See Appendix 1 for a list of agreements that refer to the precautionary principle. These are discussed in detail in chapter two.

[2] Green, P. and Western, R. (1994). *Time to face the inevitable: a submission from Friends of the Earth Ltd to the UK Department of the Environment's review of radioactive waste management policy.* London: Friends of the Earth, 25 October 1994, p33 and 37.

Here they talk about the precautionary principle as if everyone understands what those 'fundamental aspects' are. This is a common position, and not just one adopted by Friends of the Earth. By contrast, I argue that the precautionary principle is usefully viewed as a 'boundary object'[3], that is, the concept creates a space in which protagonists encounter each other, and in which they sustain the sense of a common debate, even when the interests at stake are fundamentally opposed. This is one of the issues this thesis addresses. In particular, I look at how the notion of a 'problem' is set up and the way in which the concept of precaution is positioned and discussed in terms of scientific evidence.

The precautionary principle is important on the world stage as it has been incorporated into a number of national and international agreements. Appendix 1 lists many of these agreements. Despite its importance, or perhaps because of it, the concept of precaution is vague and is therefore the subject of numerous, divergent interpretations. The precautionary principle has consequently not been applied methodically in national decision-making, although there have often been calls for such an application. Through researching what has been written about the precautionary principle and through undertaking case studies of its application in two divergent cases, I have come to realise that the precautionary principle comes into being as it is negotiated in practice in relation to each new issue.

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[3] Star, S.L. and Griesemer, J.R. (1989). Institutional ecology, translations and boundary-objects: amateurs and professionals in Berkeley's museum of vertebrate zoology 1907-1939. *Social Studies of Science* 19, (3): 387-420.

Core questions

From an initial set of questions about the definition of precaution, further lines of inquiry developed. I found that as I pursued meanings of precaution I obtained more questions rather than answers. This helped me determine the type of fieldwork that I would undertake and my approach to the rhetoric of precaution.

However, I began with the more practical question: on what basis can the precautionary principle be applied to a specific environmental issue? Some environmental issues appear to be appropriate areas in which to apply the precautionary principle. Why is that? Who are the key players involved? Is there a link between whose voice is heard and the perceived relevance of the precautionary principle? Does the nature of the issue itself make a difference, and if so, how and in what ways? Are the systems and structures currently in place for making decisions tightly bound or institutionally flexible? Why does conflict arise around particular environmental issues and how does controversy drive interests in precaution?

If the precautionary principle is about making decisions in the presence of uncertainty and before there is sufficient scientific evidence then what can be the basis of these decisions? I found that thinking along these lines was unrewarding as it implied that decisions based on scientific evidence were unproblematic and that if certainty could be achieved then decisions were easy. I thought it was important to investigate this hypothesis so I asked myself about how decisions are based on scientific evidence. How is science used in environmental decision-making? Working back, what are the structures and frameworks in place that enable decisions to be formulated and made?

Critically, how does the principle of precaution fit into different environments of decision-making and into different fields of scientific (un)certainty? In order to empirically investigate the precautionary principle in action, and so understand its characteristics and qualities I felt it was necessary to look at two areas of environmental concern that provided sufficient contrast in terms of the history of the problem, whether the problem was of media interest, the nature of the perceived environmental risks and consequences, and the range of voices that could be heard talking about it. I chose the two environmental problem areas of radioactive waste disposal and endocrine disrupting chemicals due to the topicality of these issues in the media, the campaigning interest that Friends of the Earth had in them and the relevance of the comparisons that could be made between them in terms of the concept of precaution.[4]

Radioactive waste is produced at all stages of the nuclear cycle. My interest is in the waste that arises from civil nuclear applications, primarily, though not exclusively, from nuclear energy production. Like all waste produced in this country, radioactive waste has to be managed and there is much controversy about how this should be done. Due to the extremely long half-lives of some radioactive isotopes (24,000 years in the case of plutonium) radioactive waste has to be disposed of in a safe and effective way. The core of the controversy is what constitutes safe and effective radioactive waste disposal.

Endocrine disruption describes a situation whereby the hormone systems of humans and wildlife are detrimentally affected, leading to physical and sexual development

[4] Full details of the selection of these case studies are covered in chapter four.

problems and abnormalities, including reproductive difficulties, which may result in the death of affected individuals. Various chemicals have been implicated although the extent and the exact causes of the problem are still in dispute.

One of the factors that became clear to me when thinking about these case studies was that there is a multitude of terms that are ambiguous and multifariously defined with regard to making decisions about any issue. The problem of definitions became a central theme. How have debates over definitions been played out in the case of radioactive waste and endocrine disruption? Controversies over definitions often centred around controversy over scientific evidence presented for and against a particular position. This made me ask questions about the nature of scientific evidence itself. What constitutes scientific 'knowledge'? How is scientific controversy resolved? Many of the agreements advocating implementation of the precautionary principle suggest that action should be taken even before science has demonstrated a link between cause and effect, that is before it is scientifically understood what is causing observed effects on humans, wildlife and the environment or before it is scientifically understood what the potential effects of a given activity might be. This raised questions of how links between cause and effect are established at present. And at what point is a link accepted by all parties and the controversy resolved? What, therefore, constitutes scientific evidence and who decides what is sufficient evidence? What informs different positions on what scientific knowledge to accept or reject? What can be learned from looking at these issues that helps understand how the precautionary principle can be operationalised?

The naivety of my initial position became more sophisticated through consideration of these questions. I argue that it is the interests of those individuals and organisations involved in making decisions about any environmental issue that shape interpretations of the precautionary principle and I suggest that the precautionary principle only occurs as it is enacted. The 'interests' approach forms a block of ideas in the sociology of science which I marry together with understandings about the uses of scientific evidence in order to ask the empirical question 'what does precaution mean?'.

This question constitutes the corner stone of this thesis. In order to address it I compare meanings of precaution advocated and developed with reference to the two case studies of radioactive waste disposal and endocrine disrupting chemicals. The radioactive waste disposal case study centres on the Nirex Inquiry, a public inquiry held in Cumbria in 1995-1996 at which UK Nirex Ltd, whose task it is to implement the government's strategy for the disposal of most low and intermediate level radioactive waste produced in the UK, appealed against the decision of Cumbria County Council not to allow planning permission for a proposed Rock Characterisation Facility.[5] The endocrine disrupting chemicals case study centres on the fact that discussion about this issue is still at an early stage and that there is still much disagreement as to what the problem actually is. I focus on the debate generated at two workshops commissioned by the Department of the Environment into environmental oestrogens and organised by the Institute for Environment and Health at Leicester University in 1995 and 1996.[6]

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[5] This case study is discussed in chapter five.

Both these case studies involve looking at how precautionary vocabulary is used and made real. In this way I show that what is seen as a 'problem' depends upon such factors as the history of the associated industry, the players involved in discussions, and research that has already been undertaken regarding the issue at stake. I show that the extent of 'industrialisation' of a problem, i.e. where an 'industrial' voice can be defined and heard, is significant as it means there is an 'industrial' position from which negotiation can take place. The importance of this is that what implementation of the precautionary principle means in specific cases will be determined by the range of voices invoking this vocabulary and the diversity of interests associated with them.

Through deconstructing the use of scientific evidence and understanding how scientific knowledge is interpreted I show how controversies are shaped and how decisions are made. This highlights some of the issues surrounding 'implementation' of the precautionary principle. By showing that science does not provide an 'objective truth' from which an indisputable course of action can be determined and by demonstrating that decisions are made by negotiation between individuals, each with their attendant interests, I set the stage for looking at alternative interpretations of the precautionary principle.

Ultimately I show that there are still many questions to answer. I conclude that although a structured set of rules cannot be created (as I so naively assumed at the outset) whereby the precautionary principle can be said to be implemented, it may be possible to create frameworks of deliberation and policy making that are more

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[6] This case study is discussed in chapter six.

sympathetic to precautionary courses of action. These could only come about through an acceptance that the positions of those involved are explicitly value-laden.

What does all this mean for the concept of precaution in practice? I suggest that the precautionary principle is a convenient tool because it takes on the meaning of the definer. Despite appearances, it cannot be assumed by those discussing precaution that they are all talking about the same thing. It cannot be taken as a reference point for absolute action but it can shape action by helping define the stage where the actors enact their parts. The set on that stage then depends on the issue at hand.

Thesis structure

This thesis takes the reader through the history of the precautionary principle, introduces the theoretical approach used, defines and justifies the choice of methodology, introduces two empirically based case studies identifying the main characteristics of those cases, draws comparisons between the two case studies and relates what is learned back to the meaning of the precautionary principle.

In this chapter, I have introduced the thesis itself, and established the central issues and how I have addressed them. In chapter two I describe the evolution of ideas about precaution and consider the historical origins of 'the precautionary principle'. I demonstrate how discussion about the precautionary principle is often couched in scientific terms in the national and international agreements that advocate its use. I highlight a tension between the notion of the precautionary principle being a law which implies a codified practice and the notion of the precautionary principle being about prudence, which is not about rules but rather about judgement. This signals an important point in this thesis, that the precautionary principle involves a move away from the *a posteriori* induction of science which proceeds from effects to causes, towards an *a priori* deduction which proceeds from causes to effects. The concept of precaution is not only deployed by 'experts' and in chapter two I review a selection of proverbs from around the world to demonstrate that precaution also exists as a common sense reaction to uncertain situations in many cultures. Following this I analyse a range of formal agreements advocating the precautionary principle and from these I identify six distinct situations in which the precautionary principle is expected to apply: situations where a causal link to effects is unclear; where scientific evidence does not yet exist; where there is no scientific evidence; where cost is a factor; where the scale of the threat is a factor; and where there are a diversity of situations to be accounted for.

In chapter three I move on to discuss uncertainty, expertise and interests. I review some of the literature about uncertainty in order to get an impression of the magnitude of meaning conveyed by the term and I establish how it is related to scientific controversy and subsequently to decision-making. I look at how expertise is defined and deployed in relation to scientific uncertainty and I review ideas from the sociology of science that relate to the notion of precaution. From this review I explain why I adopt an 'interests' approach as a theoretical framework for analysing my case studies.

In chapter four I explain how my research was designed and constructed, discussing the merits of a CASE award, and introducing the two case studies of radioactive waste disposal and endocrine disrupting chemicals. I discuss my chosen methodology of semi-structured interviews and provide a justification for why this method, as opposed to other methods of qualitative data gathering, was appropriate for this piece of research.

Chapters five and six are the empirical chapters of this thesis. In them I identify the characteristics of radioactive waste management and endocrine disrupting chemicals, respectively, that have a bearing on the application of the precautionary principle. I focus on the concepts of scientific evidence and uncertainty, as these are the issues around which deliberations take place. This reframes the emphasis from looking at a reified 'precautionary principle', about which there is little detailed discussion to focus on those factors that the involved actors considered relevant to their deliberations. This reconciles the issues behind the 'rhetorical precaution' discussed in chapter two and the issues analysed through the case studies.

In chapter five I review interpretations of radioactive waste by comparing my respondents' views and by looking at documentation produced by relevant organisations. Additionally I look at the way in which 'evidence' was defined, used and deployed by participants in the Nirex Inquiry and I analyse the formal structure of a public inquiry in order to show how such an 'event' structures debate and reveals contrasting perspectives of precaution. In chapter six I identify a number of scientific studies that have been drawn upon to indicate that endocrine disruption is a subject worthy of further research and policy action. I investigate debate about the relationship between cause and effect by looking at definitions of the endocrine 'problem' as related by my respondents and as documented in reports from conferences and workshops set up to discuss the endocrine disruption issue. I show how these definitions reveal and reflect the positions of the various actors involved. I also look at the way in which the notion of how much evidence is sufficient to demonstrate that there is a problem worth taking policy action over has been debated and interpreted by my respondents.

I undertook my fieldwork during 1996 and 1997 and I limit discussion of the issues surrounding both radioactive waste disposal and endocrine disruption to the state of these debates at that time. I am very aware that the situation in both these fields has moved on since then. The career of each of these issues has developed and the discussion in my empirical chapters may seem oddly of out date. However, this does not impinge on the content or quality of this thesis, since one of the main points that I am making is that each environmental problem is unique and it is the history of the issue and the stage in its 'career' that has been reached that determines the level at which decisions are being made. I have used two snapshots of the way decisions are made in order to investigate the process of decision-making and what this means for the deployment of the precautionary principle. It is the process that is important to this thesis rather than the outcome.

In chapter seven I undertake a comparison of the two case studies. I identify five key areas especially relevant in that comparison: the emergence of an environmental 'problem'; the widespread nature of the problem; the role of 'industry'; the extent of institutionalisation; and the rhetorical absence/presence of the precautionary principle in deliberations. I consider these with reference to the set of precautionary themes identified from my analysis of the agreements invoking the precautionary principle in chapter two. This comparison brings two main concerns to the fore: the 'interests' of the players involved in making decisions and the role that 'scientific evidence' plays in the process. I show how deeply the use of science and the quest for certainty is entrenched in decision-making. I also reveal that the scientific evidence presented in each debate is full of uncertainties so that decisions come about through the consensus of those involved rather than because some inherent, unambiguously determining 'truth' becomes known. If it is accepted that decisions are currently made through consensus reached by negotiation amongst individuals each with their associated interests, and not because science provides an indisputable guide to a precautionary course of action, then it is possible to start looking at alternative bases for implementing the precautionary principle. Finally I discuss the potential for moving 'beyond science' in decision-making and what that means for the precautionary principle.

I conclude this thesis by reviewing its content and setting out the argument succinctly, demonstrating the limitations contained within it and describing the contribution it makes to academic debate and practical action. I discuss the implications of this thesis for an academic audience in terms of interests theory, scientific evidence and the precautionary principle. I also look at the implications for Friends of the Earth, this time in terms of how the research might impact on their campaigning and use of the precautionary principle. Finally I look at the implications for a corporate audience, discussing the impacts this thesis could have on future policy making and the implications of that for corporations.

Chapter Two

The precautionary principle

'It is often necessary to make a decision on the basis of knowledge sufficient for action, but insufficient to satisfy the intellect'[1]

[1] Kant, I in Lyons, G. (1995). *Reassessing pollution: wildlife, humans and toxic chemicals in the environment*. Godalming: WWF UK. February 1995, p4.

Introduction

This chapter describes the evolution of precaution into what has become known as the precautionary principle. I illustrate the vagueness of the concept and highlight that currently there is no framework within which the precautionary principle can be said to operate. I trace the emergence of precaution from its origins as *Vorsorgeprinzip* in Germany to its use as a principle within international agreements and I introduce the notion that what the precautionary principle means in practice is a matter for negotiation between the stakeholders involved in deliberations about particular environmental problems. With reference to various formal agreements I demonstrate how the rhetoric of precaution has moved from *a precautionary approach* to *the precautionary principle*, a move that makes the concept unique and familiar and allows it to be applied to different situations. However, I also show that none of these agreements express what the precautionary principle might mean in terms of implementation.

Subsequently I discuss how the precautionary principle has been interpreted in particular environmental contexts highlighting a difference between what is labelled science and what is labelled precaution – a distinction rooted in the difference between *a posteriori* induction and *a priori* deduction. Through discussing this difference I establish the relation between the two.

In the following section I introduce proverbs from around the world in order to show that the concept of precaution exists as a common sense reaction to uncertain situations. Following this I analyse a range of formal agreements in order to identify specific elements of precaution. I identify six situations in which the precautionary principle is expected to apply: situations where a causal link to effects is unclear; where scientific evidence does not yet exist; where there is no scientific evidence; where cost is a factor; where the scale of the threat is a factor; and where there are a diversity of situations to be accounted for.

Finally I introduce the two studies that I have undertaken in order to investigate the application of the precautionary principle. I discuss the comparable and contrasting features of the issues of radioactive waste disposal and endocrine disrupting chemicals in order to illustrate the array of situations in which the precautionary principle is invoked.

What is the precautionary principle?

In this thesis I do not advocate any one definitive meaning of the precautionary principle. Rather, I show how the concept of *precaution* has developed and changed over time and how it has come to be referred to as a *principle*. This involves analysing some of the agreements in which reference has been made to precautionary actions. Having outlined this development, I analyse the language used in these agreements in order to isolate the different elements that have come to be identified as part of the precautionary principle. I identify a relationship between the empirical use and rhetorical use of precaution, both implying that the precautionary principle is not any one thing but is created each time it is invoked. These elements are explored later in the thesis with regard to the two case studies. This highlights a perceived paradox regarding the internal consistency of the precautionary principle, that it is described both as a tool to be applied to various situations and as a result or an end in itself. However, I do not adjudicate between these descriptions as it is this very inconsistency that makes the precautionary principle challenging.

Interpreting precaution

Definitions of the precautionary principle are open to negotiation.[2] The concept embodies many different notions of caution, care, preventative action, common sense and responsibility although an explicit definition has never been agreed upon.[3] Whether an explicit definition is actually desirable or possible is one of the questions this thesis addresses. Tim O'Riordan states that

> '...the precautionary principle is neither a well defined principle nor a stable concept ... It is because the mood of the times needs an organising idea that the precautionary principle is getting a fair wind'.[4]

This implies that there is currently no overall framework within which precautionary decisions can be made but that such an idea nonetheless promises a means of dealing with the complexities that modernity brings with it. It suggests that the precautionary principle, despite being so ambiguous, is being regarded as having great potential because it recognises these complexities and offers potential and hope that a

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[2] See Bodansky, D. (1991). Scientific Uncertainty and the Precautionary Principle. *Environment* 33, (7): 4-5 & 43-45; Ramchandani, R. and Pearce, D.W. (1992). *Alternative approaches to setting Effluent Quality Standards: precautionary, critical load, and cost-benefit approaches*. Norwich: CSERGE. 1992.

[3] Hunt, J. (1994). The social construction of precaution. In, O'Riordan, T. and Cameron, J., (eds), *Interpreting the precautionary principle*:117-125. London: Earthscan Publications Ltd, p121.

[4] O'Riordan, T. and Jordan, A. (1995). The precautionary principle in contemporary environmental politics. *Environmental Values* 4, (3): 191-212, p191.

framework can exist.[5] O'Riordan goes on to say that

> '... The precautionary principle has much efficacy because it captures an underlying misgiving over the growing technicalities of environmental management at the expense of ethics, environmental rights in the face of vulnerability, and facilitative manipulation of cost-benefit analysis'.[6]

He is saying here that the precautionary principle is valuable because it provides an alternative to a purely technology-based environmental management, it brings ethics into the discussion, allows environmental rights a voice, and challenges the appropriateness of cost-benefit analysis as a decision-making tool.[7] O'Riordan believes that the vagueness over the meaning of the precautionary principle may actually be its strength:

> '...precaution will remain politically potent so long as it continues to be tantalisingly ill-defined and imperfectly translatable into codes of conduct, whilst capturing the emotions of misgiving and guilt'.[8]

In light of the above apparent vagueness over its meaning and potential implementation, it is important to recognise that the precautionary principle has been invoked in international agreements and policy documents.[9] One such agreement that is widely quoted with reference to the precautionary principle is the Rio Declaration of

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[5] Cameron and Abouchar discuss the idea of a legal framework through which the precautionary principle could be operationalised, Cameron, J. and Abouchar, J. (1991). The Precautionary Principle: a fundamental principle of law and policy for the protection of the global environment. *Boston College International and Comparative Law Review* 14, (1): 1-27.

[6] O'Riordan, T. and Jordan, A. (1995). The precautionary principle in contemporary environmental politics. *Environmental Values* 4, (3): 191-212. p192

[7] See Ramchandani, R. and Pearce, D.W. (1992). *Alternative approaches to setting Effluent Quality Standards: precautionary, critical load, and cost-benefit approaches*. Norwich: CSERGE. 1992. for an evaluation of the effects of combining the precautionary principle with cost-benefit analysis

[8] O'Riordan, T. and Jordan, A. (1995). The precautionary principle in contemporary environmental politics. *Environmental Values* 4, (3): 191-212, p193.

1992:

> "Principle 15: In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."[10]

This and other international agreements and policy documents are discussed in detail later in this chapter. First I consider the history of the concept and how its meaning has been negotiated.

German origins of precaution

The concept that we know as the precautionary principle originated in Germany as *Vorsorgeprinzip* in the 1970's and is one of five fundamental principles[11] underlying German environmental policy. The literal German translation is 'Vor', meaning 'before', 'Sorge', meaning 'care', and 'Prinzip' meaning 'principle'. This translates into 'the principle of taking care before we act'. Boehmer-Christiansen, who has written a detailed history of the *Vorsorgeprinzip* in German environmental policy,[12]

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[9] See Appendix 1
[10] United Nations Conference on Environment and Development (UNCED), Agenda 21, Rio Declaration, June 1992, quoted in Young, M.D. (1993). *For our children's children: some practical implications of inter-generational equality and the precautionary principle.* Canberra: Australian Government Publishing Service. November 1993, p40-43.
[11] The others are the Polluter Pays Principle (*Verursacherprinzip*), Consensus (*Kooperation*), the Principle of Proportionality in cost and gain (*Wirtschaftliche prinzip*) and the Common Burden Principle (*Gemeinlast Prinzip*). See Boehmer - Christiansen, S. (1994). The Precautionary Principle in Germany: enabling government. In, O'Riordan, T. and Cameron, J., (eds), *Interpreting the Precautionary Principle*:31-60. London: Earthscan Publications Ltd, p33.
[12] See Boehmer - Christiansen, S. (1994). The Precautionary Principle in Germany: enabling

states that the five principles, of which the precautionary principle is one, ensure that all political actors bargain with each other on the basis of agreed ground rules rather than 'sound science'.[13] She does not, however, identify what these agreed ground rules are. This illustrates part of the complicated issue of the implementation of the precautionary principle, as it appears that no agreed ground rules actually exist. Whether ground rules can actually be agreed is a matter for negotiation between stakeholders involved in decision-making about specific environmental issues.

In discussing what implementation of the precautionary principle might look like in practice, Boehmer-Christiansen points out that some of the other German principles underlying their environmental policy may counteract or over-rule precaution and so it would be a mistake to consider German environmental policy as totally precautionary. She suggests there are many forms of action the Vorsorgeprinzip might inspire and legitimise: it can promote basic research and technological research and development; it can force the setting up of liability and compensation regimes; it can require the immediate investment into existing cleaner technologies through regulation and it can employ the use of economic measures such as state subsidies or taxation to

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government. In, O'Riordan, T. and Cameron, J., (eds), *Interpreting the Precautionary Principle*:31-60. London: Earthscan Publications Ltd, p31-60. See also von Moltke, K. (1987). *The vorsorgeprinzip in West German environmental policy - a report prepared at the request of the Royal Commission on Environmental Pollution (United Kingdom) for its study on the application of the concept of 'Best Practicable Environmental Option'*: Institute for European Environmental Policy.
von Moltke, K. (1991). Three reports on German environmental policy. *Environment* 33 (7): 25-29.
[13] Boehmer - Christiansen, S. (1994). The Precautionary Principle in Germany: enabling government. In, O'Riordan, T. and Cameron, J., (eds), *Interpreting the Precautionary Principle*:31-60. London: Earthscan Publications Ltd, p34. See also von Moltke, K. (1987). *The vorsorgeprinzip in West German environmental policy - a report prepared at the request of the Royal Commission on Environmental Pollution (United Kingdom) for its study on the application of the concept of 'Best Practicable Environmental Option'*: Institute for European Environmental Policy., for a discussion of *Vorsorgeprinzip*

'internalise' externalities,[14] so that

> '... Vorsorge becomes a metaphor for a wide-ranging industrial and economic strategy'.[15]

Boehmer-Christiansen's notion of what the precautionary principle can be is restrictive in that she limits it to industrial and economic strategy, leaving out social strategy. This means that the embedded interests of the players involved in decision-making may be ignored due to a concentration on more fiscal or practical matters.

From its German origins in "Vorsorgeprinzip", the concept of precaution has gone through a number of stages on its journey to becoming a 'principle'. This chapter traces the development of the ideas of precaution from a concept to a 'principle' in the international policy arena. The type of strategy the precautionary principle embodies evolves as interpretations of precaution are deconstructed and analysed.

Boehmer-Christiansen states that in Germany a large number of political actors participate in environmental debate, and must agree on compromises since their ideologies and constituencies are so very different that unanimity would never be reached. She maintains that these differences are openly acknowledged.[16] Whereas in other parts of Europe and North America it is the natural sciences that dominate the advisory process, in Germany the engineering profession plays a central role. An

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[14] Boehmer - Christiansen, S. (1994). The Precautionary Principle in Germany: enabling government. In, O'Riordan, T. and Cameron, J., (eds), *Interpreting the Precautionary Principle*:31-60. London: Earthscan Publications Ltd. p48

[15] Boehmer - Christiansen, S. (1994). The Precautionary Principle in Germany: enabling government. In, O'Riordan, T. and Cameron, J., (eds), *Interpreting the Precautionary Principle*:31-60. London: Earthscan Publications Ltd, p51.

[16] Boehmer - Christiansen, S. (1994). The Precautionary Principle in Germany: enabling government. In, O'Riordan, T. and Cameron, J., (eds), *Interpreting the Precautionary Principle*:31-60. London:

illustration of this is German investment in 'clean' and 'environmentally friendly' technologies as a way of addressing environmental problems. This contrasts with such methods as toxicological risk assessment, which are employed to provide evidence of harm, an approach often used in the UK, for example.[17] Additionally, in Germany, the courts play a major role in interpreting and implementing environmental regulation and in deciding whether precaution has been adequately complied with. This illustrates the diversity of situations, due to national regulatory differences and political differences, in which the precautionary principle is required to operate. The precautionary principle, as an aspect of the environmental debate, requires negotiation between many political, industrial and other interested bodies, and there is no fixed or established formula available whereby consensus amongst these participants can be reached. By identifying that different measures are used to advise different policy regimes in particular national contexts, Boehmer-Christiansen establishes the subjectivity involved in determining which factors are relevant to particular environmental policy decisions. This compounds the problem of whether a set of ground rules for assessing whether the precautionary principle has been applied can be formulated.[18]

Boehmer-Christiansen says:

> 'The outcome of this constellation of institutional and cultural factors

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Earthscan Publications Ltd, p51.

[17] See, for example, Department of the Environment (1995). *A guide to risk assessment and risk management for environmental protection*. London: HMSO, p44 which states that 'taking a risk assessment approach to the precautionary principle ensures that best use is made of what scientific evidence is available'.

[18] Tickner asserts the necessity for a common definition of the precautionary principle and a set of criteria for precautionary decision-making, Tickner, J. (1997). The precautionary principle. *The Networker* 2, (4). p4

has been a technology-led environmental policy justified less with reference to Vorsorge than by the rapid dissemination of best available technology'.[19]

Here she states that policy is not being driven by precaution but rather that preventative action is being taken in situations where known or threatened harms can occur. She claims that it is the vast array of social and institutional factors that have led to a reliance on technological solutions to environmental problems. However, it is also this array of factors that prompt calls for action to be based on precaution rather than on a science that is uncertain. From its roots in a specific national context, the precautionary principle has been appropriated at an international level.[20]

Precaution in national and international agreements

Internationally the precautionary principle has evolved in a rather ad hoc manner, a point that is illustrated by looking at the list of national and international policy agreements making reference to precaution (see Appendix 1). Even a cursory glance at this list shows that reference to the precautionary principle brings with it no explicit rules for implementation.[21] All manner of activities have been described as precautionary, for example the use of ALARA[22] in relation to radioactive emissions

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[19] Boehmer - Christiansen, S. (1994). The Precautionary Principle in Germany: enabling government. In, O'Riordan, T. and Cameron, J., (eds), *Interpreting the Precautionary Principle*:31-60. London: Earthscan Publications Ltd, p52.

[20] See Gundling, L. (1990). The status in International Law of the Principle of Precautionary Action. *International Journal of Estuarine and Coastal Law (Special edition 'The North Sea: Perspectives on Regional Environmental Co-operation')* : 23-30.; Bodansky, D. (1991). Scientific Uncertainty and the Precautionary Principle. *Environment* 33 (7): 4-5 & 43-45.

[21] See Costanza, R. and Cornwell, L. (1993). The 4P Approach to dealing with Scientific Uncertainty. *Environment* 34 (9): 12-20 & 42, p15.

[22] ALARP (As Low As Reasonably Practicable) is a legal principle controlling the level of risks associated with an activity and is fundamental to safety regulation in the UK. It permits cost to be taken

from nuclear installations, the banning of beef on the bone in the UK in response to the BSE crisis, and the banning of soy-based breast implants due to a number of observed adverse effects. The precautionary principle is able to encompass all these themes under the same umbrella because it is so broad and lacking in tight definition.

I now illustrate with reference to a list of agreements referring to precaution,[23] how it is that the precautionary principle came to be a *principle* as opposed to an approach or a method. This distinction is important because there is value in identifying something as *the precautionary principle* as opposed to *a precautionary approach*. Using the definite article 'the' rather than the indefinite article 'a' is emphatic and makes the concept unique and familiar. It implies something that can be moved around and applied to other situations. However, it also raises problems as it raises expectations and adds a value that is generalisable and variously applicable.

In 1980 the EC Council, in a Decision about CFCs in the environment, stated that:

> "Whereas, in accordance with the common position of Member States of 6 December 1978 and in accordance with recommendation III of the

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into account when determining how much risk should be reduced. In relation to nuclear safety, the requirement is extended so that risks are reduced to levels that are as low as reasonably achievable (ALARA). Defined in Cumbria County Council (1994). *Best practicable environmental option (BPEO) for radioactive wastes: issues relating to storage, late disposal or early disposal. Vol 2*: Cumbria County Council, pD1.

[23] See Appendix 1. This list has been put together by reviewing literature that refers to the precautionary principle. I have followed up citations that refer to agreements invoking the precautionary principle and have made use of lists compiled by others, particularly Young, M.D. (1993). *For our children's children: some practical implications of inter-generational equality and the precautionary principle*. Canberra: Australian Government Publishing Service, November 1993, and Haigh, N. (1993). *The precautionary principle in British environmental policy*. London: Institute for European Environmental Policy.
Haigh, N. (1994). The introduction of the precautionary principle into the UK. In: O'Riordan, T. and Cameron, J. (eds), *Interpreting the Precautionary Principle*:229-251. London: Earthscan Publications Ltd.

Munich Conference, a significant reduction should, as a *precautionary measure*, be achieved in the next few years in the use of chlorofluorocarbons giving rise to emissions."[24] (my emphasis)

The Vienna Convention for the Protection of the Ozone Layer in 1985[25] also refers to precautionary measures, as does the preamble to the Montreal Protocol of 1987.[26] By November of 1987 the Ministerial Declaration of the Second International Conference on the Protection of the North Sea is referring to a precautionary approach:

> "in order to protect the North Sea from possibly 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 has been established by absolutely clear scientific evidence."[27] (my emphasis)

The move from a *measure* to an *approach* as illustrated by these two examples is subtle but distinctive. It implies a transition from taking a suitable action in order to reduce a harm by restricting the use of the harmful substance to something more approximate that allows for action to control inputs of harm without making restriction on the use of those inputs. This notion of a precautionary approach is echoed in the 1989 Convention for the Protection of the Mediterranean Sea against

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[24] EC Council Decision 80/372 concerning CFCs in the environment - April 1980 in Haigh, N. (1994). The introduction of the precautionary principle into the UK. In, O'Riordan, T. and Cameron, J. (eds), *Interpreting the Precautionary Principle*:229-251. London: Earthscan Publications Ltd, p243.

[25] Vienna Convention for the Protection of the Ozone Layer, March 1985 in Haigh, N. (1994). The introduction of the precautionary principle into the UK. In, O'Riordan, T. and Cameron, J., (eds), *Interpreting the Precautionary Principle*: 229-251. London: Earthscan Publications Ltd, p243.

[26] Preamble to the Montreal Protocol to the Vienna Convention for the Protection of the Ozone Layer, 1987 in Young, M.D. (1993). *For our children's children: some practical implications of inter-generational equality and the precautionary principle.* Canberra: Australian Government Publishing Service, November 1993, p40-43.

[27] Ministerial Declaration of the Second International Conference on the Protection of the North (1987), in Haigh, N. (1994). The introduction of the precautionary principle into the UK. In, O'Riordan, T. and Cameron, J., (eds), *Interpreting the Precautionary Principle*: 229-251. London: Earthscan Publications

Pollution.[28] The term 'precaution' is being used here to advocate different levels of intervention.

In 1990 the UK government published its first White Paper on the environment, *This Common Inheritance*, which claims to be a '...comprehensive review of every aspect of Britain's environmental policy.'[29] This White Paper has a chapter entitled 'First Principles' which introduces the precautionary principle by saying that:

> "... given the environmental risks, we must act responsibly and be prepared to take *precautionary action* where it is justified. ... Where there are significant risks of damage to the environment, the Government will be prepared to take precautionary action to limit the use of potentially dangerous materials or the spread of potentially dangerous pollutants, even where scientific knowledge is not conclusive, if the balance of likely costs and benefits justifies it. This *precautionary principle* applies particularly where there are good grounds for judging either that action taken promptly at comparatively low cost may avoid more costly damage later, or that irreversible effects may follow if action is delayed."[30] (my emphasis)

Precautionary action may be justified on the grounds that there are significant risks of damage to the environment, although this is qualified with reference to the balance of costs and benefits. Exactly what constitutes a significant risk is not made clear and

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Ltd, p244.

[28] Convention for the Protection of the Mediterranean Sea against Pollution (Barcelona Convention) 1989 in Young, M.D. (1993). *For our children's children: some practical implications of inter-generational equality and the precautionary principle*. Canberra: Australian Government Publishing Service, November 1993, p40-43.

[29] Command Paper 2100 (1990). *This common inheritance*. London: HMSO. September 1990, p9.

what the good grounds for judgement might be are not explicated. Reference to a principle is made without there being any notion of what that principle embodies. The statement implies that action will be taken even when scientific uncertainty exists, but suggests that the judgement will then be based on economic criteria.

What becomes clear from these national and international agreements is that the rhetoric of precaution is used without any express understanding of what the notion might mean in terms of implementation. While the terminology has developed from 'measure' to 'approach' to 'principle', and while governments and NGOs alike have advocated the 'principle', there has been less attention paid to how it can be successfully operationalised. This question of how and whether it can be implemented in practice is of key importance to this thesis. I use my later case studies on radioactive waste disposal and endocrine disruption to consider what precaution has and can mean in the context of those situations, and to ascertain what more general conclusions can be deduced regarding the meaning of precautionary action in other situations.

The precautionary principle in environmental contexts

I now look at the meanings and interpretations that have been attached to the precautionary principle in the context of particular environmental issues and the scientific controversies surrounding them.

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[30] Command Paper 2100 (1990). *This common inheritance.* London: HMSO. September 1990, p10&11.

Many of the national and international agreements which refer to the precautionary principle express that action should be taken even if there is no, or insufficient, scientific evidence to link a cause with an effect.[31] This implies that action should be taken before the environment starts to show harm, an idea that shifts the burden of proof from the protector of the environment to the polluter.[32] The Ministerial Declaration of the Second International Conference on the Protection of the North Sea in 1987 used the phrase '...even before a causal link has been established by absolutely clear scientific evidence'.[33] In 1990 there were many references to the lack of scientific evidence, for example the UK Government White Paper *This Common Inheritance* stated '... even where scientific knowledge is not conclusive ...'.[34] In 1991 an OECD Council Recommendation on Integrated Pollution Prevention and Control stated that 'the absence of complete information should not preclude precautionary action to mitigate the risk of significant harm to the environment'[35] and in 1992 the United Nations Conference on Environment and Development (UNCED) stated in what has become known as the Rio Declaration '... Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental

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[31] See Appendix 1
[32] Wynne, B. and Mayer, S. (1993). How science fails the environment. *New Scientist* 5 June 1993: 33-35. For further discussion on the implications of reversing the burden of proof see Purchase, I.F.H. (1997). Comments to 'Can we reverse the burden of proof?'. *Toxicology Letters* 90: 229-232. Hansson, S.O. (1997). Can we reverse the burden of proof? *Toxicology Letters* 90: 223-228. Gelbke, P. (1997). Comments to 'Can we reverse the burden of proof?'. *Toxicology Letters* 90: 233-234..
[33] Quoted in Haigh, N. (1994). The introduction of the precautionary principle into the UK. In, O'Riordan, T. and Cameron, J., (eds), *Interpreting the Precautionary Principle*: 229-251. London: Earthscan Publications Ltd, p244.
[34] Command Paper 2100 (1990). *This common inheritance*. London: HMSO. September 1990, p11.
[35] OECD Council Recommendation C(90)164 on Integrated Pollution Prevention and Control - January 1991 in Haigh, N. (1994). The introduction of the precautionary principle into the UK. In, O'Riordan, T. and Cameron, J., (eds), *Interpreting the Precautionary Principle*:229-251. London: Earthscan Publications Ltd. p245

degradation.'[36] [37] The phrasing of these agreements establishes that there is broad recognition of the existence of scientific uncertainty. The view is that this should not hinder policy to protect the environment.[38]

From the above it can be seen that the precautionary principle has become established as a popular policy refrain within the environmental arena although its roots are embedded in an earlier language which is now black-boxed within the agreements in which it is used. Each 'new' environmental issue brings with it reference from some quarter or another to the precautionary principle and the need for its application. This was seen in the case of the BSE crisis in the UK when the government claimed that it should ban beef on the bone for precautionary purposes.[39] It has also been claimed by environmental groups that genetically modified crops should not be allowed to undergo field trials because not enough is known about their ability to cross-pollinate

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[36] United Nations Conference on Environment and Development (UNCED), Agenda 21, Rio Declaration, June 1992 in Young, M.D. (1993). *For our children's children: some practical implications of inter-generational equality and the precautionary principle.* Canberra: Australian Government Publishing Service. November 1993. p40-43

[37] Other agreements include the Paris Commission (PARCOM) in 1989 Recommendation 89/1 of which states '...even when there is no scientific evidence to prove a causal link between the emissions and effects ("the principle of precautionary action") ...'; the Third Conference on the North Sea in the Hague Declaration, March 1990 , which uses the phrase '... even when there is no scientific evidence to prove a causal link between emissions and effects'; and the Bergen Ministerial Declaration, 16 May 1990, which states '... lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.' Also in 1990 the Houston Declaration used the words '... lack of full scientific certainty is no excuse to postpone actions which are justified in their own right' and the Noordwijk Declaration on Atmospheric Pollution and Climate Change stated '... lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent such environmental degradation'. In 1992 Article 3 of the Framework Convention on Climate Change echoed the Rio Declaration by stating that '... Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures...' and Article 2(2)(a) of the Convention for the Protection of the Marine Environment of the North-East Atlantic used the phrase '...even when there is no conclusive evidence of a causal relationship between the inputs and the effects.'

[38] See Earll, R.C. (1993). *The Precautionary Principle: making it work in practice.* London: The Environment Council. 24 November 1993. for a list of barriers to implementation and suggestions of resolutions

[39] Department of Health (1997). Research on transmissible spongiform encephalopathies: first meeting of new review committee - press release issues jointly by Department of Health and MAFF:2. London.

with non-GMO crops, and that this would be in line with the precautionary principle.[40] These cases suggest that what is considered to constitute implementation of the precautionary principle are discrete, distinct actions that relate specifically to the issue in question but which do not provide general guidelines for broader implementation.[41]

While the precautionary principle refers to the use of scientific knowledge and the concept of uncertainty is critical, the idea of precaution does not, in itself, influence the production of scientific knowledge.[42] Additionally it is not a legal principle in the sense that there is no legal definition against which implementation can be judged.[43] It has evolved through documentation and is now translated wholesale by those wishing to use it in order to advocate a specific course of action.

There is a level at which the precautionary principle can be understood as reflecting a common-sense notion that the environment should be protected from deleterious

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[40] Rissler, J. and Mellon, M. (1993). *Perils amidst the promise: ecological risks of transgenic crops in a global market.* Cambridge, MA: Union of Concerned Scientists. December 1993.
Hill, J. (1994). The regulation of genetically modified organisms. In, O'Riordan, T. and Cameron, J., (eds), *Interpreting the Precautionary Principle*:172-182. London: Earthscan Publications Ltd.. For further discussion about regulation of GMOs in terms of the precautionary principle see Levidow, L. (1996). Regulating GMO releases: Britain's precautionary dilemmas. *Natures-Sciences-Societes* 4, (2): 131-143.. See also Mayer, S., Grove-White, R., and Wynne, B. (1996). *Uncertainty, precaution and decision making.* Brighton: Global Environmental Change Programme. June 1996.
[41] See Bodansky, D. (1991). Scientific Uncertainty and the Precautionary Principle. *Environment* 33, (7): 4-5 & 43-45. who cautions against believing the precautionary principle will resolve all the difficult problems of international environmental regulation or prevent new environmental hazards emerging in the future.
[42] Gray, J.S. (1990). Statistics and the Precautionary Principle. *Marine Pollution Bulletin* 21, (4): 174-176. p176, goes further than this, asserting that 'the precautionary principle *should not* be part of science'.
[43] However, Cameron and Abochar suggest that a definition is less important than a framework for action, Cameron, J. and Abouchar, J. (1991). The Precautionary Principle: a fundamental principle of law and policy for the protection of the global environment. *Boston College International and Comparative Law Review* 14, (1): 1-27.

anthropocentric activities.[44] On another level the precautionary principle can be understood as an expert issue in which risk and uncertainty and the weight of evidence play central roles.[45] The difference between these lay and expert interpretations is that the former requires no concrete factors upon which to base precautionary action, while the latter implies that risk, uncertainty and scientific evidence can all be weighed up by experts in order to determine what implementation should involve. Paradoxically, linking the precautionary principle back to risk and scientific evidence in many ways undermines the very reasons why international agreements call for action to be based on precaution in the first instance, namely that the scientific uncertainty that surrounds many environmental problems emphasises that risk cannot always be quantified and evidence is not always available. This tends to be forgotten in some calls for a more comprehensive set of criteria by which implementation of the precautionary principle can be judged.[46] The environmental arena is not the only one to which the precautionary principle has been applied, but as I show in the next section, and the rest of the thesis, it is a field in which scientific and common-sense interpretations of precaution have developed along significantly different tracks. Conflict between them is the subject of the following sub-section.

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[44] Freestone, D. and Hey, E., (eds) (1996). *The precautionary principle and international law: the challenge of implementation*. The Hague, London, Boston: Kluwer Law International.; Bilder, R.B. and Brunnee, J. (1997). Book review and note: the precautionary principle and international law - the challange of implementation. *American Journal of International Law* 91: 210-212.

[45] Department of the Environment (1995). *A guide to risk assessment and risk management for environmental protection*. London: HMSO.

[46] For example, at a meeting I attended in Brussels in 1999, representatives of the chemical industry were calling for more quantitative criteria by which they could be deemed to be implementing the precautionary principle. European Commission - Directorate General for Environment, Nuclear Safety and Civil Protection and Directorate General for Industry (1999). Industrial chemicals: burden of the past, challenge for the future. Industrial chemicals: burden of the past, challenge for the future: Brussels, Belgium. European Commission.

Lay and expert understandings of precaution

Looking at dictionary definitions of the words precaution and principle draws attention to potential conflict within the term itself. According to the Oxford English Reference Dictionary a principle is defined as:

> 'a fundamental truth or law as the basis of reasoning or action'.[47]

And precaution is defined as

> 'an action taken beforehand to avoid risk or ensure a good result; or prudent foresight'.[48]

Therefore, by putting the terms together the precautionary principle can be interpreted as a fundamental law of prudent foresight. However, there is a tension between the notion of law, which implies a codified practice, and prudence or precaution in which no rule exists, but in which judgement is critical. The more the prudence line is taken the more conflict there is with a science concept that relies on proof, ratification and falsification – i.e. a set of certain criteria. This is an important tension to recognise as it identifies an area from which critical differences might stem. Science relies on *a posteriori* induction, proceeding from effects to causes, in order to make informed inferences about the world. The precautionary principle implies a move from *a posteriori* to *a priori* reasoning, which proceeds from causes to effects. Potential causes may be identified while the full effects are still uncertain. This is where the problem lies (in the move from an *a posteriori* induction to an *a priori* deduction) in that our *a posteriori* experience (on which science is based) is no longer a safe basis

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[47] Pearsall, J. and Trumble, B., (eds) (1996). *The Oxford English Reference Dictionary*. Oxford: Oxford University Press. p1149

[48] Pearsall, J. and Trumble, B., (eds) (1996). *The Oxford English Reference Dictionary*. Oxford: Oxford

on which to form judgements or principles on how we should act. This is because science creates a culture of risk in which certainty cannot be attained although it alludes to a promise of certainty, which creates anxiety, fear and distrust.[49] This was demonstrated in the BSE crisis.[50] Precaution and prudence suggest that this inability to create certainty is acknowledged, thus moving away from the notion of *a posteriori* knowledge. Deleterious effects on the environment are extremely complex and it is difficult, on purely scientific criteria, to gain an understanding of what is 'really' going on. This is demonstrated in the ongoing debate about global warming and climate change.[51] Thus *a posteriori* inferences do not tell us everything we might like to know about complex situations, in order to make good decisions.

Everybody makes decisions in the course of everyday life, sometimes based on formalised information, sometimes not. Whatever the level of information available, decisions often have to be made in a fixed period of time, and sometimes with hardly enough time to weigh up the alternative options. People make decisions about

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University Press. p1138

[49] Beck, U. (1992). *Risk society: towards a new modernity*. Translated by Sage Publications. London: Sage Publications.

[50] ENDS Report (1996). Risk without honour. *ENDS Report* 254: 1.
Wynne, B. (1996). Patronising Joe Public. *The Times Higher* 12 April 1996: 13.

[51] Barraclough, I.M. (1991). Pathways to man - the effect of climatic change. Future climatic change and radioactive waste disposal. International Workshop: UEA, Norwich. UEA Norwich.
British Government Panel on Sustainable Development (1996). *Second Report*. London: DoE. January 1996.
British Government Panel on Sustainable Development (1995). *First Report*. London: DoE. Jan 1995.
British Government Panel on Sustainable Development (1997). *Third Report*. London: DoE. Jan 1997.
UK Government (1996). *Government Response to the Second Annual Report of the Government's Panel on Sustainable Development*. London: DoE. March 1996.
Churchill, R. and Freestone, D., (eds) (1991). *International law and global climate change*. London: Graham and Trotman / Matinur Nijhoff.
Shackley, S. and Wynne, B. (1996). Representing uncertainty in global climate change science and policy: boundary-ordering devices and authority. *Science, Technology and Human Values* 21, (3): 275-302.
Zwick, A. (1996). Decisions in a climate of uncertainty: addressing the CO2 issue. *The IPTS Report* 2: 17-21.

everyday matters based on their intuition regarding the safety of a particular course of action. They don't evaluate scientific data before reaching a decision. Proverbs often represent short pithy expressions of the type of precautionary behaviour used in everyday decision-making. In this they offer an insight into lay behaviour and some also provide moral support for particular courses of action.

A brief review of such proverbs show that precaution exists as a common-sense concept, and reveals some of its qualities. That is not to say that proverbs dictate *the* lay position but rather that conventional wisdom can be considered by analysing proverbs, as distinct from expert positions on precaution. My aim here is to identify the different levels on which precaution can be understood and to show that the notion of precaution is not something new, only recently found within international agreements embodying expert understandings, but something which can be traced back through many different cultures. This is relevant since it is important to understand the tensions that exist between intuitive or lay interpretations of precaution and other expert interpretations, in order to think about what the precautionary principle might mean in practice, in particular with reference to contemporary environmental issues.

In English two of the most common proverbs relating to caution are 'Look before you leap' and 'Don't put all your eggs in one basket'. Many other cultures have proverbs, the sense of which is identical to these. In Israel they say 'The wise man has eyes in his head, but the fool walks in darkness'[52] and 'The prudent man considers his steps'[53]

[52]Westermann, C. (1995). *Roots of wisdom: the oldest proverbs of Israel and other peoples*. Edinburgh:

while in Japan they say 'Add caution to caution'.[54] Two old Persian proverbs are 'Don't jump into the water where there is no ford'[55] and 'Don't cut without measuring'[56] which equate with the Scottish 'Look before ye loup, ye'll ken better how to light'.[57] And an American proverb is 'He that will not look before him will have to look behind him'.[58] All these proverbs are to do with direct, individual experiences related to local situations over which the individual has ability to take one course of action or another. They are common sense and can be applied to local experiences and everyday situations. This contrasts with the more expert 'scientific' approach to decision-making which relies on indirect knowledge, through scientific theory and practice, and which promises extrapolation of understandings on an ambitious scale. The proverbial level of decision-making relies on a direct knowledge gained through experience and familiarity with the local. By highlighting the cultural diversity of proverbs I suggest that lay notions of precaution are not fixed in one culture, but are as global and broadly implied as the more political international agreements mentioned earlier.

In order to analyse the relevance of these proverbs to my thesis on the precautionary principle I now look at the meanings behind them. Although this does little to inform us as to how the precautionary principle might be implemented in practice it does

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T&T Clark. p102

[53]Westermann, C. (1995). *Roots of wisdom: the oldest proverbs of Israel and other peoples*. Edinburgh: T&T Clark. p55

[54]Galef, D. (1995). *'Even monkeys fall from trees' and other Japanese proverbs*. Rutland, Vt and Tokyo: Charles E Tuttle Company. p128

[55]Elwell-Sutton (1954). *Persian proverbs*. London: John Murray. p23

[56]Elwell-Sutton (1954). *Persian proverbs*. London: John Murray. p23

[57] Hislop, A. (1868). *The proverbs of Scotland: with explanatory and illustrative notes and a glossary*. Edinburgh: Alexander Hislop and Company. p217

[58]Mieder, W., (ed). (1992). *A dictionary of American proverbs*. New York, Oxford: Oxford University Press. p384

demonstrate the applicability of the notion of precaution to the case studies under examination in this thesis. The implication of 'look before you leap' is that it is common sense to be cautious and to try to work out in advance what the possible consequences of one's actions are before engaging in potentially risky activities. The concept of 'look before you leap' (precaution), if it were to be applied to the issue of endocrine disrupting chemicals suggests there are unknowns waiting on the other side of what is being leapt into (there may be consequences due to the use of certain chemicals in the environment).

Another common English proverb advocating caution is 'Don't put all your eggs in one basket'. A connection can be made between this concept and the radioactive waste disposal issue. The implication of the proverb is that investing everything in one enterprise (nuclear technology) could turn out to be dangerous, that is if the basket is dropped (the question of what to do with the created radioactive waste). Some proverbs about caution and foresight may be more relevant to the understanding of particular environmental problems than others. This is not surprising for proverbs are generally selected in order to make a particular point in a specific situation. This demonstrates both the versatility of proverbs and the parallels that can be drawn with the precautionary principle.

To give another example, the proverb 'Don't count your chickens before they're hatched' suggests that it is not wise to assume that all is as it appears (chemicals are safe) because surprises may be in store in that some of the eggs may not hatch or may be dropped (there may be effects that have not been tested for or mixtures of chemicals in the environment may create unanticipated toxins). Again there are a number of other cultures with similar proverbs: The Japanese say 'Don't estimate the value of a badger skin before catching the badger'[59], while the Scots say 'Dinna gut your fish till ye get them'[60]; the Dutch echo the Scottish proverb with 'Don't cry herrings till they are in the net' while the Italians have a similar proverb to the Japanese with 'Don't sell the bearskin before you have caught the bear'. The German proverb of 'Unlaid eggs are uncertain chickens'[61] echoes the English equivalent. These proverbs advise caution against assuming there will be no unforeseen problems arising (nuclear power is a clean technology) and suggest that it is unwise to make plans about the future based on uncertain knowledge (ignoring the implications of radioactive waste disposal).

This thesis illustrates that there is a difficulty at the expert/institutional level of putting common-sense precaution into practice. Many of the agreements mentioned earlier embody a common-sense notion of precaution as can be seen from the view that scientific uncertainty should not stand in the way of taking a precautionary approach. Having situated the common sense concept of caution in popular culture I now identify specific elements of precaution identified within the rhetoric of formal agreements.

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[59]Galef, D. (1995). *'Even monkeys fall from trees' and other Japanese proverbs*. Rutland, Vt and Tokyo: Charles E Tuttle Company. p70

[60] Hislop, A. (1868). *The proverbs of Scotland: with explanatory and illustrative notes and a glossary*. Edinburgh: Alexander Hislop and Company. p79

[61] Hislop, A. (1868). *The proverbs of Scotland: with explanatory and illustrative notes and a glossary*. Edinburgh: Alexander Hislop and Company. p79

Formalised precaution

From the previous sections it can be seen that precaution is widely established as a documented principle in the environmental arena as well as a lay ethos. I now unpack some of the characteristics of precaution as embodied in the formal national and international agreements cited above in order to create a framework with which to analyse and compare the radioactive waste disposal case study and the study of endocrine disruption.

From the agreements I examined,[62] I identify six situations in which the precautionary principle is expected to apply:

a) situations where a causal link to effects is unclear
b) where scientific evidence does not yet exist
c) where there is no scientific evidence
d) where cost is a factor
e) where the scale of the threat is a factor
f) where there are a diversity of situations to be accounted for.

These are not mutually exclusive but serve to indicate the range and reach of the concepts behind the rhetorical 'precautionary principle'. Additionally, they are not unique to the idea of the precautionary principle (they are factors relevant to many forms of hazard assessment) but as they are provided as caveats within the agreements identified, it is relevant to consider them as embodying the core ingredients of

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[62]See Appendix 1

precaution. I now look at each of these in turn in order to demonstrate the formal embodiment of common-sense understandings and the tensions between these and science-based strategies.

a) where a causal link to effects is unclear

The Ministerial Declaration on the Protection of the North Sea in 1987 states that:

> "...in order to protect the North Sea from possibly 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* has been established by absolutely clear scientific evidence."[63] (my emphasis)

This indicates a situation where it is already known that possible deleterious effects may occur by continuing with a given activity (deep-sea dumping). The unknowns are precisely what effects there might be and exactly what inputs might cause them. Applying the precautionary principle with this proviso allows for the possibility that action can be taken where scientific evidence is still in dispute. It sets up the possibility that something other than scientific evidence may be used as a basis for a decision. However, it stops short of addressing the question of what that other something might be and how the process of deciding what action might be required would be negotiated. Debate about the dumping of the Brent Spar, an oil platform, illustrates just such a case. The potential consequences of dumping one oil platform

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[63] Ministerial Declaration, Second International Conference on the Protection of the North Sea, London, November 1987, quoted in Haigh, N. (1994). The introduction of the precautionary principle into the UK. In, O'Riordan, T. and Cameron, J., (eds), *Interpreting the Precautionary Principle*:229-251.

were not so much in dispute as the consequences of setting a precedent that many more oil platforms would be dumped. The argument over precedence-setting was decisive in this instance.[64]

b) where scientific evidence does not yet exist

The preamble to the Montreal Protocol to the Vienna Convention for the Protection of the Ozone Layer in 1987 states that:

> "[The parties are] determined to protect the ozone layer by taking precautionary measures to control equitably total global emissions of substances that deplete it, with the ultimate objective of their elimination *on the basis of developments in scientific knowledge*, taking into account technical and economic considerations"[65] (my emphasis)

This indicates a situation where, although evidence does not currently exist, there is an assumption that it will be found. Precaution in this example is equated with control of risky substances while science is equated with their elimination. There is an assumption that human behaviour will not be required to be modified because science will ultimately come up with a replacement for the pollutant in question. The Montreal Protocol allows for precautionary measures to dictate action on ozone depleting substances, although it also stops short of suggesting what those measures might be. It additionally accepts that scientific evidence will be required to justify the

London: Earthscan Publications Ltd. p244

[64] ENDS Report (1996). NERC embarrasses DTI with report on Brent Spar. *ENDS Report* 256: 12.

[65] Taken from Young, M.D. (1993). *For our children's children: some practical implications of inter-*

most rigorous action toward ozone depleting substances, that of banning them. The implicit assumption is that ultimately decisions must be based on scientific evidence but in the meantime, common-sense precaution is advisable.

c) where there is no scientific evidence

Recommendation 89/1 of the Convention for the Prevention of Marine Pollution from Land Based Sources states that:

> "[The contracting parties] accept the principle of safeguarding the marine ecosystem of the Paris Convention area by reducing at source polluting emissions of substances that are persistent, toxic and liable to bioaccumulate by the use of 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 when there is *no scientific evidence to prove a causal link* between the emissions and effects ("the principle of precautionary action") ..."[66] (my emphasis)

This indicates a situation where some harms are known to exist but where there is no scientific evidence to link those harms to effects. By stating the intention to reduce substances that are persistent, toxic and bioaccumulative it is supposed that there is

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generational equality and the precautionary principle. Canberra: Australian Government Publishing Service. November 1993. p40-43

[66] The Paris Commission (PARCOM) established by the Convention for the Prevention of Marine Pollution from Land Bared Sources, 22 June 1989, Recommendation 89/1, quoted in Young, M.D. (1993). *For our children's children: some practical implications of inter-generational equality and the precautionary principle.* Canberra: Australian Government Publishing Service. November 1993. p40-

some way of identifying which substances these are. Therefore, scientific evidence at least at that level *is* assumed to exist. The reference to there being *no* scientific evidence is related to evidence of a causal linkage, i.e. that there is no evidence of a mechanism whereby the 'polluting emissions' are causing environmental effects. Again what is lacking in this convention as in the previous ones is any notion as to what the decision should be based upon given the lack of scientific evidence. This notion of not waiting for scientific evidence to prove causality before making a decision is echoed in the Hague Declaration of 1990.[67]

d) where cost is a factor

The UK Government White Paper 'This Common Inheritance' stated in 1990 that:

> "... given the environmental risks, we must act responsibly and be prepared to take precautionary action where it is justified. ... Where there are significant risks of damage to the environment, the Government will be prepared to take precautionary action to limit the use of potentially dangerous materials or the spread of potentially dangerous pollutants, even where scientific knowledge is not conclusive, *if the balance of likely costs and benefits justifies it.* This precautionary principle applies particularly where there are good grounds for judging either that action taken promptly at comparatively low cost may avoid more costly damage later, or that irreversible

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[67] See Appendix 1

effects may follow if action is delayed."[68] (my emphasis)

This indicates a situation where the use of potentially dangerous materials and pollutants will be restricted as a precautionary measure without full scientific evidence being available but with the added dimension that it can be justified with recourse to a cost-benefit analysis. It talks about significant risks of damage to the environment without indicating how a significant risk would be determined and it qualifies its call for action according to the costs that the action would involve. This takes the decision-making out of the realm of solely scientific determination and adds an additional factor (cost) into the equation. The Montreal Protocol also makes reference to economic considerations as a factor in applying the precautionary principle.

e) where the scale of the threat is a factor

The Bergen Ministerial Declaration of 1990 states that:

> "In order to achieve sustainable development, policies must be based on the precautionary principle. Environmental measures must anticipate, prevent and attack the causes of environmental degradation. Where there are *threats of serious or irreversible damage*, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation."[69] (my emphasis)

This indicates a situation where environmental degradation must be tackled by means of the precautionary principle. However it qualifies the type of degradation that must

[68] Command Paper 2100 (1990). *This common inheritance*. London: HMSO. September 1990. p10&11
[69] The Bergen Ministerial Declaration of 1990, quoted in Young, M.D. (1993). *For our children's children: some practical implications of inter-generational equality and the precautionary principle.*

be tackled by stating that it must be serious or irreversible. This introduces the notion that the scale of the potential degradation should be weighed up in order to judge what kind of action is most appropriate. It suggests that if the threat is serious or irreversible then action should not be postponed. What constitutes a serious threat is not explicated although again lack of scientific consensus is not to be used as a reason not to take action. Here the issue of scientific uncertainty is acknowledged although there is no discussion of how it could be handled. What is clearly important is when the threat is great something should be done to mitigate any potential effects. The difficulty comes in translating that into action.

f) where there are a diversity of situations to be accounted for

In Article 130r of the "Maastricht Treaty" of 1992 it states that:

> "Community policy on the environment shall aim at a high level of protection taking into account *the diversity of situations* in the various regions of the Community. It shall be based on the precautionary principle and on the principles that preventive action should be taken, that environmental damage should as a priority be rectified at source and that the polluter should pay. Environmental protection requirements must be integrated into the definition and implementation of other Community policies."[70] (my emphasis)

This indicates that there are a myriad of situations within one area (the EU) and that

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Canberra: Australian Government Publishing Service. November 1993. p40-43

[70] "Maastricht Treaty", Treaty on European Union, February 1992, Article 130r, paragraph 2, quoted in Young, M.D. (1993). *For our children's children: some practical implications of inter-generational*

the precautionary principle must be prepared to deal with all of them. The Maastricht Treaty shows that each region may be exposed to different hazards and risks with the significant point in common being that they may all impact on the environment. It links the precautionary principle to other environmental protection requirements implying that it is not a principle that should work on its own. By associating it with the polluter pays principle it gives a first indication of how the precautionary principle might be implemented in practice.

Having identified these six situations it can be seen that the precautionary principle is invoked in a multitude of agreements which all claim to be for the benefit of the environment but which position the precautionary principle in different ways. It is important to recognise that these agreements reflect the specific circumstances for which they were drawn up. Scientific evidence, for example, is used as a criterion in many of the agreements but not in a uniform manner. Sometimes the fact that there is no scientific evidence is invoked as a reason to employ the precautionary principle. On other occasions the fact that the evidence is not there *yet* is a good reason to invoke it although there is the assumption that science will eventually provide evidence that will justify the precautionary actions. In other agreements the fact that there is no clear link between cause and effect should not be used as a reason for not taking precautionary action and again there is an implicit assumption that decisions about action should, necessarily, be based on something other than scientific evidence. Even between agreements advocating the position that science cannot be relied on to provide answers when required there is still a rhetoric that comes back to science

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equality and the precautionary principle. Canberra: Australian Government Publishing Service.

being the eventual source of truth. In these agreements science remains the basis for decision-making, despite acknowledgement that actions need to be made prior to the point at which scientific knowledge offers such a foundation. Looking back, it may be said that the precautionary principle fills the vacuum created by a science that continually searches for certainty but which continually fails to deliver. Because 'certainty' is created within boundaries on the basis of agreed assumptions and error margins science will never be able to offer undisputed truth. There will always be uncertainty because certainty is always contingent on other factors. It is the acknowledgment of this that the precautionary principle prompts. What is left after it is acknowledged that decisions will never be based on certainty is a risk society[71], i.e. a society in which the precautionary principle represents a practical conceptual corollary to science-based decision-making.

Reviewing formal agreements in this way illustrates the tensions that exist about scientific evidence and the differing levels at which the precautionary principle is invoked in relation to it. This gives me a place to start. In itself the precautionary principle offers little indication of how to undertake empirical research regarding its application. Due to a lack of situations in the UK where the precautionary principle has been explicitly used as the driving force behind environmental policy decisions I have had to consider alternative ways of understanding what the precautionary principle may mean in practice. The agreements identified suggest that understanding how scientific evidence is marshalled and how uncertainty is acknowledged and used

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November 1993. p40-43

[71] This is a term coined by Beck, U. (1992). *Risk society: towards a new modernity*. Translated by Sage Publications. London: Sage Publications.

is key to the rhetoric of the precautionary principle. I therefore focus on these areas in relation to two case studies of radioactive waste disposal and endocrine disrupting chemicals. By doing this I reframe the emphasis from looking at 'the precautionary principle' about which there is little detailed discussion within deliberations on these issues, to analysing those factors that deliberators about these cases do find relevant and which are central to the theme of precaution, broadly defined. Through looking at scientific evidence and the factors related to its definition and deployment, I demonstrate how the interests of individuals and organisations involved influence the positions taken in the process of making decisions and implementing precautionary strategies.

While decisions based on common-sense or anticipatory precaution and those based on scientific evidence may be considered conceptual corollaries they both have something in common – the contingent interests of those involved in making the decisions. In this thesis I identify differing interests and their consequences, both for the making and marshalling of scientific evidence, and its use in decision-making in environmental arenas. It is therefore important to understand the way in which scientific evidence is created and used by different players involved in making a decision, what they identify as relevant evidence to support or oppose and the ways in which concepts of relevance to the decision in question are constructed and used in order to serve particular purposes.

The foci of my empirical studies therefore centre on the nature of evidence with attention given to the nature of definitions, disputed evidence, sufficient evidence, scientific uncertainty and the interests of government, industry and NGOs at various institutional levels. In the following section I describe the empirical cases studied in this thesis and outline how these themes are relevant to each case.

Cases of precaution

In order to explore the proposition that decisions based on the precautionary principle are the theoretical corollary to decisions based on an uncertain science it has been necessary to identify environmental issues which are the subject of controversy and intrigue and which reflect something of the array of problems with which decision-makers are faced. The chosen case studies illustrate different situations in which the precautionary principle is invoked and simultaneously depict areas of commonality. This sheds light on the question of whether there is any scope for a broad application of the precautionary principle and the degree to which its meaning is defined by the issue to which it is applied.

A number of potential candidates initially came to mind, including genetically manipulated organisms, particulate emissions from exhausts, climate change, radioactive waste disposal and endocrine disrupting chemicals.[72] The latter two were ultimately selected as the most feasible and relevant case studies. At the time of starting my PhD a public inquiry into a planning application by UK Nirex Ltd to excavate a Rock Characterisation Facility (RCF) at Longlands Farm near Sellafield in Cumbria was under way. Nirex is the company responsible for managing intermediate level radioactive waste in the UK. It had submitted this application to the planning

[72] Full details of the selection and rejection of particular cases are discussed in chapter four

office to construct an RCF to investigate the geology and hydrology of the site in order to assess the site's suitability as a deep disposal site for intermediate level waste. At around the same time the subject of the potential endocrine disrupting characteristics of certain chemicals was making headlines in the media. A number of scientific studies were indicating that the reproductive development of humans and wildlife was deteriorating.[73] Suggestions that these effects were being caused by manmade environmental chemicals were escalating[74] and demands were being made from various sectors including academia, environmental NGOs and government for further research into this area.

Certain features of these two issues made them suitable candidates for my empirical research.[75] The radioactive waste issue provided an opportunity for an historical study dating back to the late 1940s. This contrasts starkly with the endocrine disrupting chemicals issue, which, by comparison, is a contemporary 1990s phenomenon (in terms of its recognition as an issue). Although decisions about radioactive waste disposal are ongoing they have a definite history with players in the debate having been established with identifiable positions. In comparison, positions in relation to potentially endocrine disrupting chemicals are still emerging.

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[73] See Carlsen, E., Giwercman, A., Keiding, N., and Skakkebaek, N.E. (1992). Evidence for decreasing quality of semen during past 50 years. *British Medical Journal* 305, (6854): 609-613., Giwercman, A., Carlsen, E., Keiding, N., and Skakkebaek, N.E. (1993). Evidence for increasing incidence of abnormalities of the human testis: a review. *Environmental Health Perspectives* 101, (supplement 2): 65-71., Berger, G. (1994). *Epidemiology of endometriosis: modern surgical management of endometriosis*. New York: Springer-Verlag.

[74] See Carson, R. (1962). *Silent spring*. Boston, MA: Houghton Mifflin Company. and Colborn, T., Peterson Myers, J., and Dumanoski, D. (1996). *Our Stolen Future*. London: Little, Brown and Company.

[75] I discuss these in detail in chapter four

Another key point of difference concerns the relationship between cause and effect. This relates to the availability (or non-availability) of scientific evidence relating identifiable consequences to specific causes. Many of the hazards and risks associated with the nuclear industry have already been acknowledged and stringent safety regimes put in place in order to control exposure to radioactivity. However this does not mean that the assessment of risk goes undisputed or that there is no conflict as to liability for particular radioactive releases. The Nirex Inquiry, discussed within this thesis, provides ample evidence that controversies still exist in relation to the role of scientific evidence with reference to decisions about radioactive waste disposal. In contrast many of the hazards and risks associated with environmental chemicals have not been determined and there is much debate over the causes of the many observed effects. Comparing the differences in the uses of scientific evidence with regard to understandings of causality in these two cases, and the deliberations over the need to wait for scientific consensus before action can be taken, is central to understanding the role and use of the precautionary principle more generally, given the aforementioned consensus that the precautionary principle should be implemented in situations where there is still (significant) scientific controversy. Looking at these case studies in the light of what has been gleaned from analysis of agreements in which the precautionary principle is invoked highlights differences between what has been agreed at a policy level and what is being discussed at the level of individual issues.

In both cases emphasis on scientific evidence and efforts to determine the potential scale of the threat involves the employment of terminology and concepts that may not be understood by all those involved in the deliberations. By investigating the way in which definitions become established and are used to construct arguments in defence of particular positions, both in discussions about radioactive waste disposal and endocrine disrupting chemicals, it can be shown how much reliance is placed on rhetorical manoeuvring in decision-making processes. This is instructive in understanding the potential of the precautionary principle. I illustrate the way in which background interests shape negotiating positions and thereby determine definitions and interpretations, which, in turn surround the precautionary principle itself.

An additional contrast concerns technical difficulties associated with detecting problems. Radiation, although not detectable with the naked eye, is readily detected with the right equipment. While this means that only specialists with access to this equipment can detect radiation it remains a relatively straightforward procedure. In contrast endocrine disrupting chemicals are not easily identified. Like radiation, endocrine disrupting chemicals are not detectable with the naked eye but nor are they easily detected with standard laboratory instruments. While the presence of certain chemicals may be detectable in water or air using specialist monitoring equipment, determining their potential endocrine disrupting capabilities is not so straightforward. The equipment, protocols and instruments for conducting such tests have not been fully developed nor agreed upon. The precautionary principle is invoked with respect to both types of problem – those where detection of exposure is possible by scientific means and those where methods of detection have not been established.

These cases provide relevant arenas in which to investigate the ways in which scientific evidence is presented and re-presented in decision-making fora. This, in turn, is important in order to determine the interests lying behind the positions adopted. By investigating how scientific evidence is presented I develop an understanding of issues that are important to those involved in making decisions about the two cases in question. Having identified what is important I can then determine what factors help shape interpretations of relevance and significance. By determining the institutional or political interests of those involved, I am in a better position to analyse what the precautionary principle might mean in these two situations.

The precautionary principle is raised as something that should be applied to a range of heterogeneous environmental situations. The contrasting features of the two case studies illuminate both the problems and the benefits of prescribing a blanket application of the precautionary principle. For example endocrine disrupting chemicals are ubiquitous in the environment with all individuals exposed to them to some degree (although not necessarily to the same degree). In contrast radioactive waste disposal provides more immediate exposures. Not everyone will automatically come into contact with radioactive waste. If it is to be used as a generalised guide to action the precautionary principle must respond to both these situations. There is much stronger and more developed legislation regulating radioactive waste matters than endocrine disrupting chemicals yet the precautionary principle is expected to deal with situations in which there are strong, weak and undeveloped legislative powers.

Both the radioactive waste disposal issue and the endocrine disrupting chemicals issue are engulfed by uncertainty: there are uncertainties at a political level about what is the best course of action to take and uncertainties at a scientific level over whether the immediate and longterm effects of any proposed action can be determined. Scientific uncertainty and the way it is handled by scientists, by the public and by policy makers is discussed in more detail in chapter three. Understanding that different interpretations of uncertainty co-exist is essential in analysing the application of the precautionary principle. Together these two case studies help reveal the complexities with which the precautionary principle is faced at the level of making decisions about environmental issues. Comparing the way in which decisions are made about radioactive waste disposal and endocrine disrupting chemicals reveals the importance of the embedded and intrinsic interests of those involved.

It is important to recognise that the case studies are not being used as simple representations of the application of the precautionary principle, but rather as instances of environmental problems about which there is wide ranging concern. They are thus used to investigate the ways in which situations identified as being rhetorically relevant to the precautionary principle are addressed at a deliberative level. By identifying the main areas of deliberation with regard the two case studies in chapters five and six I relate these back to the six situations of precaution identified in this chapter. Critically, these issues concern the definition and uses of scientific evidence. What is consequently seen is that factors that are integral to the rhetoric of precaution are also discussed in deliberations about policy options with regard to environmental issues regardless of whether 'the precautionary principle' itself is being actively invoked. The implications of this for the meaning of the precautionary principle and how it might be applied to other environmental issues are varied and are discussed in chapter eight.

Summary

Having established that the precautionary principle is vague and ill-defined I traced its origins from *Vorsorgeprinzip* in Germany through to its invocation in various formal international agreements. I identified that no agreed ground-rules exist regarding the complicated question of implementing the precautionary principle. I identified that the precautionary principle is required to operate in diverse situations and revealed that there is no established formula whereby consensus amongst the various stakeholders can be reached.

With reference to a review of formal agreements, I illustrated the evolution of precaution from *a precautionary approach* to *the precautionary principle*, an important distinction as it emphasises the definite article, the, which implies something tangible and unique that can be applied in a multitude of situations.

I went on to show that the precautionary principle can be understood at two levels: a common-sense level that suggests the environment should be protected, and a more expert level where risk, uncertainty and the weight of evidence play central roles. The former offers a generalised, but unspecific, guide to action while the latter implies that experts can weigh up the risks and uncertainties and determine what constitutes implementation. This 'scientising' of precaution arguably undermines the very reasons why formal agreements call for action to be based upon the precautionary principle, namely that risk cannot always be quantified and evidence is not always available.

Through discussing the difference between common-sense precaution and scientific practice I show that the precautionary principle does not fit easily into the scientific paradigm. Scientific controversy is conventionally resolved through consensus and peer review and this process may take years, although it may be that dominant voices in the scientific field come to be accepted as the current position of scientific knowledge. In contrast the precautionary principle has no accepted set of practices and regulations and there is no established framework through which consensus can be reached. I show that the precautionary principle implies a move from *a posteriori* induction (on which science is based) to *a priori* deduction and that this is important because effects may be uncertain while causes may be identifiable.

Further analysis of formal precautionary agreements allowed me to identify six situations in which the precautionary principle is expected to apply: situations where a causal link to effects is unclear; where scientific evidence does not yet exist; where there is no scientific evidence; where cost is a factor; where the scale of the threat is a factor; and where there are a diversity of situations to be accounted for. By identifying these six situations I have shown the way in which scientific knowledge is included as an integral part of these agreements despite the fact that it has been acknowledged that decisions need to be made prior to science being in a position to offer any level of certainty. From this I have suggested that the precautionary principle is a practical conceptual corollary to science-based decision-making.

This line of reasoning explains the development of the following chapters. I have looked at scientific evidence and other related issues precisely because they are invoked in the same agreements that recommend the application of the precautionary principle. By looking at these issues I explore how the interests of individuals and organisations involved in making decisions influence positions taken with regard to scientific knowledge. By attempting to understand the way in which scientific evidence is created and used by different players involved in making decisions I start to identify their contingent interests. My empirical research concentrates on detailed investigation of the nature of definitions, disputed evidence, sufficient evidence, scientific uncertainty and the interests of government, industry and NGOs at an institutional level. These themes provide a platform from which to analyse what the precautionary principle means in relation to disparate and contrasting environmental problems.

This thesis is about understanding the rhetoric of precaution and the practice of decision-making in areas of environmental controversy. It untangles the rhetoric, as established in documented agreements referring to precaution, from the constituent ideas that embody it, as characterised by those who deliberate on its application. This is what connects my analysis of documents referring to the precautionary principle to my empirical work on radioactive waste disposal and endocrine disrupting chemicals. By analysing the way in which the rhetoric of precaution is framed within these documents I have been able to identify different elements that make up the principle in theory. I then use these elements as the starting point for my analysis of radioactive waste disposal and endocrine disrupting chemicals. By focussing on the constituent ideas behind the precautionary principle I am able to move forward from the stalemate of rhetoric that could become the focus of attention itself.

Chapter Three

Uncertainty, Expertise and Interests

Introduction

In the previous chapter I suggested that precautionary practices reflected interpretations of the nature of evidence, the nature of definitions, disputed evidence, sufficient evidence, scientific uncertainty, and the interests of government, industry and NGOs. In this chapter I analyse their connection to each other and attempt to draw out inter-relationships between these constituent themes. In addition I review some of the literature about uncertainty in order to get a sense of the breadth of meaning that this term conveys. I establish how the issue of uncertainty is related to scientific controversy and decision-making, and look at how expertise is defined and deployed in relation to scientific uncertainty. In the course of this chapter I introduce ideas from the sociology of science and relate these to debate about the precautionary principle. Science studies identifies 'facts' as social products rather than as objective entities and raises issues of social negotiation and interaction.[1] Various authors assert that the concept of 'fact' is misleading in the sense that everything that is accepted as knowledge comes about through negotiation rather than objective discovery.[2] Additionally they set up decision-making as something that has been socially constructed, viewing sites of controversy as points at which associated interests are brought together. By introducing these ideas from science studies and giving a brief

[1] See Fujimura, J.H. (1991). On methods, ontologies and representation in the sociology of science: where do we stand? In, Maines, D., (ed)., *Social organization and social process: essays in honor of Anselm L Strauss*:207-248. Hawthorne, NY: Aldine de Gruyter. p224. See also Jasanoff, S. (1989). Guest Editorial: Norms for Evaluating Regulatory Science. *Risk Analysis* 9, (3): 271-273. p272 where she says facts are accepted within a 'system of shared conventions'.

[2] Collins, H.M. (1982). The replication of experiments in physics. In, Barnes, B. and Edge, D., (eds), *Science in context: readings in the sociology of science*:94-116. Milton Keynes: The Open University Press. p111-112; Pinch, T. and Bijker, W. (1984). The social construction of fact and artefacts: or how the sociology of science and the sociology of technology might benefit each other. *Social Studies of Science* 14: 399-441. p401-402; Campbell, B.L. (1985). Uncertainty as symbolic action in disputes among experts. *Social Studies of Science* 15: 429-453. p450. See also Rip, A. (1985). Experts in public

outline of the prevalent issues within the discipline that relate to my study of the precautionary principle I explain why I have adopted an interests approach as a theoretical framework for analysing my case studies.

Interests theorists are typically concerned to uncover the reasons behind the different positions taken on particular scientific controversies.[3] What follows is a review of literature on the interests approach. This allows me to evaluate what the position has to offer and how it has been used by researchers of scientific controversy. I too argue that interests are socially constructed and that they are associated with institutional beliefs and over-riding paradigms. In order to justify my use of the interests approach in relation to the precautionary principle I address some of the criticisms that have been levelled against it. I use Woolgar's work extensively in the penultimate section, as he has been a very outspoken and articulate critic of the approach. Finally I identify aspects of interests theory that are of use to me in this thesis and, stating where I stand with regard to its use, I provide a justification of my use of that approach. I close the chapter with a summary of the main points elucidated within it.

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arenas. In, Otway, H. and Peltu, M., (eds), *Regulating industrial risks: science, hazards and public protection*:94-110. London: Butterworths. where he talks about the 'hard-fact' myth.

[3] See, for example, Collins, H.M. (1983). An empirical relativist programme in the sociology of scientific knowledge. In, Knorr-Cetina, K.D. and Mulkay, M., (eds), *Science observed: perspectives on the social study of science*:85-113. London: Sage Publications Ltd. p85-113; Barnes, B. and MacKenzie, D. (1979). On the role on interests in scientific change. In, Wallis, R., (ed)., *On the margins of science: the social construction of rejected knowledge*:49-66. Keele, Staffs: University of Keele. p49-66; Shapin, S. (1979). The politics of observation: cerebral anatomy and social interests in the Edinburgh phrenology disputes. In, Wallis, R., (ed)., *On the margins of science: the social construction of rejected knowledge*:139-178. Keele, Staffs: University of Keele. p139-178

Questions of Uncertainty

In the previous chapter I identified six distinct situations in which the precautionary principle is expected to apply: in situations where a causal link to effects is unclear, where scientific evidence does not yet exist, where there is no scientific evidence, where cost is a factor, where the scale of the threat is a factor and where there are a diversity of situations to be accounted for. These led me to identify a number of themes (the nature of evidence, the nature of definitions, disputed evidence, sufficient evidence, scientific uncertainty and the interests of government, industry and NGOs) as being critical with regard to interpretations of the precautionary principle. In this chapter I develop a justification for concentrating on these in my empirical work. The aim here is to develop an argument about the relationship between academic literature on uncertainty and literature on interests. I do this by introducing various types of uncertainty and then discussing the role uncertainty plays within policy. The notion of interests is then introduced, with a subsequent sub-section on expertise, linking uncertainty and interests.

Types of uncertainty

According to O'Riordan and Cameron there are three fundamental forms of uncertainty with which science must cope: uncertainty as lack of data; uncertainty as variability of process; and uncertainty as indeterminacy.[4] These notions of uncertainty need further explanation.

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[4] O'Riordan, T. and Cameron, J., (eds) (1994). *Interpreting the Precautionary Principle.* London: Earthscan Publications Ltd. p62-66

Lack of data is probably the most easily explained source of uncertainty and can occur because the systems and processes under consideration have not been monitored for long enough for 'sufficient' data to have accumulated. This could be due to lack of knowledge about what exactly should be monitored or because financial constraints have imposed a limit on the amount of monitoring possible or even because data is withheld due to commercial confidentiality or national security. The technique selected to collect data may itself be uncertain – it may have been used successfully in a different situation but be inappropriate for the present requirements or it may be a new method that has not been tested before. The interpretation of data by different 'experts' may also contribute to this form of uncertainty. Wynne and Mayer's description of the British government and the Central Electricity Generating Board's demands for more research on acid rain in the 1980s – before they would consider imposing abatement measures – exemplifies the uses of such an uncertainty argument.[5] The British government and the CEGB argued that existing scientific data, which was good enough for most other countries, was 'too' uncertain. Their object was to stall making a decision until science 'proved' a link between emissions and acid rain.

One of the ways in which scientists have overcome this problem of lack of data is by means of extrapolation and modelling. As O'Riordan and Cameron put it:

> 'This is the so-called Newtonian view of estimating uncertain outcomes, utilising the logic of extrapolation from careful

[5] Wynne, B. and Mayer, S. (1993). How science fails the environment. *New Scientist* 5 June 1993: 33-35. p33-35

observation and experimentation, coupled to experience and peer reviews.'[6]

This approach is, however, problematic as it involves assumptions about natural processes and causes and effects and the data used in the modelling may itself be extrapolated from a smaller sample of data.

> 'Only by investing in more painstaking monitoring and careful collaborative comparisons of many ecological conditions, can any certainty be created.'[7]

Other factors that must be considered are that the characteristics and qualities of the models used to 'plug' gaps in data inevitably simplify the systems they are supposed to represent and may leave out so many factors that this transforms the system in question into something completely different.[8] In any event, the key point is that observations and extrapolations are both taken to constitute 'data', some forms being more 'sufficient' and others more 'uncertain'.

The second form of uncertainty, according to O'Riordan and Cameron, is 'uncertainty as variability of process.' By this I understand them to mean that the mechanisms and relationships which exist in the natural world are poorly understood, and that they are chaotic and variable in structure. This implies that it may be impossible to predict accurately the end results of an initial happening especially if the processes involved are unknown. An example of this kind of uncertainty is the issue of 'global warming'

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[6] O'Riordan, T. and Cameron, J., (eds) (1994). *Interpreting the Precautionary Principle.* London: Earthscan Publications Ltd. p63

[7] O'Riordan, T. and Cameron, J., (eds) (1994). *Interpreting the Precautionary Principle.* London: Earthscan Publications Ltd. p63

[8] See Funtowicz, S.O. and Ravetz, J.R. (1991). A new scientific methodology for global environmental issues. In, Costanza, R., (ed)., *Environmental Economics: the science and management of sustainability*:137-152. Columbia: Columbia University Press. p139 for a discussion of the data associated with computer models.

where there is still no consensus as to the nature or dynamics of the problem. O'Riordan and Cameron underline the importance of peer review in managing this type of uncertainty:

> 'There is always the danger of group fallibility in such exercises. The only adequate answer is to ensure that such constellations of opinion have the widest range of views, and are open to examination, so that unusual interpretations get a proper airing'.[9]

There are implications in this for policy making as any decisions based on an assumption about a particular ecological relationship, even if that relationship is accepted by consensual agreement, must ultimately be a subjective decision. Concepts of subjectivity, values and interests are addressed later in this chapter.

Uncertainty as indeterminacy is a much more complex form. Wynne tells us that indeterminacy is not just uncertainty in the form of imprecision, which it is assumed will be narrowed down by more research, but rather a state of affairs which relates to whether things are classified as the same or different and on what specific properties or criteria.[10] As O'Riordan and Cameron state:

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[9] O'Riordan, T. and Cameron, J., (eds) (1994). *Interpreting the Precautionary Principle.* London: Earthscan Publications Ltd. p64-65. See also Funtowicz, S.O. and Ravetz, J.R. (1991). A new scientific methodology for global environmental issues. In, Costanza, R., (ed)., *Environmental Economics: the science and management of sustainability*:137-152. Columbia: Columbia University Press. p149. This point is acknowledged by the Office of Science and Technology, Department of Trade and Industry - Office of Science and Technology (1997). *The use of scientific advice in policy making.* London: DTi. March 1997. p4, paragraph 6. However, for a fuller discussion on the merits of peer review for regulatory science see Jasanoff, S. (1990). *The Fifth Branch: science advisors as policymakers.* Harvard, US: Harvard University Press. p61-83

[10] Wynne, B. (1992). Uncertainty and environmental learning: reconceiving science and policy in the preventive paradigm. *Global Environmental Change* 2, (June): 111-127. p126

'Indeterminacy means that the systems being studied operate to processes that cannot be encapsulated in traditional scientific terms.'[11]

In developing a similar position, Wynne challenges Ravetz *et al*'s notion of indeterminacy, which he states is simply a larger-scale uncertainty.[12] He states that

'Ravetz *et al* imply that uncertainty exists on an objective scale from small (risk) to large (ignorance), whereas I would see risk, uncertainty, ignorance and indeterminacy as overlaid one on the other, being expressed depending on the scale of the social commitments ('decision stakes') which are bet on the knowledge being correct.'[13]

Wynne argues that indeterminacy

'underlies the construction of scientific knowledge, as well as the wider social world in which we create environmental effects.'[14]

And continues:

'...scientific knowledge proceeds by *exogenizing* some significant uncertainties, which thus become invisible to it.'

The point here is that scientific endeavour works by treating a system as if particular uncertainties are insignificant thereby building up a particular knowledge. It is

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[11]O'Riordan, T. and Cameron, J., (eds) (1994). *Interpreting the Precautionary Principle*. London: Earthscan Publications Ltd. p65

[12]Wynne, B. (1992). Uncertainty and environmental learning: reconceiving science and policy in the preventive paradigm. *Global Environmental Change* 2, (June): 111-127. p116, referring to Funtowicz, S. and Ravetz, J., (eds) (1990). *Uncertainty and quality in science for policy*. Dordrecht: Kluwer Academic.

[13]Wynne, B. (1992). Uncertainty and environmental learning: reconceiving science and policy in the preventive paradigm. *Global Environmental Change* 2, (June): 111-127. p116

[14]Wynne, B. (1992). Uncertainty and environmental learning: reconceiving science and policy in the preventive paradigm. *Global Environmental Change* 2, (June): 111-127. p112

however, these very uncertainties that must be acknowledged before extrapolation can occur. Quoting MacKenzie, Wynne states that

> 'Indeterminacy exists in the open-ended question of whether knowledge is adapted to fit the mismatched realities of application situations, or whether those (technical and social) situations are reshaped to 'validate' the knowledge.'[15]

Wynne asserts that the distinction between uncertainty and indeterminacy is important

> 'because the former enshrines the notion that inadequate control of environmental risks is due only to *inadequate scientific knowledge*, and exclusive attention is focused on intensifying that knowledge, to render it more precise.'[16]

To summarise, indeterminacy can be understood as necessary uncertainty. It is a consequence of the unavoidable limits of scientific knowledge, not a result of the failure to adequately develop or apply scientific method to the problem at hand. This means that science cannot always provide answers for policy makers to use in determining policy.

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[15]Wynne, B. (1992). Uncertainty and environmental learning: reconceiving science and policy in the preventive paradigm. *Global Environmental Change* 2, (June): 111-127. p115, quoting MacKenzie, D. (1990). *Inventing accuracy: a historical sociology of nuclear missile guidance*. Cambridge, MA: MIT Press.
[16]Wynne, B. (1992). Uncertainty and environmental learning: reconceiving science and policy in the preventive paradigm. *Global Environmental Change* 2, (June): 111-127. p118

Uncertainty and its place in policy

According to Ravetz there is a range of possible solutions to the policy problem of handling uncertainty.[17] He classifies them as technical, political and moral and he defines what he calls *policy science*, also known as 'post-normal science',[18]

> '...where, typically, facts are uncertain, values in dispute, stakes large, and decisions urgent.'[19]

These issues are of obvious relevance to the precautionary principle. The 'policy science' discussed by Ravetz may not describe the kind of science which scientists consider they perform but it is the kind of science that is used in making policy decisions. Ravetz emphasises the need for scientists and policy makers to work in partnership to control uncertainty and to manage ignorance.[20]

Ravetz describes the birth and growth of a new technology in order to illustrate the level of ignorance that exists in situations where longer-term effects cannot be estimated:

> 'At that point, its effects on its natural and social environment cannot be realistically estimated so much depends crucially on such unknowable aspects as the rate and direction of growth, that all

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[17] Ravetz, J.R. (1987). Uncertainty, ignorance and policy. In, Brooks, H. and Cooper, C.L., (eds), *Science for Public Policy*. Oxford: Pergamon Press. p78.

[18] Funtowicz, S.O. and Ravetz, J.R. (1991). A new scientific methodology for global environmental issues. In, Costanza, R., (ed)., *Environmental Economics: the science and management of sustainability*:137-152. Columbia: Columbia University Press. p138 defines 'the post-normal situation is one where the traditional opposition of 'hard' facts and 'soft' values is inverted.'

[19] Ravetz, J.R. (1987). Uncertainty, ignorance and policy. In, Brooks, H. and Cooper, C.L., (eds), *Science for Public Policy*. Oxford: Pergamon Press. p81; Funtowicz, S.O. and Ravetz, J.R. (1991). A new scientific methodology for global environmental issues. In, Costanza, R., (ed)., *Environmental Economics: the science and management of sustainability*:137-152. Columbia: Columbia University Press. p137

scenarios are speculative, with little to distinguish among them. Hence, for policy purposes, they are not probability-based uncertainties but only thinly disguised ignorance. So social control is impossible because of ignorance; then the technology grows and eventually some effects are revealed. *Then* some might want to step in, but by that point the technology is realised in a collection of institutions, with inertia, vested interests in growth, and means of keeping critics in some degree of ignorance about their activities. Hence, social control is now impossible because of impotence; the technology rides high.'[21]

This description suggests that it is impossible to install checks on the early stages of technological development. Ravetz implies that technologies are likely to have become irretrievably embedded before potentially negative effects are discernible. This makes policy decisions difficult, if not impossible, since there is no more than the idea of a technology at stake at the point when it is really possible to make a difference. This is significant in relation to the precautionary principle because it is inherently about making decisions regarding technologies that have emerging environmental consequences.

Policy makers, confronted with uncertainty, typically refer to experts and expert knowledge.[22] However, as Ravetz argues, experts have expertise only in their small,

[20] Ravetz, J.R. (1987). Uncertainty, ignorance and policy. In, Brooks, H. and Cooper, C.L., (eds), *Science for Public Policy*. Oxford: Pergamon Press. p82
[21] Ravetz, J.R. (1987). Uncertainty, ignorance and policy. In, Brooks, H. and Cooper, C.L., (eds), *Science for Public Policy*. Oxford: Pergamon Press. p83
[22] See Rip, A. (1985). Experts in public arenas. In, Otway, H. and Peltu, M., (eds), *Regulating industrial risks: science, hazards and public protection*:94-110. London: Butterworths. p96

select field and therefore they are unable to foresee adverse consequences in other fields in which they are not trained.[23] Pinch goes further than this. He states:

> 'It appears that different perceptions of certainty are available and that such perceptions tend to be polarised between different specialities, with each blaming the other for the problem.'[24]

Experts in particular fields assume certain norms and relationships in their everyday work that may seem like wild assumptions to a person from outside that field – although they might equally hold certain norms and relationships to exist in their own specialist field. This means that for a given problem each expert will assume uncertainty to exist in a field other than her or his own.[25] This is difficult for policy makers as they will probably have no expertise in any of the fields in question, and may be presented with conflicting information from different 'experts'. Even so, policy makers are forced to act on the scientific knowledge and advice that is available to them.

MacKenzie suggests that policy makers' distance from the immediacies of knowledge production is critical. He recognises the difference between those close to the knowledge production and those committed to using the knowledge in what he terms the 'certainty trough' (see next page).[26] He distinguishes between the 'uncertainty of

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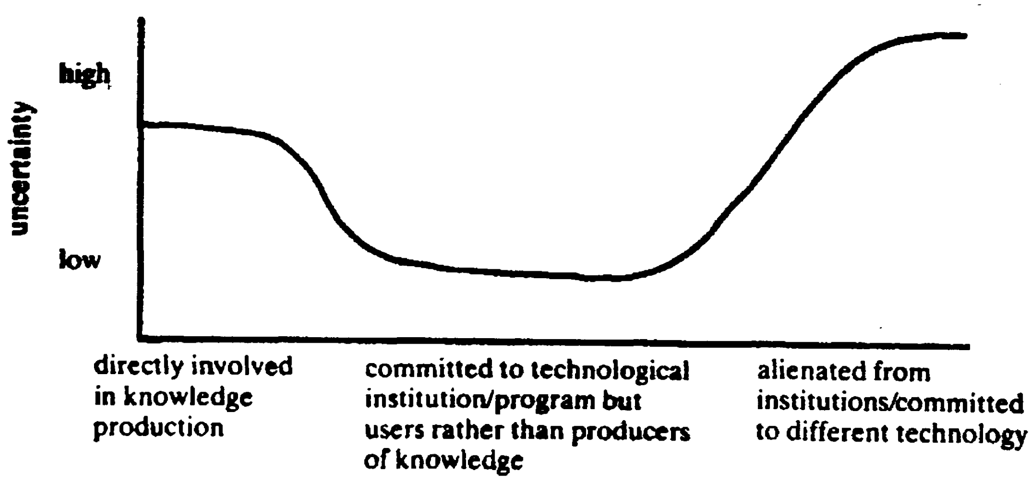
[23] Ravetz, J.R. (1987). Uncertainty, ignorance and policy. In, Brooks, H. and Cooper, C.L., (eds), *Science for Public Policy*. Oxford: Pergamon Press. p81
[24] Pinch, T.J. (1981). The Sun-Set: the presentation of certainty in scientific life. *Social Studies of Science* 11, (1): 131-158. p136
[25] Pinch, T.J. (1981). The Sun-Set: the presentation of certainty in scientific life. *Social Studies of Science* 11, (1): 131-158. p139. However, Star, S.L. (1985). Scientific work and uncertainty. *Social Studies of Science* 15: 391-427. p407-408 offers a different explanation in her discussion of the transformation of local uncertainty into global certainty at the institutional level. She says 'researchers tended to attribute certainty to *other* fields ...'
[26] MacKenzie, D. (1990). *Inventing accuracy: a historical sociology of nuclear missile guidance*. Cambridge, MA: MIT Press. p370-372

the alienated' and the 'uncertainty... of those closest to the heart of the production of knowledge of accuracy'.[27] He says:

> 'Between those very close to the knowledge-producing technical heart of the programs, and those alienated from them or committed to opposing programs, lie the program loyalists and those who simply "believe what the brochures tell them". These lie in what one might call the "certainty trough"...'.[28]

<u>MacKenzie's 'certainty trough'</u>



Source: (MacKenzie, D. 1990) p372

In sum, the view is that policy makers who are removed from the production of knowledge minimise the degree of uncertainty because they lie in this trough.

[27] MacKenzie, D. (1990). *Inventing accuracy: a historical sociology of nuclear missile guidance.* Cambridge, MA: MIT Press. p371. This is what Ezrahi, Y. (1980). Utopian and pragmatic rationalism: the political context of scientific advice. *Minerva* 18, (1): 111-131. p113-114, calls the 'pragmatic rationalist' approach: 'The pragmatic rationalist knows that the 'scientific knowledge' ... used by politicians and others engaged in contentions over policy might not be what qualified scientists would be willing to acknowledge as valid.'

[28] MacKenzie, D. (1990). *Inventing accuracy: a historical sociology of nuclear missile guidance.* Cambridge, MA: MIT Press. p371

Uncertainty, policy-making and interests

In the above two sections I have illustrated three types of uncertainty. I have shown that despite the uncertainties inherent in scientific knowledge, policy decisions still take this knowledge into consideration. Above, Ravetz showed how uncertainty is perceived by those in one scientific field to be something created in another scientific discipline, of which they have little or no knowledge. In contrast to this MacKenzie shows that it is those both close to and distant from the scientific knowledge in question who acknowledge uncertainties, although for different reasons. Meanwhile those who have to make practical use of the scientific knowledge minimise the extent and impact of the uncertainties. This notion of a 'certainty trough' is useful in order to make a connection between uncertainty and the interests embedded in the positions of those involved in decision-making. In this view individual's responses to uncertainty depends on their proximity to or distance from the source of knowledge production and on their need to use that knowledge to make decisions. Positions in turn relate to social hierarchies and interests.

Pinch has pointed out that

> 'most scientists carry with them the notion of a prestige hierarchy of scientific disciplines. One factor related to this hierarchy is judgements as to the confidence to be placed in the knowledge produced by different disciplines.'[29]

These judgements can also be said to be determined by the interests embedded at the different levels of the hierarchy. Extended beyond scientific disciplines, the question arises as to where values, subjective judgements, intuition and emotion are placed. This thesis investigates the embedded interests implicitly entrenched within these hierarchies and positions. By exploring these concepts through contrasting case studies of radioactive waste disposal and endocrine disrupting chemicals I attempt to understand the precautionary principle in action. These case studies allow the multiplicity of science and diversities of uncertainty to emerge and these, in turn, are explored through discussion of disputed evidence, sufficient evidence and definitions of scientific and policy 'problems'.

In relation to these case studies I analyse documents produced for and by specific decision-making fora in addition to interviewing key players in those deliberations. This provides a strong basis for determining the level of uncertainty admitted by different players at different levels. By analysing this data in terms of my pre-established themes of definitions, sufficient evidence and disputed evidence I explore embedded institutional interests. These case studies, discussed in chapters five and six, also suggest that scientists admit to different types of uncertainty according to their audiences,[30] lending further support to MacKenzie's model of the certainty trough.

[29] Pinch, T.J. (1981). The Sun-Set: the presentation of certainty in scientific life. *Social Studies of Science* 11, (1): 131-158. p142

[30] Pinch, T.J. (1981). The Sun-Set: the presentation of certainty in scientific life. *Social Studies of Science* 11, (1): 131-158. p155. See also van Eijndhoven, J. and Groenewegen, P. (1991). The construction of expert advice on health risks. *Social Studies of Science* 21: 257-278. who, in their discussion of experts, state that 'they manage to build an assessment which incorporates within it the social situation for which their advice is being asked.'

The concept of expertise

One of the ways that I demonstrate the connection between uncertainty and the idea of interests is through analysing expertise. The way that uncertainty is dealt with in decision-making is dependent on the different types of expertise involved. This is demonstrated more fully in my empirical chapters where I identify the interests associated with the key players in each process, key players who are considered to have expertise in particular areas either by others and/or by themselves. In this section I look at some of the literature on scientific expertise to identify how it is described and how different researchers use the concept.

Describing a person as an 'expert' gives no clue as to which area their expertise lies in nor does it shed light on the level of expertise that they have. In policy domains the term expert has been appropriated and black-boxed to specify expertise from the academic, government or the commercial sector. These types of expertise may be commissioned for specific purposes and can be acted upon or ignored by those who receive it. Expertise may also be suppressed depending on the power structures involved. Committees of experts may, for instance, be established to advise on specific issues, such as the USEPA EDSTAC[31] committee for advising on the testing and screening of potential endocrine disrupters, or they may be more formal bodies which meet on a regular basis and have long-term strategies such as Advisory Committees for new drugs or food safety.

In this respect it is relevant to note Webster's view that

'[S]ociologists have shown how expert scientists allow their *anticipation* of what is likely to be more widely acceptable to influence the sort of technical judgements they offer those who have commissioned their advice. ... [E]xpertise has more generally been associated with broad ideological positions which favour certain interests over and against others. ... More recently it has been an accusation levelled at expert advisers working ostensibly as independent scientists within government departments or state agencies: this is particularly so of the controversies that have surrounded nuclear power and radioactive waste disposal.'[32]

The implication is that scientific advisors anticipate the political positions of those they advise.[33] Government positions are sometimes easy to discern, as illustrated in the following statement made by the British government about its policy on disposal of radioactive waste in the sea:

"We recommend that the UK should continue to seek to develop realistic international standards for disposal of low and intermediate level waste at sea. We believe that there can be quantitative justification for an increased sea dumping programme and we recommend urgent research to build up a body of knowledge which will demonstrate this."[34]

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[31] United States Environmental Protection Agency Endocrine Disruption Screens and Tests Advisory Committee

[32] Webster, A. (1991). *Science, technology and society*. Basingstoke: Macmillan Press Ltd. p49-50

[33] See van Eijndhoven, J. and Groenewegen, P. (1991). The construction of expert advice on health risks. *Social Studies of Science* 21: 257-278. who, in their discussion of experts, state that 'they manage to build an assessment which incorporates within it the social situation for which their advice is being asked.'

[34] Department of the Environment (1979). *A review of Command Paper 884: the control of radioactive wastes*. London: Department of the Environment. 1979. p118 In: Webster, A. (1991). *Science, technology and society*. Basingstoke: Macmillan Press Ltd. p51

This policy makes it very clear to scientific advisors that sea dumping is considered desirable and that evidence can be provided to justify that position. The position that an alternative to sea dumping may be a preferred option is not up for negotiation. This demonstrates the way in which the political interests of government indirectly shape and reinforce the advice that is obtained from experts.[35] In this case the uncertainties inherent in the option of sea dumping are negated in order to validate a predetermined stance.

In industrialised society policy-makers tend to rely on expert scientific advice since this is regarded as authoritative and is accorded significant weight in government decisions. This is because governments want their decisions to be rational and based on the best advice available. Webster states,

'[T]his presupposes that such advice is free from prejudice or self-interest, an image of science which ... resurrects the Mertonian picture of science as 'disinterested' and 'objective'.'[36]

He goes on to say that sociological research has found expertise to be what he calls

> '*socially contingent*', that is, perceived, evaluated, and rewarded according to the audience and the context in which it appears.'[37]

He states that many case studies have explored scientific controversy and found that what counts as 'good (expert) evidence' or advice depends on the relative *power* of different groups to define some knowledge claims rather than others as more objective

[35] See Barker, A. and Peters, B.G., (eds) (1993). *The politics of expert advice: creating, using and manipulating scientific knowledge for public policy*. Edinburgh: Edinburgh University Press. p10 who say 'the most common use of advice is to legitimate a decision that an organisation wanted to make anyway.'
[36]Webster, A. (1991). *Science, technology and society*. Basingstoke: Macmillan Press Ltd. p48
[37]Webster, A. (1991). *Science, technology and society*. Basingstoke: Macmillan Press Ltd. p49

and so more acceptable[38] and that it therefore comes about that experts will affiliate with interest groups whose collective ethic is in line with their own. Jasanoff says:

> 'In areas of high uncertainty, political interest frequently shapes the presentation of scientific facts and hypotheses to fit different models of "reality".'[39]

This is a key idea that connects the concept of uncertainty in all its manifestations to the interests of those involved in decision-making. Given the aforementioned types of uncertainty, as lack of data, as ignorance and as indeterminacy, Jasanoff is suggesting that interpretations of scientific evidence are not determined by these uncertainties but are significantly filtered by the political interests of the decision-makers who have their own paradigms and realities.[40] In this thesis I extend the notion of interests beyond the political to those that are more broadly socially determined in addition to those that arise through institutional affiliations and regulatory obligations (which are in themselves socially determined). In the following section I introduce the interests approach of the Edinburgh School, and explore its potential and relevance for understanding the links between expertise and uncertainty.

The Interests Approach

Much debate about the precautionary principle focuses on scientific uncertainty and on how much scientific evidence is necessary before action should be taken to protect

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[38] For example, see Nelkin, D. (1979). *Controversy: the politics of technical decisions.* New York: Sage.
[39] Jasanoff, S. (1987). Contested boundaries in policy-relevant science. *Social Studies of Science* 17, (12): 195-230.195-230
[40] This is echoed by Gillespie *et al* who describe a situation where the US and UK governments reached contradictory conclusions to the same problem on the basis of the same scientific evidence: Gillespie,

the environment. The sociology of scientific knowledge provides tools for analysing the uses of science and its development and application. Interests theory helps explain the way in which scientific uncertainty is managed and manipulated by decision-makers. It sheds light on the way that decision-making processes are constructed and helps draw out the point that scientific uncertainty underpins discussions about definitions, sufficient evidence and disputed evidence without necessarily being explicitly named.

I now review and locate the interests approach within the wider disciplinary framework of the sociology of knowledge. Since Webster has produced a comprehensive review of the developments within the sociology of science I draw on his work in this section.[41] Subsequently I discuss empirical research that has been carried out using the interests approach, focussing on work by Bloor and by Collins. This is followed by a review of critiques of the interests approach, especially those provided by Woolgar. Finally, I construct an argument for why, despite the critiques of the approach, I still find the interests approach to provide an appropriate theoretical framework for analysing the operation of the precautionary principle with respect to radioactive waste disposal and endocrine disrupting chemicals.

As will become clear, my contribution to theoretical knowledge lies in the application of interests theory to a new case i.e. the precautionary principle, rather than in the theoretical development of this position *per se*.

B., Eva, D., and Johnston, R. (1979). Carcinogenic risk assessment in the United States and Great Britain: The case of Aldrin/Dieldrin. *Social Studies of Science* 9: 265-302.
[41] Webster, A. (1991). *Science, technology and society*. Basingstoke: Macmillan Press Ltd.

Interests in context

In 1949, American sociologist Robert Merton argued that there were four *norms* in science (universalism, communality, organised scepticism and disinterestedness) that together function to produce objective scientific knowledge.[42] Although he proposed that this is *how* scientists behave he did not explain *why* they do so. Other sociologists challenged Merton's notion of a 'scientific community' conforming to a 'scientific ethos'. In 1976 Mulkay reasoned that Merton's 'norms' were actually 'vocabularies of justification' used by scientists to justify their particular behaviour in particular contexts.[43] Additionally he claimed that scientists are rewarded according to what other scientists find useful, and that this in turn varies according to the long-term and short-term interests of researchers, their financial circumstances and government and commercial attitudes.

Bourdieu also challenged the notion that scientific knowledge is based on a set of norms. In 1975 he wrote,

> "The market in scientific goods has its laws and they are nothing to do with ethics or norms ... Claims of legitimacy [of ideas] draw their legitimacy from the relative strength of the group whose interests they express".[44]

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[42] See Merton, R.K. (1968). *Social theory and social structure*. New York: Free Press.
[43] Mulkay, M.J. (1976). Norms and ideology in science. *Social Science Information* 15, (4): 637-656. reproduced in Mulkay, M. (1991). Norms and ideology. In, Mulkay, M., (ed)., *Sociology of science: a sociological pilgrimage*. Milton Keynes: Open University Press. p77
[44] Bourdieu, P. (1975). The specificity of the scientific field and the social conditions of the progress of reason. *Social Science Information* 14: 19-47. 19-47, quoted in Webster, A. (1991). *Science, technology and society*. Basingstoke: Macmillan Press Ltd. p8

This supposes that some scientists will have favourable recognition which is independent of the quality of their research, based more on the recognition afforded them by their previous research and the institution to which they belong. This can be described as a credibility cycle where more prominent researchers' work is recognised more readily and afforded more status than those researchers whose credibility has yet to be established.

The theme of scientific interests was further developed in the 1970s and 1980s through an academic focus on controversy in science, examples of which are provided by Barnes and MacKenzie[45] and Shapin[46] and are discussed later in this chapter.[47]

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[45]Barnes, B. and MacKenzie, D. (1979). On the role on interests in scientific change. In, Wallis, R., (ed)., *On the margins of science: the social construction of rejected knowledge*:49-66. Keele, Staffs: University of Keele.

[46]Shapin, S. (1979). The politics of observation: cerebral anatomy and social interests in the Edinburgh phrenology disputes. In, Wallis, R., (ed)., *On the margins of science: the social construction of rejected knowledge*:139-178. Keele, Staffs: University of Keele.

[47] Other examples include: Crenson, M.A. (1971). *The un-politics of air pollution: a study of non-decisionmaking in the cities*. Baltimore, MD: The John Hopkins Press.; Habermas, J. (1971). *Knowledge and human interests*. Boston: Beacon Press.; Barnes, B. (1974). *Scientific knowledge and sociological theory*. London: Routledge and Kegan Paul.; Wynne, B. (1976). C.G Barkla and the J Phenomenon: a case study in the treatment of deviance in physics. *Social Studies of Science* 6, (3&4): 307-347.; Barnes, B. (1977). *Interests and the growth of knowledge*. London: Routledge and Kegan Paul.; MacKenzie, D. (1978). Statistical theory and social interests. *Social Studies of Science* 8: 35-83.; Barnes, B. and Shapin, S., (eds) (1979). *Natural Order: historical studies of scientific culture*. Beverly Hills and London: Sage Publications Ltd.; Dean, J. (1979). Controversy over classification: a case study from the history of botany. In, Barnes, B. and Shapin, S., (eds), *Natural Order: historical studies of scientific culture*:210-230. Beverly Hills and London: Sage Publications Ltd.; Parssinen, T.M. (1979). Professional deviants and the history of medicine: medical mesmerists in Victorian Britain. In, Wallis, R., (ed)., *On the margins of science: the social construction of rejected knowledge*:103-120. Keele, Staffs: University of Keele.; MacKenzie, D. and Barnes, B. (1979). Scientific Judgement: the Biometry - Mendelism controversy. In, Barnes, B. and Shapin, S., (eds), *Natural Order: historical studies of scientific culture*:191-210. Beverly Hills and London: Sage Publications Ltd.; Pinch, T.J. (1981). The Sun-Set: the presentation of certainty in scientific life. *Social Studies of Science* 11, (1): 131-158.; Collins, H.M. (1981). Knowledge and controversy: studies of modern natural science. *Social Studies of Science* 11, (1 special issue): 158.
Collins, H.M. (1983). An empirical relativist programme in the sociology of scientific knowledge. In, Knorr-Cetina, K.D. and Mulkay, M., (eds), *Science observed: perspectives on the social study of science*:85-113. London: Sage Publications Ltd.
Collins, H.M. (1985). *Changing Order*. London: Sage.; Pickering, A. (1982). Interests and analogies. In, Barnes, B. and Edge, D., (eds), *Science in context: readings in the sociology of science*:125-146. Milton Keynes: The Open University Press.; Shapin, S. (1988). Following scientists around. *Social Studies of Science* 18: 533-550.;

This work showed how scientific knowledge was dependent on negotiation and debate between interested parties: practitioners of science and 'lay' people.[48]

To give just one example, Dorothy Nelkin has written on the theme of controversy and she has shown how publicly controversial issues involve participants in claims and counter-claims that cannot be easily resolved by an appeal to the 'evidence', since there may be no consensus on what the 'facts' are. She writes,

> "In all disputes broad areas of uncertainty are open to conflicting scientific interpretation. Decisions are often made in a context of limited knowledge about potential social or environmental impacts and there is seldom conclusive evidence to reach definitive resolution. Thus power hinges on the ability to manipulate knowledge to challenge the evidence presented to support particular policies, and technical expertise becomes a resource exploited by all parties to justify their political and economic views."[49]

Empirical analyses of scientific controversies have since underlined the point that uncertainties are embedded in scientific knowledge and that these uncertainties mirror the interests of those both constructing and interpreting that knowledge. Arguments about the socially constructed nature of knowledge and the interests attached to it are central to understanding how the precautionary principle can be/is being applied in the UK. Recognition of these continually constructed systems of ideas and the interests of

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[48]Webster, A. (1991). *Science, technology and society*. Basingstoke: Macmillan Press Ltd. p11

[49]Nelkin, D. (1979). *Controversy: the politics of technical decisions*. New York: Sage. p16, quoted in Webster, A. (1991). *Science, technology and society*. Basingstoke: Macmillan Press Ltd. p12. Also on the theme of controversy Rip, A. (1985). Experts in public arenas. In, Otway, H. and Peltu, M., (eds), *Regulating industrial risks: science, hazards and public protection*:94-110. London: Butterworths. p102-103 talks about 'the myth of consensual objectivity.'

relevant decision-makers is central to understanding how the value of precaution is or is not being incorporated into decision-making.

The following section introduces the interests approach of the Edinburgh School and illustrates the interpretation and use of interests theory with reference to a number of empirical studies. The aim is to show how the interests approach has helped elucidate the dynamics of scientific controversy.

Interests theory

Based on ideas from sociologists at Edinburgh University the interests approach maintains that scientists' knowledge-claims will embody or be informed by certain social or political interests.[50] This is a sub-set of what is known as the Edinburgh School. Shapin,[51] and Barnes and MacKenzie[52] provide some of the more detailed empirical illustrations of the interests approach and I discuss their work in more detail later in this chapter.

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[50]Webster, A. (1991). *Science, technology and society*. Basingstoke: Macmillan Press Ltd. p16
[51] Shapin, S. (1984). Talking history: reflections of DA. *Isis* 75, (276): 125-130.
Shapin, S. (1979). The politics of observation: cerebral anatomy and social interests in the Edinburgh phrenology disputes. In, Wallis, R., (ed)., *On the margins of science: the social construction of rejected knowledge*:139-178. Keele, Staffs: University of Keele.
[52]Barnes, B., (ed). (1972). *Sociology of science*. Harmondsworth: Penguin Books Ltd.
Barnes, B. (1974). *Scientific knowledge and sociological theory*. London: Routledge and Kegan Paul.
Barnes, B. (1977). *Interests and the growth of knowledge*. London: Routledge and Kegan Paul.
Barnes, B. and MacKenzie, D. (1979). On the role on interests in scientific change. In, Wallis, R., (ed)., *On the margins of science: the social construction of rejected knowledge*:49-66. Keele, Staffs: University of Keele.; MacKenzie, D. (1978). Statistical theory and social interests. *Social Studies of Science* 8: 35-83.
MacKenzie, D. and Barnes, B. (1979). Scientific Judgement: the Biometry - Mendelism controversy. In, Barnes, B. and Shapin, S., (eds), *Natural Order: historical studies of scientific culture*:191-210. Beverly Hills and London: Sage Publications Ltd.

The interests approach to scientific knowledge is associated with the 'strong programme'[53] in the sociology of scientific knowledge due to the fact that it adopts a strongly relativist position indicating that scientific knowledge is itself open to sociological analysis. Exemplifying this position, Bloor challenged the position of sociologists as solely looking at the 'sociology of error', claiming that, regardless of whether science produced what was labelled as 'true' or 'false' knowledge, sociologists should aim to understand how that knowledge is produced. Woolgar tells us that Bloor

> '...complained that the insistence of rationalist philosophy on the inherently (given) true or false character of knowledge was directly opposed to attempts to study the social determination of 'truth' and 'falsehood'.'[54]

According to Woolgar, Bloor's position is that rationalism only addresses whether knowledge can be regarded as true or false in a reasoned way without addressing *why* some knowledges come to be accepted as true and some as false. Bloor believes that the social construction of these knowledges also need to be analysed.

Those embracing this position believe it is possible to show how social interests are embedded within the very construction and defence of knowledge-claims, and how these social interests determine just which ideas get adopted as 'science' and which are discarded.[55] Social interests can stem from political and institutional affiliations as well as from more personal and community-based customs. The idea of social and

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[53] Bloor, D. (1976). *Knowledge and Social Imagery*. London, Henley and Boston: Routledge and Kegan Paul.; Woolgar, S. (1981). Interests and explanation in the social study of science. *Social Studies of Science* 11: 365-394.; Rose, H. (1985). Hand, Brain and Heart: a feminist epistemology for the natural sciences. *Signs: Journal of women in culture and society* 9, (1): 73-91.

[54] Woolgar, S. (1993). *Science: the very idea*. London: Routledge. p42

institutional interests are not discrete in a relativist context since all interests can be said to be constructed by social arrangements which form and shape the pattern of those interests.

Assuming that knowledge is a result of consensus amongst individuals, the next step is to identify what influences those individuals' positions. Bloor identifies four tenets that he argues must be present in the sociologist's thoughts in order to understand how knowledge is produced:

> '... causality, impartiality, symmetry and reflexivity [which] define what will be called the strong programme in the sociology of knowledge.'[56]

Bloor challenges the received status which causality is afforded in analytical philosophy. He argues that it is not enough to look for causes to explain error and falsehood but that causes should also be identified to explain accuracy and truth. He states that

> 'They all divide behaviour or belief into two types: right and wrong, true or false, rational or irrational. They then invoke causes to explain the negative side of the division. Causes explain error, limitation and deviation. The positive side of the evaluative divide is quite different. Here, logic, rationality and truth appear to be their own explanation. Here causes do not need to be invoked.'[57]

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[55]Webster, A. (1991). *Science, technology and society*. Basingstoke: Macmillan Press Ltd. p19
[56]Bloor, D. (1976). *Knowledge and Social Imagery*. London, Henley and Boston: Routledge and Kegan Paul. p5
[57]Bloor, D. (1976). *Knowledge and Social Imagery*. London, Henley and Boston: Routledge and Kegan Paul. p6

Bloor concludes that if this teleological model is true then the strong programme is false because they are two opposed metaphysical standpoints.[58] He qualifies this by saying that

> '...it is unlikely that any decisive, independent grounds could be adduced 'a priori' to prove the truth or falsity of such major metaphysical alternatives. ... All that can be done is to check the internal consistency of the different theories and then see what happens when practical research and theorising is based upon them.'[59]

His point here is that the two distinct theoretical positions that causality should be invoked to explain both truth and falsehood (Bloor's proposition) and the opposite that truth is given and that causality should be invoked to explain only falsehood can only be investigated through empirical studies and not solely deduced through reasoning. He points out that if, through this process, the teleological model is consequently rejected then all its associated distinctions, evaluations and asymmetries go with it. The empiricist take on knowledge asserts that the only source of knowledge is experience.[60] Bloor also rejects this. He asks

> 'Does not individual experience, as a matter of fact, take place within a framework of assumptions, standards, purposes and meanings which are shared?'

And continues

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[58]Bloor, D. (1976). *Knowledge and Social Imagery*. London, Henley and Boston: Routledge and Kegan Paul. p9
[59]Bloor, D. (1976). *Knowledge and Social Imagery*. London, Henley and Boston: Routledge and Kegan Paul. p9
[60]Bloor, D. (1976). *Knowledge and Social Imagery*. London, Henley and Boston: Routledge and Kegan Paul. p12

> 'Society furnishes the mind of the individual with these things and also provides the conditions whereby they can be sustained and reinforced. If the individual's grasp of them wavers, there are agencies ready to remind him; if his view of the world begins to deviate there are mechanisms which encourage realignment.'[61]

Bloor argues that an individual's views are always shaped and enforced by the 'society' s/he is part of. Bloor asserts that what is considered 'scientific knowledge' is predominantly 'theoretical' and that theories give meaning to experience by offering a story about what underlies, connects and accounts for that experience.[62] In other words theories of scientific knowledge are created in order to make sense of what is experienced by the individual. In this way, experience, knowledge and interests are inter-linked.

Bloor was one of the original advocates of the interests approach and the above brief account has been important in order to illustrate his ideas about the social construction of scientific knowledge.[63] Bloor refutes the notion of a natural or given 'truth' in favour of the notion that knowledge is constructed from external stimuli and that interests, both institutional and disciplinary, play a role in that construction.

In the following section I review some of the literature that applied interests theory to the analysis of empirical studies.

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[61]Bloor, D. (1976). *Knowledge and Social Imagery*. London, Henley and Boston: Routledge and Kegan Paul. p12

[62]Bloor, D. (1976). *Knowledge and Social Imagery*. London, Henley and Boston: Routledge and Kegan Paul. p12

[63] For other examples of work that assumes the social construction of scientific knowledge see Campbell, B.L. (1985). Uncertainty as symbolic action in disputes among experts. *Social Studies of Science* 15: 429-453.; Michael, M. (1996). *Constructing Identities*. London: Sage Publications Ltd. Thompson, M., Ellis, R., and Wildavsky, A. (1990). *Cultural theory*. Oxford: Westview Press.

Interests theory in action

Collins, who is a social realist, is also an advocate of the interests approach and has focused his empirical studies on the 'core-set' of scientists who are involved in particular controversies.[64] The core-sets studied include those individuals who form the small expert elite group lying at the heart of any scientific speciality and who typically hold prestigious academic and research positions.[65] Collins has demonstrated that it is they who play the principal role in determining the outcome of scientific debate.[66] Collins shows how in practice a consensus over scientific knowledge-claims only emerges by way of negotiation and debate.[67] He claims that science *can* only make perceptible 'progress' precisely because its practitioners draw on a wide range of socio-technical strategies to produce an ultimate consensus out of controversy.[68]

This does not mean focussing only on agreement. The interests approach can also look beyond internal scientific debates to debates over scientific 'expertise' in public settings such as public inquiries. As Webster puts it

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[64] Collins, H.M. (1981). Knowledge and controversy: studies of modern natural science. *Social Studies of Science* 11, (1 special issue): 158.; Collins, H.M. (1983). An empirical relativist programme in the sociology of scientific knowledge. In, Knorr-Cetina, K.D. and Mulkay, M., (eds), *Science observed: perspectives on the social study of science*:85-113. London: Sage Publications Ltd.; Collins, H.M. (1985). *Changing Order*. London: Sage.
[65] Webster, A. (1991). *Science, technology and society*. Basingstoke: Macmillan Press Ltd. p20
[66] Collins, H.M. (1981). Knowledge and controversy: studies of modern natural science. *Social Studies of Science* 11, (1 special issue): 158. and Collins, H.M. (1983). An empirical relativist programme in the sociology of scientific knowledge. In, Knorr-Cetina, K.D. and Mulkay, M., (eds), *Science observed: perspectives on the social study of science*:85-113. London: Sage Publications Ltd., cited in Webster, A. (1991). *Science, technology and society*. Basingstoke: Macmillan Press Ltd. p20
[67] Collins, H.M. (1985). *Changing Order*. London: Sage. It is this idea that I exploit in order to show the interests at play in controversial decision-making processes about radioactive waste disposal and endocrine disrupting chemicals.
[68] Webster, A. (1991). *Science, technology and society*. Basingstoke: Macmillan Press Ltd. p20

'core-sets not only involve 'allies' but also 'enemies' who contest their claims.'[69]

Those involved in the core-set are not necessarily all in agreement. This is particularly the case when there is still controversy about the scientific knowledge in question. Situations such as public inquiries arguably represent moments when the knowledge of those included in the core-set is open to question. This raises the ambiguous nature of 'science policy'. The term science policy is used to mean two distinct things. On the one hand it is used to describe policy regulating scientific practice and endeavour while conversely it is also used to describe the use of scientific knowledge as a basis for policy decisions. The interests approach is primarily concerned with the latter, the use of scientific knowledge as the basis for making policy decisions.

In public inquiries as in other situations the key question is how negotiation is ended in practice and how closure of debate and scientific consensus comes about.[70] This is important in terms of policy making since the scientific knowledge on which policy is based is a product of social determination and interests. Subscribers to the interests approach believe they can show how scientists' investment in certain ideas, their use of cognitive and social resources to advance those ideas and the network of relationships they have with power-brokers or decision-makers in the wider society are all implicated in the eventual closure of scientific debate.[71] This is an explanation that I exploit in my empirical research. I show, in the following empirical chapters, how the interests of those involved in making decisions about radioactive waste

[69]Webster, A. (1991). *Science, technology and society*. Basingstoke: Macmillan Press Ltd. p21
[70]Webster, A. (1991). *Science, technology and society*. Basingstoke: Macmillan Press Ltd. p30-31

disposal and endocrine disrupting chemicals are instructive in determining the terms of the decision-making process as well as its outcome.

I now introduce some of the relevant empirical uses of the interests approach within the sociology of scientific knowledge. I focus particularly on work by Collins,[72] Shapin[73] and Barnes and MacKenzie[74] as they provide examples of early uses of interests theory.

In their paper 'On the role of interests in scientific change' Barnes and MacKenzie[75] distinguish between instrumental interests and social interests. They say that it is plausible to hypothesise that when a sub-culture evaluates knowledge the process should be understood to some extent in terms of the goal-orientated character of its thought and activity, rather that in a totally abstract contemplative way. It is this goal-oriented-ness which they refer to as 'instrumental interests'. They claim that scientific paradigms are evaluated against each other in relation to some set of context-dependent (situated) instrumental interests.

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[71]Shapin, S. (1984). Talking history: reflections of DA. *Isis* 75, (276): 125-130.125-128, cited in: Webster, A. (1991). *Science, technology and society*. Basingstoke: Macmillan Press Ltd. p31

[72] Collins, H.M. (1983). An empirical relativist programme in the sociology of scientific knowledge. In, Knorr-Cetina, K.D. and Mulkay, M., (eds), *Science observed: perspectives on the social study of science*:85-113. London: Sage Publications Ltd.

[73] Shapin, S. (1979). The politics of observation: cerebral anatomy and social interests in the Edinburgh phrenology disputes. In, Wallis, R., (ed)., *On the margins of science: the social construction of rejected knowledge*:139-178. Keele, Staffs: University of Keele.

[74] Barnes, B. and MacKenzie, D. (1979). On the role on interests in scientific change. In, Wallis, R., (ed)., *On the margins of science: the social construction of rejected knowledge*:49-66. Keele, Staffs: University of Keele.

[75]Barnes, B. and MacKenzie, D. (1979). On the role on interests in scientific change. In, Wallis, R., (ed)., *On the margins of science: the social construction of rejected knowledge*:49-66. Keele, Staffs: University of Keele.

'Where scientists disagree in their choice of paradigms one should hence check whether they do not differ also in the instrumental interests which pre-structure their evaluations.'[76]

They go on to claim that instrumental interests are generally related to a set of, what they describe as, social interests which they define as the consequence of the ongoing activity of a group of scientific specialists.[77] These social interests, they state, modulate conceptions of what counts as prediction or problem solution which partially define the situated instrumental knowledge-constituting interests of the scientists.

Barnes and MacKenzie go on to state that the instrumental interests that inform scientific evaluation need not be related solely to those social interests that are internal to science:

'They may relate to more general social interests, either directly, or indirectly in the sense that the social interests of some esoteric scientific sub-culture may themselves be expressions of more general social interests. ... What we wish to show is that opposed paradigms and hence opposed evaluations may be sustained, and probably are in general sustained, by divergent sets of instrumental interests usually related in turn to divergent social interests.'[78]

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[76]Barnes, B. and MacKenzie, D. (1979). On the role on interests in scientific change. In, Wallis, R., (ed)., *On the margins of science: the social construction of rejected knowledge*:49-66. Keele, Staffs: University of Keele. p52
[77]Barnes, B. and MacKenzie, D. (1979). On the role on interests in scientific change. In, Wallis, R., (ed)., *On the margins of science: the social construction of rejected knowledge*:49-66. Keele, Staffs: University of Keele. p53
[78]Barnes, B. and MacKenzie, D. (1979). On the role on interests in scientific change. In, Wallis, R., (ed)., *On the margins of science: the social construction of rejected knowledge*:49-66. Keele, Staffs: University of Keele. p54

The key point here is that the instrumental interests at play within a particular discipline may relate specifically to the social interests of that disciplinary culture or they may relate more broadly to the interests of a larger culture or society.

Barnes and MacKenzie make these points with reference to a controversy within the small community of British statisticians early in the twentieth century over the measurement of association. The controversy centred on the merits of two alternative kinds of solution to the association problem, those of Karl Pearson and those of George Udny Yule. Barnes and MacKenzie claim that Yule's evaluation of measures of association was pre-structured by an instrumental interest in nominal data as distinct separate phenomena whilst Pearson's evaluation of measures was pre-structured by an instrumental interest in prediction and technical control defined by existing work on interval data.[79] This polarisation of their instrumental interests continued, and they and their followers remained in a state of controversy for many years. Pearson and Yule had started from a position of shared assumptions, meanings and competences – Yule having been a student of Pearson – but their positions diverged. In seeking to understand why that divergence occurred Barnes and MacKenzie claim that

> '... the most likely answer would seem to be that it was generated and sustained by contrasting social interests.'[80]

These social interests were identified with the 'biometric school'[81] on the part of Pearson, whose work built the characteristic hereditarian assumptions of eugenics into

[79]See Barnes, B. and MacKenzie, D. (1979). On the role on interests in scientific change. In, Wallis, R., (ed)., *On the margins of science: the social construction of rejected knowledge*:49-66. Keele, Staffs: University of Keele. p55-60 for a full description of this controversy.

its basic structure and circumvented any systematic consideration of the influence of environment on the phenomena he studied.[82] In contrast, Yule's work indicated no concern with eugenics and his ideas on association were developed in connection with vaccination and its efficacy.[83] This distinction might have been explained in terms of disciplinary interests except that both men started from the same disciplinary backgrounds and so both understood the underlying paradigms within that discipline. It was their social interests that caused their controversy to remain unresolved.

Having illustrated instrumental and social interests Barnes and MacKenzie conclude that controversy cannot be explained solely in terms of disciplinary paradigms because controversies may still evolve even when the disciplines are shared. Social interests offer a partial explanation for the difference in position taken by the different players.

In his paper, 'The Politics of Observation', Shapin analyses disputes over the validity of phrenology[84] in Edinburgh in the 1800s with particular focus on the two main

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[80]Barnes, B. and MacKenzie, D. (1979). On the role on interests in scientific change. In, Wallis, R., (ed)., *On the margins of science: the social construction of rejected knowledge*:49-66. Keele, Staffs: University of Keele. p59

[81]Biometry is the application of statistical analysis to biological data and this school was dominated by Karl Pearson and based upon the biometric and eugenic laboratories at University College London. See Barnes, B. and MacKenzie, D. (1979). On the role on interests in scientific change. In, Wallis, R., (ed)., *On the margins of science: the social construction of rejected knowledge*:49-66. Keele, Staffs: University of Keele. p59

[82]Barnes, B. and MacKenzie, D. (1979). On the role on interests in scientific change. In, Wallis, R., (ed)., *On the margins of science: the social construction of rejected knowledge*:49-66. Keele, Staffs: University of Keele. p60

[83]Barnes, B. and MacKenzie, D. (1979). On the role on interests in scientific change. In, Wallis, R., (ed)., *On the margins of science: the social construction of rejected knowledge*:49-66. Keele, Staffs: University of Keele. p61-62

[84] Phrenology is the study of the shape and size of the cranium as a supposed indication of character and mental faculties. Pearsall, J. and Trumble, B., (eds) (1996). *The Oxford English Reference Dictionary*. Oxford: Oxford University Press. p1094

proponents, Gall and Spurzheim.[85] His argument is that social interests act upon knowledge in ways rather different from those usually assumed and that they may therefore have a more pervasive influence on knowledge. He states that

> 'In the Edinburgh disputes over phrenology, as in most other scientific contexts, a participant could hope to discredit the knowledge of his opponent by detecting the presence of social interests in it. Where the effect of social interests on knowledge is held to be corrupting, the display of the presence of such interests in knowledge seems a sound strategic move. ... Each party's reaction may then well be to produce accounts in which it becomes more and more difficult for its opponents to expose interests'.

Strategically, there may be advantages to be gained from detecting the presence of social interests in an opponent's position if the presence of such interests is considered to be a corruption of scientific knowledge. If this is the case players will be motivated to disguise their interests in order that their accounts appear to be more objective. Shapin suggests that this may be a reason why interests are so embedded and difficult to identify. He is not suggesting that it be inferred from the absence of apparent interests that they are really present, but he is introducing the notion that it may be the operation of such interests which brings about their very invisibility.[86] This notion of discrediting opposing knowledge is important in understanding the application of the precautionary principle. I show in my empirical chapters on radioactive waste disposal and endocrine disrupting chemicals the tactics and methods employed by

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[85] Shapin, S. (1979). The politics of observation: cerebral anatomy and social interests in the Edinburgh phrenology disputes. In, Wallis, R., (ed)., *On the margins of science: the social construction of rejected knowledge*:139-178. Keele, Staffs: University of Keele.

opposing groups to bring the discussion around to their point of view and the attempts they make, often by rhetorical appeal, to make their interests invisible. Additionally I reveal the often hidden and embedded interests associated with these viewpoints.

In summing up, Shapin suggests that it is often easier to detect explicit interests regarding new and especially deviant bodies of knowledge, and that it is harder to do so for institutionalised established fields. In accord with Bloor he says

> 'Indeed, there is some evidence that this is what is developing in the social history of science: a sociology of error, of deviance and of rejected knowledge but not, as yet, much in the way of a sociology of 'truth'.'[87]

He is saying that evidence can be found that a sociology of error exists where interests are identified to explain deviance from 'truth' but that 'truth' itself is accepted without recourse to explanational causal factors. He wants to work towards such a sociology of 'truth' which means questioning how accepted scientific knowledge comes to be accepted because focusing on a sociology of error is inadequate. This is important for my analysis as it is a focus on the way in which controversy is resolved or at least the way in which attempts are made to resolve controversy that I analyse in order to uncover the factors involved in decision-making about environmental problems. Focusing on error is not adequate for my analysis since some of the issues have been agreed upon, at least within certain disciplines and institutions. Focusing on how those agreements have been reached and what is left to be resolved and the individuals

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[86]Shapin, S. (1979). The politics of observation: cerebral anatomy and social interests in the Edinburgh phrenology disputes. In, Wallis, R., (ed)., *On the margins of science: the social construction of rejected knowledge*:139-178. Keele, Staffs: University of Keele. p140

involved in reaching those agreements is what is relevant to an understanding of the implementation of the precautionary principle.

To conclude Shapin asserts that

> 'Science does not guarantee its growth towards esoteric naturalism by systematically immunising itself from the action of social interests. Rather, it may be the action of conflicting social interests, and actors' ability to assign ideological concerns to knowledge claims, which provide a significant push towards the development of increasingly naturalistic forms. ... Hence, social conflict and ideological considerations may be seen as an important element in the development of bodies of knowledge valued as 'interest-free', rather than as a feature of the environment which retards such development.'[88]

Shapin is saying that it is the very existence of conflicting social interests that help bring about an image of scientific knowledge as 'interest-free' and that helps produce the illusion of the objectivity of science. Though a plausible claim, this presents practical problems for empirical analysis. There are, however, other more theoretical difficulties associated with the interests approach. Some of these are reviewed below.

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[87] Shapin, S. (1979). The politics of observation: cerebral anatomy and social interests in the Edinburgh phrenology disputes. In, Wallis, R., (ed)., *On the margins of science: the social construction of rejected knowledge*:139-178. Keele, Staffs: University of Keele. p171

[88] Shapin, S. (1979). The politics of observation: cerebral anatomy and social interests in the Edinburgh phrenology disputes. In, Wallis, R., (ed)., *On the margins of science: the social construction of rejected knowledge*:139-178. Keele, Staffs: University of Keele. p171

Critics of interests theory

Interests theory is not without its critics. Of these, Steve Woolgar has been especially vocal and eloquent. One of his main points is that it claims that the content of science should be amenable to social study[89] yet he argues that attempts to 'identify' interests neglect important features of scientific practice. He is uncertain about the precise form of empirical work that could be said adequately to follow the strong programme[90] implying that it is conceptually flawed if a research method can not be identified. Woolgar is particularly concerned about which specific aspects of the social are to be studied and how they can be incorporated into an understanding of the mechanisms of knowledge generation.[91] He states that

> 'In the writing of those who recommend interests explanations there is a recurrent appeal to the need for a 'naturalistic' approach to the social study of science. Indeed, the notion of naturalistic inquiry goes hand in hand with the idea of explaining scientific action in terms of interests. This suggests that an examination of the use of the concept of 'naturalism' is prerequisite to an appreciation of some of the deficiencies of interests explanation.'[92]

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[89] Woolgar, S. (1981). Interests and explanation in the social study of science. *Social Studies of Science* 11: 365-394.
Woolgar, S. (1988). *Science: the very idea*. Chichester: Ellis Horwood.
[90] Woolgar, S. (1981). Interests and explanation in the social study of science. *Social Studies of Science* 11: 365-394. p365
[91] Woolgar, S. (1981). Interests and explanation in the social study of science. *Social Studies of Science* 11: 365-394. p366
[92] Woolgar, S. (1981). Interests and explanation in the social study of science. *Social Studies of Science* 11: 365-394. p367

Woolgar provides a critique of Barnes' use of 'naturalism' maintaining that the concept is never explicated or clearly defined in Barnes' work.[93] He states that this confusion over the use of 'naturalism' extends to the invocation of interests as a primary explanatory resource. His understanding of how the strong programme employs the notion of interests is that interests are regarded as an explanatory resource whose existence is taken for granted and which is separate and distinct from the scientific content they are said to explain. My own view is that this is not a good interpretation of what interests theory is about. I agree that interests are invoked as an explanatory resource, indeed this is exactly what advocates of the interests approach are trying to do. By attempting to uncover the interests at stake, advocates of the approach are attempting to deconstruct controversy and consensus. However, as has been shown in the previous section, there are different types of interests at play and some of them are intricately linked to the content of the scientific knowledge being scrutinised whilst others are dependent on wider social ideologies and the uses to which scientific knowledge is put. Thus, we can use interests whilst not reifying them.

Woolgar claims that

> 'Interests can be used to *explain* knowledge generation. This is not to suggest that the scope of the game is restricted to simple causal determination ... This means that interests can be shown to *influence* rather than determine knowledge production, or that

[93]Woolgar, S. (1981). Interests and explanation in the social study of science. *Social Studies of Science* 11: 365-394. p367-368

particular scientific episodes can be better understood *in the light of* the particular interests of the involved parties...'[94]

He points out that users of the interests approach frequently play down arguments about causality. He says

> 'To say, for example, that a discussion of interests 'helps to shed light on' a particular series of scientific actions is significantly different from saying that these actions 'resulted from' or 'were caused by' these interests.'[95]

Having explained his understanding of what the interests approach means he then demonstrates how it is used:

> 'The general strategy is to reveal interests as a kind of backcloth of attendant circumstances, and to imply that this revelation throws into better perspective the knowledge claim or event which is at issue. In its weakest form the job can be managed merely by juxtaposing, in the same report, the knowledge event and the revealed circumstances, preferably with cautious caveats about the difficulty of speculating on the precise causal mechanisms at work.'[96]

Woolgar's main criticisms are that invoking interests is not sufficient to adequately explain how knowledge production is determined and that at its most significant level interests can only hope to shed light on the knowledge claim in question rather than explain it. He criticises users of interests theory for simply juxtaposing what is

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[94]Woolgar, S. (1981). Interests and explanation in the social study of science. *Social Studies of Science* 11: 365-394. p369

[95]Woolgar, S. (1981). Interests and explanation in the social study of science. *Social Studies of Science* 11: 365-394. p387

determined as knowledge with some interests that they associate with the determination of that knowledge whilst simultaneously giving careful explanations as to why interests may not be adequate to explain the causality of knowledge production.

Woolgar elaborates on the problematic of the assumed existence of interests in constructing explanation. He is concerned that if knowledge can always in principle be explained by recourse to the interests of the actors involved then those interests can eventually be discovered and hence an explanation of the knowledge will be found. Central to Woolgar's critique of Barnes' use of interests is his desire for greater reflective attention to be given to the *explanatory form* of interests explanations.[97] The key point here is that Woolgar wants the user of interests theory to be more reflexive about the interpretation they, as researcher, place on the knowledge they examine in order to demonstrate their awareness of their role as the constructor of the explanation for the knowledge event being evaluated.

Woolgar states that the interests approach is simply an 'alternative construction' to a deficient philosophical model that portrays scientists as 'rationality-dopes'. He contends that

> 'To replace one by the other misses at least two important questions: what counts as legitimate construction in practical

[96]Woolgar, S. (1981). Interests and explanation in the social study of science. *Social Studies of Science* 11: 365-394. p369-370

[97]Woolgar, S. (1981). Interests and explanation in the social study of science. *Social Studies of Science* 11: 365-394. p373, Woolgar's emphasis.

argument; and what counts as adequate grounds for substitution of one construction for another?'[98]

This is an important criticism as it identifies the difficulties involved in replacing one theoretical explanation with another without addressing the underlying question of whether the new theoretical explanation is more legitimate than the first.

A further criticism by Woolgar is that

> 'Proponents of the interests model obviously begin with some notion of the nature and variety of desires they will 'identify'. ... my point is ... that it is clear that a very large (if not infinite) number of alternative desires is in principle discernible; the selection and construction of a set of desires from the number potentially available thus involves complex argumentative work.'

This is a key point, as the approach itself provides no criteria for identifying relevant interests, values and desires. It is difficult therefore to determine which interests are indeed in play and it may indeed be the inclinations and biases of the researcher that define what they are. However, to contextualise this is important as, without necessarily assuming the pre-existence of interests, it is possible to observe that individuals and organisations all operate within social spheres which, through regulations and legislation, impact on the manner in which they behave. Since regulations and legislation reflect shared cultural norms it is misleading to suggest that it is solely the researcher who identifies underlying desires and interests. Collective convention attributes desires and interests to particular individuals and organisations in specific circumstances. Interests theory recognises what some of these interests are

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[98]Woolgar, S. (1981). Interests and explanation in the social study of science. *Social Studies of Science*

and uses them to attempt to understand the nature of negotiation and consensus forming in decision-making.

Woolgar concludes by claiming that the methodological difficulties inherent in using the interests approach have been backgrounded, minimised and otherwise made to seem inconsequential by the use of various rhetorical and argumentative strategies and recommends that a more reflexive approach to methodology is undertaken.[99] He argues that proponents and opponents of the strong programme draw upon preconceived ideas about science in order to defend their position in relation to the programme.[100] To illustrate this he recounts one of Bloor's own arguments:

> 'Bloor says that the principles of the strong programme "embody the values which are taken for granted *in other scientific disciplines*". The strong programme, he says, "possesses a certain kind of moral neutrality, namely the same kind as we have learned to associate with all *other sciences*" and denial of its tenets would be a betrayal "... of the approach of empirical science". "If knowledge could not be applied in a thorough-going way to scientific knowledge it would mean that science could not scientifically know itself". ... "If we want an account of the nature of scientific knowledge, surely, we can do no better than adopt the scientific method itself".'[101]

11: 365-394. p379

[99]Woolgar, S. (1981). Interests and explanation in the social study of science. *Social Studies of Science* 11: 365-394. p388-389

[100] Woolgar, S. (1993). *Science: the very idea*. London: Routledge.

[101]Woolgar, S. (1993). *Science: the very idea*. London: Routledge. p44, quoting Bloor, D. (1976). *Knowledge and Social Imagery*. London, Henley and Boston: Routledge and Kegan Paul. p4,10,40, ix.

To Woolgar this demonstrates an uncritical acceptance of 'what science is (actually) like'. He argues that although the interests approach is right to show how judgements about knowledge are always socially informed, its supporters fail to recognise that their own judgements about science are also constructions and versions of 'reality' that cannot be given any special authority.[102] He claims that the interests approach is based on an unwarranted assumption that it *is* possible to produce an authoritative statement about 'the world' which does *not* embody any particular interests position i.e. that the sociologists interpretation is not itself constrained by the sociologists' interests.[103]

In the following section I discuss the aspects of the interests approach that are of relevance to my research, highlighting the points about the approach that make it suitable for analysing decision-making about environmental issues, specifically in order to ascertain how aspects of the precautionary principle are embodied in current practices. Additionally I address many of the criticisms raised above in order to justify my continued use of the approach.

Interests Theory and the Precautionary Principle

Developments in the Sociology of Scientific Knowledge have moved away from a theory of interests that had its heyday in the late 1970s and early 1980s. I am currently reviving the use of the interests approach because of its value in understanding scientific negotiation and controversy.

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[102]Woolgar, S. (1981). Interests and explanation in the social study of science. *Social Studies of Science* 11: 365-394. and Woolgar, S. (1988). *Science: the very idea*. Chichester: Ellis Horwood.

There are six key factors about the approach that are relevant to my research on the precautionary principle. Firstly, the interests approach suggests that scientists' knowledge-claims embody, or are informed by, social and political interests and these may reflect disciplinary, professional and ideological interests and objectives. This is important in relation to the precautionary principle due to the range of different players involved in decision-making processes about environmental issues. This approach offers a way in to understanding what shapes the positions of those taking oppositional stances on the issue in question. A criticism of this is that it is difficult to determine what empirical research should be carried out in pursuit of the interests approach. My strategy was to conduct semi-structured interviews with individuals explicitly involved in deliberations about radioactive waste disposal and endocrine disrupting chemicals. By conducting these interviews and supporting the data obtained from them with documentary material from other sources, I analysed the self-stated interests lying behind different positions. Some of these interests were related directly from the individuals interviewed whilst others were suggested by third parties or related literature. Whilst this does not exempt me from the criticism of identifying the interests myself it provides a stronger basis for their determination than solely my suggestion.

Secondly, the interests approach aims to understand how knowledge is produced as opposed to simply understanding what knowledge is taken to exist. This is important in relation to the precautionary principle, as it is the factors involved in shaping decisions about environmental issues that are relevant, rather than the outcomes of those decisions. Understanding the roles of different players is essential in

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[103]Webster, A. (1991). *Science, technology and society*. Basingstoke: Macmillan Press Ltd. p22

understanding what the precautionary principle might mean. A criticism of this is that proponents of the interests approach take the existence of interests for granted and simply look for examples of such interests in order to support their position about how knowledge is produced. I rebuke this criticism in relation to my research by saying that it was a not a thesis that I started out with. I followed the positions of groups and individuals which expressly allied themselves with the debates I investigated.

Thirdly, the interests approach reasons that knowledge is the result of consensus amongst individuals rather than being inherently 'true'. This is particularly relevant to an analysis of the precautionary principle since decision-making about environmental matters revolves around establishing that controversy exists over the knowledge that is relevant to the decision at hand. Exposing the fact that any agreement is the result of negotiation and consensus amongst interested parties allows me to establish that decision-making invoking precaution is not unusual in the extent to which it involves the promotion of values and interests. Another criticism of the interests approach is that the analyst must make a connection between the observed action and the desire or interests that prompted the action, and that this involves a judgement by the analyst. By claiming that knowledge is the result of consensus the analyst is making a judgement about how that knowledge came about and is forcing a rationalist explanation onto the process. I again defend my use of this approach by saying that all theory is about finding an explanation for the observed phenomenon.

Fourthly, the interests approach asserts that frameworks of assumptions, standards, purposes and meanings exist which are shared by individuals and which are reinforced by conditions within society. Additionally it maintains that science is a social process, which follows a set of procedures in order to modify or elaborate a previous theory, and this establishes and reinforces institutional and disciplinary interests. This is important in relation to the precautionary principle as it implies that individuals associated with particular institutions and disciplines are influenced by social frameworks outside those institutions as well as by interests associated with the social framework of the discipline itself. Understanding the precautionary principle is about determining how the value of precaution underlies current decision-making and it is therefore important to uncover the social frameworks and interests of participants in the decision-making process. A criticism levelled at this is that proponents of interests start out with a notion of the nature and variety of desires they will identify and neglect the fact that an infinite number of alternative desires are in principle identifiable. In response to this I would say that while the researcher may start out with some idea of what she or he will find, is this not the case in all scientific research? Apart from using grounded theory[104] all theoretical positions start out with a notion of what might be encountered. This will be informed by the experience of the researcher in tandem with other research conducted in the same field. In relation to my work on the precautionary principle, while I expected to identify certain institutional and disciplinary interests I did not limit my analysis to these. Thus other interests also manifested themselves in the course of my research.

Fifthly, much of the empirical work that follows the interests approach looks at debates over scientific 'expertise' in public settings. The relationships between scientists, power-brokers and decision-makers are all involved in the closure of scientific debate. This is another key aspect in relation to the precautionary principle

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[104] Glaser, B.G. (1978). *Theoretical sensitivity: advances in the methodology of grounded theory.*

as decision-making about environmental issues involves a wide range of 'experts'. The point to identify here is that it is the relationships between these players that are important as well as establishing what their individual expertise is based upon. A criticism levelled at proponents of the interests approach is that there is little reflexivity on their part regarding their own research. This implies that although relationships are identified and analysed between scientists, power-brokers and decision-makers, the researcher often leaves herself out of the picture, thus implying that her presence has no role in the identification of those relationships and no impact on the relationships themselves. In contrast to this, I am well aware of my impact as a researcher and address some of the issues regarding my impact in chapter seven on science, interests and uncertainty. Whilst it is important to be reflexive about one's work and to recognise the impact one has on the researched it is also necessary to be aware that whatever the theoretical stance taken and whatever the methodologies used to obtain data the researcher will always have an impact. That is why choice of methodology is important along with an understanding of the limitations of that methodology.

Sixthly and finally, it has been pointed out by advocates of the interests approach that opponents of a particular scientific paradigm often attempt to discredit that knowledge by identifying the presence of social interests in it. This harks back to a notion that scientific knowledge should and can be purely objective in nature. This notion is discredited by advocates of the interests approach who show that interests can be identified in all forms of scientific knowledge. Of relevance to my research is the view that the presence of interests is not therefore unique to decision-making

California: The Sociology Press.

involving implementation of the precautionary principle, indeed it is present at all levels of scientific knowledge formation and implementation. A criticism that addresses this point is made by Woolgar when he says that the sociology of science has no special authority and that any analysis it produces is only one of many possible representations of the world. Advocates of the interests approach produce one representation of the world that suggests that the identification of interests is not sufficient to discredit a knowledge claim because all knowledge claims have embedded interests. Opponents of the approach suggest that this is only one representation and there are others that may produce equally satisfactory explanations. In response to this I say that while I agree that there are many other sociological representations that could have been drawn upon to help explain the interactions observed with regard to decisions about radioactive waste disposal and endocrine disrupting chemicals, the data I obtained supports the contention that those involved themselves recognise the interests at play at the site of scientific controversy and consensus forming. Therefore interests theory provides many useful and relevant insights into an analysis of the application of the precautionary principle.

The above section details the reasons why the interests approach is an appropriate theoretical tool to use in my thesis and justifies my use of it despite the critiques that have been levelled at it. I now reiterate that the contribution I make theoretically in this area of interests theory is to link interests with uncertainty. This is due to a data-driven re-discovery of interests theory. This connection between interests and uncertainty has not been explicitly made before. In many ways interests have been used in an over-simplistic way. I expand on these previous uses by analysing two case studies to show how self-stated interest groups interact in decision-making processes, in negotiations over uncertainty, and thus with regard to the interpretation and application of the precautionary principle.

Summary

Building on a science studies approach I have reviewed some of the literature on uncertainty in order to establish a connection between uncertainty and interests as understood in the context of the Edinburgh School's Strong Programme. I focused on three types of uncertainty: uncertainty as lack of data, uncertainty as ignorance and uncertainty as indeterminacy and discussed the distinctions between these in order to show how uncertainty is of relevance to a discussion of the precautionary principle. Following this I reviewed a selection of the literature that relates scientific uncertainty to policy, establishing the distinction between the uncertainties understood by those close to the production of scientific knowledge and those more distant from it. I illustrated this with reference to MacKenzie's 'certainty trough', which indicates that it is the users of scientific knowledge, namely policy makers, who assume a reduced level of uncertainty in their interpretation of scientific advice. Following this I made the connection between uncertainty and interests.

This led me to review interests theory itself. I started by placing interests theory within the context of the sociology of science. Subsequently I considered the work of Barnes and MacKenzie, Shapin, and Collins, which provides useful insights into the way in which interests theory has been used at an empirical level, and I reviewed some of their case studies in order to show this. As with any other theory, the interests approach has many critics and I identified Woolgar as a particularly articulate opponent. I reviewed many of his criticisms in order to position myself clearly within the debate and used his criticisms as a measure against which to evaluate my use of the theory.

The following chapter describes the evolution and development of my research and methodology. In it I explain the collaborative nature of my PhD funding and account for the choice of case studies undertaken. Additionally I justify my choice of empirical research methodology, and explain why alternative methodologies were not used.

Chapter Four

Research Design and Methodology

Introduction

In this chapter I introduce the way my research was designed and constructed. I discuss the advantages and disadvantages of having collaborative funding through an ESRC CASE Award and consider the selection of the case studies I chose to investigate the application of the precautionary principle, those being radioactive waste disposal and endocrine disrupting chemicals. This section explains why those particular cases were most appropriate and discusses the justification for not researching other, perhaps also relevant, cases. I then detail how these two case studies are used in the subsequent two chapters to explore the themes that are relevant to the precautionary principle, as identified in chapter two. Following from this I outline my methodology, which involved semi-structured interviews with key players in the decision-making fora on radioactive waste disposal and endocrine disrupting chemicals. I give a justification for why semi-structured interviews as opposed to alternative forms of qualitative data gathering were appropriate in the context of this research and discuss the appropriateness of my strategy for selecting interviewees. In addition I used documentary sources of data and I justify my use of this material as a support to my primary data. Issues of access are considered in the last section.

CASE Awards and Collaboration with Friends of the Earth

CASE Awards are research studentships awarded by the Economic and Social Research Council (ESRC) in conjunction with a collaborating body. My studentship, in collaboration with Friends of the Earth and based at the Centre for Science Studies at Lancaster University, was designed to examine the evolution and application of the precautionary principle. This attracted me because of my interest in environmental policy along with my desire to create links with an environmental NGO and because I wanted my research to be of practical value. The precautionary principle was something that I already knew about, and I was, even then, aware of the ambiguity surrounding its implementation.

Being a CASE student is quite different from being in receipt of an ordinary ESRC studentship. I think it is important to detail here some of the benefits and limitations that this has had on my research. Additionally, my relationship with my collaborative body, Friends of the Earth, has had an impact on my work. Being associated with Friends of the Earth has, for example, allowed me open access to their resources. This has been invaluable, especially at the outset of my research into the precautionary principle and when designing my case studies.

The corollary of this is that having a CASE award has also made the scope of my PhD more restricted. Being tied to Friends of the Earth has meant that deviation from the initially agreed PhD and timetable has had to be negotiated. In the beginning there was a lack of definition about what they wanted from my PhD. The field was open for negotiation but the parameters were extremely broad. The basic proposal was drawn up by Friends of the Earth in conjunction with the Centre for Science Studies and I elaborated on this in my application. The advantage was that I had a basic idea of what Friends of the Earth wanted in terms of empirical research and the field was left open for me to decide on theoretical argument and methodology. This also had its disadvantages as I discovered that there are many different ways of looking at the subject of decision-making involving uncertainty, which is what my research on the precautionary principle evolved into. That Friends of the Earth gave me the freedom to choose my own methodology and theory has had advantages and disadvantages. Where CASE bodies have been very instrumental in defining the parameters of work, as is the case with some of my colleagues, there is limited scope for manoeuvre. There is a real tension therefore between the advantages of having a definite target to be reached and having a target that is always moving and being re-negotiated.

Selecting Case Studies

Given the nature of the precautionary principle, as detailed in chapter two, it soon became obvious that determining its application would not simply be a matter of looking at how it was adopted in the UK. It was apparent that it was not something tangible, and I would have to find some means of attempting to understand its application in decision-making processes. I decided that the best option would be to conduct a number of case studies of environmental issues in order to ascertain how the precautionary principle was being conceived in those situations. In order to do this I attempted to select contrasting issues that provided a range of situations to which the precautionary principle was applicable.

I initially agreed with Friends of the Earth that I would conduct three case studies that would be of interest to myself, of campaigning significance to Friends of the Earth and of relevance to an understanding of the precautionary principle. We agreed that radioactive waste disposal would be one of them. Having chosen to come to university in a town only four miles from two nuclear reactors and living just down the coast from one of the largest nuclear sites in England which buries and stores domestic civilian radioactive waste, imports foreign radioactive waste and undertakes reprocessing of spent fuel I was convinced that this was an industry worth looking at in terms of how the precautionary principle applied to it. A more long-standing personal reason for being interested in this study is that while growing up on the east coast of Ireland I was constantly being made aware of the potential dangers from Sellafield (then known as Windscale), of the dangers of swimming in the Irish sea, of eating sea-food from the Irish sea and of leukaemia clusters along the east coast allegedly connected to the nuclear industry's radioactive emissions. I wanted to know more about what happens to radioactive waste. At the time of starting my PhD (October 1995) Friends of the Earth was involved in giving evidence at a public inquiry into a planning application to excavate a Rock Characterisation Facility (RCF) at Longlands Farm near Sellafield in Cumbria. Nirex, the company responsible for the disposal of intermediate level radioactive waste, had selected this site as a suitable repository for intermediate level radioactive waste and had submitted a planning application to construct what they called an RCF to investigate the geology and hydrology of the site further. A long public inquiry ensued with Cumbria County Council, Friends of the Earth and Greenpeace, amongst others, opposing the application. This meant that there was a lot of knowledge and experience that I could draw on from Friends of the Earth. Dr Rachel Western, Nuclear Researcher in the Energy, Nuclear and Climate Team at Friends of the Earth, gave me a lot of her time and full access to all the resources that she had gathered together. This was invaluable to me at the start of my research. Additionally she was able to supply me with names and contacts for people who would be relevant interviewees.

As a case study for the precautionary principle radioactive waste disposal was an ideal choice as it provided a historic study dating back to the late 1940's. I was able to follow the debate as it had taken place through records such as white papers and government reports, and later through advisory committee reports and government panel reports. Far-reaching decisions about the ultimate disposal route for intermediate level waste (ILW) had already been taken and it is currently government policy that this should involve deep underground burial. This case study enabled me to look at how decisions had already been taken and also, in light of the Nirex inquiry, to ponder on how precautionary decisions are being made at present. Now, with the new labour government conducting a review on policy regarding the disposal of radioactive waste, this case study of mine has become more topical.

A second case study was more difficult to select. At the beginning of my research I was very interested in PM10s – the tiny particulates emitted from vehicle exhaust – because they were being discussed locally and nationally as an issue of urban air quality. I undertook some work critiquing a couple of reports that had come out about the health effects of PM10s.[1] Another important issue in the media at this time was Genetically Manipulated Organisms (GMOs).[2] This was a very topical subject as some genetically altered products had just been allowed on the market in the UK. There was (and currently still is) a lot of discussion about the labelling requirements of products containing GMOs. One of the contentious issues is that not much is known about the medium to long-term effects of these products either on human health or on the wider environment and so the safety of the products cannot be

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[1] Department of Health - Committee on the Medical Effects of Air Pollutants (1995). *Non-biological particles and health*. London: HMSO. and Department of the Environment - Expert Panel on Air Quality Standards (1995). *Particles*. London: HMSO.

[2] Greenpeace Business (1997). European opposition to genetically modified organisms (GMOs) gains momentum. *Greenpeace Business* 36, (April/May 1997): 6-7.
Grove-White, R., MacNaghten, P., Mayer, S., and Wynne, B. (1997). *Uncertain world: genetically modified organisms, food and public attitudes in Britain*. Lancaster: Lancaster University. March 1997.
Levidow, L. (1996). Regulating GMO releases: Britain's precautionary dilemmas. *Natures-Sciences-Societes* 4, (2): 131-143.

demonstrated. More recently a crop of genetically altered soy beans were produced in the US which were developed because they had a resistance to a particular herbicide that was used to spray the crops. A big debate followed, the outcome of which was that the genetically altered soybeans would be mixed in with non-genetically-altered beans as there was deemed to be no significant biological difference between them.[3] I felt this would make a suitable case study for researching the application of the precautionary principle. Duncan McLaren, Senior Research Co-ordinator in the Sustainable Development Research Unit, my supervisor at Friends of the Earth, agreed but was hesitant due to the fact that at that time Friends of the Earth did not have a campaigner working on biotechnology or food issues.

Another topical issue, causing a media sensation at the time, was endocrine disrupting chemicals. These are chemicals that have been implicated as disrupters of the hormone systems of animals, both human and non-human. A number of studies have been conducted that have shown a link between particular chemicals and particular reproductive dysfunction. I became fascinated by this topic, as the chemicals in question are pervasive in today's society. In fact no society, whether they actively use these chemicals or not, is free of their potential effects as can be seen from the fact that chemicals have been observed in animals living in the Arctic.[4] This seemed to me to be a suitable contrast to the radioactive waste disposal case study, which is much more local in its potential effects. Friends of the Earth were also interested in environmental chemicals and agreed that I should conduct a second case study on this theme. At the same time as starting this case study, Michael Warhurst, who had been

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[3] GenEthics News (1996). Genetic engineering, ethics and the environment. *GenEthics News* 13, (Sep/Oct 1996): 12. p1

working with Friends of the Earth Scotland on endocrine disrupters moved to London to work with Friends of the Earth in the Industry and Pollution team there. He has subsequently given me a lot of help in terms of material and contacts.

Conducting a case study on endocrine disruption was timely given media concerns about reproductive health.[5] Additionally, it provided a significant contrast to the radioactive waste study. Where the radioactive waste debate has been an historic one with an abundance of information on the subject readily available, the debate about endocrine disrupting chemicals is still relatively new, meaning that there is much less publicly available information on the topic. Conducting a study on endocrine disrupting chemicals gave me the opportunity to talk to decision-makers whilst positions were still be negotiated and 'decisions' still being taken. It provided an opportunity to look at a subject where the state of the knowledge was disputed, where there was little consensus about the scientific facts and where there was little consensus about what action needed to be taken immediately, if any. Information about radioactive waste disposal comes from a wide variety of disciplines including physics, geology, hydrology, engineering, sociology, epidemiology and toxicology whereas information about endocrine disrupting chemicals tends to come from toxicological and ecological studies. As yet there has been little in terms of sociological research conducted into endocrine disrupting chemicals. This issue about the amount of information and expertise available is significant because, as has been identified in the precautionary principle chapter, the precautionary principle is about making decisions even when there is a lack of scientific evidence. An additional

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[4] PCBs have been found in the body fat of polar bears on the Norwegian Svalbard Island. Colborn, T., Peterson Myers, J., and Dumanoski, D. (1996). *Our Stolen Future*. London: Little, Brown and Company. p101-104

[5] Pinchbeck, D. (1996). Downward motility. *Esquire* January 1996: 79-84.

contrasting feature between these two cases is that while there are pressure groups in existence that are dedicated to campaigning on nuclear issues there are (as yet) no dedicated pressure groups campaigning on issues of endocrine disruption. This limits the amount of exposure the public may have to these two issues although there are some multi-issue environmental groups campaigning on both issues. This is also significant in relation to the precautionary principle as it is often through efforts by pressure groups that wider society is made aware of such controversial issues. Invocation of the precautionary principle relies on there being an indication of a problem to start with.

Another contrasting feature was the ability to identify key players in decision-making processes about the two issues. With radioactive waste disposal this was relatively straightforward whereas with endocrine disrupting chemicals it involved more research and personal judgement. Because the precautionary principle is about making decisions about environmental harms it is relevant that with some issues decision-makers are easily identifiable whilst with others they are more obscure, dispersed and harder to pin down.

Other features of contrast between the two case studies were the level of scientific consensus about the link between what caused particular observed effects, whether scientific equipment was sophisticated enough to look for particular known effects, whether the effects were felt by particular individuals in specific locations or more ubiquitously by everyone, whether individuals could control their own exposure through personal choice and the current level of government policy with regard to the

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Ryder, R. and Allen, R. (undated). Are chemicals affecting male fertility? *Toxcat* Special - Part 1: 1-6.

two issues. These are all significant in that it must be recognised that the precautionary principle has to be applied to all these diverse situation.

Initially we had agreed that I would do three case studies, in order to get a broad perspective of the issues to which the precautionary principle might be applied, but we had not decided on what the third would be. Friends of the Earth suggested that climate change would make a good study because it was the focus of their main national campaign. I wasn't so keen on this because I felt that issues where there are scientific controversies would make more suitable studies. Although there is still a lot of controversy within the climate change debate, with the establishment of the IPCC there is at least consensus among scientists that there is a problem. The climate change debate has been going on for a long time and a huge amount of literature had been produced about it. Practically every government in the world has a position on it and I felt that tackling it would not provide as much useful data as the other two studies already selected. On top of that I was keener to focus on GMOs, as I am more attracted to subject areas that members of the public can identify with in some way. There seems to be an immediacy about endocrine disruption that people can identify with due to the fact that people are concerned about things that could possibly affect their or their children's reproductivity. Similarly with GMOs, people have a direct interest in what they consume. In contrast climate change seems to be a step removed from the ordinary person, more of a global issue than a local one. Although both radioactive waste disposal and endocrine disrupting chemicals have global relevance they're not being dealt with globally. My main interest was to look at issues that are being dealt with at a UK decision-making level. For this reason I pushed for my third case study to be on GMOs.

However, it soon became apparent to me that undertaking three case studies was an extremely ambitious proposal and not entirely necessary due to the significant differences between the two case studies already conducted. I felt that the radioactive waste disposal study and the endocrine disrupting chemicals study provided sufficient examples of the contrasting range of problems and situations that the precautionary principle would be faced with to eliminate the necessity for a third one. I therefore decided that two detailed case studies would be more beneficial to my research than three less detailed ones. This was one of the decisions where I had to negotiate with Friends of the Earth as my CASE sponsor, in order to change our initial agreement about the content of the research. Fortunately Friends of the Earth and my supervisors agreed with this analysis of the situation, hence my thesis draws on two case studies rather than three.

From the above, and from chapter two, it can be seen that radioactive waste disposal and endocrine disruption make useful case studies from which to examine the precautionary principle because they effectively demonstrate the wide range of contrasting problems associated with environmental issues. Despite the fact that the precautionary principle itself is not a major component of the deliberations about either radioactive waste disposal or endocrine disruption, useful understandings can still be deduced from their examination. Rather than exploring how the precautionary principle is applied in practice in the UK this thesis is about examining to what extent the themes established in chapter two as constituent parts of rhetorical precaution (i.e. as identified from the agreements listed in Appendix 1) are in fact elements of current deliberations about two specific environmental issues. From this I am able to consider the implications precautionary rhetoric might have for other environmental issues.

Having shown in chapter two, through analysing six situations that can be identified from agreements referring to the precautionary principle, that the key to understanding what lies behind the precautionary principle is an understanding of how scientific evidence is organized and how uncertainty is acknowledged and used, I use the two case studies of radioactive waste disposal and endocrine disruption to explore these issues in some detail.

Both case studies offer useful insights into the day to day operation of precautionary ideals, and the role of evidence and uncertainty. In chapter five on radioactive waste disposal I organise ideas about the marshalling of evidence with regard to the Nirex Inquiry into sections that cover how definitions of radioactive waste and related concepts are created and used by the different participants at the inquiry; how information, data and argument are deployed; and the ways in which uncertainty is exploited by participants to variously support or undermine the claims of themselves or others. In chapter six I follow deliberations on endocrine disrupting chemicals from the point where the Department of the Environment commissioned a workshop to discuss environmental oestrogens. In that chapter I argue that subsequent deliberations about endocrine disrupting chemicals were framed around issues of scientific uncertainty, weight of evidence and the definition of terms, as established by the setting up of that initial workshop. Both these case studies show that the themes that are implicit within rhetorical precaution at the level of formal agreements are also implicit at the empirical level of deliberations about environmental problems, despite there being little explicit reference to the precautionary principle itself within those deliberations. This lends weight to my decision to focus on these areas.

Interviews and Interviewees

I chose to undertake approximately twenty semi-structured interviews for each case study. I selected particular individuals on the basis that I wanted to track the history and arguments of the issues in question. I felt that structured interviews were too restricting and would not allow me to obtain the type of data I was looking for. May considers that structured interviews are dependent upon good pilot work and upon the interviewer being similar to the target group in terms of sharing a similar culture so that the interpretation of the questions and the dynamics of the interview do not vary to a great extent.[6] He quotes Benney and Hughes as saying

> 'Where languages are too diverse, where common values are too few, where the fear of talking to strangers is too great, there the interview based on a standardised questionnaire calling for a few standardised answers may not be applicable. Those who venture into such situations may have to invent new modes of interviewing.'[7]

For these reasons semi-structured interviews seemed more appropriate. Although I still had a list of pre-set questions, I used these as the basis for the ensuing discussion rather than making coverage of these issues an end in its own right. This allowed me to probe the interviewee about particular points that I considered relevant as the interview progressed. As May points out

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[6] May, T. (1993). *Social research: issues, methods and process.* Buckingham, Philadelphia: Open University Press. p92

[7] Benney, M. and Hughes, E. (1984). Method: evidence and inference - evidence and inference in ethnomethodology. In, Button, G., (ed)., *Ethnomethodology and the human sciences*:278. Cambridge: Cambridge University Press., quoted in May, T. (1993). *Social research: issues, methods and process.* Buckingham, Philadelphia: Open University Press. p92

> 'Qualitative information about the topic can then be recorded by the interviewer who can then seek both *clarification* and *elaboration* on the answers given. This allows the interviewer to have more latitude to *probe* beyond the answers.'[8]

May also considers that the context of the semi-structured interview is an important aspect of the process. He says

> 'Given this greater degree of latitude offered to the interviewer and the greater need to understand the context and content of the interview, while trained interviewers may be used, researchers themselves often conduct the interviews.'[9]

I arranged the interviews in the location of choice of the interviewees. This usually meant they took place in their work environment although sometimes it took place in their homes, depending on whom the interviewee was representing. Although this meant a lot of travel on my part it was beneficial in that the interviewees were more relaxed in familiar surroundings and it gave me an opportunity to evaluate their surroundings.

While focused interviews or unstructured interviews may have provided detailed accounts of the interviewee's particular concerns, and allowed them more freedom to expand in areas of interest to themselves, given the time constraints involved in my interviewing schedule it was important to at least have the bones of the information I hoped to elicit. As Robson states:

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[8] May, T. (1993). *Social research: issues, methods and process.* Buckingham, Philadelphia: Open University Press. p93

[9] May, T. (1993). *Social research: issues, methods and process.* Buckingham, Philadelphia: Open University Press. p93

> 'Interviewers have their shopping list of topics and want to get responses to them, but as a matter of tactics they have greater freedom in the sequencing of questions, in their exact wording, and in the amount of time and attentions given to different topics.'[10]

Again, I felt that semi-structured interviews were the best format to use as they allowed me the control of pre-set questions with the freedom to deviate and address issues which I had not foreseen arising. In this way I was able to obtain a huge amount of relevant data.

Another method I considered being inappropriate was self-completed questionnaires. An advantage of these is that they are time and effort efficient for the researcher as they can be copied, circulated and completed in a lot less time than it takes to conduct the same number of interviews. However, for my purposes there are many disadvantages. I would have had to conduct a postal survey which generally has a high rate of non-response. The questions would have to be very precise and could not allow for the respondent to expand in a lot of detail on every question. Given the range of people I interviewed one standard questionnaire would not have been appropriate and so a number of different questionnaires would have had to be created for the different interviewees. This would have been extremely time-consuming and potentially counter-productive as I would have been anticipating the answers from the different interviewees in the questions I asked.

As this was my first venture in conducting interviews I was a little anxious about my first few. In order to minimise any potential problems I carefully selected who I

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[10] Robson, C. (1993). *Real world research: a resource for social scientists and practitioner-researchers*. Oxford: Blackwell. p237

would interview first. I chose people who I felt would be sympathetic to the aims of my research and who would be open in their replies to my questions. These were environmentalists and academics. After these first few interviews I went on to conduct interviews with representatives of industry, of government and regulatory bodies. By this stage I had refined the way in which I raised particular topics and was confident in my ability to interject when the content of the interview appeared to be wavering.

I interviewed approximately 20 individuals for each case study.[11] These people were selected on the basis of their involvement with the issue in question. Friends of the Earth gave me a lot of names and contacts of people who would be relevant to talk to. I also looked at the participants lists of various conferences and workshops in order to ascertain whether I had missed any important voices. With regards the radioactive waste disposal case study I contacted a lot of people who had been involved in the Nirex Inquiry (discussed in detail in chapter five on radioactive waste disposal) as well as organisations who have dealings with the nuclear industry in the UK who were not directly involved with that inquiry. With regards the endocrine disrupting chemicals case study I selected people based on their involvement in workshops on endocrine disruption or their statutory obligations for particular areas of public concern, for example, water or food. I interviewed people from a broad range of organisations in order that I had representations from a range of different interest groups. These people were individuals who have been fairly vocal in the discussions of the issues of concern and who could be said to be the key players in the debate. All the people I interviewed I spoke to in their capacity as a representative of a particular

[11] See Appendix 2

organisation as opposed to their 'individual selves'. I was not trying to obtain individual's accounts of what the key issues were but rather I wanted to know what particular organisations and statutory bodies had to say on the issues. In order to acquire an broad range of opinions I ensured that I had representatives who could speak for government, industry and non-governmental organisations.

I used a combination of tape-recording the interviews and taking notes as I found this the most effective method of eliciting detailed responses from my interviewees. Leaving a tape running meant that I did not miss anything that was said and the majority of my interviewees were happy to be recorded. Taking notes myself seemed to encourage the interviewees to forget about the tape and to concentrate on the questions. It also had the advantage of prompting the interviewees to continue talking while I was note-taking as I had observed that when I was solely taping the interviews the interviewee would stop more quickly in anticipation of the next question.

My choice of methodology relates very clearly to my theoretical use of interests theory. By conducting semi-structured interviews I gave my interviewees the opportunity to talk about the issues they felt were relevant to the decision-making process. This meant that some of their interests were expressly identified by themselves, a factor that addresses one of the criticisms aimed at the interests approach, that the researcher identifies pre-determined interests of their own conjuring. Additionally, some interviewees expressed opinions about the embedded interests of other participants in the decision-making processes under study and this gave me a starting point for identifying the underlying interests in the rest of my data. Had I conducted structured interviews or used questionnaires the criticism of searching for particular interests would be more real as it would have been very difficult to construct questions that would not be seen as leading the interviewee in a particular direction. Semi-structured interviews supported by documented material was the obvious methodology to use so as not to fall into this trap as identified by critics of the interests approach.

Other Data

In addition to my interview data I used lots of published and grey material. In order to obtain a significant background of the details of the two case studies it was necessary to undertake a thorough literature review of material published on the issues. This gave me a significant understanding of the scientific issues involved in the discussions about the two cases as well as leading me to other appropriate material. An advantage of using published material is that it provides a record of research in a certain field and can reveal the public position of particular organisations. As May says:

> 'Documents inform the practical and political decisions which people make on a daily and longer-term basis and may even construct a particular reading of past social or political events.'[12]

The types of documentary material I consulted includes historical documents such as government White Papers, European Directives, journal articles, official reports, internal memos, letters, newspaper articles, press releases, pamphlets, evidences to public inquiries, government records including Hansard, government committee records and reports. Some of these documents were public documents which made access easy while others were private and were either given to me by the people I interviewed or were passed on to me through another source. May also issues a warning about relying on documented material:

> '...what people decide to record, to leave in or take out, is itself informed by decisions which relate to the social, political and economic environment of which they are a part. History, like all social and natural sciences, is amenable to manipulation and selective influence.'[13]

It would not have been appropriate to base all my research on documented material as often the issues that inform decision-making come from other sources. However it has provided an extremely useful supplementary source of detailed information which has been valuable both in helping to identify the position of my interviewees prior to the interviews and in providing enough background information so that I did not have to cover those issues during the interviews.

Questions of Access

With any research involving interviewing selected individuals there is always an issue about access. Although I was interviewing people involved in decision-making processes about two distinct environmental issues I was not a witness to any of the actual deliberations. I relied on both documented information about those deliberations in addition to verbal accounts by those who were involved. I had very little difficulty obtaining access to individuals in order to interview them. Most people seemed very willing to talk about their own work and experience. However,

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[12] May, T. (1993). *Social research: issues, methods and process*. Buckingham, Philadelphia: Open University Press. p133

[13] May, T. (1993). *Social research: issues, methods and process*. Buckingham, Philadelphia: Open University Press. p149-150

not having access to the actual decision-making operations meant that I was unable to observe the negotiations that led to the resolution of controversy (when they did), or that clarified that no consensus had been reached. Therefore, when obtaining governments and regulators perceptions I targeted particular individuals and have used their words as representative of the department or body they work for.

It must be remembered that decisions made in particular workshops and inquiries will depend on a lot of behind-the-scenes deliberation, as will decisions about particular institutional stances. Reading reports does not give access to this material, as it is usually the outcomes rather than the process that are discussed. Similarly, speaking to particular individuals may not give access to this process, as they themselves may not have been involved in the behind-the-scenes deliberations. Conversely they may have been personally involved in meetings at which informal agreements were recognised but may not be willing to acknowledge this either to me as a researcher or even to themselves. I decided that it was not possible to acquire an understanding of these internal processes without undertaking a genuinely ethnographic study. I felt that it would be impossible to access some of those areas save as an insider and, in the context of my two cases, becoming an 'insider' would be time-consuming if not impossible. Therefore I do not make reference to internal deliberations unless through reference to internal documents. However, even internal documents don't detail everything. Due to the range of individuals and institutions I was interviewing these problems could not have been overcome in a study of this size. Obtaining inside information from every organisation would in any event require the liberty to follow the interviewee around and witness all their deliberations, formal and informal. This method of research has numerous drawbacks and limitations due to the pressure the interviewee can feel from being under such close scrutiny. This may in turn affect the way discussions and deliberations take place. For these reasons my research was limited to one-to-one semi-structured interviews supplemented by additional documented material.

Summary

The previous chapter on uncertainty, expertise and interests helped inform my research design, a design also influenced by the process of obtaining an ESRC Case Award in conjunction with an external organisation (Friends of the Earth). Together these considerations led to a discussion of the pros and cons of collaboration in terms of the focus of the work involved, and from there to the identification of the two case studies used in this thesis, namely radioactive waste disposal and endocrine disrupting chemicals. I then introduced the methodology used to obtain my data, justifying it in terms of my goal of eliciting as much information as possible on the positions of the individuals interviewed, taking these to be representative of the institutions they were associated with. Due to the limitations on the data obtained through interviewing I supported this with documented material obtained from various sources. In this chapter I have justified the use of the various types of documents I have used and have given structured reasons as to why other means of obtaining information were inappropriate to this study.

Additionally, I have shown that analysing the precautionary principle itself is not an empirical possibility and to get around this I use the themes identified from analysing documented agreements that refer to the precautionary principle as a position to start from. These themes were determined in chapter two and are shown to be significant elements of both 'rhetorical' precaution, that is the core concepts invoked in formal agreements, and in real-life environmental deliberations.

The following two chapters review my empirical work on radioactive waste disposal and endocrine disrupting chemicals. In these chapters I show how the issues of evidence, definitions and uncertainty are discussed in relation to these case studies. The relationship between the two case studies, the relevance of an interests approach and the implications of the case studies for the implementation of the precautionary principle are subsequently discussed in chapter seven.

Chapter Five

Radioactive Waste Disposal

'Radioactive waste management is a profoundly serious issue, central to the environmental evaluation of a nuclear power programme. There must be a clear, identifiable, policy centre and a means to ensure that the issues posed by waste management are fully considered at the outset of a nuclear programme, not dealt with many years after the decisions on developments that lead to the wastes have been made and when options may have been effectively foreclosed.'[1]

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[1] Command Paper 6618 (1976). *Nuclear power and the environment: Royal Commission on Environmental Pollution, 6th report: (The Flowers Report)*. London: HMSO. 1976. p164

Introduction

In this chapter I identify the characteristics of the radioactive waste management problem that make it a suitable case study for analysing what application of the precautionary principle might mean. I introduce the main players in this arena and make a case for reviewing their deliberations and positions in terms of their prior institutional interests. On this basis I distinguish between the three sectors of government, industry and non-governmental organisations.

At the beginning of this section I introduce the Nirex Inquiry – a public inquiry into an application by UK Nirex to build a Rock Characterisation Facility as a first stage towards the building of a radioactive waste repository in Cumbria. I have used details from and interviews with people involved in this inquiry extensively throughout this chapter. There was very little explicit reference to the precautionary principle at the inquiry (Greenpeace mentioned it in their closing submissions) and no detailed debate about how it should or could be applied in the particular context. Therefore it has not been possible to analyse the application of the precautionary principle itself to this case and I have had to take the less direct route that I outlined in the previous chapter. Therefore, the main body of this chapter compares interpretations of definitions of radioactive waste and the nature of evidence deployed in radioactive waste related controversies, as these are themes that I identified in chapter two as being significant aspects of rhetorical precaution. Understanding the way in which evidence is used to inform decision-making about radioactive waste management is key to understanding the extent to which precaution is a factor in decision-making processes. I have broken the first sub-section on definitions into three in order to assess the extent of institutional polarisation on this issue. The most apparent distinctions that I found, both in documentation and by my respondents, were to do with definitions of plutonium as an asset, or a waste product, or weapons material; to do with interpretations of the scale of the radioactive waste ‘problem’ in terms of the quantification of waste by half-lives or volume; and to do with the characterisation of radioactive waste as risk. The sub-section on evidence addresses the way in which ‘evidence’ was defined, used and deployed by each of the involved parties at the Nirex public inquiry. The resulting discussion shows how this aspect of precaution, namely, the reliance on and definition of evidence worked out in practice.

Finally I look at the formal structure and process of a public inquiry showing how this ‘event’ structures debate and reveals contrasting perspectives on the themes that constitute rhetorical precaution. A second aim is to identify the benefits and limitations of the public inquiry as a potential forum for precautionary decision-making and to investigate the way in which evidence, definitions and their attendant interests shaped the outcome of this particular process.

Characteristics of Radioactive Waste

Radioactive waste has a number of distinctive characteristics that make it an especially revealing subject to study with regard to the application of the precautionary principle.

Firstly, there is a well-established framework within which decisions about radioactive waste policy are made and the roles of key institutions are fairly explicit. Although government policy is continually being reassessed and changed there are strict guidelines to which the nuclear industry must adhere through licensing and monitoring processes. There has been explicit policy on radioactive waste disposal since the 1970s, and various government departments continue to play a central role in its development and implementation.

Within the structured framework of the UK policy process "the public" are able to have their say and the many public inquiries into the development of nuclear installations have heard self-confident members of the public expressing their views. These frameworks may be restrictive in the extent to which ordinary members of the public feel they can participate and in the issues allowed to be discussed but the fact remains that a platform exists for expressions of discontent and support.

The key actors in the debate about radioactive waste disposal are easily identified as many of the roles and issues have been in existence for a long time. Within government and the regulatory bodies specific departments and sub-divisions are responsible for particular areas of nuclear policy with identifiable individuals filling distinct roles. Within industry, key individuals are also readily identified as again specific roles exist within company structures.

Opponents to nuclear energy are also easily identified due to their vociferousness and their commitment to communicating their beliefs to a wide audience. Over the years specific pressure groups have been set up to campaign on nuclear issues. These include groups such as CND (Campaign for Nuclear Disarmament) and CORE (Cumbrians Opposed to a Radioactive Environment). Additionally, multi-issue environmental groups such as Friends of the Earth and Greenpeace also campaign about nuclear issues. These groups have had a lot of time to develop and consolidate their position on these issues, and this has enabled them to actively engage in decision-making processes about the future of nuclear power and radioactive waste.

It must be acknowledged however that the nuclear industry was established long before environmental concerns were recognised and radioactive waste was not publicly acknowledged as a serious problem until the end of the 1950s.[2] This was partly due to the culture of secrecy within which the nuclear industry operated due to its military origins. Despite this history a significant amount of information about radioactive waste is now in the public domain, which means that anyone interested in or concerned about nuclear issues has access to it.

Stories about radioactive waste and the nuclear industry make news due to the emotional response that they elicit in people. This means that the public often gets sensationalised coverage of nuclear incidents.[3] This is important since the way in which the public responds to nuclear issues is of great concern to the nuclear industry

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[2] Command Paper 884 (1959). *The control of radioactive wastes*. London: HMSO.
[3] See, for example, the headlines associated with the following newspaper articles: Brown, P. (1998). Atom waste bill £355m. *The Guardian*, Wednesday April 1 1998, 5.
Brown, P. (1997). Turmoil over nuclear safety: threat to 2bn disposal project. *The Guardian*, Thursday 16 January 1997, 1.
Nuttall, N. (1997). Leak fuels nuclear dump fears. *The Times*, January 1997.
Boulton, L. (1997). Leaked memo puts nuclear waste plan at risk. *Financial Times*, Thursday 16 January 1997.
King, T. (1997). Leaked memo questions safety of plans to bury atomic waste at Sellafield. *Telegraph*, Thursday 16 January 1997, 6.
Leake, J. (1998). 'Nuclear dustbin' fears could force Sellafield to close. *Sunday Times*, 25/01/98, 6.
Anon (1998). Mox weapons warning. *Whitehaven News*, 21/05/98.
Siddall, D. (1998). Thorp's terror potential. *Carlisle News Star*, 03/08/98.
Beavis, S. and Brown, P. (1996). New fears on design of reactors. *Guardian*, 19/03/96.
Brown, P. (1996). Never say nuclear: the risks we choose to fear. *The Guardian*, Wednesday 29 May 1996.
Smythe, D.K. (1996). Nirex 'lost the scientific debate'. *The Scotsman*, 21 November 1996.
Lean, G. (1998). Soil tests condemn Sellafield. *The Independent on Sunday*, 6.

which aims to promote a particular way of thinking. One of the industry's key arguments is that there are such large social benefits tied in with the current state of electricity generation that it would be impracticable to close the nuclear industry down.[4] In contrast opponents of nuclear power insist that enough is known about alternative energy production to make substitution feasible.[5] They claim that if as much money was invested into research and development of alternative energy production it would be able to compete with nuclear on an equal footing. Both sides need public support to legitimate their positions, and both enlist the media for their own ends.

One of the reasons why radioactive waste is such an emotive issue is because radiation is invisible and can cause serious long term damage to people and wildlife. Many studies have established a direct link between radiation and specific physiological effects.[6] However establishing a link between specific geographical pockets of observed effects and a specific radiation source is more problematic. Clusters of leukaemia have been identified around some nuclear sites[7] although in these cases the

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[4] See British Nuclear Industry Forum (1994). *Environment and Nuclear Power*. Didcot, Oxfordshire: AEA Technology. 1994.
British Nuclear Fuels plc (1992). *Nuclear waste: what's to be done about it?* Warrington, Cheshire: BNFL. 1992.
British Nuclear Fuels plc (1994). *Don't be left in the dark*. Warrington, Cheshire: BNFL. January 1994.
[5] See Aubrey, C., Grunberg, D., and Hildyard, N., (eds) (1996). *Nuclear Power: Shut it Down!: an information pack on nuclear power and the alternatives. Vol 2*: The Ecologist.
[6] See Bertell, R. (1996). Estimates of uranium and nuclear radiation casualties attributable to activities since 1945. In, Crispin, A., Grunberg, D., and Hildyard, N., (eds), *Nuclear Power: Shut it Down!: an information pack on nuclear power and the alternatives. Vol 1*, 1:82-87: The Ecologist.
Bertell, R. (1999). Victims of the nuclear age. *The Ecologist* 29, (7): 408-411.; Nomura, T. (1982). Parental exposure to x-rays and chemical tumours induces heritable tumours and anomalies in mice. *Nature* 196, (8 April 1982).
[7] See Gardner, M.J., Snee, M.P., Hall, A.J., Powell, C.A., Downes, S., and Terrell, J.D. (1990). Results of a case-control study of leukaemia and lymphoma among young people near Sellafield nuclear plant in West Cumbria. *British Medical Journal* 300, (6722): 423-429.; Green, P. (1996). Low level radiation: questions and answers. In, Crispin, A., Grunberg, D., and Hildyard, N., (eds), *Nuclear Power: Shut it Down!: an information pack on nuclear power and the alternatives. Vol 1*, 1:53-72: The Ecologist.

nuclear industry argues that there is not enough evidence to link the cause to the observed effect and suggests other factors may be involved.

This inability to determine aetiology is exacerbated by the fact that individuals cannot detect exposure to radiation with the naked eye and may be exposed unknowingly. However equipment does exist which allows the presence of radiation to be identified easily which allows suspect sources of radiation to be monitored and tested.

Since sources of radiation resulting from radioactive waste are localised rather than generic, some members of the public will be closer to the source of risk than others. Individuals who are close to the source will not be able to minimise their exposure, as they have no way of controlling their intake of radiation. An important fact to bear in mind about radiation is that manmade radiation adds to natural background levels creating a cumulative effect. Whilst natural radiation exists everywhere, the background level will be different from place to place. Any reasoning that manmade emissions are close to background levels disguises this fact and also ignores any potential additive effects.[8]

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p71; Mihill, C. and Morris, M. (1990). Sellafield fathers' cancer link: Ministers concerned as study tracks leukaemia risk. *Guardian*, 16 February 1990.; Downs, S. (1996). The ten years of investigation into the health impact of the Sellafield reprocessing plant on local communities in Cumbria. In, Crispin, A., Grunberg, D., and Hildyard, N., (eds), *Nuclear Power: Shut it Down!: an information pack on nuclear power and the alternatives. Vol 1*, 1:93-96: The Ecologist.
Cook-Mozaffari, P.J., Darby, S.C., Doll, R., Forman, D., Hermon, C., Pike, M.C., and Vincent, T. (1989). Geographical variation in mortality from leukaemia and other cancers in England and Wales in relation to proximity to nuclear installations, 1969-78. *British Journal of Cancer* 59, (3): 476-485.
Kinlen, L. (1988). Evidence for an infective cause of childhood leukaemia: comparison of a Scottish new town with nuclear reprocessing sites in Britain. *Lancet* 2, (8624): 1323-1327.
[8] See Green, P. (1996). Low level radiation: questions and answers. In, Crispin, A., Grunberg, D., and Hildyard, N., (eds), *Nuclear Power: Shut it Down!: an information pack on nuclear power and the alternatives. Vol 1*, 1:53-72: The Ecologist. for a discussion of background radiation, p66-68

Finally, there are many uncertainties regarding the health effects of exposure to radioactive waste. At this point, a distinction should be made between low-dose chronic exposure and high-dose one-off exposures. The effects of chronic exposure to low doses of radiation are not well understood, partly because many studies have been aimed at high-dose one-off exposures (for example studies of Hiroshima survivors). Such cases are easier to monitor since the exact cause is known and the effects on particular individuals can be seen. Low dose chronic exposure, by contrast, is more difficult to monitor because the exposed populations are harder to identify.

All of the above characteristics of radioactive waste and the framework within which decisions about its management are made are important factors in helping to understand how the themes that make up rhetorical precaution relate to current environmental applications. Having described these features of radioactive waste that make it a relevant case study, I now identify the stakeholders involved in debating the future of radioactive waste disposal and identify the specific precautionary issues that this issue raises.

Cast of Players

In order for a discussion on the ways in which definitions, disputed evidence and scientific uncertainty (as identified in chapter two from the six situations that make up rhetorical precaution) to have meaning with regard to the precautionary principle and radioactive waste disposal, it is important to distinguish between the actors involved. Identifying the cast of players helps in understanding how the interests associated with institutional arrangements and social practices influence the way decisions are made and how controversy is closed. The Nirex Inquiry (a public inquiry held in Cumbria in 1995-1996 at which UK Nirex Ltd appealed against the decision of Cumbria County Council not to allow planning permission for their proposed Rock Characterisation Facility)[9] reveals a particular cohort of interests and their interaction. Detailed analysis of these underpins this chapter.

Reviewing documentation of the Nirex Inquiry enabled me to identify fifteen key players: the Department of the Environment Radioactive Substances Division; the Environment Agency; the Ministry of Agriculture, Fisheries and Food; the National Radiological Protection Board; the Health and Safety Executive's Nuclear Installations Inspectorate; the Radioactive Waste Management Advisory Committee; the Planning Inspector; the Secretary of State; UK Nirex Ltd; the United Kingdom Atomic Energy Authority; British Nuclear Fuels Ltd; Friends of the Earth; Greenpeace; the Campaign for Nuclear Disarmament; and Cumbrians Opposed to a Radioactive Environment. I have organised the following review of the positions adopted by these groups under the headings of government, industry and NGOs.

Government

There are many different voices within the UK government concerned with nuclear matters. Some, although not all, were involved in the Nirex Inquiry. Each of the government departments or bodies involved had specific functions and responsibilities and I detail some of these below.

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[9] Details of this public inquiry are discussed further later in this chapter.

Both ministers and officers are involved in decision-making at government level. Officers in government departments must advise ministers on appropriate courses of action in particular circumstances. They must have a knowledge and understanding of current scientific controversies including whether and how consensus has been reached regarding these controversies. Their roles include the translation of scientific knowledge into potential policy and advising on possible policy measures when there is a lack of scientific certainty. They inform ministers who are ultimately responsible for enacting policy. Officers will normally be attached to particular departments and their advice will be geared toward potential effects or consequences in certain sectors, for example officers associated with MAFF will be concerned with public health and food production. Whilst there may be overlap between some departmental interests, departments are typically responsible for particular issues, hence the need for interdepartmental liaison in order to avoid potentially conflicting priorities and advice.

The Radioactive Substances Division of the Department of the Environment[10] looks after the DoE's interests on radioactive matters primarily under the Radioactive Substances Act (RSA). One of its concerns is radioactive waste management and related radioactive discharges and policy. The Division is not responsible for authorisations of particular radioactive waste projects, which are dealt with by the Environment Agency, but if the applicant thinks the conditions applied are unreasonable they can appeal to the Secretary of State who will then make a decision. The Secretary of State has the power, under the RSA, in conjunction with MAFF, to

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[10]After the 1997 General Election when the Labour Party came to power the Department of the Environment (DoE) and the Department of Transport (DoT) merged to become the larger Department of Environment and Transport (DETR). At the time of my fieldwork they were still separate and to

take certain cases away from the Environment Agency. This hasn't happened since the inception of the RSA but if it did it would be part of the job of the Head of the Radioactive Substances Division to advise the Secretary of State on the particular case. There are no standard criteria by which to decide what would be an appropriate case for the Secretary of State to get involved in so it would be the role of the Head of the Radioactive Substances Division to advise on that in their role as a civil servant.[11] The primary responsibility of the Radioactive Substances Division is to deal with policy that needs to be adopted in the UK for radioactive waste management and also on legislation. The Division's interest is in proposing policy that is accepted by society whilst simultaneously making decisions based on available scientific evidence. As the top government advisors it is important for those at the Division to be seen to give objective, clear advice.

The Environment Agency (previously Her Majesty's Inspector of Pollution) is the principal environmental regulator in England and Wales and has a major role under the RSA 1993 in regulating disposal and storage of radioactive wastes in the UK. The Agency is responsible for authorising discharges and disposals of radioactive wastes from nuclear sites as well as from small non-nuclear premises such as hospitals and universities. It provides the enforcement function and has inspectors on the ground who issue authorisations and registrations. A spokesperson from the Environment Agency told me that under Statute they must now take the costs of regulation into account and the company being investigated must not incur expenditure grossly in

avoid any confusion I refer to them as separate departments in this thesis.
[11]Interview 16/10/96, transcript p2

excess of benefits.[12] The Environment Agency has responsibility for protecting the environment on behalf of the public. It is clear that the Environment Agency is subject to potentially opposing interests, being responsible for maintaining a cost-benefit balance on behalf of the industry they regulate whilst simultaneously maintaining the safety of the public.

The Ministry of Agriculture, Fisheries and Food (MAFF), under their own legislation, are concerned with radioactivity in foodstuffs and are also a statutory consultee for any authorisations to dispose of radioactive wastes. MAFFs main interest with regard to radioactive waste is the protection of public health and it is with this in mind that MAFF is consulted by government about radioactive waste disposal.

'The National Radiological Protection Board was created by the Radiological Protection Act, 1970 to give advice, to conduct research and to provide technical services in the field of protection against both ionising and non-ionising radiations. The NRPB is responsible for advising government departments on radiological protection criteria to be applied to the disposal of all types of solid radioactive waste, including wastes arising in gaseous or liquid form which will be converted to solid form prior to disposal.'[13] The NRPB has no regulatory role and is limited to giving advice on the effects of radiation on people, dose implications, risk limits and targets.[14]

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[12]Interview 16/12/96, transcript p1
[13]Statement of purpose printed in all documents published by the NRPB, e.g. National Radiological Protection Board (1992). *Board Statement on Radiological Protection Objectives for the Land-Based Disposal of Solid Radioactive Wastes*: NRPB. 1992. p1
[14]Interview 27/11/96, transcript p1

The Nuclear Installations Inspectorate (NII), which is part of the Health and Safety Executive (HSE), is concerned with licensing the operation of nuclear plant. Their primary objective is to protect workers and the public from work activities. They operate under the Nuclear Installations Act (1965) which is the responsibility of the Department of Trade and Industry (DTi). NII is concerned with activities inside the boundary fence of the site in contrast to the Environment Agency which is concerned with what goes out into the environment. 'It's slightly confused because the HSE was recently transferred to DoE as a sponsoring department but they're still answerable to the DTi for their operation of nuclear licensed sites.'[15] The NII's interests are tied to radioactive concerns within any nuclear site boundary. This includes the storage and management of radioactive waste. Once radioactivity crosses the site boundary it comes under the jurisdiction of the Environment Agency. The NII are concerned about the rights of the workers at the site and their exposure to radiation, and it is their interests that they represent.

The Radioactive Waste Management Advisory Committee (RWMAC) is an independent body that advises the Secretaries of State for the Environment, Scotland and Wales, on the technical and environmental implications of major issues concerning the development and implementation of an overall policy for all aspects of the management of civil radioactive waste, including research and development.[16] Although independent it is dominated by pro-nuclear members. This means that as a body its interests are defined by an institutional framework which accepts nuclear power.

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[15]Interview 16/10/96, transcript p2

An additional role of the government comes at the level of the public inquiry where a Planning Inspector has the responsibility of sieving through evidence in order to write a report summing up the material presented, which is then submitted, together with a recommendation, to the Secretary of State, an elected Minister. The Secretary of State has been invested with the authority to grant or deny permission for any application, even going against the recommendation made by the Inspector who co-ordinates the inquiry. In the case of the Nirex Inquiry, which is discussed later in this chapter, the Inspector recommended that permission be denied to the applicant and the Secretary of State followed this advice. The Inspector is embedded in the Local Government planning system and therefore has a particular way of viewing evidence and sifting thorough what she or he considers to be relevant and irrelevant. The Secretary of State, as an elected Member of Parliament, may have little formal knowledge of the issues under question but nevertheless has a powerful position in the planning process. Local MPs such as those with a stake in the Nirex Inquiry are interested in making decisions that are publicly acceptable in order that they are viewed in a positive light in future elections. However they also have the conflict of wanting to support industry and development and promote employment opportunities within their constituencies.

Government, as can be seen from the above, encompass a diverse collection of interests and responsibilities. As a collective the divisions, departments and bodies involved have interests in public health and safety, industrial safety and development. However, due to the fact that the many departments work independently of each other there can be situations where the interests of one clashes with the interests of another.

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[16]RWMAC (1994). *Annual Report*: Radioactive Waste Management Advisory Committee. 1994. p8

Industry

The nuclear industry in the UK is very closely associated with government due to its military past but also due to the fact that it was, until recently, completely government owned. Privatisation has now separated industry from government although the historic link has influenced the cultures within both organisations. The nuclear industry is keen to establish a safe management system for radioactive waste. The problem of radioactive waste management must be sorted out if there is to be any future expansion of nuclear energy. A number of different organisations now make up what I generically call the 'nuclear industry' each with distinct responsibilities.

The Nuclear Industry Radioactive Waste Executive (Nirex) was set up in 1982 by four organisations working in partnership – British Nuclear Fuels plc, the Central Electricity Generating Board (now Nuclear Electric plc), the South of Scotland Electricity Board (now Scottish Nuclear Ltd), and the UK Atomic Energy Authority. It was reconstituted as UK Nirex Ltd in November 1985 with all shares held by the partner organisations and with one special share being held by the Secretary of State for Trade and Industry on behalf of the Government. UK Nirex's task is to implement the Government's strategy for the disposal of most low and intermediate-level radioactive waste produced by the UK nuclear industry and by users of radioactive materials in hospitals, industry, research and defence.[17] It is important to Nirex to maintain a high public service profile due to the controversial nature of the product

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[17]UK Nirex Ltd (1991). *Safe for all time: the story of research into radioactive waste disposal.* Didcot, Oxon: UK Nirex Ltd. October 1991.p3 and UK Nirex Ltd (1987). *Facts on Nirex: the disposal of radioactive waste.* Didcot, Oxon: UK Nirex Ltd.

with which it deals. However, due to the fact that Nirex's business is radioactive waste management, it relies on activities that continue to produce radioactive waste. It therefore has a dual interest in managing radioactive waste and in managing public perceptions of the safety issues around radioactive waste.

The United Kingdom Atomic Energy Authority (UKAEA) is responsible for managing nuclear sites at Dounreay, Windscale, Dunfrith, and Harwell and for undertaking a programme of decommissioning on facilities where government funded research was undertaken.[18] The UKAEA used sea disposal as its method of disposing of Intermediate Level Waste until 1982/83. Now it is drummed at source and put in purpose made stores at the site where it is produced. UKAEA's interests lie in determining the safety of particular sites according to established risk assessment procedures and in undertaking the decommissioning of sites in order to allow them to be managed into the future. UKAEA also wants the public to be trusting of its decommissioning skills.

Another important player in the UK is British Nuclear Fuels Limited (BNFL) which produces fuel for all the nuclear power stations in Britain; manufactures and enriches uranium fuel; transports and reprocesses spent fuel; and is responsible for the management of waste products, and, ultimately for decommissioning. It has been constituted as a public limited company in which the government holds all the shares. It operates from five sites: Risly near Warrington where it has its Head Offices; Springfields near Preston where it manufactures uranium fuel; Capenhurst near

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[18]Interview 10/12/96, transcript p1

Chester where it enriches uranium; Sellafield in Cumbria where it reprocesses spent nuclear fuel and manages waste and Annan in Scotland where it operates the Chapelcross nuclear power station. Due to the multitude of activities with which it is involved BNFL is clearly interested in the continuation of the nuclear industry. BNFL has responsibilities at all levels of the nuclear process and has chosen to diversify activities in order to keep future options open. By being involved at so many levels in the nuclear cycle the company is in a strong position to shape decisions.

BNFL and Nirex have built up a body of experience on nuclear matters that far exceeds the knowledge of others not involved in the industry. Where others may have generalised knowledge of nuclear matters, BNFL and Nirex have the advantage of understanding the precise operation of specific plants and processes. They do, however, have a credibility problem with the public and have often sought the corroboration of 'independent experts' in order to improve their public image especially on issues of safety.

As can be seen from the above there are two main industrial players in the UK involved in radioactive waste management – UK Nirex Ltd and BNFL. Their interests are closely tied together and between them they are responsible for all levels of the nuclear cycle. While they are concerned about nuclear safety and potential liabilities they are also dependent on the continued existence of nuclear power production.

Non-Governmental Organisations

The third group of voices heard in discussions of radioactive waste is that of non-governmental organisations (NGOs). Commonly they tend to speak with a collective voice, opposing nuclear energy and advocating particular storage methods for radioactive waste. However, they each have their separate agendas, and it is this which distinguishes one from another.

Friends of the Earth and Greenpeace are both environmental NGOs with a history of campaigning against the nuclear industry, particularly against nuclear power and reprocessing of spent fuel.[19] The Campaign for Nuclear Disarmament (CND) is another NGO and it campaigns against nuclear weapons and nuclear installations. Cumbrians Opposed to a Radioactive Environment (CORE) is an anti-nuclear group set up in Cumbria specifically to campaign against the nuclear industry's activities at Sellafield and Drigg.[20] CORE is primarily concerned with effects of radiation on the

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[19] See Friends of the Earth (1992). *The MOX myth: why British Nuclear Fuels has got it wrong on plutonium and mixed oxide fuels*: Friends of the Earth. December 1992.
Friends of the Earth (1993). *Nothing ventured, nothing gained: failing to invest in the future. Friends of the Earth's response to the draft UK strategy for sustainable development.* London: Friends of the Earth.
Friends of the Earth (1996). *The international shipment of radioactive waste in the context of UK national policy: Friends of the Earth response to the RWMAC consultation.* London: Friends of the Earth. September 1996.
Friends of the Earth (undated). *British Nuclear Fools plc: the case against reprocessing*. London: Friends of the Earth.
Wallace, H. (1996). *Our radioactive legacy*. London: Greenpeace.
Greenpeace (1995). *Nirex's rock characterisation facility*. London: Greenpeace. November 1995.
Greenpeace (undated). *Deep crisis: Britain's nuclear waste: who's burying who?* London: Greenpeace.
Friends of the Earth (1991). *Profits before safety: radioactive discharges from the British Nuclear Fuels Springfields works*. London: Friends of the Earth. November 1991.
Greenpeace (1995). *Jobs and Nirex's nuclear waste dump*. London: Greenpeace. November 1995.
Friends of the Earth (1998). FoE demands end to British nuclear farce:2. London: Friends of the Earth.
[20] See CORE (1996). *Proof of evidence by M.G Forward on behalf of CORE (Cumbrians Opposed to a Radioactive Environment': Town and Country Planning Act 1990. Town and Country Planning (Inquiries Procedure) Rules 1992. Appeal by United Kingdom Nirex Limited. Rock Characterisation*

local Cumbrian population.[21] Despite their differences all these NGOs have the ultimate, more generic, aim of closing down the nuclear industry, focusing on the long-lived nature of radioactive waste in pursuit of that goal. Greenpeace and Friends of the Earth employ scientists and campaigners to promote this agenda.

NGOs frequently claim to speak on behalf of the 'public', a constituency which rarely has a strong or coherent voice in complex decision-making processes. A definition of 'public' is difficult to pin down in this context and it is sometimes said that, in a democracy, elected government ministers speak on behalf of 'the public'. Since the public is an amorphous entity it is difficult to determine exactly what it wants. Despite this ambiguity, industry seeks to keep it on its side in order to avoid costly disputes. In order to assess public perceptions of particular issues, various polls have been undertaken. Nirex commissioned one such poll from Gallup in 1995,[22] the results of which were used in evidence to the public inquiry, showing that there was public support in Cumbria for the development of the Rock Characterisation Facility.[23] Polls such as these are used to authenticate claims about the 'public'. Gallup has a history and an impressive reputation in survey research, and represents another type of 'expertise' used by various sides in a debate in support of divergent claims. Because the public is such a heterogeneous group there is always scope for ambiguity. For example, some members of the public will be more affected by safety issues around

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Facility Longlands Farm, Gosforth, Cumbria: CORE. 23/01/96.
CORE (undated). The environmental impact of Sellafield:8.
CORE (undated). Cumbria - nuclear dustbin:4.
[21] CORE (undated). The health effect of Sellafield:4.
[22] See UK Nirex Ltd (1996). *Disposal of radioactive waste*. New Malden: The Gallup Organisation. March 1996.
UK Nirex Ltd (1994). *Attitudes towards the storage/disposal of radioactive waste*. London: The Gallup Organisation. October 1994.

radioactive waste whereas others will be more interested in their own job security.[24]

Due to the heterogeneity of the public it is impossible to represent everyone simultaneously. Between them, the above mentioned NGOs cover most of the issues about radioactive waste which may be of concern, despite having their differences. For example, at the Nirex Inquiry, Greenpeace's case was that current scientific and technical knowledge was not detailed enough to justify creating the Rock Characterisation Facility at present and that other potentially more suitable sites which may offer higher levels of radiological protection should also be examined.[25] Like Friends of the Earth they had interests in undermining the Nirex case on a political as well as a scientific level in order to attempt to get their question of indefinite storage back onto the agenda.

Summary

There are many voices contributing to the debate about radioactive waste management. Such voices represent a wide range of disciplines and backgrounds each with their own interests at stake. Those interests can be split along the institutional lines of government, industry and NGOs, as shown above. In the following section I show how these voices polarise on the issue on the nature of evidence. I do this by looking at how definitions of radioactive materials are used and the way in which

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[23]Interview 07/01/97, transcript p4

[24] See Wynne, B., Waterton, C., and Grove-White, R. (1993). *Public perceptions and the nuclear industry in West Cumbria.* Lancaster: CSEC, Lancaster University. September 1993. for a discussion of the complexity of 'public attitudes'.

[25]Tripley, D. (1996). Closing submissions on behalf of Greenpeace Limited. In, Haszeldine, R.S. and Smythe, D.K., (eds), *Radioactive waste disposal at Sellafield, UK: site selection, geological and*

evidence is disputed.

The Nature of Evidence

In this section I limit my discussion of what constitutes evidence (of radioactive waste and of radioactive waste as a problem) to the analysis of one particular public inquiry, the Nirex Inquiry, that took place in Cumbria in 1995-1996. On 17 March 1997 the Secretary of State for the Environment dismissed Nirex's appeal against Cumbria County Council's refusal to grant planning permission for their proposed Rock Characterisation Facility(RCF) at Longlands Farm near Sellafield in Cumbria. This was the culmination of a long process that started when Sellafield was identified as one of twelve potential sites for an Intermediate Level Waste (ILW) repository.[26] Nirex had intended to submit a planning application for the ILW repository in the autumn of 1992 but revised its plans in the light of concern about the hydrogeological inadequacies of the site. It submitted an application for a Rock Characterisation Facility (RCF) instead. This was to be the first stage in the process of creating a final repository. Nirex wanted to have firm data available by the time it came to apply for permission for the repository and the development of the RCF, Nirex felt, would provide that. As mentioned already, planning permission was not granted for the RCF. This was on the grounds that the evidence given by Nirex was 'too uncertain' for the Secretary of State to have confidence in the safety of the proposal.[27]

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engineering problems:197-205. Glasgow: Glasgow University Print Unit. p197-198
[26]See Kelling, G. and Knill, J. (1997). The Nirex Story: a geological perspective. *Geoscientist* 7, (7): 10-13. p10-11 for a summary of the events leading up to the identification of these sites.

This analysis of contrasting interpretations of evidence is important in relation to the precautionary principle, since such definitions formed a significant part of the Nirex Inquiry. In this section on 'the nature of evidence' I show how definitions are created and used and the manner in which evidence is disputed. Under the sub-heading of 'definitions of radioactive waste' I look at how different players involved in the radioactive waste issue define radioactive waste and associated concepts and how these definitions shape their positions on what should be done with regard to its management. Under the sub-heading of 'disputed evidence' I look at how information, data and argument are used by different players and identify particular areas of controversy surrounding potential solutions to the disposal of radioactive waste. These issues are both relevant to an analysis of the application of the precautionary principle for they draw out associated interests and values embedded in the decision-making framework under scrutiny.

Definitions of radioactive waste

It is instructive to compare definitions typically offered by the key players in the Nirex Inquiry. Radioactive waste is a generic term that covers a multitude of activities and products. This is due to the diverse origins of the materials that constitute it as well as the potential options for its 'disposal' or 'end uses'. Definitions range from 'hazardous waste' to 'useful by-products' with various in-between positions reflecting the institutional, political and social ideologies of the individuals or institutions involved. The 'official' definition of radioactive waste breaks the term down into

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[27] See Greenpeace (1997). John Gummer refuses Nirex planning appeal - news release:2: Greenpeace.

three main component parts: High Level Waste, Intermediate Level Waste and Low Level Waste.[28] Elements included in these definitions are plutonium, spent fuel, uranium, buildings, clothing, and machinery which arise at all stages of the nuclear cycle, from the mining of the uranium ore through the use of the uranium as a fuel to the eventual decommissioning of nuclear infrastructure, and these items are classified according to the level of radioactivity present and their heat generating capacity. However, actual uses of the term radioactive waste do not follow these official conventions, as shown in the following sub-sections.

a) Plutonium – asset, waste or weapon?

Answers to the question of whether plutonium is an asset, a waste product or a potential weapons material depend on who is being asked and when. In 1955 the government did not see plutonium as waste but as a valuable asset which would free Britain from dependency on uranium imports.[29] This reflected the post-war desire to be self-sufficient in energy. At that time the government did not consider that radioactive waste disposal would present a major difficulty because 'The volume of waste will be small...'[30] The complexities surrounding decommissioning and management of spent fuel were not understood adequately and at that point the government was optimistic that a solution to waste problems would materialise when necessary. One of the ways in which the industry intends to reduce plutonium

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[28] See British Nuclear Industry Forum (1994). *Environment and Nuclear Power*. Didcot, Oxfordshire: AEA Technology. 1994.
UK Nirex Ltd (1987). *Facts on Nirex: the disposal of radioactive waste*. Didcot, Oxon: UK Nirex Ltd.
British Nuclear Fuels plc (1992). *Nuclear waste: what's to be done about it?* Warrington, Cheshire: BNFL. 1992.
[29]Command Paper 9389 (1955). *A Programme of Nuclear Power*. London: HMSO. February 1955. p4

stockpiles is through the creation of Mixed Oxide Fuel (MOX) which they view as a commercial asset.[31]

The industry, in the form of BNFL, talks about plutonium as 'a valuable source of energy', and plays down its 24,000 year half-life, concentrating on explaining strict protection measures and the fact that plutonium is an alpha emitter which 'cannot penetrate even thin layers of materials'.[32] Alpha particles are toxic if inhaled or ingested and there have been public concerns in Cumbria about the levels of alpha radiation near the Ravenglass Estuary which have been shown to be higher than official readings suggest.[33] By defining plutonium as valuable, the industry has translated it from a problematic product to a resource, and by emphasising its inability to penetrate thin layers of material the industry attempts to re-define the perceived characteristics of the stuff itself. By re-defining plutonium as a valuable asset, the industry reduces the quantity of radioactive waste that it has to manage.

BNFL also compare plutonium to other toxic substances:

> 'There are also other radioactive substances found in nature which are more toxic than plutonium' and 'There are also many well known substances in everyday use which are very toxic if they are not handled properly.'[34]

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[30]Command Paper 9389 (1955). *A Programme of Nuclear Power*. London: HMSO. February 1955. p4
[31] British Nuclear Fuels plc (undated). *The use of plutonium in the civil nuclear fuel cycle*. Warrington, Cheshire: BNFL.
British Nuclear Fuels plc (undated). *Reprocessing*. Warrington, Cheshire: BNFL.
[32]British Nuclear Fuels plc (undated). *The use of plutonium in the civil nuclear fuel cycle*. Warrington, Cheshire: BNFL. p1
[33]Aubrey, C. (1993). *Thorp: The Whitehall nightmare*. Oxford: Jon Carpenter. p24
[34]British Nuclear Fuels plc (undated). *The use of plutonium in the civil nuclear fuel cycle*. Warrington,

By highlighting other, potentially more dangerous, substances the nuclear industry tries to reduce the perceived dangers from its processes and products. BNFL quote the Hon. Mr Justice Parker in order to offer reassurances on this point:

> '"It is not true that an escape of plutonium would be a unique disaster, The damage done ... by the breaking open of a tanker of chlorine of the size which regularly travels by road and rail would be a great deal more damaging than the breaking open of a container of spent fuel with its plutonium content".'[35]

By defining plutonium against other markers which are as, or more, toxic the nuclear industry is attempting to show that their product is not uniquely dangerous. The above example is used to suggest that the nuclear industry is a clean industry. The example of a chlorine disaster fails to explicate the full range of risks associated with a chlorine spill. Mr Justice Parker fails to say why it is to be considered more damaging. This example illustrates the way in which the nuclear industry re-defines plutonium by reference to what it is not, or what can be considered worse than it in order to relativise the specific risks associated with radioactive waste.

Interpretations of plutonium as waste or not also revolve around whether it could be used to create nuclear weapons. The nuclear industry dismisses this possibility on the basis that 'civil' plutonium contains a different mixture of isotopes from that used in nuclear weapons, and that even if it were to be used to create a crude explosive devise

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Cheshire: BNFL. p1. See also British Nuclear Industry Forum (1994). *Fission fusion and safety and nuclear power*. Didcot, Oxfordshire: AEA Technology. 1994. p18-19

[35]British Nuclear Fuels plc (undated). *The use of plutonium in the civil nuclear fuel cycle*. Warrington, Cheshire: BNFL. p7, quoting 'The Windscale Inquiry', report by the Hon. Mr Justice Parker, January 1978.

the creator would need specialist skill and knowledge which are not generally available. BNFL also contend that because it would take so long to create such a device it would be impossible to do so secretly.[36] By calling their plutonium the 'wrong kind of plutonium' the nuclear industry diverts attention from a potentially contentious issue that could cause serious commercial and political harm. However, CND and other NGOs fear that if plutonium fell into the wrong hands it could be used to create nuclear weapons. NGOs dismiss claims by the nuclear industry that it is the wrong type of plutonium arguing that with the right skill it could be used to make a bomb. Additionally they believe it is dangerous to assume that the expertise to make a bomb could be kept secret until such a device was produced.

As can be seen from the above examples how plutonium is defined depends on who is doing the defining. It is defined as a valuable asset by those who want to exploit its energy potential (government and industry) and as weapons material by those who want to highlight the negative uses to which it could be put if in the wrong hands (NGOs). These definitions, re-definitions and non-definitions are used emotively by different 'voices' and interest groups in order to support their own agendas.

b) Representing radioactive half-lives

Divergent interpretations of what plutonium is are matched by contrasting representations of the waste 'problem'. Concentrating on the volumes of waste that need to be managed as opposed to their long-lived and life-threatening effects has

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[36]British Nuclear Fuels plc (undated). *The use of plutonium in the civil nuclear fuel cycle*. Warrington,

allowed industry to minimise the public perception of the risk. Volumes are measurements with which many people are familiar whilst radioactivity levels and half-lives are not. The nuclear industry employs this strategy of referring to waste levels in terms of volumes by equating waste levels to football pitches, double decker buses and taxis.[37]

In contrast to the nuclear industry's definitions of radioactive waste local environmentalists are very concerned about the radioactive half-lives and long-lived nature of nuclear waste products. As a member of a local Friends of the Earth group who was involved in the Nirex Inquiry told me:

> '... obviously we're dealing here with something that's going to be dangerous for a long long time and has to be kept out of the human environment for a long long time so we can't do anything that we can't prove to be safe – and Nirex can't prove that what they want to do with the waste is safe because they're not going to have monitoring equipment or the ability to retrieve the waste once the dump is sealed...'[38]

Here the threat posed by the waste is being defined in terms of how long it stays active in the environment, but this raises a further problem with definitions of safety in terms of risk assessment and dose limits (see next sub-section on the risks of radioactive waste). Although it may be politically expedient for government, and commercially expedient for industry, to talk about radioactive waste in terms of volume, such

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Cheshire: BNFL. p2

[37]British Energy (1996). British Energy share offer:39. UK: Secretary of State for Trade and Industry. p12-13; British Nuclear Industry Forum (1994) p17-18; UK Nirex Ltd (1987). *Facts on Nirex: the disposal of radioactive waste*. Didcot, Oxon: UK Nirex Ltd.; British Nuclear Fuels plc (1992). *Nuclear waste: what's to be done about it?* Warrington, Cheshire: BNFL. 1992. p4-5

[38]Interview 01/10/96, transcript p4

discourse does not satisfy the environmentalists.

The above illustrates the way in which scientific measures are appropriated by different interest groups to advance their positions. The measurement of radioactive half-lives in thousands of years is an emotive tool that can be exploited by NGOs wanting to persuade others of the inter-generational consequences of poor management of radioactive waste and it reflects their own concerns and paradigms. This is the very reason why the nuclear industry tends to focus instead on volumes of waste rather than half-lives, for volumes are measurements which are readily understood and clearly limited. These contrasting representations of 'the problem' are congruent with the agendas of the defining parties.

c) The risks of radioactive waste

Finally I consider how radioactive waste is defined in terms of risk. The Department of the Environment places a lot of weight on statistical analysis in order to establish its position regarding the level of acceptable risk associated with radioactive waste. A spokesperson from the Radioactive Substances Division told me:

> 'The dose/risk relationship in terms of the radiation exposure to which people are exposed can be translated into risk, and actually that's something that we did do in our White Paper ... that's how dose limits are indeed set – by considering a level of risk.'[39]

By defining radiation exposure in these terms the government is able to set out

[39]Interview 16/10/96, transcript p3

concrete policy positions. It is then possible to create parameters within which the nuclear industry must operate. The government justifies its actions on the basis of 'scientific evidence'.

The nuclear industry is also careful to ensure that their definitions of different levels of waste and nuclear emissions are scientifically grounded. The industry quotes recommended dose levels and talks about percentage points above background levels of radiation in order to try to persuade a seemingly sceptical public that their activities do not pose a significant threat.[40] By using definitions which refer to statistical assessment of risk the nuclear industry also seeks to legitimate its position in a way which disallows contradiction or disagreement.

In contrast, NGOs resist debates framed by pre-determined levels of risk. A representative of a local Friends of the Earth group told me:

> '... there isn't a level of radiation that's safe, therefore it's very hard to say that there's a level of risk that's acceptable ... and I suppose because there's no safe level of radiation and we've got an awful lot of radioactive waste, in effect we're going to have to come to some kind of acceptable risk level because there's no other way to go forward. But it's got to be as low as possible and that doesn't just mean building the Nirex dump and keeping the risk as low as possible, it means deciding to do something with the waste that is going to make as low a risk as possible.'

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[40]British Nuclear Fuels plc (1992). *Nuclear waste: what's to be done about it?* Warrington, Cheshire:

The concern here is that a decision should not be made about a particular management option without judging the risks associated with other options. This ties in with the NGOs' general argument about radioactive waste management options and their concerns about the risks associated with all such strategies.[41]

All three groups, government, industry and NGOs see the risks associated with radioactive waste as something that can be managed, but differ in the ways in which they see that management taking place. This illustrates the different ways in which risk can be defined, such that it can be considered unproblematic once a numerical value is determined as in the case of government and industry, or that it can be seen as something that must be minimised to whatever extent possible as in the case of the NGO.

To summarise, the above examples show how definitions of radioactive waste are made and strategically deployed by the various parties involved in the debate. Those who manage to influence the dominant definition put themselves in a stronger position by setting the terms of subsequent debate. By focusing on a narrow definition relating to radioactivity and heat content, the whole controversy about plutonium, half-lives and associated risks can be sidelined and the problem can be defined as a narrowly technical issue. This, in turn, sets the scene in which evidence is marshalled, defined and disputed.

BNFL. 1992. p18-19

[41]Wallace, H. (1996). *Our radioactive legacy*. London: Greenpeace.; Green, P. and Western, R. (1994). *Time to face the inevitable: a submission from Friends of the Earth Ltd to the UK Department of the Environment's review of radioactive waste management policy*. London: Friends of the Earth. 25 October 1994.; Greenpeace (undated). *Deep crisis: Britain's nuclear waste: who's burying who?* London: Greenpeace.

Disputed evidence

This section offers an interpretation of what evidence was seen to be important and relevant for the different players involved in the Nirex Inquiry. In it I look at the nature of evidence, from what counts as evidence through more general questions about whether evidence exists or not to more specific questions of whether there is evidence that particular options are safe or not. It is helpful therefore to sub-divide this section into reviews of the positions each of the three main institutional groupings of government, industry and NGOs take on the question of evidence.

A public inquiry forces some of the meanings of contested evidence into the open and in this section I review the evidence in dispute at the Nirex Inquiry. Most, but not all, of the evidence that is disputed in the context of radioactive waste disposal is of a scientific nature. At the Nirex Inquiry there was an initial assumption on the part of those giving 'evidence' that they were not allowed to discuss the possible future repository because the inquiry was solely about the Rock Characterisation Facility. Because the inquiry in question was about the RCF and not about a radioactive waste repository, planning procedures could disallow evidence about the future repository. In the event the Inspector at the inquiry allowed people to say whatever they wanted, explaining that it was then up to the Secretary of State to decide what was or was not relevant. His reason for doing this was to allow individuals who wished to speak about emotive subjects to do so. However, one consequence of this approach was that no one knew exactly what the Secretary of State would take into consideration in his final decision. The fact that the Secretary of State has such discretionary power means that there was an element of guesswork involved when presenting evidence to the inquiry. What counted as relevant evidence was not fixed and unchanging, and this worked to the advantage and disadvantage of different players as detailed in the following sub-sections.

a) Industry's position

The nuclear industry in general and Nirex in particular are under enormous pressure to find a suitable location for a repository due to the large quantity, in terms of both volume and radioactive half-lives, of radioactive waste that still has an undetermined resting place. It is important to bear in mind that it is currently government policy that intermediate level waste (ILW) should be put into a deep underground repository. The nuclear industry is therefore under pressure to identify a suitable location. The Nirex Inquiry was the culmination of a series of events that led to the selection of Longlands Farm in Cumbria as the site with greatest potential in the eyes of the nuclear industry. In this discussion I review Nirex's evidence of geological complexity and safety as presented at the inquiry as well as their reactions to evidence of radioactive discharges on a broader level.

One of the criteria for determining whether a site is suitable for burial of radioactive waste is the geological stability of the site. It was essential for Nirex to show that knowledge of geological characteristics was uncontroversial. When I spoke to one of Nirex's technical support witnesses at the inquiry I was told that although the Sellafield site is geologically complex the same could be said of all possible sites:

> 'It's okay provided you can handle that complexity and the Sellafield site can be handled. ... There will always be uncertainty – you can't get

> rid of it. There seems to be a lot of talk amongst the opposition that uncertainty is always wrong. As long as you know what the impacts of the uncertainties are you can make a case.[42]

It was absolutely necessary for Nirex to persuade anyone with doubts about the Rock Characterisation Facility that the complexity of the geology could be 'managed' and that it was not a problem. Providing evidence in the form of a consultant's report showing that all potential sites have inherent geological uncertainties allows Nirex to claim that this is not a characteristic unique to the proposed site. By employing a consultant who states that these uncertainties are also 'manageable' Nirex draws on the credibility of an independent authority. However, by employing a consultant who does a lot of work for the nuclear industry, Nirex provides opponents with the opportunity to say such a view merely supports the paymaster's position. Nirex's 'evidence' that geological complexity is manageable is not conclusive, as will be seen in the following sub-sections on the positions of government and NGOs, but it is nonetheless evidence deployed in support of a particular position.

The inquiry also focused on the question of the safety of a repository that was sealed versus one that was retrievable. Nirex's evidence to the public inquiry stated that the material that would be used to seal the repository would be excavatable. Their technical witness told me that this was serendipitous in that they needed that particular material anyway. The fact that it is also easy to dig out was a bonus. However my informant believed that it would be better to 'seal it up and throw away the key'.[43] Politically, he believed that would not be possible but technically he felt closure to be

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[42]Interview 29/11/96, transcript p1

the best option. Additionally he argued that people won't know what to do if the repository was monitored. He pointed out that the solution Nirex opted for is designed to perform when completely backsealed and closed. This shows that Nirex constructed a convenient rationale in order to promote their preferred option. By acknowledging the opposition's wish for retrievability and given the fact that the material which they have to use is excavatable, Nirex can provide evidence that their repository meets their safety case (that it is sealed) whilst simultaneously meeting opposition demands (that it is retrievable). The official I spoke to from Nirex supported this position:

> 'There are certain types of retrievability that would compromise safety ... our safety case must stand up on the understanding that it is sealed and not opened up. It's difficult ground if one wanted to incorporate retrievability that impinged on longterm safety. Other things being equal we think that if we can prove that retrievability is possible without compromising longterm safety we'd look at it'.[44]

This demonstrates a very subtle use of what could be considered inconsistent evidence. It is important that the industry is seen to take the safety issue seriously and therefore evidence is produced to show how safe the repository will be when it is completely backsealed. On the other hand the industry is aware that it may be politically unacceptable for the waste not to be retrievable and so they produce evidence to show that the backfill is excavatable as well as being permanent. The important thing to recognise here is that Nirex is able to offer whatever evidence is deemed necessary to support their position.

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[43]Interview 29/11/96, transcript p3.

Moving on from Nirex, we can observe similar evidence-based controversy with regard to nuclear discharges from BNFL. BNFL have often been criticised for pumping low-level radioactive waste out to sea but the industry claims the amount of radioactivity is negligible. However, the Swedes:

> '... could identify radioactive traces in fish off their coasts being largely attributable to Sellafield, greater even than contamination from adjacent Swedish nuclear power stations.'[45]

This indicates the distance these emissions have travelled without dispersing. BNFL's response to this is that

> 'this is more a reflection of the sensitivity of their measuring instruments than an indication of high levels, as these are in fact negligible.'[46]

The problem here is a conflicting interpretation of data. On the one hand the Swedes have monitored the fish in their waters and have reached the conclusion that radioactive traces have come from Sellafield rather than their own nuclear stations. On the other hand the British nuclear industry is stating that 'the problem' is that the monitoring equipment used is too sensitive and that the levels of radiation are not a threat. It is interesting to consider why this dispute arose. The Swedes, who have stronger environmental policies, are concerned about radioactive pollution in their waters and are concerned that the source of the problem is Britain's BNFL. Despite the distance, radioactivity from Sellafield is greater in their waters than radioactivity from Sweden. BNFL, in a country with less stringent environmental policies and an

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[44]Interview 07/01/97, transcript p4
[45] King, P. (1990). *Nuclear Power: the facts and the debate.* London: Quiller Press. p78
[46]King, P. (1990). *Nuclear Power: the facts and the debate.* London: Quiller Press. p78

historic commitment to nuclear power, is concerned not to introduce an expensive clean-up process. By 'blaming' the monitoring equipment BNFL attempt to pass 'the problem' back to the Swedes.

Similar differences of measurement, policy and practice are identified by Aubrey who reports that

> 'Readings taken along the creek of the nearby Ravenglass Estuary have shown large variations in the levels of alpha radiation, suggesting that official monitoring, taken at greater distances, may miss out hot spots.'[47]

These readings were taken by the environmental group Cumbrians Opposed to a Radioactive Environment (CORE). I asked a representative from BNFL whether this finding was significant and was told

> 'The levels around Ravenglass are not unsafe – it's a headline catching sentence. ... They're quite right in the sense that the levels at Ravenglass are higher than background radiation.'[48]

The representative explained that this was due to past military activities and that although it might be a useful campaigning tactic against Sellafield it was not BNFL's responsibility or anyone else's to clean it up. While the evidence that there are higher levels of radiation at Ravenglass than elsewhere is not disputed the responsibility for them is absolutely denied by BNFL. The costs associated with cleaning up the Ravenglass estuary would be huge and are costs that the industry would wish to avoid. In this case BNFL accepts that the evidence exists but rejects the attribution of

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[47] Aubrey, C. (1993). *Thorp: The Whitehall nightmare.* Oxford: Jon Carpenter. p24

liability.

These few examples show how evidence and uncertainties have been handled by the nuclear industry both at the Nirex Inquiry and more generally, and how the management of scientific expertise is framed by competing interests in the nuclear industry. The following section examines similar issues from government's perspective.

b) Government's position

There are various levels at which government operates with regard to radioactive waste disposal. In this sub-section I look at the way in which scientific evidence is treated by government both at a national and local level and the weights attached to it. I consider the way in which definitions of risk are constructed and used by government to establish an acceptable level of safety. Additionally I discuss the ways in which different parts of government talked about the geological complexity of the RCF site at the Nirex Inquiry in order to show the difficulty in determining what constitutes sufficient evidence of safety.

It is important to understand the way in which scientific evidence is treated by government in order to see how it is subsequently used in precautionary decision-making. The weight that is placed on scientific evidence in relation to other types of evidence can determine the outcome of a decision. I spoke with a representative from

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[48] Interview 12/12/96, transcript p4

the Radioactive Substances Division of the DoE about this issue and was told that

> 'It's hard to say whether it's equally or whatever ... I don't recall any decision being made that is counter to science but clearly the social views on things may condition a particular course, or a particular decision. But ... it should still be technically sound, but, you know, a particular conclusion you come to will also be conditioned by the wider socio-economic views as well. But ... however much people may like to at times you can't overturn Newton's Laws, you know'.[49]

This illustrates the realist dimension in government thinking, and its need for a formal, logical rationale on which to base decisions. Weighting scientific evidence in this way allows government to justify decisions within this paradigm.

The notion that scientific evidence outweighs other evidence is countered by the following account of the site selection process through which Sellafield was selected as the favoured location for a radioactive waste repository. In this example the County Council feels that insufficient weight was afforded to scientific evidence and that other priorities were dominant. An officer at Cumbria County Council told me that Nirex started looking for a site for co-disposal[50] in 1987 and finally identified Sellafield after a consultation exercise. He maintains that it was BNFL who actually proposed the site. A Multi Attribute Decision Analysis (MADA) was undertaken by Nirex to select the site and the chair of the group, Dr Lawrence Phillips of LSE, was called to give

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[49] Interview 16/10/96, transcript p13

[50] In 1987 the government announced that Nirex was to give up its search for shallow sites and that they would co-dispose of Low Level Waste and Intermediate Level Waste in a deep repository. Interview 20/11/96, transcript p1.

evidence at the public inquiry.[51] Until the Nirex Inquiry none of the MADA process had been made public and it transpired that it hadn't paid much attention to safety. This was due to the fact that it was assumed that all the sites were potentially licensable, and therefore equally safe. The County Council asserted that the Nirex Board, the government and RWMAC put too much weight on evidence of public support at Sellafield and insufficient weight on margins of safety.[52] By using the MADA technique, which is a reputable approach to complex decision-making, Nirex hoped to lend authority to their decision to locate the repository at Sellafield. By concentrating on the lack of weight given to safety criteria Cumbria County Council hoped to bring the whole selection process to task thereby strengthening their claim that Sellafield was not a suitable site for a nuclear repository. This again illustrates the complex ways in which evidence is used by government and other bodies. On one hand national government is saying that scientific evidence will always outweigh other evidence while this example shows this was not the case in the site selection process. Local government, on the other hand, picks up on this lack of the use of scientific evidence to forward their arguments. This case does not, however, reveal government's special role with respect to the specification and definition of risk.

It is the National Radiological Protection Board, which advises government departments on radiological protection issues, that establishes the radioactive dose limits set within waste disposal licenses. These limits classify waste in terms of the

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[51] UK Nirex Ltd (1995). *Proof of evidence of Dr L.D. Phillips: Multi-attribute decision analysis for recommending sites to be investigated for their suitability as a repository for radioactive wastes (incl. figures and tables). Town and Country Planning Act 1990. Town and Country Planning (Inquiries Procedure) Rules 1992. Appeal by United Kingdom Nirex Limited. Rock Characterisation Facility Longlands Farm, Gosforth, Cumbria*: UK Nirex Ltd. 1995.; Stirling, A. (1995). *The Nirex Multi-Attribute Decision Analysis as a justification for the siting of the rock characterisation facility at Sellafield.* London: Greenpeace UK. September 1995.; Greenpeace (1995). *Nirex's rock characterisation facility.* London: Greenpeace. November 1995.

number of people it is likely to kill in a given population. The spokesperson I talked with told me:

> 'So how do you set a limit? – there's no threshold for general cancer. It's set on a balance of risks that people normally take. 10^{-5} is the dose limit. 10^{-6} is set at the level people consider trivial in normal life. It is a balance – and radiation protection is all about that. ... 10^{-6} is a target – it's trivial – no one worries about it. You have to justify anything above it. Anything above 10^{-6} we say is not good enough.'[53]

These are the dose limits and levels of risk that are in standard use currently in the UK. They are used in evidence, for example in public inquiries, to show that these levels of risk from nuclear installations are acceptable. The NRPB's actions and advice are based on this limit and the scientific knowledge and methodology on which it is based, and they are not willing to re-open debate on this issue. Government evidence which relies on this methodology is, however, open to challenge by others who disagree with the acceptability of the risk setting procedure.

In the previous section I showed how industry handled the issue of whether or not the RCF would be excavatable. I now consider the government's position on the same issue. When I spoke to a representative of the Radioactive Substances Division about the Sellafield site's geological complexity I was told that

> '... if it does prove to be sufficiently complex or it's unmodelable and we can't do the safety assessments as a consequence then that's clearly something that's going to preclude giving a authorisation. By the same

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[52]Interview 20/11/96, transcript p2

token I think that a degree of uncertainty is probably inevitable and has to be taken account of when making the judgement.'[54]

This implies that the DoE is waiting for a certain but undefined 'level' of evidence before making a decision about the safety case. The DoE accept that a degree of uncertainty is inevitable but do not indicate how it will be taken into account in making decisions. In contrast to the nuclear industry, which claimed that uncertainty is manageable, the DoE is still awaiting evidence to prove this is the case. They are, however, open to persuasion. It would obviously be impossible for a government to say that authorisation would be given if the safety case was not met, however, it is still not clear what the government would consider to be sufficient evidence to show that the geological safety of the site has been proven.

Cumbria County Council, representing government at a local level, has been vocally opposed to the Nirex application. One of their objections was to the drilling of the boreholes that Nirex had to undertake to obtain preliminary data from the selected site area. A spokesperson from Cumbria County Council told me that this inevitably interrupts the geology of the site.[55] They also pointed out that it could be construed ('by the conspiracy theorists amongst us') that Nirex was very clever in applying for small applications leading up to the full repository as it would then be less likely that future applications would fail.[56] Cumbria County Council suggests that the very act of obtaining data about the site will actually undermine the safety of the site and will

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[53]Interview 27/11/96, transcript p3
[54]Interview 16/10/96, transcript p15
[55]Interview 20/11/96, transcript p2-3
[56] Interview 20/11/96, transcript p3

jeopardise any evidence of safety that might be found.[57]

The Nirex case shows that tensions can exist within different levels of government about the weight and use of scientific evidence. Nonetheless, this section also shows that government has a dominant and decisive part to play in framing the radioactive waste debate by setting out a framework of risk and thereby a framework of what counts as relevant evidence.

c) NGOs' position

Environmental NGOs have to make use of scientific evidence if they are to challenge proposals from government and industry. How do they go about this? In this sub-section I show how evidence about the geological safety of the proposed Sellafield repository site was challenged by the NGOs and how they used conflicting evidence to support their position that the site's safety was still in dispute. I also look at the use of evidence with respect to the balance of power and where the burden of proof lies in

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[57] See ERM - Environmental Resources Management (1994). *Cumbria County Council. Nirex deep repository Post Closure Safety Case: Safety Assessment methodology and safety criteria. Technical Environmental Review TER/3*: ERM. Oct 1994.
ERL - Environmental Resources Limited (1992). *Cumbria County Council. Boreholes and rock laboratories to demonstrate a safety case: response to the October 1992 Rock Characterisation Facility Consultative Document (Nirex Report 327) Interim Technical Appraisal Report ITA/7*: ERL. Dec 1992.
ERM - Environmental Resources Management (1994). *Cumbria County Council. Nirex deep repository at Sellafield: site selection. Technical Environmental Review TER/2*: ERM. Oct 1994.
ERM - Environmental Resources Management (1994). *Cumbria County Council. Nirex deep repository at Sellafield: Assessment of Nirex Geological Investigation and Science Programme. Technical Environmental Review TER/4*: ERM. Oct 1994.
ERM - Environmental Resources Management (1994). *Cumbria County Council. Best Practicable Environmental Option (BPEO) for radioactive wastes: issues relating to storage, late disposal or early disposal. Volume 2: Annexes. Volume 1: Report. Technical Environmental Review TER/1*: ERM. Oct 1994.
ERM - Environmental Resources Management (1993). *Cumbria County Council. Summary of radioactive waste disposal policy and environmental issues affecting Cumbria. Interim Technical*

debates and decision-making as conventionally structured.

At the Nirex Inquiry, those opposing the planning application challenged the possibility of determining the geological suitability of the site given that the explosives used to excavate the Rock Characterisation Facility would upset the natural characteristics of the rock at the site. If it could be determined that the excavation process would have an adverse impact on the very material under investigation then the case of the opposition would be strengthened.[58] In addition to the geological evidence being disputed, information was also provided about the hydrology at the site which indicated that there could be serious repercussions if groundwater was able to find its way into the burial chambers and then leach out into the surrounding area.[59]

One of the controversies was whether 2-dimensional computer models, as used by Nirex, were sufficient to illustrate the flow of water through the ground beneath the site. Friends of the Earth maintained they were not and that 3-dimension models should be used. I had been reminded by a spokesperson from the NRPB that any model is only as good as the data put into it and that in this case the more complicated the model the more information you need.[60] The 3-dimensional models required much more data, only some of which was 'raw'. In this field it is not always possible to know what data is real and what is extrapolated for many models rely on recycling results they have previously generated. This helps explain why Nirex and Friends of

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Appraisal Report ITA/9: ERM. Oct 1993.

[58] See Western, R. (1994). *Undermined: the destruction of safety assessment data through RCF excavation*. London: Friends of the Earth. August 1994.

[59] See Haszeldine, R.S. and Smythe, D.K., (eds) (1996). *Radioactive waste disposal at Sellafield, UK: site selection, geological and engineering problems*. Glasgow: Glasgow University Print Unit.

[60] Interview 27/11/96, transcript p2

the Earth hold opposing positions about the type of model most appropriate for predicting safety. Nirex want and need to make their case as clear and straightforward as possible and Friends of the Earth want to undermine the Nirex safety case. By pointing out that Nirex's 2D models cannot hope to emulate all the complexities of the site Friends of the Earth challenges Nirex's analysis of suitability. By referring to the value of 3D modelling Friends of the Earth highlight their contention that the hydrogeology of the site is extremely complex and that it is impossible to know what will happen at the site for hundreds and thousands of years to come. Friends of the Earth refers to the relevance of a more complex methodology to undermine Nirex's position by claiming it is too simplistic.

As I have already discussed, one of the disputes at the Nirex Inquiry was whether radioactive waste should be capped and sealed forever or whether it should be monitorable and retrievable. In the sub-section relating to industry I outlined Nirex's position on this issue and here I contrast that with Greenpeace's position. Greenpeace argued that waste which has already been created needs to be managed in a monitorable and retrievable form so that there is no need to make predictions about discharges because real data always exist.[61] Greenpeace made an argument about giving future generations a choice in order to support this position. They believe that under this scenario future generations will be better informed than if waste is buried and sealed. Greenpeace was pointing out that not enough is known about the full range of options in order for a final decision to be made and that a more detailed discussion must take place before any options are ruled out.

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[61]Interview 26/11/96, transcript p3

Greenpeace has always favoured above ground storage. Dr Helen Wallace, Senior Scientist at Greenpeace told me:

> 'Underground means there will be discharges into the environment. The concept in people's minds is that deep disposal is geological containment that locks away the waste forever. Then the question becomes what can be done. Above ground storage for 100 years or so – but that is intergenerational. It's a reason to shut down the nuclear industry.'[62]

By indicating that deep disposal is not an ultimate solution that gets rid of the problem of radioactive waste Greenpeace attempts to reopen the debate and refocus attention. The strategy employed here is to illustrate the way in which evidence allowed at the inquiry is curtailed because of previous decisions. Greenpeace wants to reopen debate about preferred options for radioactive waste management and is not satisfied with the prospect of merely looking at evidence about whether a selected site is 'safe enough' or not.

One of the reasons why NGOs seek to redefine the terms of debate has to do with where the burden of proof lies with regard to making the safety case, both for the preferred policy option and for the chosen site. Opponents of the nuclear industry argue that currently the burden of proof lies in favour of the industry and that it is necessary for this position to change if the environment and the public are to be protected. They believe that when evidence is disputed the industry is already in a stronger position to win the controversy. A representative of Greenpeace told me that

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[62]Interview 26/11/96, transcript p3

while it is impossible to prove safety from a scientific perspective it is possible to prove safety from a legal perspective by addressing the weight of evidence on each side.[63] By bringing in a legal definition of the weight of evidence Greenpeace seeks to destabilise the traditional platform through which decisions are made based on scientific criteria and to redefine the decision.

In this sub-section I have shown how NGOs use scientific evidence, and how they try to reframe or reopen debates assumed to be closed by other actors.

To summarise, in this section on disputed evidence, I have demonstrated that the future of radioactive waste is contentious. I have considered questions about the nature of evidence deployed in such cases: does evidence exist or not?; is there evidence that a course of action is safe or not?; how is evidence used to show that a proposed strategy is the best option? Taking the Nirex Inquiry as an example I have shown that industry presented its evidence in such a way as to show that it can handle the scientific uncertainties that arise. Where 'scientific evidence' reveals a 'problem', industry may then deny responsibility for actions which have led to contamination. I have shown with regard to government that weight is shifted between scientific evidence and other priorities depending on the situation. While national government advocates that scientific evidence should not necessarily be the determining factor in decision-making it is typically used as such. Finally, with regard to NGOs, I have demonstrated how they have used evidence to advance their positions. They have tried to use scientific evidence to undermine the opposition while also challenging the

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[63]Interview 26/11/96, transcript p2

assumptions underlying the policies and frameworks that define current practice.

Decision-making Processes

This chapter has mainly, although not exclusively, centred on the Nirex Inquiry. In order to tie together the previous sections identifying the cast of institutional interests involved and evidence, I now look in more detail at approaches to the formal organisation of decision-making about radioactive waste disposal. Here I describe the processes involved in a public inquiry. The objective is to show how decisions are negotiated and agreement reached, rather than to evaluate the outcome.

Scientific uncertainty lies at the root of disagreements about the way evidence is defined and used. However, in terms of the public inquiry uncertainty is an underlying concept that is explicated through rhetoric about definitions and evidence rather than being a concept that is openly and explicitly discussed as an issue in its own right. The concept of time is rather different, although also critical. There is, for instance, a timeframe available in which decisions must be made. Time is also of importance in the radioactive waste decision-making process due to the inter-generational timeframes associated with life of radioactive waste itself. It is necessary therefore to look at this theme in more detail in relation to the public inquiry in question.

The problem of the longterm nature of radioactive waste was brought to a head at the public inquiry. It is instructive to look at this in relation to the cast of issues and voices involved in the inquiry. Radioactive waste will be around for a long time. The element plutonium has a half-life of 24,000 years, a time concept that does not easily fit into our normal decision-making timeframes. The issue of whether plutonium is defined as an asset or a waste product has already been discussed and has been seen to depend on the interests of the player doing the defining. However, regardless of the status afforded it, decisions regarding its management will still have to be made in current decision-making timeframes. This creates an anomaly as regards the length of time available to conduct any more research, the timing of which reflects political and pragmatic considerations, and the kind of time scales that would have to be understood in order to make fully informed decisions. This is one of the issues the public inquiry has to balance, and one which is critical to the interpretation and implementation of precaution.

At a public inquiry each group vies for as much time as possible to put their views on the agenda. However the inquiry is regulated with set procedures and protocols which establish running orders and the kinds of questions that can be directed at witnesses and the types of evidence that can be presented. Once all the evidence has been presented and all the cross-examinations have taken place the Inspector then writes his or her report to submit to the Secretary of State. This can take months with all the interested parties awaiting a decision while being unaware of when that decision will be announced.

As previously discussed, the Nirex Inquiry was undertaken to determine whether Nirex should be given planning permission to construct an RCF at Longlands Farm in Cumbria. This inquiry involved all the players previously mentioned and each of these brought forward evidence (with attendant definitions) to try to persuade the

Inspector of their position. The Nirex Inquiry opened in September 1995 and ran until February 1996 but even before it started different groups were involved in the debate, putting forward their views through published reports and the media. Therefore by the stage the 'official' centre for debate opened (the Inquiry itself) many of what subsequently became the main players had already been identified.

The inquiry gave different groups the opportunity to dispute each others evidence and reopen previously closed controversies. The limitations of this process were set by the Inspector who has the authority to determine what evidence is acceptable and what should be given more weight. His decisions were informed by his knowledge of planning law and precedence about what is acceptable at an inquiry and what is not.

Knowledge of the planning system can also be used by the applicants and their opponents. By applying for planning permission for a Rock Characterisation Facility rather than a radioactive waste repository Nirex was claiming that this would help establish the true character of Sellafield's geology which was, as yet, incompletely understood. Nirex assumed the Rock Characterisation Facility would help prove the safety case for the repository that would subsequently be built. Nirex was very aware of public resistance to the building of a repository and so developed a strategy whereby planning permission would be sought in stages. The first major stage of this was the application for the RCF.[64] Because the RCF was not to be a radioactive waste disposal facility the planning process automatically excluded certain players and certain types of evidence. It was fortunate for the opposition that the Inspector took a

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[64] Previous applications had been applied for and granted for bore-holes in the area to obtain

broad view of relevance and decided to allow all evidence to be given.

For Nirex, the inquiry was viewed as a platform from which to convince the government and anyone else who opposed them that the Rock Characterisation Facility was small, temporary and necessary. Nirex claimed that information about the suitability of other potential sites was irrelevant to this inquiry because that decision had already been made. Re-visiting the site selection process would hold up their timetable of subsequent action. Nirex preferred to treat site selection as a closed black box. Cumbria County Council, on the other hand, was very keen to re-open that black box by claiming that Longlands Farm was a poor site and chosen for the wrong reasons. By re-opening controversy over the selection process, Cumbria County Council wanted to draw attention to the politics involved, as well as questioning the geological unsuitability of the site. One of Nirex's reasons for choosing the site was because it expected that the local population would be in favour because of local reliance on the nuclear industry for employment.

Debate at the inquiry concentrated on areas of expert knowledge in the fields of geology, hydrogeology, geophysics and engineering. Both Nirex and those in opposition to the application obtained expert witnesses who were called to give evidence. The public inquiry system is a formal process whereby evidence is submitted in advance of the inquiry. Those who submit evidence in advance can then present that evidence at the inquiry and call witnesses to support their position. It excludes many who might wish to give evidence but are unable to do so because of the

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preliminary data on the geology of the site.

formalities involved with submission dates, the technical competence required of those who do give evidence, the time involved in compiling evidence and the knowledge of what is the remit of the inquiry and whether this remit can be challenged. However it also provides the space for those with appropriate resources who are willing to challenge the wishes and desires of large corporations. Assuming adequate resources, both in time and finances, all parties have a chance of persuading the Inspector of their case.

However, due to time constraints inherent within the planning process certain questions cannot be revisited. For example, the issue of whether nuclear power is necessary at all was not addressed at the Nirex Inquiry, nor was there scope for raising the issue of reprocessing which contributes significantly to the creation of nuclear waste. These are questions that are addressed in other, also formal, settings, possibly at other public inquiries.[65] In these situations similar constraints limit participation in the decision-making processes, certain parties will be involved in the discussions and certain parties will be excluded and certain evidence will be ruled relevant while other

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[65] One of these settings is the House of Lords. In November 1997 the House of Lords issued a call for evidence into the management of nuclear waste House of Lords (1997). Select Committee on Science and Technology Sub-Committee II - The Management of Nuclear Waste. Call for Evidence:2. p1-2. They set fairly tight boundaries around what would and wouldn't be the focus of the inquiry. They wanted to hear about international experience with radioactive waste management but ruled out an inquiry into the future of nuclear power *per se*. They wanted to hear about sustainable solutions and how the institutional responsibility for radioactive waste in this country could be improved and whether an international solution might be desirable and feasible. They also wanted to consider the site selection process for a potential repository and what criteria that process should be based upon. Additionally they asked for submissions on how risk could be assessed and the effects on intergenerational equity. This call for evidence was sent out to a wide range of institutions and was also published on the internet. Anyone, whether an individual or an institution could respond to it. Submissions were due by 30 January 1998. The Select Committee called witnesses to elaborate on their submissions. Friends of the Earth used the inquiry to reiterate some of their opinions about MOX (Mixed Oxide Fuel) which is produced at Sellafield and also to emphasise the point that the institutional bodies responsible for long-term management are committed to additional production. Their aim was to influence the Committee to view radioactive waste in the wider framework of nuclear power rather than as a separate entity. They believed that by seeing the whole picture the Lords Committee would be more likely to come to the

evidence will be ruled irrelevant.

It is the Secretary of State who makes the final decision at a public inquiry, based on the report written by the Inspector. In the statement issued by the Secretary of State following the Nirex Inquiry he expressed concern

> '... about the scientific uncertainties and technical deficiencies in the proposals presented by Nirex which would also justify refusal of this appeal. I am also concerned about the process of site selection and the broader issue of the scope and adequacy of the environmental statement.'[66]

This demonstrates that the evidence and counter-evidence presented at the Nirex Inquiry on the issues discussed in the sections on definitions and evidence were significant in determining the outcome of this particular inquiry.

Summary

This chapter began with an explanation of why the radioactive waste management issue was a suitable topic for a case study of the precautionary principle. Decisions about radioactive waste have been made within well-established frameworks and the key players involved are easily identifiable due to the subject's long history. Having identified the cast of players involved in the radioactive waste management debate I was able to categorise them along institutional lines. Despite a common precautionary

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opinion that further production of radioactive waste should cease.
[66]Quoted in Kelling, G. and Knill, J. (1997). The Nirex Story: a geological perspective. *Geoscientist* 7, (7): 10-13. p13

umbrella, derived from national legislative commitments, it became apparent that the interests of different government departments might clash due to their differing legislative obligations. It was also clear that there are two significant industrial players whose existence depends on the continued existence of nuclear facilities. The sub-group of NGOs is also prominent due to their united stance against nuclear power in general and their criticism of the handling of radioactive waste.

In the sub-section that followed I showed how these interest groups interact, and how the themes of precaution that I identified in chapter two were very present in debates at the public inquiry despite there being little specific reference to the precautionary principle itself. I used interview material about the Nirex Public Inquiry to show how positions on evidence, uncertainty and risk differed in practice. By looking at the way in which definitions were created and used I was able to show how positions were strengthened as terms were re-defined to fit institutional agendas. Each had different ways of defining plutonium, seeing it as an asset, a waste product or weapons material. Similarly, quantities of waste were talked about in terms of volumes or in terms of half-lives. Subsequently I identified how evidence is used and what counts as evidence for each of the three institutional groups. Each of these groups had different interpretations of evidence that they felt were most important to the making of their case at the inquiry. This has important implications for the 'precautionary principle' since it suggests that the potential implications of the 'principle' multiply in practice. In other words, there are as many forms of precaution as there are interpretations of evidence.

Finally I showed how the process of the public inquiry system functions and how various types of 'evidence' are marshalled and deployed. The public inquiry provided a platform for particular voices and interests while excluding others. As might be expected it can be manipulated and managed by those who are familiar with its workings.

The public inquiry functions as a 'machine' for managing decision-making and in doing so measurably, if inadvertently, frames debates and agendas in particular ways. As we'll see in chapter seven, this formalised system positions the issue of precaution within a highly structured bureaucratic environment in which scientific and administrative rationality dominate.

Chapter Six

Endocrine Disrupting Chemicals

'For the first time in the history of the world, every human being is now subjected to contact with dangerous chemicals, from the moment of conception until death. In the less than two decades of their use, the synthetic pesticides have been so thoroughly distributed throughout the animate and inanimate world that they occur virtually everywhere. They have been recovered from most of the major river systems and even from streams of groundwater flowing unseen through the earth. Residues of these chemicals linger in soil to which they may have been applied a dozen years before. They have entered and lodged in the bodies of fish, birds, reptiles and domestic and wild animals so universally that scientists carrying on animal experiments find it almost impossible to locate subjects free from such contamination. They have been found in fish in remote mountain lakes, in earthworms burrowing in soil, in the eggs of birds – and in man himself. For these chemicals are now stored in the bodies of the vast majority of human beings, regardless of age. They occur in the mother's milk, and probably in the tissues of the unborn child.'[1]

[1] Carson, R. (1962). *Silent spring*. Boston, MA: Houghton Mifflin Company. p15-16

Introduction

It is not possible for individuals to minimise their exposure to manmade chemicals due to their presence in water, food and other everyday products. Even in parts of the world where particular chemicals have never been used traces of them can be found due to dispersal by the winds, the sea and through the food chain. Problems regarding toxicity have a long history and are only partially resolved. A relatively new problematic characteristic, which has been identified in some chemicals and is suspected in others, is endocrine disrupting behaviour. Endocrine disruption is the situation whereby the hormone systems of wildlife and humans are being detrimentally affected and this can lead to physical and sexual developmental problems and abnormalities. This in turn may lead to reproductive difficulties for affected individuals or species. This may have significant effects when considered alongside the wide-ranging dispersal of manmade chemicals.

Many studies have indicated that the endocrine systems of humans and wildlife have been affected. It has been reported that sperm counts have decreased in men over the last 50 years.[2] Giwercman has shown an increase in genitourinary abnormalities, cryptorchidism (undescended testicles), hypospadia (abnormal urethral opening) and

[2] Carlsen, E., Giwercman, A., Keiding, N., and Skakkebaek, N.E. (1992). Evidence for decreasing quality of semen during past 50 years. *British Medical Journal* 305, (6854): 609-613.; Irvine, D.S. (1994). Falling sperm quality. *British Medical Journal* 309: 476.; Ginsburg, J., Okolo, S., Prelevic, G., and Hardiman, P. (1994). Residence in the London area and sperm density - letter. *Lancet* 343, (8891): 230.; Carlsen, E. and al., e. (1995). Declining semen quality and increasing incidence of testicular cancer: is there a common cause? *Environmental Health Perspectives* 103, (suppl 7): 137-139.; Auger, J., Kuntsman, J.M., Czyglik, F., and Jouannet, P. (1995). Decline in semen quality among fertile men in Paris during the past twenty years. *New England Journal of Medicine* 332, (5): 281-285.; Irvine, S., Cawood, E., D, R., E, M., and J, A. (1996). Evidence of deteriorating semen quality in the United Kingdom: Birth cohort study in 577 men in Scotland over eleven years. *British Medical Journal* 312, (7029): 467-471.

testicular cancer.[3] Berger has shown that young girls are reaching puberty earlier and that the incidence of endometriosis (the appearance of the tissue lining of the womb outside the womb) is increasing.[4] Bradlow discusses the effects that pesticides can have on the incidence of breast cancer.[5] Chemicals which have been released into the environment have been shown to bind to intracellular receptor proteins for steroid hormones[6] and evoke hormonal effects in animals[7], humans[8], and cell culture.[9] Laboratory experiments have demonstrated that exposure of foetuses to endocrine-disrupting chemicals can profoundly disturb organ differentiation[10] because they act as hormone agonists or antagonists. Colborn says that exposure to endocrine disrupters

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[3] Giwercman, A., Carlsen, E., Keiding, N., and Skakkebaek, N.E. (1993). Evidence for increasing incidence of abnormalities of the human testis: a review. *Environmental Health Perspectives* 101, (supplement 2): 65-71.

[4] Berger, G. (1994). *Epidemiology of endometriosis: modern surgical management of endometriosis.* New York: Springer-Verlag. Cited in Birnbaum, L.S. (1994). Endocrine effects of prenatal exposure to PCBs, dioxins and other xenobiotics: implications for policy and future research. *Environmental Health Perspectives* 102, (8): 676-679. p676

[5] Bradlow, H.L., Sepkovic, D.W., Telang, N.T., Tiwari, R., Davis, D., and Osborne, M.P. (1996). Effects of chlorinated pesticides on estrogen metabolism and breast cancer risk. Effects of organochlorines on human health workshop: Academic Medical Centre, University of Amsterdam. .

[6] Korach, K.S., Sarver, P., Chae, K., McLachlan, J.A., and McKinney, J.D. (1988). Estrogen receptor-binding activity of polychlorinated hydroxybiphenyls: conformationally restricted structural probes. *Molecular Pharmacology* 33, (1): 120-126.

[7] Gray, L.E., Ostby, J., Ferrell, J., Rehnberg, G., Linder, R., Cooper, R., Goldman, J., Slott, V., and Laskey, J. (1989). A dose-response analysis of methoxychlor-induced alterations of reproductive development and function in the rat. *Fundamental and Applied Toxicology* 12, (1): 92-108.; Soontornchat, S., Li, M.-H., Cooke, P.S., and Hansen, L.G. (1994). Toxicokinetic and toxicodynamic influences on endocrine disruption by polychlorinated biphenyls. *Environmental Health Perspectives* 102, (6-7): 568-571.

[8] Guzelian, P.S. (1982). Comparative toxicology of chlordecone (kepone) in humans and experimental animals. *Annual Review of Pharmacology and Toxicology* 22: 89-113.; van Loveren, H., de Heer, C., Ross, P.S., and Vos, J.G. (1996). Immunotoxicity: studies in rats, wildlife populations and man. Effects of organochlorines on human health workshop: Academic Medical Centre, University of Amsterdam. .; Sharpe, R.M. and Skakkebaek, N.E. (1993). Are oestrogens involved in falling sperm counts and disorders of the male reproductive tract? *The Lancet* 341: 1392-1395.

[9] Soto, A.M., Justicia, H., Wray, J.W., and Sonnenschein, C. (1991). para-nonyl-phenil: an estrogenic xenobiotic released from 'modified' polystyrene. *Environmental Health Perspectives* 92: 167-173. Cited in Colborn, T., vom Saal, F., S, and Soto, A.M. (1993). Developmental effects of endocrine-disrupting chemicals in wildlife and humans. *Environmental Health Perspectives* 101, (5): 378-384.; Soto, A.M. and al, e. (1995). The E-SCREEN assay as a tool to identify estrogens: an update on estrogenic environmental pollutants. *Environmental Health Perspectives* 103, (Supplement 7): 113-122.

[10] Gray, L.E. (1992). Chemical-induced alterations of sexual differentiation: a review of effects in humans and rodents. In, Colborn, T. and Clement, C., (eds), *Chemically induced alteration in sexual and functional development: the wildlife/human connection*:203-. Princeton, NJ: Princeton Scientific Publishing.; Peterson, R.E., Theobald, H.M., and Kimmel, G.L. (1993). Developmental and reproductive toxicity of dioxins and related compounds: cross-species comparisons. *Critical Reviews in*

during critical periods of development is of major concern as it may have profound and permanent effects on the future well-being of wildlife and humans. She also states that chronic exposure after maturity can also present a health risk.[11] Whilst these studies suggest that there may be a problem with the reproductive health of humans and wildlife, many in government and industry do not believe the evidence is sufficient to warrant taking action against particular chemicals.

Characteristics of Endocrine Disrupting Chemicals

In this chapter I outline the features of the endocrine disruption problem relevant to how scientific advice is used in policy making and how decision-making frameworks are structured. I give a brief history of the development of endocrine disruption as an 'environmental issue' and identify the scientific studies that have been drawn upon in the debate about the need for precautionary policy and further research. I show that viewpoints on what action is appropriate range from 'doing more research' to banning whole families of chemicals.

Because the career of endocrine disruption as an environmental issue is at a much earlier stage of development than radioactive waste disposal I am able to look at deliberations about endocrine disruption from the point where the UK government is starting to wonder whether this is an issue that will require policy action. In the section on decision-making processes I show that there have, as yet, been no decisions about endocrine disrupting chemicals. I describe contributions to two workshops that

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Toxicology 23, (3): 283-335.

[11]Colborn, T., vom Saal, F., S, and Soto, A.M. (1993). Developmental effects of endocrine-disrupting

have played a central role in the emergence of a debate about endocrine disruption, the Institute of Environment and Health workshop on environmental oestrogens in January 1995 and a later round-table discussion on environmental oestrogens held in April 1996. Both of these workshops were commissioned by the Department of the Environment and both set the background against which I selected and conducted my interviews.

By looking at the positioning of these workshops I show that the focus of discussion was on scientific research studies and that debate about whether action should be taken with regard endocrine disrupting chemicals was framed around issues of scientific uncertainty, weight of evidence and the definition of terms.

I then look at the nature of evidence as used by participants at those workshops, and by my interviewees. In the section on definitions I discuss the contention that has arisen about endocrine disrupters and *potential* endocrine disrupters and show that the term 'endocrine disrupter' is often used as a boundary object, with each user assuming that others all mean the same thing. I demonstrate that even when consensus is reached about a definition that does not close controversy over the meaning of a term; in actuality, one definitional issue leads to another.

I also look at the question of what constitutes sufficient evidence and discover that this depends on who is answering the question. I consider the different opinions on the issue of *in vivo versus in vitro* tests as evidence of endocrine disruption and I look at the arguments put forward by different interest groups regarding 'taking action

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chemicals in wildlife and humans. *Environmental Health Perspectives* 101, (5): 378-384.

against' specific chemicals.

The purpose of this chapter is to show how particular identified 'experts' have embedded interests which they bring with them to the negotiation table. The positions they argue from reflect these embedded interests whilst attempting to maintain an appearance of open-mindedness. By describing this scene I create the space to analyse, in the following chapter, the similarities and differences between radioactive waste disposal and endocrine disrupting chemicals as issues to which the precautionary principle could and should be applied.

Formulating the Debate

The endocrine disrupting chemicals case study is unlike the radioactive waste case discussed in the previous chapter in that there have been no actual 'decisions' made as to what action should be taken about them.[12] Whereas, with the radioactive waste problem I was able to focus on a public inquiry, the outcome of which was a decision not to allow the creation of a Rock Characterisation Facility, with the endocrine disrupting chemicals problem there is no similarly obvious moment of precautionary decision-making. This may partly be due to the fact that there is currently less

[12] This situation has developed and changed since I undertook my fieldwork in 1997 about endocrine disrupting chemicals. In 1998 the Environment Agency undertook a public consultation to seek views on what actions should be taken with regard endocrine disrupting substances in the environment (see Environment Agency (1998). *Endocrine-disrupting substances in the environment: what should be done?* Bristol: The Environment Agency. January 1998.) and the Department of the Environment, Transport and the Regions undertook a public consultation to seek views on ways in which a more precautionary approach to chemicals in the environment might be taken (see Department of the Environment, Transport and the Regions (1998). *Sustainable production and the use of chemicals: consultation paper on chemicals in the environment.* London: DETR. July 1998.). However, I limit my discussion to the situation prior to 1998 and justify this by saying that this timeframe provides a snapshot of an 'environmental problem' at a particular stage in its career and that it is the different stages that a 'problem' goes through that are shown in this thesis to be relevant with respect to how the

consensus that there is even a problem with regard to endocrine disrupting chemicals. When we look at the current locations of debate about what should be done about endocrine disrupting chemicals we find ourselves looking at workshops and conferences, places where options and alternatives are discussed but not where decisions are made. Some of these workshops have resulted in consensus statements and recommendations for further research, but they have not had any legal power attached. It is important to point out at this stage that it is the process through which decisions come about that it of importance to this thesis rather than the decision outcomes. With this in mind the workshops and conferences mentioned above take on greater importance as they are the forerunner to more established frameworks where decisions can be made and therefore they help set the boundary of what 'the problem' is.

In 1994 the Department of the Environment commissioned the Medical Research Council's Institute for Environment and Health at Leicester University[13] to review existing literature and scientific opinion on the possible links between the production and release of manmade chemicals into the environment and oestrogenic effects on humans and wildlife in order to get a balanced perspective on the issue with a view to developing an effective Departmental policy.[14] I focus on this and a later workshop run by the Institute for Environment and Health because at this time endocrine disruption was only just surfacing as 'an issue' of environmental and public concern

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precautionary principle might be applied.

[13] The Institute for Environment and Health was established in 1993 and is partly funded by the Department of the Environment, the Department of Health and other Government Departments and Agencies by way of specific research and consultancy contracts (Institute for Environment and Health (1995). *IEH assessment on environmental oestrogens: consequences to human health and wildlife.* Leicester: Institute for Environment and Health.)

[14] Department of the Environment (1995). Environmental oestrogens: assessment of international research shows the way forward - newsrelease 376:9: Department of the Environment.

and this commission was proposed in response to growing concerns about the possible impacts of oestrogen-mimicking chemicals on the reproductive health of human and wildlife populations.

A workshop designed to fulfil this task took place in Leicester in January 1995 and the resultant report was published in July 1995.[15] The objectives of this assessment were stated as follows:

> '[to] review existing literature and scientific opinion on the evidence for changes in human reproductive health and effects in wildlife, and to examine possible links between the production and release into the environment of man-made chemicals and the observed effects, *and* identify the gaps in knowledge, information and research that need to be filled and to make recommendations and establish priorities for future research, addressing in particular those areas which will provide the best information for policy decisions.'[16]

In order to fulfil these objectives the Institute prepared background scientific review papers on the effects of environmental oestrogens in humans and wildlife. They then invited

> '...acknowledged international experts in the field, together with representatives from a number of government and other interested organisations, to discuss these documents at a workshop...'[17]

The final report concluded that:

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[15] Institute for Environment and Health (1995). *IEH assessment on environmental oestrogens: consequences to human health and wildlife*. Leicester: Institute for Environment and Health.
[16] Institute for Environment and Health (1995). *IEH assessment on environmental oestrogens: consequences to human health and wildlife*. Leicester: Institute for Environment and Health. p1
[17] Institute for Environment and Health (1995). *IEH assessment on environmental oestrogens:*

'Proof of a cause-effect relationship between exposure to oestrogens in the environment and adverse effects on human reproductive health is likely to remain elusive. Similarly it may not be possible to identify conclusively which agents, acting singly or in combination, are responsible for adverse effects in wildlife populations.'[18]

The conclusion continues by recommending that further human, wildlife and experimental studies are required before a risk assessment of the risks to human health from environmental oestrogens can be made.

The 'acknowledged international experts' who took part in the IEH workshop included those who had participated in previous international scientific workshops.[19] The participant list[20] reflects a high level of participation from government and academia with a much smaller representation from interest groups and industry.[21]

In February 1995 WWF wrote about their concerns about who would be involved in the proposed workshop:

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consequences to human health and wildlife. Leicester: Institute for Environment and Health. p2

[18] Institute for Environment and Health (1995). *IEH assessment on environmental oestrogens: consequences to human health and wildlife.* Leicester: Institute for Environment and Health. p70

[19] Workshops to discuss the link between oestrogenic activity and a number of environmental contaminants had been convened by the Danish Environmental Protection Agency, the German Federal Environment Agency and the United States Environmental Protection Agency.

[20] Dr G Brighty, National Rivers Authority; Dr A Cassidy, Dunn Clinical Nutrition Centre; Dr A Dawson, Institute of Terrestrial Ecology; Dr J Ginsburg, Department of Medicine, Royal Free Hospital; Prof L J Guillette, University of Florida; Dr S Jobling, Brunel University; Dr R J Kavlock, United States Environmental Protection Agency; Dr M Litchfield, Melrose Consultancy; Prof J McLachlan, Tulane University; Dr P Matthiessen, MAFF Fisheries Laboratory; Dr S Milligan, King's College; Dr D Peakall, King's College; Dr A Poole, DOW Europe SA; Prof S H Safe, Texas A&M University; Prof N Skakkebaek, national University Hospital, Copenhagen; Dr A Smith, MRC Toxicology Unit; Dr R Thompson, Zeneca Ltd; Dr J van Zorge, Directorate-General for the Environment; Dr I White, MRC Toxicology Unit; Prof C Wilson, St George's Hospital Medical School; Dr R Otter, Ms M Thomas, Mr R Tregunno, Department of the Environment; Dr S Barlow, Department of Health; Dr P T C Harrison, Dr C D N Humphrey, Dr L K Shuker, Prof L Smith, Institute for Environment and Health.

[21] See Appendix 3 for a list of groups and their particular interests and responsibilities with regard to endocrine disruption.

> 'A small technical group was expected to provide a direction for the review and the Institute was planning to hold a meeting to bring the technical experts together. However, in November 1994 it seemed that within some government departments and universities several people were unaware of the initiative.'[22]

National environmental groups who had been very involved in this issue and had published reports about endocrine disruption are conspicuous by their absence.[23] Given the stated objectives of the workshop, including such voices may have focused the discussion and resulting report in an alternative direction to the one it took. The result of the workshop has therefore been a very scientistic and academic appraisal of current research, identifying particular ongoing scientific studies (indeed many of the participants are academics currently undertaking some of these projects) and determining future scientific studies that may be necessary. By framing the workshop in this way the IEH has prevented wider discussion about the use of science as a decision-making aid and its limitations given inherent uncertainties. These areas of discussion might also have fallen within the remit of the workshop. Excluding voices concerned with sustainability, community participation, social responsibility and justice has meant that the debate has remained within a conventional scientific paradigm. Narrowing the focus of the debate in this manner at this stage has had implications for, and defined the scope of, future workshops and research priorities.

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[22] Lyons, G. (1995). *Reassessing pollution: wildlife, humans and toxic chemicals in the environment.* Godalming: WWF UK. February 1995. p4

[23] See for example Lyons, G. (1995). *Reassessing pollution: wildlife, humans and toxic chemicals in the environment.* Godalming: WWF UK. February 1995.
WWF (1995). *Atrazine: an organochlorine herbicide.* Godalming: WWF. May 1995.
Warhurst, M. (1995). *An environmental assessment of alkylphenol ethoxylates and alkylphenols.* Edinburgh: Friends of the Earth Scotland. January 1995.
WWF (1994). *The right to know: the promise of low-cost public inventories of toxic chemicals.* Washington, DC: WWF. 1994.; Greenpeace (1994). *Achieving zero dioxin: an emergency strategy for dioxin elimination.* London: Greenpeace.

Not only did the IEH select the participants for this workshop, they also prepared a set of background scientific review documents on the effects of environmental oestrogens in humans and their impact on wildlife. These were distributed to all participants prior to the workshop. These documents then became a central part of the ensuing report. A distinguishing feature of the commentary on the scientific literature was that where uncertainty exists, more study and analysis is required to establish the mechanisms involved. The participants at the workshop therefore had a stage set in front of them where the props were already in place. The IEH decided who the actors would be although the actors each brought their own story lines with them. These lines reflected individual, institutional or research disciplines. This was to be expected for these were the grounds on which participants were selected. Other aspects, such as the necessity of particular chemicals, the rights of individuals to determine what goes into their bodies, and acceptance of predetermined levels of risk with regard to environmental oestrogens were not to be considered and no background papers referring to these issues were circulated.

It was only following publication of the report that some of the excluded voices were able to voice their opinions about the scope of the workshop. *ENDS Report* includes comments by Friends of the Earth, WWF, the Chemical Industries Association and the British Plastics Federation, none of which participated in the workshop, and states that

> 'the review is in danger of understating the full force of the scientific argument behind current concerns because of its focus on gaps in the evidence.'[24]

[24] ENDS Report (1995). DoE report understates evidence of oestrogen pollution. *ENDS Report* 246: 2. p1

In the following section on the nature of evidence I address the issue of scientific knowledge and how it is used in areas of controversy around endocrine disrupting chemicals. I look at the evidence that my interviewees identify as being relevant and important to discussions about endocrine disruption. In this section I continue by setting out the background against which my interviews took place and thereby establishing the justification for interviewing the individuals I selected.

In a press release put out by the Department of the Environment, the Conservative Environment Secretary, John Gummer, welcomed the IEH report saying:

> 'In commissioning this independent assessment last year the Government recognised the growing concerns about environmental oestrogens. ... It gives us a sound basis for taking forward our policies and reinforces the need for further research to clarify whether real problems exist.'[25]

The Government's response, as stated in this press release, was that:

> 'In line with the Government's commitment to the precautionary principle, we will be considering carefully the implications and recommendations for research. ... As a result of current environmental policy, controls are already in place to limit releases of chemicals into the environment and their presence in food. ... The report provides no justification for any immediate additional action on any particular chemicals. However the Government will reconsider this ... if and when further scientific evidence is available.'[26]

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[25] Department of the Environment (1995). Environmental oestrogens: assessment of international research shows the way forward - newsrelease 376:9: Department of the Environment. p1
[26] Department of the Environment (1995). Environmental oestrogens: assessment of international

It appears from this statement that the Government is basing a lot of its justification for not taking any further action on endocrine disrupting chemicals on the conclusions and recommendations of this report. This bring further into question why particular voices were included in and omitted from participation.

Three months after their assessment report came out, the Institute for Environment and Health held a planning meeting to discuss the organisation of a 'round table discussion meeting on environmental oestrogens' which would be held in April 1996. This round-table meeting was part of an ongoing programme of work commissioned by the Department of the Environment.[27] The planning meeting of 30 October 1995 was attended by eight people: Professor Lewis Smith (Director of the Institute for Environment and Health), Dr Paul Harrison and Dr Charles Humphrey (IEH), Ms Ruth Stringer (Greenpeace), Ms Gwynne Lyons (WWF), Mr Roger Lilley (Friends of the Earth), Dr Michael Warhurst (Friends of the Earth Scotland) and Dr Linda Smith (Department of the Environment). At this meeting Ruth Stringer asked what the ultimate purpose of the round-table meeting was and how it would contribute to either research activities or government policy. Lewis Smith responded that reports published subsequent to the IEH Assessment would be discussed and Linda Smith added that the Department of the Environment was keen to take all views into account when formulating policy which would be developed in the areas where Britain could have influence.[28] The purpose of the meeting was proposed as being a forum for the exchange of views in order to identify both areas of agreement and the key research

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research shows the way forward - newsrelease 376:9: Department of the Environment. p2

[27] Medical Research Council (1996). Institute for Environment and Health round table discussion meeting on environmental oestrogens: environmental groups, industry and government agree on priorities for action on environmental oestrogens - press notice:3. p2

[28] Institute for Environment and Health (1995). Environmental Oestrogens - a planning meeting, Notes

activities required to help address areas of disagreement.[29] It was also thought that it would be useful to include a review and discussion of the mechanisms of regulation and policy formulation at the meeting.[30]

It was envisaged that the round-table meeting would consist of about thirty active scientists comprising approximately six from environmental groups, six from industry, six from government, six from the IEH plus relevant independent scientists. Gwynne Lyons of the WWF commented that it was disappointing that all the stakeholders were not present at the first workshop.[31] It was agreed at this meeting that everyone attending would be involved in deciding what issues should be addressed and who should be invited and that Ruth Stringer, Gwynne Lyons, Roger Lilley and Michael Warhurst would inform IEH of other relevant environmental groups and independent scientists working in the field. This gave the potential for this round-table meeting to be much broader in scope than the previous assessment meeting.

The final list of participants included representatives from government departments, academia, industry and environmental groups.[32] It was agreed that Chatham House

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produced by the Institute for Environment and Health:4: Institute for Environment and Health. p1

[29] Institute for Environment and Health (1995). Environmental Oestrogens - a planning meeting, Notes produced by the Institute for Environment and Health:4: Institute for Environment and Health. p2

[30] Institute for Environment and Health (1995). Environmental Oestrogens - a planning meeting, Notes produced by the Institute for Environment and Health:4: Institute for Environment and Health. p1

[31] Institute for Environment and Health (1995). Environmental Oestrogens - a planning meeting, Notes produced by the Institute for Environment and Health:4: Institute for Environment and Health. p1

[32] Participants at this meeting included representatives from the Department of the Environment, Department of Health, Ministry of Agriculture, Fisheries and Food, Health and Safety Executive, the Environment Agency, the Medical Research Council, the Chemical Industries Association, British Plastics Federation, European Centre for Ecotoxicology and Toxicology of Chemicals, Water Services Association, European Chemical Industry Council, Greenpeace, Worldwide Fund for Nature, Friends of the Earth, Friends of the Earth Scotland, Dr Richard Sharpe, MRC Reproductive Biology Unit, Edinburgh, Prof. John Sumpter, Brunel University, Prof. Stephen Farrow, Barnet Health Authority, Dr Jean Ginsberg, Royal Free Hospital, London, Dr Philippa Darbre, University of Reading.

Rules[33] would apply to the reporting of the discussions.[34]

Prior to the actual discussion, Gwynne Lyons circulated a letter to those at Greenpeace, Friends of the Earth and the WWF saying that she felt

> '... it was very telling that the IEH report did not pay much attention to the precautionary principle, but talked about weight of evidence.'[35]

She added that it was important to underline the fact that the government and the Department of the Environment had signed up to the precautionary principle and therefore proposed that 'acceptance of the precautionary principle' be added to the meeting's agenda.

The round-table discussion took place on 26 April 1996 and culminated in agreement that the possible impact of environmental oestrogens is a serious issue which should be addressed.[36] The question of the applicability of the precautionary principle to the issue of environmental oestrogens was raised and drew different responses from participants. The discussion centred on the amount of evidence required before action could be taken and it was felt by some groups that the spirit of the precautionary principle was being met merely by discussing the issues and investing in further research.[37] There was a general view that whilst government departments consider

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[33]Chatham House Rules provide that particular comments should not be attributed to individuals.
[34] Institute for Environment and Health (1995). Environmental Oestrogens - a planning meeting, Notes produced by the Institute for Environment and Health:4: Institute for Environment and Health. p3
[35] Lyons, G. (1995). Letter to Ruth Stringer, Greenpeace Laboratories; Michael Warhusrt, FoE Scotland; Roger Lilley, FoE; Sally Nicholson and Sian Pullen, WWF UK. Re: Agenda for proposed DoE/IEH spring meeting on endocrine disrupters. (letter). 1995.
[36] Medical Research Council (1996). Institute for Environment and Health round table discussion meeting on environmental oestrogens: environmental groups, industry and government agree on priorities for action on environmental oestrogens - press notice:3. p1
[37] Institute for Environment and Health (1996). *Report of the MRC Institute for Environment and Health Round Table Discussion Meeting on Environmental oestrogens*. Leicester: Institute for Environment and Health. 26 April 1996. p14. Due to Chatham House Rules being in operation these

that they are taking a precautionary approach to the issue by carrying out further research, others, including the environmental groups, consider that this in itself is not sufficient and that actions to date have been too slow.[38] A positive suggestion, that was said to be in keeping with the precautionary principle, was made to develop a regulatory framework that could be put in place rapidly should the balance of evidence show that human health and/or the environment are likely to be harmed by exposure to these chemicals.[39] What exactly that balance of evidence would consist of was not agreed. There was further major disagreement between governmental, industrial and environmental groups on the issue of when and how it might be necessary to substitute endocrine disrupting chemicals with alternatives. Crucially, this debate focussed on the weight of evidence required to demonstrate that a chemical is an environmental oestrogen.[40]

This sets the background against which I conducted my interviews about endocrine disrupting chemicals. I selected individuals to interview due to their own or their organisation's involvement in the above workshops, because they were conducting research in the area of endocrine disruption or because other interviewees either suggested their names or provided introductions.[41] I interviewed 28 individuals in

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views are not accredited to specific individuals.

[38] Medical Research Council (1996). Institute for Environment and Health round table discussion meeting on environmental oestrogens: environmental groups, industry and government agree on priorities for action on environmental oestrogens - press notice:3. p2

[39] Medical Research Council (1996). Institute for Environment and Health round table discussion meeting on environmental oestrogens: environmental groups, industry and government agree on priorities for action on environmental oestrogens - press notice:3. p2

[40] Institute for Environment and Health (1996). *Report of the MRC Institute for Environment and Health Round Table Discussion Meeting on Environmental oestrogens*. Leicester: Institute for Environment and Health. 26 April 1996. p15

[41] I did not always interview the person who had been the participant at the workshop because the organisation or government department concerned felt that someone else would be more appropriate. Due to there being no one individual in many government departments and organisations with direct responsibility for endocrine disruption it was not always easy to find the relevant spokesperson to interview.

total including representatives from MAFF,[42] Friends of the Earth, Friends of the Earth Scotland, Department of the Environment,[43] the Environment Agency,[44] the Institute for Environment and Health, Greenpeace, Pesticides Action Network,[45] Dr Farrow from Barnet Health Authority,[46] Dr Darbre from the University of Reading,[47] Dr Ginsberg from the Royal Free Hospital,[48] Dr Howard from the University of Liverpool, Dr Tyler from Brunel University,[49] Scientist from Thames Water, Mr Baltz from Healthcare Without Harm, Dr McLachlan from Tulane University[50] and Dr Soto and Dr Sonnenschien from TUFTS University[51].[52]

The subject of endocrine disruption is a trans-national one and in December 1996 another workshop took place to consider the European-wide nature of the issue.

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[42] They have commissioned and undertaken many research studies into oestrogen activity and screening methods.
[43] They commissioned the IEH workshops and other research into screening methods for chemicals
[44] They support work at MAFF and Brunel University including studies looking at potential endocrine disrupting chemicals in sewage effluent.
[45] Pesticides Action Network was not involved in the workshops I have discussed but many pesticides are implicated as endocrine disrupting chemicals.
[46] Dr Farrow has written about male reproductive health and the question of falling sperm quality. Farrow, S. (1994). Falling sperm quality: fact or fiction? *British Medical Journal* 309: 1-2.
[47] Dr Darbre has written about the oestrogenic behaviour of chemicals. Nesaretnam, K., Corcoran, D., Dils, R.R., and Darbre, P. (1996). 3,4,3(prime),4(prime) - Tetrachlorobiphenyl acts as an estrogen *in vitro* and *in vivo*. *Molecular Endocrinology* 10, (8): 923-936.
[48] Dr Ginsberg has written about a study of sperm density in London. Ginsburg, J., Okolo, S., Prelevic, G., and Hardiman, P. (1994). Residence in the London area and sperm density - letter. *Lancet* 343, (8891): 230.
[49] Dr Tyler is part of the team at Brunel University undertaking research supported by MAFF and the DoE into oestrogenicity in sewage effluent. Purdom, C.E., Hardiman, P.A., Bye, V.J., Eno, N.C., Tyler, C.R., and Sumpter, J.P. (1994). Estrogenic effects of effluents from sewage treatment works. *Chem Ecol* 8: 275-285.
[50] Dr McLachlan has been undertaking research into detecting oestrogenicity and the potential synergistic effects of chemicals. Korach, K.S. and McLachlan, J.A. (1995). Techniques for detection of estrogenicity. *Environmental Health Perspectives* 103, (supplement 7): 5-8.
Arnold, S.F., Klotz, D.M., Collins, B.M., Vonier, P.M., Guillette, L.J.J., and McLachlan, J.A. (1996). Synergistic activation of estrogen receptor with combinations of environmental chemicals. *Science* 272: 1489-1492.
[51] Dr Soto and Dr Sonnenschien have developed an *in vitro* screen to detect oestrogenicity. Soto, A.M., Lin, T., Justicia, H., Silvia, R., and Sonnenschein, C. (1992). An 'in culture' bioassay to assess the estrogenicity of xenobiotics (E-SCREEN). In, Colborn, T. and Clement, C., (eds), *Chemically induced alteration in sexual and functional development: the wildlife/human connection*:295-309. Princeton, NJ: Princeton Scientific Publishing.
Soto, A.M. and al, e. (1995). The E-SCREEN assay as a tool to identify estrogens: an update on estrogenic environmental pollutants. *Environmental Health Perspectives* 103, (Supplement 7): 113-122.

Again the Institute for Environment and Health was involved in setting up and reporting on this event.[53] This European Workshop took place in Weybridge, UK and the subsequent report has become known as 'the Weybridge Report'.[54] This is one of many International Workshops convened with an agenda that covers endocrine disruption and chemicals but without a wider framework in which to orientate the ensuing discussions, recommendations and decisions.[55] In parallel to the IEH workshops, the focus of the Weybridge event was also on scientific research studies. Discussion about action with regard to endocrine disrupting chemicals was once more framed around issues of scientific uncertainty, the weight of evidence and the definition of terms.

The following section picks up the theme of the 'nature of evidence'. Using empirical material obtained from my interviews, I discuss the relevance of 'scientific

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[52] See Appendix 2 for a complete list of interviewees

[53] The European Workshop in the Impact of Endocrine Disrupters on Human Health and Wildlife was organised by the European Commission, the European Environment Agency, the WHO European Centre for Environment and Health, the OECD, national authorities and agencies of the UK, Germany, Sweden and The Netherlands, CEFIC and ECETOC.

[54] Environment and Climate Research Programme, D.X.E.C. (1996). European workshop on the impact of endocrine disrupters on human health and wildlife. Weybridge Conference: Weybridge, UK. .

[55] Work Session on Chemically Induced Alterations in Sexual Development: the wildlife/human connection, Wingspread Conference Center, Racine, Wisconsin, 26-28 July 1991; Work Session on Environmentally Induced Alterations in Development: a focus on wildlife, Wingspread Conference Center, Racine, Wisconsin, 10-12 December 1993; Work Session on Chemically-Induced Alterations in the Developing Immune System: the wildlife/human connection, Wingspread Conference Center, Racine, Wisconsin, 10-12 February 1995; Work Session on Chemically-Induced Alterations in the Functional Development and Reproduction of Fishes, Wingspread Conference Center, Racine, Wisconsin, 21-23 July 1995; Work Session on Environmental Endocrine-Disrupting Chemicals: neural, endocrine and behavioural effects, International School of Ethnology , Ettore Majorana Centre for Scientific Culture, Erice, Sicily, November 5-10 1995; Workshop on the Effects of Organochlorines on Human Health, Academic Medical Centre, University of Amsterdam, Amsterdam, 3-4 February 1996; IEH Round Table Discussion Meeting on Environmental Oestrogens, Medical Research Council, Institute for Environment and Health, University of Leicester, Leicester, 26 April 1996; Work Session on the Health Effects of Contemporary-Use Pesticides: the wildlife/human connection, Wingspread Conference Center, Racine, Wisconsin, 27-29 September 1996; Institute for Environment and Health Workshop on Male Reproductive Health, on behalf of the Health and Safety Executive, IEH, University of Leicester, Leicester, 6-7 November 1996; European Workshop in the Impact of Endocrine Disrupters in Human Health and Wildlife, Weybridge, UK, 2-4 December 1996; Second Session of the Intergovernmental Forum on Chemical Safety, Ottawa, 10-14 February 1997; IBC Conference on Endocrine Disrupters in the Environment, The Merchant Centre, London, 20-21 May 1997.

uncertainty', 'weight of evidence' and 'definitions' to debate about endocrine disrupting chemicals and the implementation of the precautionary principle.

The Nature of Evidence in Debate about Endocrine Disrupting Chemicals

It is clear that there is much controversy as to the status of the 'problem' of endocrine disruption. There is still no consensus as to what causes some of the observed abnormalities in human and wildlife reproductive health despite a number of studies indicating the oestrogenic properties of particular chemicals in laboratory studies. Disagreement hinges around the question of what actually is endocrine disruption, what constitutes an adverse effect in a human or wildlife population, what tests can demonstrate that a particular chemical or mixture of chemicals causes particular adverse effects to humans or wildlife, whether *in vitro* or *in vivo* tests are more appropriate and meaningful, and how much evidence is necessary before policy action is taken against specified chemicals. In this section I look at three aspects of what I term 'the nature of evidence'. I discuss definitions of endocrine disruption employed by my respondents, consider the way these definitions relate to interpretations about what constitutes sufficient evidence of endocrine disruption to warrant taking action against particular chemicals and, review the role that scientific uncertainty plays in these deliberations.

Definitions of endocrine disruption

Definitions help structure any debate by defining the vocabulary and categories used by those involved in the discussion. Within the endocrine disruption debate there are many terms that are used as boundary objects, that is where those using them are not necessarily talking about the same thing but where differences are disguised by a common terminology. Identifying which definitions have consensual agreement regarding their use and those which are still disputed and regarded as problematic helps in understanding the different positions observed in debate on endocrine disruption and the closure of controversy.

Using the case of the Weybridge workshop I discuss the term 'endocrine disrupter' and show the diversity of positions at stake. The question of 'what exactly' constitutes an endocrine disrupter is one that underpins further policy debate about options for the future.[56] A 'precise' definition has not been forthcoming although the Weybridge workshop, set up on behalf of the European Commission in order to assess the scope of the problem of endocrine disrupters in Europe, managed to endorse a couple of definitions.[57]

A distinction was made at this workshop between endocrine disrupters and *potential* endocrine disrupters such that

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[56] Institute for Environment and Health (1995). *IEH assessment on environmental oestrogens: consequences to human health and wildlife*. Leicester: Institute for Environment and Health. Institute for Environment and Health (1996). *Report of the MRC Institute for Environment and Health Round Table Discussion Meeting on Environmental oestrogens*. Leicester: Institute for Environment and Health. 26 April 1996.; Environment and Climate Research Programme, D.X.E.C. (1996). European workshop on the impact of endocrine disrupters on human health and wildlife. Weybridge Conference: Weybridge, UK. .

[57] Environment and Climate Research Programme, D.X.E.C. (1996). European workshop on the impact

'An endocrine disrupter is an exogenous substance that *causes* adverse health effects in an intact organism, or its progeny, secondary to changes in endocrine function' (emphasis added)

and

'A *potential* endocrine disrupter is a substance that possesses properties *that might be expected to lead to* endocrine disruption in an intact organism' (emphasis added)

It was generally agreed at this workshop that an endocrine disrupter could only be identified through testing in a whole animal, i.e. *in vivo*, although it was accepted that the identification of *potential* endocrine disrupters could be based upon data obtained from *in vitro* studies.[58]

These definitions, even if agreed, open further areas of debate. At a conference I attended in May 1997 on 'Endocrine Disrupters in the Environment'[59] there appeared to be considerable discrepancy between participants about what these 'agreed' definitions meant. For example, one dispute was over what exactly constitutes 'adverse health effects'. Industry representatives felt that this meant *harmful, permanent* changes and that it was better to think of this as meaning 'abnormal'. Dr John Ashby of Zeneca Central Toxicology Laboratory said that the word adverse was in there because there was a fear that the whole of policy would be based on changes rather than things that were adverse problems. This was a major point of disagreement as a number of academic scientists felt exactly that, that *any* changes to an intact

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of endocrine disrupters on human health and wildlife. Weybridge Conference: Weybridge, UK. . p53
[58] Environment and Climate Research Programme, D.X.E.C. (1996). European workshop on the impact of endocrine disrupters on human health and wildlife. Weybridge Conference: Weybridge, UK. . p53
[59] IBC Technical Services (1997). Endocrine disrupters in the environment. Endocrine disrupters in the environment: The Merchant Centre, London. IBC Technical Services.

organism should be considered as adverse.[60]

Representatives from various chemical companies suggested that 'sufficient evidence' was necessary before something could be called an endocrine disrupter but would not commit themselves to what sufficient evidence might be.[61] It was important for the chemical industry representatives to keep debate over definitions of endocrine disrupters going as this has the potential to delay further action, some of which may have financial implications for the chemical industry.

Circular logic seems to apply in the above example of how an endocrine disrupter is defined and how much evidence is necessary before a particular chemical can be called an endocrine disrupter. On one hand 'sufficient evidence' is required to implicate a particular chemical as an endocrine disrupter which necessitates that what an endocrine disrupter is is agreed, i.e. defined. On the other hand a definition of an endocrine disrupter is only accepted if it causes 'adverse effects' which requires that some method of determining those effects exists and is considered 'sufficient'. This problem was also highlighted during my fieldwork when I found few people willing to define what they would accept as 'sufficient evidence' that endocrine disruption was an issue or that a particular chemical was an endocrine disrupting chemical. This was despite the fact that there seemed to be an unofficial consensus amongst scientists involved in the debate that something called 'sufficient evidence' was required before policy action could be taken.

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[60] IBC Technical Services (1997). Endocrine disrupters in the environment. Endocrine disrupters in the environment: The Merchant Centre, London. IBC Technical Services. and personal notes taken at the conference during discussion periods

[61] IBC Technical Services (1997). Endocrine disrupters in the environment. Endocrine disrupters in the environment: The Merchant Centre, London. IBC Technical Services. and personal notes taken at the

Through being aware of the context in which the debate on endocrine disruption and the associated definitions has evolved I can identify potential conflicts of interest and shed light on how these interests have been constructed and represented. By showing that the debate itself is a construction of different interests each vying for recognition and legitimacy it is possible to visualise how different interests might promote a different debate, or a different controversy. The workshops referred to above create the space for definition-making by bringing together interested parties who have a stake in future invocations of those definitions. However, even when 'endocrine disruption' is defined, as at the Weybridge workshop, definitions may still be problematic as their constituent terms are picked apart, as demonstrated above.

Sufficient evidence of endocrine disruption

As introduced in the previous sub-section the question of what constitutes 'sufficient evidence' of there being an endocrine disruption problem is tied up with the debate over defining endocrine disruption. Through such events as the IEH workshops, the Weybridge workshop and the IBC conference, debate about endocrine disruption has become focused on the specification of endocrine disrupting chemicals although there is, as yet, no consensus, either scientific or political, that chemicals are causing the observed effects. Due to this there is much dispute about whether to take action as if chemicals are the culprits or whether to delay taking action until more research into potential causes and effects has been conducted. This is an important problem in terms of precaution because those that advocate alternative positions both consider them to be precautionary. This again demonstrates the variety of interpretations to

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conference during discussion periods

which the precautionary principle can be subjected.

The question of what constitutes 'sufficient evidence' of endocrine disruption is one that has an impact on both the scientific research carried out and the policy decisions which are, or are not, made. Other possible causes of endocrine disruption have been mooted, ranging from the use of particular types of underwear, through ideas about geographic location and modern sexual behaviour, to sitting at a desk all day or driving a car. These suggestions tend to be made by those representing large corporations. However these possibilities are not disputed by the environmentalists I spoke to. Their feeling is that there could be many possible causes and that they should all be treated seriously. They agree that this might mean some chemicals are assumed guilty and later prove to be innocent, but they insist that is what the precautionary principle is about. Environmental groups such as Friends of the Earth and Greenpeace claim to speak for an uninformed and uninvolved public. They are concerned with the power that large corporations can draw on at an international level and have used the idea of precaution to set targets for particular chemicals which they believe should be banned or phased out.

One of the unresolved debates is about what evidence is sufficient to signify a link between cause and effect. How much proof is required to indicate that substance A or process B is causing an effect in situation X or eco-system Y? One of the dilemmas is whether political action can be taken if no evidence at all exists to indicate a potential causality. Here a distinction must be made between there being no evidence due to a lack of resources to look for that evidence, and there being no evidence despite having conducted an agreed set of tests and come up with no clear conclusion.

In order to consider this question of what evidence is sufficient as a basis for political action I organise this section into two. Firstly I consider variant opinions on the issue of *in vivo versus in vitro* tests as evidence of endocrine disruption and, secondly, I look at the arguments put forward by different interest groups regarding 'taking action against' specific chemicals. I have chosen a 'topic led' categorisation rather than an 'institutional-led' one based on analysis of my fieldwork data.

a) *in vivo* and *in vitro* tests as evidence of endocrine disruption

Here I focus on the views expressed regarding *in vivo* versus *in vitro* testing of chemicals as a way of determining whether a chemical is an endocrine disrupter. I look at how this theme informs the assessment of policy options. This also highlights further debate about the limitations of extrapolating from *in vivo* and *in vitro* tests to real world situations. I identify the government's position on the use of *in vivo* and *in vitro* tests and discuss their adherence to a formula for acquiring more data and evidence before they consider there to be sufficient evidence on which to base action. I discuss disciplinary adherence to particular scientific paradigms when I look at the way in which science is used as a basis for making decisions, and I question the applicability of science in that role. I also consider the perspectives of NGOs who believe that there is already sufficient evidence to take action in particular circumstances. I draw attention to their *a priori* commitment to there being sufficient evidence, a position established due to their commitment to the precautionary principle.

On the question of *in vivo* versus *in vitro* tests I spoke with an academic scientist doing research on fish in British rivers. He told me that a lot of research is being undertaken and that in the next few years more information will be available relating to specific laboratory testing of various compounds and chemicals. With regard to using this data to inform policy decisions he said

> '... at the end of the day the environment is very complex and to try and extrapolate from the very simplistic *in vivo* or *in vitro* experiments and trials to what's happening in the real world is still going to be a really big jump.'[62]

This is an important point as it has implications for whatever tests are conducted into endocrine disruption, whether they are *in vivo* or *in vitro*. There are limitations with all types of tests since none will be sophisticated enough to emulate real world complexity.

Since *in vivo* and *in vitro* tests are the two laboratory methods that exist for testing chemicals, and since extrapolation is so complex, I asked the Head of the Chemicals and Health Branch of the Department of the Environment how testing of potentially disruptive chemicals might be prioritised. She told me:

> 'There's a piece of work at the moment to prioritise chemicals – looking within groups at specific chemicals. The suspicion would be that they're positive *in vitro*, and the suspicion increases if they're positive *in vivo*.'[63]

I was curious as to how this 'suspicion' became translated into 'evidence'.

> 'There isn't a cut-off point. There is a feeling that there is sufficient

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[62] Interview 24/04/97, transcript p5.
[63] Interview 25/04/97, transcript p2.

evidence – no formal guidelines.'[64]

This demonstrates that the government is aware that there is no specific moment when there suddenly 'is' enough evidence, although they still prioritise certain types of scientific evidence. On one hand, there is an adherence to an objectivist paradigm of a hierarchy of scientific proof and, on the other hand, there is an acknowledgement that subjective 'feeling' plays a role.

By accepting the co-existence of these two aspects, the government can give the impression of doing all that is possible in the present circumstances. The government wants to be seen to be protecting the public from unseen potential risks (hence the more subjective aspect) whilst at the same time supporting industry and by their reasoning, the economy (through adopting science as a basis for making decisions).

Friends of the Earth also takes a 'scientific' approach with regard to evidence, although they suggest that *in vitro* evidence should be sufficient to indicate endocrine disruption:

> 'We should find out if it binds to the oestrogen receptor in cell culture and if it enters cells in cell culture and gets an idea of how it's metabolised in the body by not killing animals. If you can show it goes into the body, into the cells. ... Should also measure levels in people to see the levels that exist in the real world. Look at what level is a problem in culture and look at what level exists in the human body. And make decisions from there.'[65]

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[64] Interview 25/04/97, transcript p2.
[65] Interview 16/05/97, transcript p1

In terms of a hierarchy of accepted evidence Friends of the Earth is willing to accept a minimum amount of scientific evidence that indicates causality.

Similarly, Friends of the Earth Scotland were emphatic that they don't feel that *in vivo* tests are necessary to establish a sufficient link between cause and effect in order for action to be taken. One representative told me:

> 'If we come across animal studies we use the results but we support alternatives to animal testing. Computer modelling would be a useful way to test. There is a whole range of cell tests and yeast tests for oestrogen. We wouldn't be calling for testing a chemical on an animal.'[66]

They feel that sufficient evidence can be established without recourse to animal experiments and, like Friends of the Earth and Greenpeace they feel that a minimum amount of evidence is sufficient to base action upon.

I also discussed the weight placed on the outcome of *in vivo* and *in vitro* testing with a toxico-pathologist from Liverpool University who told me:

> '*In vitro* tests are not sufficient to *prove* there is a problem, they show there is *probably* a problem. ... *in vivo* is stronger evidence...'[67]

Within science it is undisputed that animal tests provide stronger evidence. The toxico-pathologist continued:

> 'Most chemicals in the environment have had no toxicological tests. ... There are crude toxicological testing – LD50 – for chemicals. *In*

[66] Interview 16/04/97, transcript p3
[67] Interview 26/03/97, transcript p1

vitro allows you to get at the mechanisms more easily – but you need animals to show if it will affect people …'[68]

There is a strong disciplinary adherence to the fact that animal testing provides stronger proof of causality of human health problems than does *in vitro* testing. Toxicology is about understanding the mechanisms at work in causing toxic effects. It is not solely a matter of establishing that a particular chemical is oestrogenic (for example) or not but also in trying to establish the limits of the effects. Those engaged in science tend to have a disciplinary allegiance to particular paradigms which allows them to view the scientific method as deterministic and this allows for the claim that a hierarchy of procedures has been established which generates stronger or weaker evidence.

This opinion about *in vitro* tests not being sufficient to prove a problem was echoed by a representative of Thames Water who told me:

> '… you can test a substance for oestrogenicity by looking at it in an assay in a particular lab [*in vitro*], does that mean you must stop using that chemical in all circumstances? What if that lab messes up the test? What if no one else can reproduce the results?'[69]

This seems tantamount to changing the goal posts once it becomes likely that the goal will be reached. By questioning the validity of the results the Water Company is insisting on a greater amount of proof before they are willing to accept that a chemical is an endocrine disrupter. This may be associated with the financial burden they would be faced with in order to clean up their water supply and the potential liability

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[68] Interview 26/03/97, transcript p1
[69] Interview 10/04/97, transcript p1-2

claims they could have aimed at them by their customers. By challenging this stage in the 'proof' process (whether an *in vitro* assay is enough to 'prove' oestrogenicity), the Water Company is trying to force the level of acceptable evidence to the *in vivo* stage i.e. taking the 'more science' position. By doing this, potentially necessary mitigation measures can be deferred to a later date.

Science practitioners speak with great authority and this is reflected in the unquestioning way in which it is assumed that doing more scientific research will provide better evidence on which to base decisions. A hierarchy of protocols exists which determine the strength of the evidence provided but these protocols are taken for granted, so, although the question of extrapolation to human populations across species barriers is a common challenge to animal testing, *in vivo* tests persist in being considered a relevant measure of cause and effect. This makes the job of attempting to determine the level of sufficiency at a low base level much more difficult.

b) 'taking action' against particular chemicals considered to be endocrine disrupters

Causal evidence linking chemicals to particular observed endocrine disruptive effects is in short supply and the chemical industry disputes that there is enough to implicate them as responsible.[70] Liz Surkovic of the Chemical Industries Association has suggested that other societal factors, such as modern lifestyles and changing dietary habits, may be the causal agents of observed physical and sexual developmental abnormalities.[71] Manmade chemicals are an intricate part of modern life and

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[70] EMSG (Endocrine Modulators Steering Group) (1998). Endocrine disruption: the position of the chemical industry:8: CEFIC. p4

[71] ENDS Report (1995). DoE report understates evidence of oestrogen pollution. *ENDS Report* 246: 2..

proponents claim that they provide huge social benefits due to their widespread use and that economic and environmental analysis must be undertaken to appraise the net benefit for society before adopting any measure that regulates or bans particular chemicals.[72] Opponents, however, argue that many of the most suspect chemicals are substitutable with available alternatives and that particular chemicals and families of chemicals should be phased out.[73]

Greenpeace have been calling for the banning of certain chemicals with a particular campaign aimed at chlorine and the phasing out of PVC.[74] Greenpeace claim that there is already enough evidence to implicate chlorine as an endocrine disrupter and that it should consequently be phased out.[75] A representative from Greenpeace told me:

> '[A] US study concluded that wildlife is affected. [We're] lacking direct evidence that humans are affected in the same way. ... Sperm count evidence. ... Similar things in animal studies and geographic variations point to an environmental factor.'[76]

For Greenpeace the very fact that wildlife is affected is enough evidence to suggest

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See also EMSG (Endocrine Modulators Steering Group) (1998). Endocrine disruption: the position of the chemical industry:8: CEFIC. p3

[72] ENDS Report (1996). DGIII buys chemical industry pleas for deregulation. *ENDS Report* 256: 48. p1

[73] Greenpeace (undated). *Body of evidence: the effects of chlorine on human health*. London: Greenpeace.

Warhurst, M. (1995). *An environmental assessment of alkylphenol ethoxylates and alkylphenols*. Edinburgh: Friends of the Earth Scotland. January 1995.; WWF (undated). *Policy options for endocrine disrupting chemicals (EDCs) within the European Union*. Godalming: WWF. undated.

[74] Greenpeace (1994). *Achieving zero dioxin: an emergency strategy for dioxin elimination*. London: Greenpeace.

Greenpeace (1996). *The problems of PVC and the alternatives*. London: Greenpeace. June 1996.

Greenpeace (1996). *Building the future: a guide to building without PVC*. London: Greenpeace. October 1996.

Greenpeace International (1994). PVC: the need for an industrial sector approach to environmental regulation. Paris Convention for the Prevention of Marine Pollution Sixth Meeting of the working group on industrial sectors: Oslo. Greenpeace International.

[75] Greenpeace (undated). *Chlorine crisis: time for a global phase-out*. London: Greenpeace.

that some action needs to be taken and the fact that an environmental factor is implicated is enough to ban particular chemicals.

The Friends of the Earth representative I spoke to was also willing to be specific about particular chemicals that he thought had enough evidence against them to justify a ban:

> 'In my opinion alkyl-phenols should have been banned in the 60's. They don't break down in the environment and there are alternatives.'[77]

In contrast, the Environment Agency believes that more information is required before it is possible to determine whether endocrine disruption is a serious problem and that particular chemicals should be regulated more stringently. A representative told me that

> '... it's still in the R&D stage – information gathering and learning more about the impact these substances are having on the biota generally.'[78]

The Environment Agency feels that it is too early to take any action as there is insufficient evidence on which to justify action. This may stem from a conflict of interest as, on the one hand, they are responsible for monitoring emissions to the environment and for initiating any necessary legal action, while on the other hand they also administer licenses to companies and negotiate with them closely about their mitigation procedures. Because of these almost opposing roles (serving the public and working with industry) they feel the need for more evidence in order to make a

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[76] Interview 09/04/97, transcript p1
[77] Interview 16/05/97, transcript p1
[78] Interview 23/04/97, transcript p5

balanced decision which is seen as fair and reasonable by all sides:

> 'What you need is more data collection, good quality information on which to base decisions. In many instances that is often lacking ... Basically if there was evidence to suggest that a discharge was causing damage we would take action. It's establishing the link which is difficult – when you're talking about these trace quantities you've often got whole cocktails of chemicals. I mean if you analysed an effluent you're looking for substances at a nanogram per litre level, which is your grain of sugar in the Olympic swimming pool, I mean you might find 800 substances so which one of those is causing a problem?'[79]

Despite saying that if there was evidence that a particular chemical was causing a problem they would take action, the Environment Agency would not be drawn to clarify exactly how much evidence they would require and what that would be.

There appears to be much rhetoric about 'taking action' without those using the phrase explicitly detailing what action they are talking about. Another example of this can be seen at the launch of the IEH assessment[80] on environmental oestrogens when the IEH director, Professor Lewis Smith, said of Dr Sharpe's findings that low-level exposure of pregnant rats to phthalates caused reduction in testis weight in their male offspring:

> 'If these effects are convincingly demonstrated in rats then my personal view is that there should be action. It would be a case of using the precautionary principle.'[81]

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[79] Interview 23/04/97, transcript p10-11

[80] Institute for Environment and Health (1995). *IEH assessment on environmental oestrogens: consequences to human health and wildlife*. Leicester: Institute for Environment and Health.

[81] ENDS Report (1995). DoE report understates evidence of oestrogen pollution. *ENDS Report* 246: 2. p1

Although he says there should be action and equates this with using the precautionary principle he stops short of saying they should be banned or what other action he would consider appropriate. ENDS Report notes that the Department of the Environment, Institute of Environment and Health and Dr Sharpe all believe that at present there is still insufficient evidence on any compound to warrant regulatory action.[82]

These examples illustrate the difficulty of establishing a precise set of scientific tests which will determine without doubt that a chemical is an endocrine disrupter. Even when evidence is produced via one set of procedures (i.e. *in vitro* tests) it can be challenged as incomplete and a case can be made that another set of procedures is more accurate (i.e. *in vivo*). This process can continue indefinitely through all the sets of existing procedures until it is recognised that no laboratory experiments are capable of emulating real world complexities.

An important feature of all the NGOs that I have identified is that they have an *a priori* commitment to there being sufficient evidence regardless of what the evidence is. Because they all support the invocation of the precautionary principle they believe that insufficient evidence should not be used as a reason for not taking action. There is no suggestion by the environmental groups that scientific evidence is not important, rather that it is important to take action based on what is known rather than waiting for some further approximation to the truth. They believe that enough is known currently about particular chemicals such as chlorine and alkyl-phenols to warrant taking action now, and the action they advocate is phasing out the use of these chemicals. What is

[82] ENDS Report (1995). DoE report understates evidence of oestrogen pollution. *ENDS Report* 246: 2. p2

obvious here is a resistance to the established line that science will eventually provide all the answers and a call to acknowledge that the evidence that does exist is already sufficient.

As well as illustrating the different interests of each of these groups I've also pointed to the ambiguities in the concept of sufficient evidence itself. The concept can mean that there is sufficient evidence that a problem exists. From my fieldwork it appears that no one is actually denying that there is a problem. It can also mean sufficient evidence of the causes of the problem. There is much more controversy in this area although many potential causes appear to be identified. Finally the concept can be interpreted as sufficient evidence to determine a direction of action. This is the area over which there is greatest disagreement with some actors insisting that causality be established before action can be taken, and others insisting that action should be taken as a precautionary measure.

The role of scientific uncertainty in deliberations about endocrine disruption

There are many areas where scientific uncertainties come to the fore in discussions about endocrine disrupting chemicals. In this section I identify three areas of uncertainty: indeterminacy, synergy and extrapolation.

I look at the effects of indeterminacy on the debate about endocrine disrupting chemicals and the associated interests that keep these indeterminacies in place. Uncertainties about observed effects are discussed in an effort to understand what it means to know if a cause has been identified. Uncertainty over whether such an observed effect is actually an effect or an error in representation or whether these cannot be distinguished between is also considered. I use the example of disputes about the long-term effects of exposure to low doses of chemicals to illustrate the uncertainties that arise in particular research areas.

A major dispute in the scientific community over the existence and effects of synergy in the case of endocrine disrupting chemicals is discussed with reference to Professor John McLachlan's report 'Synergistic activation of estrogen receptor with combinations of environmental chemicals'[83] which was subsequently withdrawn from publication.[84] This study has major implications on both scientific and policy levels. Finally I discuss the methodological uncertainties associated with carrying out research on adult populations to the exclusion of embryonic populations, the reasons why this might happen and the problems that extrapolation between the two might produce.

a) Indeterminacy around endocrine disrupting chemicals

Indeterminacy is the aspect of uncertainty that acknowledges there are many things that cannot be known. It is one of three forms of uncertainty referred to by O'Riordan and Cameron, the others being uncertainty related to lack of data and uncertainty as variability of process.[85] I have discussed indeterminacy as a form of uncertainty in

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[83] Arnold, S.F., Klotz, D.M., Collins, B.M., Vonier, P.M., Guillette, L.J.J., and McLachlan, J.A. (1996). Synergistic activation of estrogen receptor with combinations of environmental chemicals. *Science* 272: 1489-1492.

[84] McLachlan, J.A. (1997). Synergistic effect of environmental estrogens: report withdrawn. *Science* 277: 462-463.

[85] O'Riordan, T. and Cameron, J., (eds) (1994). *Interpreting the Precautionary Principle*. London: Earthscan Publications Ltd. p62-66

detail in chapter three. In this section I discuss indeterminacy as it relates to endocrine disrupting chemicals.

A first dimension of indeterminacy-related uncertainty concerns the question of whether the effects observed about human reproductive health are actually effects at all. This has been highlighted with regard to studies that have observed reduced sperm counts in men and was raised in an interview with a representative from the Institute for Environment and Health which has undertaken research into oestrogenic effects on humans and wildlife.[86] My interviewee pointed out that prior to answering the question of *what* is causing this reduction in sperm counts a fundamental question that must be answered is *whether* they are actually reducing at all. There is a lot of conflicting data on this subject and he states that:

> 'Generally there are problems with the analysis, with the recording of environmental factors etcetera, and I think that there appears to be … regional differences. There are very clear geographical variations but exactly what the reasons for that is, what the causes are not clear at the moment.'[87]

Not only is there scientific uncertainty about what might be causing reduced sperm counts (if it *is* a real phenomena) but there is the indeterminacy of whether the phenomena exists.

One complicating factor that adds to this indeterminacy is the dimension of human

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[86] Institute for Environment and Health (1995). *IEH assessment on environmental oestrogens: consequences to human health and wildlife*. Leicester: Institute for Environment and Health. Institute for Environment and Health (1996). *Report of the MRC Institute for Environment and Health Round Table Discussion Meeting on Environmental oestrogens*. Leicester: Institute for Environment and Health. 26 April 1996.

error. Many of the sperm count studies rely on questionnaire data or interviews which may lead to biased results due to the sensitive nature of the questions being asked. Measures of sperm count are affected by stress, time since previous ejaculation, and temperature – to name a few factors. Questions about these issues may not elicit honest responses and this may lead to an exaggeration or minimisation of the extent of the problem of reduced sperm counts.

A second aspect of indeterminacy-related uncertainty concerns identification of cause/effect relationships between chemicals and environmental problems either locally or more broadly due to the widespread dispersal of manmade chemicals. The ubiquity of chemicals in the environment is such that a 'natural state' against which to gauge exposure is hard to determine. Background levels themselves contain manmade chemicals. For this reason it is very difficult to monitor the effects that legislation to reduce the amount of chemicals entering the environment locally might have. It is also impossible to determine the full effects that particular processes or chemicals might have in particular environments.

Additional to this, circumstances which were once indeterminate may at another point in time become known or agreed upon. A representative from the Environment Agency gave me a very localised example:

> 'We've had a situation of a discharge into the Mersey where we were finding substances which the discharger didn't know he was discharging. It's actually a trace quantity of a substance which is being synthesised as part of his processing. He didn't know about this. ...

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[87] Interview 02/05/97, transcript p4

we're talking about very very small quantities here. This particular substance was being detected in mitolis mussel ... samples and also in fish. It doesn't necessarily mean it's harmful but ...'[88]

There are a number of issues that arise from this example. Firstly, it raises the question of whether the discharger should have known about the synthesised substance which he was discharging. If the process through which the synthesised by-product is created has not been scientifically validated then this is a classic case of indeterminacy – an uncertainty which cannot be known. The discharger will behave as if their process does not produce unwanted by-products and will continue to do so until such a time as those by-products are detected and associated with their activities – as is the case in the example. It would be expensive and time consuming for the discharger to investigate whether their site was producing unknown discharges and so if an association between the discharge and the by-product has not previously been established, without liability there is no motivation for the discharger to try to discover possible associations.[89] Secondly, this example illustrates the Environment Agency's response to new knowledge coming to light. The Environment Agency representative told me:

'The costs for analysing these trace quantities are huge, you couldn't routinely put procedures in place which would enable you to monitor all discharges of all substances.'[90]

The Environment Agency has financial restrictions in place which prevents it from undertaking all the detailed monitoring that it might like to conduct. The resources at

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[88] Interview 23/04/97, transcript p8

[89] This situation is different if there is a pre-determined association of which the discharger is unaware. The discharger may then be held legally responsible for his actions although it may be that any penalty he receives for such an act is worth risking in comparison to the cost of mitigation techniques. This, however, is not a case of indeterminacy.

the Agency's disposal are not sufficient (and could never be sufficient) to identify the many uncertainties which exist let alone to deal with them. Finally this example illustrates the difficulty in determining cause and effect. The substance traces which were identified in the fish had to be traced back to the discharger and a connection found which linked the product to the by-product. Again, this is a lengthy and expensive process because of the multiple possible linkages and methods which could exist.

The indeterminacy of effects over time is another area of scientific uncertainty. One of my interviews was with a scientist at Reading University who was concerned with the long-term effects of chronic doses of chemicals. My respondent claims the effects of long-term exposure to low-level doses have not been studied adequately. One-off exposures to high-level doses are much simpler to study because accidents provide scope to study such cases and laboratory tests can be easily set up. Long-term studies are always more difficult to set up as they require time, adequate funding and a control population. As previously mentioned there is the added uncertainty as to whether a control population of individuals who are unexposed to low levels of chemicals actually exists. This scientist pointed out that:

> 'If there is one major assault on the body the body can cope in time and the body can recover. What happens to low-dose long-term effects is that the body is not designed to cope with that.'[91]

She went on to describe Sir Alex Jeffrey's claim that long-term low-dose radiation could produce mutation effects which short-term high doses couldn't and says she sees

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[90] Interview 23/04/97, transcript p8

[91] Interview 10/04/97, transcript p3

an analogy to chemicals in his claim:

> 'It's the only data that will support long-term low-dose as a problem.'[92]

A toxico-pathologist from Liverpool University agreed with this concern about low-dose chronic effects when he said, with regard to endocrine disruption, that:

> 'We're not dealing with toxic effects – we're dealing with subliminal background chronic effects.'[93]

Short term, high-dose studies produce more immediate results which can then be used to inform policy decisions. Funding for research into low-dose long-term effects does not appear to be a priority either by government or by industry and this may be because we live in a policy world where scientific results are required on a more urgent basis.

b) Synergy and uncertainty

There is a great deal of scientific uncertainty about the synergistic effects of chemicals in the environment due to the problem of measuring composite effects. The scientific tools currently available are able to detect which chemicals make up a mixture but are less able to determine the effects such a mixture might have on humans and wildlife. Studies have been undertaken to determine the carcinogenic effects of a combination of two substances[94] but such a study has not been undertaken for endocrine disrupting effects. A scientist at Brunel University told me:

> 'We should be looking at mixtures and the complexity of mixtures to

[92] Interview 10/04/97, transcript p3
[93] Interview 26/03/97, transcript p1
[94] For details of a study on the combined effects of radon and tobacco see Monchaux, G. (1997). Synergism of radon exposure with other pollutants. Pollutant Mixtures: law and ethics: Liverpool University. .

get any idea of what real wildlife populations are being exposed to and we need information in particular on things like what happens to these compounds once they get into the bodies of animals – some are just excreted straight away so they're not going to have any effect, others are bio-metabolated, or broken down into … compounds, in some cases non-active compounds are bio-metabolated into active compounds. ... we're probably at the tip of the iceberg – but it's a very long journey before we can really start to get real grips as to what happens in a laboratory or what can happen in the laboratory and what's really happening in the environment and how you can gel the two together.'[95]

In the real world environment, chemicals do not exist in isolation and there is always a mixture of chemicals to which individuals are exposed. Synergistic effects may be a result of this multiple exposure although that is still uncertain. Synergy implies a greater than additive effect and the point in the above example is that science is unable to understand many of the mechanisms chemicals go through in the metabolism process and so is unable to determine whether effects might be additive let alone synergistic.

In order to get a government opinion on potential synergistic effects I spoke with the Head of Environmental Contaminants in Food at MAFF. He told me:

'I wouldn't say it's a serious problem. The overall policy is set by the DoE who are developing a strategy for looking at potential endocrine disrupters. They are developing a battery of tests. Our primary concern

[95] Interview 24/04/97, transcript p5

is to establish exposure of individual effects.'[96]

Because the effects of individual chemicals is not understood, the government is choosing to concentrate efforts in that research area. Focusing on synergistic effects would compound the problems associated with determining aetiology. This may be related to the time scale in which decisions must be made. The government is more likely to get quick answers from studies of individual chemicals, which the DoE can organise, than would be possible from studies investigating synergistic effects. Additionally, the government is implying that if chemicals are established to be endocrine disrupters at the individual level then there will be enough information with which to make policy decisions. This may fend off some of the issues around synergy, since it may reduce the number of individual chemicals in the environment, but many of the complexities will still be indeterminate.

An example that highlights this issue of the uncertainties about synergy in the endocrine disruption debate is the publication of a study by John McLachlan in the journal Science which was subsequently withdrawn from publication.[97] The study showed that combinations of two or three common pesticides, at levels that might be found in the environment, were up to 1600 times as powerful as any of the individual pesticides by themselves. It also showed that chlordane, a chemical that shows no ability to disrupt hormones by itself, greatly magnified the ability of other chemicals to disrupt hormones. The report was withdrawn because no one, including the original research team, was able to replicate the results of the study. A spokesperson for

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[96] Interview 08/04/97, transcript p2

[97] For the original article see Arnold, S.F., Klotz, D.M., Collins, B.M., Vonier, P.M., Guillette, L.J.J., and McLachlan, J.A. (1996). Synergistic activation of estrogen receptor with combinations of environmental chemicals. *Science* 272: 1489-1492.. For the withdrawal see McLachlan, J.A. (1997). Synergistic effect of environmental estrogens: report withdrawn. *Science* 277: 462-463.

Greenpeace talked to me about this study:

> 'Look at Sumpter's letter to Science. He repeated the synergistic study on two pesticides and didn't get the same result – no synergy. This is typical of the oestrogen debate and the sperm count debate. Sumpter doesn't make a job of going around and knocking studies. It was done in Zeneca's labs. It's an ongoing debate. How much evidence do you wait for? Forever? That's what industries want and governments.'[98]

Even though there is much uncertainty about whether synergy exists, Greenpeace believes this should not be used as a reason for waiting and doing nothing in the meantime. Greenpeace have taken on a responsibility to speak out on behalf of the environment and to advance a moral challenge against the current assumption that everything is acceptable until it is proven to be a problem. It is important to recognise that the withdrawal of the report does not indicate that the uncertainties surrounding synergy have been resolved. It is not a reason to believe that synergy is not occurring. Greenpeace view this as all the more reason to assume there could be a problem and use this as a reason for suggesting that action needs to be taken on this issue.

The scientists who conducted the initial research and published the report were forced to withdraw it in order to sustain their status as reputable scientists. They are still conducting research on environmental endocrinology and to do this it is important to be able to attract further research funds. Due to the process of peer review and the sense of experimental validification through replication these scientists had to acknowledge the shortcomings of their research.[99] They also had a responsibility to

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[98] Interview 09/04/98, transcript p2

[99] Collins, H.M. (1985). *Changing Order*. London: Sage.

the people who were using their report for political purposes.

The example of synergy as a form of uncertainty demonstrates that increased complexity can be used narrowly to prevent action from being taken (thus calls for increased research) or more broadly as a warning that there are so many unknowns that the scientific method will not be able to provide solutions (and thus decisions must be based on something other than scientific facts). The difficulty of establishing the existence of synergy as a scientific artefact has been shown through Professor McLachlan's study of pesticides which subsequent to publication had to be withdrawn.

c) Extrapolation and uncertainty

Extrapolation is a scientific tool full of methodological uncertainties. Results of experiments conducted under controlled conditions in laboratories are often extrapolated to real world situations without acknowledging that additional complexities of the real world have been assumed away in the controlled experiment. This is an example of the middle section of MacKenzie's 'certainty trough' which shows the users (as opposed to the producers) of scientific knowledge assuming a low level of uncertainty in the knowledge they want to use.[100] Often the extrapolation is undertaken by different parties to the one which undertook the initial research and so many of the finer methodological nuances are lost in interpretation. In the case of endocrine disrupting chemicals many experiments on individual chemicals have been undertaken on specific species or at particular stages of development. This has

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[100] See MacKenzie, D. (1990). *Inventing accuracy: a historical sociology of nuclear missile guidance.* Cambridge, MA: MIT Press. p370-372, discussed in chapter three of this thesis

important implications for making policy about real world exposures based on results from these experiments.

Toxicological experiments are often carried out on full-grown, adult populations in order to determine the physiological, behavioural and neurological effects of particular substances. As a scientist at Brunel University pointed out to me:

> '... so far the major focus has been on ... exposing adults to these various compounds. It's very likely that the younger stages of the embryos are much more sensitive to these endocrine and hormone changes. And really it's all the ... genetic programming and endocrine programming that determines how fit you are reproductively. It sets you up early in life. So if you screw the system up early on basically you'll have repercussions later on.'[101]

Not much research has been carried out to determine the effects of chemicals at different stages in development. If it is the case that early stages of development are more vulnerable to endocrine disruption than adult stages then looking at results from adult studies will not give much information about the effects that can be expected early in the development cycle. This has circular implications as research on adults may also be identifying effects which initiated at an embryonic stage.

An additional problem is cross-species extrapolation. There is a great degree of uncertainty about the appropriateness of extrapolating from one species to another. Laboratory experiments conducted on mice, rats or guinea-pigs will give data about what the effects of particular chemicals are on those species but will not give categorical evidence as to what will happen if a human is exposed to the same dose for the same length of time. Due to this methodological problem there is no consistent way to use animal experiment results.

To summarise, indeterminacy, in the sense of the impossibility of knowing a problem, can be used in an expedient way by government, the industrial sector, academics and environmentalists alike. Academics who are conducting much of the research into endocrine disruption are keen to obtain more funding to undertake further research. The promise of reducing high levels of scientific uncertainty are conducive to receiving further research funds. One of the features of the various international workshops on the subject of endocrine disruption is the recommendation for further research to establish the extent of the problem and to determine methods of screening suspect substances due to the uncertainties and lack of knowledge in the area. Government departments are already supporting further research into some of the suggested areas.

Inherent uncertainties are also used by the chemical industry to deflect responsibility from themselves. They are anxious to demonstrate that there could be a range of reasons for the observed effects, some of which I have mentioned previously, and that it would be premature to take any radical actions such as banning particular chemicals until such uncertainties have been resolved (which they never can be). For this reason they too have been funding research into projects about endocrine disruption. Environmentalists, on the other hand, use indeterminacy to argue for a more precautionary approach to policy decisions. To them, whilst more research is

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[101] Interview 24/04/97, transcript p2

welcome and the results should be considered when making decisions, policy should be made recognising that these indeterminacies exist rather than waiting for research results.

In this section on the nature of evidence I've examined how definitions help shape the context of deliberations about endocrine disrupting chemicals and I determine the language used by actors in those deliberations. I've also examined the way in which what is considered 'sufficient evidence' and definitions of endocrine disrupters are tied together in these deliberations and I've shown how scientific uncertainty manifests itself in the endocrine disruption debate with regard to indeterminacy, synergy and extrapolation. What this suggests is that the definition of the 'problem' is as important within deliberations as is the understanding of evidence.

Summary

The aim of this chapter has now been realised. I have shown that the development of endocrine disruption as an environmental issue is in its early stages and that the UK government is starting to consider related policy implications. No 'decisions' have yet been made about endocrine disrupting chemicals, although a number of workshops and conferences have been held in the UK to discuss environmental implications. I have illustrated that from the initial commissioning by the Department of the Environment of the Institute for Environment and Health to undertake a review of the situation, a traditional scientific approach has been taken in line with the interests of those doing the organising and the commissioning. I have shown that despite an explicit emphasis on the precautionary principle when the NGOs became involved the deliberations still returned to discussions of scientific evidence and uncertainty. The parties involved and key characteristics of the endocrine disruption issue have both shaped the framework of those deliberations. I established that scientific evidence and its associated paradigms, values and institutional affiliations, all underpinned that framework.

In discussing the nature of the evidence that is drawn upon, both, in the workshops convened and by my interviewees, I show that definitions of endocrine disrupters are still open to negotiation and that there is an attempt by institutionalised parties to frame discussion around existing scientific paradigms and practices. The theme of precaution, in relation to endocrine disrupting chemicals, is being translated into debate about evidence and definitions.

Chapter Seven

Science, interests and uncertainty

Introduction

In chapter two I introduced the concept of precaution, discussing its evolution from a measure to an approach and finally to a principle. Through looking at various national and international agreements I observed that what the precautionary principle 'is' is open to broad interpretation and that this raises significant questions about its implementation.[1] Having examined the wording used in a selection of agreements I was able to identify a set of six (not mutually exclusive) situations with which the precautionary principle must cope. These include:

a) situations where a causal link to effects is unclear
b) where scientific evidence does not yet exist
c) where there is no scientific evidence
d) where cost is a factor
e) where the scale of the threat is a factor
f) where there are a diversity of situations to be accounted for.

Through analysing each of these situations in chapter two I demonstrated that, despite there being no explicit expression of what the precautionary principle might mean in practice, lying behind each is a more explicit reference to science and uncertainty. From this I deduced that the key to understanding the precautionary principle was to look at how scientific evidence is organised and how uncertainty is acknowledged and used in current environmental situations.

[1] See Appendix 1 for a list of the formal agreements discussed in chapter two

In chapters five and six I undertook case studies on radioactive waste disposal and endocrine disruption where I examined the specific issues each raised with respect to themes of scientific evidence and uncertainty. This led me to focus on and compare similarities and differences in terms of the nature of evidence, contested definitions, disputed evidence and scientific uncertainty.

In this chapter I undertake a comparison of these two case studies in order to ascertain what can be learned about the definition and implementation of precaution from a study of these underlying themes. Five key areas of comparison are especially relevant. They are:

a) the emergence of a 'problem'
b) the widespread nature of the problem
c) the role of 'industry'
d) the extent of institutionalisation
e) the rhetorical absence/presence of the precautionary principle in deliberations

I identified these five themes of comparison through reviewing the history of debates about both radioactive waste disposal and endocrine disruption, through looking at the arenas in which those debates take place, the stage in the career of the 'problem' that has been reached, and through identifying the individuals involved in those deliberations and decisions. These themes are discussed in detail later in the chapter.

Having compared the cases of radioactive waste disposal and endocrine disruption in these terms I then look at the relationship between these dimensions of comparison (i.e. those factors observed as having significant impact on the deliberative processes about these two issues) and the six situations identified in the precautionary principle chapter (i.e. those factors that make up rhetorical precaution as derived from official definitions). This allows me to consider the contexts and circumstances of precaution and to review the relationship between that concept and specific environmental situations to which the precautionary principle might be applied. Distilled further, two core concerns come to the foreground. These are the 'interests' of the players involved in decision-making and the role of 'scientific evidence'.

These two areas of 'interests' and 'scientific evidence' need further discussion in order to understand what the relationship between them might be and how that has a bearing on precautionary practice. Here I discuss the relevance of 'interests' theory and offer an explanation of the way in which interests are identified and interpreted. Taken further I review the influence they have on the evolution of the issues under consideration. To parallel this I discuss the relevance of scientific evidence in deliberations about policy making. Having undertaken these analyses I highlight the way in which the theme of 'uncertainty' is a factor for both interests and scientific evidence because of the interdependence between the two. Uncertainty is inherent in science, as discussed in chapter three, and has significant implications for the way in which controversy is resolved. As identified by MacKenzie, those who use scientific knowledge in making decisions are usually removed from the production of that knowledge and so they gloss over the levels of uncertainly existent within it.[2] I show from my case studies that this glossing over of uncertainty relates to the interests of those individuals involved.

[2] MacKenzie, D. (1990) *Inventing accuracy: a historical sociology of nuclear missile guidance,* MIT Press, Cambridge, MA. p370

This thesis identifies a need to go beyond science when attempting to understand and implement the precautionary principle. I finally discuss what this might mean in today's policy culture of science.

(Un)establishing precaution

In chapter two I identified that the rhetoric of precaution is used in many national and international agreements without any express reasoning of what the notion might mean in terms of implementation. I demonstrated that although there has been broad agreement that the precautionary principle is about taking action even if there is no, or insufficient, scientific evidence to link a cause with an effect there has been no agreement as to what implementation of the precautionary principle really involves. This has left the precautionary principle open to being ascribed any meaning that the advocate or critic desires. I have discussed the tensions between lay and expert interpretations of precaution in order to give insight into the problem of translating common-sense understandings of precaution, as demonstrated through cultural proverbs, into a more robust formula for application to more extensive and dispersed issues that have relevance for wider society and which are beyond the control of individuals. Now I analyse how arguments between actors about what counts as evidence and about whether there is sufficient evidence to justify a decision, as demonstrated through the two case studies, relate to official definitions of the precautionary principle.

Six situations of precaution

Reviewing a selection of policy documents and international agreements led me to identify six situations in which the precautionary principle is expected to apply.[3] Although scientific evidence is mentioned often in these agreements it is not invoked in a uniform manner and I suggested that the precautionary principle fills the vacuum created by a science that continually searches for certainty but which continually fails to deliver due to the fact that 'certainty' is contingent upon agreed assumptions and error margins. Science therefore is unable to offer undisputed truth and the precautionary principle, as used in official agreements, prompts acknowledgement of this.

However, it is not enough to solely identify these features of the precautionary principle from policy documentation. In order to examine the concept of precaution in the wider policy world with regard to environmental issues it is also necessary to look at specific case studies to see what factors are relevant in the deliberations about policy action. What follows is a comparison of my two case studies of radioactive waste disposal and endocrine disruption in which I identify five key areas that have relevance to understandings of the precautionary principle. Subsequently I discuss the connection between the six situations of precaution and these five keys areas of comparison described below.

[3] See chapter two for a full discussion of these situations

Comparing the Case Studies

The precautionary principle has been mentioned in reference to such diverse issues as radioactive waste disposal, endocrine disrupting chemicals, climate change, genetically manipulated organisms, BSE and breast implants. Because the precautionary principle is so broad and ill-defined it is left to those involved in specific debates to shape and define it in accordance to their needs and the needs of the issue in question. Whilst it is upheld as a worthy environmental principle, as indicated in the agreements reviewed in chapter two, implementation is a localised and specific social process. The issue at stake therefore is crucial in determining the meaning of the precautionary principle. The question that arises here is 'Is there anything about a particular issue (for example, radioactive waste or endocrine disrupting chemicals) that determines how the precautionary principle is or could be implemented?' It is this question that I attempt to answer in the following section.

In chapters five and six I identified some of the main characteristics of radioactive waste disposal and endocrine disrupting chemicals. Some of these characteristics are specific to one topic whilst others may apply to both. These similarities and differences between the two case studies can be broken down into five key areas: the emergence of a 'problem'; the widespread nature of the problem; the role of 'industry'; the extent of institutionalisation; the absence/presence of the precautionary principle in deliberations. These aspects are especially relevant for application of the precautionary principle to diverse situations. By considering how the problems of radioactive waste disposal and endocrine disrupting chemicals emerged I establish that understanding the history of a problem helps identify what stage that 'problem' is at in its development and this helps in identifying types of institutions likely to be involved in debating it as an issue. By considering the geographical spread of a problem I show that the precautionary principle is invoked in diversely affected localities. I look at the role that industry plays in deliberations about radioactive waste disposal and endocrine disrupting chemicals because this also helps identify the range of voices involved and I show that when there is a defined 'industry', as in the radioactive waste case, it is easier to fix interests according to institutionalised categories. The extent of institutionalisation is considered as a separate issue as it has further implications for the frameworks within which deliberations take place. Additionally, the degree to which 'the precautionary principle' itself is discussed within deliberations about radioactive waste disposal and endocrine disrupting chemicals is considered in relation to the outcome of those deliberations.

The emergence of a 'problem'

The histories of the issues of radioactive waste disposal and endocrine disruption are very different. Where radioactive waste disposal has a long history during which many public inquiries have been held, many policies been made and re-negotiated, and the industry concerned has become narrowly defined, the issue of endocrine disruption is emergent with workshops and seminars taking place, policy options being discussed and a bounded 'industry' being impossible to identify. In this section I discuss how the sense of a problem comes about, identifying this with reference to the two case studies.

The question of radioactive waste disposal, as a formalised problem, dates from 1955[4] and as such many debates, both public and political, have taken place. Much documentation has therefore been produced on the subject, a considerable amount of which is in the public domain. In comparison the question of endocrine disruption is relatively new although a considerable amount of data has already built up on this issue. A distinctive difference is that the radioactive waste debate started at a time when secrecy was considered the norm within the nuclear industry due to its military history (although this has changed considerably). In contrast, the endocrine disruption debate has been held in public (through academic journals, workshops, conferences and the media). In terms of the emergence of a problem it has been easier to follow the debate about endocrine disruption from its inception than that of radioactive waste disposal. A paradox of this is that there is more consensus about what the problems with radioactive waste disposal are than there is about what causes endocrine disruption.

However, new insights into any issue will always be forthcoming, and these bring with them their own inevitable biases and constraints. New information constantly challenges old positions so renegotiations are necessary in order to reach a new consensus about knowledge positions. This is seen clearly in the case of endocrine disrupting chemicals where new research is constantly being commissioned in order to try to fill 'information gaps' with an ongoing circularity due to the recognition of further 'information gaps' brought about by the undertaken research. In this way information, and hence documentation, increases and the complexity of the problem emerges.

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[4] See Command Paper 9389 (1955),HMSO, London, pp. 22. p4 which says 'The disposal of radioactive waste products should not present a major difficulty ... The volume of waste will be small and great

As new research is undertaken, so new players become involved in debate about the issue in question. The key players in the radioactive waste disposal case are easily identified as many have been around for a long time, and within government, industry and regulatory bodies, their positions are well established. In contrast the key players in the endocrine disruption case are rather more emergent. This is because, at present, many of the discussants of endocrine disruption are academics whose area of research may be impacted upon by endocrine disrupting chemicals, chemical manufacturers whose products and processes are suspects, government officials whose roles include regulation of water, food and the environment, and water company spokespersons who have a remit to provide safe drinking water and health professionals. There are no specific roles (at the time of writing) within government or the regulatory bodies to deal with the issue of endocrine disruption and/or endocrine disrupting chemicals. An additional contrast is the existence and non-existence of pressure groups campaigning about the issues in question. There have long been groups actively campaigning against the nuclear industry with CND and CORE working specifically on nuclear matters and multi-issue environmental groups such as Friends of the Earth and Greenpeace devoting many resources to anti-nuclear campaigning. In contrast there are no single issue groups campaigning specifically about endocrine disruption although multi-issue groups such as Friends of the Earth, Greenpeace and WWF are devoting more and more resources to the topic.

The above illustrates that the career of a problem can develop in different ways. With radioactive waste disposal the key players have been in position for a long time, shaping and negotiating the boundaries of the debate. The nuclear industry has existed in Britain since the 1940s and the question of radioactive waste has been

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efforts are being made to determine the most economical methods of storing or disposing of it'.

around since then (although not explicitly acknowledged until 1955). Over time, the parameters of discussion have changed with lobby groups challenging established positions. However, as the Nirex Inquiry illustrated, some subjects are not open to re-negotiation due to the constraints of specific decision-making fora, such as a public inquiry. In contrast the career of the endocrine disruption problem is at an early stage. The boundaries of the debate are still open, although they are being shaped in terms of toxicology. The sense of the problem is emerging through studies identifying developmental problems in wildlife and laboratory studies identifying endocrine disrupting effects of specific chemicals. With radioactive waste there is a consensus that there is a real issue that needs to be managed, but with endocrine disruption there is still no consensus that chemicals are the cause of the problem, or even that there is a problem at all.

Another factor of significance in understanding the sense of a problem concerns the consensus regarding the links between cause and effect. With radioactive waste disposal these are more clearly established since there is, to a certain extent, consensus as to the health effects of radiation. Therefore, certain health and safety standards exist to protect workers within the nuclear industry and emissions quotas exist to limit the extent of manmade radiation in the environment. In contrast the health effects of potentially endocrine disrupting chemicals are not established and there are no health and safety standards for workers specifically related to the endocrine disrupting nature of the substances with which they work. Similarly there are no emissions quotas for chemicals specifically related to their endocrine disrupting potential.

Despite there being differences in health and safety standards, studies have shown there to be clusters of leukaemia around nuclear sites[5] and reproductive disorders in individuals working with particular pesticides.[6] Both the nuclear industry and manufacturers of chemicals, however, have argued that there is not enough evidence to link these effects with their processes and suggest that other factors might be involved. For example, the fact that elements other than endocrine disrupting chemicals may be involved is used as a reason by chemical manufacturers for delaying taking any rapid action regarding banning or phasing out particular implicated products.[7] There have been suggestions that tight underwear or the fact that men spend much more time sitting down now than in the past might be causing the observed fall in sperm counts. Phytoestrogens have also been implicated as potential causes. Those who advocate immediate action concerning chemicals do not refute the idea that these other factors may be involved but do not accept these as reasons for not taking actions regarding the chemicals prior to some scientifically determined certainty about their effects.[8]

The above illustrates that what becomes seen as an 'issue' arises in different ways dependent upon the history of the associated industry, the players involved in debate, studies that have already been undertaken and the level of consensus with regard to causality. How the career of an issue then develops can depend on the level and range of expertise involved. Certain practices may become preferred because of the way the

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[5] Gardner, M. J., Snee, M. P., Hall, A. J., Powell, C. A., Downes, S. and Terrell, J. D. (1990) *British Medical Journal,* **300,** 423-429.; Downs, S. (1996) In *Nuclear Power: Shut it Down!: an information pack on nuclear power and the alternatives. Vol 1*, Vol. 1 (Eds, Crispin, A., Grunberg, D. and Hildyard, N.) The Ecologist,, pp. 93-96.

[6] Watterson, A. (1996) In *Effects of organochlorines on human health workshop*Academic Medical Centre, University of Amsterdam.; Lindstrom, G. (Ibid.).

[7] EMSG (Endocrine Modulators Steering Group) (1998),CEFIC,, pp. 8.; CEFIC (European Chemical Industry Council) (1997) In *OSPARCOM head of delegation meeting*CEFIC, London, pp. 4.

debate has developed and alternatives may be neglected because they fall outside conventional ways of thinking. This could be seen with the radioactive waste disposal issue until fairly recently when the British Government Panel on Sustainable Development recommended that:

> 'the Government's research strategy on radioactive waste should be widely based, including intermediate-level waste, and that all options for disposal should be explored ... [and] that the Government should review the ways in which information is made available and decisions are taken...'[9]

With the endocrine disruption issue still emerging there is the potential to look at a range of possible options from the onset of the debate. However, whether this actually happens depends very much on the political climate and the accepted range of expertise.

The suggestion is that different environmental 'issues' have different careers and that at any particular point in time the 'issue' of concern is at a particular point along the trajectory of a career path. This is not to suggest that every issue of environmental concern follows the same trajectory, nor that identifying the point along the trajectory of a particular issue's career will determine how a generic 'precautionary principle' can be applied to it. However, understanding an environmental issue in terms of its career trajectory helps in locating the level of deliberations about it, the voices involved in those deliberations and the influence they have on policy developments. Since each environmental issue has a distinctive trajectory the concept of the precautionary principle may be invoked at different stages in relation to different

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[8] Santillo, D., Stringer, R. L., Johnston, P. A. and Allsopp, M. (1998),Greenpeace Research Laboratories,, pp. 11.

issues. This means that the principle must be adaptable to those different situations. If something is recognised as an 'environmental problem' at an early stage, precautionary policy options can be voiced at the onset. At such a point a diverse range of precautionary options may be discussed. When an 'environmental problem' is at a more developed stage, as in the case of radioactive waste disposal, the structures of debate have become more institutionalised and so the range of precautionary options may be more limited. Deliberations are shaped by predetermined paradigms.

The widespread nature of a 'problem'

A second relevant point of difference between the radioactive waste disposal and endocrine disruption cases concerns the geographical location of the 'problem'. Despite the fact that the 'problem' of endocrine disruption is still emergent, individuals are very close to it in terms of being exposed to chemicals. This is because chemicals are ubiquitous and no individual can prevent her or his exposure to them. Because radioactive waste is located in specific places the wider public is not exposed to its immediate effects, (barring transportation of the waste around the country and imports of waste from other countries which subsequently travels through populated areas). The argument can be made that the public can distance themselves from radioactive waste in a way that they are unable to do with endocrine disrupting chemicals.

This again illustrates the extremely varied situations in which the precautionary principle is adopted. Exposure to potential hazards may be within or beyond an

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[9]British Government Panel on Sustainable Development (1996),DoE, London, pp. 20. p18

individual's or community's control in terms of the ubiquity of the hazard, and decisions about the potential hazard may be beyond their control due to the structure of frameworks of policy and decision-making. Complementary to the question of control is that of detection, namely the ability of an individual to detect whether they are being exposed or not. It is not possible for individuals to eliminate their exposure to endocrine disrupting chemicals, indeed it may not be possible to limit one's exposure. In contrast, radioactive waste is more localised in terms of its production and storage and so some members of the public will be closer to the source of risk than others. However in both cases people may not be aware of their exposure due to the difficulties of detection. This highlights another problem that the precautionary principle must handle. The question of how many people can be allowed to be exposed to a risk before action is taken and the issue of whether a particular risk is acceptable is often addressed in scientific terms but can be reframed as a question of social acceptability. Establishing a statistical figure for tolerance regarding exposure and detection denies the social negotiating that takes place in determining the risk, yet the two case studies imply that these social dimensions are critical.

Neither radiation nor endocrine disrupting chemicals can be detected with the naked eye and people exposed to either substance may be so unknowingly. This is not to suggest that invisible dangers are necessarily more of a hazard than detectable ones but rather to highlight the point that many hazards may be unknown to those at greatest risk. It is important to note that being invisible to the naked eye does not necessarily imply that the hazard is not detectable. A study of the nuclear industry shows that it is possible to regulate certain, known 'invisible' dangers. With the use of scientific measuring devices levels of radiation can be detected and stringent regulations have been put into practice regarding radiation levels and safety. This contrasts with the case of endocrine disrupting chemicals where screens and tests are not readily available to detect hazards that are not detectable with the naked eye (although research is under way to develop such tests).

For the implementation of the precautionary principle this demonstrates yet another source of difficulty with regard to the use of scientific methods. If a hazard cannot be detected with the naked eye then there is a reliance on scientific equipment to make the detection. This relies on there existing sophisticated enough equipment for harmful levels of the particular hazard to be detected and this in turn relies on judgements as to what counts as harmful (also usually defined in scientific terms).

The role of 'industry'

As I have already stated, the key players involved in any debate play a determining role in defining and bounding how any decision comes about and thus whether it is precautionary or not.

With the radioactive waste disposal case study the 'industry' is very clearly defined, with Nirex plc and BNFL playing central roles and having specific legal responsibilities. Proponents and opponents of the 'nuclear industry' are readily discernible. With the endocrine disruption case study this is not so. Despite the fact that chemicals are the main protagonists in the story there is not one clear 'chemical industry'. Chemicals are produced by a wide range of companies for a vast array of applications and despite the fact that a chemical industry council (CEFIC) exists in order to create one voice, different manufacturers have their own concerns and responsibilities. Unlike the 'nuclear industry' with its statutory responsibilities with regard to radioactive waste, chemicals manufacturers don't have statutory responsibilities with regard to endocrine disruption.

What does this distinction between having an identifiable 'industry' or not having one tell us about the precautionary principle? Although many of the same names recurred at the various workshops and conferences on endocrine disruption, the list of institutions involved got longer over time as new research was undertaken and more sectors began to see the potential impacts on themselves. The potential 'industrial' voice has become larger over time in the endocrine disruption case whereas in the radioactive waste disposal case industrial interests are stable. As more voices are added so the potential for conflict increases, but there is more to it than that.

Many of the people involved in the radioactive waste disposal debate in the UK have had the same nuclear training and therefore belong to the same school of thought whether they work for the regulators, government or the industry itself. The implication is that they all start out with the same basic paradigms and so their perspectives are skewed in the same directions. The endocrine disruption debate contrasts with this as those involved come from a variety of backgrounds including toxicology, chemistry, food science, aquatic research, health and pollution control to name a few. Whilst each of these disciplines has its own basic paradigms they are sufficiently different to require a more deliberative debate on the issue. This difference between the two case studies illustrates that the backgrounds of those involved in making decisions can have a large impact on the debate that takes place forcing some issues to be minimised at the expense of others. In a situation where the majority of players share the same institutional background those who oppose the status quo have a more difficult job as they are arguing against an established way of thinking. It is apparent from my two case studies that a point of relevance for decision-making in general, and therefore for invoking the precautionary principle, is that debate is shaped by the established institutions involved and their associated paradigms.

The extent of institutionalisation

The fourth relevant comparison between the radioactive waste disposal and endocrine disruption case studies is the degree to which 'decisions' have been defined and made, and the existence or non-existence of a framework for decision-making.

Decisions about radioactive waste disposal have become highly institutionalised, being made within established frameworks, such as planning inquiries. In contrast, at the time of my fieldwork, decisions about endocrine disruption were emergent and not part of established frameworks.

The ultimate decision about the RCF, as discussed in chapter five, was made by the Secretary of State after the Planning Inspector at the public inquiry produced his report. In that case it was the planning system, laid out by government, which determined which voices could be heard and which couldn't. Some bodies had a statutory duty to be involved whilst others were able to present their evidence if they submitted their documents in the proper format at a predetermined time. In contrast there is no framework into which decisions regarding endocrine disrupting chemicals can slot and no sense even of what these might be. Deliberations have come about through conferences and workshops set up by academic institutions, NGOs and commercial conference organisers. Government departments have been involved in these discussions and debates but they have not established their own frameworks for prompting or forcing decisions.[10]

One factor that has a strong influence on when and how 'decisions' come about is the state of current government policy. The contrast between policy on radioactive waste disposal and endocrine disrupting chemicals is stark. Currently there is government policy on radioactive waste disposal and none on endocrine disruption with regard to chemicals.[11] However, in April 1998 the Environment Agency conducted a consultation into endocrine disrupting chemicals[12] and in July 1998 the DETR produced a consultation paper which demanded responses by October 1998.[13] This shows that policy-making is a dynamic enterprise. Similarly, the House of Lords undertook a review on radioactive waste policy in 1997.[14]

Policy with regard to these two issues has emerged and developed under different political ideologies. Nuclear power was a national industry developed at a time when energy self-sufficiency was considered important by the then government. The various components of the 'chemical industry' developed privately, although it was

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[10] Since conducting my fieldwork this situation has changed with the European Commission having conducted a number of workshops on the subject of endocrine disruption. See European Commission - Directorate General for Environment, N. S. a. C. P. a. D. G. f. I. (1999) In *Industrial chemicals: burden of the past, challenge for the future*(Ed, Commission, E.) European Commission, Brussels, Belgium.
[11] I write this as applying at the time of my fieldwork (1996-1997) as policy is always in a state of flux with adaptations and developments constantly occurring.
[12] Environment Agency (1998),The Environment Agency, Bristol, pp. 13.
[13] Department of the Environment, T. a. t. R. (1998),DETR, London, pp. 34.
[14] House of Lords (1997),, pp. 2.

encouraged by government policy due to the employment it brought to particular regions. Both nuclear power and chemical production are regulated by government but the conditions for regulations have changed over time. Chemicals are stringently regulated with regard to carcinogenicity but no regulations exist with regard to endocrine disruption since this is a relatively newly observed phenomenon. The nuclear industry regulates radioactive waste disposal stringently according to the radioactivity of the substances to be managed. The guidelines for assessing radioactivity relate to a substance's radioactive and heat producing properties. A similarity that can again be detected from these two case studies is the reliance on scientific determinants to ascertain the 'hazardousness' of a product or process. The status of current policy is the springboard for future policy and this can have a stifling effect such that the concept of the precautionary principle may be backgrounded due to the way in which existing policy came into being.

The rhetorical absence/presence of the precautionary principle in deliberations

A final point of comparison between the two case studies is the degree to which the rhetoric of the precautionary principle has been a part of these deliberations. In the case of radioactive waste disposal there was minimal reference to the precautionary principle at the Nirex Inquiry whereas with the endocrine disrupting chemicals case NGOs were anxious from the beginning to include explicit discussion of the precautionary principle in deliberations.

As discussed in chapter five, the Nirex Inquiry centred on a debate about evidence, uncertainty and risk. The only explicit reference to the precautionary principle itself was made by Greenpeace in order to assert that the site selection process was the important relevant factor. In their closing submissions they stated:

> 'The choice of a site which is more robust under worst case scenarios would fit with the precautionary approach.'[15]

Further discussion of the precautionary principle did not become a focal point of the inquiry. Instead the inquiry focussed on areas that I identified in chapter two as being component parts of rhetorical precaution and deliberations expanded on those.

In contrast the precautionary principle was more explicitly invoked in the endocrine disrupting chemicals case study. As shown in chapter six, the NGOs were not involved in the initial workshop set up by the Institute for Environment and Health but became more involved at the second workshop where they made a concerted effort to have acceptance of the precautionary principle a critical part of the agenda. They were concerned that the first workshop had focussed on the weight of evidence that was available as an indicator of how policy should progress, and they wanted the precautionary principle to be more explicitly recognised as a theme in its own right. However, despite this subsequent deliberations again focussed on issues of scientific evidence, uncertainty and definitions.

Having made this observation I must point out that despite the precautionary principle being (effectively) absent from the Nirex Inquiry, nevertheless a decision was ultimately made – that the RCF should not be granted planning permission to be excavated. In contrast, at the time of my fieldwork, negotiations about endocrine disrupting chemicals were still very much at the deliberations stage and no decision

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[15] See Haszeldine, R. S. and Smythe, D. K. (Eds.) (1996) *Radioactive waste disposal at Sellafield, UK: site selection, geological and engineering problems,* Glasgow University Print Unit, Glasgow. p202

was imminent, despite the explicit invocation of the precautionary principle early on. What is clear from both case studies, however, is that the themes I identified as component parts of rhetorical precaution in chapter two were component parts of both sets of deliberations. In both cases issues of evidence, uncertainty and definitions were central to the process.

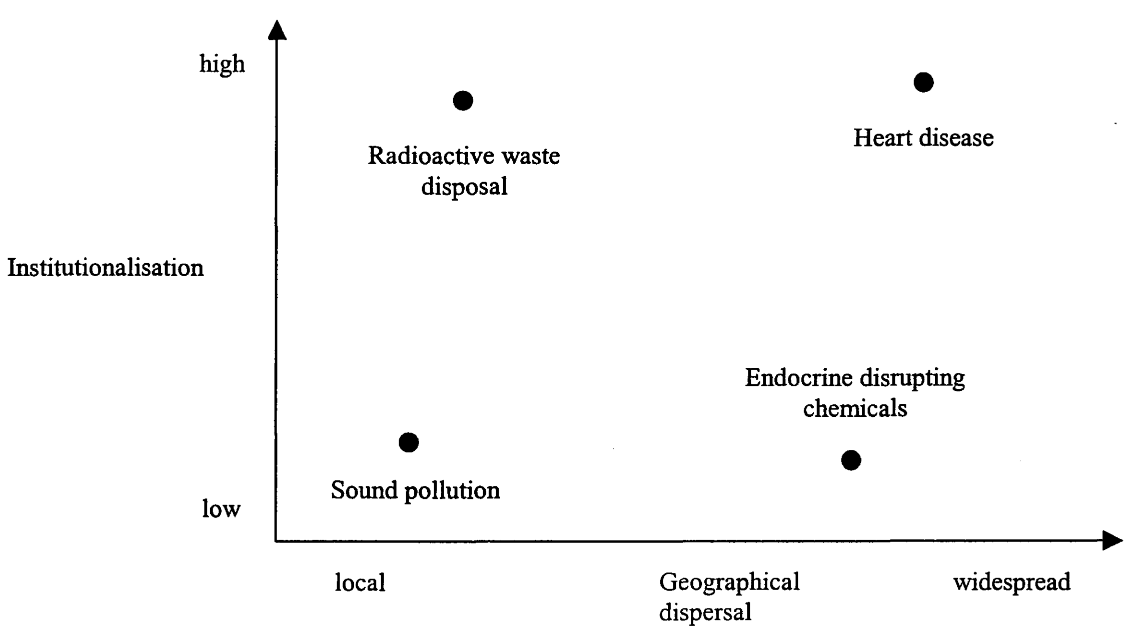
Five areas of comparison and six situations of precaution

My intention in elaborating on these five areas of comparison between my case studies is to illustrate the complexity of situations in which the precautionary principle is applied. An environmental issue may be at any position along its career trajectory when it becomes seen as a 'problem'. 'The precautionary principle' may be invoked at the point when it is recognised as a 'problem'. The form of 'invocation' depends on the problem at stake and the level of institutionalisation. As was seen in the radioactive waste disposal and endocrine disrupting chemicals case studies some participants felt that invoking the precautionary principle meant doing more research whilst others felt that this was missing the point of precautionary action and advocated more interventionist measures. The positions taken reflect institutional, disciplinary, political and social interests and, since those involved in deliberations about each new environmental 'problem' will be different, so the range of alternative implementations advocated will also be diverse.

There appears to be no 'optimum' time at which it could be said the precautionary principle should be implemented since the nature of each problem and the institutionalisation of the fora in which deliberations about each problem are made are unique and dynamic. Additional to this, there is no universal consensus as to what 'the precautionary principle' is and so it has become a reified term, which is applied in a blanket fashion, with the users of the term unsure about what exactly they are invoking.

With the aid of diagrams the diversity of situations with which the concept of the precautionary principle is faced can be illustrated more clearly. Figure one, below, illustrates the relationship between the geographical dispersal of the 'problems' of radioactive waste disposal and endocrine disrupting chemicals and the level of institutionalisation of decision-making.

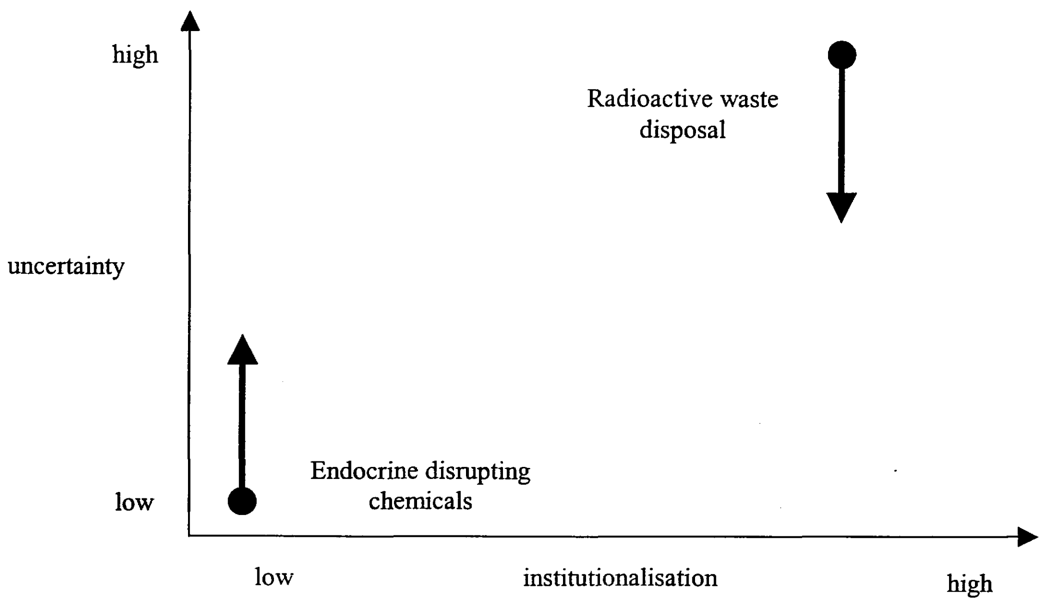
Figure one: Institutionalisation and geographical dispersal of environmental problems



As discussed above, endocrine disrupting chemicals are ubiquitous and individuals cannot control exposure to them. Radioactive waste, on the other hand is more localised and so the environmental 'problems' associated with it are located where it is created and where it is stored. This places them at opposite ends of figure one. However, the institutionalisation of each problem in terms of the decision-making fora that exist for deliberating on them is very developed for radioactive waste disposal and at a much more emergent stage for endocrine disrupting chemicals. This places these issues at opposite ends of the other axis in diagram one. Other issues can also be placed on this diagram. Sound pollution, for example, is very localised, similar to radioactive waste, but it has a low level of institutionalisation. Heart disease, on the other hand, is geographically widespread but has a high level of institutionalisation. Therefore it can be seen that endocrine disruption and radioactive waste disposal are only two of a much larger population of issues.

Figure two (below) illustrates the direction that scientific uncertainty is currently moving for both radioactive waste disposal and endocrine disrupting chemicals. The institutionalisation of endocrine disruption is currently low and as such the understanding of the uncertainties embedded in knowledge about it is low. As deliberations open up, more participants are involved and institutionalisation increases, so the uncertainties increase. This is because, as more research is undertaken and discussed, more uncertainties come to light. However, there appears to be a stage, with the radioactive waste issue, at which the level of uncertainties starts to decrease. As radioactive waste disposal deliberations have become highly institutionalised many uncertainties have come to light, although they have not necessarily been resolved.

Figure two: Scientific uncertainty and institutionalisation of endocrine disrupting chemicals and radioactive waste disposal



Previously I identified six situations in which 'the precautionary principle' is expected to apply through looking at documentation that invokes the term precaution. Looking at these situations, the importance placed on the existence or non-existence of scientific evidence is immediately apparent. The lack of 'scientific evidence' is used as a criterion in many of the agreements that invoke precaution, although not in a uniform manner. Having analysed these situations I suggested that understanding how scientific evidence is marshalled and how uncertainty is acknowledged and used is key to considering what lies behind the precautionary principle. From comparing the case studies five main themes came to the fore. These also indicate a reliance on scientific evidence, the specific relevance of which depends on the career of the issue and the range of interests at stake. It is this reference to scientific evidence and uncertainty that connects the concept of precaution as embodied in official documents in chapter two with my analysis of the real-life deliberations surrounding radioactive waste disposal and endocrine disrupting chemicals. From this connection implications for implementing the 'precautionary principle' can be derived.

Scientific Evidence and Interests

In the following sections I discuss how I rediscovered interests theory through my data and its advantages and limitations as an aid to understanding the way in which scientific evidence is used in making precautionary decisions about environmental problems. Additionally I deconstruct the use of scientific evidence in my two case studies in order to open up the question of what factors other than science are currently used as the basis for decisions. This shows that we come back to the problem of 'uncertainty' as an underpinning feature both when deconstructing science and when looking at the case studies of radioactive waste disposal and endocrine disruption in terms of the interests involved.

Rediscovery of interests

In chapter three I identified six key factors relating to interests theory that are of relevance to my research on the implementation of the precautionary principle and I now evaluate them in relation to my case studies. These are:

a) Scientists' knowledge-claims embody, or are informed by, social and political interests and these may reflect disciplinary, professional and ideological interests and objectives.

With reference to the Nirex Inquiry, discussed in chapter five, it is apparent that there was a scientific conflict of opinion in respect to the safety of the proposed RCF. I have demonstrated that this conflict came about due to the institutional and ideological interests and responsibilities of the players involved at the inquiry. Some of this is due to statutory responsibilities laid down by law as with the Department of the Environment and the Environment Agency which forces a professional framework upon the individuals involved. This meant that, for the scientists involved, only certain parameters were open for discussion and so they confined their contributions to those areas. For other groups, ideological interests and objectives could be seen to be more relevant as with Friends of the Earth and Greenpeace. Their campaign priorities and philosophical beliefs led them to advance evidence in order to reopen debates that would otherwise have remained closed. Disciplinary and professional interests and objectives could also be seen in the way in which Nirex and BNFL handled their evidence at the inquiry. They accepted that the safety question had been satisfactorily closed and therefore they provided evidence to indicate that their 'science' was uncontroversial.

My fieldwork on endocrine disruption also indicated disciplinary, institutional and ideological interests and objectives. Although a distinct 'industry' was not obvious in this case, the different players were all drawn from narrow professional groupings. In this case all discussants are agreed that scientific knowledge is not at a point where consensus has been reached that certain chemicals cause particular effects, but there is still a wide range of opinions as to what point scientific knowledge has reached. Again, government bodies such as MAFF and the Environment Agency are bound by the disciplinary frameworks within which government institutions operate and as such they view the current state of knowledge about endocrine disrupters as given within the scientific disciplines that have produced that knowledge, for example toxicology. They then commission further research in response to this previous set of 'knowledge'. As with the radioactive waste case, NGOs such as the WWF and Friends of the Earth have their ideological interests and objectives which can be seen in their unwillingness to accept that there isn't already enough scientific evidence of a problem with chemicals to warrant policy action.

b) The interests approach aims to understand how knowledge is produced as opposed to simply understanding what knowledge is taken to exist.

Both case studies illuminate the way in which knowledge is produced, identifying that it is through the structures and frameworks that exist or are set up to discuss the issues that what is considered 'knowledge' comes about. Certainly a public inquiry such as the Nirex Inquiry can be seen to be a stage for airing and debating the knowledge that is already taken to exist but I would take that further, suggesting that such frameworks themselves can produce the 'knowledge' by endorsing certain beliefs at the expense of others. What may start out as conflicting evidence at a public inquiry is eventually summed up as a more certain, 'known' knowledge. By looking at the endocrine disruption case study, another mechanism by which knowledge is produced is identified. In this case what is considered 'known' came about by trial and error and by developing previous research activities. Some of the studies that discovered problems with wildlife and others that discovered endocrine disrupting qualities of particular chemicals happened almost accidentally while the researchers were studying other interactions.[16] What both case studies identified is that the individuals involved in discussing radioactive waste disposal and endocrine disruption were instrumental in producing the knowledge subsequently debated and that they were influenced by the interests and objectives discussed in the above point.

c) The interests approach reasons that knowledge is the result of consensus amongst individuals rather than being inherently 'true'.

This point is also supported by my case studies as I indicated in chapters five and six. What is taken to be 'known' is a matter for negotiation between key players, at the Nirex Inquiry in the case of radioactive waste disposal and in conferences, workshops and academic journals in the case of endocrine disruption. Where consensus is reached, knowledge is considered to exist. For example, with regard to endocrine disruption it is agreed by those involved in the workshops discussed in chapter six that *in vivo* studies provide a more detailed understanding of the mechanisms whereby chemicals may cause endocrine disruption than do *in vitro* studies. The consensus is that data produced by replicable *in vivo* studies is considered to be stronger evidence, giving it the position of 'truth'. In contrast data produced by *in vitro* studies is not considered sufficient in and of itself, despite the fact that *in vitro* studies can also demonstrate endocrine disruption. When looking at ethical debates about animal experimentation one common argument is that proving an adverse effect in one

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[16] See Soto, A. M., Justicia, H., Wray, J. W. and Sonnenschein, C. (1991) *Environmental Health Perspectives*, **92,** 167-173.

species does not necessarily imply an adverse effect in another species.[17] The implication of this is that *in vivo* tests demonstrating endocrine disruption in rats, for example, need not necessarily imply endocrine disruption in humans, or conversely that *in vivo* tests showing no endocrine disruption in one species does not imply no endocrine disruption in another. This establishes that it is the consensus of the experts involved in the endocrine disruption debate that determines what counts as 'knowledge'.

The radioactive waste disposal case study also illustrates this point of knowledge being a consensus of opinion. The public inquiry provided a platform where all that was known about the geology and hydrology of the proposed RCF site near Sellafield could be debated. Positions about the geology and hydrology differed and the final outcome was that the Secretary of State was not satisfied that there was enough consensus of opinion about the safety of the site to allow the RCF to go ahead. Each representative who gave evidence at the inquiry spoke from a position of relative expertise, and presented evidence that, within their discipline or institution, was considered as closed. When these disparate 'knowledges' were brought together it was clear that an objective 'truth' did not exist and indeed that a consensus may only have existed within a select group of individuals. Involving a wider audience meant less consensus and so generated a sense of less certain knowledge.

d) The interests approach asserts that frameworks of assumptions, standards, purposes and meanings exist which are shared by individuals and which are reinforced by conditions within society. Additionally it maintains that science is a

[17] See for example LaFollette, H. and Shanks, N. (1996) *Brute science: dilemmas of animal experimentation*, Routledge, London and New York.

social process, which follows a set of procedures in order to modify or elaborate a previous theory, and this establishes and reinforces institutional and disciplinary interests.

The radioactive waste disposal case and more specifically the Nirex Inquiry illustrates very succinctly one such framework in which assumptions, standards, purposes and meanings do exist. As discussed in chapter five, many of the individuals involved in discussions about radioactive waste disposal come from the same disciplinary background. These paradigms are further reinforced by society whose more civil frameworks, such as planning inquiries, afford an expertise to those from such disciplines. A hierarchy of frameworks can be seen to exist, both scientific and civil, which depend upon each other for reciprocal support.

In both case studies, the view of science as a social process can be seen. With endocrine disruption, where there is still contention as to what is causing certain observed effects, various theories exist as to what the aetiology is. Research is continually being undertaken based on these theories in order to gain a further understanding of the processes involved. Individuals conducting research into the oestrogenic effects of individual chemicals, for example, already work within a particular scientific discipline, and this shapes the particular types of experiments and fieldwork that is undertaken. For this reason much of the research into endocrine disruption has centred around toxicology.

Finance is a major factor in determining the type of research that is undertaken. It is apparently easier for scientists to obtain funding that draws upon previously 'successful' research than it is to obtain funding to test new, possibly contentious theories. Both my case studies highlighted a commitment to scientific knowledge as the arbiter of controversy, through calls for more scientific research to be undertaken in the case of endocrine disruption in order to determine if there is a 'problem' and the extent of it, and through the use of scientific evidence at the Nirex Inquiry by all the participants in order to advance their position. All the research involved in attempting to understand endocrine disruption and radioactive waste disposal has attached costs which are undertaken in an effort to reduce uncertainty. However, the costs involved in undertaking different types of research will influence the research that actually gets undertaken due to the limited resources available.

e) Empirical work that follows the interests approach looks at debates over scientific 'expertise' in public settings. The relationships between scientists, power-brokers and decision-makers are all involved in the closure of scientific debate.

The empirical work that I conducted into both radioactive waste disposal and endocrine disruption looks at debates over scientific 'expertise' in public settings. In chapters five and six I discuss the ways in which scientific evidence is obtained and used and the relationships between the key players involved in those debates. I illustrate the interests of scientists, industry spokespersons, government officials and campaigners, and suggest that the interaction between them shapes and brings about closure of the debate.

f) Advocates of the interests approach show that interests can be identified in all forms of scientific knowledge – discrediting the notion that scientific knowledge should and can be purely objective in nature.

My research has shown that knowledge claims have depended on the disciplines, paradigms and institutional affiliations of the individuals involved.

Analysing interests

I use the idea of interests in an unproblematic way in this thesis in order to tell my empirical story from a particular perspective. However, if the interests that I identify don't actually exist or are caused by other phenomena outside of the radioactive waste disposal or endocrine disruption debates is it then possible to say they are the cause of the positions taken within those debates? This illustrates a circularity in the theory of interests. If interests are caused by something external, for example social factors, and then they are applied in another context, for example a position on the evidence related to radioactive waste, do they then create further interests within the radioactive waste debate? The argument from the opposite direction asks what interests caused the social interests. If the interests identified are separate and distinct from the scientific context which I use them to explain then the same interests should be able to explain other areas of scientific conflict. My empirical work shows this to be the case. While the actual professional and institutional interests involved in the radioactive waste disposal debate and endocrine disruption debate are different it remains the case that there are professional and institutional interests at play in both instances.

It is important to recognise that an interests perspective only affords one interpretation of the way in which scientific knowledge is produced and the way in which scientific evidence is used. In the same way that it is problematic to assume that scientific practice is capable of producing an authoritative statement about the world due to the uncertainties which are endemic to it, it is similarly problematic to assume that the interests which an interests approach identify allow one to produce an authoritative statement about the scientific and policy making world. Where recognition of interests can help is with an understanding of how uncertainty is defined and used by different people in different contexts. However, such recognition does not help with resolving those uncertainties or bringing about a consensus.

It may be that I am the one imposing particular interests on the individuals involved and that the relationships are more intricate and complex than I can hope to suggest. Even so, I believe that the interests approach can help to identify who is regarded as an expert and the social and institutional reasons for why this is the case. In my two case studies I have identified interests through knowing something of the backgrounds of the institutions and organisations discussed, through knowing something of their institutional agendas, and through taking respondents' own observations at face value. Other approaches, for example Actor Network Theory, may give an alternative picture of the involvement of all the actors, both human and non-human, but I would suggest that an advantage of looking at expertise from an interests perspective is that it offers a simplified analysis of decision-making processes and therefore provides a useful baseline for further enquiry.

It is important to note that interests are not static, unchanging attributes that can be attached to particular entities like labels. They will develop and change depending on context and situations. Therefore when individuals take up certain roles and positions their interests may change accordingly. This is not something that is denied through my empirical work as it is the institutional and disciplinary interests that I show to be at work in shaping positions. I have looked at a static snapshot of time with regard to the two case studies and within that snapshot it is possible to regard the interests as fixed as the individuals involved have defined roles and responsibilities. I have, however, placed considerable emphasis on the notion that problems and issues have careers, and that levels of institutionalisation, and the range and types of interests involved change over time.

Adherence to scientific evidence

Above I have looked at the way my empirical research is illuminated by interests theory, thereby showing the importance interests have in making decisions about the two environmental problems of concern in this thesis. I now look into why so much importance is placed on scientific evidence both in relation to the meaning of the precautionary principle and within disputes about radioactive waste disposal and endocrine disruption.

When discussing the precautionary principle the subject of sufficient scientific evidence comes up again and again, both at the level of official documentation and in relation to specific environmental issues. One of the main distinctions made in the various agreements discussed in chapter two, and between those discussing what action should be taken in the radioactive waste disposal and endocrine disruption cases, is the strength of causality that is required and how it should be determined. Some individuals argue that action should not be taken before aetiology is established whereas others argue that precaution means to take action before causality is determined. Even if a link between cause and effect is not already established many suggest that it must be plausible that a link could exist before action can be taken. This is more difficult to reach agreement on as different individuals have different interpretations of levels of evidence that they would find sufficient to indicate that link. Measures of risk are often used to help determine what action is appropriate in particular situations. However risk analysis itself is open to criticism. Additionally, if risk is well understood, action is preventative rather than precautionary.

Scientific evidence is obtained through various forms of research. This itself imposes limits on what can be discovered, thus adding to the uncertainties and indeterminacies at stake. Researchers in the UK who have been studying endocrine disruption have been focusing on identifying the specific effects of particular pollutants, for example studying the feminisation of fish downstream of sewage effluent plants.[18] Additionally, other research is looking at whether there is a trend in reduced sperm counts and other reproductive disorders, especially in males.[19] In contrast, in the US the USEPA has set up a committee to identify a battery of screens and tests to check chemicals against in order to identify which ones are endocrine disrupting. Both the UK and the US are looking for scientific evidence of a problem but are going about it in different ways. The UK is attempting to identify environmental effects in the field, of chemicals that are already dispersed in the environment and trying to associate

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[18] See Purdom, C. E., Hardiman, P. A., Bye, V. J., Eno, N. C., Tyler, C. R. and Sumpter, J. P. (1994) *Chem Ecol,* **8,** 275-285. and Desbrow, C., Routledge, E., Sheenan, D., Waldock, M. and Sumpter, J. (1996),MAFF Fisheries Laboatory and Brunel University, Bristol, pp. vi, 65, xi.
[19] See Montague, P. (1997),Montague, Peter.
Sharpe, R. M. and Skakkebaek, N. E. (1993) *The Lancet,* **341,** 1392-1395.; Irvine, S., Cawood, E., D, R., E, M. and J, A. (1996) *British Medical Journal,* **312,** 467-471.
Carlsen, E., Giwercman, A., Keiding, N. and Skakkebaek, N. E. (1992) Ibid., **305,** 609-613.
Auger, J., Kuntsman, J. M., Czyglik, F. and Jouannet, P. (1995) *New England Journal of Medicine,* **332,** 281-285.
Irvine, D. S. (1994) *British Medical Journal,* **309,** 476.
Ginsburg, J., Okolo, S., Prelevic, G. and Hardiman, P. (1994) *Lancet,* **343,** 230.
The Lancet Editorial (1995) *The Lancet,* **345,** 933-935.
Institute for Environment and Health (1997),Institute for Environment and Health, Leicester, pp. 5.
Sexton, S. (1993) *The Ecologist,* **23,** 212-218.

these effects with certain causes. In contrast, the US is undertaking laboratory studies to determine a set of characteristics whereby individual chemicals can be determined endocrine disrupters or not. This illustrates that different scientific approaches are possible and shows how one issue, endocrine disruption, can be framed as a different type of scientific problem. The main point here is that scientific evidence is being looked for in each case although at a different stage within the boundary of the problem.

If the UK strategy is followed and the scientific evidence that is being searched for is found, the next step is that more evidence will be demanded, possibly along the lines of the scientific research being undertaken in the US. However, one difficulty with the US approach is that tests and screens for identifying all the possible permutations that chemicals take may not be developed, thus prolonging the time spent undertaking research in order to obtain scientific evidence on which to base decisions and working out what those might be.

The availability of evidence in itself is not sufficient to determine a decision. How it is contextualised and presented also determines outcomes. Even when meanings of evidence are formalised, as at a public inquiry, the questions remain unanswered as to what constitutes sufficient evidence and how much evidence is enough.

Chemical manufacturers advocate further research to determine whether there is actually a problem at all. In contrast pressure groups state that there is already evidence that certain chemicals are causing reproductive problems in humans and wildlife and that these chemicals should be phased out and replaced immediately.[20] Although many of my interviewees talked about the need for sufficient evidence before action could be taken, none were actually willing to state what that might be. The above sections on interests and scientific evidence show that both these factors are of great relevance to a discussion on the precautionary principle because they both affect the way in which decision-making is organised and the positions taken on particular issues. However, of themselves neither an understanding of interests involved nor the meanings of scientific evidence can help us to implement the precautionary principle. They can only help us to understand how controversies are shaped and decisions are made. While this may appear to be very limiting it actually offers a great insight into the obstacles standing in the way of understanding the precautionary principle.

Interests, evidence and implementation

Having made comparisons between the two case studies of radioactive waste disposal and endocrine disruption, and having looked at written agreements that invoke precaution, I have been able to identify the relationship between the empirical use and the rhetorical use of precaution. Both 'empirical precaution' and 'rhetorical precaution' rely heavily on science as a proposed arbiter of disputes involving uncertainty. Both imply that the precautionary principle is not any one thing but is created each time is it invoked. This relationship between the empirical and rhetorical use of precaution brings together the use of scientific evidence and the interests involved in particular issues. The actual interests (i.e. professional, disciplinary, and

[20] See Greenpeace (1996b) *Taking back our stolen future: hormone disruption and PVC plastic*, Greenpeace, London.

institutional) and the scientific evidence (i.e. related to the subject) used in each case are very different but my explanation of their relevance is the same. The defining reason why the precautionary principle is so difficult to implement is because of the scientific uncertainties inherent within the 'knowledge' of the issues of concern. Written agreements pertaining to the precautionary principle advocate use of precaution without addressing how it can be implemented and managed. Looking at two particular issues demonstrates that scientific evidence is again a centrally contentious issue and that this contention is shaped by the interests of those involved. The scientific evidence presented in each debate, as illustrated in chapters five and six, is so full of uncertainties that decisions come about through the consensus of those involved rather than because some inherent 'truth' becomes known.

This is key to understanding what the precautionary principle might mean in practice. If we accept that decisions are currently made through consensus reached by negotiation between interest groups, and not through common reference to an agreed body of scientific knowledge, then we can start looking at alternative factors that might be used as a basis for implementation. Accepting a move away from the rhetoric of scientific evidence and from the determination of cause and effect is the first stage in attempting to define what precautionary action might be.

One suggestion of how the precautionary principle might be implemented is by reversing the burden of proof.[21] There might certainly be benefits to doing this as the

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Greenpeace (1996a),Greenpeace, London, pp. 32.

[21] The idea of reversing the burden of proof transfers responsibility to the polluter to prove their actions are not detrimental to the environment. See Bodansky, D. (1991) *Environment*, **33**, 4-5 & 43-45. Bodansky, D. (1994) In *Interpreting the Precautionary Principle*(Eds, O'Riordan, T. and Cameron, J.) Earthscan Publications Ltd, London, pp. 203-228.
Jackson, T. and Taylor, P. J. (1992) *Chemistry and Ecology*, **7**, 123-134.
O'Riordan, T. (1992),CSERGE, Norwich, pp. 31.

onus would then be on the polluter to justify their actions. However, this would require a pre-determined level of safety to be established. This once again brings in the question of evidence and what would constitute sufficient evidence that safety had been demonstrated. If safety is measured in scientific terms this would entrench implementation of precaution once more in the rhetoric of science and certainty. I suggest therefore that reversing the burden of proof is not in itself a suitable way of implementing the precautionary principle.

Another suggestion has been to look at the potential risks associated with an issue, product or process and to determine how large those risks are.[22] Risk can be gauged in many different ways, Cost Benefit Analysis (CBA) and Risk Assessment (RA) being two common methods of calculation. Both have drawbacks that make them unsuitable as a ways of applying the precautionary principle. Both CBA and RA rely on quantitative analysis. CBA involves putting a price on activities and the things they affect in order to determine whether something is valuable or invaluable. RA relies on obtaining numerical statistical data, involving calculations of probabilities to determine how high a risk is. Such methodologies assume that these statistics can be determined and again reinforce decision-making based on scientific evidence and measurements. This therefore excludes CBA and RA as suitable ways of applying the precautionary principle.

O'Riordan, T. and Jordan, A. (1995) *Environmental Values,* **4,** 191-212.
Cross, F. B. (1996) *Washingon and Lee Law Review,* **53,** 851-925??
Jordan, A. and O'Riordan, T. (1998),CSERGE,, pp. 24.
[22] See for example Department of the Environment (1995) *A guide to risk assessment and risk management for environmental protection,* HMSO, London. and Gibson, S. B. (1976) *Journal of Occupational Accidents,* **1,** 85-94.

Risk can also be gauged as a judgement, and judgement can be based on levels of social-wellbeing which could be derived by judging the scale of the impact of the activity concerned. The impact could be judged as the number of people who would potentially be affected, or it could be judged in terms of the geographical range within which the effects could be felt. However, this also relies on assumptions about cause and effect in relation to pathways of effects and so we're back once again to a reliance on scientific evidence.

This suggests that in order for the precautionary principle to mean something we have to go beyond science in some way, although from the above we can also see just how entrenched in science our way of thinking is. In the following section I discuss the potential for going 'beyond science' and what that means for implementing the precautionary principle.

Precaution Beyond Science

This chapter has shown how deeply our decision-making is entrenched in the use of science and the quest for certainty and it has also demonstrated how fruitless that quest is due to the interests that shape what is regarded as 'scientific knowledge'. Here I attempt to look at what going beyond science might mean for the precautionary principle, although I do not claim to provide answers to the question of what implementation of the precautionary principle should actually look like. I do not believe a structured set of rules can exist whereby the precautionary principle can be said to have been implemented although I do believe that frameworks of deliberation and policy-making can be created that are more sympathetic to precautionary courses of action.

Considering once again the issue of scientific evidence a host of questions can be derived. If an agreement on what constitutes sufficient evidence is not reached, individuals will none the less still be exposed to risk. The actual risk faced is not dependent on consensus about the nature or scale of the risk. Does it make a difference for the precautionary principle whether a select number of localised individuals are exposed to a problem, as in the radioactive waste case, as opposed to everyone being exposed, as in the chemical case? Is more precautionary action required in situations where individuals cannot control their own exposure to risks and hazards? Does the precautionary principle imply finding an acceptable exposure which is harmless and is it actually possible to find an exposure which is harmless? What does it mean if there is no exposure which is harmless and the exposure is continued indefinitely? Who becomes responsible for the consequences of such exposures? Who has the authority to set risk limits? Are these legally and/or morally justifiable? Doesn't justification rely on scientific evidence also? Are dangerous substances acceptable, or more acceptable, if they exist within closed systems and never leave those closed systems? Are such closed systems possible to create? How might such a closed system be disposed of? This set of questions is a sub-set of an infinite array which arise when considering the issue of sufficient evidence in relation to the precautionary principle. They open debate about the *type* of issue as a matter of importance. Part of the challenge for those implementing the precautionary principle is to be aware of the questions and issues it raises and to be ready to make decisions before having all the answers. This makes the precautionary principle a political rather than a scientific tool.

By looking at the two case studies of radioactive waste disposal and endocrine disruption it is obvious that commercial interests are a distinctive feature. Could this be a starting point for invoking the precautionary principle? The identification of commercial interests surrounding an issue means that the product or process in question is being driven by profit motivation. This may exclude factors such as social well-being, social need or social good.

We need to consider whether the argument about social benefits is valid. For example, would quality of life get better or worse if certain industries (or the contentious aspects of them) were closed down? Should implementation of the precautionary principle be governed by economic justifications of particular courses of action, or is it constrained by economic justification? How would social benefits be measured and does this bring cost-benefit analysis back into the picture? When are environmental policies in opposition to economic interests? Is cost always a limiting factor?

Talk about commercial interests and profit motivation raises the subject of costs and benefits which is also a qualifying factor mentioned in many of the agreements discussed in chapter two. This has implications for the way in which the precautionary principle can be applied more generally. The commercial prevalence of particular industries and products will determine the wider effects that policy measures directed at them will have. This means that economic justifications will be used both to promote and to oppose any such measures. This raises another issue of the balance of weight between economic considerations and health, safety and environmental issues.

The above demonstrates a plethora of questions that arise when considering what the precautionary principle means and when attempting to untangle how judgements can be made about implementing it. Perhaps 'judgement' itself is the key. If it were to be acknowledged and accepted that in policy decisions judgement should be an ethical or moral judgement then individuals involved in making decisions would be freer to openly voice their interests and values and the process would not be constrained by attempts to portray it as objective and scientific.

One way of moving towards this type of judgement is to stop looking at issues about the fundamental certainty of science and to start looking at who makes decisions and what their reasons are for involvement. Once interests are established, questions can be raised about what are the excluded interests in particular instances. Precaution is not just about scientific uncertainty, it is also about social good – what kind of world we want and what risks we are prepared to take – and ultimately about who decides.

However, the question arises as to whether it is possible for the precautionary principle to supersede manipulation by interests at the level of decision-making. Won't interests also appear in judgements based on ethics and morals? I would suggest that the interests associated with these factors are more explicit since ethics and morals are intrinsically value laden. Therefore such interests are not hidden in rhetoric of certainty and objectivity as they are in decisions based on science.

Establishing ethical judgement as a legitimate ground for decision-making allows for less 'scientific' parameters to be evaluated. For example, one way of evaluating a product or process is to look at the concept of need. This is potentially a narrow parameter as there are many things that cannot be said to be 'needed' but which society has become used to and which are therefore seen as expedient and necessary. Substitutability with alternatives is often suggested in relation to problematic products and processes[23] but this brings us full circle with the alternatives themselves coming under the same scrutiny as that for which they are a substitute.

It is apparent that something far more radical than has been suggested so far is necessary in order to embed precaution into environmental decision-making. A major restructuring and reordering of decision-making processes themselves with an explicit acknowledgement of the limitations of the decisions that can be made with indeterminacy being waved as a banner at all times is in order. The challenge is not how to make decisions based on uncertainty but rather how to review the whole system of making decisions and what it is to make a decision.

The above calls for a move towards a system that does not view science as the arbitrator of decisions and does not assume that such evidence will eventually be forthcoming. It challenges the economic views of profit as necessarily good and demands an equal platform for voicing opinions about social well-being. It allows that ethical judgements are legitimate factors in making decisions.

[23] An example is Greenpeace's demands for the substitution of PVC - Greenpeace (1996a),Greenpeace, London, pp. 32.

The implication is there is no fixed formula for implementing the precautionary principle because there is no general consensus as to what 'the precautionary principle' means and so each case and situation will have to be judged on its own merits and terms. However, what analysing the precautionary principle does show is that it is the frameworks in which decisions are made that need to be restructured rather than defining a rigid scientific structure that authenticates decisions.

Chapter Eight

Conclusions and Implications

Introduction

In this concluding chapter I review the argument of the thesis, taking the reader through the rhetorical evolution of precaution, explaining the power of 'interests theory' as a way of analysing scientific controversy and consensus forming, and highlighting my conclusions about the precautionary principle based on case studies on radioactive waste disposal and endocrine disrupting chemicals. I show that the career trajectory of an environmental issue and the extent of institutionalisation of fora of deliberation shape what the precautionary principle means in practice. I show that the precautionary principle is not one thing, but comes into being as it is applied.

In this chapter I also reflect on the limitations of the thesis, identifying constraints due my own approach to the project and the methodology I used. Finally, I look at the different contributions this work makes to its various audiences. I look at the implications it has for an academic audience in terms of interests theory, the concept of scientific evidence and most relevantly, the precautionary principle; I review its relevance for Friends of the Earth in terms of their campaigning interests; and for a corporate audience in terms of its implications for policy-making.

Review of Thesis

I began by analysing the way the rhetoric of precaution is used within policy documents. By focusing on the constituent ideas behind the precautionary principle I moved beyond the stalemate position of taking the rhetoric to be the focus of attention itself. I identified a recourse to scientific evidence as the arbiter in precautionary decision-making at this level and I suggested that understanding how scientific evidence is marshalled and how uncertainty is acknowledged and used is key to considering what lies behind the precautionary principle.

In chapter three I developed an argument about the relationship between academic literature on uncertainty and literature on interests. I showed that of three different types of uncertainty identified by O'Riordan and Cameron[1] (lack of data, variability of process and indeterminacy) indeterminacy is the most complex and least understood and that due to it science cannot always provide answers for policy makers to use in determining policy. Pinch[2] claims that norms and relationships are assumed in all specialist fields and these may appear to specialists in other fields to be wild assumptions that are translated as uncertainties. Those making policy decisions have none of this specialised expertise and yet must use the available science with its inherent norms and relationships as a basis for their decisions. The differences between those close to the knowledge production, those distant from it and those committed to using the knowledge are recognised by MacKenzie[3] in his analysis of the 'certainty trough' where he shows the way uncertainty is handled by those different groups. To put the idea of the 'certainty trough' into practice I address the question of expertise and who is considered 'expert'. Webster[4] argues that expertise is associated with broad ideological positions favouring certain interests above others. He implies that scientific advisors anticipate political positions and offer expert advice accordingly.

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[1] O'Riordan, T. and Cameron, J., (eds) (1994). *Interpreting the Precautionary Principle*. London: Earthscan Publications Ltd.

[2] Pinch, T.J. (1981). The Sun-Set: the presentation of certainty in scientific life. *Social Studies of Science* 11, (1): 131-158.

[3] MacKenzie, D. (1990). *Inventing accuracy: a historical sociology of nuclear missile guidance*. Cambridge, MA: MIT Press.

In reviewing a selection of literature from the sociology of science I suggested that the important question is *why* scientists and policy makers behave as they do. I argued that the uncertainties embedded in scientific knowledge are managed in ways which reflect the interests of those constructing and interpreting that knowledge, and I have shown how the 'Interests Approach' of the Edinburgh School elucidates the dynamics of scientific controversy. Bloor,[5] one of the original advocates of the interests approach, argues that empirical studies must be undertaken in order to identify the interests that shape the construction of scientific knowledge. I have suggested that the interests approach can be extended to offer a perspective which looks beyond internal scientific debates, and which offers a useful angle from which to view debates over scientific 'expertise' in public settings, such as public inquiries.

While Woolgar[6] criticises users of interests theory for imposing their own interpretations of the desires they identify during empirical research, this must be contextualised. Regulations and legislation reflect shared cultural norms and these impact on the social spheres in which individuals and organisations operate. Collective convention attributes desires and interests to individuals and organisations in specific circumstances and interests theory recognises these processes, using the outcomes (i.e. a catalogue of positions) to help understand the nature of negotiation and consensus forming in decision-making. In my research some of the interests identified were related directly by the individuals interviewed whilst others were suggested by third parties. In defence of my use of interests theory I asserted, in chapter three, that all theory is about constructing an explanation for observed

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[4] Webster, A. (1991). *Science, technology and society*. Basingstoke: Macmillan Press Ltd.
[5] Bloor, D. (1976). *Knowledge and Social Imagery*. London, Henley and Boston: Routledge and Kegan Paul.

phenomenon and so the use of interests theory represents no more of a value judgement by the analyst (me) than were I to have chosen any other perspective. I concluded that while there are many other theoretical perspectives that I could have drawn upon, my data shows that ideas of interests can be useful when trying to analyse sites of scientific controversy and consensus forming.

In chapter four I discussed the reasons for choosing radioactive waste disposal and endocrine disrupting chemicals as case studies and concluded that these two studies provided examples of the contrasting range of problems and situations that advocates of the precautionary principle would face. I defended my choice of semi-structured interviews on the grounds that it gave my interviewees the opportunity to talk about issues they felt were relevant without me necessarily directing them in the way that questionnaires or structured interviews may have. This related clearly to my theoretical use of interests theory as it meant that interviewees' interests were expressly identified by themselves or suggested by other interviewees, thus addressing one criticism levelled at interests theory, that the researcher identifies predetermined interests of their own invention. Also in chapter four, I explained how I selected my interviewees, a combination of their involvement in deliberations about the issues of radioactive waste disposal and endocrine disrupting chemicals or their having contacts with Friends of the Earth. I interviewed people from a broad range of organisations in order that I had representations from a range of different interest groups and in order that I didn't miss any important voices.

[6] Woolgar, S. (1981). Interests and explanation in the social study of science. *Social Studies of Science* 11: 365-394.

In chapters five and six I focus on the concepts of scientific evidence and uncertainty, as these are issues around which deliberation takes place. This reframes the emphasis from looking at 'the precautionary principle', about which there is little detailed discussion. While the 'precautionary principle' isn't the subject of explicit debate, its constituent components definitely are. Time and again, questions of evidence and uncertainty were factors that the involved actors considered relevant to their deliberations. This reconciles the issues behind the 'rhetorical precaution' discussed in chapter two and the issues analysed through the case studies.

In chapter five I reviewed the cast of players involved in debate about radioactive waste disposal, and showed that how public decisions are made and the way in which controversies are closed depends on institutional arrangements and their attendant interests. In this case, I established that interests are broadly split along the institutional lines of government, industry and non-governmental organisations despite there being differences within these groups. Through looking at 'the nature of evidence' I showed how definitions of radioactive waste and associated concepts are created and used by the different players, and how these polarise according to both the interests and values of the players involved within the public inquiry framework. I concluded that definitions, re-definitions and non-definitions are used emotively by different 'voices' and interest groups according to their own agendas and that those who manage to influence the dominant definition put themselves in a stronger position by setting the terms of subsequent debate. Finally I discussed the actual framework of a public inquiry showing how decisions are negotiated and agreements reached, concluding that it measurably, if inadvertently, frames debates and agendas in particular ways.

Chapter six examined the very different case of endocrine disruption. Again I focused on the 'nature of evidence' (encompassing definitions of sufficiency and types of uncertainty), interests, and decision-making processes as key areas in which precautionary issues dominate decision-making. I showed that precise definitions of the problem of endocrine disruption and its causes are a construction of a realist discourse that provides an impression of objectivity. I established that the players involved in the endocrine disruption debate cannot be broken down into the same institutionalised groupings as in the radioactive waste disposal debate and that a bounded 'industry' voice is not so apparent. Finally, I examined the framework of policy-making on the subject of endocrine disruption in the UK and concluded that 'policy' related to this issue is at an early stage of formation. So far, there is only a patchwork of existing research data and legislative requirements. I showed that the focus of debate on this issue was narrowed from the beginning due to the selective range of voices invited to participate in key workshops (organised by the Institute for Environment and Health at Leicester University on behalf of the Department of the Environment) the purpose of which was to identify gaps in knowledge about endocrine disruption in order to inform policy decisions. This ensured that debate was framed within the conventional scientific paradigm, and imposed an order on an otherwise wide-ranging field.

In chapter seven I analysed and compared the cases studies of radioactive waste disposal and endocrine disrupting chemicals in order to answer the question 'what is involved in applying the precautionary principle to such contrasting areas of environmental concern?'. I argued that the career of an environmental problem can develop in different ways and that precaution means different things depending on the stage at which the 'problem' is being addressed. What is seen as a 'problem' arises in different ways and depends upon such factors as the history of the associated industry, the players involved in debate about the issue, and research studies that have already taken place. Additionally I showed that the established frameworks through which decisions are made may be inclusive or exclusive.

I also identified the implications of the extent of 'institutionalisation' for implementation of the precautionary principle. Where an 'industry' can be defined (as in the radioactive waste case) an 'industrial' voice can be heard, creating an 'industrial' position from which to negotiate. Without an 'industry' so clearly defined the range of voices is much increased. What implementation of the precautionary principle will mean in specific cases will be determined by the range of voices, due to the diversity of interests associated with them. I uncovered the way scientific evidence and the interests of individuals and institutions combine in current debates and decisions. Through deconstructing the use of scientific evidence in my two case studies and observing the interests involved I uncovered the problem of 'uncertainty' as an underpinning feature. I showed that neither understanding interests nor understanding the meanings of scientific evidence in themselves help in implementing the precautionary principle. However, they do help in understanding how controversies are shaped and decisions are made, thereby highlighting some of the obstacles facing implementation of the precautionary principle. A simple view would be that these contextual features create obstacles impeding the ready implementation of the precautionary principle. By demonstrating that decisions reflect the outcome of negotiation amongst individuals each of whom have associated interests, and that decisions do not therefore represent the simple expression of scientific 'truth', I set the stage for looking for alternative ideas about what constitutes precaution and what it might mean to implement the precautionary principle.

I concluded that although a structured set of rules cannot be created whereby 'the precautionary principle' can be said to have been implemented, frameworks of deliberation and policy making influence interpretations of precautionary courses of action.

I demonstrated that an infinite number of questions can be asked when attempting to look at the precautionary principle from the perspective of scientific evidence because all questions asked bring forth further questions rather than answers. I suggested that the key may be in understanding 'judgement' and in accepting the subjective nature of judgement as an integral part of making decisions. Precaution is about social good, the kind of world we want and the risks we are prepared to take, and ultimately about who decides what, and how.

My central contention is that the precautionary principle exists only as it is invoked and applied in practice. Reviewing formal agreements that invoke the precautionary principle exposes tensions that exist about understandings and applications of scientific evidence on a rhetorical level. I suggest that decisions based on the precautionary principle are the theoretical corollary of decisions based on a necessarily uncertain science. Looking at scientific evidence and the factors related to it from the perspective of two contrasting case studies (radioactive waste disposal and endocrine disrupting chemicals) I argued that the interests of individuals and organisations influence positions adopted in the process of making decisions. I have shown that the way scientific evidence is presented depends on interpretations of relevance and significance and that these reflect institutional and political affiliations, interests due to affiliations to disciplinary paradigms, and interests related to the wider cultural and societal associations of those involved. Uncertainties are embedded in scientific knowledge and I have shown that different interpretations of uncertainty co-exist. Like Jasanoff,[7] I suggest, interpretations of scientific evidence and uncertainty are significantly filtered by the political interests of individuals who have their own paradigms and realities.

Through looking at the way in which scientific knowledge was invoked in the two case studies, I was able to uncover the interests and the institutional framing of debate involved in both cases. From this position I was able to argue that the interests at play depend on the disciplinary and institutional background of those involved. Although the actual interests were not the same in both cases, it could be seen that the interests that did exist shaped the development of debates. Having uncovered the way in which scientific evidence was used in both cases and the way in which scientific uncertainty was highlighted or minimised depending on who was presenting evidence, I then argued that since interests and uncertainty are bound together so closely, it is wrong to see the precautionary principle as an 'external' criteria for decision-making. Having looked at two situations where the 'career' of the issue is at different stages, and where decision-making is therefore at different stages, I showed that definitions of precaution were themselves contested, and that such definitions formed part of the 'career' of the issues at stake, i.e. radioactive waste disposal and endocrine disruption.

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[7] Jasanoff, S. (1987). Contested boundaries in policy-relevant science. *Social Studies of Science* 17, (12): 195-230.

In sum, precaution is contested, contextual and situational in a way that no one principle can accommodate. I conclude that there is a tension between the precautionary principle that policy makers are seeking to implement, that being a reified, codified entity, and what is actually happening in practice where component aspects of precaution (scientific evidence, uncertainty and definitions) are being deliberated in relation to specific issues. I discuss the implications of this for different audiences below.

Limitations of the Thesis

In this section I want to address the limitations of this thesis. Firstly, I attempt to be reflexive about my work, drawing out the limitations brought about by my own involvement in the research as well as those brought about due to my theoretical perspective. Secondly, I discuss the methodological limitations of the data I obtained and my methods of data collection. In this part I discuss further research that could be undertaken and the value that other studies might have in understanding the implementation and interpretation of the precautionary principle.

Reflecting on my approach

Woolgar[8] is concerned that proponents of interests theory are not reflexive enough about the interpretation they themselves put on the knowledge they examine. He wants researchers to demonstrate their awareness of their role as the constructor of the explanation for the knowledge event being evaluated. In this section I attempt to be reflexive about my own involvement with my research and also say something about the limitations of interests theory.

This research started due to my own interest in environmental matters and my desire to undertake research that would be of interest and benefit to those seeking to protect the environment. I wanted to contribute something that helped and promoted the environmental agenda. Additionally, the case studies that I chose, although having concrete academic reasons for doing so, were chosen because of my own interest in those areas. These personal reasons I have talked about more in the introduction to the thesis. I am very aware that I have a personal interest in the data that I obtained in my empirical work. Through writing, reading and re-writing my thesis I was able to reduce this bias although I would never suggest that I have no influence on the result. One example of this is that I was very wrapped up in identifying an 'industrial' voice in the endocrine disruption case study simply because I had identified such a voice in the radioactive waste disposal case study. It took a lot of looking at the data, analysing it and questioning myself before I was able to see that such a voice did not exist in this case. Realising this made me recognise that the precautionary principle was a relative concept and forced me to consider new ways of thinking about decision-making and the uses of science.

One of the difficulties with suggesting that different groups use and interpret scientific evidence in different ways (for example depending on their interests) is that those interests are identified by me, the researcher. It is impossible to determine whether this is only one of many possible alternative 'logical' explanations. As I stated in

[8] Woolgar, S. (1981). Interests and explanation in the social study of science. *Social Studies of Science* 11: 365-394.

chapter seven I have identified 'interests' in my case studies through knowing something of the backgrounds of the institutions and organisations discussed, and through knowing something of their institutional agendas. However, one limitation of interests theory is that it fails to show the direction of causality. It is possible to say that the interests identified shed light on the possible strategies involved in the alternative uses of scientific evidence but it is not possible to say which came first. The interests approach does however help by highlighting the different perspectives from which knowledge can be created and understood. By describing my empirical work from an interests perspective I deploy one way of looking at knowledge in use. The point is that there is no 'true' way of looking at and using knowledge, only interpretations. Knowledge is represented according to the theoretical position of the interpreter. Therefore, while interests theory has its limitations, the same is true of other theoretical positions. Since this thesis was never primarily about testing the value of different theoretical positions, all I want to say here is that I am aware of the limitations of using one theoretical perspective, but that it would take a different type of research to test the value of alternative theories.

Limitations of methodology

Despite having defended my use of semi-structured interviews in chapter four, which was unmistakably the preferred methodology given the scope of this thesis, I can, nevertheless, identify several methodological limitations within this piece of work.

I have relied on data obtained from a total of forty interviews, all chosen because of their connections with radioactive waste disposal and endocrine disruption. However, given a longer research period and more resources, a wider set of interviewees would have been approachable. Despite having approached specific chemical companies for interviews none of them were able to meet with me. This has meant that many of the chemical manufacturers' voices have been derived from documented material. This in itself has limits, as discussed in chapter four, due to the selective nature of what is recorded and what is left out.

In order to get other perspectives on how people see these issues, and thereby on how decisions could be made, it might have been possible to set up either a number of focus groups or a citizens' panel. These would have given the thesis a completely different viewpoint. I considered focus groups impossible due to the geographical distribution of the individuals involved and the expense of arranging for corporate representatives, government officers, campaigners and councillors to be at the same location at the same time. However, given a larger budget and access to all the individuals and organisations required, such a study could provide much richer data than obtained through interviews such as conducted for my thesis. Further benefits could possibly be obtained through organising a citizens' jury, especially if any decision reached by such a jury was fed directly into a policy-making process. Such a jury would need to have access to all the witnesses they requested in order to meet their demands for technical, scientific and philosophical information. This in itself would prove costly, but such a fora could potentially reveal multiple interpretations of key issues about interests, scientific evidence, uncertainty and precaution.

Implications of the Thesis

In this section I evaluate the importance of this thesis by showing the different areas to which this research contributes.

I break this section into three parts in order to distinguish between the implications of the thesis for different audiences. Firstly, I look at the implications for an academic audience and here I discuss the way in which the theory I started with has changed as a result of my research work. I discuss these implications in terms of interests theory, scientific evidence and most relevantly, the precautionary principle. Secondly, I look at the implications of my work for Friends of the Earth and I discuss the way in which this research might impact on their own campaigning with regard the precautionary principle. Finally, I look at the implications for a corporate audience, discussing the impact that these insights might have on future policy-making. Each of these audiences will read this thesis with a different aim in mind. Even readers have institutional and disciplinary interests, a point I addressed in the previous section on limitations of my research under the sub-heading of being reflexive.

Implications for an academic audience

Initially I started out with the idea that I would discover how exactly the precautionary principle could be implemented in practice. I believed that by undertaking a number of case studies I would learn how decisions based on precaution were made and that I would be able to create a determinate list of criteria whereby the precautionary principle could be applied to other environmental problem areas. I soon reasoned that this was not to be. For a start, deliberations about the precautionary principle itself were not significant parts of the deliberations involved in the case studies. Rather it was the issues behind the rhetorical notion of precaution that were significant components of the deliberations. By showing that each problem has its own unique set of characteristics it became apparent that there could be no uniform guidelines for implementing precaution. By identifying the key players within debates around my case studies and reviewing the way in which they all used science as evidence I showed that institutional, disciplinary and social interests play a determining role in decision outcomes. Implications can be drawn from this with regard to future academic research. I found interests theory a useful theoretical basis for my work as it offered a model of how knowledge is determined and decisions made. I developed this typically static approach through an analysis of the careers of two key environmental issues. This work could provide a benchmark from which further research could be developed into the dynamics of interest formation.

In this thesis I did not set out to test interests theory or to apply it to a new situation but rather rediscovered it through analysis of my empirical data. Despite theory in the sociology of scientific knowledge having moved on from the heyday of interests approaches as developed in the 1970s, these ideas can still be put to use, and as my case studies show, contemporary applications can be revealing.

My research has concluded that the development and emergence of a problem, the widespread nature of a problem, whether or not a clear 'industry' exists in relation to the problem, and the extent of institutionalisation and decision-making structures are all factors of significance that bear on implementing the precautionary principle. Any subsequent research into the precautionary principle should be undertaken with this in mind.

Finally I want to talk about the academic implications of my research in terms of what it means for the precautionary principle itself. Is the precautionary principle any more 'implementable' due to this research? Have I shown the precautionary principle to be nothing other than a rhetorical device? I have demonstrated that decision-making frameworks generate contrasting interpretations of precaution and that there is no one principle to implement. This conclusion highlights the significance of decision-making processes and lends support to those who argue for their re-organisation.

Further academic research into 'the precautionary principle' should start from a position where it is not reified, as this creates major blocks to understanding and analysis. It is necessary to move beyond the notion that it is one principle that is applicable to many situations and to understand that it embodies several elements, each of which are significant factors in already ongoing deliberation. Taken further, this thesis identifies the need to better understand decision-making structures, as it is at this level that a more structured framework may be applicable. This would move research away from particular environmental issues and would perhaps identify social and political structures that could be applied more broadly in different environmental contexts.

Implications for Friends of the Earth

The second audience for which this thesis has implications is Friends of the Earth due to the fact that they were the collaborative body associated with my CASE award. The factors that are of importance to them are somewhat different to those that are relevant to an academic audience. Because Friends of the Earth is an environmental campaigning organisation they will be interested in what the thesis concludes about the precautionary principle in practice, what it says about the case studies undertaken and how its results and conclusions can be used from a campaigning perspective.

That I have concluded that there can be no absolute set of criteria whereby the precautionary principle can be said to have been implemented and that it only comes into being as it is put into practice is of great significance to Friends of the Earth, especially as it follows from the revelation that the players involved determine the debate about each environmental issue under consideration and the form and shape it takes. This means that Friends of the Earth's role as campaigners is all the more significant. If they are early players in helping shape what are seen to be significant factors within a contentious field they will influence the direction the debate takes. If scientific evidence is continually used as a deciding factor in decision-making then Friends of the Earth will find itself attempting to invoke the precautionary principle, and constantly justifying its position through recourse to scientific evidence. My conclusion that what is required to 'operationalise' the precautionary principle changes over time and from case to case, that the mix of interests is central to the decision-making process, and that uses and definitions of scientific evidence and uncertainty are contextual, will put Friends of the Earth in a much stronger campaigning position. This is because they currently share the perspective that greater scientific knowledge minimises the level of uncertainty contained within it. By playing within this conventional framework the scope of Friends of the Earth to advance alternative ways of looking at a problem is limited. They also play the game of using science in an unproblematic way (despite challenging the science that is presented by their opposition). A framework that admitted the value laden content of all knowledge would allow Friends of the Earth to advance arguments about fairness, justice, equity and need.

Additionally, Friends of the Earth should take note of the finding that the precautionary principle is not one particular thing that can be applied in various situations. By working to change the structures and fora in which deliberations take place, they will be in a better position to alter the decision outcomes. Invoking a reified precautionary principle does nothing to advance their position on an environmental issue. With specific reference to the two case studies the NGOs made the progress they did by working within the deliberative structures available. By working to change those deliberative structures to make them more inclusive and to include wider concepts than scientific evidence they will increase the possibility of achieving their objectives.

Implications for a policy audience

The third audience for whom my thesis has implications is the policy world. This includes government and business. The relevance is that it challenges the current status quo in decision-making and implies that factors other than quantifiable scientific criteria may be important.

For business this has large implications. The business world operates within identifiable structures of decision-making bounded by their own business and company arrangements, legal regulations and legislation and economic factors including the market place. They tend to be responsive to calls for environmental protection if such calls are justified in scientific or economic terms, that is, terms that are quantifiable. My conclusion that precaution is an essentially contested subject and that decision-making must go beyond science runs against what the corporate world has come to expect and accept. The current position whereby each environmental issue (or potential environmental issue) is looked at in isolation puts corporations in a powerful position especially since the burden of proof is not on them currently. Creating decision-making frameworks that accepted issues of judgement, equity and need as relevant, would mean that corporations would be required to move their line of arguments from what they see as the objective scientific sphere, and start to engage openly in a much wider debate.

For government there are further implications. Both the European Commission and the UK government have been struggling to find an interpretation of the precautionary principle that they can implement. There is a clear tension between what policy makers want in terms of an implementable precautionary principle and what this thesis demonstrates to be the way forward. Often, policy makers want a categorical 'precautionary principle' that can be applied in multiple situations whereas this thesis shows that it is the themes that lie behind rhetorical precaution, namely those of evidence, uncertainty and problem definition, that are relevant when looking at real environmental problems. Policy makers still discuss 'the precautionary principle' in reified terms because they want something that can be applied in various situations and which will produce results. The way forward for a more generalisable 'precautionary principle' is to look at deliberative processes more broadly, to accept that it is the interests and values of those involved in making decisions that determine outcomes and to consider whether specific deliberative frameworks could be established that can be extrapolated from one situation to another. This may be a more time intensive route but attempting to find a blanket set of criteria to apply to a multitude of situations will prove futile. A detailed discussion of how to operationalise of this suggestion is beyond the scope of this thesis. Nevertheless it is clear that the central issues of accepted and contested knowledge, of interests, and of problem definition define the contexts and situations in which the spirit of precaution has meaning.

Appendix One

Formal agreements referring to precaution and/or the precautionary principle

This list of national and international agreements which incorporate the ethos of precautionary action has been put together by reviewing literature that refers to the precautionary principle. I have followed up citations that refer to agreements invoking the precautionary principle and have made use of lists compiled by others, particularly Young[1] and Haigh.[2] It is arranged in chronological order.

EC Council Decision 80/372 concerning CFCs in the environment - April 1980.

Vienna Convention for the Protection of the Ozone Layer, March 1985.

Preamble to the Montreal Protocol to the Vienna Convention for the Protection of the Ozone Layer on Substances that Deplete the Ozone Layer, 16 September 1987.

Ministerial Declaration, Second International Conference on the Protection of the North Sea, (London Declaration), 24-25 November 1987.

Inputs of Dangerous Substances to Water: Proposals for a Unified System of Control – Department of the Environment/Welsh Office, July 1988.

The Paris Commission (PARCOM) established by the Convention for the Prevention of Marine Pollution from Land Based Sources, 22 June 1989, Recommendation 89/1.

Sixth Meeting of the Contracting Parties to the Convention for the Protection of the Mediterranean Sea against Pollution (Barcelona Convention), October 1989.

Nordic Council, International Conference on Pollution of the Seas, October 1989.

UK Government White Paper, Command 1200 'This Common Inheritance: Britain's Environmental Strategy' 1990.

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[1] Young, M.D. (1993). *For our children's children: some practical implications of inter-generational equality and the precautionary principle*. Canberra: Australian Government Publishing Service. November 1993.

[2] Haigh, N. (1994). The introduction of the precautionary principle into the UK. In, O'Riordan, T. and Cameron, J., (eds), *Interpreting the Precautionary Principle*:229-251. London: Earthscan Publications Ltd.; Haigh, N. (1993). *The precautionary principle in British environmental policy*. London: Institute for European Environmental Policy.

Preamble of the Final Declaration of The Third International Conference on the Protection of the North Sea - Hague Declaration, 7-8 March 1990 .

Bergen Ministerial Declaration (ECE), 16 May 1990.

Fifty-second Ordinary Session of the Council of Ministers of the Organisation of African Unity, Addis Ababa, 3-7 July 1990.

Houston Declaration, 11 July 1990.

UN Economic and Social Commission for Asia and the Pacific (ESCAP), Ministerial Conference on the Environment, Declaration on Environmentally Sound and Sustainable Development in Asia and the Pacific, October 1990.

The Noordwijk Declaration on Atmospheric Pollution and Climate Change, 7 November 1990.

OAU Pan African Co-ordinating Conference on Environment and Sustainable Development, (The Bamako Convention, article 4, paragraph 3), Bamako, Mali, 30 January 1991.

OECD Council Recommendation C(90)164 on Integrated Pollution Prevention and Control - January 1991.

Caring for the Earth (1991) IUCN-UNEP-WWF.

South Pacific Environment Ministers Declaration, 9 July 1991.

Australian ESD Intersectoral Issues Report, 1992, p40.

Report of the Fisheries Task Force to the Minister of Fisheries an the Review of Fisheries Legislation, New Zealand 1992.

"Maastricht Treaty", Treaty on European Union, signed February 1992 (in force from November 1993), Article 130r (2).

United Nations Conference on Environment and Development (UNCED), Agenda 21, Rio Declaration, June 1992.

Framework Convention on Climate Change - June 1992.

Royal Commission on Environmental Pollution, 16th report – Freshwater Quality, paragraph 1.24, June 1992.

Ministerial Meeting of the Oslo and Paris Commissions: Convention for the Protection of the Marine Environment of the North-East Atlantic, Article 2(2)(a), Paris, 21-22 September 1992.

OECD Secretariat draft guidelines for minimising the negative environmental effects of trade policies, November 1992.

United Nations Environment Program (UNEP) Governing Council Decision 15/27, 15th Session.

UK Strategy for Sustainable Development, consultation paper, paragraph 1.20 – Department of the Environment, July 1993.

International Joint Commission Seventh Biennial Report on Great Lakes Water Quality, 1994.

Sustainable Development: The UK Strategy – Command Paper 2426, 1994.

The following expands the above list to include the text referring to precaution:

EC Council Decision 80/372 concerning CFCs in the environment - April 1980:

> "Whereas, in accordance with the common position of Member States of 6 December 1978 and in accordance with recommendation III of the Munich Conference, a significant reduction should, as a precautionary measure, be achieved in the next few years in the use of chlorofluorocarbons giving rise to emissions."[3]

Vienna Convention for the Protection of the Ozone Layer, March 1985:

> "*Mindful also* of the precautionary measures for the protection of the ozone layer which have already been taken at the national and international levels."[4]

Preamble to the Montreal Protocol to the Vienna Convention for the Protection of the Ozone Layer on Substances that Deplete the Ozone Layer, 16 September 1987:

> "[The parties are] determined to protect the ozone layer by taking precautionary measures to control equitably total global emissions of substances that deplete it, with the ultimate objective of their elimination on the basis of developments in scientific knowledge, taking into account technical and economic considerations"[5]

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[3] Quoted in Haigh, N. (1993). *The precautionary principle in British environmental policy*. London: Institute for European Environmental Policy.
[4] Quoted in Haigh, N. (1994). The introduction of the precautionary principle into the UK. In, O'Riordan, T. and Cameron, J., (eds), *Interpreting the Precautionary Principle*:229-251. London: Earthscan Publications Ltd. p243
[5] Quoted in Young, M.D. (1993). *For our children's children: some practical implications of inter-generational equality and the precautionary principle*. Canberra: Australian Government Publishing

Ministerial Declaration, Second International Conference on the Protection of the North Sea, (London Declaration), 24-25 November 1987:

> "... in order to protect the North Sea from possibly 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 has been established by absolutely clear scientific evidence; ... [the parties] [t]herefore 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 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")."[6]

Inputs of Dangerous Substances to Water: Proposals for a Unified System of Control – Department of the Environment/Welsh Office, July 1988:

> 'In addition, for those substances which represent the greatest threat to the environment, the Government considers it is necessary to ago further by seeking to minimise inputs to all parts of the environment as part of a more precautionary approach to water pollution'.[7]

Service. November 1993. p43

[6] Quoted in Cameron, J. and Abouchar, J. (1991). The Precautionary Principle: a fundamental principle of law and policy for the protection of the global environment. *Boston College International and Comparative Law Review* 14, (1): 1-27. p5

[7] Quoted in Haigh, N. (1994). The introduction of the precautionary principle into the UK. In, O'Riordan, T. and Cameron, J., (eds), *Interpreting the Precautionary Principle*:229-251. London: Earthscan Publications Ltd. p247

The Paris Commission (PARCOM) established by the Convention for the Prevention of Marine Pollution from Land Based Sources, 22 June 1989, Recommendation 89/1:

> "[The contracting parties] accept the principle of safeguarding the marine ecosystem of the Paris Convention area by reducing at source polluting emissions of substances that are persistent, toxic and liable to bioaccumulate by the use of 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 when there is no scientific evidence to prove a causal link between the emissions and effects ("the principle of precautionary action") ..."[8]

Sixth Meeting of the Contracting Parties to the Convention for the Protection of the Mediterranean Sea against Pollution (Barcelona Convention), October 1989:

> "[Contracting parties agree]to fully adopt the principle of precautionary approach regarding the prevention and elimination of contamination in the Mediterranean Sea area ..."[9]

Nordic Council, International Conference on Pollution of the Seas, October 1989:

> '[The signatories take into account] the need for an effective precautionary approach, with that important principle intended to safeguard the marine ecosystem by, amongst other things, eliminating and preventing pollution emissions where there is reason to believe that

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[8] Quoted in Cameron, J. and Abouchar, J. (1991). The Precautionary Principle: a fundamental principle of law and policy for the protection of the global environment. *Boston College International and Comparative Law Review* 14, (1): 1-27. p15

[9] Quoted in Cameron, J. and Abouchar, J. (1991). The Precautionary Principle: a fundamental principle of law and policy for the protection of the global environment. *Boston College International and*

damage or harmful effects are likely to be caused, even where there is inadequate or inconclusive scientific evidence to prove a causal link between emissions and effects.'[10]

UK Government White Paper, Command 1200 'This Common Inheritance: Britain's Environmental Strategy' 1990:

'... given the environmental risks, we must act responsibly and be prepared to take precautionary action where it is justified. ... Where there are significant risks of damage to the environment, the Government will be prepared to take precautionary action to limit the use of potentially dangerous materials or the spread of potentially dangerous pollutants, even where scientific knowledge is not conclusive, if the balance of likely costs and benefits justifies it. This precautionary principle applies particularly where there are good grounds for judging either that action taken promptly at comparatively low cost may avoid more costly damage later, or that irreversible effects may follow if action is delayed.'[11]

Preamble of the Final Declaration of The Third International Conference on the Protection of the North Sea - Hague Declaration, 7-8 March 1990 :

"[parties]will continue to apply the precautionary principle, that is to take action to avoid potentially damaging impacts of substances that

Comparative Law Review 14, (1): 1-27. p15

[10] Quoted in Cameron, J. and Abouchar, J. (1991). The Precautionary Principle: a fundamental principle of law and policy for the protection of the global environment. *Boston College International and Comparative Law Review* 14, (1): 1-27. p16

[11] Command Paper 2100 (1990). *This common inheritance*. London: HMSO. September 1990. p10&11

are persistent, toxic and liable to bioaccumulate even when there is no scientific evidence to prove a causal link between emissions and effects."[12]

Bergen Ministerial Declaration (ECE), 16 May 1990:

"In order to achieve sustainable development, policies must be based on the precautionary principle. Environmental measures must anticipate, prevent and attack the causes of environmental degradation. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation."[13]

Fifty-second Ordinary Session of the Council of Ministers of the Organisation of African Unity, Addis Ababa, 3-7 July 1990.[14]

Houston Declaration, 11 July 1990:

"We agree that, in the face of threats of irreversible environmental damage, lack of full scientific certainty is no excuse to postpone actions which are justified in their own right."[15]

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[12] Quoted in Cameron, J. and Abouchar, J. (1991). The Precautionary Principle: a fundamental principle of law and policy for the protection of the global environment. *Boston College International and Comparative Law Review* 14, (1): 1-27. p16

[13] Quoted in Young, M.D. (1993). *For our children's children: some practical implications of inter-generational equality and the precautionary principle.* Canberra: Australian Government Publishing Service. November 1993. p40

[14] Cited in Freestone, D. (1991). The Precautionary Principle. In, Churchill, R. and Freestone, D., (eds), *International Law and Global Climate Change*:21-39. London: Graham and Trotman / Matinur Nijhoff. p29

[15] Quoted in Young, M.D. (1993). *For our children's children: some practical implications of inter-generational equality and the precautionary principle.* Canberra: Australian Government Publishing Service. November 1993. p40

UN Economic and Social Commission for Asia and the Pacific (ESCAP), Ministerial Conference on the Environment, Declaration on Environmentally Sound and Sustainable Development in Asia and the Pacific, October 1990:

> '[We are] deeply concerned about the threat to environmentally sound and sustainable development due to economic degradations and the depletion of natural resources in the ESCAP region, .. [and we] [b]elieve that, in order to achieve sustainable development, policies must be based on the precautionary principle.'[16]

The Noordwijk Declaration on Atmospheric Pollution and Climate Change, 7 November 1990:

> "Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent such environmental degradation. The measures adopted should take into account different socio-economic contexts."[17]

OAU Pan African Co-ordinating Conference on Environment and Sustainable Development, (The Bamako Convention, article 4, paragraph 3), Bamako, Mali, 30 January 1991:

> 'Waste generation in Africa – The adoption of precautionary measures:
>
> (f) Each Party shall strive to adopt and implement the preventive,

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[16] Quoted in Freestone, D. (1991). The Precautionary Principle. In, Churchill, R. and Freestone, D., (eds), *International Law and Global Climate Change*:21-39. London: Graham and Trotman / Matinur Nijhoff. p29-30

[17] Quoted in Young, M.D. (1993). *For our children's children: some practical implications of inter-generational equality and the precautionary principle.* Canberra: Australian Government Publishing

precautionary approach to pollution problems which entails, *inter alia*, preventing the release into the environment of substances which may cause harm to humans or the environment without waiting for scientific proof regarding such harm. The parties shall cooperate with each other in taking the appropriate measures to implement the precautionary principle to pollution prevention through the application of clean production methods, rather than the pursuit of a permissible emissions approach based on assimilative capacity assumptions.'[18]

OECD Council Recommendation C(90)164 on Integrated Pollution Prevention and Control - January 1991:

"the absence of complete information should not preclude precautionary action to mitigate the risk of significant harm to the environment."[19]

Caring for the Earth (1991) IUCN-UNEP-WWF:

"All governments should adopt the precautionary principle. This means minimising, and where possible, preventing discharges of substances that could be harmful."[20]

South Pacific Environment Ministers Declaration, 9 July 1991:

Service. November 1993. p41

[18] Quoted in Freestone, D. (1991). The Precautionary Principle. In, Churchill, R. and Freestone, D., (eds), *International Law and Global Climate Change*:21-39. London: Graham and Trotman / Matinur Nijhoff. p29

[19] Quoted in Haigh, N. (1994). The introduction of the precautionary principle into the UK. In, O'Riordan, T. and Cameron, J., (eds), *Interpreting the Precautionary Principle*:229-251. London: Earthscan Publications Ltd. p245

[20] Quoted in Young, M.D. (1993). *For our children's children: some practical implications of inter-generational equality and the precautionary principle.* Canberra: Australian Government Publishing Service. November 1993. p42

"Declare our commitment to work individually and collectively, including through SPREP, to achieve sustainable development in the South Pacific region, in particular by making every effort to ... formulate resource and development planning policies which take into account the precautionary principle".[21]

Australian ESD Intersectoral Issues Report, 1992, p40:

"Dealing cautiously with risk implies that where considerable uncertainty surrounds a proposed action, the decision should lean on the side of caution. This does not mean that development should not proceed whenever we cannot be certain of its ecological impact. It does mean that the need for particular caution needs to influence the balance between a need to preserve natural capital and a need to proceed."[22]

Report of the Fisheries Task Force to the Minister of Fisheries an the Review of Fisheries Legislation, New Zealand 1992:

"We propose that the statute contain a set of environmental principles which cover such matters as consideration of ... avoidance of the risk of significant irreversible change, and allowance for major impacts and scientific uncertainties."[23]

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[21] Quoted in Young, M.D. (1993). *For our children's children: some practical implications of inter-generational equality and the precautionary principle.* Canberra: Australian Government Publishing Service. November 1993. p40

[22] Quoted in Young, M.D. (1993). *For our children's children: some practical implications of inter-generational equality and the precautionary principle.* Canberra: Australian Government Publishing Service. November 1993. p42

[23] Quoted in Young, M.D. (1993). *For our children's children: some practical implications of inter-*

"Maastricht Treaty", Treaty on European Union, signed February 1992 (in force from November 1993), Article 130r (2):

> "Community policy on the environment shall aim at a high level of protection taking into account the diversity of situations in the various regions of the Community. It shall be based on the precautionary principle and on the principles that preventive action should be taken, that environmental damage should as a priority be rectified at source and that the polluter should pay. Environmental protection requirements must be integrated into the definition and implementation of other Community policies."[24]

United Nations Conference on Environment and Development (UNCED), Agenda 21, Rio Declaration, June 1992:

> "Principle 15: In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."[25]

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generational equality and the precautionary principle. Canberra: Australian Government Publishing Service. November 1993. p42

[24] Quoted in Young, M.D. (1993). *For our children's children: some practical implications of inter-generational equality and the precautionary principle*. Canberra: Australian Government Publishing Service. November 1993. p42 and Haigh, N. (1994). The introduction of the precautionary principle into the UK. In, O'Riordan, T. and Cameron, J., (eds), *Interpreting the Precautionary Principle*:229-251. London: Earthscan Publications Ltd. p245

[25] Quoted in Young, M.D. (1993). *For our children's children: some practical implications of inter-generational equality and the precautionary principle*. Canberra: Australian Government Publishing Service. November 1993. p41-42 and Haigh, N. (1994). The introduction of the precautionary principle into the UK. In, O'Riordan, T. and Cameron, J., (eds), *Interpreting the Precautionary Principle*:229-251. London: Earthscan Publications Ltd. p245-246

Framework Convention on Climate Change - June 1992:

> "Article 3: the parties should take precautionary measures to anticipate, prevent or minimise the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures..."[26]

Royal Commission on Environmental Pollution, 16th report – Freshwater Quality, paragraph 1.24, June 1992:

> 'Fifthly, a precautionary approach to pollution control should be maintained.'[27]

Ministerial Meeting of the Oslo and Paris Commissions: Convention for the Protection of the Marine Environment of the North-East Atlantic, Article 2(2)(a), Paris, 21-22 September 1992:

> "[The Contracting Parties shall apply] the precautionary principle, by virtue of which preventive measures are to be taken when there are reasonable grounds for concern that substances or energy introduced, directly or indirectly, into the marine environment may bring about hazards to human health, harm living resources and marine ecosystems, damage amenities or interfere with other legitimate uses of the sea, even when there is no conclusive evidence of a causal relationship

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[26] Quoted in Haigh, N. (1994). The introduction of the precautionary principle into the UK. In, O'Riordan, T. and Cameron, J., (eds), *Interpreting the Precautionary Principle*:229-251. London: Earthscan Publications Ltd. p246

[27] Quoted in Haigh, N. (1994). The introduction of the precautionary principle into the UK. In, O'Riordan, T. and Cameron, J., (eds), *Interpreting the Precautionary Principle*:229-251. London:

between the inputs and the effects."[28]

OECD Secretariat draft guidelines for minimising the negative environmental effects of trade policies, November 1992:

> "The following are environmental concepts and principles relating to standards for consideration by trade policy makers. ...*precautionary principle* - the absence of full scientific information should not constitute an obstacle to the adoption of environmental standards or environmental measures."[29]

United Nations Environment Program (UNEP) Governing Council Decision 15/27, 15th Session:

> "Recognising that waiting for scientific proof regarding the impact of pollutants discharged into the marine environment may result in irreversible damage to the marine environment and in human suffering ... [the Governing Council] recommends that all the governments adopt the 'principle of precautionary action' as the basis of their policy with regard to prevention and elimination of marine pollution ..."[30]

UK Strategy for Sustainable Development, consultation paper, paragraph 1.20 – Department of the Environment, July 1993:

Earthscan Publications Ltd. p250

[28] Oslo and Paris Commissions (OSPAR) (1992). *Ministerial meeting of the Oslo and Paris Commissions*. Paris: OSPAR. 21-22 September 1992. p84

[29] Quoted in Young, M.D. (1993). *For our children's children: some practical implications of inter-generational equality and the precautionary principle*. Canberra: Australian Government Publishing Service. November 1993.

[30] Quoted in Cameron, J. and Abouchar, J. (1991). The Precautionary Principle: a fundamental principle

'Where appropriate(for example, where there is uncertainty combined with the possibility of the irreversible loss of valued resources), actions should be based on the so-called 'precautionary principle' if the balance of likely costs and benefits justifies it. Even then the action should be in proportion to the risk.'[31]

International Joint Commission Seventh Biennial Report on Great Lakes Water Quality, 1994:

'Precaution in the introduction and continued use of chemicals substances in commerce is a basic underpinning of the proposed virtual eliminations strategy. It is generally agreed, in principle, that the burden of proof concerning the 'safety' of chemicals should lie with the proponent for the manufacture, import or use of at least new substances ... rather than with society as a whole to provide absolute proof of adverse impacts. ... This principle should ... be adopted for all human-made chemicals shown or reasonably suspected to be persistent and toxic... The onus should be on the producers and users of any suspected persistent toxic substance to prove that it is, in fact, both 'safe' and necessary ...'[32]

Sustainable Development: The UK Strategy – Command Paper 2426, 1994:

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of law and policy for the protection of the global environment. *Boston College International and Comparative Law Review* 14, (1): 1-27. p14

[31] Quoted in Haigh, N. (1994). The introduction of the precautionary principle into the UK. In, O'Riordan, T. and Cameron, J., (eds), *Interpreting the Precautionary Principle*:229-251. London: Earthscan Publications Ltd. p251

[32] International Joint Commission (1994). *Seventh Biennial Report on Great Lakes Water Quality*: International Joint Commission. 1994. p9

'when potential damage to the environment is both uncertain and significant, it is necessary to act on the basis of the precautionary principle.'[33]

[33] Command Paper 2426 (1994). *Sustainable development: the UK strategy*. London: HMSO. 1994.

Appendix Two

List of Interviewees

Radioactive Waste Disposal

NAME/ JOB TITLE	REPRESENTING...	INTERVIEWED
Campaigner	North Lakes Friends of the Earth	1 October 1996
Head of Radioactive Substances Division	Department of the Environment	16 October 1996
District Councillor	Gosforth Parish Council	18 November 1996
Drigg resident	Ex Copeland District Councillor, Ex Secretary for the Six Parish Councils, Ex Drigg Parish Councillor, Ex BNFL chemist	19 November 1996
Chair of Gosforth Action Group Cumbrian businessman	Gosforth Parish Council	19 November 1996
Environmental Planning Manager	Cumbria County Council	20 November 1996
Senior Scientist	Greenpeace	26 November 1996
Computer Modeller	National Radiological Protection Board	27 November 1996
Dr Gordon McKerron Science Policy Research Unit	University of Sussex	28 November 1996

Dr Frans Berkhout Science Policy Research Unit	University of Sussex	28 November 1996
Geosciences Group Leader	QuantiSci	29 November 1996
Harold Bolter Ex-Director BNFL	Author of 'Inside Sellafield'	3 December 1996
Convenor of the British Government Panel on Sustainable Development	Oxford University	10 December 1996
Research, Development and Strategy Manager	UKAEA	10 December 1996
Waste and Effluent Treatment Director	BNFL	12 December 1996
Sellafield Site Inspector	Environment Agency	16 December 1996
Chief Executive	UK Nirex Ltd	7 January 1997
Senior Nuclear Research Officer	Friends of the Earth	Many occasions

Endocrine Disruption

NAME/ JOB TITLE	REPRESENTING...	INTERVIEWED
Dr Vyvyan Howard Department of Fetal and Infant Toxico-Pathology	University of Liverpool	26 March 1997
Head of Food Contaminants Division, Food Safety and Science Group	MAFF	8 April 1997
Head of Environmental Contaminants in Food, Food Contaminants Division	MAFF	8 April 1997
Campaigner Number 1	Greenpeace	9 April 1997
Campaigner Number 2	Greenpeace	9 April 1997
Director of Public Heath	Barnet Health Authority	9 April 1997
Dr Philippa Darbre School of Animal and Microbial Sciences	University of Reading	10 April 1997
Senior Scientist	Thames Water Authority	10 April 1997
Head of Research	Friends of the Earth Scotland	16 April 1997
Campaigner	Friends of the Earth Scotland	16 April 1997
Regional Scientist	Environment Agency	23 April 1997
R&D Management Support Officer	Environment Agency	23 April 1997
Dr Charles Tyler Department of Biology and Biochemistry	Brunel University	24 April 1997

Head of Chemicals and Health Branch	Department of the Environment	25 April 1997
Dr Charles Humfrey	Institute of Environmental Health	2 May 1997
Industry and Pollution Researcher	Friends of the Earth	16 May 1997 and many occasions
Endocrinologist	Royal Free Hospital	16 May 1997
Physician	EDSTAC Physicians for Global Responsibility, Boston	3 July 1997
Dr Carlos Sonnenschein	TUFTS University, Boston	7 July 1997
Dr Ana Soto	TUFTS University, Boston	7 July 1997
Special Assistant to the Director, Tulane/Xavier Centre for Bioenvironmental Research	Tulane University, New Orleans	9 July 1997
Dr John McLachlan Director, Tulane/Xavier Center for Bioenvironmental Research	Tulane University, New Orleans	9 July 1997
Lawyer	Environmental Law Clinic, New Orleans	11 July 1997
Lawyer	Environmental Law Clinic, New Orleans	11 July 1997

Campaigner	Greenpeace, New Orleans	12 July 1997
Jeanna Solomon	Natural Resources Defence Council On EDSTAC	31 July 1997
Davis Baltz	Commonweal Healthcare without Harm	31 July 1997
Campaigner	Pesticides Action Network, San Francisco	31 July 1997

Appendix Three

Groups and Their Interests and Responsibilities with Regard to Endocrine Disrupting Chemicals

A great range of individuals and groups have been involved in debates about endocrine disrupting chemicals, some through a legal requirement to be involved and others through specific interests. In this appendix I identify who many of these are and establish what their interests and responsibilities are.

a) The Department of the Environment (DoE) has policy responsibilities to protect the natural and man-made environment, to maintain air, water and soil quality, and to protect human health from exposure to hazardous substances via environmental pathways. The DoE is responsible for assessing the risks currently posed by oestrogenic chemicals in the environment to human health and wildlife and whether current controls are adequate.

b) The Department of Health acts as an advisor to other governmental departments in order to guide research and policy decisions. They are not directly involved in the implementation of policy or the funding of research in the area of endocrine disruption although they do have close links with the Medical Research Council which promotes and supports research into environmental oestrogens at its various units including the Institute for Environment and Health in Leicester which produced an assessment of environmental oestrogens.

c) The Ministry of Agriculture, Fisheries and Food (MAFF) is involved in measuring the levels of chemicals in food and develops analytical techniques and determines the average and high level exposure to environmental oestrogens. MAFF, with its interest in fisheries, has been investigating the oestrogenic effects in wildlife of sewage effluent discharge. To date, almost all discharges investigated have proved to be oestrogenic to fish, as measured by the induction of vitellogenin. One of their areas of concern is the lack of knowledge of the effects of environmental oestrogens at current levels on aquatic populations and they also plan to investigate marine populations.

d) The Health and Safety Executive is interested in the reproductive effects of occupational chemicals and in investigating animal models to look for biomarkers of toxicity.

e) The Environment Agency is responsible for protecting controlled water from polluting discharges and has a statutory duty to carry out research and development to support its main functions. It supports work at MAFF and Brunel University and has a number of ongoing projects including studies to identify and quantify the substances in sewage effluent, which are responsible for vitellogenic responses in fish, and a study aimed at assessing oestrogenic effects in wild fish. They plan further laboratory and field investigations and the development and recommendation of environmental quality standards followed by the assessment of compliance.

f) The Chemicals Industries Association (CIA) represents 200 of the UK's leading chemical producers and it addresses product regulatory issues including health, safety and the environment, science and education issues and employee relations. It is concerned about potential endocrine disrupting effects of chemicals but feels that current evidence is not conclusive with respect to human reproductive health problems and the possible causal factors.

g) The European Chemical Industry Council (CEFIC) covers all major European chemicals companies and has established an Endocrine Modulators Steering Group (EMSG) which is committed to clarifying and understanding the issues and to the elimination of unsustainable impacts on man or the environment.

h) The British Plastics Federation covers about 4000 firms in the UK most of which are plastics users. It believes that the science is at an early stage with conflicting data but it is keen to support CEFIC and other research initiatives.

i) The World Wide Fund for Nature has been very active in the field of endocrine disruption. It has published a book[1] and a number of reports[2] and is funding some basic research by MAFF into the effect of oestrogenic pollutants on fish populations. They believe that the precautionary principle should be applied now to reduce environmental and human exposure and that accurate no-observable-adverse-effect-levels need to be established, especially for behavioural effects at very low levels of exposure. WWF considers that, under the Environment Act, environmental oestrogens should be classed as prescribed chemicals by application of BATNEEC[3]

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[1] Colborn, T., Peterson Myers, J., and Dumanoski, D. (1996). *Our Stolen Future*. London: Little, Brown and Company.
[2] For example, WWF (1995). *Atrazine: an organochlorine herbicide*. Godalming: WWF. May 1995.
WWF (1996). *A framework convention for the phase-out and elimination of POPs. Prepared for the Intergovernmental Forum on Chemical Safety Meetings on Persistent Organic Pollutants, Philippines*. Gland, Switzerland: WWF. 17-22 June 1996.
WWF (1997). *Overview of policy initiatives relating to endocrine disrupting chemicals (EDCs)*. Godalming: WWF. 5 May 1997.
WWF (undated). *Policy options for endocrine disrupting chemicals (EDCs) within the European Union*. Godalming: WWF. undated.
WWF (undated). *Lindane*. Godalming: WWF. WWF (1996). *Bisphenol A (BPA)*. Godalming: WWF. June 1996.
WWF (1996). *Vinclozolin*. Godalming: WWF. June 1996.
WWF (1996). *Alkyl Phenol Ethoxylates (APEs) and related compounds*. Godalming: WWF. June 1996.
[3] BATNEEC means Best Available Technology Not Exceeding Excessive Cost.

and that regulators should set emission limits and look for areas of high and low contamination.

j) Greenpeace has been running a campaign against PVC and chlorine with the aim of seeing these banned. They believe that efforts should be concentrated on hazard identification and that current techniques should be examined to see if they are applicable to environmental oestrogens. They also believe the risk arising from an inability to identify the causal agents should be considered.

k) Friends of the Earth and Friends of the Earth Scotland would also like the precautionary principle to be invoked with regard to endocrine disrupting chemicals. They highlight the need to develop an accurate inventory of industrial emissions, which they suggest should be carried out by the Environment Agency and SEPA, and more appropriate methodologies to assess the risk of new chemicals.

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