1 Introduction: Ecology for policy

"In recent years it has become impossible to talk about man's relation to nature without referring to 'ecology'. Such leading scientists as Rachel Carson, Barry Commoner, Eugene Odum, Paul Ehrlich and others have become our new Delphic voices [....] So influential has their branch of science become that our time might well be called the 'Age of Ecology'." (Worster 1994)

The above quote is from the preface to the second edition of Donald Worster's "Nature's Economy." The "Age of Ecology" refers to the period that started after World War II and that has lasted until today. Indeed, with the rise of environmental problems, biology, and more specifically ecology, has become indispensable in environmental policies. The role of ecologists in the post World War II society is best known for discovering environmental problems, with Rachel Carson's "Silent Spring" from 1962 as a classical example. Increasingly important, however, became the notion of ecologists as solvers of environmental problems. The latter role rapidly developed in the second half of the 1960s and the first half of the 1970s, as a result of strong ambitions on the side of ecologists and high expectations of authorities. In the first edition to Krebs' textbook on ecology (Krebs 1972) two reasons for studying ecology were given, namely to increase one's understanding of the world we live in and to provide a basis for practical action on environmental problems.

But not only practical action was considered necessary. A need was felt to use science as a basis for decision-making and management. According to Küppers et al. (1978), an increasing number of problems had an interdisciplinary character, and administrations could no longer rely on "accidentally applicable knowledge," but had a need for a systematic longer term knowledge, developed in accordance with defined problems. Nelkin (1987) attributed the vast growth of scientists employed by the administration to the increasing complexity of policy decisions, and the use of science as a source of authority by which consensus in public affairs could be reached: "Scientific standards have a universal appeal as an authoritative basis of rational decision making." According to Jasanoff (1990), regulatory agencies developed in the early 20th century and were mainly dealing with fact finding. The tasks of these agencies became increasingly complex. From the beginning of the 1970s new scientific duties emerged, such as sponsoring basic research, conducting inspections, performing risk assessments and developing analytical methodologies. At first the agencies could not cope with these tasks. For these reasons a scientific basis for public policy had to be developed.

The call for science as a basis for decision-making and management is still topical, as was illustrated by Gro Harlem Brundtland (1997) who stated:

"In ocean management, as in most other areas of human endeavour, close co-operation between scientists and politicians is the only way to move forward. Science must underpin our policies. If we compromise on scientific facts and evidence, repairing nature will be enormously costly, if possible at all."

It is clear from the above that there were, and still are, high expectations to science to support public policies. But what then is and what has so far been the impact of science? At first sight, the influence of ecology and ecologists on public policy is clearly visible in the changes that have occurred in environmental policies in the past decades. Environmental policies have become ecologised and are developing from sectoral (pollution, species protection) to so-called integrated ecosystem policies (see for example De Jong 1994). At the same time (ecological) science has become politicised, meaning that more scientists have become involved in decision-making, for example as civil servants (see among others Nelkin 1987; van der Windt 1992; De la Mothe and Dufour 1995), and scientific research has become more policy applied.

But has science indeed contributed to solving and managing environmental problems? Already in 1975 Nelkin described the rise of public expectations towards ecologists in view of increased awareness of environmental problems, and the corresponding problems ecologists were faced with when trying to live up to these expectations (Nelkin 1975). De la Mothe and Dufour (1995), in a more recent commentary in Nature, were very critical about the supposed capacities of science: "The scientific community [....] has for decades promised the public and politicians far more than it could deliver. The 'endless' frontier of science has not managed to translate itself into an 'endless solution'." The tension between science and politics is not only about the delivery of solutions, but also about the differences in attitude between scientists and politicians, as is illustrated by the following example: According to a member of the UK House of Lords' subcommittee on fisheries, "scientists should say clearly that there are certain visible trends, which, if allowed to continue, will lead to catastrophe. I feel if they had said this earlier, it would have had an impact on policy-makers" (Masood 1996). In contrast, a quote is presented by fisheries ecologist Niels Daan in the Dutch weekly magazine "Vrij Nederland": "I feel that it is a threat to scientific research that we are forced more and more to present hard statements. Also when it is not possible" (Van Wijnen 1995).

The central question of this book is whether ecology has indeed contributed to solving environmental problems and, if yes, to what extent and in which way. This question will be investigated in detail for the case of marine eutrophication in the North Sea and the Northeast Atlantic Ocean. Already in the 1950s marine ecologists had recognised marine eutrophication, the loading of the marine environment with phosphorus and nitrogen compounds, as a potential pollution problem. The issue started to achieve world-wide attention in the 1970s, be it predominantly from the side of marine ecology. The 1980s were the decade of political action to combat marine eutrophication in the North Sea, the Baltic Sea and the Northeast

Atlantic Ocean. Scientists connected serious oxygen depletion events in the Danish Belt Seas, the Kattegat and the German Bight with excess loads of nutrients from the mainland to the sea, caused by human activities. National and international political action followed, resulting in 1987, at the second International Conference on the Protection of the North Sea (London 1987), in the agreement between North Sea states to reduce by 1995 inputs of nitrogen and phosphorus compounds to the North Sea by 50%. However, this was required only for discharges of nutrients into areas "where these substances may cause pollution." Such areas would, as decided at the third North Sea Conference (The Hague 1990), have to be determined on the basis of scientific research. By doing so, politics had laid a heavy burden upon the scientific community and, consequently, marine eutrophication research had become substantially politicised.

1.1 Science for policy

Before embarking upon the analysis of the role of marine ecology in marine eutrophication policy, it is necessary to address in more detail why science is considered potentially beneficial for policy-making, and in which way science may contribute to the policy process. This will provide the theoretical framework for the analyses, and allow a more precise formulation of the main questions to be addressed. In the following sections two relevant aspects of science for policy will be addressed:

1. The necessity of science for decision-making;
2. The use of science in the different phases of the policy process.

1.1.1 Rational policy-making

What are the presumed capacities which make science so suitable to make a positive contribution to public policies? In the social studies of science the concept "rational policy-making" or "rational decision-making and management" is used to describe policies and management for which science is regarded a necessary condition (Brooks 1987; Nowotny 1987; Underdal 1990; Jasanoff 1990). Underdal (1989) concluded that there is general consensus among decision-makers and scientists that theoretical understanding of cause-effect relationships, as well as relevant descriptive information, are necessary conditions for rational management. Knowledge is both a tool for diagnosing an environmental problem and for prescribing remedial action. Underdal (loc.cit.) stated that science is not the only provider of knowledge, but "the more technical the measurement required, the more complex and less transparent the cause-effect relationships and the more stable the dynamics of the system studied, the greater seems to be the comparative advantage of systematic research over more impressionistic modes of generating knowledge." According to Underdal (loc.cit.), this has two implications:

1. Decision-makers will turn to science for advice on complex questions. Generally, science will not be able to give precise answers on short term (as usually required). From this it can be concluded that the claim of research to play a role in management is primarily based on what is described above, and not on its ability to provide instant answers to questions from policy makers.
2. Natural sciences seem to have an advantage over social sciences, although they are in principle not more relevant. Underdal stated: "the advantage of natural sciences and technology stems largely from their likely ability to make a greater marginal contribution in terms of advancing further beyond the informed judgement of the decision makers themselves or the immediate experience of the general public."

Young (1989) concluded that the scientific community is not only effective in the identification of unknown problems, but that it also "can play a significant role in the pursuit of compliance at the international level by operating as an organised interest group. This community is unusually, perhaps uniquely, transnational in character." Another advantage is that it is well organised. For these reasons "the scientific community is capable not only of transcending the parochial concerns of individual states, but also of bringing pressures to bear on national governments that exceed the pressures more localised groups can muster" (Young, loc.cit.).

1.1.2 The policy life-cycle

Different possible contributions of science to the policy process were mentioned above, but in order to analyse the role of science in the different phases of the policy process, it is first necessary to describe this process in more detail. A simple model of the policy process was developed by Winsemius (1986), on the basis of his experiences as Dutch Minister of Environment. He proposed the so-called policy life-cycle, an amended version of which is in Fig. 1.1.

The policy life-cycle consists of three phases: In the first phase, the discovery phase, the issue is recognised as a (potential) problem. In this phase there is high uncertainty and controversy regarding both the seriousness of the issue, and the need for and dimensions of abatement policies. In this phase the problem is not yet a political issue. In the political or decision-making phase the issue is placed on the political agenda, and negotiations about possible solutions to the problem will start, followed by political decisions. At the beginning of this phase there is still considerable controversy, which gradually decreases as more information becomes available. In phase three, the management phase, political decisions are implemented and management instruments developed and applied. This phase is, furthermore, characterised by a decrease in political interest and a further decrease in uncertainty.

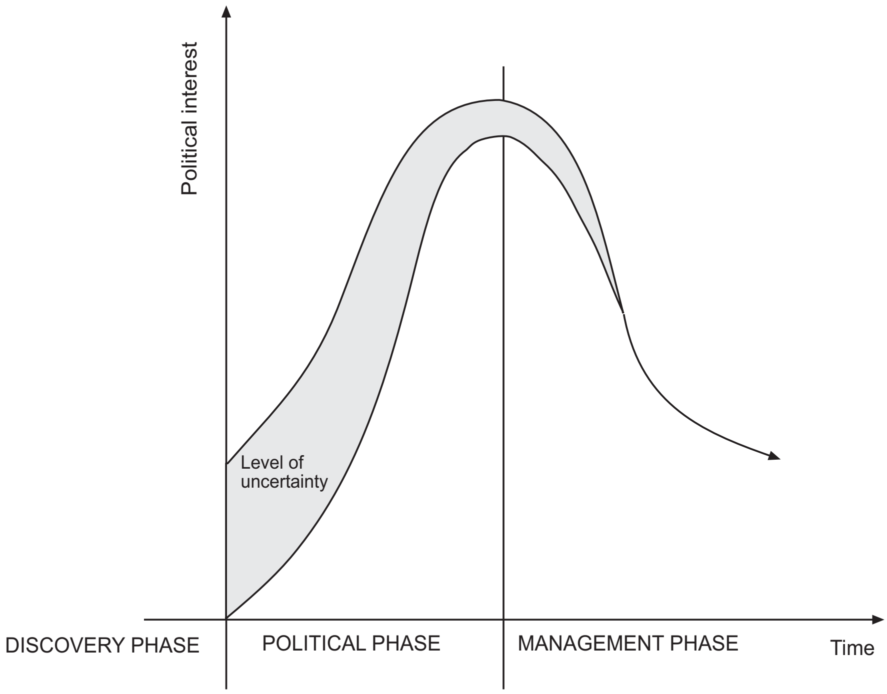

Fig. 1.1. The policy life-cycle. Modified from Winsemius (1986)

How can science best contribute to policy-making in the different phases of the policy life-cycle? Hannigan (1995), who regards environmental problems as social constructions, has identified three elements, the assembly, the presentation and the contesting of the problem. For the first element, which includes the discovery, the problem definition and the establishment of the main parameters, science is considered the central forum. The mass media play a dominant role in the presentation of the problem, and politics are mainly responsible for invoking action, mobilizing support and defending ownership (Hannigan, loc.cit.). As explained above (1.1.1), the rational policy-making model assumes an important contribution by science to political decision-making. Wettestad and Andresen (1990) have suggested that in the phase of political negotiations crude knowledge may be sufficient, but that in the following phase of implementation and compliance, i.e. the management phase, a further development of knowledge is necessary for the fine-tuning of policies. This is confirmed by the wish to gain more knowledge, which is part of most political agreements. Winsemius (1986) has pointed to the fact that in the decision-making phase measures usually have a crude character, and should first of all be effective. In the subsequent phase of solving the problem there will be increasing emphasis on efficiency.

In summary, the following five main goals may be served by science:

1. Assembly of the problem, i.e. the discovery, problem formulation and establishment of main parameters;
2. Providing the scientific basis for political decisions;
3. Reduction of uncertainty as a basis for justification of political decisions. An essential feature of the Winsemius model is that the uncertainty declines in the course of the process (figure 1.1). Lambright (1995) has underlined the importance of reducing uncertainty and concluded that an important factor in the success of the CFC case (the depletion of the ozone layer by chlorofluorocarbons [CFCs]) had been the speedy (2-3 years) narrowing of scientific uncertainty;
4. Specification (fine-tuning) of political decisions;
5. Development of management instruments necessary for the compliance with the new policies, i.e. monitoring, prediction and assessment.

1.2 Science for policy: a myth?

Although the above assessment of the role of science in policy, especially that of international science in international policies, was generally judged positively, other studies have come to much more negative conclusions. Several analysts contend that the impact of scientific knowledge on public policies is limited. According to Engelhardt and Caplan (1987), controversies over environmental issues often have the character of scientific controversies, although in many cases the "non-scientific" factors are the most important ones. They called these, scientific controversies with an overlay. This overlay can be ethical, cultural, economical or otherwise. Boehmer-Christiansen (1989) emphasised the importance of economic factors in decision-making regarding pollution control:

"the economic and technological consequences of proposed environmental regulations, as well as the capacity and willingness of political institutions to respond to their concerns, all contribute to the making of environmental policy at the national level and thus affect international decisions as well. Governments are rarely fully in control of the issues raised and domestic policies thus becomes a part of international negotiations."

When there are differences between countries regarding environmental issues, economic and technological consequences of pollution abatement become decisive factors in international negotiations. Boehmer-Christiansen (1987) concluded that in order to assess the role of science, first political priorities, ideological commitments, political stability (especially with regard to pressures from interest groups) and the connection with the "environmental learning process" of specific governments must be known, as well as the economic and technological consequences of specific abatement techniques.

However, apart from the above non-scientific factors, there are difficulties within the scientific community itself, as well as principal differences between the scientific and political processes, which hamper the use of science in policy. Because of these differences, several authors even distinguish between science carried out within the regular academic settings (academic science) and science for policy, i.e. scientific research with the purpose of generating information for the policy process (Brooks 1987; Nowotny 1987; Jasanoff 1990). Jasanoff (1990) has termed the latter type “Regulatory Science.” The contextual factors which hamper the use of science for policy purposes, and which are covered in more detail below, relate to consensus building, dealing with uncertainty, dealing with values, as well as differences in time frames between the scientific and political processes.

1.2.1 Contextual factors

Consensus

Miles (1989) suggested that the most important factor in the application of knowledge is whether or not the knowledge is consensual. Young (1989) compared the CFC and acid rain cases with regard to the success of the scientific community in influencing the political agenda, and concluded that key factors were whether scientists could reach consensus amongst themselves – which is foreign to scientists, who “seek competition as a method of advancing knowledge” – and whether the scientific community could overcome “the natural tendency [….] to exhibit extreme caution in the interest of avoiding any appearance of overstating the inferences to be drawn from available evidence.” Boehmer-Christiansen (1989) acknowledged that the scientific community has an “intrinsic power to encourage co-operation even among political opponents,” but also concluded: “science itself, because of its own internal propensity for conflict, can only make a limited contribution to the resolution of international conflicts over public choices.” Collingridge and Reeve (1986) underlined that modest critique is an important feature of the development of science. They argued that heavy critique is counterproductive to scientific progress and, in fact, not necessary because the so-called “error-costs” are low. In other words, not much harm will be done if "false" conjectures remain unchallenged. However, as soon as science is used in policy-making with high stakes, the level of critique will increase, and a scientific debate will start with a high level of controversy. Such scientific debates may continue for long periods of time, and will thus not be helpful in political decision-making.

Collingridge and Reeve (1986) identified a second factor responsible for increased scientific debate, namely the fact that political questions are generally not confined to one scientific discipline. Such was also found by Andresen (1989), according to whom the scientific community is characterised by uncertainty, disagreement, caution and difficulty of simple communication, in particular when the number of disciplines increases. This also includes the social sciences, especially in cases of resource management. Each discipline has its own basic values which do not necessarily coincide with those of other disciplines.

Complexity and uncertainty

According to Underdal (1989), uncertain knowledge in international negotiations has the disadvantage that those, in favour of new regulations, will have to prove their case. For opponents it is far easier to come with substantive critique than it is for the advocate to reduce or remove the uncertainty. This is especially so for science to be used in public policy ("regulatory science"), which often works "at the margins of existing knowledge, whereas academic science works within established paradigms" (Jasanoff 1990). Complexity and uncertainty are especially relevant for large-scale environmental issues. The apparent complexity of ecosystems has been a major obstacle in the development of general ecosystem theories and, consequently, understanding the system and predicting developments (compare Peters 1991; Edwards et al. 1994; Macgarvin 1995; Sagoff 2003).

Another problem with complexity of ecosystems is the management of information. Collingridge and Reeve (1986) questioned the ability of policy makers to manage and integrate the huge amount of often controversial expert information, generated by scientific research. One of the myths of rational decision-making is, according to these authors, the assumption that it should be based on the availability of full information. They used in this respect the term "synoptic rationality."

Dealing with values

Science mainly deals with facts, whereas politics mainly deals with value judgements and conflict solving. The question poses itself whether and to what extent value judgements and the resolution of conflicts can be improved by the use of science. Nowotny (1987) discussed the principal question whether scientific proof can be used to solve conflicts. She has worded this as follows:

> "It is worthwhile to recall the great appeal that the scientific method once commanded as a way of settling disputes, and the futile hope that was expressed again and again, in scientific and political utopias alike, that it would be possible to arrive at similar rational procedures for solving conflicts in the political realm."

Engelhardt and Caplan (1987) have compared different ways of closing disputes. They concluded that many controversies have important ethical or political aspects and cannot be solved by using "sound" arguments. In such cases negotiation is the only way of closing the dispute.

Differences in time frames

Time is a critical factor in regulatory science because decisions must often be taken before a consensus has been formed about the acceptability of evidence (Jasanoff 1990). Lambright (1995) used the term "readiness of knowledge" in the question whether or not science is prematurely introduced into policy deliberations. According to Lambright, the issue of readiness of knowledge is perhaps most visible in the environmental field. He concluded from an evaluation of the CFC case that the speeding up of the communication of available science had worked well, but "science by press conference [....] can also burn the provider and policy user if the information proves faulty." The latter was underlined by Jasanoff (1990), according to whom "ripeness of knowledge" is an important factor in reducing scientific controversy.

The ecologist Likens (1992) complained that sponsored studies must emerge at a specified time and usually in a specified format. According to Likens (loc.cit.), "these requirements mean that the process is fatally flawed from a scientific point of view. It is not possible to buy full and complete answers to complex environmental problems within a specified period of time." Also the customary quality review process in peer-reviewed journals is, for reasons of time, amounts and nature of the contents, "largely bypassed." "The result can lead to poor scientific communication as applied to complex environmental problems" (Likens, loc.cit.).

1.2.2 Science in the policy life-cycle

The next question is what will happen with science, once it has entered the policy process. The policy life-cycle model, proposed by Winsemius, is simple and straightforward, and assumes a regular course of events from discovery to solving the problem, making use of science to reduce uncertainty. But science may not always function in accordance with this model. Hischemöller et al. (1998) and Groenewegen et al. (1998) have questioned the linearity of the policy cycle. They concluded that environmental problems change in structure in the course of time, but that this change is not necessarily from unstructured to structured and from conflict to consensus, as assumed in the Winsemius model. Problems may also develop from structured to unstructured, depending, among others, on the emergence of new knowledge or changes in societal perception. According to Jasanoff (1990) scientific advice is not a "one-shot process". In complex decision-making, which takes often many years, there will be multiple rounds of consultation, whereby, as a result of the emergence of new knowledge (often as a result of purposeful scientific activity), a constant redefinition of the state of knowledge is necessary. Jasanoff (loc.cit.) stated that such changes must be taken into account in any comprehensive account of science policy. Central questions are which role parties play in the redefinition of the state of knowledge, and to what extent a change in the state of knowledge can be a reason for a change of policies. That new knowledge not necessarily contributes to the expectations of policy makers was underlined by Miles (1989), who contended that the outcome of scientific research may be a "wild card" in the policy process, in other words, an unknown variable. Likens (1992) argued that environmental problems are not necessarily solved by the delivery of appropriate science. Other scenarios are that a problem remains unsolved because it either does not become a political issue, or because the public and/or politics lose interest.

1.3 Matching science and policy

In the past decades, several solutions to overcome the above problems have been proposed and tested. In the literature dealing with the interaction between science and politics, an often heard solution for handling the incompatibility between science and politics is improved communication (Timberlake 1989; Andresen 1989; Underdal 1989; Wettestad and Andresen 1990; Porrit 1993). Communication problems are caused by the contextual factors listed above, as well as the "jargon" used by scientists, the "ivory tower" attitude of scientists and, most important, the inability of scientist to differentiate between policy-relevant and science-relevant facts. On the side of politics there is the inability to formulate proper scientific questions, and ignorance about the scientific methodology. For an effective communication between science and politics, including the translation of scientific knowledge into politically usable knowledge, specific mediators or mediating bodies are considered necessary (Andresen 1989; Timberlake 1989; Wettestad and Andresen 1990; Lambright 1995). The North Sea Task Force (NSTF), which will be addressed in detail in this study, and the Intergovernmental Panel on Climate Change (IPCC), are examples of mediating bodies established at the international level.

According to Lambright (1995), the principal actors in the interaction between science and politics are researchers, politicians and managers. Normally, that is under normal research conditions, these actors are distant. But in the case of policy-relevant science, that is when science is needed in the policy process, either advocated by scientists (science driven) or by politicians (policy pulled), the relationships intensify and the science-policy connectivity is enhanced. Increased science-policy connectivity is accompanied by the formation of institutions for the communication between science and policy. Hoogerwerf and Herweijer (2003) have defined a policy network as a group of actors, which develop sustained interaction and communication patterns, directed at solving certain policy problems. In this study I will use the term "science-policy network" for the network consisting of the scientific community, the political community and mediating bodies. The latter will be referred to as the "science-policy interface."

The most important functions of the science-policy interface are the translation of scientific knowledge into political language and vice-versa, and the closing of (scientific) controversies through negotiation. The persons working at the science-policy interface should, according to Timberlake (1989), be "as conversant with theory as the research scientist," but must also have a good understanding of the bureaucratic process. Generally, the participants in the science-policy interface are "civil servant scientists," i.e. civil servants with a scientific background. Jasanoff (1990) has analysed the Science Advisory Board (SAB) of the US Environmental Protection Agency (USEPA), the membership of which has developed into repeated assignments and informal interest balancing "into the special subculture of regulatory science rather than short rotation of 'top-flight research scientists'." This was, according to Jasanoff (loc.cit.), done under the authority of USEPA, which was aware of the fact that the position of "neutral" experts can generally be predicted in advance. It is, therefore, essential to have a balancing of different points of view from a diversity of backgrounds and interests. Board members are, generally, selected on broad scientific expertise, rather than specific knowledge. Especially in cases where there is insufficient knowledge, the members must be able to use subjective judgement, a quality which very specialised scientists usually do not have (Jasanoff, loc.cit.).

1.4 Aims and structure of the study

The aim of this study is twofold. First, to provide a comprehensive account of the history of marine eutrophication, comprising its discovery, the construction of the issue as a political problem, political decision-making and management. Second, to analyse the role of science in these different phases. The material provided in the following chapters is intended to serve both purposes, but is should be noted that in some cases the descriptive material is more elaborate than strictly necessary for the second aim.

The analysis of the role of science in decision-making and management with regard to marine eutrophication focuses on three aspects, relevant for the interaction between science and policy, the normative, the structural and the temporal aspect.

The normative aspect

The starting point is the model of rational decision-making and management. According to this model science is a necessary basis for decision-making and management. In the foregoing, several problems with the application of this model have been addressed, which are expected to be relevant for marine eutrophication as well. Marine eutrophication is a highly complicated issue. This complexity is related to the size, the openness and the dynamics of the marine ecosystem. Moreover, nutrients are an essential natural feature of the marine ecosystem, and it is therefore hard to separate man-induced from natural causes. For these reasons, marine eutrophication is a very scientific environmental problem, which may explain the strong demand from politics to science to help structure and manage the problem. Because marine eutrophication is an international issue, it is also possible to investigate the role of the international scientific community in policy-making. Finally, policies to combat marine eutrophication are about reducing nutrient inputs, demanding large investments in sewage treatment and agricultural practices. This requires justification, both in terms of management efficiency and expected improvements in the marine environment.

The central issue addressed in the analysis is whether and how science has contributed to decision-making and management. This query is the starting point for a more detailed analysis, which will focus on the following questions:

A. How has the notion of rational decision-making with regard to marine pollution and marine eutrophication developed over time?

B. What has been the impact of science on the policy process? This question can be further specified as follows:

- B.1 What has been the role of ecology in the construction of the marine eutrophication problem?
- B.2 Has ecology been used as a basis for political decision-making?
- B.3 Has ecology been used as a basis for justifying decisions?
- B.4 To what extent has new knowledge, i.e. knowledge that has become available after decisions have been taken, influenced the political status quo.

B.5 Has ecology contributed to the fine-tuning of decisions and the elaboration of management instruments, i.e. monitoring, prediction, assessment and validation?

C. Have contextual factors influenced the impact of science? These are:
C.1 Complexity and uncertainty;
C.2 Consensus within the scientific community;
C.3 Different time frames;
C.4 Dealing with values.

The structural aspect

The interaction between science and politics takes place within certain structures, in this study referred to as the science-policy network. Of particular relevance is the so-called science-policy interface, in which the communication between science and politics is facilitated. The main structural question for the marine eutrophication case is:

D. What has been the role of the science-policy network for the use of science in the policy process? More in particular, the following questions will be addressed:
D.1 Which structures have been developed for the interaction between science and policy?
D.2 Have there been changes in these structures and if yes why and how?
D.3 How have these structures, in particular the science-policy interface, functioned with regard to the use of science in policy making?

The temporal aspect

The policy life-cycle (figure 1.1) will be used as the temporal framework for the analysis. The main questions addressed with regard to the temporal aspect are:

E. Have developments with regard to marine eutrophication in the North Sea and the North East Atlantic Ocean followed a pattern of discovery, decision-making and management, and what has been the role of science in these different phases?

Outline

The general structure of this book reflects the temporal aspect, in accordance with the three phases of the policy life-cycle: the discovery phase, the political or decision-making phase and the management phase. The discovery of marine eutrophication is covered in Chap. 3, in which an overview of the development of marine eutrophication during the period 1950-1980 is given, including the main scientific issues at stake, the scientific relevance of marine eutrophication and the assessment of the severity, as well as the political awareness of this particular problem. Chapter 3 is relevant for the analysis of questions A, B1, C1, C2

Chapter 4, “The politics of marine eutrophication,” covers the period 1980 to 1990 and focuses on marine eutrophication in the North Sea. The analysis in Chap. 4 focuses on the role of ecology in the agenda-setting and political decision-making with regard to marine eutrophication. The information presented and the analyses carried out in this chapter relate to questions A, B, C, D and E, with particular emphasis on A, B1 and B2.

In Chap. 5 the international management of marine eutrophication is described. The focus is on the North Sea and the Northeast Atlantic Ocean. The period covered is 1990 – 2005. The analysis in this chapter is about the use of ecology for the fine-tuning of political decisions and the development of management instruments. Questions addressed are B, C, D and E with an emphasis on B3, B4, B5 and D.

Because marine eutrophication is a special field within marine pollution, its political and management developments are rooted in those of marine pollution in general. This is the reason why in Chap. 2 a general introduction to the development of marine pollution is given, together with a description of the emergence of a marine pollution science-policy network. Chapter 2 focuses on questions A and D.

In the final Chap. 6 the main findings from Chaps. 2 to 5 are summarized and discussed from the perspective of the whole policy life-cycle, and compared with other international cases of environmental policy. This chapter also presents and analyses alternatives to the rational policy-making model.

Material

The material used in this study consists of scientific literature and reports of official meetings, supplemented with a small number of interviews with key persons. The scientific sources have, as much as possible, been limited to proceedings of major international conferences and key scientific review articles. This is for two reasons. The first is a practical one. In the past 50 years the scientific literature related to marine pollution and marine eutrophication has grown exponentially. A description of some 50 years of scientific developments is only possible through the selective use of aggregated scientific material. Secondly, and very relevant for this study, is the question why international scientific conferences on specific topics were organised. This is particularly interesting if such a conference is the very first one in its field. Several of these "first-time" conferences were organised in the first decade of marine pollution research, i.e. the period 1959–1970, and are analysed in this study. In particular, the prefaces to the proceedings of these conferences, as well as the recommendations formulated by the participants, provide useful material for the analysis of historical and scientific developments.

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