FROM CHAOS TO CONSILIENCE: THE NEED FOR SCIENCE-BASED POLICY TO PREVENT MARINE DEGRADATION FROM LAND-BASED ACTIVITIES

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Introduction

Marine Degradation from Land-based Activities: Navigating Chaos and Complexity

Part I Regime Chaos and MDLBA

Marine degradation from land-based activities ("MDLBA") is an issue that has been on the international agenda in one form or another for several decades, and its management is now recognised as imperative for sustainable development. Acknowledgement of this comes in the form of the 109 nation states' endorsement of the 1995 Global Programme of Action for the Protection of the Marine Environment from Land-based Activities ("GPA").[1]

The fact that there is no legally binding global treaty, but only the morally binding GPA is suggestive of, at the very least, the perceived intractability of issues associated with MDLBA. The intractability transcends the commonly voiced political, socio-economic, multi-jurisdictional, and ecological issues, and involves fundamental and emotionally charged issues such as sovereignty, values, ethics, cultural and religious beliefs, human rights, human welfare, and the right to environmental security. There is a growing consciousness that MDLBA has moved beyond characterisation as an environmental issue and into the significantly more complex domain of social issues.

1 Global Programme of Action for the Protection of the Marine Environment from Land-based Activities, 5 December 1995, UNEP (OCA)/LBA/IG.2/7 (1995).

Such complexity has lead to MDLBA policy-making being largely reactive, sectoral, fragmented, and random. The result is policy chaos as policy-makers, lawyers, managers, and interested actors operate without a coherent, comprehensive, multi-disciplinary and fully integrated policy regime. This sense of chaos prevails despite efforts by policy-makers to integrate traditional policy sectors and involve widespread considerations in policy-making. It is significant that in this regime building effort, while many disciplines and numerous interested actors are now being included in policy-making processes, natural sciences and its practitioners in its many sub-disciplines are at present largely undervalued and neglected, and more troublesome, in many cases, misused.

A. Natural Sciences

Scientific knowledge is a "universal possession of humanity" and it "comprises what we know of the material world with reasonable certainty".[2] Without such scientific knowledge, ecologically sound and economically efficient policy, let alone an effective regime, remains an unattainable objective, as science, and only science, can reveal the impacts of human activities on the global ecosystem, or "ecosphere".[3]

However, there has been a general failure to incorporate, and more importantly, institutionalise sound science into MDLBA policy-making processes. This is not surprising as the majority of policy-makers, lawyers, and other key actors involved have a very poor comprehension of science (including ecology) and scientific

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[2] E.O. Wilson, *Consilience: The Unity of Knowledge* (New York: Alfred A. Knopf, Inc., 1998), at p. 268. By definition, scientific knowledge includes both what is scientifically "known" and what is not known, whether it is recognised but not yet understood, or completely unknown at this time.

[3] The ecosphere is the narrow band of land, air, and water that supports all life on Earth. It is also known as the biosphere. The term "ecosphere" is preferred, as it conveys the inter-relationship of living entities with the physical environment. As "bio" refers to "living" or "life", the use of "biosphere" may result in a narrower interpretation and foster a lack of attention to the physical environment among non-scientists.

methodologies, to the degree that they can be said to be functionally science illiterate.[4] Their critical understanding of both scientific methods and ecology is generally below the level that is required to make effective decisions about environmental issues and discern sound policy options. Hence, key actors have neglected or ignored science as their education and experience render them more comfortable with other factors to the exclusion of science, they include science as one of many factors without appreciating its unique and significant role in environmental protection, or they choose poor science over sound science. It should be stated up front that this is not the fault of the actors, but a result of historical societal bias and the organisation of dichotomous educational systems, which will be discussed in Chapter 2.

Unfortunately, scientific illiteracy among key actors in the MDLBA policy-making process has contributed to poor policy choices for the management of human behaviour and protection of the environment. Paradoxically, scientific influence on policy is declining at the time when systemic degradation issues desperately require sound science to inform policy, and at the time when scientists are very well placed to provide useful and reliable advice.[5]

Science should be infused into the policy-making process to inform actors of the biological, physical, and chemical implications of human activities, set out the ecological priorities, and advise on the ecological and, not coincidentally, economic soundness of policy options. Scientists should have a defined role in managing environmental issues, utilising the best available scientific knowledge to tailor policies that most effectively accommodate socio-economic or political concerns, while

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4 See Anonymous, "Unscientific Readers of Science", Moreover Section, *The Economist,* 9 May 1998, pp. 97-8.

5 See J.M. Bewers, "The Declining Influence of Science on Marine Environmental Policy", 10 *Chemistry and Ecology* 9 (1995). Further, see Appendix 1, The Paradox of Science, herein, which lists articles and books that discuss the declining influence of science.

providing adequate ecological protection. Further, scientific knowledge can place other influencing factors, such as values and conflicting interests in a context that may reduce the perceived intractability of MDLBA regulation. Sadly, science is at present an underutilised resource.

B. MDLBA: Complexity and Chaos

Humans are ultimately bonded to and dependent upon the sustained integrity of the marine environment, for the simple reason that the oceans, which cover two-thirds of the planet, provide fundamental services that make life on Earth possible. However, the protection of the marine environment from degradation associated with land-based activities ("LBA") is one of the most pressing and yet intractable environmental problems on the international agenda.[6] A global regime, comprising legal authority from the United Nations Convention on the Law of the Sea ("LOSC"),[7] guidance from the GPA[8] and Agenda 21,[9] and various regional instruments, is slowly emerging.

Policy progress regarding MDLBA is slow, due to its chaotic nature, of which there are at least four significant aspects. First, the marine habitat is inherently inter-linked with the terrestrial and freshwater habitats, which together with the atmosphere comprise the ecosphere. The ecological inter-dependencies and inter-linkages mean that degradation in one ecospheric component may have repercussions for others, or for the overall integrity of the ecosphere. It also means that there may be "webs" of effects, complicating and extending the traditional purview of impacts.

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6 For a general discussion on complexity, see L.H. Ekstrand and R. Ray, "Chaos and Complexity in Development", 8 *International Journal of Sustainable Development and World Ecology* 127 (2001).

7 United Nations Convention on the Law of the Sea, 10 December 1982, UN Doc. A/Conf.62/122 (1982), 21 ILM 1261 (1982).

8 GPA, *supra* note 1.

9 Agenda 21, 13 June 1992, UN Doc. A/Conf.151/4 (1992).

Second, MDLBA is not “an issue” as it is commonly portrayed, but an amalgamation of many issues. It effectively comprises all activities on land, many of which may have not only identifiable localised impacts but also cumulative effects that make them regional or global concerns.[10] Further, it is inseparable from sectorally addressed issues that range from environmental concerns such as marine dumping, ozone depletion, global warming and sustainable fisheries, to human rights issues such as health and welfare, poverty, population, and human settlements. This is a departure from the view of MDLBA as yet another environmental issue and raises the issues of values, culture and beliefs, and human rights-related issues. Although it may add a layer of complexity, it is prudent to recognise MDLBA as a social issue and one requiring the management of humans, and not management of the environment.

Third, marine degradation cannot be addressed without addressing the degradation of other habitats and ecosystems. The rationale is two-fold. First, impacts from LBA are often experienced in many habitats prior to reaching the sea, as contaminants and the effects of physical habitat destruction often, if not usually, cause impacts on terrestrial and freshwater environments, the water table, or atmosphere, not to mention the health of humans and other species. Second, given the number of states bordering common seas and the ubiquity of the marine environment, the seas provide a focus for co-operative management, inasmuch as the cumulative effects of LBA both inside and outside national jurisdiction have regional significance, and cumulative regional degradation may compromise global environmental integrity.

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10 See J. McHale, *The Ecological Context* (London: Studio Vista Limited, 1971), pp. 4-5. This early article notes that a local environmental issue does not exist as the ecosystem is a global web and, therefore, it involves and is affected by the “whole spectrum of human activities”.

Fourth, the character of MDLBA has shifted over the past three decades from traditional, or classical, pollution – noxious, visible, localised impacts from industry, agriculture, and domestic waste – to increasingly invisible, chronic, and systemic impacts from myriad LBA that have increased in scale, technological sophistication, and global distribution. Although classical pollution persists, activities resulting in systemic degradation may be classified largely as risk management issues. The very nature of risk management transcends the boundaries of the traditional legal domain, as the determination of acceptable levels of risk and viable management strategies is a *social process* that is intricately inter-woven with ethics and values. Acknowledging MDLBA, and more accurately, ecospheric degradation from LBA, as a social issue that requires the participation of new and diverse actors is a positive step. However, the policy-making process must be revised accordingly to ensure that sound policy is the product.

To this end, it should be accepted that MDLBA itself is not the "problem", but a *symptom* of a problem, namely the poor management of human activities. In order to effectively address MDLBA, or, more accurately, manage human activities on land, policy-making must be based on a combination, and integration, of legal, technical, political, technological, scientific, and economic factors, while also acknowledging the prevailing ethic and societal and individual values. This has the potential to lead to further chaos, but, with forethought, it is a challenge that can be successfully navigated.

C. Rescuing Common Sense

Compounding the policy chaos associated with MDLBA is the apparent jettisoning of common sense, particularly in relation to the ecologically sensible and economically efficient use of the capacity of the marine environment specifically, and the ecosphere generally, to absorb and assimilate the impacts of human activities. For centuries, man believed the oceans to be an infinite sink for all waste, regardless of toxicity. Thus, environmentalists and scientists welcomed the relatively recent acknowledgement by the global community that the oceans have a finite capacity. Ironically, many non-scientists have sought to interpret the finite capacity to mean that nothing should be discharged into the oceans, and this may lead to unwarranted impacts on other components in the ecosphere, as they become the receiving habitats.

Reflecting the increasing societal value ascribed to a clean environment, the goal of a near-pristine marine environment is philosophically laudable. However, the potential costs of this are generally unrecognised, as chosen alternatives for waste disposal may have greater ecological impacts on the ecosphere, may be ecologically less effective despite a high level of investment, or may have higher economic and social costs than the foreclosed marine option.

Until such time that purely value-driven standards are economically and socially feasible, it makes both ecological and economic sense to utilise the marine environment's (and other habitats') capacity to absorb the impacts of human activities. This was voiced in a seminal scientific article over two decades ago, and remains true today.[11] Expressed then, and re-emphasised now, is the need for common sense in utilising the marine assimilative capacity to human advantage. The common sense approach is to find the best *ecological* option, not *marine* option or *land* option, by

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[11] E.D. Goldberg, "Our Oceans as Waste Space: The Argument", *Oceanus*, Vol. 24, No. 1, pp. 2-9 (1981). Also see K.S. Kamlet, "Our Oceans as Waste Space: The Rebuttal", *Oceanus*, Vol. 24, No. 1, pp. 10-17 (1981). Most, if not all, scientists agree that the marine environment can assimilate a quantity of waste, depending on the type of waste and the characteristics of the receiving environment. Disagreement relates primarily to whether or not the assimilative capacity should be utilised for policy purposes, and if so, how it should be applied.

taking into account all relevant factors. Employing nature's available services evinces common sense.

This is topical, as an evolving ecological ethic and the increasing value placed on marine environmental protection allowed the precautionary concept to gain momentum as a legal principle. While the concept is philosophically sound, nonetheless new values and (perceived) scientific inability to predict the assimilative capacity have contributed to the declining influence of science on policy-making processes. The truth is that the assimilative capacity as a regulatory tool was never implemented properly, and that scientists have much to offer to policy-making processes, even where scientific uncertainty is high. Common sense suggests that science should be used to inform policy-making, particularly where policy is value-driven.

D. Navigating the Chaos: "Consilience"

In addressing the need to infuse science, a recently reintroduced concept is invoked. This concept is "consilience", which is the bringing together, or the "jumping together", of knowledge from diverse disciplines.[12] "Consilience" is useful as a unifying concept to provide direction to the legal principle of integration.[13] It is particularly relevant to MDLBA issues, given their chaotic and multi-disciplinary nature.

1) Consilience and the Legal Concept of Integration

The introduction of yet another term into the legal-policy domain requires careful consideration, particularly as it may be rendered a " buzz word", or worse, viewed as

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12 Wilson, *supra* note 2, p. 8.

13 For a discussion about the meanings of integration, see D.L. VanderZwaag, *Canada and Marine Environmental Protection: Charting a Legal Course Towards Sustainable Development* (London, The Hague, Boston: Kluwer Law International, 1995), pp. 8-12.

merely more jargon. The introduction of “consilience” offers new depth to policy-making processes as it embodies integration of the very knowledge on which sound policy is built. “Consilience” is very close to “integration” in meaning and intent, and arguably, they may appear to be synonymous. Consilience certainly embodies the whole concept of integration as used by policy-makers and environmental lawyers and managers. Integration has many meanings, with at least five commons ones,[14] and it has become a fundamental principle of environmental law and management. Integration is a useful and effective term, if not tool, for sound management. The risk is that consilience could become just one more application, or another common meaning, of integration.

However, consilience is important enough that it warrants a place in environmental regime building. “Consilience” involves an additional and very specific form of integration, and that is the integration of knowledge and information for comprehensive understanding of the issues. It is a reminder for actors in the environmental arena that relevant and sound knowledge and information from diverse disciplines, particularly the natural sciences, must come together before effective integration in the current legal sense can be attained. In this regard, consilience can be viewed as a pre-condition to, or as underpinning, the conception of integration. Consilience is consistent with integration and it should facilitate the application of the principle of integration to environmental issues. Consilience can be a very powerful concept as the current processes of environmental policy-making frequently fail to include such information in their quest for integration in its various meanings.

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[14] *Ibid.* The five meanings noted are external integration, internal integration, interdisciplinary integration, integration at the national, regional, and global levels, and finally, the integration of management of competing uses in a given habitat.

Effective policy-making for MDLBA, in addition to a scientific grounding, requires comprehensive integration of policies and inter-linkage of strategies across sectors, disciplines, and regions. The preponderance of legal and policy instruments, regional regulatory regimes, and the emergence of legal principles that are integrative – such as integrated coastal management, watershed management, inter-generational equity, environmental impact assessment, and sustainable development – together with the evolution in other disciplines of integrative tools, such as environmental economics[15] and environmental sociology,[16] provide evidence that integration is underway.

However, it is commencing on a chaotic, or random, basis within various disciplines, lacking a master plan or comprehensive strategy for systematically considering and integrating knowledge from the array of sources and actors. These incremental steps towards comprehensive integration should be institutionalised and directed within a process for maximum effect. The process, requiring thoughtful and wise development, may be named "consilience".

2) Consilience as a Concept for Unification

The term, "consilience", is not new to the English language, having been introduced by William Whewell in his 1840 publication, *The Philosophy of the Inductive Sciences.*[17] Although rarely used since its inception, it was recently revived in *Consilience: The Unity of Knowledge*, an illuminating text by the eminent scientist, Edward O. Wilson.[18]

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15 See O. Giarini, "Economics, Ecology and Welfare", 1 *Ecologist Quarterly* 249 (1978); R. Costanza, H.E. Daly, and J.A. Bartholomew, "Goals, Agenda, and Policy Recommendations for Ecological Economics", in R. Costanza (ed.), *Ecological Economics: The Science and Management of Sustainability* (New York: Columbia University Press, 1991), pp. 1-20; E.F. Schumacher, *Small is Beautiful: A Study of Economics as if People Mattered* (London: Vintage, 1973, 1993); and B.C. Field, *Environmental Economics: An Introduction* (New York: McGraw-Hill, Co., 1994).

16 L. Lutzenhiser, "Environmental Sociology: The Very Idea", 15 *Organisation and Environment* 5 (2002). Also see this journal volume for a selection of articles under the title of "Symposium of Environmental Sociology".

17 Wilson, *supra* note 2, p. 8.

18 *Ibid*.

"Consilience" means " 'the jumping' together of knowledge by the linking of facts and fact-based theory across disciplines to create a common groundwork of explanation".[19] More simply put, it refers to the unification of knowledge from the three great branches of learning (the arts, humanities, and sciences) to foster an intellectual and comprehensive understanding of events and issues.[20] "Consilience" becomes increasingly important as issues become more complex and require the application of sufficiently informed opinions and knowledge from outside the traditional policy/legal domain. It is a neutral term, unencumbered with connotations, interpretations, and "baggage" from prior usage. It can be used to describe a specific process to foster effective management of MDLBA, or, more aptly, all environmental issues.

Wilson's well-reasoned proposition is that during the Age of Enlightenment in the 18th century, the three great branches of learning were unified as knowledge from one was integrated with the other branches.[21] Spanning the late 17th and 18th centuries, the Enlightenment was dominated by a handful of scientists and philosophers, namely Bacon, Descartes, Hobbes, Hume, Locke, Newton, Grotius, Galileo, Kant, and Leibniz, whose objectives were to "demystify the world and free the mind from the impersonal forces that imprison it".[22] Among the commonalities binding these men, "they believed in the unity of all knowledge and agreed on the power of science to reveal an orderly and understandable universe and thereby lay an enduring base for

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[19] *Ibid*., p. 8.

[20] *Ibid*., pp. 8-13. Also see E.O. Wilson, "Consilience among the Great Branches of Learning", in P. Galison, *et al.* (eds.), *Science in Culture* (New Brunswick, N.J.: Transaction Publishers, 2001), pp. 131-50.

[21] For an encapsulation of "consilience", see E.O. Wilson, "Resuming the Enlightenment Quest", 22 *The Wilson Quarterly* 16 (1998). Also see the two responses, respectively opposing and supporting the notion of "consilience": R. Rorty, "Against Unity", 22 *The Wilson Quarterly* 28 (1998). *Cf.* P.R. Gross, "The Icarian Impulse", 22 *The Wilson Quarterly* 39 (1998). Most debate about "consilience" concerns its philosophical merits, with opposition strong among post-modern philosophers. Adoption of the concept herein is functional, consistent with Wilson's sound renderings, and thus outside of the philosophical debate. A search of the word "consilience" on the Internet will provide more insight, although caution is advised as, as with any new idea, it is interpreted and debated beyond the concept advanced by the original author.

[22] Wilson, *supra* note 2, at p. 21.

free and rational discourse”.[23] Today’s uni-disciplinary students studying these practitioners of intellectual unity and natural philosophy would probably be intrigued to learn of their intellectual contributions to other disciplines.

“Consilience” is particularly relevant for MDLBA policy-making, given the latter’s complexity and its intersection with diverse disciplines and concerns. “Consilience” in relation to MDLBA and environmental issues, therefore, calls for greater integration of the relevant disciplines and the synthesis of knowledge from them to create a broad knowledge base and a critical understanding of environmental issues. In essence, “consilience” provides a context for the inter-disciplinary nature and integrative themes of contemporary environmental regulation, or more accurately, environmental management.[24] A constant theme throughout Wilson’s book is that comprehensive knowledge allows for wise choices. “Consilience” offers the opportunity for MDLBA policy-making processes to embrace both knowledge and a sufficient understanding of the issues to move away from the randomness and chaos of present policy-making processes, which, despite good intentions, do not necessarily produce effective policies.

Part II Objectives and Overview

A. Objectives

The objectives of this thesis are three-fold. The primary objective is to emphasise the need to integrate *sound science* into policy-making processes to produce ecologically

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[23] *Ibid*.

[24] See H.D. Lasswell and M.S. McDougall, *Jurisprudence for a Free Society: Studies in Law, Science and Policy* (New Haven, Boston, London, and Dordrecht: New Haven Press and Martinus Nijhoff Publishers, 1992). Although “consilience” is not specifically referred to by Lasswell and McDougall, it is wholly compatible with the philosophy of their book and that of Yale’s School of Policy Science, which was developed by the two authors.

effective and economically efficient policy, and to underscore the need for a basic level of scientific literacy to bring about that integration.[25] The second objective is to present MDLBA management as an experiment in managing environmental risks emanating from human behaviour. Consequently, there is a need for "consilience" of not only science and law, but also of all relevant disciplines, in order to inform policy-makers of substantive environmental issues and provide them with a critical understanding of the underlying issues. These include less traditional considerations such as psychological aspects, societal and cultural biases, and public perceptions as influenced by the media, in addition to the expected socio-political and economic concerns. The final objective is to relate the first two objectives to scientific literacy, and illustrate how understanding basic scientific principles provides a means of constructively addressing much of the complexity of MDLBA. The premise is that a knowledge base and an informed position empower participants in the policy-making process to pose salient questions and reach sound conclusions.

To this end, Chapter 1 establishes the complex and chaotic nature of MDLBA issues. Chapter 2 describes the historical tension between the legal (policy) and science domains, and how it has been exacerbated in the last decade by various factors, including the debate surrounding the precautionary concept. It also notes the high degree of scientific illiteracy throughout society, and how this negatively affects perceptions of and commitment to scientific knowledge and scientists. Chapter 3 reviews the historical regulation of pollution and the growth of international environmental law since the 1972 Stockholm Conference on the Human Environment

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[25] See J. Cairns Jr., "Healing the World's Ecological Wounds," 8 *International Journal of Sustainable Development and World Ecology* 185 (2001), where it is noted that society must recognise the "wounds" to the Earth and then become sufficiently literate to effectively address them and prevent further damage.

(“Stockholm”),[26] noting that science had a marginal role in the formation of international law and development of legal principles related to environmental issues. Chapter 4 offers proof of the need for sound science to inform policy, as it chronicles many cases of poor interpretation or unsound application of legal principles due to inadequate understanding of scientific principles, and offers many examples of ecologically and economically unsound policy due to various misuses of science. Chapter 5 proposes options for addressing scientific illiteracy and incorporating sound science into policy-making processes. Chapter 6 draws conclusions relating to the “consilience” of science and law and other disciplines to help shift MDLBA policy-making processes from chaos to consilience. The chapters are described in more detail below.

B. Overview

Chapter 1 Caught in a Whirlpool: Ecospheric Complexity and the Intractability of Land-based Issues

This chapter highlights four complexities that contribute to the perceived intractability of MDLBA. First, the wide array of LBA that contribute to marine degradation is canvassed. A realistic perspective is proposed in which MDLBA is not considered just another environmental issue, but rather an issue of managing human behaviour. Second, ecospheric complexity is illustrated, discussing inter-linkages among habitats, such as wetlands, seagrass beds, and coral reefs, with distant habitats and their inhabitants, through air and water currents. Third, the vast range of impacts from LBA are discussed, utilising the classifications in the GPA. Fourth, the dramatic increase in the number and range of actors involved in MDLBA is discussed, noting the necessity

[26] United Nations, *Report of the United Nations Conference on the Human Environment*, Stockholm, 5-16 June 1972, A/Conf.48/14/Rev.1, 1973.

to include all legitimate interests for effective environmental problem-solving. The multitude of actors involved, or seeking involvement, in MDLBA issues are categorised into various roles, such as degraders, investigators, determiners, enablers, influencers, and educators. It will be shown that actors currently may assume many roles at one time. As the roles are undefined, it becomes confusing as to the extent and type of participation. To this end, role definition offers an opportunity to clarify interests and values, reduce complexity by sorting actors into categories, and hence incorporate actors' contributions into the policy-making process at the appropriate stage. This is particularly relevant to current policy-making, as influencers often usurp the role of investigators.

By the end of this chapter the reader should appreciate the challenges policy-makers face as they become caught in a whirlpool of complex scientific, political, social, economic, cultural, and ethical factors that pertain to many MDLBA issues.

Chapter 2 Encountering a Rip Tide: Evidence, Ignorance, Proof, and Uncertainty in the Scientific and Legal Domains

This chapter discusses the "opposing currents" of law and science, pointing out that tension between the two domains has evolved from the historical arrangement of society, resulting in a high degree of scientific illiteracy among non-scientists. It highlights the paradox of society's blind faith in scientific technology for environmental fixes, but its reticence to utilise natural scientific information for environmental protection. Basic scientific concepts, the scientific method, and the facts and myths regarding scientific uncertainty are canvassed. A discussion of the assimilative capacity and precautionary concept debate follows, highlighting ecologically and economically unsound interpretations of the two concepts.

Chapter 3 Sailing with the Current or Tacking into the Wind?: The Emerging Global Regime for MDLBA

The chapter commences with a summary of the traditional regulatory approach to pollution, the forerunner of MDLBA. Pollution issues on any regulatory agenda were commonly dictated by public pressure, available technology fixes, and, later, medical science, usually on a reactive and *ad hoc* basis. After Stockholm, however, policy-makers began to proactively pursue environmental protection strategies. This chapter focuses on three aspects of international environmental protection. First, it notes the changing character of MDLBA issues, from classical pollution to what is now seen, in ecological terms, as systemic degradation and, in socio-political terms, as risk management.

Second, it distinguishes the mindsets of law of the sea ("LOS") formalists and international environmental law ("IEL") functionalists, and highlights the indicators of a merger between the two disciplines, such as the symbiotic relationship between IEL soft-law and LOS hard-law instruments, and the progressive use of innovative legal tools and principles to reach a workable solution.

Third, socio-economic and ethical developments and advances in scientific knowledge and technology are chronicled, together with international legal developments, from Stockholm to the present. Understanding legal development in this broader context allows greater understanding of the past and present role of science in policy-making, and how values, interests, and ethics are inherently inter-twined with MDLBA policy-making.

The chapter concludes with the observation that the available legal and policy tools are sufficient for effective environmental management, but an effective international regime is yet to emerge. Two issues of note are the necessity for further changes of mindset to reflect a balanced and common-sense approach to ecologically and economically sound interpretation and application of the existing principles and tools, and the somewhat surprising fact that sound science and scientists still are afforded only a marginal role in environmental policy-making.

Chapter 4 Red Sky in the Morning: Weathering Ecologically Unsound Policy

This chapter provides evidence to substantiate the need for scientific literacy so that policy-makers may be empowered to strengthen the policy-making process by integrating sound science. It illustrates many instances in which policies that are ecologically ineffective and economically unsound have arisen because of the under-utilisation or misuse of science. Misuse of science is discussed under several sub-categories, ranging from poor scientific understanding despite good intentions, to malfeasance, and intentional manipulation of science for political or other purposes. Examples of poor policies are illustrated, and an effort is made to acknowledge the plight of scientifically illiterate policy-makers and other actors who are confused by the conflicting voices of science and frustrated by the lack of concrete answers to policy questions.

Chapter 5 Red Sky at Night: Prospects for "Consilience" of Science and Law for Effective Policy-making

This chapter offers promise for "consilience" by proposing ways to integrate science and law for more effective MDLBA policy. It focuses on three primary means of infusing science into policy-making. The first is to ensure that through educational strategies, policy-makers are appropriately trained to fulfil their professional duty, and that laymen's confidence in science and scientists is bolstered through scientific literacy. The second means of infusing science focuses on institutional transformations, including the institutionalisation of a role for scientists in each phase of policy-making, institutional changes and strategies, and the invocation of the precautionary concept as a philosophy to underpin policy-making. The final section focuses on two concrete proposals to foster "consilience". The first proposal is for the IMO/FAO/UNESCO-IOC/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection ("GESAMP") to undertake a practical study to analyse the need for and means of implementing a scientific literacy programme for select groups of actors in MDLBA policy-making processes. The second proposes a diplomatic strategy for fostering implementation of the GPA, and related instruments and regimes, which focuses on process rather than substance. It suggests that the international community, particularly state actors and other primary actors, should acknowledge that many regional and international regimes have not succeeded in solving environmental problems, notwithstanding their relative success in changing actor behaviour. It recommends formal acknowledgement of the commitment to address the reasons *underlying* the failed problem-solving policies, with ways and means of gaining a critical understanding of environmental issues and soundly applying legal principles and management strategies. The emphasis is not on developing new legal principles, but stressing the need to apply existing ones more effectively.[27]

Chapter 6 Conclusions: Land Ahoy!

The "consilience" of law, science, and other disciplines compliments the presently unnamed and informal integration of knowledge from many diverse disciplines that has been underway for several decades now. The "consilience" of science and law is

[27] It should be noted that this does not mean that policy-makers should not strive to develop new legal principles where needed.

absolutely necessary because science is at the core of environmental issues, and in order to foster such “consilience”, education for scientific literacy should be a priority. Imbuing the policy-making process with sound science, common sense, and a precautionary ethic will foster rational policy. This final chapter summarises the benefits and means of incorporating the under-utilised resource of natural science to move the MDLBA policy-making process from chaos to “consilience”.

Chapter 1

Caught in a Whirlpool:
Intractability of Land-based Activities

Part I Conceptual Intractability: A Whirlpool of Issues

MDLBA results from human activities on land, including urban, industrial, and agricultural activities, and development processes such as deforestation and dam construction.[1] MDLBA disrupts ecological processes and it is the most serious problem threatening the coastal seas.[2] Although most nation states have indicated concern about MDLBA by endorsing the 1995 GPA,[3] a legally binding instrument is unlikely. Although concepts of infringement of sovereignty are slowly eroding, these and other factors continue to impede regulatory progress.[4] A primary factor is the real and perceived intractability of issues surrounding MDLBA.

In many ways, the regulation of MDLBA can be likened to a whirlpool, a natural phenomenon caused by specific geo-physical conditions coming together. In the

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1 See generally GESAMP, *Protecting the Oceans from Land-based Activities: Land-based Sources and Activities Affecting the Quality and Uses of the Marine, Coastal and Associated Freshwater Environment*, GESAMP Reports and Studies No. 71, 2001b; GESAMP, *A Sea of Troubles*, GESAMP Reports and Studies No. 70, 2001a; GESAMP, *The State of the Marine Environment*, GESAMP Reports and Studies No. 39, 1990; and E.D. Gomez, *et al*., *State of the Marine Environment in the East Asian Seas Region*, UNEP Regional Seas Reports and Studies No. 126, 1990.

2 See GESAMP reports, *ibid*. and M. Rémond-Gouilloud, "Land-based Pollution", in D.M. Johnston (ed.), *The Environmental Law of the Sea* (Berlin: Erich Schmidt Verlag, 1981), p. 231.

3 Global Programme of Action for the Protection of the Marine Environment from Land-based Activities, 5 December 1995, UNEP (OCA)/LBA/IG.2/7.

4 Most states now realise the cumulative effects of local issues on a region, which is lessening the reliance on national sovereignty as a political obstruction to co-operation.

MDLBA "whirlpool", myriad complex issues come together; including scientific, ecological, technological, social, economic, psychological, and cultural factors.[5] The inter-relationships among these issues are poorly understood, and in attempting to grasp them, regulators, politicians, and other interested actors become confused, paralysed, or overwhelmed. Regulating MDLBA becomes an experiment in managing not the marine or even the global environment, but in managing humans and their activities.[6] There are no single uniformly correct or globally applicable strategies, but rather an array of tools and strategies that are applicable in accordance with the issue and associated conditions and their content and use is always influenced by values, ethics, uncertainties, compromises, conditions, assumptions, and negotiations. It is not surprising that policy-makers might feel a sense of helplessness, as if spiralling towards a dark vortex of a whirlpool.

Managing MDLBA by managing human activities involves diverse factors that cut across most intellectual disciplines. However, the focus herein is primarily on the challenges arising from ecological complexity, with the hope that an understanding of them will reduce real and perceived intractability and lay a foundation for "consilience"[7] of regulation of MDLBA. This chapter reviews four areas of intractability:

- Defining MDLBA;

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5 For an interesting discussion on the inter-linkage of issues, see J.F. Cuber, "Ecotactics: The Critical Link (An Analysis of Values in Conflict)", 3 *International Journal of Environmental Studies* 23 (1972). From a transboundary perspective, see J. Nalven, "Transboundary Environmental Problem Solving: Social Process, Cultural Perception", 26 *Natural Resources Journal* 793 (1986).

6 See S.L. Pimm, *The World According to Pimm: A Scientist Audits the Earth* (New York: McGraw-Hill, 2001), pp. 233-49 and W.D. Ruckelshaus, "Stopping the Pendulum", in R.V. Percival and D.C. Alevizatos (eds.), *Law and the Environment: A Multi-disciplinary Reader* (Philadelphia: Temple University Press, 1997), pp. 397-400.

7 See E.O. Wilson, *Consilience: The Unity of Knowledge* (New York: Alfred A. Knopf, Inc., 1998). "Consilience" is the "jumping together of knowledge". It is discussed in detail in the Introduction, herein.

- Ecological Inter-connectivity;
- The Maelstrom of Land-based Activities and Their Impacts; and
- Participatory Intractability.

A. Defining MDLBA: The Vortex of the Whirlpool

If the regulation of MDLBA is perceived as a whirlpool of complexity, the definition of MDLBA is at the vortex, and it is the first intractability. In the past, including the ten-year period of the Third United Nations Conference on the Law of the Sea ("UNCLOS III"), issues were generally compartmentalised as distinct and separate environmental issues, such as marine pollution, marine dumping, ozone depletion, or integrated coastal management ("ICM"). However, the emerging ecological order, with its emphasis on global inter-connectivity, has led to a broadening of the definition of MDLBA, as recognised by the drafters of the GPA. The inter-linkage of sectoral issues and inclusion of habitat destruction in the GPA reflect ecological reality, but the vast scope of MDLBA-related issues can be overwhelming to those with a traditional sectoral mindset. To overcome the problem it is necessary to understand the logic and ecological sensibility behind the expanded definition, and its impact on regulatory efforts.

MDLBA is a relatively new concept that first appeared in its broadened form in Agenda 21, Chapter 17.[8] Subsequently appearing in the GPA, MDLBA is used as a descriptive term, rather than a defined term.[9] This new conceptualisation of MDLBA

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[8] Agenda 21, 13 June 1992. UN Doc. A/Conf.151/4 (1992), Chapter 17, paragraphs 17.23-29, under the heading, "Prevention, Reduction, and Control of Degradation from Land-based Activities".

[9] GPA, *supra* note 3. The GPA is unique in that it chooses not to define any terms, but instead refers to the Law of the Sea Convention (LOSC), *infra* note 10, and Agenda 21, *ibid*., for a legal and institutional framework to work within. The GPA is discussed further in Chapter 3, herein.

in the GPA expands on earlier definitions in the 1982 United Nations Law of the Sea Convention ("LOSC")[10] and the 1985 Montreal Guidelines for the Protection of the Marine Environment Against Pollution from Land-based Sources ("MGs"),[11] both of which incorporate the significantly narrower concept of "marine pollution from land-based sources".

The GPA's conscious adoption of the term "land-based activities", as opposed to the traditional phrase "land-based sources", demonstrates recognition that sources are only one component in marine degradation.[12] Diverse contributory LBA articulated in the GPA include aquaculture, the destruction of valuable coastal habitats for development projects such as ports and tourism, and the damming of rivers.[13] The reference to "activities" establishes connections to land-use planning and integrated management, and merits an expanded range of innovative measures to prevent and control marine degradation.

Shifting from the traditional and restrictive term "marine pollution" to the broader phrase "marine degradation" implies that the range of impacts transcends the legally accepted definition of marine pollution.[14] Pollution, as defined in the LOSC, is a chain

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[10] United Nations Convention on the Law of the Sea, 10 December 1982, UN Doc. A/Conf.62/122 (1982), 21 ILM 1261 (1982).

[11] Montreal Guidelines for the Protection of the Marine Environment Against Pollution from Land-based Sources, 19 April 1985, Decision 13/18/II of the Governing Council of UNEP, 24 May 1985, reprinted in 14 *Environmental Policy and Law* 77 (1985).

[12] Note that the report by GESAMP, 1990, *supra* note 1, helped advance the concept of *activities* as opposed to merely *sources*. Among other things, the report notes that "[t]he behaviour of every individual contributes to the nature and extent of environmental damage". *Ibid*., at p. 3.

[13] GPA, *supra* note 3, paragraphs 131(d), 149, and 150, respectively.

[14] The LOSC, *supra* note 10, Article 1(4) defines pollution of the marine environment as "the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, which results *or is likely to result* in such deleterious effects as harm to living resources *and marine life*, hazards to human health, hindrance to marine activities, including fishing *and other legitimate uses of the sea*, impairment of quality for use of sea water and reduction of amenities" (emphasis added). This definition, or a similar version, has been adopted by most international conventions and legal instruments. See M. Tomczak Jr., "Defining Marine Pollution: A Comparison of Definitions Used by International Conventions", 8 *Marine Policy* 311 (1984) and A.L. Springer, "Towards a Meaningful Concept of Pollution in International Law", 26 *International and Comparative Law Quarterly* 531 (1977).

of events commencing with the *introduction* of substances or energy, culminating in actual *or potential* impacts of a deleterious nature.[15] "Marine degradation" eliminates the legal requirement that there be an identifiable *introduction* of substance or energy, and instead focuses on a broad range of *impacts* from a broader range of activities. This reflects a subtle evolution to an increasingly ecological mindset.

The GPA identifies priority concerns, including contaminants, physical alteration, point and non-point sources of degradation, atmospheric deposition, and vulnerable habitats such as nursery grounds, shorelines, watersheds, habitats of endangered species, and small islands.[16] From an ecological perspective, this holistic approach is a welcome improvement over the narrower LOSC and MGs approaches. However, its recognition adds a degree of intractability that does not arise when issues are dealt with sectorally. As an understanding of ecological inter-connectivity, the second area of intractability, helps to place the complexities in perspective, it is discussed briefly below.

B. Ecological Inter-connectivity

The ecosphere – the narrow envelope of atmosphere, land, and water that sustains human, plant and animal life – is organised in natural hierarchies much as the geo-political world is organised.[17] Geo-political hierarchies such as "world", "nations", "provinces", "towns", "communities", and "individuals" have counterparts in nature:

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[15] The LOSC definition, *ibid*., does not require deleterious effects for pollution to occur, but the mere likelihood that they may occur. GESAMP, which originally formulated the definition of pollution, requires the fact of deleterious effects. See GESAMP, 2001b, *supra* note 1, Glossary. GESAMP's definition, and the one adopted by scientists has quite a different meaning from the LOS definition, and hence it could cause some confusion. This is discussed further in this chapter in Part I C.1)(a).

[16] GPA, *supra* note 3, paragraph 21.

[17] E.P. Odum, *Ecology and Our Endangered Life-support System*, 2nd ed. (Sunderland, Massachusetts: Sinauer Associates, Inc., 1993), pp. 25-7.

the ecosphere, biomes, landscapes or habitats, populations, and organisms.[18] This ecological organisational hierarchy is inter-linked by food-webs, energy flows, and bio-geochemical cycles of nutrients, carbon, water, and other substances. Given the intricate inter-connections among marine and terrestrial habitats and the global life-support systems, the focus of MDLBA solely on the marine environment is ecologically shortsighted.

An understanding of the intricate relationships within of the ecosphere draws on all the biological, chemical, and physical sciences (i.e., the natural sciences).[19] Evolutionary biology, genetics, ecology, biochemistry, and physics are just a few of the broad scientific disciplines required to understand ecosystem principles working at all levels, from the sub-atomic to the ecospheric. Recent decades have witnessed the rise of hybrid scientific domains, such as molecular genetics, chemical ecology, physical chemistry, chemical physics, eco-toxicology, and ecological genetics, as "consilience" within the natural sciences has become imperative for a comprehensive understanding of the physical world.[20]

Habitats in the ecosphere are inter-connected, not only by geo-chemical cycles, but also by food inter-dependencies and migration and recruitment (of new individuals) processes. "Habitat" is an ecological term meaning:

> The physical space where an organism, population or species lives. Habitats are usually categorised by particular physical or biological characteristics (e.g., coral reefs, mangrove forests).[21]

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[18] *Ibid*.

[19] An understanding of *Homo sapiens'* relationship to the natural world draws on the social and natural sciences, as well as the humanities. See O.A. Houck, "Are Humans Part of the Ecosystem?", 28 *Environmental Law* 1 (1998).

[20] Wilson, *supra* note 7, p. 11.

[21] GESAMP, 2001b, *supra* note 1, Glossary.

Habitats usually have definable boundaries and specific attributes with populations of species that are adapted to live within the conditions, with other examples of habitats being estuaries, freshwater marshes, forested wetlands, deserts, tundra, grasslands, and forests.[22] The many habitats meld into a single global ecosystem (i.e., the ecosphere), of which *Homo sapiens* is an integral species.[23]

Provided that inter-connectivity is borne in mind, a habitat offers a neatly defined unit of properties for regulatory purposes. Unlike “habitat”, “ecosystem” is an amorphous term describing a “discrete unit of living and non-living parts, interacting to form a stable system”, that can be applied at all scales, from microscopic to global.[24] GESAMP’s definition is more comprehensive:

> A community or several communities of organisms together with their physical environment. A conceptual view of interaction within and inter-dependence among species and communities emphasising the nature and flow of materials and energy among these parts and the feedback loops from one part to another.[25]

The following section discusses the dominant habitats and the ecosystem principles that meld them into the global ecosystem.

1) Marine and Inter-related Habitats

Humanity everywhere is ultimately bonded to and dependent upon the sustained integrity of the marine environment, no matter how far from any shore. The oceans cover two-thirds of the planet, and in addition to regulating carbon, oxygen, and other chemical balances in the atmosphere, they play a major role in global climate regulation, the extent of which is still under investigation. By absorbing carbon

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[22] See Odum, *supra* note 17, pp. 221-67.

[23] Regarding humans’ place, see O.A. Houck, *supra* note 19.

[24] *The Concise Oxford Dictionary of Ecology* (Oxford and New York: Oxford University Press, 1994). The term, “ecosystem” is often used inter-changeably with “habitat”, and thus both coastal habitat and coastal ecosystem are commonly heard.

[25] GESAMP, 2001b, *supra* note 1, Glossary.

dioxide from the atmosphere, oceans maintain the balance of atmospheric gases and moderate the greenhouse effect implicated in global climate change. The ocean's primary producers (tiny plants known as phytoplankton) are the basis of the marine food-chain, producing oxygen as a by-product of photosynthesis.[26] Oceans also have a natural capacity to assimilate contaminants from human and natural sources;[27] provide reservoirs of consumable protein (fish), minerals, pharmaceuticals, and energy; and are often the basis for whole economies as individuals, villages, and states harvest its wealth of living and non-living resources. Tourism, seaside resorts, cruises, eco-tourism, and marine-based recreation generate significant revenue, particularly for developing states with tropical climates.

The oceans are highly diverse in every respect imaginable, including temperature, salinity, and natural levels of some contaminants.[28] Marine habitats include coral reefs, sandy bottoms, seagrass beds, rocky substrates, deep sea, and open sea, with each having unique characteristics depending on, for example, their location in temperate, tropical, or arctic regions. Oceanic and atmospheric currents transport and distribute eggs, larvae, and non-motile species, along with contaminants, over long distances. The food-web is highly complex as species migrate among marine habitats, including the coastal zone. The marine environment is intricately inter-woven with terrestrial habitats, as water flows, or seeps through the ground, to the lowest point, the

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[26] J.L. Sumich, *Introduction to the Biology of Marine Life,* 5th ed. (Dubuque, Ia., U.S.A.: Wm. C. Brown Publishers, 1992), 51-9. Also see P. Castro and M.E. Huber, *Marine Biology,* 2nd ed. (Dubuque, Iowa: Wm. C. Brown Publishers, 1997).

[27] See E.D. Goldberg, "Our Oceans as Waste Space: The Argument", *Oceanus,* Vol. 24, No. 1, pp. 2-9 (1981). The marine environment has a natural capacity for waste absorption, and it makes economic sense to utilise that capacity in managing the overall health of the ecosphere. This argument remains valid today.

[28] Some ocean areas naturally have higher levels of certain contaminants, often related to rock composition or natural terrestrial run-off.

oceans. The hydrologic cycle (i.e., circulation of water) binds terrestrial life to the oceans in the endless loop of connectivity among land, atmosphere, and sea.

The magnitude of inter-dependencies and exploitative behaviour among and between marine species and marine habitats at least equals that of terrestrial species and habitats.[29] Each species has a niche to fill and a function to perform to maintain ecological equilibrium.[30] Natural processes – for example, disruptions of food sources, addition or removal of nutrients, temperature changes, water and air quality changes, introduction or removal of predators, and a host of other factors such as salinity or amount of precipitation – can influence the ecological equilibrium. Competition for food and resources within habitats, and for food and mates within populations, keeps the ecosystem in check, although external factors, both natural and human-induced, may harm some species or provide other species with unfair advantages, and thus disrupt the equilibrium.

Complexity in the natural world extends to the organism level. Scientists toil to understand internal systems and how substances are metabolised at the molecular and sub-molecular level, what the break-down products are, whether the products are stored in the body or discharged, and, if the former, where in the body and to what consequence.[31]

Despite the extreme complexity of the marine ecosystem, scientists are making progress, in their respective fields and through cross-disciplinary collaboration, fitting

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[29] See GESAMP, 2001a, *supra* note 1, p. 12. Coral reefs, the "rainforests" of the ocean, are particularly diverse and dynamic.

[30] See Sumich, *supra* note 26 and Castro and Huber, *supra* note 26, for a general introduction to marine ecology. Odum, *supra* note 17, provides a good introduction to ecosystems.

[31] For example, isolating the biochemical roots of instinctive behaviour could provide long-term benefits for marine sustainability. For example, chemical changes to water may cause biochemical interference with navigation systems, causing whale-beaching events and spawning failure in salmon.

together pieces of the geo-physical, ecological, and biochemical puzzle. The tasks of accumulation and reconciliation of scientific knowledge (i.e., "consilience"), previously well managed by scientists, are enhanced by ubiquitous access to the Internet, through which scientists can exchange research data and discuss scientific issues on a continuous basis, between conferences and other meetings. Collaborative research by scientists in different geographic regions is easier today, than even compared to a decade ago.

(a) Rivers

Rivers are intricately related to the marine environment as, regardless of size, they generally drain into the seas or marine areas, carrying contaminants, sediments, nutrients, and fresh water to the coastal interface of land and sea, and beyond.[32] Estuaries, at the interface, are biologically diverse, productive, and economically valuable for the commercial harvest of food such as rice. Estuaries, and coastal and near-coastal areas, rely on annual floods for sediment replenishment and vital nutrients, although too much can result in physical smothering and oxygen depletion due to nutrification.[33]

(b) Coastal Area and Coastal Ecotones

The coastal zone is the dynamic land/sea interface where production, consumption, and exchange processes occur at high rates of intensity with the ebb and flow of daily

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32 Rivers, representing the primary pathway for contaminants to the sea, annually transport more than 25 billion tons of particulates and dissolved solids. See J.D. Milliman, *et al., River Discharge to the Sea: A Global River Index (GLORI)*, Land-Ocean Interactions in the Coastal Zone (LOICZ) Reports and Studies, April 1995, p. i. Also see generally Intergovernmental Oceanographic Commission, *IOC/WESTPAC Workshop on River Input of Nutrients to the Marine Environment in the Western Pacific*, Penang, Malaysia, 26-29 November 1991, IOC Workshop Report No. 79, 1991 and GESAMP, *Anthropogenic Influences on Sediment Discharge to the Coastal Zone and the Environmental Consequences*, GESAMP Reports and Studies No. 52, 1994.

33 Nutrification is discussed below. Also see W.G. Camp and R.L. Donahue, *Environmental Science for Agriculture and Life Sciences* (Albany, New York: Delmar Publishers, Inc., 1994), pp. 146-50. The GPA, *supra* note 3, identifies both nutrification (excessive nutrients) and lack of nutrients from damming or other construction as environmental problems.

tides.[34] The onshore-offshore axis typically crosses ecological systems, such as coastal lowlands and islands, salt marshes, wetlands, and beaches.[35] An ecosystem-based boundary may extend seaward to the edge of the continental shelf, and landward to include the entire watershed (river system) draining into the marine environment, encompassing hundreds of miles of rivers, streams, and tributaries. The coastal zone is the primary sink for the by-products of LBA, mostly through rivers and run-off. Coastal zones are fragile ecosystems stressed further by expanding human settlements, with estimates that by 2020 two-thirds of humanity will live within 60 miles of coastlines.[36] GESAMP recently targeted increasing coastal populations and tourism, and the associated stresses from domestic, municipal, and industrial wastes as priority concerns affecting marine integrity.[37]

Ecologically-based boundaries are important, because political and legal boundaries, although expedient, fail to recognise the highly interactive processes associated with coastal habitats, known scientifically as "ecotones". An ecotone is a transition zone between two or more ecosystems (or habitats) that has properties that do not exist in the adjacent ecosystems (habitats), and is typically rich in both species diversity and abundance.[38] Coastal ecotones comprise highly specialised species and complex inter-dependencies among species and their habitat. Each species has to adapt to the harsh

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34 E.D. Gomez, "Coastal Zone Management and Ecosystem Protection", in K.L. Koh, *et al*. (eds.), *Sustainable Development of Coastal Areas in Southeast Asia: Post-Rio Perspectives* (National University of Singapore, SEAPOL and IUCN (CEL), 1995), p. 192. Also see N. Ginsberg, "The Lure of Tidewater: The Problem of the Interface between the Land and Sea", in E. Young and Lord Ritchie-Calder (eds.), *Pacem In Maribus*: *The Ocean Environment,* Volume V (Malta: The Royal University of Malta Press, 1971), pp. 59-65.

35 See E.C. Penning-Rowsell, "Introduction", in *Coastal Zone Management: Selected Case Studies* (France: OECD, 1993), pp. 15-23 and A. Barcena, "Some Reflections on a New Approach to Ocean and Coastal Management", in A. Couper and E. Gold (eds.), *The Marine Environment and Sustainable Development: Law, Policy and Science* (Honolulu: University of Hawaii, 1993), p. 1.

36 Agenda 21, *supra* note 8, paragraph 17.3.

37 GESAMP, 2001b, *supra* note 1, pp. 31-2.

38 Odum, *supra* note 17, p. 49.

environment created by tidal movements and the influx of both salt and fresh water, sediments, and nutrients.

Coastal ecotones provide many valuable services, but as yet, the value of these services has only been roughly calculated in economic terms.[39] Intrinsic ecological services and functions performed by coastal ecotones are as follows:[40]

- reservoir for run-off and floodwaters, thus reducing riverbank and coastal erosion;
- buffer for the terrestrial environment against wave impact, storm surge, and intrusion of salt water;
- buffer for the marine environment against freshwater infusion, nutrient enrichment, and sedimentation;
- assimilation of wastes by absorbing, breaking down, or accumulating industrial and agricultural chemicals and sewage;
- high productivity supporting diverse and abundant fish and wildlife species through various life stages, including commercially valuable species for consumption and pharmaceuticals;
- atmospheric utility as a carbon sink, and in the global cycling of nitrogen,

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[39] R. Costanza, R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O'Neill, J. Paruelo, R.G. Raskin, P. Sutton, and M. van den Belt, "The Value of the World's Ecosystem Services and Natural Capital", 387 *Nature* 253 (1997). Also see J.N. Abramovitz, "Valuing Nature's Services", in L. Starke (ed.), *State of the World 1997: A Worldwatch Institute Report on Progress Toward a Sustainable Society* (London and New York: W.W. Norton & Company, 1997), pp. 95-114.

[40] See generally R.E. Heimlich, *et al.*, "Recent Evolution of Environmental Policy: Lessons from Wetlands", 52 *Journal of Soil and Water Conservation* 157 (1997); Costanza, *et al.*, *ibid.*; GESAMP, 2001b, *supra* note 1; and T. Hare (ed.), *Habitats* (New York: Macmillan, Inc., 1994).

carbon, sulphur, and oxygen;[41] and

- although not technically an ecological service, significant economic benefits can be derived through preservation for tourism purposes.

Although these functions can have local and regional benefits, their ecospheric significance is being investigated by scientists who, adopting a holistic approach, look at individual components and the emergent properties resulting from an integration of components.[42] This is compatible with an approach to ICM that focuses on habitat-based management units, as long as they are considered in relation to broader ecosystem interactions.

Wetlands, which include swamps, marshes, bogs, salt ponds, and mangroves, are among the most ecologically important and biologically productive habitats on Earth.[43] Essential life-support systems, wetlands absorb the annual land-based floodwaters during wet seasons and spring thaws, helping to maintain the saline balance of the marine environment, control coastal erosion, and protect fragile seaward habitats. Wetlands are home to many species, including migratory birds, which have been genetically programmed over millions of years of evolution to rest or breed in a particular wetland. Species dwelling here are often biologically specialised to exploit a specific niche or specific food to maintain ecological balance. Wetlands in particular serve as spawning, nursery, and feeding grounds for numerous marine species,

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41 See Odum, *supra* note 17, pp. 221-69 and GESAMP, 2001b, *ibid.*, p. 47. See generally E. Odum, "A New Ecology for the Coast", in T.C. Jackson and D. Reische (eds.), *Coast Alert: Scientists Speak Out* (San Francisco: Friends of the Earth Publications, 1981), pp. 146-65 and IUCN/UNEP, *Management and Conservation of Renewable Marine Resources in the East Asian Seas Region,* UNEP Regional Seas Reports and Studies No. 65, 1985.

42 Odum, 1981, *ibid*., p. 154.

43 GESAMP, 2001b, *supra* note 1, pp. 28-30. See generally E. Maltby, *Waterlogged Wealth* (London: Earthscan, 1986) and J.N. Paw and T.E. Chua, "Climate Changes and Sea Level Rise: Implications on Coastal Area Utilization and Management in South-east Asia", 15 *Ocean and Shoreline Management* 205 (1991).

including economically valuable species such as shrimp, shellfish, and commercial and sport fish.

Seagrass beds, coral reefs, and soft and rocky substrates are fragile and productive inshore/coastal habitats with distinct properties. Seagrass beds and coral reefs in particular are intricately inter-connected with wetlands, and destruction of one will threaten the integrity of the others.[44] Coral reefs rely on wetlands to filter water, bind and immobilise persistent contaminants, and utilise excess nutrients from sewage and organic industrial waste. Coral reefs act as wave breaks, dissipating wave energy and protecting wetlands and beaches from erosion. Seagrass beds are often found as the transition zone between the turbid waters of the wetlands and the clear waters of coral reefs, which absorb residual wave energy and provide nursery grounds for commercial fish, baitfish, and endangered mammals (e.g., dugongs and manatees).[45]

(c) Open Seas

The open and deep seas lie beyond the coastal and inshore habitats. Their biological diversity is still being investigated, and indications are that they are more biologically rich than originally thought. Economically significant is the offshore fishery, comprising larger commercial pelagic species such as tuna, swordfish, and sharks. The deep sea influences coastal and open sea fisheries by contributing nutrients through upwelling, and nurturing baitfish and commercial species, for example, anchovy.

The commonly perceived value of the open and deep seas is in the oil and gas reserves and mineral deposits on and below the ocean floor. However, the economic and

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[44] GESAMP, 2001b, *ibid.*, pp. 27-30.

[45] *Ibid.*, p. 28; M.D. Fortes, "Seagrass-Mangrove Ecosystems Management: A Key to Marine Coastal Conservation in the ASEAN Region", 23 *Marine Pollution Bulletin* 113 (1991) and D.I. Walker and A.J. McComb, "Seagrass Degradation in Australian Coastal Waters", 25 *Marine Pollution Bulletin* 191 (1992). Note that baitfish are the fish on which species higher up the food-chain feed. The availability of baitfish is significant for commercial fisheries as fewer baitfish may act to limit the numbers of available commercial fish.

intrinsic values are protein from sustainable fishing and global climate regulation, as the massive oceanic conveyor belt currents dictate weather patterns and provide ecological services in the exchange of atmospheric gases.[46] While the open ocean remains relatively unpolluted, an emerging concern is the amount of fixed nitrogen entering the open ocean.[47] Human-created nitrogen sources provide nutrients to normally nutrient-poor waters, resulting in an increase in the number of species that thrive on nitrogen.[48] Computer modelling indicates the possibility of important impacts on both regional biological production and the marine carbon cycle, and the likelihood of increased tropospheric ozone production over these areas.[49]

2) MDLBA and Ecological Inter-connectivity

(a) MDLBA and the New Ecological Order

To recognise the variety and inter-connectedness of ecological issues associated with MDLBA in the GPA is to acknowledge the rise of a new ecological order.[50] The concept of systemic degradation replaces the focus on visible, sector-based pollution of decades past. Systemic degradation is pernicious, as impacts from LBA occur not only in the marine environment, but also in habitats traversed *en route* to the marine environment.

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46 See S.G. Philander, *Is the Temperature Rising?: The Uncertain Science of Global Warming* (Princeton: Princeton University Press, 1998), pp. 235-7. Also see P. Brown, *Global Warming: Can Civilisation Survive?* (London: Blandford Books, 1996), pp. 75-80 and S. Schneider, “Global Warming: Neglecting the Complexities”, *Scientific American*, Vol. 286, No. 1, pp. 60-3 (2002).

47 GESAMP, 2001b, *supra* note 1, pp. 51-2.

48 *Ibid*.

49 *Ibid*. Ozone production may be affected, as nitrogen oxide is critical to the photochemical formation of tropospheric ozone. *Ibid*.

50 For a discussion on the new ecological order, and the inability of international law, in 1975, to address it, see R.L. Friedheim, “Ocean Ecology and the World Political System”, in J.L. Hargrove (ed.), *Who Protects the Ocean?* (St. Paul, Minn.: West Publishing Co., 1975), pp. 151-90. Also see S.O. Funtowicz and J.R. Ravetz, “Uncertainty, Complexity and Post-normal Science”, 13 *Environmental Toxicology and Chemistry* 1881 (1994) and W.J. Davis, “The Need for a New Global Ocean Governance System”, in J.M. Van Dyke, *et al*. (eds.), *Freedom for the Seas in the 21st Century: Ocean Governance and Environmental Harmony* (Washington, D.C. and Covelo, California: Island Press, 1993), pp. 147-70. The new ecological order may be “newer” to non-scientists than to scientists.

The new ecological order is not new to natural scientists, although the diplomatic law-making community is just accepting it.[51] In fact, Jacques Cousteau, the late ocean explorer, alerted the general public to the concept of systemic degradation with his 1971 comment on pollution:

> In publication, in conferences, in international units the matters are generally divided into air pollution, land pollution and water pollution. In fact, there is only one pollution because every single thing, every chemical whether in the air or on land will end up in the ocean.[52]

Cousteau's words, long unheeded by the international legal community, should be a clarion call at the outset of the new millennium. The mindset underlying the GPA encourages expansion of this concept of inter-connectivity to include every activity – not just every contaminant – undertaken on land by humans. As an inter-locking web of food-chains, bio-geochemical cycles, energy flows, and niche-specific and highly specialised species, the ecosystem "…is not only more complex than we think, but more complex than we *can* think".[53]

The conception of MDLBA as a single environmental issue is dangerously over-simplified as it fails to recognise ecological complexity and the diversity of LBA, and, most importantly, the need for a diverse range of management and regulatory strategies. Instead, MDLBA should be conceptually extended to encompass all

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51 Although international lawyers recognised the changing character of environmental issues, it has taken time to permeate the legal community. See D.M. Johnston, "Systemic Environmental Damage: The Challenge to International Law and Organizations", 12 *Syracuse Journal of International Law and Commerce* 255 (1985).

52 J. Cousteau, *Our Oceans are Dying* (New York Times, November 14, 1971), at p. 13, col.3. It is cited in L.A. Teclaff and A.E. Utton (eds.), *International Environmental Law* (New York/London: Praeger Publishers, 1975), p. 104. For insight into the spread of pollution, see K.H. Ballschmiter, O. Froescheis, W.M. Jarman, and G. Caillet, "Contamination of the Deep-sea", 34 *Marine Pollution Bulletin* 288 (1997).

53 C. Ray, "Ecology, Law and the Marine Revolution", in E. Young and Lord Ritchie-Calder (eds.), *Pacem In Maribus*: *The Ocean Environment*, Volume V (Malta: The Royal University of Malta Press, 1971), at p. 99.

environmental issues resulting from LBA, including those presently regulated by issue-specific instruments.[54]

As previously noted, the focus on marine degradation is ecologically shortsighted, but perhaps by design or serendipity, it is intellectually long-sighted. Conceptually, marine degradation is the unifying factor, as noted by Cousteau, and it may be used as a *catalyst* for international and regional cooperative efforts to manage impacts from LBA, which traditionally have been domestic concerns.

The sheer complexity of systemic degradation and its relationship with inter-connectivity of environmental issues due to the melding of smaller ecosystems into global ecosphere can be overwhelming. Following is a brief overview of the inter-relationships among some issues currently on the international agenda, which contribute to at least the perceived intractability of MDLBA.

- *Ozone depletion*: Ozone depletion[55] arises from activities on land, namely the release of chlorofluorocarbons ("CFCs"), and can lead to degradation of the marine environment (coastal and open seas) as increased ultra-violet ("UV") radiation affects sensitive plankton that inhabit the top few centimetres of surface water.[56] As plankton are the critical base of the marine food-web, any interference in their production can destabilise the marine food-web. This can be particularly devastating for developing nations, which rely heavily on protein

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[54] Impacts from shipping and marine transportation are inter-connected with MDLBA as vessels transport waste generated from LBA and shipping impacts, such as the introduction of alien species and accidental spills, commingle with marine impacts from LBA. GESAMP, 2001b, *supra* note 1, notes both alien species (p. 33) and marine transport (p. 35) as factors to consider, with the latter contributing to the need to dredge channels to allow for the increasing drafts of ocean-going vessels.

[55] Regulation is pursuant to the Convention for the Protection of the Ozone Layer, 22 March 1985, 1990 UKTS 1, 26 ILM 1516 (1987), and the Protocol (to the 1985 Vienna Convention) on Substances that Deplete the Ozone Layer, 16 September 1987, 1990 UKTS 19, 26 ILM 1541 (1987).

[56] GESAMP, 2001a, *supra* note 1, p. 18. Also see Brown, *supra* note 46.

from marine sources.

- *Global climate change*: Greenhouse gases from human activities on land may directly affect the ecological balance of marine habitats or indirectly affect the ecosphere through changes in ocean currents.[57] Warming oceans can result in the disruption of fisheries as temperature-sensitive species redistribute. Commercial fisheries may relocate, or opportunistic species may invade and decimate commercial populations.[58] Anticipated sea-level rise could be devastating for coastal areas and low-lying islands. Other problems include major impacts on the Earth's climate-regulation mechanisms, primarily major ocean currents that affect temperatures and climate on land, as evidenced by the El Niño effect.[59] Ocean warming and the influx of fresh water from polar ice-cap melting may affect ocean currents, resulting in plunging temperatures, droughts, and excessive precipitation in various areas. Global climate change is not a matter of gentle, uniform global warming, media reports to the contrary.

- *Migratory and straddling fish stocks*: Commercial fish stocks and sport fisheries, already suffering declining populations from over-fishing, may suffer

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57 Note that although scientists agree that global climate change is occurring, the degree to which human activity, as opposed to natural phenomenon, is driving it remains undecided, and the predicted impacts of global climate change, mostly derived from computer modelling, range significantly, along with the projections as to the impacts of reducing the emission of greenhouse gases. See the Intergovernmental Panel on Climate Change, *Climate Change 1995: The Science of Climate Change,* (Cambridge: Cambridge University Press, 1996) and GESAMP, 2001a, *ibid.*, pp. 16-17. Also see C. Bright, "Tracking the Ecology of Climate Change", in L. Starke (ed.), *State of the World 1997: A Worldwatch Institute Report on Progress Toward a Sustainable Society* (London and New York: W.W. Norton & Company, 1997), pp. 78-94; L.B. Lave and H. Dowlatabadi, "Climate Change: The Effects of Personal Beliefs and Scientific Uncertainty", 27 *Environmental Science and Technology* 1962 (1993); Mobil Corporation, "Climate Change: A Prudent Approach", *Asian Wall Street Journal* (4 December 1997), p. 4; S. F. Singer, *Hot Talk, Cold Science: Global Warming's Unfinished Debate,* 2nd ed. (Oakland, California: The Independent Institute, 1999); and S. Schneider, *supra* note 46.

58 An example of this is the invasion of the Arctic cod in the Grand Banks off Newfoundland, Canada. Arctic cod feed on commercially fished cod eggs and larvae. Unfortunately, Arctic cod are not a commercially viable species, as they are thought to be unpalatable. See M. Kurlansky, *Cod: A Biography of the Fish that Changed the World* (London: Vintage/Random House, 1999).

59 See Brown, *supra* note 46, p. 77.

further decline by MDLBA due to impacts on habitats that sustain juvenile life forms and baitfish.[60] Persistent organic pollutants ("POPs"), which bioaccumulate (concentrate in species) to significant levels, may act as endocrine disrupters that may impair reproductive success in some species.[61]

- *Deforestation*:[62] The oceans and forests remove carbon from the atmosphere, which helps reduce global "climate-change gases". Removing trees removes a valuable carbon sink, which may impact on the marine environment as the global equilibrium is disturbed. Clearing forest cover causes the erosion of soil, which can cause freshwater and marine sedimentation, flooding, and loss of agricultural land. It also removes one of nature's filters, as rainfall is purified by percolating slowly through foliated areas.

- *Habitat destruction*: The destruction of coastal habitats causes a range of impacts. Nature's filtration system, namely wetlands that bind contaminants, nutrients, and sediments in the root systems, is lost.[63] Excessive nutrification and sedimentation can harm near-shore habitats, namely coral reefs and seagrass beds. Nursery grounds for many species of commercial fish and baitfish are lost, and over-fishing is accelerated as fewer juveniles grow to adulthood. Habitats for shrimp and mollusc culture are also impaired.

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[60] See GESAMP, 2001b, *supra* note 1, pp. 15-16.

[61] See T. Colborn, D. Dumanoski, and J.P. Myers, *Our Stolen Future* (London: Abacus, 1997). GESAMP, 2001b, *ibid*., pp. 49-50 provides a more cautious assessment, suggesting that there may be reason for concern, but more research is needed. Also see S. Safe, "Another Enviro-Scare Debunked", *Asian Wall Street Journal* (25 August 1997), p. 6 and S. Safe, "Endocrine Disruptors: New Toxic Menace?", in R. Bailey (ed.), *Earth Report 2000: Revisiting the True State of the Planet* (New York: McGraw-Hill, Inc., 2000), pp. 189-202.

[62] For further discussion on the effects of deforestation, see E.D. Enger and B.F. Smith, *Environmental Science: A Study of Inter-relationships*, 5th ed. (Dubuque, Iowa, USA; Wm. C. Brown Publishers, 1995), pp. 197-8, 226, 246, and 352; G.W. Cox, *Conservation Ecology: Biosphere and Biosurvival* (Dubuque, Iowa, USA; Wm. C. Brown Publishers, 1993), pp. 66-7, and 321; and G.T. Miller Jr., *Environmental Science: Working with the Earth*, 6th ed. (Belmont, California: Wadsworth Publishing Company, 1997), pp. 399-418.

[63] See generally GESAMP, 2001b, *supra* note 1, pp. 26-31. See also Heimlich, *et al*., *supra* note 40.

- *Coral reef destruction and unsustainable fish harvesting*: Coral reefs, bastions of biodiversity, are very fragile habitats, requiring clear, low-nutrient water. They are being devastated by sedimentation and nutrification from LBA such as deforestation and habitat destruction. Coral reef destruction removes nature's breakwater, which helps dissipate the force of ocean swells and stormy seas, and protects the coastal areas and shore-dwelling communities from flooding and erosion. Poverty is often associated with unsustainable reef use.[64] Demand generated by lucrative aquarium fisheries and live seafood markets encourages the use of dynamite and cyanide to stun targeted species. Unregulated eco-tourism can be equally devastating. Poverty-stricken jurisdictions often harvest coral to sell to tourists and to use as building materials. The impacts of unsustainable practices on reef species, species further up the food-chain, and the fragile reef infrastructure are devastating. Coral bleaching and an increasing incidence of coral reef diseases are emerging concerns emanating both directly from LBA and indirectly from the impacts of LBA (e.g., global climate change).[65]

- *Mariculture*: The intensive farming of shrimp, salmon, molluscs, and other species contributes to marine degradation, as coastal habitats are often destroyed to accommodate mariculture ponds.[66] Antibiotics used in fish food and contaminated, if not polluted, water from fishponds affect the marine environment and near-shore habitats. Another concern is the mixing of the genetic pool as farmed species escape and breed with their wild counterparts.

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[64] E. Ayres, *God's Last Offer: Negotiating for a Sustainable Future* (New York, London: Four Walls Eight Windows, 1999), p. 222.

[65] GESAMP, 2001b, *ibid.*, pp. 47-8.

[66] *Ibid.*, p. 30.

Seaweed harvesting is an increasingly popular form of mariculture, particularly in the tropics. Over-harvesting of seagrass beds removes nature's filters, which affects coral reefs and destroys nursery grounds, as described above.[67]

- *Ocean dumping*: Regulated pursuant to the 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter ("London Convention"),[68] the materials traditionally dumped at sea emanate from LBA. Few international lawyers or policy-makers recognise this connection, and instead view dumping as a maritime source of contamination. Due to lack of comprehensive assessment of disposal options, impaired marine integrity may be an unintended effect of the increased restrictions on dumping under the London Convention, as waste that is dumped or incinerated on land, instead of being dumped at sea, may find its way, via air currents or water flow, to the already stressed coastal zones.

- *Transport and disposal of hazardous wastes*: The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal[69] deals specifically with waste generated by LBA but, as in ocean dumping, the connection to MDLBA is overlooked. Aside from concerns about safe transport, disposal methods in receiving states may contaminate the air or water (e.g., ash from incineration, or by-products from processing hazardous materials) or improper disposal may have ultimate impacts on the marine

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[67] See Fortes, *supra* note 45.

[68] Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 29 December 1972, 1976 UKTS 43, 26 UST 2403, TIAS 8165, 11 ILM 1294 (1972) and the 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972, 7 November 1996, IMO Doc. LC/SM 1/6, 36 ILM 1 (1997).

[69] Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, 22 March 1989, 28 ILM 649 (1989).

environment through leaching into the water table.[70]

- *Population*: The carrying capacity of the Earth is a subject of debate, but it is generally accepted that it cannot support, worldwide, the level of resource use per capita of an average citizen in a developed country.[71] Over-population will degrade the ecosphere as habitats are cleared for development, resources are further strained, and waste continues to accumulate. Directly relevant to marine integrity is the tendency to settle in coastal zones, and the propensity for the great cities of the world to be located on oceans or major rivers.[72]

- *Marine protected areas ("MPAs")*: The designation of MPAs is encouraging, but not necessarily ecologically successful.[73] Decision-makers tend to choose politically appealing sites without fully considering their ecological merit and requirements. MDLBA and MPAs inter-relate in at least two ways that non-scientists seldom imagine. First, contamination from a distant area *outside the MPA* may be concentrated *inside* the MPA through geo-physical forces (e.g., wind and currents), having a negative impact on the species and habitats within that MPA. Second, habitat destruction or contamination in a distant area may

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70 These are just a few examples of the many disposal methods that may affect the marine environment and other habitats en route to the sea. GESAMP, 2001b, *supra* note 1, p. 35, notes that a related impact from marine transport is the need to dredge deeper channels in straits and harbours to allow for the increasing drafts of vessels.

71 See Wilson, *supra* note 7, pp. 280-2. For more information on the "ecological footprint" concept, which is useful for comparing the relative environmental impact of an individual or city, see W.E. Rees and M. Wackernagel, "Ecological Footprints and Appropriated Carrying Capacity: Measuring the Natural Capital Requirements of the Human Economy", in A. Jansson, *et al.* (eds.), *Investing in Natural Capital: The Ecological Economics Approach to Sustainability* (Washington, D.C.: Island Press, 1994), pp. 362-90.

72 More than half of the global population now lives within 60 km of a shoreline. Continuing migration to urban areas could raise this to 3/4 of the world's population by 2020. See Agenda 21, *supra* note 8, Chapter 17, paragraph 17.3.

73 This is discussed in Chapter 4, herein, in relation to policy-failure due to lack of ecological understanding. Personal discussions with many scientists suggests that as of the late 1990's, more than 50% of MPAs failed to preserve the targeted marine habitat, with the percentage even higher in developing regions. A major problem seems to be unscientific designation of areas, although implementation and enforcement are also problematic in many jurisdictions.

affect an MPA if the population and biodiversity of that MPA rely on recruitment (e.g., larvae carried by currents) from damaged distant habitats. MPA designation requires prior scientific studies to determine habitat population and geo-physical patterns. Failure to do so may affect not only the success of the MPA, but also issues such as commercial fish stocks, as the commercial species or its baitfish may spend part of their lifecycle within the MPA.

- *Biodiversity*: The greater its biological diversity, the greater the stability of an ecosystem.[74] Each species occupies a specialised ecological niche, with ecosystem equilibrium maintained through predator-prey relationships and other ecological variables relevant to that species. Biodiversity is negatively affected by the degradation or destruction of marine habitats, particularly wetlands, seagrass beds, and coral reefs, and through the impairment of water quality by LBA. Another potential threat to biodiversity from LBA is POPs, should they in fact impair reproduction.[75]

- *Freshwater issues*: Groundwater contamination, freshwater contamination, riparian rights, international shared rivers and watersheds, draining of aquifers resulting in intrusion of seawater and/or subsidence in cities (e.g., Bangkok), tourism development and golf courses, and damming of rivers for hydroelectric

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[74] See generally Odum, 1993, *supra* note 17 and P.G. Risser, "Biodiversity and Ecosystem Function", in F.B. Samson and F.L. Knopf (eds.), *Ecosystem Management: Selected Readings* (New York: Springer-Verlag New York, Inc., 1996), pp. 451-5. The oceans are more biologically diverse than once thought, including the deep sea. See GESAMP, 2001a, *supra* note 1, pp. 12-13. For a practical understanding of biodiversity, see E.O. Wilson, *The Diversity of Life* (New York: W.W. Norton and Company, Inc., 1992).

[75] POPs are listed in the GPA, *supra* note 3, as a priority contaminant. GPA, paragraph 21(b) (ii) and they are now the subject of an international treaty, Stockholm Convention on Persistent Organic Pollutants (for adoption by the Conference of Plenipotentiaries), 9 March 2001, UNEP/POPS/Conf/2. They have been under scientific investigation for some time, but were placed on the political agenda after the publication of the disturbing book, *Our Stolen Future*, by Colborn, *et al.*, *supra* note 61. Scientific studies are not conclusive as to the extent of such impacts. See S. Safe, *supra* note 61. Also see GESAMP, 2001b, *supra* note 1, pp. 49-50, which lists endocrine disruption by POPs as an emerging issue of concern.

and irrigation purposes are all issues inter-related with marine degradation. Water, following the physical laws of nature, always drains to the lowest point, which is the ocean. Coastal areas rely on an influx of fresh water from rivers, and manipulation of water flow and contaminated water can have diverse ecological impacts on habitats and plant and animal species, and also severe impacts relating to human health and economic loss.[76] Impacts may be experienced in aquatic or terrestrial habitats *en route* to coastal or marine habitats.

- *Integrated coastal management (ICM)*: Both MDLBA and ICM must be addressed simultaneously, as the impact of human activities inland affects terrestrial, riverine, and coastal habitats prior to entering marine habitats.[77] Also, degradation of inshore marine habitats, such as physical destruction of reefs, may affect coastal and shoreline habitats, given the inter-connectivity of coastal ecotones. MDLBA issues and ICM are inseparable.

The GPA recognises the new ecological order and the conceptual broadening of MDLBA through reference to international conventions that impose duties to protect and preserve the marine environment.[78] The GPA also highlights the need for ecological integration of issues through reference to other environmental issues, such

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76 See generally Odum, 1993, *supra* note 17*;* GESAMP, 1994, *supra* note 32; and GESAMP, 2001b, *ibid*. Also see R.W. Edwards and G.G. Goodman, “Pollution of Air, Soil, Freshwater and the Sea”, 2 *International Journal of Environmental Studies* 263 (1972) and E.S. Howard, “Pollution Prevention in the Watershed: Protect the Land to Protect the River”, 5 *Review of European Community and International Environmental Law* 116 (1996).

77 GESAMP, 2001b, *ibid.* and GESAMP, 1990, *supra* note 1, p. 1.

78 GPA, *supra* note 3, paragraph 7. The conventions listed are the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matters, *supra* note 68; Basel Convention on the Control of Transboundary Movements of Hazardous Waste and Their Disposal, *supra* note 69; United Nations Framework Convention on Climate Change, 9 May 1992, UN Doc. A/Conf.151/26, 31 ILM 849 (1992); Convention on Biological Diversity, 5 June 1992, UN Doc. UNEP/Bio. Civ/Conf/L. 2, 31 ILM 818 (1992); International Convention for the Prevention of Pollution from Ships, 2 November 1973, 1340 UNTS 184, 1983 UKTS 27, 12 ILM 1319 (1973); and the regional seas conventions (see the Bibliography, herein).

as the need for ICM,[79] recognition of the basic linkages with freshwater and marine environments and watershed management issues,[80] the requirement to evaluate inter-media (air/water/terrestrial) effects to create a net environmental benefit,[81] and consideration of the impacts of dammed river systems.[82] The GPA, through its linkages, implies the broader conceptualisation of MDLBA, but it could have been more definitive.

(b) MDLBA: Amalgamating Environmental Issues

MDLBA is not "an issue", but a complex amalgamation of environmental issues. Attempts to tackle issues piecemeal would have serious implications for the integrity of the marine environment, and economic costs that are associated with addressing problems in isolation. To help understand the need for multi-issue and net-benefit assessment, following is an example of inland deforestation that, contrary to expectation, affects distant offshore commercial fisheries. The causal chain begins with soil erosion from deforestation that gives rise to sedimentation downstream, which damages coral reefs and seagrass beds. The extent of damage to the reefs and seagrass can be exacerbated by destruction of mangroves for development purposes. Consequently, the reefs and seagrass beds are unable to support larvae and juvenile life forms that are normally nurtured there. Distant reefs, part of an MPA, suffer as recruitment from the damaged area declines. Baitfish, the food supply of commercial species, that reside in both the damaged area and in the distant MPA may become

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79 GPA, *ibid*., paragraphs 11 and 23(a).

80 *Ibid*., paragraph 23(b).

81 *Ibid*., paragraph 27(g).

82 *Ibid*., paragraph 150.

depleted, and thus the commercial species may suffer declining numbers due to food shortages. Fishing removes the few adults of reproductive age, and the fishery crashes.

In scenario just described, the LBA of deforestation has impacts far beyond those expected, and it has links to environmental issues of biodiversity, MPAs, ICM, habitat destruction, desertification, global climate change, freshwater quality, and migratory and straddling fish stocks. Social issues, such as poverty, unregulated industry, and population pressures, are at the heart of the problem, as the question is which factors or conditions allowed humans to conduct themselves in contravention of sustainable deforestation practices.

The above highlights the schism between the traditional legal definition and perception of MDLBA and the ecological reality. Notwithstanding the integrated approach of the GPA and Agenda 21, policy-makers and lawyers are seldom equipped with a level of ecological understanding that allows them to embrace the broader view of MDLBA discussed above.

Unfortunately, restricting the definition of MDLBA ignores ecological and social reality, as human activities must be managed from an ecosystem perspective. Acknowledging MDLBA as an amalgamation of virtually every environmental issue currently on the political agenda and extending it to include emerging issues is overwhelmingly complicated. Regardless, the approach must be to address sectoral issues systematically, although in a much broader context, utilising methods and mechanisms best suited ecologically and economically to the issue.

C. The Maelstrom of Land-based Activities and Their Impacts

The shift in mindset from marine “pollution” to marine “degradation” broadens the scope for considering impacts from LBA, as degradation involves monitoring ecosystem and human health and demands a higher level of awareness of the overall impacts from LBA, as compared to pollution issues, which focused primarily on the input of substances. Largely adhering to the GPA categorisation, the discussion below addresses the diverse range of impacts from LBA that result in marine degradation.

1) Marine Degradation

The GPA identifies contamination and physical alteration of habitats as leading causes of marine degradation. LBA have been estimated to account for 77% of all marine degradation,[83] although, according to some, the figure may be closer to 90%.[84] It is estimated that 44% of all contaminants entering the marine environment are from water-borne sources.[85] Much of the waste from human activities, even activities as innocuous as washing dishes or changing oil in cars, drains directly or indirectly into rivers, one of the dominant pathways through which contaminants are transported from land to sea. Air-borne contamination, accounting for approximately 33% of the total, is more difficult to trace as atmospheric currents can carry it thousands of miles from source.[86]

(a) Contamination

The GPA identifies eight priority contaminants, namely sewage, POPs, radioactive substances, heavy metals, oils (hydrocarbons), nutrients, sediment mobilisation, and litter.[87] Although they are the most notorious, the list is not exhaustive. Classification

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83 GESAMP, 1990, *supra* note 1, p. 88. This number refers to marine pollution, rather than degradation, and allocates water pollution at 44% and air pollution at 33%. The estimate of 90% may be partially attributable to greater success in the international regulation of ship-generated pollution.

84 B.C. Wood-Thomas, “Land-based Marine Pollution and Coastal Zone Management: Role of State and Local Government in the U.S.A”, 18 *Marine Policy* 165 (1994), p. 165.

85 GESAMP, 1990, *supra* note 1, p. 88.

86 An example is the migration of POPs to the Arctic regions, where it contaminates the breast milk of indigenous people. See GESAMP, 2001b, *supra* note 1, p. 18.

87 GPA, *supra* note 3, paragraph 21(b) (i-viii). They are not listed in order of priority here or in the GPA.

of contaminants into classes of ecological impact helps non-scientists understand the range and degree of severity of impacts. The classes are as follows:[88]

- *Class 1:* Biodegradable or utilisable materials that cause problems (pollution) only when the assimilative capacity is exceeded. Examples are sewage, nutrients, oils (hydrocarbons), some solid litter, and biodegradable wastes from industries such as paper pulp production, food processing, and brewing and distilling.

- *Class 2:* Material inputs which are dissipated by natural dilution or neutralisation, but may have localised impact (e.g. heat, acids and alkalis, and low-salinity discharges). None of these is listed among the GPA priorities, but they can have dire impacts on fragile ecosystems.

- *Class 3:* Inert materials, which may smother or cause turbidity, such as sediments from inland and coastal construction, erosion and deforestation, mining wastes and industry waste (e.g., china clay). These contaminants often emanate from habitat modification/destruction. Sediments may be contaminated with class 4 contaminants, thus posing a significantly greater hazard to the marine environment.

- *Class 4:* Persistent (resistant to biodegradation and weathering) elements and compounds capable of direct or indirect effects on the food-chain through bioaccumulation or chronic/lethal toxicity, such as heavy metals, halogenated

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88 D. Cormack, “Scientific and Technical Background”, 16 *Marine Policy* 5 (1992), pp. 5-6.

hydrocarbons, POPs (e.g., pesticides,[89] PCBs, and others), and radioactive substances.

Of note in the GPA is the progressive use of the term, "contaminant", as opposed to "pollutant". Scientists use the term, "contaminant" to refer to the presence of a substance (or energy) that is foreign, but not necessarily deleterious.[90] Scientifically, this is significant as contamination is distinct from pollution, although the legal definition of pollution confuses the two terms, and unfortunately, non-scientists have not been educated to understand the difference.[91]

The distinction between contaminants and pollutants is important from both policy and scientific perspectives, as it recognises the inherent assimilative capacity of the ecosphere, in which foreign substances (contaminants) can be broken down, absorbed, or utilised, without necessarily degrading the environment. In the scientific sense, "contamination" becomes "pollution" when the contaminant reaches a critical "dose" or level at which the assimilative capacity is surpassed and deleterious effects are present.[92] Contamination requires different policy action from pollution, the latter requiring remedial action to address degradation. The distinction affects the mindset

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89 For an informative overview of the use of pesticides, including the positives and negatives, see L.P. Pojman (ed.), *Environmental Ethics: Readings in Theory and Application* (Boston, London, Singapore: Jones and Bartlett Publishers, 1994), pp. 355-69.

90 See J.M. Bewers, "The Declining Influence of Science on Marine Environmental Policy", 10 *Chemistry and Ecology* 9 (1995), pp. 10-12. GESAMP, 2001b, *supra* note 1, Glossary, defines contamination as "the anthropogenic increase in the concentration of a substance in the marine environment [and]…the term 'contamination' makes no inference about the existence of deleterious effects".

91 LOSC, Art. 1(4), *supra* note 10, confuses contamination and pollutant as it uses the phrase, "…results, or is likely to result in…", whereas the GESAMP definition of pollution uses the definitive "…results in…". Arguably, the LOSC definition encompasses a greater number of acts of introduction of substances or energy, but the GESAMP definition clearly distinguishes pollutants from contaminants. See J.M. Bewers and R.G. Boelens, "Options for the Revision of the GESAMP Definition of Marine Pollution", paper dated 17 January 1991 and submitted to the International Maritime Organisation for the 21st Session of GESAMP, 18-22 February 1991. For discussion on the technical aspects of pollution, see Tomczak, *supra* note 14 and Springer, *supra* note 14.

92 See A. Wildavsky, *But Is It True?: A Citizen's Guide to the Environmental Health and Safety Issues* (Cambridge, Massachusetts and London, England: Harvard University Press, 1997), p. 270.

and provides clarity of purpose: whereas contamination is an ongoing concern, pollution calls for action.[93]

The enlightened use of the term "contaminants" within the GPA alerts policy-makers to the value of long-term feedback monitoring, to prevent contamination from reaching levels that will cause it to be scientifically classified as pollution, meaning that deleterious impacts are present. Although the legal definition of pollution within the international conventions is unlikely to be amended, lawyers and others involved in environmental policy-making should adopt the scientific distinction between "contamination" and "pollution".

(b) Physical Alteration of Habitats

Pursuant to the GPA, physical alteration includes habitat destruction and modification.[94] For management purposes, it is significant that the drafters of the GPA chose "habitats" as the unit for environmental management, rather than "ecosystems", the latter being more amorphous and difficult to define, as will be discussed later. The GPA lists eight primary areas of concern:[95]

(i) critical habitats, including coral reefs, wetlands, seagrass beds, coastal lagoons, and mangrove forests;

(ii) habitats of endangered species;

(iii) ecosystem components, including spawning, nursing, and adult areas, and feeding grounds;

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93 The present confused definition of pollution fosters the "wait and see" mentality as the "likely to result in deleterious effects" aspect is debated.

94 GPA, *supra* note 21, paragraph 21(c).

95 *Ibid*., paragraph 21(e)(i)-(viii).

(iv) shorelines (erosion concerns);

(v) coastal watersheds;

(vi) estuaries and their drainage basins;

(vii) specially protected marine and coastal areas; and

(viii) small islands.

Physical alteration of habitats causes both direct and indirect impacts. Direct impacts dislocate or impede settlement of plant and animal communities that normally make their homes in the damaged or destroyed habitat. This includes endangered mammals, migratory birds, and species of commercial value (pharmaceuticals and human protein sources). Seldom recognised direct impacts are the loss of ecological services formerly provided by the damaged habitat, as discussed above.

Indirect impacts are often unanticipated by non-scientists, as they are intricately intertwined with the contamination and destruction of other habitats. For instance, wetland destruction permanently removes the wetland's filtration services, so that high quality water is not available to fragile coral reefs, resulting in their degradation. This in turn removes the ecological services that reefs provide. More insidious, wetland destruction removes a sink for POPs, and at the same time re-releases contaminants that were previously bound within the wetland. POPs re-mobilised in this way resume their journey towards ultimate concentration in Polar Regions, where they are already known to contaminate the breast milk of indigenous people.[96] As discussed above, alteration of inland habitats may affect coastal and marine habitats, e.g., deforestation

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[96] See GESAMP, 2001b, *supra* note 1, pp. 18 and 49-50. GESAMP cites recent studies regarding POPs.

upriver may affect distant MPAs and commercial fisheries.[97] Damming of rivers, another type of habitat alteration, can affect the annual flood cycles, which may affect estuarial agriculture, the migration of anadromous and catadromous species, biodiversity, and commercial fisheries.[98]

2) Ecological and Health Impacts and Hazards

Impacts associated with LBA can be subdivided into two broad categories: health hazards (to humans and animals) and ecosystem disruption. An overlap occurs where health hazards, normally expressed in terms of exposed individuals, have implications for whole populations, whereby ecosystem equilibrium may be affected. For example, POPs are an emerging concern with regard to impaired reproductive capacity in humans, but the basic hormonal-driven reproductive system is common to all animal species, from frogs to human beings. Given POPs' ubiquity in the environment, concerns for habitats, and even the global ecosystem, transcend concerns for specific species or populations.

Impacts within the two categories can be sub-divided into acute (from short-term exposure to high doses, usually associated with imminent death or disease) and chronic (from long-term exposure to low doses, usually associated with delayed or subtle, and often sub-lethal, impacts).[99] Acute impacts are usually isolated and addressed by decision-makers on a priority basis. Examples are fish kills from identifiable events,

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[97] See Miller, *supra* note 62, for a concise and clear discussion of habitat inter-relationships and Enger and Smith, *supra* note 62.

[98] Anadromous species, i.e., salmon, migrate from salt to fresh water to spawn and then die. Catadromous species, i.e., some eels, live in fresh water, migrating to certain marine areas to spawn. For the impacts from dams, see GESAMP, 1994, *supra* note 32.

[99] The political and social mindset of the 1970's focused on acute human health problems, often involving carcinogens. The integrity of the marine environment was not a high priority, except where commercially valuable species were concerned.

human illnesses (e.g., from tainted seafood or water-borne pathogens), and poisoning (e.g., Minamata disease).

Chronic impacts contribute to the systemic degradation of the global ecosystem. Scientists are amassing evidence of chronic (long-term) impacts from the insidious accumulation of low-level contaminants over the long term, which may have widespread, subtle effects that are difficult to detect against natural background variability.[100] Of concern are increasing incidences of fish diseases, including lymphocystis, ulcers, and fin rot; sea mammal deaths, such as thousands of seal deaths in northern European waters from viral infections;[101] and the ostensible increase in fish kills and algal blooms in recent years.[102] Scientists are investigating whether the causes are pollution-related or natural occurrences, or even climate-related in some cases. Causes of chronic impacts are very difficult to isolate, even when a substance is detected in a species. For example, in the case of one particular seal die-off in Europe, data indicated that other seal populations with higher levels of the suspected contaminant were not suffering the same fate.[103] The overall impact of an accumulation of subtle effects may have very serious implications for the marine environment, so policy-makers must recognise the potential for harm, and act before it becomes too late.[104]

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[100] GESAMP, 1990, *supra* note 1, p. 102.

[101] *Ibid.*, p. 70.

[102] For more information regarding algal blooms, see GESAMP, 2001b, *supra* note 1, pp. 32-3.

[103] GESAMP, 1990, *supra* note 1, p. 70. The most scientists can do is ascertain correlations, keep data banks, ensure rigorous quality control of the data, and exchange results, looking for patterns and clues. Science is a process that offers insights through the accumulation of blocks of evidence from different scientific disciplines that are connected over time with scientific theory. See Wilson, *supra* note 7, p. 59.

[104] Scientists refer to subtle changes that can result in catastrophe as "discontinuities". It is debated whether the ecosphere, like most habitats, has a threshold of tolerance that, once breached, will lead to collapse of the whole system. See N. Myers, "Environmental Unknowns", 269 *Science* 358 (1995).

The ecosystem and health effects are best understood by reviewing priority contaminants listed in the GPA, which are as follows:

(a) Sewage[105]

Scientifically, pure sewage is considered waste and it is not a contaminant *per se*, but the nutrients in it are contaminants. Given that sewage is comprised of such a high percentage of nutrients and the volumes of sewage are significant, and growing with the human population, sewage has been given its own category. As nutrients pose the greatest concern, sewage is classified as a class 1 contaminant, although sewage often carries contaminants from other classes, particularly in industrialised and urbanised areas. Chemically uncontaminated sewage in moderate quantities is innocuous or even beneficial, as its nutrient value enriches the coastal and marine habitats, increasing the habitat's biological productivity. However, contaminated sewage or sewage in quantities that surpass the local assimilative capacity can have severe impacts on human health and the local habitat.[106]

Health hazards from pure sewage are primarily related to diseases contracted through bathing and swimming in waters contaminated with sewage and other wastewater discharges and from ingesting seafood harvested in contaminated wastewater.[107] Gastro-intestinal and respiratory infections from pathogens, and diarrhoea, cholera, and viral hepatitis are the main concerns, with the last being almost wholly associated

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[105] See generally GESAMP, 2001b, *supra* note 1, p. 21; Intergovernmental Oceanographic Commission, *supra* note 32; GESAMP, 1994, *supra* note 32; GESAMP, 1990, *supra* note 1, pp. 62-5; L.C.C. Koe and M.A. Aziz, *Regional Programme of Action on Land-based Activities Affecting the Coastal and Marine Areas in the East Asian Seas*, RCU/EAS Technical Reports Series No. 5, 1995 and Gomez, *et al.*, 1990, *supra* note 1, pp. 31-3.

[106] See GESAMP, 2001b, *ibid.*, p. 21.

[107] *Ibid.*, p. 42.

with seafood consumption.[108] Illnesses from water recreation are classified by GESAMP as an emerging issue, as estimates indicate that the high rate (tentatively estimated at 250 million/year) of clinical cases of upper respiratory illness and gastroenteritis from marine exposure result in financial losses of around US$1.6 billion/year.[109]

The major habitat issue associated with pure sewage input is nutrification from sewage's rich organic content, which can lead to eutrophication and periodic anoxia.[110] Although organic wastes and "grey water"[111] are biodegradable and easily assimilated by the marine environment, particularly where flushing via tides and currents is rapid, nutrification occurs where the quantity of sewage overwhelms the environment's assimilative capacity. Nutrient enrichment (too many nutrients) may lead to eutrophication, which is the depletion or significant reduction of life-supporting oxygen in the water column.[112] The impacts of nutrification and eutrophication are discussed under the contaminant, "Nutrients", below.

Other impacts associated with sewage are suspended solids, causing turbidity (cloudiness), which may have deleterious impacts on seagrass communities, coral reefs, and sensitive species in particular, as each requires clear water. The population

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[108] GESAMP, 1990, *supra* note 1, pp. 56-7 and Gomez, *et al.*, *supra* note 1, pp. 31-6. Pathogens present in sewage can cause severe outbreaks of fatal diseases, such as cholera, or more general malaise throughout the population (e.g., diarrhoea), particularly in developing states where seafood is the main source of protein. See Gomez, *et al.*, *ibid.*, pp. 33-6.

[109] GESAMP, 2001b, *supra* note 1, p. 42.

[110] See *ibid.*, pp. 21 and 24-5.

[111] Grey water refers to waste water from bathing, laundry, and other uses, which does not contain human or industrial waste or harsh chemicals. At levels below the assimilative threshold, it is not harmful to the marine environment, and may even be beneficial.

[112] GESAMP, 2001b, *supra* note 1. See the Glossary for definitions and pp. 14-15 and 24-5 for discussion of nutrification and eutrophication. Also see *The Concise Oxford Dictionary of Ecology*, *supra* note 24 and Miller, *supra* note 62, Glossary.

dynamics of affected habitats can shift, causing substantial changes in the ecosystem and economic impacts, as a result of degradation.

The second category of impacts from sewage results from contaminants mixing with the sewage, or wastewater, including litter, heavy metals, pesticides (including some POPs), oils, and other chemicals from industrial and urban run-off. The impacts of these can be severe, as discussed below.

(b) Persistent Organic Pollutants (POPs)[113]

Scientifically classified as synthetic organic compounds, POPs are either human-made chemicals produced for specific purposes, such as pesticides, or the by-products of manufacturing and incineration processes, as in the case of dioxins and furans.[114] Their known and suspected impacts are diverse, and sufficient to mobilise the negotiation of an international treaty, the Stockholm Convention on Persistent Organic Pollutants,[115] which addresses the worst offenders, known as the "dirty dozen". POPs are part of a larger category of persistent toxic substances, which are currently the focus of an evaluation funded by the Global Environment Facility ("GEF").[116]

POPs are regarded as pollutants, as small amounts bioaccumulate as they travel through the food-chain, until they reach levels that are deleterious to the consuming organism. POPS are physically volatile, depending on temperature, which allows them

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113 See generally GPA, *supra* note 3, paragraphs 100-106; GESAMP, 2001b, *ibid.*, pp. 22-3; GESAMP, 1990, *supra* note 1, pp. 36-9 and 88-9; Arctic Monitoring Assessment Programme (AMAP), *Arctic Pollution Issues: A State of the Arctic Report* (Oslo: AMAP, 1997), pp. 71-91; Colborn, *et al.*, *supra* note 61 and R. Carson, *Silent Spring* (New York and Boston: Houghton Mifflin Company, 1962, 1994).

114 GESAMP, 2001b, *ibid.*, pp. 21-2. Dioxins (polychlorinated dibenzo-*p*-dioxins, or PCDD) and furans (polychlorinated dibenzo-furans, or PCDF) enter the environment as by-products of pulp and paper industry that use chlorine as a bleaching agent and some treated wood feedstock, and on a much larger scale through waste combustion. *Ibid*.

115 Stockholm Convention on Persistent Organic Pollutants, 23 May 2001, [2001] ATNIF 7, 40 ILM 532 (2001).

116 GESAMP, 2001b, *supra* note 1, p. 21. Also see GESAMP, *Review of Potentially Harmful Substances: Choosing Priority Organochlorines for Marine Hazard Assessment*, GESAMP Reports and Studies No. 42, 1990, which provides an overview of classes and types of persistent toxic substances.

to evaporate and be carried by air currents or, in colder climates, to become heavy and sink. They resist biodegradation, which allows them to travel long distances through air, water, and the food-chain, and remain active in the environment for decades, if not longer. Once POPs are released, cleaning them up is virtually impossible.

POPs have been associated with eggshell thinning in fish-eating birds, cancers, reproductive disorders, and suppression of the immune system. POPs may be implicated in endocrine disruption.[117] Among the more potentially serious effects is sexual amorphism, which renders an organism sterile and could result in the decline or even crash of a population. Concerns abound, as preliminary research indicated that a declining sperm count in some human populations might have some correlation with POPs.[118] As scientists learn more about the molecular structure and properties of POP compounds and the biochemistry of organisms, and how hormones, enzymes, chemical receptors, genes, and other mechanisms of an organism interact, the predictability of pathways, targets, and impacts will improve.

Scientific research may require additional time to determine the full potential for damage from POPs, but their current known impacts are sufficient to elevate them to the status of priority contaminants. As noted by GESAMP, current policy only addresses a small fraction of the potentially dangerous POPs, and there are many chemicals with similar physical-chemical structures to consider a broadening of the legal list of notorious chemicals.[119]

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[117] Although the scientists have not reached consensus yet on the degree of risk, it is serious enough for GESAMP to include endocrine disruption as an emerging concern of MDLBA. See GESAMP, *ibid*., pp. 49-50.

[118] Colborn, *et al.*, *supra* note 61. Scientists are being cautious, as newer studies have suggested that the risks have been over-stated. See Safe, *supra* note 61, p. 6. Further research is warranted. The scientific process can be slow and awkward, but it is the only sure way to the facts.

[119] GESAMP, 2001b, *supra* note 1, p. 22.

(c) Radioactive Substances[120]

Radioactive substances, both naturally occurring and artificial, emanate from numerous human activities, including the production of energy, reprocessing of spent fuel, military and medical activities, nuclear testing, and some industrial processes.[121] The hazard from low-level contamination varies with the radionuclide. They evoke fear, as people tend to focus on the dramatic impacts of high-dose incidents such as Chernobyl and Three Mile Island. In a marine context, radioactive substances pose a human health hazard primarily through consumption of contaminated seafood. They are most often cited as carcinogens in both humans and animals, and they are associated with health problems such as mutations, tumours, and the possibility of genetic defects in subsequent generations.

Marine environmental impacts tend to be localised at the discharge site, although water currents can concentrate contaminants in distant areas or disperse them throughout the marine environment. Radionuclides are among the most stringently regulated substances internationally, largely due to public demand for vigilance. Although radionuclides pose a genuine health hazard at known, scientifically-determined

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[120] See generally GPA, *supra* note 3, paragraphs 107-113; J.M. Bewers and C.J.R. Garrett, "Analysis of the Issues Related to Sea Dumping of Radioactive Wastes", 11 *Marine Policy* 105 (1987); P. Strand, M. Balonov, A. Aarkrog, J. M. Bewers, B. Howard, A. Salo, and Y. Tsaturov, *Arctic Pollution Issues: Radioactive Contamination*, A Report from an International Expert Group to the Arctic Monitoring and Assessment Programme (Østerås: Norwegian Radiation Protection Authority, 1997); and GESAMP, 1990, *supra* note 1. For an older article, see E.D. Brown, "International Law and Marine Pollution: Radioactive Waste and Other Hazardous Substances", 11 *Natural Resources Journal* 221 (1971). Dumping of radioactive wastes is internationally regulated by the London Convention and its 1996 Protocol, *supra* note 68.

[121] GESAMP, 2001b, *supra* note 1, p. 22.

doses,[122] the publicly perceived risk is disproportionate to the real threat, and eclipses issues that are more serious.[123]

(d) Heavy Metals[124]

Heavy metals, natural constituents of the Earth's crust, include cadmium, mercury, arsenic, selenium, and lead. Like POPs, heavy metals tend to bioaccumulate through the food-chain,[125] and they are persistent in the environment. Their impacts are usually geographically localised and usually involve health hazards, including death, tumours, reproductive impairment, and mutations. Bottom-dwelling marine species are among the most affected, as metals tend to settle in sediments, where they persist until re-mobilised through dredging or destruction of, for example, wetlands that bind contaminants. Humans are at risk through the consumption of contaminated seafood. The impact on the marine environment has been scientifically studied and the impacts are adequately understood, subject to unexpected impacts that only time and new scientific understanding may reveal.[126] Heavy metals and POPs pose indirect threats, as their breakdown products in the body may produce toxic substances. For instance, mercury is converted within the body from its inorganic form to a poisonous organic

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[122] Bewers and Garrett, *supra* note 120. Through mathematical modelling using experimental data, the authors calculate the number of possible deaths based on various doses. The acceptable level of risk must be determined by society. Perspective must be maintained as funds allocated to further reduce this risk may be better spent saving more lives in other sectors, such as improved road systems and hospitals. *Ibid*., p. 122.

[123] See J. Spiller and C. Hayden, "Radwaste at Sea: A New Era of Polarization or a New Basis for Consensus?", 19 *Ocean Development and International Law* 345 (1988). Also, private conversations with scientists confirm that the time and resources devoted to the issue of low-level radioactive waste are unwarranted, while more mundane issues, such as sewage and sedimentation, having far greater impacts, remain unregulated.

[124] See generally GPA, *supra* note 21, paragraphs 114-120; GESAMP, 2001b, *supra* note 1, pp. 22-3; and GESAMP, 1990, *supra* note 1, pp. 58-60.

[125] Any calculation of the potential exposure of humans at the top of the food-chain must consider cumulative and collective effects from both land and marine sources.

[126] Unexpected impacts, or "unknown unknowns", are occurrences presently unpredictable based on existing scientific knowledge. Increased knowledge reduces the risk of unknown unknowns, but they are a fact of science and do not reflect the quality of either the process or the individual. See C. Garrett, "Oceanographic and Modelling Considerations in Marine Environmental Protection", 25 *Marine Pollution Bulletin* 41 (1992), p. 41 and Myers, *supra* note 104.

form (methylmercury) that causes illness and death, as in the cases of poisoning in Minamata, Japan.[127] Other metals, or "trace elements", as they are sometimes called, can have chronic or acute effects on marine species, particularly on immature and juvenile life forms (e.g., larvae).

(e) Hydrocarbons (Oils)[128]

Hydrocarbons comprise a diverse range of substances that are associated with numerous LBA, such as industrial processes, oil spills, and daily domestic releases of mechanical and cooking oil. Hydrocarbons have the public's attention, primarily due to the high-profile catastrophic spills, usually involving vessels.[129] However, land-based sources are the primary contributors of oil to the marine environment.[130]

Hydrocarbons in large quantities can foul a habitat, but they do degrade through weathering processes and habitat recovery is expected.[131] Heavier aromatic hydrocarbons can be persistent. Impacts, well studied by scientists, range from toxicity when ingested or absorbed through the skin or gills, the fouling of fur and feathers (causing death from hypothermia), the physical smothering of habitats, the tainting of seafood and water supplies, and the fouling of beaches, the last resulting in

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[127] GESAMP, 1990, *supra* note 1, p. 9.

[128] See generally GPA, *supra* note 3, paragraphs 121-126; GESAMP, *Impact of Oil and Related Chemicals and Wastes on the Marine Environment*, GESAMP Reports and Studies No. 50, 1993; GESAMP, 2001b, *supra* note 1 (hydrocarbons, p. 23 and polycyclic aromatic hydrocarbons (PAHs), pp. 23-4); and GESAMP, 1990, *ibid.*, pp. 42-3 and 99.

[129] Consequently, vessel-source oil pollution is well regulated, and improved navigational aids and traffic separation schemes reduce the number of incidents further.

[130] GESAMP, 1993, *supra* note 128, pp. 4-5. About 15% of oil in the marine environment comes from natural seepage. The remainder, less a small percentage from shipping and offshore hydrocarbon activities, comes from the land.

[131] Fragile ecosystems, like coral reefs, which take years to develop, take much longer to recover, and may not fully recover. However, recovery is good if the coverage is not extreme.

lost tourism revenues and recreational enjoyment.[132] Coastal tropical habitats such as mangroves, coral reefs, and seagrass beds are particularly sensitive.[133]

Scientists have concerns about chronic (sub-lethal and long-term) impacts, which include disruption to reproductive, developmental, and behavioural processes. As juvenile life forms can be sensitive to oil exposure, with adult and juvenile crustaceans (lobsters, crabs, and crayfish) and echinoderms (starfish) being more sensitive than fish, exposure may involve long-term effects on populations.[134] Another concern is that hydrocarbons from LBA may be significant carriers of other contaminants, namely polyaromatic hydrocarbons ("PAHs"), lead, dioxins, and furans and other industrial chemicals.[135]

(f) Nutrients[136]

Nutrification entails excessive inputs of nutrients, primarily nitrogen and phosphorus, which disrupt the local equilibrium.[137] Nutrients enter the marine environment via rivers, from sewage, agricultural run-off (fertilisers are nutrient-rich), food and beverage and pulp and paper production, and industries producing organic wastes. An emerging pathway is that of groundwater.[138] Another growing concern is atmospheric

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132 GPA, *supra* note 3, paragraph 121. Toxic effects vary depending on the dose, but it can in a few cases entail ecosystem-wide impacts if the degree of contamination causes reproductive failure.

133 GESAMP, 1993, *supra* note 128, p. 6.

134 *Ibid*., p. 5.

135 *Ibid*., pp. 75-82. PAHs are produced as a result of incomplete combustion in engines. They have carcinogenic/mutagenic properties and are a concern for the marine environment, particularly in urban and port areas. *Ibid*., p. 6. Other industrial chemicals include corrosion inhibitors, detergents, and anti-oxidants. *Ibid*., p. 6.

136 See generally GPA, *supra* note 3, paragraphs 127-132; GESAMP, 2001b, *supra* note 1, pp. 24-5; IOC, *supra* note 32; GESAMP, 1994, *supra* note 32, GESAMP, 1990, *supra* note 1, pp. 62-5; E.D. Gomez, *et al.*, *supra* note 1, pp. 31-3; and Koe and Aziz, *supra* note 105. For an overview of the nutrients and how they act in the ecosystem, see Camp and Donahue, *supra* note 33, pp. 146-9.

137 GESAMP, 1990, *ibid*., p. 2. The nutrients are often in the form of nitrates and phosphates.

138 GESAMP, 2001b, *supra* note 1, pp. 52-3.

transport of nitrogen from land to the open ocean, where it may affect ecosystem balance by favouring growth of nitrogen dependent species.[139]

Most habitats benefit from the addition of some nutrients, but amounts greater than the habitat's assimilative capacity can result in deleterious effects to varying degrees. Nutrification is the primary concern, as it relates to eutrophication and periodic anoxia,[140] and there is a growing concern about its role in the occurrence of red tides and harmful algal blooms. Nutrification can upset a habitat's equilibrium as excessive nutrients support prolific plankton/algae production, followed by a massive die-off as their carrying capacity is exceeded. Eutrophication results from excessive nutrification. As the decomposition of organic matter requires oxygen, the dissolved oxygen in the water is consumed, causing local marine life to relocate or suffocate, which in turn further depletes oxygen levels through decomposition.[141] The habitat can be rendered biologically dead (incapable of supporting life) or impaired so that it cannot sustain sensitive species, allowing opportunistic species to move in. Either way, habitat disruption occurs.

The degree of eutrophication experienced in relation to the quantity of nutrient input depends upon the properties of the receiving environment. Each area of coastline has a different assimilative capacity, dictated by wave action, biological productivity, temperature, currents and tides, and the general circulation patterns and flushing, or water exchange, rates. For example, areas of low water circulation and low nutrient input may be more prone to eutrophication than areas where waters are well circulated but the quantities of nutrient input is significantly higher. Habitat recovery from

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139 *Ibid.*, pp. 50-2.

140 *Ibid.*, p. 30.

141 The decomposition of all living things, on land or in water, requires oxygen.

eutrophication may be expected over time, providing the input is removed and the habitat is not too severely damaged. Not all original species may return, however, and the recovery of fragile habitats, such as coral reefs, is less predictable. Although the impacts are primarily localised around input zones, the cumulative effects from coastal settlements, riverine input, and regional atmospheric transport threaten coastal waters worldwide.

Another concern associated with nutrification and eutrophication is the possible increase in the incidence of harmful algal blooms ("HAB"), which encompass blooms that have diverse effects, from aesthetic impairment to toxin-producing algae (e.g., red tides).[142] Non-toxic algal blooms can disrupt habitats by, for example, impairing light penetration to seagrass beds. Human health can be threatened by toxic algal blooms, as blooms of specific algae and phytoplankton may produce toxins that accumulate in species, particularly filter-feeding shellfish, and ultimately affect human consumers. The associated diseases include paralytic shellfish poisoning, amnesic shellfish poisoning, ciguatera, neurotoxic shellfish poisoning, and diarrhoeic shellfish poisoning.[143] While the toxins are naturally occurring, scientific suspicions are aroused as to the role of increased nutrients in triggering blooms.[144]

(g) Sediment Mobilisation[145]

Sediment mobilisation results from various activities, including unsustainable deforestation and agricultural practices and unregulated development. The resulting erosion and run-off can strip land of vast quantities of productive soil and translocate it

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[142] GESAMP, 2001b, *supra* note 1, pp. 32-3 and 43.

[143] *Ibid*., p. 43.

[144] *Ibid*., p. 33.

[145] See generally, *ibid.*, p. 25; GESAMP, 1994, *supra* note 32; GESAMP, 1990, *ibid.*, pp. 19-20 and 96; Gomez, *et al.*, *supra* note 1, pp. 20-21; and Koe and Aziz, *supra* note 105, p. 20.

to rivers and the coastal zone. Physical impacts include smothering of species within coastal habitats, increased turbidity of water due to suspended solids, and relocation of mobile species to more suitable habitats. Biological impacts occur when sediments are contaminated with heavy metals, pesticides, or industrial chemicals. Sedimentation is particularly threatening to tropical nations. High population density, construction and development, large-scale agriculture, and denuding of rainforests threaten particularly sensitive habitats such as coral reefs and seagrass beds. Compounding the impact is the rampant destruction of wetlands, which would normally intercept sediment and thereby protect inshore habitats.

The reverse of sediment mobilisation is sediment load reduction, a consequence of damming rivers. While reduced sediment loads may benefit coral reefs, they present concerns for estuarial farming and coastal erosion. Both increasing and reducing sediment loads may result in effects locally and regionally that are more significant than commonly acknowledged.[146]

(h) Litter[147]

With the advent of a "disposable generation", solid waste is mounting at an exponential rate around the world in both developed and developing states.[148] The nature of litter has evolved from biodegradable materials (paper) to persistent plastics and polystyrene, in everything from fast-food containers and product packaging, to disposable cameras. Litter dumped on purpose or blown by the wind from ill-managed waste heaps enters the marine environment primarily through rivers and storm drains.

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[146] GESAMP, 2001b, *ibid*., p. 25.

[147] GPA, *supra* note 3, paragraphs 140-148; GESAMP, 2001b, *ibid*., pp. 25-6; and GESAMP, 1990, *supra* note 1, p. 8.

[148] See L. Scarlett, "Doing More with Less – Unsung Environmental Triumph", in R. Bailey (ed.), *Earth Report 2000* (New York: McGraw-Hill, Inc., 2000), pp. 41-62. This article discusses the progress made in reducing the amount of material waste, but notes the increasing number of people contributing to waste accumulation.

Some municipalities dump litter directly into the marine environment, as do many recreational users of the marine environment.

The impacts from litter vary from endangering sea-life by strangulation, suffocation, and ingestion, to aesthetic impairment of beaches and coastal areas, and economic losses from declining tourism.[149] Indirect impacts of litter arise as many new materials produce toxic air particulates when burned, or leach chemicals when disposed of in landfills or scattered in the environment, thus contributing to the toxic chemical load as chemicals migrate to the marine environment.[150] Litter is primarily a local problem and should be tackled at source, but the extensive use of the marine environment for disposal, oceanic currents and tides that transport litter across political boundaries, and its ubiquity in the ecosphere have rendered it a global concern.

3) From Whirlpools to Eddies: Investigative Difficulties.

The challenge for science is to predict the collective effects of contamination, alteration of coastal habitats, manipulation of the hydrological cycle, climate change, increased UV radiation, and human stresses from burgeoning populations in the coastal zones. The investigative ability of scientists is limited by the sheer complexity of natural systems that comprise organisms, interactions among organisms, and interactions among living and non-living components of the global ecosphere. Compounding this complexity are the effects of human activities on the natural environment, including the ability of ecosystems to assimilate substances and maintain ecological equilibrium despite stress. Considering the complexities, scientists are

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[149] GPA, *ibid*., paragraph 140. Sea turtles and other species that habitually prey on jellyfish and other non-motile species are particularly at risk, as they mistake litter for food. Once ingested, the litter can impair digestion and lead to starvation. Plastic rings and strapping, replacing cardboard packaging, can cripple or strangle seabirds, turtles, and fish. Regarding tourism, GESAMP, 2001b, *supra* note 1, notes that it is becoming more problematic, rather than decreasing in degree.

[150] Most developed nations have rubbish collection services, often involving recycling schemes, but in developing communities, often the only alternative is to let rubbish accumulate in the environment.

showing remarkable progress deciphering the laws and mechanics of nature. Their challenge can be appreciated by recognising a few of the investigative difficulties they face.

Very important to understanding investigative difficulties is the distinction between "toxic substances" and "toxic doses". Most chemicals and substances are not inherently toxic, but a dose can be toxic if it exceeds the organism's or ecosystem's ability to assimilate it.[151]

Consequently, scientists focus on "dose-response relationships" to determine the point at which a dose becomes harmful to an organism, habitat, or ecosystem. Scientists are confronted with the complex task of identifying harm, and quantifying harmful doses, not only for each organism, but also for each life stage of an organism, as each organism, at each life stage, varies in its ability to assimilate substances, and each substance imparts its unique fingerprint on an organism or ecosystem.[152] This distinction between toxic chemicals and toxic doses is akin to the difference between a contaminant and a pollutant, or a medicine and a poison. The simplistic policy view that a substance itself is toxic only leads to ecologically and economically unsound decisions and ultimately unworkable solutions.[153]

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[151] Wildavsky, *supra* note 92, p. 70. Although in technical terms it may be true that a dose can be found at which a given substance has no impact, substances such as POPs that bioaccumulate in the environment may warrant the view that no dose is safe, as concentration is likely to occur, even if it takes many years. This is somewhat simplified as toxicologists distinguish "deterministic effects" (toxicity above some threshold, i.e., metals, like copper, are essential, but at some dose become toxic) and "stochastic effects" (the risk of adverse effect is proportional to exposure). Some of the debate surrounding POPs has been whether they should be treated as having deterministic or stochastic effects.

[152] Substances can have genetic, molecular, physical, hormonal, reproductive, carcinogenic, or developmental impacts, to name a few. Scientists must isolate the specific impact associated with a substance. Tumours, death, mutations, reproductive impairment, sterile offspring, cancers, developmental abnormalities, and a host of other symptoms must be studied.

[153] POPs are one of the few substances that are accepted as "pollutants", due to their unique characteristics that allow them to persist, bioaccumulate, and inflict harm.

A cursory glance at just five of the difficulties that scientists encounter in relation to quantifying harm illustrates to non-scientists the complexity of the relationship between dose and response.

- *Complexity of the ecosystem*: Detection of human-induced impacts against a background of natural fluctuations is difficult, as changes, if detectable, may be the result of unrecognised physical, biological, or chemical stresses, natural or human-induced ecosystem changes and imbalances, synergies of contaminants, or a number of other possibilities. Scientists' understanding of the ecosystem is improving, but there are still unknowns in basic ecosystem operations, flows, and cycling that make some effects difficult not only to detect, but also to predict. Shortages of funding and the channelling of existing funds to publicly perceived priority issues have resulted in lacunae of essential baseline data from which to gauge environmental change.

- *Inherent characteristics of the marine environment*: Marine scientists' efforts to study the marine environment are often hampered in ways that their terrestrial colleagues' studies are not.[154] Direct observation is difficult, as marine scientists are unable to remain under water for extended periods and poor visibility impedes investigation. Unlike terrestrial ecologists, who have "birders", amateur naturalists, and hikers to indicate or confirm trends, marine scientists work mostly in isolation, although some commercial fishers are beginning to offer data on fish populations. Further, visible impacts such as coral bleaching and smothered seagrasses are hidden from the general public's view. Two effects are that the public cannot provide useful information, and marine research funding

[154] Access to the marine environment is expensive and difficult, particularly where collections are offshore or in the deep sea.

fails to benefit from public pressure for action. Finally, the sheer expanse of water bodies allows inputs to travel long distances, mix with other substances, and cause impacts on species and habitats far from the original source.

- *Identification of impacts*: First, effects can be chronic or acute, biological, chemical, or physical, and at the individual, population, community, or ecosystem level. The aggregation of effects spatially and temporally compounds stresses from both physical alteration and contamination, and makes it difficult to scientifically isolate a cause-effect relationship. Second, impacts can occur a great distance from the source of degradation, despite the offending contaminant or activity remaining wholly within state boundaries. For example, a coral reef that depends on a reef in another political jurisdiction for species recruitment will suffer if the latter reef is damaged.[155] Third, unlike the pollution issues of the 1950's and 1960's, MDLBA today is more frequently insidious and chronic, with long-term ramifications, the precise nature of which largely remains unknown.[156] "Systemic degradation" and risk assessment encapsulate the nature of contemporary environmental concerns.

- *The multiplicity and nature of contaminants*: Only a fraction of the thousands of chemicals in use has been tested.[157] Each contaminant has its own chemical

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[155] Reef biodiversity is maintained in part by the influx of larvae and eggs carried by currents from distant reefs. Thus, destruction of one reef may affect other reefs, which in turn affects the success of environmental protection policies that fail to acknowledge the inter-connectedness of the ecosphere.

[156] S. Nurmi "Issues and Problems in the Protection of the Marine Environment", in J.E. Carroll (ed.), *International Environmental Diplomacy* (Cambridge: Cambridge University Press, 1988), p. 12. Also see GESAMP, 1990, *supra* note 1, p. 2 and GESAMP, 2001b, *supra* note 1, pp. 21-2, both of which highlight the need to research low concentrations of hazardous substances and T. Page, "A Generic View of Toxic Chemicals and Similar Risks", 7 *Ecology Law Quarterly* 207 (1978).

[157] See Colborn, *et al*., *supra* note 61. Also see E.P. Eckholm, *Down to Earth: Environment and Human Needs* (New York and London: W.W. Norton and Company, 1982), which notes that in the early 1980's , 55,000 synthetic chemicals were on the market, with several thousand added each year. Very few (less than one eighth) had been tested properly. Eckholm, *ibid*., pp. 107-8. Unfortunately, this remains the case.

structure and properties, behaving very differently from other chemicals in the environment. Species have distinctive metabolisms, biochemical processes, and specialised organs/functions that may make them more or less sensitive to a particular contaminant. In the environment, contaminants of concern are often invisible, temporally and spatially diffuse, insidious, and accretionary, and, unlike oil slicks, fail to evoke an equivalent degree of public awareness.[158] Persistent contaminants are seldom traceable to a source,[159] or even to a particular sovereign state.

- *Ecologically-imposed limits on scientific experiments*: Field experiments are limited by the nature of the ubiquitous medium, the inability to control all variables, and the inability to reproduce experimental procedures in the wild.[160] Conversely, laboratory experiments are limited because it is very difficult to simulate the complexity of the marine habitat. Scientists have done remarkably well in establishing dose-response relationships through the use of key species in laboratories. The knowledge thus gleaned is essential and valuable, but more is needed to predict chronic impacts over the course of generations and to predict outcomes in light of other environmental stresses.

Scientists have the capacity, the technology, and, most importantly, a broadened perspective on potential pathways, targets, and impacts to research and ultimately design predictive models,[161] and to make adequate predictions for regulatory purposes,

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158 Rémond-Gouilloud, *supra* note 2, pp. 230-1.

159 Nurmi, *supra* note 156, p. 12.

160 Scientists are judged by their peers, not according to their conclusions – which cannot be deemed right or wrong – but by their scrupulous and rigorous adherence to quality data control and the scientific method. See Chapter 2 for a detailed discussion.

161 Models are utilised in environmental fields to simulate and define the probabilities of certain outcomes. Although uncertainty is always a factor in a model, the input of accurate and comprehensive data increases their

incorporating a margin of error (pessimism) for scientific uncertainty.[162] What is lacking is political will and pressure from an informed public to direct funds towards research that will address scientific and environmental priorities, and away from generally lower-priority issues like radionuclides and heavy metals.

4) MDLBA: Local Issues with Global Impacts

Until recently, many actors perceived and addressed MDLBA as a domestic issue, on the basis that most of the impacts were localised, within the coastal zone of the nation state. The 110 signatures to the GPA indicate an evolving mindset as the transboundary and global nature of impacts become evident. At least three factors indicating the need for global action are as follows:

(i) scientific evidence shows that long-range transport of contaminants is an issue of growing global concern, as persistent contaminants become ubiquitous in marine and terrestrial habitats;

(ii) the universality of coastal habitat destruction, the prevalent and continued use of rivers and coastal waters as waste receptacles, and the cumulative effects of domestic activity underpin the need for global rules to prevent continued impairment of global marine environmental quality; and

(iii) many coastal states border enclosed or semi-enclosed seas where degradation, both localised and trans-boundary, has regional impacts.

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reliability. When they are used properly and their inherent uncertainties are acknowledged, models can be very useful. Refer to J.L. Casti, *Would-be Worlds: How Simulation is Changing the Frontiers of Science* (New York: John Wiley and Sons, Inc., 1997). Also see Garrett, *supra* note 126.

[162] See T. Munn, A. Whyte, and P. Timmerman, "Emerging Environmental Issues: A Global Perspective of SCOPE", *Ambio*, Vol. 28, No. 6, pp. 464-71 (1999); J.S. Gray and J.M. Bewers, "Towards a Scientific Definition of the Precautionary Principle", 32 *Marine Pollution Bulletin* 768 (1996); and P.G. Wells and R.P. Côté, "Protecting Marine Environmental Quality from Land-based Pollutants: The Strategic Role of Ecotoxicology", 12 *Marine Policy* 9 (1988). Also see GESAMP, *Global Strategies for Marine Environmental Protection*, GESAMP Reports and Studies No. 45, 1991, which discusses scientific progress, including computer modelling.

The ecosystem transcends political boundaries, making a global perspective of MDLBA appropriate. However, MDLBA can and should be addressed at the local level, as the impacts are most often felt locally, and conditions of the local receiving habitat affect the assimilative capacity associated with a particular activity, whether it is a discharge or habitat alteration. Measures must be taken with a view to the global perspective and through co-operation with other nation states. The perceived intractability cannot permit avoidance of policy action. Systemic degradation requires systematic response. Scientists and other actors, working as a team, can plan and tailor measures for the various components of MDLBA to effect the most ecologically and economically sound policies.

D. Participatory Intractability

A legion of actors have an interest in the management of MDLBA: individuals, groups, institutions, governments, non-governmental organisations ("NGOs"), intergovernmental organisations, lenders, planners, lobbyists, economists, ethicists, industrialists, lawyers, doctors, administrators, naturalists, scientists, politicians, philosophers, property owners, and taxpayers, to name but a few. Who should, who has a right, and who is qualified to participate? How should interested actors participate? Determining whom to involve and how is daunting enough, but additional complexity arises from the implication of the demands of increased participation in policy-making processes – how decisions will be made, what type of consensus is required, and how to balance interests are but a few of the questions.

The policy-making process itself has not evolved to include, or even acknowledge, the totality of actors, primarily due to the constraints of traditional precepts of international and domestic law that have limited participation to diplomats, bureaucrats, politicians, and a handful of experts.[163] The last few decades in particular have witnessed an expansion in the range of actors interested in and actively pursuing environmental quality-related issues. Policy-makers, including lawyers, continue to grapple with issues regarding which actors should be included in policy-making processes and how to include them. Consequently, this section adopts a novel perspective on the categorisation of the actors in the MDLBA policy-making process, with three objectives.

The first objective is to group actors into broad role-oriented categories. The aim is to draw attention to their roles and away from individual identities and conflicting interests. The intention is to focus not on tensions among various actors, but on the validity of each actor's interests and the need for or utility of participation in a given role, or perhaps several roles.[164] This is intended to foster a comprehensive understanding and appreciation of the unique, conflicting, and overlapping roles to be assumed, and reduce the "pandemonium of actors" to an organised and functional system of roles. It should enhance the flow of the policy-making process by defining roles and then sorting actors accordingly.[165] It provides a systematic method for clarifying existing roles, highlighting those that are ill defined or under-developed, and categorising existing and potential actors by function, as appropriate. It is a dynamic

[163] In the past, NGOs and citizens' groups often have been excluded due to their lack of standing. The legitimacy of various interests has only recently been recognised by courts and policy-makers, partially because of slow recognition that environmental issues are in essence social issues.

[164] See E. De Bono, *The Six Thinking Hats* (London: Penguin, 1985, 1990) and R. Fisher and W. Ury, *Getting to Yes: Negotiating Agreements without Giving In* (London: Arrow Books Limited, 1981, 1987). De Bono, the thinking-development specialist and creator of "lateral thinking", and Fisher and Ury emphasise the fundamental necessity of deflecting attention away from personalities and towards the issue at hand. More psychology needs to be applied to policy-making processes.

[165] Sorting items into categories and reducing complexity is human instinct. From a young age, children are transfixed by the task of sorting by shape, colour, and size. This is not lost with age. Understanding is enhanced and problems less overwhelming when a pattern can be discerned and a disorganised array of items compartmentalised. The risk is over-simplification, which generates misunderstanding.

process, which is intended to reduce complexity by ensuring that information entering the policy-making process remains in its proper context and function.

The second objective of role-oriented categories is to highlight the need for an underlying critical understanding of environmental issues, particularly by policy-makers. Quite simply, given that the quality of policies depends on the quality of input from actors, the ability to assess the quality of an actor's input and put it into a decision-making framework or context becomes essential. As discussed further in Chapter 4 herein, this assessment is sadly lacking in current policy-making processes and management plans.

An actor's input, or knowledge, may be viewed as the product of a two-tier internal analytical process. The second tier is *subjective knowledge*, which is the synthesis of data and information taken in by that actor, and tempered by personal experiences, beliefs, biases, desires, and existing knowledge. This subjective knowledge is the actual knowledge imparted – what the actor communicates to others and what others hear. To put this in context, the subjective knowledge is only as reliable as the *underlying critical understanding of the issue*. The underlying level of critical understanding of the issue, being the first tier of internal knowledge analysis, moulds subjective knowledge. For instance if an individual lacks an understanding of basic ecological principles, his subjective knowledge about the fate of a contaminant in the marine environment, which he may use to influence the policy-making process or rely upon himself to reach a policy decision, may be flawed. More insidiously, an actor may believe himself to be knowledgeable or perhaps worse, be seen to be knowledgeable by others, but if his underlying critical understanding is flawed, so is his subjective knowledge that he inputs into the policy-making process.

Unfortunately, the policy-process does not include any mechanisms to test the critical understanding of the actors – either those contributing information and opinions or those making decisions. In fact, most actors do not give this more than a passing thought, if at all. However, appreciating the need for critical understanding is relevant to MDLBA policy-making, where diverse actors from diverse backgrounds contribute substantive knowledge. This is particularly true in relation to the critical understanding of science, including ecology. Failure to identify a lack of critical understanding of issues can result in a poor basis for policy and have far-reaching policy implications. Returning to functional role categorisation for actors, determining if an actor has the qualifications to fulfil a role can provide a check on the quality of knowledge that enters and influences the policy-making process.

The third objective, inter-locked with the first and second, is to encourage all actors to accept the validity of one another's interests and claims. If critical understanding is articulated during the policy-making process, ensuring that false premises, incorrect assumptions, and biases are highlighted and clarified, the actors should be in a factually informed position to better appreciate the intricacies of respective interests and positions of other actors.

A critical understanding of each group's underlying interests and motivation improves transparency, so that the focus can shift from the posturing and protection of individual positions to the formation of sound environmental policy. Conflicts can be identified and managed through co-operation grounded in common acceptance and understanding of the validity of all interests. This should reduce inter-actor tension and foster co-operation and transparency in the policy-making process.

Following is a brief overview of actors by role: "degraders" (comprising "generators" and "disruptors"), "determiners" and "enablers", "technologists", "investigators", "influencers", and "educators". Degraders, determiners, and enablers are grouped together under "Insider Roles", being those inherently involved in MDLBA policy-making processes. The other actor-roles are grouped under "Outsider Roles", which includes actors who are invited into the policy-making process, or who traditionally have had no "right" to be present and whose role is not yet systematically infused into policy-making processes.

1) Insider Roles

(a) Degraders of the Environment

As previously noted, the GPA identifies two leading causes of marine degradation: contamination and physical alteration of habitats. Thus, *degraders* can be subdivided into two types of actors according to their ecological impacts, namely *generators* of contaminants and *disruptors* of habitats. Although these actors are usually examined under the label "sources of degradation" in the GPA,[166] personifying sources as *generators* and *disruptors* reaffirms that *human* management, not environmental management, is required for effective regulation of MDLBA. Most importantly, this approach to the classification of degradation focuses attention on the type of issue to be resolved, as each entails unique considerations, specific impacts, and appropriate solutions.

The GPA identifies three main sources of degradation: point, non-point, and atmospheric sources.[167] The contaminants from point sources emanate from distinct, identifiable entities, whereas non-point sources, largely the by-products of other

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[166] GPA, *supra* note 3, paragraph 21(d).

[167] *Ibid*., paragraph 21(d)(i)-(iii). Point source contaminants emanate from distinct and identifiable generators such as industrial, power, and sewage treatment plants. Non-point source contaminants enter the marine environment indirectly via land, water, and the atmosphere. Once in the marine environment, contaminants from point and non-point sources commingle, making it impossible to meet the legal requirement of correlating causation with impact.

activities, are an aggregation of substances, materials, chemicals, compounds, and nutrients that are washed, leached, or poured into drainage systems, watersheds, rivers, topsoil, and the terrestrial environment generally.[168] Enlightened drafters of the GPA included atmospheric sources in MDLBA, which rectifies an arbitrary and ecologically unjustified distinction that the LOSC makes between land-based and atmospheric-based sources.[169]

Classification into point and non-point sources is sensible for regulation, but arbitrary in terms of ecology, as both sources can cause severe degradation and, once in the marine environment, sources are often indistinguishable or unidentifiable. Reactive domestic regulation has traditionally targeted point-source generators, primarily pursuant to tort law principles.[170] Subsequently, non-point sources were recognised as environmental threats, but their subtle and ubiquitous character prevented scientific and legal correlation of source with impact. Their regulation was largely overlooked due to the demands of traditional legal regimes that hinged on identifying culprits of environmental damage. Identifying sources as point, non-point, and atmospheric is helpful to remind actors of the broad range of contributors to MDLBA.

Understanding sources as actors *generating contaminants* or *disrupting habitats* focuses policy-makers on both conceptualising the problem and identifying appropriate policy options. For instance, aquaculture may generate significant amounts of contaminants in the form of antibiotics, biocides, and organic enrichment. It is also notorious for destruction of coastal habitats, as wetlands are converted to ponds. In

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168 GESAMP, 2001b, *supra* note 1, pp. 16-17, discusses the three sources of degradation.

169 LOSC, *supra* note 10, Part XII, Articles 207 and 212 concern land-based sources and atmospheric sources, respectively. Atmospheric sources relate to MDLBA as incineration at sea (pursuant to Article 212) usually involves waste generated by LBA. Incineration may produce as by-products POPs and other toxic compounds, as well as greenhouse gases.

170 Chapter 3 provides an historical overview of marine environmental regulation.

this case, by *perceiving aquaculture as a generator in its operational phase and a disruptor in its development phase*, the policy-maker can better identify specific ecological issues involved, determine the type of anticipated environmental damage, and identify the appropriate form of regulation, including land-use planning options. Classification as "generators" and "disruptors" provides information that is more succinct for regulatory purposes and raises more questions relating to critical understanding than the traditional distinction of "point" and "non-point sources". The latter remain useful for identifying management strategies, but their limitations must be recognised.

However, the generator/disruptor approach to categorisation is unavoidably arbitrary. Policy-makers and other actors should appreciate that although nature, as a complex web of inter-relationships, does not lend itself to arbitrary categorization, any such categories are attempts to better understand issues in the face of overwhelming complexity. The "generator/disruptor" distinction is intended to acknowledge ecological complexity while placing actors into transparent and manageable units for purposes of clarity and comprehensive consideration in policy-making processes.

(i) Generators

The generators of environmentally degrading inputs are diverse actors, from individuals to multi-national corporations and government enterprises. Generators of coastal and upstream point source contaminants in the GPA are wastewater treatment facilities, industrial facilities, power plants, military installations, recreational/tourism facilities, research centres, and aquaculture.[171] Atmospheric deposition from power

[171] GPA, *supra* note 3, paragraphs 21(d)(i)a.-e. and h.-i., respectively. Items in paragraph 21(d)(i) f. (construction works, e.g., dams, coastal structures, harbour works, and urban expansion), g. coastal mining, e.g., sand and gravel, j. habitat modification, and k. the introduction of invasive species, fall within the category of disruptors. They are primarily disruptors of habitats, but they are also generators, as all of them generate contamination in

plants, industrial facilities, and incinerators are also point-source generators.[172] Non-point coastal and upstream generators in the GPA are landfills and hazardous waste site operators, and contributors to urban, agricultural, and horticultural run-off.[173] Atmospheric deposits identified in the GPA that fall within non-point sources are transportation (e.g., vehicle emissions) and agricultural operations.[174] The generators are thus vehicle operators in the first case and, in the second case, farmers and the agricultural industry.

These sources generate and add to the environment a multitude of contaminants that would not otherwise be there. The types of impacts and the appropriate form of redress for these are very different from those associated with disruption of habitats, which removes ecological services.

(ii) Disruptors[175]

Point sources of degradation in the GPA associated with disruptors are construction works (e.g., dams, coastal construction, harbour works, and urban expansion), habitat modification (e.g., dredging, filling of wetlands, or clearing of mangrove areas), coastal mining (e.g., for sand and gravel), and the introduction of invasive species.[176]

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the form of sedimentation. They may also exacerbate contamination from other sources by removing a habitat that, for example, absorbed contaminants.

172 These sources are listed in GPA, paragraph 21(d)(iii)b. and c.

173 GPA, paragraph 21(d)(ii)a., b., and f. Items 21(d)(ii)c. forestry run-off, d. mining waste run-off, e. construction run-off, and g. erosion from habitat modification could be deemed either generators or disruptors. They have been categorised here as the latter, as they are primarily activities associated with disruptors, although they generate sedimentation, and possibly re-mobilise chemicals where soil is contaminated.

174 GPA, paragraph 21(d)(iii)a. and d.

175 The term "disruptors" is not perfect. However, it is preferable to "destroyers", which is harsh and, in many cases, inaccurate as damaged habitats can usually recover with time. The GPA refers to the alteration of habitats (paragraph 21(c)). Alterors (or alterers) could have been chosen, but it can convey the notion of fixing or mending as clothes are altered to fit and carpenters alter cabinets. Conversely, altered habitats are usually impaired or compromised.

176 GPA, *supra* note 3, paragraph 21(d)(i)f., g., j., and k, respectively.

Non-point source disruptors include forestry run-off, mining waste run-off, construction run-off, and erosion from physical modification of coastal features.[177]

The sources may contribute contaminants to the environment, but they are consigned to the category of disruptors, as their primary effect is the destruction of relevant habitat. For instance, forestry run-off could be eliminated through sustainable deforestation practices. Some sources, like construction run-off and mining run-off, could and perhaps should be considered under both generator and disruptor categories, depending on circumstances, to encourage comprehensive and effective regulatory action.[178]

The sub-category of disruptors is further linked with generators as the effects of contaminants may be compounded if, for instance, wetlands destroyed for port or tourism purposes would have been available otherwise to bind contaminants and prevent their entry into the marine environment. Additionally, disruptors frequently generate contamination in the form of sedimentation and re-mobilisation of contaminated soil. Historically, disruptors of habitats were not linked to marine degradation, primarily because policy-makers did not appreciate the vital ecological roles of habitats and their inter-dependence with other habitats.

(iii) Characteristics of Degraders

Although the GPA identifies the major degraders, all industries regardless of size may have impacts of varying severity. The accretionary effects of many small enterprises is recognised as a concern for regional seas and the global community, although each

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177 *Ibid.*, paragraph 21(d)(ii)c.-e. and g., respectively.

178 For example, extraction of minerals and the related run-off commonly disrupt habitats and generate toxic wastes, which harms rivers and ultimately the marine environment. For clarity, it may be helpful for actors to consider both aspects for what they are.

entity in and of itself may have minimal impact. A significant degrader not identified in the GPA is the individual. Considering the current global population, the actions of six billion individuals have the potential to bring about a significant degree of degradation. Many individual degraders in developing nations are disruptors, who, due to social, political, and economic constraints, have no other viable options. They continue to cut mangroves for family cooking fuel, clear land for aquaculture, use cyanide while fishing on reefs (disruptors), and degrade the environment in trying to eke out a subsistence standard of living. Conversely, individuals from developed states are more likely to be generators who subscribe to modern conveniences and are often uninformed or uncaring as to the appropriate disposal or use of various substances, or who have limited choice in alternative “eco-friendly” products.

Most degraders, particularly generators, are sectorally regulated, often without consideration of cross-media impacts or temporally and spatially distant effects. As noted, not until recently has habitat loss or destruction been considered in terms of the loss of ecological services. Degraders, particularly multi-national and domestically prominent corporations, industrial concerns, and economically enticing developments such as tourist facilities, have a strong influence on policy-making, as it must balance socio-economic opportunity with environmental standards. Degraders and campaigning NGOs’ commonly suffer antagonistic relations as the latter usually seek high environmental standards. Evidence of an evolving environmental mindset is the fact that degraders are becoming aware of the ecological repercussions of their activities and have determined that, at least for publicity reasons, it is in their corporate interests to adhere to ecologically sensitive practices.[179]

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[179] See Scarlett, *supra* note 148.

To summarise, degraders are a diverse group comprising traditional generators and, more recently acknowledged, disruptors. Although degraders are a diverse group, a common characteristic is that, whether multi-national corporations or resource-scarce individuals in developing states, all are economically bound to conduct activities in ways that perpetuate their survival. Degraders have a valid interest in actively participating in environmental policy-making processes, as their long-term survival has socio-economic benefits for the employees and community, and their actions have ecological impacts, which may be more effectively changed through consultation and co-operation.

The diversity and multiplicity of degraders and the ubiquity of the marine environment renders policy distinctions such as non-point, point, and atmospheric sources less relevant. Instead, understanding an actor not as a *source of pollution,* such as a power plant or a farmer with agricultural run-off, but as an *agent of ecological impact* enhances systematic and comprehensive processing of information. Conceptualising in terms of an entity, i.e., power plant, encourages "small" thinking – a lone entity with a single problem. Conceptualising issues by thinking in terms of degraders raises issues beyond a single entity to other degraders that may also be contributing to the ecological problem. Policy-makers have an effective context in which to consider the extent of degradation, the determination of the type of preliminary data and expertise required to address the issue, which other actors may have a valid interest in the matter, and the appropriate policy options and management strategies. Most of all, it encourages a participatory and co-operative process, which are the hallmarks of consilience – the bringing together of knowledge.

(b) Determiners and Enablers

“Determiners” and “enablers” are the actors who “operationalise” the environmental agenda, weighing and balancing data and information, and drafting, implementing, managing, and enforcing environmental policies at both international and domestic levels. “Determiners” include politicians, decision-makers, policy-makers, negotiators, international diplomats, lawyers, and those in positions to make policy decisions. “Enablers” implement laws and policies, often having to make determinations in the course of their duties. Individuals may perform both roles, but they are two distinct facets of policy processes.

The range of individuals and government ministries and departments involved varies considerably. Internationally, lawyers, diplomats, and trans-national bureaucrats negotiate and draft environmental standards, with the heads of state formally, or through ministers endorsing conventions, declarations, programmes of actions, and other forms of instruments. Domestically, policy falls to sectorally organised departments and agencies, and to bureaucrats with various backgrounds, from engineering to political science and law. Academic lawyers and legal consultants have a regulatory and policy role as advisors or resource persons to regional and international policy-making process, and as advisors to domestic governments drafting legislation to implement international instruments or domestic legislation.

More environmental standards are being determined in the international arena as more issues move from the domestic to the international agenda. A major problem is the lack of continuity of, and communication between, determiners and enablers at the international level, where rules are negotiated, and the domestic level, where implementation takes place. Other problems associated with determiners and enablers relate to their critical understanding of technical information from various disciplines, and in particular, science and ecology. Given the structure of most national educational systems, few have even basic science courses beyond secondary education.[180] It is unsettling that many determiners fail to appreciate that a basic understanding of ecology and science would promote effective policy, and help reduce many of the complexities and perceived intractability surrounding environmental issues.[181]

2) Outsider Roles

The roles below are grouped under "outsiders", as they have been, and continue to be, largely excluded from policy-making processes. The objective is to identify and incorporate these roles as "insiders" to inform and influence the policy-making process as appropriate.

(a) Technologists

Technologists are numerous in number and function, and include engineers and specialised, often "hybridised", scientists such as molecular biologists, biochemists, and genetic engineers. Practical and logistical "fixers" and problem-solvers, technologists have applied innovative science and technology to improve the human condition.

Technologists have directed their energies wherever the demand for new technology has been greatest. During WWII, the focus was on ammunitions, aircraft, submarines,

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[180] Many education systems require that students take at least one science course in the senior years of public schooling, although the natural sciences may be avoided completely by students following the arts and social science education stream. Universities seldom require non-science majors to take science courses, although they may be taken as an elective (in practice, few take this option).

[181] Research for this thesis entailed discussions with dozens of policy-makers, government ministerial representatives, academic and environmental lawyers, international and domestic bureaucrats, and scientists, to ascertain their opinions on the role of science in policy-making and their level of scientific literacy. Some admitted that they did not know, but more disturbing was the number encountered who believed that they sufficiently understood ecological issues, but in talking with them it became evident that they did not possess the underlying critical understanding of science.

radar, and other war-related applications. Later, it was improving daily life through increased agricultural output, streamlined manufacturing processes, and the design of many appliances and machines that are now taken for granted. Today, the focus is on life sciences, telecommunications, information management, and ecological enhancement, as well as continued economic development.

Traditionally, most environmental technologists were engineers inventing and designing sewage systems, water filters, and industrial waste technology such as smoke stacks and effluent outfalls.[182] Engineers are largely results-oriented, often seeking to resolve identified problems through prosthetics, being technology that addresses the symptoms and not the underlying problem. An example is aquaducts that bring in clean water from afar, rather than cleaning the local supplies.

Engineers are sometimes criticised, unfairly, for having created more environmental problems than they have resolved. This is attributable to historical circumstances where regulators encouraged treatment of the symptoms and not the cause, so many engineering designs effectively diluted, dispersed, or redirected contaminants; with past examples including taller chimneys to reach wind currents to carry ash and smoke away and longer outfall pipes to carry effluent miles offshore. As in so many other disciplines today, engineers are becoming ecologically literate through their university training, and are now responsible for inventing and designing clean technology and providing environmentally sound solutions.

After W.W.II, many scientists became entrenched as technologists, as many wartime inventions had commercial applications. Improved instrumentation encouraged forays

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[182] The content and success of many laws and policies is often attributable to available technology that provided alternatives. For example, in the case of water quality aqueducts piped clean water from afar, addressing the symptom rather than forcing policy to confront causes of local water contamination.

into molecular structure and genetic mechanisms, which spawned a new generation of technologists. Gene splicing and genetic engineering offered hope for feeding burgeoning populations with high-yield hybrids and pest-resistant plant strains, and experiments in atom-splitting raised the possibility of alternatives to traditional sources of energy.

Technologists should not be confused with scientific investigators. Although a given scientist may in fact be both, the functional use of their respective knowledge, and their roles in policy-making, although equally vital, differ. Investigators, discussed below, *seek information*, whereas technologists use knowledge to *create solutions* to problems and ease physical effort. The distinction is important, given that anti-science sentiment is mounting.[183] Society's profound faith in the ability of scientists to invent 'fix-it' technology to remedy environmental ills and improve the quality of human life is giving way to the inaccurate belief that technology is at the root of environmental problems.

Anti-science sentiment can be reduced by an appreciation of the various roles scientists play as investigators and technologists. Dissatisfaction with (the application of) technology should not be transferred to investigators, who have little input into the use of technology and in fact identify and isolate problems generated by the application of technology.[184] Investigators rely on technology to conduct their research, and technological advances allow them to probe further and deeper than they could even a

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[183] Paradoxically, this is the age of science and technology, and yet the anti-science sentiment within mainstream society is increasing. The reasons for this are discussed in Chapter 2, herein. Many eminent world-class scientists are concerned about the marginalisation of science, and recently they have been speaking out. See Appendix 1, The Paradox of Science, which lists publications by scientists, science writers, and others who discuss the declining influence of science on policy-making.

[184] Technologists are often dismayed at the uses to which industry and government put their inventions. Society often blames technologists for so-called harmful technology, but it is other actors, not scientists, who determine how technology will be applied.

decade ago. Technologists are now able to understand the environmental-technological interface of issues in a broader ecological and socio-economic context by drawing on information provided by investigators.[185] Consequently, technologists often work closely with investigators and technologists from other disciplines to produce task-specific technology,[186] and environment-enhancing technological options. Finally, with the acceptance of a single global ecosystem, macro and micro scientific research into causes and effects, and societal and political support for environmental sustainability, technologists are assuming the mandate to move from the singular anthropocentric focus of improving the human condition to that of creating economically affordable and ecologically sound technology. The success of many technology strategies inherently depends on available technology.

(b) Investigators

Investigators of marine environmental degradation are primarily natural scientists (e.g., biological, geo-chemical, mathematical, and physical), social scientists (e.g., anthropologists, sociologists, and psychologists), and environmental economists. Many other disciplines and individuals contribute their expertise. Naturalists, "birders", fishermen, and indigenous and local people may also participate as investigators. They compile data and statistics, conduct research on the natural world and into impacts of contaminants and habitat modification, study human inter-connectedness with the natural environment, and study related socio-economic-

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[185] Technologists should not be faulted for failing to draw on broader information in the past, as prior to the 1972 Stockholm Conference technologists were not encouraged to view issues in a wider context. See Chapters 3 and 4 for discussions on the development of environmental investigations and their interface with policy.

[186] Examples of this are computer-driven remote submersible vehicles and computer hardware for modelling exercises. Other examples are "clean technologies" advocated in numerous international instruments. Historically, society placed blind faith in the ability of technology to improve the human condition and fix problems should they arise. The faith has not been misplaced, as technology is available to address most environmental problems, but what is lacking is the political will and societal commitment to apply the technology appropriately and soundly.

political aspects, from the repercussions of policy options to the way people react to various environmental concerns. The investigators should be objective and sincere as they provide the determiners and enablers with data, knowledge, and informed opinions for decision-making purposes. Without investigators, actors would not understand the impacts of human activities on the natural environment or society and culture, and their interface with environmental issues.

The multitude of problems associated with investigators are anchored in the complexity of the ecosystem and the requisite need for multi-disciplinary, multi-sectoral, and inter-media research. Never before has there been so great a need to understand the natural environment in a holistic way, as human environmental interests, such as farming, fishing, forestry, and other resource uses, have evolved from a purely localised and individualised scale to a regional and global scale. Further, investigators have been conditioned through traditional research needs, sectoral employment, and funding conditions to approach research on a sectoral and predominantly single-discipline basis. Nonetheless, recognising human-made environmental degradation, investigators were among the first to respond to the call for holistic ecological research and an understanding of the human interface with the global ecosystem.

Five factors affect the ability of investigators to effectively contribute to policy-making processes. First, the results and informed opinions of many investigators are misinterpreted and misused by policy-makers, due to a lack of critical understanding of the basics of the relevant discipline. This is particularly true in the natural sciences, where policy-makers seldom understand ecology or the scientific method.

Second, essential and relevant research is compromised due to lack of funding, or conditions attached to funding that artificially determine, direct, or limit the scope and nature of the research and participating disciplines. The result is scientifically (and often economically) unjustified research and policy priorities, lacunae in data, neglect of essential research issues, and impediments to multi-disciplinary, inter-media studies.[187]

Third, few investigators are perceived as non-biased, as most are employed or funded by institutions, agencies, or corporations that are seen to have an interest in the research outcome. Any investigator whose results favour the funder's position becomes suspect. While circumspection is required to assess whether there may be bias, many investigators are credible and do offer sound advice, as will be discussed in Chapter 4, herein.

Fourth, while non-investigators may be somewhat overwhelmed with the amount of information available regarding environmental issues from various sources, what disconcerts them is the prevalence of conflicting information. This can be alleviated with a sufficient degree of scientific literacy that will help separate sound from unsound science.

Finally, a significant number of research projects are uncoordinated and sectorally driven, with minimal exchange of information among researchers, disciplines, sectors, governments, agencies, and other actors who would benefit from co-operation or contribute to the value of the data in some way.

Natural scientists, the relevant investigators herein, are employed by numerous organisations and agencies. A few examples of investigators are: government and government agency employees; experts and consultants appointed to committees and

[187] The implications of funding sources and conditions on scientific research and identifying priorities for research and management are discussed further in Chapter 4.

councils; members of national academies established to advise governments; national commission members mandated with investigating and reporting on designated issues; experts partaking in legislative enquiries and public hearings; interest-driven individual scientists; *ad hoc* groups of scientists (banding together for a specific interest, often involving academicians and popular media scientists); professional groups of scientists, such as the International Council for the Exploration of the Seas ("ICES"), the Union of Concerned Scientists ("UCS"), and the International Council of Scientific Unions ("ICSU"); UN agency employees and consultants, such as members of GESAMP, Intergovernmental Oceanographic Commission ("IOC"), the Intergovernmental Panel on Climate Change ("IPCC"), the Food and Agriculture Organisation ("FAO"), the United Nations Environment Programme ("UNEP"), and the United Nations Development Programme ("UNDP"); and scientist members of environmental NGOs (e.g., Greenpeace and Friends of the Earth).[188] Scientists in these groups can also act as influencers, as will be discussed below.

The inter-linkage of investigators with one another and with other actors involved in the policy-making process requires significant effort. It is challenging to attempt to co-ordinate biologists studying similar issues across the groups mentioned above, even before consideration of multi-disciplinary, multi-sectoral, and inter-media co-operation among social scientists, environmental economists, and all other natural scientists. However, efforts are being made to co-ordinate activities, standardise methodologies and measurements, create databases, reduce uncertainties, direct funding at priority issues, and improve transparency to minimise biases, real and perceived. The vital role

[188] Scientists hired by, or affiliated with, organisations are often considered biased without looking at the facts. This is unfair as bias can be addressed and managed, particularly through the peer-review process that is fundamental to the scientific method.

of investigators is yet to be fully recognised by actors who are overwhelmed by the "whirlpool" of information, much of which lacks quality assurance.

Finally, those who are traditionally absent from the category of investigators are indigenous and local peoples, who have a wealth of ecological knowledge from their long history of direct dependence upon, and co-existence with, nature.[189] Their knowledge of local ecosystems and the abundance of resources within them, especially in developing countries, is slowly being recognised as an important resource to be tapped. Essentially, investigators can be anyone from any profession with *informed* opinions or *quality-assured* knowledge of an issue.

(c) Influencers

Those who influence the policy-making process, regulatory efforts, environmental research agendas, and the application of environmental technology are too numerous to list. A few include national development agencies, the World Bank, regional development banks, journalists behind the media portrayal of environmental issues, international and national NGOs,[190] deeply committed ecological ethicists (primarily non-scientists, they are confusingly referred to as "deep ecologists"), the green backlash (or "brownlash"[191]), industrial lobbies, UN bodies, medical doctors (at the

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[189] Technologists can learn from indigenous peoples with regard to sustainable practices in agriculture, fishing, and other resource use, for example medicinal applications from plants and animal parts.

[190] NGOs play several important roles in the control of MDLBA, including the role of an organised public conscience. International NGOs promote the development of local NGOs by providing technical expertise, funding, and moral support. Governments now consult NGOs on technical and policy issues. For a general view of NGO participation, see K. Stairs and P. Taylor, "Non-governmental Organizations and the Legal Protection of the Oceans: A Case Study", in A. Hurrell and B. Kingsbury (eds.), *The International Politics of the Environment: Actors, Interests, and Institutions* (New York and Oxford: Oxford University Press, 1992), pp. 110-41; G. Peet, "The Role of (Environmental) Non-governmental Organizations at the Marine Protection Committee (MEPC) of the International Maritime Organization (IMO), and in the London Dumping Convention (LDC)", 22 *Ocean and Coastal Management* 3 (1994); V. Pravdic, "International Cooperation in Marine Sciences: The Non-governmental Framework and the Individual Scientist", 5 *Ocean Yearbook* 117 (1985); and D. Reed, "The Global Environment Facility and Non-governmental Organizations", 9 *American University Journal of International Law and Policy* 191 (1993).

[191] See P.R. Ehrlich and A.H. Ehrlich, *Betrayal of Science and Reason: How Anti-environmental Rhetoric Threatens Our Future* (Washington, D.C.; Covelo, California: Island Press, 1996), pp. 1-2, 11-12, 17, 19, 36-7.

interface between human health and environmental issues), politicians, the general public, labour unions, resource users, generators, disruptors, popular scientists, and science and environmental writers.

Unlike investigators who contribute objective knowledge, influencers may be motivated by values, ethics, personal (or group) agenda, or pre-ordained results, and thus, they may (or most likely will) offer biased and scientifically untested input. This is legitimate, and is in fact necessary to debate and resolve conflicting interests. However, it is important to distinguish influencers from investigators, as their input serves different purposes. The significance of this cannot be overstated as the same individual or agency may act as either an investigator or an influencer, depending on the circumstances. Thus, it is necessary to evaluate their input to determine its quality and utility.

Three observations can be made about influencers that confirm the importance of categorising them as such to avoid wrongful exclusion or participation: (a) the spectrum of actors ranges from deep ecologists who wish to preserve the environment for its intrinsic value, to industrialists or developers who may seek to exploit the environment for financial gain; (b) the multiplicity of interests and the diverse nature of the actors ensures conflicting interest at every stage of the policy-making process, including their influence on inclusion of issues on the public and political agenda; and (c) an historical inequality of interests, biases for and against various actors, the subtlety or fervour of each, lack of co-operation, and the lack of formalised access to

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They note that the "brownlash" is not a co-ordinated movement, but rather an aggregated body of anti-science rhetoric emanating from industrialists and pro-development lobbies; individuals, and groups with right-wing affiliations; well-meaning individuals; and those who claim to represent the scientific perspective while misstating or putting a misleading gloss on scientific findings. *Ibid*., p. 2. Also see J.V. Switzer, *Green Backlash: The History and Politics of Environmental Opposition in the US* (Boulder and London: Lynne Rienner Publishers, Inc., 1997).

the policy-making process have served to polarise many actors as either pro- or anti-environmentalist.[192]

The result is a tangled web of interacting interests and influences that almost rival the ecosystem in complexity. The aim is to appreciate the inter-relationships that subtly or overtly affect both the policy-making process and the effectiveness of any resulting regulation. Hard choices have to be made regarding socio-economic benefits and employment opportunities, versus environmental protection. Industrial lobbies and industrialists strongly voice their interests, and they are traditionally heard by determiners and enablers, given the prevailing pro-development and economy-based mindset.

Countering the political influence of industrial might, environmental NGOs, rising to the forefront in the 1970's, have often adopted radical and sensational actions to publicise their interests. International environmental NGOs, like Greenpeace, launch massive campaigns, mobilising the public to demand political action. The media takes these campaigns and other counter-campaigns to the individual. The portrayal of the issue will often depend on the ideological bent of a given publication and the contributing journalist's critical understanding of an issue.

Paralysis or fear may set in if the public feel bombarded with conflicting opinions and advice, particularly when scientists whose research is summarised in the media are seen to espouse conflicting opinions.[193] Scientists who popularise science or publish

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[192] An example of this polarisation is the vociferous and antagonistic debate between the green backlash and environmental NGOs. See Switzer, *ibid.* Also see M. Bookchin, *Remaking Society: Pathways to a Green Future* (Boston: South End Press, 1990), pp. 8-9, where it is suggested that the thoughts of the environmental NGOs and the backlash are generally closely parallel.

[193] See generally H.A. Cohl, *Are We Scaring Ourselves to Death?: How Pessimism, Paranoia, and a Misguided Media are Leading Us Toward Disaster* (New York: St. Martin's Griffin Press, 1997). Also see Chapters 4 and 5 herein, which discuss confusion brought on by the unsophisticated use of science. Regarding sophisticated

books, editorials, or articles in the popular media may contribute to the confusion if, as is often the case, the public (including policy-makers) cannot evaluate the authors' credibility or ascertain whether the opinion represents good science, misstated science, or pseudo-science, or is even blatantly incorrect. The individual's credentials may become irrelevant, as publication under the banner of science is often powerful enough to galvanise public reaction.[194]

A self-perpetuating cycle is the polarised "brownlash" and NGOs influencing policy-makers through lobby-groups, both in formalised processes and through the media. The general public influences policy-makers through politicians, who ultimately influence the environmental agenda. The public, in turn, are influenced by the media, by the publication of polarised viewpoints, and by direct personal experience or interest in a given issue. The interests of various groups are usually broader than any one environmental issue under discussion, and include economic, political, and cultural interests.

Victory-seeking may be another factor, with positions on topical environmental issues sometimes used to mask hidden agendas. Environmental issues are often part of a larger decision for determiners, as they must consider input from other sectors, disciplines, and affected parties. Once again, inability to distinguish the investigator's quality-assured input from the influencers lower quality and often interest-driven input can result in misplaced reliance and increased confusion about facts. By capitalising

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users of science, see D.L. Faigman, *Legal Alchemy: The Use and Misuse of Science in Law* (New York: W.H. Freeman and Company, 2000).

194 Since UNCED, environmental issues are discussed in print and broadcast media, and it is primarily through these sources that members of the public glean their understanding of environmental issues. Scientists who contribute to printed media range from the very highly respected to those who lack credibility. Sometimes even non-scientists who appear knowledgeable are assumed to be scientists. In such circumstances, it is difficult, if not impossible, for the public to discern good science from impostors.

on fear and confusion, those who wish to can manipulate the environmental agenda in an arbitrary fashion.

(d) Educators

Taking a broad view, environmental education emanates from formal and informal sources, such as examples schools, polytechnics, colleges, and universities; civil servant training courses; popular environmental books and journals; printed, televised, and electronic (the Internet) media; NGOs and UN bodies; and indigenous and local peoples. Many educational forums may be solely dedicated to environmental issues, while others may include the environment as a component of a wider curriculum. The opportunities for education are quite remarkable, if the desire to learn is present.

Formal education systems have been very effective at producing professionals with single-discipline and sectoral orientations. However, traditional multiple-degree combinations have been concentrated in two distinct groupings: the first being the non-sciences, such as business or political science combined with law, political science and business, political science and public administration, and economics and business; and the second being a mix of sciences, such as biology and chemistry or mathematics, physics and engineering. An individual with both science and law is rare. As a result, many policy-makers and managers come from the non-science formal education streams, and although they may be very competent within their fields, they lack the scientific component necessary to make balanced and informed decisions.

Many universities, recognising the need for a basic understanding of the natural sciences (and other disciplines) that are relevant to environmental management have instituted multi-disciplinary degrees for marine affairs, ICM, and environmental management.[195] This may help address the critical understanding of issues for key individuals in the policy-making process, but relatively few graduates are produced, and they tend to be presently in the early stages of career development, without much influence on policy outcomes. Thus, the benefits from multi-disciplinary programmes are yet to be realised, and meanwhile, most graduates of public schools and universities remain science-illiterate.

Environmental issues now dominate domestic and international agendas and recall that ecological impacts are largely the symptoms of social issues. Therefore, it becomes more important that all actors have a multi-disciplinary appreciation of relevant issues. The role of educators in the management and regulation of MDLBA (and all environmental issues) has been highly underrated and overlooked. Education should be viewed as pivotal, with actions undertaken to ensure heightened scientific and ecological literacy for society in general.

Part II Summary: A Whirlpool of Complexity

In summary, MDLBA is a fact, consequence, and by-product of the technologically- and development-oriented basis of modern society. It is an insidious problem complicated by the effects of poverty,[196] consumption, and other social issues. Contrasted with the discrete, sector-based traditional approach to environmental regulation, MDLBA is a whirlpool of complex inter-linkages, inter-relationships, and causes and effects among human actors operating within the ecosphere. A static

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[195] Among the recognised marine affairs programmes is the Masters in Marine Management, offered by Dalhousie University, Halifax, Canada. It covers science, management skills, and law, taught by professionals from the respective disciplines. The University of Washington and the University of Delaware, both in the US, have highly respected multi-disciplinary programmes, as does the University of Sydney, Australia, the University of Wales Institute of Science and Technology (UWIST), and the University of London, to name a few.

[196] To understand the inter-relationship between poverty and environmental integrity, see World Bank, *World Bank Development Report 2000/2001: Attacking Poverty* (Oxford: Oxford University Press, 2001).

picture of any MDLBA issue fails to capture a fraction of the complex reality, yet the limited and limiting perception of MDLBA to date has been perpetuated through sectoral “snapshots”, which fail to integrate all the issues involved.

Policy-makers and the global community fail to recognise this complexity, and only recently have a few actors begun to appreciate MDLBA as a kaleidoscopic and dynamic blending, melding, and inter-fusing of components. For the most part, however, the perception prevails that MDLBA is chaotic and unmanageably complex.

The objective of the global community should be to avoid being overwhelmed by the complexity of MDLBA issues, and instead seek a critical understanding of socio-economic, political, and ecological issues and their inter-connectedness. A global priority should include ordering the apparent whirlpool of issues connected with MDLBA; moving from a perception of inherent intractability, to acceptance that an effective holistic regime for LBA is possible for marine environmental protection, and for ecospheric protection.

Upon acknowledging that issues associated with MDLBA are complex, and sometimes seemingly intractable, the next step is committing resources and energy to finding ways to reduce or penetrate the intractability. As discussed in the following chapters, there is promise for an effective regime for MDLBA.

Chapter 2

Encountering a Rip-tide: Evidence, Ignorance, Proof, and Policy in the Scientific and Legal Domains

A. Introduction: Science for Effective Law and Policy

In society today, few people other than scientists understand even the basics of the methodology and mechanisms of science. In particular, they have little understanding of ecology, "the branch of science studying the interactions among living things and their environment".[1] Mounting environmental concerns make it urgent to address this literacy problem because science, as "one of the most potent forces shaping the development of [modern] civilization",[2] is fundamental for understanding the ecosphere and human impacts on it.[3] This urgency is underscored by the fact that it is primarily non-scientists who set global and domestic policies regulating human impacts on the environment, and non-scientists who determine how the findings of science will be applied. With the purpose of understanding the reason for a high degree of scientific illiteracy in the legal domain, and in society in general, this chapter

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1 GESAMP, *Protecting the Oceans from Land-based Activities: Land-based Sources and Activities Affecting the Quality and Uses of the Marine, Coastal and Associated Freshwater Environment*, GESAMP Reports and Studies No. 71, 2001b, Glossary.

2 B. Dixon, *What is Science For?* (Middlesex, England: Pelican Books, 1976), p. 227.

3 D.H. Kohl, "The Environmental Movement: What Might It Be?", 15 *Natural Resources Journal* 328 (1975), p. 340. Scientists are custodians of knowledge that is vital for sound social, political, environmental, and economic decision-making. *Ibid.*

explores the historical and contemporary relationship between the scientific and legal domains, and the inherent differences in the approaches of each profession.

The scientific and legal domains embrace a wide range of actors. There are many scientific disciplines relevant to policy-making processes, but the natural scientists are most vital. The legal domain encompasses policy-makers, regulators, civil servants, NGOs, and other actors – many of whom are “influencers”, not traditionally associated with law making. This relatively new extension of actors involved in policy-making and the legal domain is necessary, as environmental regulation relies heavily on soft-law instruments, action plans, and non-binding agreements and policies at global and domestic levels, which by nature involve a broader range of actors. Most of these actors act, directly or indirectly, pursuant to instruments agreed upon and drafted by domestic lawmakers and international diplomats (most of whom are lawyers), and sanctioned by politicians (many of whom are lawyers). Although scientific and ecological understanding is relevant for all actors described in Chapter 1, lawyers are key figures, given their positions as determiners and enablers in both the international and domestic arenas.

B. The Rip-tide at the Interface of Science and Law

A rip-tide is a natural phenomenon of opposing water flow, which can threaten even the most experienced swimmer.[4] On the surface, it is deceptively calm (the energies of the opposing flows reduce surface perturbation) and is often visible only to the trained eye. Swimmers and boaters who venture unawares into a rip-tide must negotiate it by applying acquired skills and predetermined methods, among them rational thought and a critical understanding of the physical processes involved. Of course, a little luck also

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4 A rip-tide, or rip-current, is a narrow band of water flowing swiftly seaward as it escapes from a pile-up of water onshore caused by strong onshore winds and incoming waves.

helps. Anyone active in or around water should acquire the knowledge and skills necessary to make sound choices for survival, should they ever find themselves caught in a rip-tide.

A rip-tide can be a metaphor for the hidden dangers at the interface of law and science.[5] The aims, methodologies, and philosophy that underpin each profession are at variance with each other, rather like opposing flows of water. Due to their insufficient knowledge of scientific methodologies and science, lawyers are often unaware of, and traditionally have felt little need to contemplate, the rip-tide-like problems at the science-law interface, but escalating environmental degradation compels environmental determiners and enablers, in particular, to now venture into unfamiliar water. They need to develop and consciously and rationally apply a critical understanding of scientific processes and mechanisms to reach more ecologically sound decisions, which in turn will foster ecological, social, and economic sustainability. Failure to develop or employ these skills will perpetuate ecologically and economically unsound policy and ultimately lead to further environmental demise. Because the inherent differences between the domains of law and science will endure in perpetuity, there is no easy option of hoping it will improve with time. Addressing the tension at the interface is the only rational option.

The focus herein is primarily on the perception and use of science by actors in the legal domain and policy-making processes, as they are responsible for multi-faceted ecological protection strategies and must therefore understand the scientific dimension.[6] To this end, the objectives of this chapter are three-fold. First, it

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[5] The incoming surf can be seen to represent mainstream society, of which determiners and enablers are a component. The anomalous water flow, the rip, is the domain of natural science, including ecology.

[6] L.M. Warren, "The Precautionary Principle: Use with Caution", in K. Milton (ed.), *Environmentalism: The View from Anthropology* (London and New York: Routledge, 1993), p. 97.

highlights the fact that scientific illiteracy among actors in the legal domain is a product of cultural and social organisation, particularly within the western hemisphere, rather than the result of actions by any single discipline, domain, or profession. Second, it facilitates basic understanding of scientific methodology and processes, noting that much of the dissatisfaction with science within the legal domain is rooted in misunderstanding, myth, and misperception. Third, it examines an area of law and policy significantly affected by scientific illiteracy.[7] It involves scientific uncertainty, the assimilative capacity, and the precautionary concept.

C. Society and Science

To understand the relationship between law and science, it is important to understand society's general perception of science. It is a complex issue that, until recently, sociologists of science have largely ignored.[8]

The perception of science by members of society varies, depending on subjective interests.[9] Scientists pursue it as an intellectual adventure, an interesting career, or a source of prestige; the military embraces it to obtain means for defence, intelligence, and resolution; industry and government perceive it respectively as a means to profit-making and increasing national wealth; and developing nations view it as a means of liberation from disease and deprivation and as a sign of national maturity and competence.[10] Environmental crusaders hold mixed views, generally (and

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7 The suggestion of scientific illiteracy is not pejorative, but rather as a statement of fact. The organisation of society that has evolved has afforded non-scientists neither opportunity nor encouragement to change this.

8 Dixon, *supra* note 2, pp. 19-20. See generally J.A. Labinger, "Science as Culture: A View from the Petri Dish", 25 *Social Studies of Science* 285 (1995); H.M. Collins, "Cooperation and the Two Cultures: Response to Labinger", 25 *Social Studies of Science* 306 (1995); S. Jasanoff, "What Judges Should Know About the Sociology of Science", 32 *Jurimetrics Journal* 345 (1992); and S. Jasanoff, *Science at the Bar: Law, Science, and Technology in America* (Cambridge, Massachusetts and London, England: Harvard University Press, 1995).

9 Dixon, *ibid.*, p. 227.

10 *Ibid*.

inappropriately) decrying science for providing technology that degrades the ecosphere and for ostensibly failing to predict impacts, but also recognising the utility of ecological sciences. The general public is not conditioned to contemplate the role of science in their lives.

1) Today's Science Paradox and Loss of Faith

Although the cumulative products of science (which includes, information, knowledge, procedures, and technology) enable humans to "transcend the limits of gravity, space, time, biology, and now, with computers, the mind",[11] there is a paradox in modern society's relationship with science.[12] The paradox is that since the products of science can greatly extend human power and comfort, and the global demand for modern conveniences and consumer goods (some of the fruits of science) is relentless; yet, science, and more precisely, technology, are increasingly blamed for environmental degradation.[13] For example, pesticides are often cited as a cause of ecological harm, but consumers fail to associate this with their demand for visually pleasing perishables, made possible in part through the application of pesticides.[14] The paradox has roots

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[11] D.W. Orr, *Ecological Literacy: Education and the Transition to a Postmodern World* (New York: State University of New York Press, 1992), at p. 39. Science and technology have improved the human condition and eased the physical burdens for millions, in everything from medical treatments to telecommunication to agriculture. At the same time, however, the success of technological advancement has further removed humans from nature and perpetuated the mindset of anthropocentric superiority. ***Ibid.***

[12] See K. von Moltke, "The Relationship between Policy, Science, Technology, Economics and Law in the Implementation of the Precautionary Principle", in D. Freestone and E. Hey (eds.), *The Precautionary Principle in International Law: The Challenge of Implementation* (The Hague, London and Boston: Kluwer Law International, 1996), p. 108; Orr, *supra* note 11, pp. 38-40; H.A. Cohl, *Are We Scaring Ourselves to Death?: How Pessimism, Paranoia, and a Misguided Media are Leading Us Toward Disaster* (New York: St. Martin's Griffin Press, 1997), pp. 19-24; and L.A. Kimball, *Treaty Implementation: Scientific and Technical Advice Enters A New Stage*, Studies in Transnational Legal Policy No. 28 (Washington, D.C.: The American Society of International Law, 1996), p. 5. For publications dealing generally with the subject, see Appendix 1, The Paradox of Science, herein.

[13] ***Ibid.*** and R. Carson, *Silent Spring* (New York and Boston: Houghton Mifflin Company, 1962, 1994). Also see Appendix 1, The Paradox of Science, herein. Many of the cited references discuss the use of technology by society, noting as discussed in Chapter 1, herein, that the perception is wrong as it is society and not scientists who determine the application of technology.

[14] See generally Cohl, *supra* note 12, pp. 60-4; W.F. Allman, "Pesticides: An Unhealthy Dependence?", *Science 85*, Vol. 6, No. 8, p. 14 (1985); Anonymous, "Pesticides Blamed for Absence of Alligators in Florida Lake", 9 *Water, Environment and Technology* 12 (1997); A.A. MacIntyre, "Why Pesticides Received Extensive Use in

reaching back to Galileo,[15] but its most recent form emerged after WWII when unprecedented investment in science produced dramatic tangible returns. Science gained prestige as the architect of human progress, and people developed a profound faith in the ability of science to produce technological fixes for environmental and social problems.[16]

Then, disillusionment and distrust of science emerged in the early 1960's as concern mounted about the adverse consequences of the uses of science, and fear of its potential effects began to build.[17] Public confidence plunged for many reasons, among them the rise of the destructive application of technologies such as Napalm, evidence of disturbing impacts from pesticide use and other chemical pollution, realisation of science's link (real or assumed) to serious social and ethical issues, and disappointment at the lack of promised returns.[18]

There is no denying the profound loss of the public's faith in science generally, evidence of which is supported by statistics[19] and the number of eminent scientists

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America: A Political Economy of Agricultural Pest Management to 1970", 27 *Natural Resources Journal* 533 (1987); T. Colborn, D. Dumanoski, and J.P. Myers, *Our Stolen Future* (London: Abacus, 1997); Editorial, "Why We Only Accept a Policy if We Know It Will Not Work", 1 *Ecologist Quarterly* 266 (1978); K.S. Kamlet, "Our Oceans as Waste Space: The Rebuttal", *Oceanus*, Vol. 24, No. 1, pp. 10-17 (1981); L.A. Thrupp, "Entrapment and Escape from Fruitless Insecticide Use: Lessons from the Banana Sector of Costa Rica", 36 *International Journal of Environmental Studies* 173 (1990); and Carson, ***ibid.***

15 Galileo's heliocentric scientific findings gave rise to deep divisions between those enthralled with scientific investigation and "hard" knowledge and those fiercely opposed to scientific investigation that posed a threat to traditional values and beliefs, particularly religious teachings. See R. Dunbar, *The Trouble with Science* (Cambridge, Massachusetts: Harvard University Press, 1995), pp. 1-2. Science, known as "natural philosophy" until the late 1800's, was denigrated by non-scientific intellectuals, as science required practitioners to "dirty their hands", a practice regarded as unbecoming to the intellectual elite. See G. Hardin, *Filters Against Folly: How to Survive Despite Economists, Ecologists and the Merely Eloquent* (New York: Penguin, 1987), p. 17.

16 Dixon, *supra* note 2, pp. 11-13. Dixon, the then editor of *New Scientist* journal, published this book in 1973 in response to the public's growing antipathy towards science. It is equally applicable today. Recommended reading is its analysis of society's historical perception of science and the suggested role for science in contemporary society.

17 *Ibid.*, pp. 12-17.

18 *Ibid*.

19 Statistics show a significant reduction worldwide in enrolment in university science programmes, particularly since 1990. See Dunbar, *supra* note 15, pp. 2-30.

speaking out in defence of science in the popular media.[20] In the 1980's, that distrust was extended to scientific knowledge and the ability of scientists to protect the environment. The declining influence of science has repercussions for the ecosphere and, ultimately, society, as scientists, the purveyors of scientific knowledge, are the only legitimate assessors of human impact on the natural environment.

2) The Blind Paradox

The paradox of science is widely acknowledged and discussed, but there is also an unrecognised social paradox: that primarily non-scientists, not scientists themselves, determine how the fruits of science, including scientific knowledge, will be applied.[21] At this juncture, it is important to distinguish between science – the quest for knowledge – and the uses to which scientific knowledge is put. Whereas science is a neutral and value-free endeavour whose application "does not exist apart from human beings",[22] its use involves ethical issues that only society can resolve through political processes.[23] Rachel Carson, in her seminal best seller, *Silent Spring*, attempted to distinguish scientific knowledge from the use of science, although the point was largely missed:

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20 See Appendix 1, The Paradox of Science, herein, for a selection of popular science books concerning the role of science.

21 Who determines the application of science varies with the era and the issue concerned. Prior to the 1970's, the public were largely excluded from decisions about how technology would be applied. See P.E. Allin, "Some Social Aspects of Modern Science: A Point of View", 3 *International Journal of Environment Studies* 49 (1972), p. 50. In the 2000's, a concerned public hold politicians and policy-makers more accountable, although the standards are often what the public perceives to be true, not what is scientifically sound.

22 Hardin, *supra* note 15, p. 10. Motivation underlying the selection and application of technology may include factors such as the best of intentions, ecological naiveté, negligence, and the lack of available options. Advanced technology in general is regarded as cleaner and safer than that developed when environmental awareness was much lower, and less valued. The important factor is whether or not a given technology ameliorates or exacerbates human impact on the environment. See von Moltke, *supra* note 12, p. 108.

23 J.M. Hollander, "Scientists and the Environment: New Responsibilities", 3 *Ambio* 116 (1972), p. 116. Allin, *supra* note 21, p. 53, states that all knowledge is good knowledge – only the uses to which it is put can be questioned. Evidence of the social and political nature includes the debates in the last century concerning eugenics, and the current debate about cloning.

> It is not my contention that chemical insecticides must never be used. I do contend that we have put poisonous and biologically potent chemicals indiscriminately into the hands of persons largely or wholly ignorant of their potentials for harm.[24]

To condemn science generally is to sidestep the real issue, which is who determines the conditions and scope of the application of scientific knowledge, and which persons, processes, and criteria should be applied to these decisions.[25] The paradox is a social construct and can be deconstructed with effort and understanding. The first step is to understand the historical events leading to contemporary society's attitude towards science.[26]

3) The Roots of Mistrust

Non-scientists have always been remote from the scientific realm.[27] C.P. Snow, scientist and novelist, described over 40 years ago the schism in academia between the literary and scientific cultures, noting the incomprehension, even dislike and hostility, that characterised their separateness.[28] The schism remains today, as, in the eyes of a non-scientist, "natural scientists remain aloof and alone, utterly confident of the value of their work and sublimely indifferent to the rest of the academy".[29] Primo Levi, distinguished chemist-turned-writer, confirms the depth of the schism:

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24 Carson, *supra* note 13, p. 12. Carson points to human failings, from the lack of testing and the overriding economic interests of industry, to the withholding of information from a public who have a right to know and to decide how technology should be applied. Also see Hardin, *supra* note 15, p. 10, where it is noted that "[f]allible humans are involved at every critical point in the system". This is also discussed in Chapter 4, herein.

25 The public are becoming more vocal in mass media communications regarding the application and use of science and technology, primarily through debates on the ethics of, for example, the scientific cloning of animals, including humans.

26 For further insight about attitudes towards science and scientists, see H.R. Bernard and P.D. Killworth, "Scientists as Others See Them", 4 *Ocean Development and International Law* 261 (1977).

27 C. Raymo, *The Virgin and the Mousetrap: Essays in Search of the Soul of Science* (New York: Viking Penguin, 1991), at p. xvii.

28 *Ibid.*, p. *xv.* Also see Hardin, *supra* note 15, pp. 16-17 and Dunbar, *supra* note 15, p. 2. See C.P. Snow, *Two Cultures and the Scientific Revolution* (New York: Cambridge University Press, 1959).

29 Raymo, *ibid.*, at p. *xvi*. Raymo cites this statement by Allan Bloom, who was a philosopher of political thought at the University of Chicago, from his book *The Closing of the American Mind*, New York: Simon and Schuster, 1987.

> I have often set foot on the bridges which unite (or should unite) the scientific and literary cultures, stepping over a crevasse which to me has always seemed absurd. There are those that wring their hands and call it an abyss, and do nothing to fill it; there are also those who work to widen it, as if the scientist and literary man belong to different human subspecies, reciprocally incomprehensible, fated to ignore each other and not engage in cross-fertilization. This is an unnatural schism, unnecessary, harmful, the result of distant taboos and the Counter-Reformation, when they do not go back to a petty interpretation of the Biblical prohibition against eating a certain fruit.[30]

The general public, with limited scientific education, identify more readily with the literary culture. Attitudes towards science fall on a spectrum with anti-science at one end, ambivalence and interest falling in the middle and, moving towards admiration, but seemingly ingrained is a deep-seated fear and hostility regarding science and its application.[31] A scientist sums up his opinion of this perception:

> Science is perceived as materialist and dehumanising, arrogant and dangerous. Its practitioners are a band of cold and unfeeling technicians wielding power without responsibility. Reductionism is suspect and uncomfortable, sabotaging all the mystery and wonders of life. The threats of nuclear war and genetic manipulation of embryos loom large.[32]

The entertainment industry further fuels, albeit unwittingly, mistrust of science through stereotyped portrayals of scientists as affable, bumbling buffoons; obsessive and irresponsible researchers; and too commonly, agents of evil.[33] Stripping away the humour and fantasy, scientists are perceived by the public to be inept and, worse, dangerous because their creations potentially threaten the welfare of humankind.[34]

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30 P. Levi, *Other People's Trades* (London: Abacus Books, 1990), at p. *viii*. The book is dedicated to bridging the schism, asserting that the alleged incompatibility between the literary and scientific cultures does not exist, and that, at times, they even compliment each other. Socio-biologist Edward Wilson has also devoted his career to bridging this schism. See generally E.O. Wilson, *Consilience: The Unity of Knowledge* (New York: Alfred A. Knopf, Inc., 1998). Also see Appendix 1, The Paradox of Science, herein, for other scientists, and science writers, who express concern about the schism and antipathy towards science.

31 Raymo, *supra* note 27, p. *xvi.*

32 *Ibid.,* at pp. *xvi-xvii.* The quote, cited in Raymo, is by British biologist, Lewis Wolpert.

33 M. Allaby, *Facing the Future: The Case for Science* (London: Bloomsbury, 1996), pp. 3-15. Scientists are stereotyped in the media and literature as wacky, mad, or downright malevolent. Innumerable films cast scientists as villains threatening humankind with destructive technology. James Bond "007" films are classic examples of the triumph of good over an evil scientist. The wacky scientist whose bumbling creates an amusing situation is epitomised by the "Honey, I Shrank the Kids" series of films. However, the most disturbing genre is epitomised by the "Jurassic Park" series, which casts scientists as impetuous experimenters who blithely and unwittingly create life-threatening situations.

34 *Ibid*.

These unfortunate attitudes result primarily from misinformation. Although scientists are partly responsible for failing to communicate the true nature of their craft,[35] the roots of the problem are deeper, as the public today are largely incapable of understanding scientific knowledge and methodology.[36] Because so few non-scientists understand science, the public are woefully uninformed about environmental science, the issues scientists face, and the ability of science to contribute to environmental policy-making.[37]

The paradox of global society is that a largely scientifically uninformed public increasingly has a direct impact on environmental policy-making through participation in NGOs, pressure groups, lobbies, voting, and grassroots action. Public input is essential, as most ecological degradation is inter-linked with social issues, but the public, like other actors, requires critical scientific understanding to prevent endorsement of the views of ill-informed actors, despite the availability of *bona fide* experts.

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[35] Scientists fail to communicate for innumerable reasons. They traditionally operate in (largely self-imposed) isolation, their debates have been traditionally limited to an audience of professional peers, and their style of communication is full of jargon that, to the outsider, is incomprehensible. The cyclical process of accumulating new knowledge and discarding that which is no longer valid confuses the public, whose acceptance of new (and sometimes mind-boggling) information always lags behind the latest developments in the scientific realm. See C. Sagan, *The Demon-Haunted World: Science as a Candle in the Dark* (New York: Random House, 1995), p. 247-63. Sagan notes that science is complex only because the natural world is complex, not because scientists are "toying" with the public. Further, an appropriate social avenue or process for communication has been lacking. Also see L.O. Hinds and G.B. Bacon, "CIDA Regional Ocean Initiative Workshop: Lessons Learned", 22 *Marine Policy* 539 (1998), where the need for better communication is noted as a priority issue.

[36] Raymo, *supra* note 27, p. *xvii*. Dr. Raymo, a physicist, believes that one remedy is for people to experience science and appreciate how it has spiritually enriched our lives by drawing threads of connection between scientific knowledge and enduring human preoccupations. He advocates understanding ourselves in a scientific context as a small fragment of a complex universe, not as the pinnacle of Creation and the favoured children of the gods. Also see O.A. Houck, "Are Humans Part of the Ecosystem?", 28 *Environmental Law* 1 (1998).

[37] P.R. Ehrlich and A.H. Ehrlich, *Betrayal of Science and Reason: How Anti-environmental Rhetoric Threatens Our Future* (Washington, D.C.: Covelo, California: Island Press, 1996), p. 23.

D. Science and the Scientific Method

1) What is Science?

Science may be defined as "the organized, systematic enterprise that gathers knowledge about the world and condenses it into testable laws and principles".[38] Science is a *process* above all else, an eternal cycle of inquiry, feedback, breakthroughs, and discovery, with each cycle building on the previous level of understanding and feeding into the larger cycle of knowledge building. Although its product is certifiable knowledge,[39] science involves the sober weighing of evidence,[40] covering "phenomena that are deterministic or whose probability of occurrence can itself be stated precisely".[41] "The method of science, as messy, stodgy and grumpy as it may be, is far more important than the findings of science."[42] If philosophy is the contemplation of the unknown, scientists' goal is "turning as much philosophy as possible into science".[43] To this end, scientific endeavour is "a forum of free enquiry without perceived answers or agendas, aimed at determining the envelope of knowledge and the magnitude of ignorance".[44] For policy purposes, science is "the process for the production of knowledge and the reduction of uncertainty"**.**[45]

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38 Wilson, *supra* note 30, at p. 53.

39 A. Cournand, "The Code of the Scientist and Its Relationship to Ethics", 18 *Jurimetrics Journal* 225 (1978), pp. 226-7.

40 D.L. Ray and L.R. Guzzo, *Environmental Overkill: Whatever Happened to Common Sense?* (New York: HarperPerennial, 1993), p. 29.

41 A.M. Weinberg, "Science and Its Limits: The Regulator's Dilemma", 2 *Issues in Science and Technology* 59 (1985-6), at p. 61. Mathematics is the language of science, as only it offers the precision necessary for certifying knowledge.

42 Sagan, *supra* note 35, at p. 22.

43 Wilson, *supra* note 30, at p. 12. During the Enlightenment and the first few centuries, early modern science was referred to in disciplinary terms as natural philosophy. Consequently, many of the early scientists were also renowned philosophers, such as Decartes, Bacon, Condorcet, Hobbes, Hume, Locke, Newton, Voltaire, Kant, Leibniz, and Galileo. *Ibid.*, p. 22. Some are more readily recognised today as philosophers and not scientists.

44 R. Costanza and L. Cornwell, "The 4P Approach to Dealing with Scientific Uncertainty", *Environment,* Vol. 34, No. 9 (1992), p. 15.

45 J.B. Skjærseth, "Towards the End of Dumping in the North Sea", 16 *Marine Policy* 130 (1992), p. 137.

2) Scientific Proof

Confusion about scientific proof and scientists' ability to offer proof of fact contributes to unsound ecological policy. Scientists can only prove associations, within certain mathematically stated levels of probability. They cannot prove the absence of an association, merely the probability that one does not exist.[46] For example, scientists can never prove that a chemical is harmless.[47] A fundamental misperception is that science can offer, first, definitive proof, or certainty of knowledge and, second, proof of harmlessness as evidenced by the call for zero-discharge policies and reverse onus policies.[48]

3) Scientific Evidence

Scientific findings, no matter how persuasive the evidence, are always subject to refutation by new, emerging evidence.[49] This is such a basic tenet of science that scientists do not always think to point this out to others. "Scientific evidence is accretionary, built from blocks of evidence joined artfully by the blueprints and mortar

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[46] This is the logic of science proposed by Karl Popper, who referred to the "falsifiability" of science as the only "truth". See K.R. Popper, *The Logic of Scientific Discovery* (New York: Harper & Row Publishers, Incorporated, 1959). Also see L. Loevinger, "Standards of Proof in Law and Science", 32 *Jurimetrics Journal* 323 (1992), pp. 326-7.

[47] See J.S. Gray, "Integrating Precautionary Scientific Methods into Decision-making", in D. Freestone and E. Hey (eds.), *The Precautionary Principle in International Law: The Challenge of Implementation* (The Hague, London and Boston: Kluwer Law International, 1996), p. 136 and A.R.D. Stebbing, "Environmental Capacity and the Precautionary Principle", 24 *Marine Pollution Bulletin* 287 (1992).

[48] See Greenpeace International, "The Precautionary Approach in the Context of Land-based Sources of Marine Pollution", paper submitted to the Meeting of Experts on the Control of Marine Pollution from Land-based Sources, Montreal, Canada, 6-10 June 1994; R.C. Earll, "Commonsense and the Precautionary Principle: An Environmentalist's Perspective", 24 *Marine Pollution Bulletin* 182 (1992); and P. Johnston and M. Simmonds, "Letters: Precautionary Principle", 21 *Marine Pollution Bulletin* 402 (1990). For arguments against these strategies, see Gray, *ibid.*; Stebbing, *ibid.*; Peterman and McGonigle, *infra* note 199, p. 233; and D. Bodansky, "Commentary: The Precautionary Principle", *Environment*, Vol. 34, No. 3, pp. 4-5 (1992), p. 4. For a balanced view of the precautionary principle generally, and zero discharge in particular, see D. Bodansky, "The Precautionary Principle in US Environmental Law", in T. O'Riordan and J. Cameron (eds.), *Interpreting the Precautionary Principle* (London: Earthscan Publications Ltd., 1994), pp. 203-28.

[49] P. Castro and M.E. Huber, *Marine Biology,* 2nd ed. (Dubuque, Iowa: Wm. C. Brown Publishers, 1997), p. 15; Hollander, *supra* note 23, p. 117; and W. Gullett, "Environmental Protection and the "Precautionary Principle": A Response to Scientific Uncertainty in Environmental Management", 14 *Environmental and Planning Law Journal* (1997), p. 53.

of theory."[50] As evidence accumulates, theories inter-lock and knowledge gains universal acceptance.[51] This has two implications for policy-making processes. First, scientific statements couched in cautious language (such as "evidence suggests/ indicates that…") are often overlooked and the simple statements, ignoring the relevant qualifications, are accepted as definitive by non-scientists.

Second, when scientific opinion appears to reverse itself, actors are frustrated by what they interpret as ineptitude. Changes in scientific opinion are fundamental to knowledge building, as science does not proceed by consensus, and the process of gathering scientific knowledge is chaotic and controversial.[52] Scientists publish findings in reputable journals, which are first screened and edited by journal editors and then reviewed and commented on by knowledgeable peers, some of whom may have attempted to repeat the experiment to compare results. This necessary and legitimate process of review maintains scientific objectivity, preserves the integrity of scientific methodology, and keeps scientists honest, as the published papers must contain systematic procedures to ensure replicability.

Historically, the publication of new findings was confined to the peer-reviewed community, and the results were not newsworthy until peer debate had confirmed the reliability of the scientific methodology employed and the findings enjoyed general acceptance within the scientific community. Now, however, new scientific findings are often pushed into the public domain before or during peer review, as ecological issues increasingly dominate political agendas and the media scramble for newsworthy findings. The established and accepted process of scientific debate also enters the

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[50] Wilson, *supra* note 30, at p. 59.

[51] *Ibid*.

[52] W.D. Ruckelshaus, "Risk, Science, and Democracy", 1 *Issues in Science and Technology* 19 (1985), p. 24 and Ehrlich and Ehrlich, *supra* note 37, pp. 30-1.

public arena, confusing laymen who fail to appreciate that such peer review is a necessary part of the scientific knowledge-building process.[53]

Scientific debate may be evenly divided, or there may be a clear consensus with a few contrary opinions. Although it is always possible that future evidence may reveal today's scientific consensus to be incorrect, the public are advised to abide by the mainstream view until such time that it may be superseded by new scientific evidence.[54]

Finally, semantics are another source of confusion about scientific evidence. In science, a theory is a hypothesis that has been so extensively tested that scientists generally regard it as true, or, on the evidentiary scale, obvious (although the caveat always exists that emerging evidence may contradict it).[55] Most non-scientists, on the other hand, assume that the word "theory" means little more than an educated guess or, at best, an unproven idea. Thus, reference to a scientific theory might be expected to inspire confidence; yet, outside the scientific domain, it has little persuasive effect. It might even provoke disdain.

4) Scientific Thinking

It is important to clarify some of the terminology applied to scientific thinking, as the terms "reductionism", "holism", "deduction", and "induction" often confuse non-scientists. "Reductionism" and "holism" are used primarily by philosophers and sociologists of science, to encapsulate two approaches to scientific research. "Induction" and "deduction" describe two methods of scientific thinking.

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53 Ruckelshaus, *ibid.*, pp. 24-5.

54 Ehrlich and Ehrlich, *supra* note 37, pp. 30-1. The mass media often cite scientists whose opinions run contrary to the mainstream consensus. Skeptics may or may not be peer-reviewed, which is a crucial distinction to make when weighing the reliability and utility of the opinions proffered.

55 Castro and Huber, *supra* note 49, p. 16.

(a) Reductionism and Systemic Thinking

With the birth of modern science came the Enlightenment and "reductionism" in scientific research. Up to that time, natural philosophers – who were in fact early modern scientists – took a holistic approach, studying universal scientific laws and pondering nature's grand scheme, as religious doctrine and the lack of scientific tools and instruments impeded research into specifics.[56] However, technological advances, in particular the microscope, and curiosity about the constituents of nature led to a new research strategy, aptly named reductionism, that permitted scientists to probe otherwise impenetrably complex systems**.**[57]

Reductionism largely dominated scientific study until the discipline of ecology emerged in the 1960's, encouraging a broader integrative approach to science in the form of "systemic", or "systems thinking".[58] The term "systemic thinking" may be preferable to "holism", as the latter, given its association with environmental ethics, now transcends the field of science and may carry connotations of bias.[59]

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[56] Wilson, *supra* note 30, pp. 54-5. For further discussion on reductionism, see J. Lovelock, "The Greening of Science", in T. Wakeford and M. Walters (eds.), *Science for the Earth: Can Science Make the World a Better Place?* (Chichester, England: John Wiley & Sons, 1995), p. 40; D. Suzuki, "Blinded by Our Minds", in Wakeford and Walters (eds.), *ibid.*, pp. 3-17; E.P. Odum, "The Emergence of Ecology as a New Integrative Discipline", 195 *Science* 1289 (1977); and B. Wynne and S. Mayer, "How Science Fails the Environment", *New Scientist,* Vol. 138, No. 1876, pp. 32-5 (1993).

[57] Wilson, *supra* note 30, p. 54. Wilson poetically encapsulates reductionism: "The love of complexity without reductionism makes art; the love of complexity with reductionism makes science". *Ibid.*, at p. 54. Reductionism seeks to reduce life and inter-relationships to the laws of physics.

[58] See F. Capra, *The Web of Life: A New Scientific Understanding of Living Systems* (New York: Anchor Books, Doubleday, 1996), pp. 17-35 for a condensed and insightful history of reductionism, holism, and systemic thinking in science, and in particular biology. Systems thinking emanates from the holistic thinking of the early modern scientists, when science was within the realm of natural philosophy. Reductionism has allowed philosophy to become science through investigation and rigorous testing.

[59] The convoluted history of the relationships among science, biology, ecology, and environmental ethics leads to misunderstanding and confusion for non-scientists. Early ethicists (the Romantics) rejected the mechanistic, or reductionist, scientific view that reduced life to laws of chemistry and physics. The near-simultaneous rise of the "vitalist" school of biology, holistic in approach and returning to science some of its mystique and "soul", bonded science with ethics. The depth of confusion is evident in environmentalists' reverence for ecology (a science), but paradoxical enduring distrust of science. See A. Wildavsky, *But Is It True?: A Citizen's Guide to the Environmental Health and Safety Issues* (Cambridge, Massachusetts and London, England: Harvard University Press, 1997), p. 441. Scientific reductionism is regarded as the epitome of a narrow, cold, and soulless science, while ecology is applauded as a newly founded ethical science. See Capra, *ibid.*, pp. 17-35. Unfortunately, the scientific definitions are confused with social usage of the same terms.

Environmentalists often cite reductionism as a major failing of science,[60] but it is a valid and necessary endeavour to understand the functional whole.[61] It is ironic that systemic thinking has been successful only because reductionist research had first provided in-depth knowledge and made it possible to rationally synthesise the components of natural systems.[62]

Scientists today have the knowledge and technology to contemplate scientific complexities across disciplinary lines and to understand ramifications of their research in a context broader than previously possible. As scientific disciplines have come together, science, using both reductionism and systemic thinking, has entered the age of "consilience".[63] Evidence of this includes the emergence of hybrid sciences such as biochemistry and molecular biology, and the transcending of specific laws into more general laws, which are ultimately reducible to universal laws of physics.[64]

(b) Induction and Deduction

Scientists generally agree that both *induction* and *deduction* are indispensable elements in scientific thinking.[65] In induction, a scientist makes a series of independent observations and then draws a general conclusion.[66] An example is that by observing gills in a sailfish, a shark, and a tuna, all known to be fish, a scientist may conclude

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60 Wynne and Mayer, *supra* note 56. Also see Wilson, *supra* note 30, at p. 54, where he notes that "[c]ritics of science sometimes portray reductionism as an obsessive disorder".

61 Odum, *supra* note 56, p. 1289.

62 Wilson, *supra* note 30, pp. 54-5.

63 *Ibid.*, p. 55.

64 *Ibid.*, pp. 54-5. Also see E.P. Odum, *Ecology and Our Endangered Life-support System,* 2nd ed. (Sunderland, Massachusetts: Sinauer Associates, Inc., 1993), p. *xiii,* for support for consilience beyond the sciences, where it notes the rise of "interface disciplines', such as ecological economics, ecology-engineering (restoration ecology), ecology-wildlife management, ecology-taxonomy (biodiversity), ecology-chemistry (ecotoxicology), ecology-geology (landscape ecology), ecology-hydrology (wetland ecology), and ecology-philosophy (environmental ethics).

65 Castro and Huber, *supra* note 49, p. 11. Scientific thinking generates not scientific conclusions, but rather scientific statements that have yet to be scientifically tested, called hypothesis.

66 *Ibid*.

that all fish have gills.[67] The inherent risk is that the scientist will arrive at a false statement, such as "all marine animals (including mammals) have gills".[68] For this reason, the quality and quantity of observations leading to a particular statement are highly relevant to any conclusion, as is the process of deduction.[69] Deduction is the process of moving from a general statement to the specific. The general statement may emanate from intuition or a hunch, but it is often a result of inductive thinking.[70] In the above example, a scientist, inducing that all marine animals have gills, may deduce (incorrectly) that whales have gills.[71]

5) The Scientific Method

As science is a "process of intense criticism",[72] a methodological framework evolved to preserve scientific integrity and distinguish science from pseudo-science. Referred to as the scientific method, it entails formulating a scientific statement known as the hypothesis, testing the hypothesis, and accepting or rejecting the hypothesis based on the results. The criterion of repeatability by independent scientists is vital to the scientific method, to confirm the accuracy of the process in relation to the conclusions. This is embodied in the peer review process, previously discussed.

(a) The Hypothesis

A valid scientific hypothesis is a statement about something that (a) might be correct and (b) is testable.[73] To be testable, a valid scientific hypothesis has to be framed so as

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67 *Ibid*.

68 *Ibid*.

69 *Ibid.*, p. 12.

70 *Ibid*.

71 *Ibid*.

72 Dunbar, *supra* note 15, at p. 31.

73 Castro and Huber, *supra* note 49, p. 14.

to render it *capable of potentially being proven false*.[74] For example, the hypothesis, "there are mermaids in the ocean" is not scientifically valid, as scientists can never prove there are none, as mermaids may in fact be there, but as yet have not been found.[75] However, the hypothesis, "there are no mermaids in the ocean" is scientifically valid, as finding one mermaid will disprove it.[76] When determining whether a substance or activity has an effect on the environment, the researcher traditionally operates under the hypothesis that there is no effect, called the null hypothesis (H_o), as this can be proven false by finding an effect.[77] An alternative hypothesis (H_A), that there is an effect, will be accepted if the null hypothesis is rejected.

(b) Testing the Hypothesis

Scientists test hypotheses in two ways: by controlled experiment in the laboratory, and through observations in the field (which can be termed "uncontrolled" experiments). Controlled laboratory experiments, although reproducible by peers for verification's sake, may produce results that do not reveal a comprehensive picture, as the innumerable variables acting on an organism in the wild cannot be recreated in an artificial laboratory setting. Thus, laboratory results must be extrapolated with caution, as the experimental conditions are well defined, and the results are relevant only to those specific conditions.[78]

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74 *Ibid*.

75 *Ibid.*, pp. 13-14.

76 *Ibid*. and see note 46, above, which notes Popper's "falsifiability" requirement of hypotheses.

77 It is emphasised that scientists think in terms of accepting and rejecting hypothesis, and not proving them. See Castro and Huber, *ibid*., p. 14.

78 For example, scientists employ tests, such as the $LC_{96,}$ which measures the dose of a compound it takes to kill 50% of the exposed population over 96 hours. These results are *limited to the precise doses and conditions involved in the test*, such as temperature, salinity, presence of other compounds, test species and life stage of that species, and other factors. See S.M. Evans, "Control of Marine Pollution Generated by Offshore Oil and

Laboratory experiments are productive and necessary, contributing to the database of information and allowing scientists to accept narrow hypotheses. They can help interpret field observations and contribute to knowledge building. However, it is vital that laymen understand the limitations inherent in the extrapolation of laboratory results to the natural environment.

Field experiments are often unreliable, as too many variables are beyond the control of the researcher and the experiment cannot be accurately reproduced to verify the results. The value of field observations is that accumulated data, particularly over the course of seasons and years, can reveal trends and unexpected events that can be further investigated, often via controlled experiments.[79] Both controlled experiments and field observation are necessary and complimentary means of testing hypotheses. As a scientific discipline highly reliant on field observations, ecology has lent credibility to the dual means of testing.

(c) Peer Review

The peer review process is intrinsic, and essential, to the testing of hypotheses. Publication in scientific journals implies that the experimental methodology involved was fundamentally sound because qualified editors approved its publication. Publication provides experts in the relevant field with an opportunity to (a) review the process and parameters involved, (b) distinguish and compare the work from existing

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Gas Exploration and Exploitation: The Scotian Shelf", 10 *Marine Policy* 258 (1986). Also see P. Johnston and M. Simmonds, *supra* note 48, p. 402.

79 Surveys of geographically distant communities / species can yield data for comparative purposes and establishing baselines. Also, anecdotal information based on observation can highlight potential concerns, such as the case with endocrine-disrupting compounds (DDT, PCBs, and other POPs). See Colborn, *et al*., *supra* note 14 and D.L. VanderZwaag, "International Law and Arctic Marine Conservation and Protection: A Slushy, Shifting Seascape", 9 *The Georgetown International Environmental Law Review* 303 (1997). Note that some controlled experiments have indicated (not proven) that endocrine disruption concerns may not be as serious as initially anticipated. See S. Safe, "Another Enviro-Scare Debunked", *Asian Wall Street Journal*, 25 August 1997, p. 6 and S. Safe, "Endocrine Disruptors: New Toxic Menace?", in R. Bailey (ed.), *Earth Report 2000: Revisiting the True State of the Planet* (New York: McGraw-Hill, Inc., 2000), pp. 189-202.

evidence, (c) repeat the experiment, and (d) comment on it in subsequently in the peer-reviewed forum. Scientists take publication very seriously and are quick to complain to editors if they believe an “unscientific” article has been published in a science journal.[80] The norm among scientists is to wait until a statistically high probability (usually 95%) exists that a hypothesis is correct before divulging it. As a scientist’s professional reputation rests on his or her scrupulous adherence to the scientific method, most are uncomfortable offering opinions without the degree of certainty that comes from extensive research. This frustrates policy-makers, who require opinions quickly and may be content with a lower standard of probability of occurrence. This is an area of contention, but it is resolvable with a little effort and understanding by actors in both domains.

E. Scientists and Lawyers

1) Parallels between Science and Law

Lawyers and scientists are among society’s intellectual elite. Both professions require impressive academic credentials for admission to competitive and respected university programmes. Success requires perseverance, dedication, and effort, as well as native intelligence. Both professions produce critical and important thinkers and problem-solvers who provide valuable and essential services to society.

Paradoxically, each profession is both respected and mistrusted by the public. This was noted previously with regard to scientists, and in the case of the legal profession, one need only consider the plethora of “lawyer jokes” and the readiness with which the media and entertainment industry ridicule lawyers. Most people, however, accept lawyers as a necessary part of modern life, and have direct or indirect contact with

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80 See J.E. Portmann and V. Pravdic, “Comment”, 7 *Chemistry and Ecology* 135 (1992) and J.M. Bewers, “The Declining Influence of Science on Marine Environmental Policy”, 10 *Chemistry and Ecology* 9 (1995), p. 14.

them – and at least a rudimentary understanding of law – as a result of property transactions, wills, litigation, the resolution of domestic disputes, corporate affairs, or high-profile cases in the media. Lawyers and the legal profession are also central to the story lines of television programmes, novels, and films. By contrast, the public have little or no contact with scientists, who remain professionally inaccessible, and the scientific and ecological domains, for the most part, have failed to inspire the entertainment business.[81]

Both professions strive to ascertain facts that are based on evidence or proof.[82] Scientists require data in order to accept or reject a hypothesis, and lawyers must collect and use evidence when drafting documents, negotiating, mediating, arbitrating, and arguing for a client. Both legal evidence and scientific data comprise facts that are used to make an intellectual determination based on the evidentiary burden of proof.[83] In both cases meticulous care, substantiation of detail, precision of presentation, immaculate record keeping, and the exercise of circumspection influence professional success and reputation among peers, the latter being vital to both lawyers and scientists.

The diverse and complex nature of their respective professions requires that scientists and lawyers specialise within a specific field. Although individual practitioners in both professions will have general knowledge outside their areas of specialisation, in neither profession are they considered competent to provide professional advice outside their respective areas of expertise, and such opinions, if rendered, should be

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81 This is changing in some jurisdictions, some of which have dedicated channels broadcasting science programmes. Nature and environmental documentaries are more prevalent in the last decade. These are excellent for informing the public about ecology, but scientific processes are largely ignored.

82 Loevinger, *supra* note 46. This article provides a cogent analysis of how the respective professions use the evidence collected, and it identifies the inherent differences and similarities.

83 *Ibid.*, p. 323.

regarded as those of non-experts.[84] Society discriminates among legal specialisations more readily than among scientific specialisations.

The practitioners of science and law have common objectives, namely "to be wholly rational, to organize and institutionalise the search for truthful data, and, above all, to seek truthful data as the basis for judgments".[85] Both law and science are concerned with securing agreement from individuals on specific issues.[86]

In short, lawyers and scientists are professionals committed to providing necessary services to society. Both professions are bound by rigorous codes, adherence to which protects their professional stature within their respective communities. Acknowledging these many fundamental similarities may help bridge the schism between the two professions, and render the differences less intractable.

2) Differences between Science and Law

The aims of science and law are different. Science and law differ in the way they seek to reach agreement among individuals. Scientists are motivated by the search for truth, driven by curiosity,[87] and, through necessity, are objective, prospective, and inquisitorial, since discovering the truth is a process of posing successive open-ended questions with no final verdict.[88] Lawyers, including those in public law, are

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84 This is noteworthy as non-scientists often fail to appreciate the degree of scientific knowledge necessary for expertise in a topic. This is relevant in the courtroom, as scientific illiteracy of legal fact-finders leads to the acceptance of poor, fringe, marginal, pseudo-, and "junk" science, often at the expense of sound science that may have been offered. See Jasanoff, *supra* note 8, p. 345. With specific reference to environmental science, reputable and distinguished scientists confuse the issue by offering opinions that contradict those of peer-reviewed scientists when commenting publicly on topics outside their research area. See G.E. Brown, "Environmental Science Under Siege in the U.S. Congress", *Environment*, Vol. 39, No. 2, pp. 12-31 (1997).

85 L. Loevinger, "Law and Science as Rival Systems", 8 *Jurimetrics Journal* 63 (1966), at p. 66.

86 *Ibid.*, p. 66.

87 Scientists, like most individuals, can be motivated by the promise of financial reward, prestige, and other benefits, but an inborn curiosity about how or why things are as they are is inherent in virtually all those who enter the domain of science.

88 A. Stewart, "Environmental Risk Assessment: The Divergent Methodologies of Economists, Lawyers and Scientists", 10 *Environmental and Planning Law Journal* 10 (1993), p. 13 and Loevinger, *supra* note 46, p. 328.

retrospective and adversarial, engaged in a dialectic process of subjectively reaching a conclusion that is just and fair, or at least perceived to be so.[89] Most simply put, scientists speculate on the outcome, while lawyers try to shape the outcome.

Objectivity, the hallmark of science, is maintained through the process of peer review and the requirement that experiments be capable of replication,[90] and scientists are professionally accountable for their product.[91] By contrast, lawyers are not accountable to their profession in the same way, since their peers do not critique their work in the same way.[92] Lawmakers "require no proof to make laws and are free to act on the basis of subjective judgment, bias and whim".[93] Lawmakers, unlike scientists, are admittedly and legitimately influenced by social, cultural, and often-conflicting pressures to reach a particular decision.[94] Scientists are, in theory, relieved of this pressure, although other factors, including funding and employment status, may indirectly influence research, most often by directing or imposing boundaries on the scope of research.

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89 *Ibid*. Also see Loevinger, *supra* note 85, p. 66. Loevinger notes that law, including the legislative process, is best described as dialectic, as it relies on testimony from human observers that is tested by examination and cross-examination, and subjectively weighed in accordance with the rules of procedure. This is very different from the testing of scientific observations.

90 These are components of the scientific method, the process by which scientists reach conclusions. See Wilson, *supra* note 30, p. 53.

91 Compounding the antipathy towards science is the failure to determine the quality of science used in legal and legislative processes. The problem with science is that a self-proclaimed expert "hired gun" can always be found to support a position. See Jasanoff, *supra* note 8, p. 345 and generally note 88, above.

92 While professional codes of conduct are rigorously upheld within the legal profession, particularly with respect to professional misconduct, publication in legal and policy journals are primarily for information sharing, idea generation, and prestige (related to professional advancement). Publication in legal journals provides fodder for debate, but publication in scientific journals maintaining scientific objectivity and adds to pool of scientific knowledge.

93 Loevinger, *supra* note 46, at p. 329.

94 For instance, in the field of environmental policy, the public may pressure legislators to relax environmental regulations to retain jobs in a particular industry, or environmental tax options may be rejected to avoid possible impacts on industry. In the 2000's, determiners are as likely to be influenced by green lobbies, pressing for costly, but ecologically unwarranted measures. Science, without an institutionalised role, may not have significant input, and the resultant policies may not be ecologically or economically sound.

The presentation of precise and accurate data is another area of divergence. Scientists who creatively interpret data risk professional embarrassment.[95] Conversely, the hallmark of a gifted lawyer is the ability to creatively interpret facts and position words and facts within accepted boundaries.

The fundamental difference between the two professions is the mindset. The scientific mindset is that of an inquisitive, open-minded, process-oriented reviewer and interpreter.[96] The traditional legal mindset is best described as short-term focused and results-oriented, as lawyers purposefully undertake action, whether it be drafting environmental protection legislation or defending a client. A clash is inevitable when the results-oriented, short-term, temporally-focused lawmaker requires scientific information immediately from the consensus-driven scientist governed by long-term temporal and spatial considerations.[97]

The pride of a scientist is precision, as the reliability of results is directly related to the care taken during an experiment. Lawyers are equally precise, particularly as wordsmiths. The type of precision in each discipline may clash, leading to confusion. The definition of marine pollution is one example of this. The original definition by GESAMP states in part, "Pollution means the introduction by man… *resulting in such deleterious effects* as harm to living resources …".[98] Thus, scientific precision defines

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95 It is difficult for scientists to deceive peers, as nature is the judge of their enterprise and the ultimate arbiter of scientific disputes. See Ehrlich and Ehrlich, *supra* note 37, p. 27. A code of ethics for scientists contains terms such as "honesty", "objectivity", "tolerance", "doubt of certitude", and "unselfish engagement". See A. Cournand, *supra* note 39, pp. 226-7.

96 The objectivity of scientists is often questioned as they, like all humans, are subject to the vagaries of human nature. Although the scientific method, by design, filters out subjectivity, fierce debates among scientists often reveal commitment to their respective value systems.

97 M.K. Wali and R.L. Burgess, "The Interface of Ecology and Law: Science, the Legal Obligation, and Public Policy", 12 *Syracuse Journal of International Law and Commerce* 221 (1985), p. 229 and D. Jamieson, "Scientific Uncertainty and the Political Process", 545 *The Annals of the American Academy of Political and Social Science* 35 (1996), p. 42.

98 See GESAMP, *supra* note 1 and GESAMP, *The State of the Marine Environment*, GESAMP Reports and Studies No. 39, 1990.

pollution as a "distinct event" where "deleterious effects" are scientifically measurable. Factually, it is or is not pollution. The legal definition adapted from the scientific definition and commonly found in many treaties, states in part, "pollution means the introduction …which results *or is likely to result in* such deleterious effects…".[99] In legal usage, pollution transcends fact to become a *possible eventuality* – a wholly different result from the factual finding of science. Although broadened in the interest of legal precision to encompass "possible" acts of pollution as well as factual acts, the legal definition obscures the scientifically precise factual distinction between contamination and pollution.[100] Such variance in the use of basic terms not only renders communication difficult, but also undermines the scientist-lawyer relationship and the common aim of ecological improvement.[101]

3) The Nature of Laws and the Laws of Nature

Perhaps the easiest way to understand the difference between the professions is to examine their fundamental nature. Laws regulating and controlling the human environment, activities, relationships, and conduct are anthropocentrically oriented, made by humans,[102] and attempt to justify and fairly balance the interests of stakeholders. Evidence of this arbitrariness is the variations in laws, both procedurally and substantively, across and among jurisdictions. Such purposeful laws should reflect

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[99] United Nations Convention on the Law of the Sea, 10 December 1982, UN Doc. A/Conf.62/122 (1982), 21 ILM 1261 (1982), Article 1(4) (emphasis added).

[100] Scientists lament the obscuring of terms and the loss of the scientifically defined term, "contamination". See Bewers, *supra* note 80, pp. 11-12 and R.B. Clark, "Assessing Marine Pollution and Its Remedies", 10 *South African Journal of Marine Science* 341 (1991), p. 341. See Chapter 1, herein, for a discussion on contamination and pollution.

[101] A survey revealed that most biologists believe pollution was always damaging, even where the definition included only the possibility of damage. See L.M. Warren, *supra* note 6, p. 105.

[102] C. Ray, "Ecology, Law and the Marine Revolution", in E. Young and Lord Ritchie-Calder (eds.), *Pacem In Maribus*: *The Ocean Environment*, Volume V (Malta: The Royal University of Malta Press, 1971), p. 99.

common sense and societal values, and they must be capable of rational amendment in order to keep abreast of changing values and new information.[103]

Conversely, the laws of nature are beyond human influence and cannot be amended or repealed by humans or technology.[104] Although this may not be strictly true anymore, given scientific advances, is a caveat that should not be forgotten. In fashioning human-made laws, actors should remember that any apparent victory over the human environment would probably lose on appeal in nature's court, where natural rules are strictly applied without reference to anthropocentric concepts of equity or fairness. The rules of nature are reducible to the laws of physics, and man is powerless to change this on a macro scale.

4) Cross-fertilisation within the Domains of Science and Law

As environmental issues have come to the fore, many practising ecologists have become involved with legal processes and have studied law, but few if any lawyers have studied ecology.[105] Scientists, as social beings and members of the global citizenry, cannot help but develop an appreciation of socio-economic and regulatory issues. By comparison, lawyers remain scientifically illiterate, as their education is primarily arts oriented and societal arrangements fail to provide the opportunity to study even the rudiments of science.[106] It was noted a few decades ago that "[l]aw is one of the last strongholds of the scientifically illiterate".[107] A more recent survey reconfirms a profound lack of basic scientific understanding on the part of non-

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[103] *Ibid*.

[104] *Ibid*.

[105] Wali and Burgess, *supra* note 97, p. 239.

[106] See Warren, *supra* note 6, p. 99; Hardin, *supra* note 15; Wali and Burgess, *ibid.*; Orr, *supra* note 11; and Loevinger, *supra* note 46. These are just a few of the articles describing scientific illiteracy in the legal domain.

[107] I.S. Shapiro, "Science and Law", 17 *Jurimetrics Journal* 195 (1977), p. 196.

scientists, particularly lawyers, and, interestingly, a different problem-solving approach to the more complex environmental issues.[108] Recently, publications indicate that scientific literacy remains a problem.[109]

Although some universities and institutes offer cross-disciplinary courses and programmes for environmental management, and some non-scientific actors are becoming science-literate, there remains insufficient cross-fertilisation between the science and law domains. The consequence of this is most evident in the debate surrounding the precautionary concept.

F. The Precautionary Concept and Scientific Caution

1) Philosophy of the Precautionary Concept

The precautionary concept,[110] commonly known as the precautionary principle or precautionary approach, is an amorphous policy/legal tool that is many things to many people.[111] Diverse and conflicting interpretations give rise to questions as to how it will become manifest as a norm of international customary law.[112] Regardless, the

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[108] Warren, *supra* note 6, p. 105.

[109] See Appendix 1, The Paradox of Science, herein. Also, see generally J. Cairns Jr., "Healing the World's Ecological Wounds", 8 *International Journal of Sustainable Development and World Ecology* 185 (2001); N. Robinson, "Legal Systems, Decisionmaking, and the Science of Earth's Systems: Procedural Missing Links", 27 *Ecology Law Quarterly* 1077 (2000); and GESAMP, 2001b, *supra* note 1.

[110] Various terms include precautionary approach, precautionary principle, precautionary concept, anticipatory and precautionary measures, and precautionary policy. For distinctions among the terms, see E. Hey, "The Precautionary Concept in Environmental Policy and Law: Institutionalizing Caution", 4 *Georgetown International Law Review* 303 (1992), pp. 304-5. Others use the terms interchangeably, noting that a fine distinction may exist. See D.L. VanderZwaag, *Canada and Marine Environmental Protection: Charting a Legal Course Towards Sustainable Development* (London, The Hague, Boston: Kluwer Law International, 1995), p. 21. For simplicity's sake, the term "precautionary concept" will be used herein. It is not intended to be a new or replacement term, theory, principle, or policy, but is meant to encompass the notion of precaution in its many formulations and usages.

[111] See A.E. Boyle, "Protecting the Marine Environment: Some Problems and Developments in the Law of the Sea", 16 *Marine Policy* 79 (1992), p. 81; VanderZwaag, *ibid.*, pp. 13-23; and D. Fleming, "The Economics of Taking Care: An Evaluation of the Precautionary Principle", in D. Freestone and E. Hey (eds.), *The Precautionary Principle in International Law: The Challenge of Implementation* (The Hague, London and Boston: Kluwer Law International, 1996), p. 147.

[112] See O. McIntyre and T. Mosedale, "The Precautionary Principle as a Norm of Customary International Law", 9 *Journal of Environmental Law* 221 (1997), p. 241 and J. Cameron, and W. Wade-Gery, "Addressing Uncertainty: Law, Policy and the Development of the Precautionary Principle", CSERGE Working Paper GEC 92-43 (Centre for Social and Economic Research on the Global Environment, University of East Anglia and

precautionary concept is philosophically embedded in international environmental law, ranking among the most significant legal developments since the Stockholm Conference.[113] It has become an accepted legal principle that increasingly permeates policy-making processes.[114]

The precautionary concept represents a paradigm shift in environmental regulation. It has been described as a shift from a focus on assimilative capacity, or permissive regulation, to an anticipatory or cautious regime;[115] from a purely tort-based approach to an anticipatory approach;[116] or from the sectoral treaty model to a cautionary and holistic model.[117] In practical terms, it has been interpreted as shifting the legal burden of proof, from that of having to prove harm to having to prove harmlessness, or at least the probability of harmlessness.[118] Philosophically, it is an ethical evolution towards

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University College London, 1992). For a range of perspectives, see J.M. Macdonald, "Appreciating the Precautionary Principle as an Ethical Evolution in Ocean Management", 26 *Ocean Development and International Law* 255 (1995); J.M. Broadus, "Creature Feature Too: *Principus precautionarium*", *Oceanus,* Vol. 35, No. 1, pp. 6-7 (1992-3), p. 6; Boyle, *ibid.*, p. 85; L. Gündling, "The Status in International Law of the Principle of Precautionary Action", in D. Freestone and T. IJIstra (eds.), *The North Sea: Perspectives on Regional Environmental Co-operation*, Special Issue of the International Journal of Estuarine and Coastal Law (London, Dordrecht, Boston: Graham & Trotman/Martinus Nijhoff, 1990), pp. 23-30; A. Nollkaemper, "The Precautionary Principle in International Law: What's New Under the Sun?", 22 *Marine Pollution Bulletin* 107 (1991); D. Bodansky, "Scientific Uncertainty and the Precautionary Principle", *Environment*, Vol. 33, No. 7, pp. 4-5, 43-45 (1991); and Bodansky, *supra* note 48. See Appendix 2, The Precautionary Concept, herein, for further reading.

113 See J. Cameron and J. Abouchar, "The Precautionary Principle: A Fundamental Principle of Law and Policy for the Protection of the Global Environment", 14 *Boston College International and Comparative Law Review* 1 (1991), p. 27; D. Freestone and E. Hey, "Implementing the Precautionary Principle: Challenges and Opportunities", in D. Freestone and E. Hey (eds.), *The Precautionary Principle in International Law: The Challenge of Implementation* (The Hague, London and Boston: Kluwer Law International, 1996), p. 268; J. Lawrence and D. Taylor, "Letters: Statistics and the Precautionary Principle", 21 *Marine Pollution Bulletin* 598 (1990), p. 599; and Gullett, *supra* note 49.

114 See C. Raffensperger and J. Tickner, *Protecting Human Health and the Environment: Implementing the Precautionary Principle* (Washington, D.C.: Island Press, 1999).

115 R.M. M'Gonigle, T.L. Jamieson, M.K. McAllister, and R.M. Peterman, "Taking Uncertainty Seriously: From Permissive Regulation to Preventative Design in Environmental Decision Making", 32 *Osgoode Hall Law Journal* 99 (1994); VanderZwaag, *supra* note 110, p. 13; and Macdonald, *supra* note 112, pp. 265-7.

116 Boyle, *supra* note 111, p. 81.

117 W.J. Davis, "The Need for a New Global Ocean Governance System", in J.M. Van Dyke, *et al*. (eds.), *Freedom for the Seas in the 21st Century: Ocean Governance and Environmental Harmony* (Washington, D.C. and Covelo, California: Island Press, 1993), p. 165.

118 Macdonald, *supra* note 112 and VanderZwaag, *supra* note 110, p. 25. See E. Hey, "The Precautionary Approach: Implications of the Revision of the Oslo and Paris Convention", 15 *Marine Policy* 244 (1991), p. 248. It must be remembered that a complete reversal is impossible, as scientists cannot prove harmlessness, but only the probability of harmlessness.

erring on the side of caution, where doubt exists about effects on future generations or the ecosphere.[119] The implications for policy-making are that it provides justification for action where no justification previously existed.[120]

At its most basic level, the precautionary concept embodies the common sense notion that it is better to prevent environmental damage than to wait for scientific certainty of harm. Systemic degradation, together with epistemological scientific uncertainty, places the precautionary concept at the very interface of law and science, and compels the two disciplines to interact in unprecedented ways.

Conflicting views about the precautionary concept block its institutionalisation.[121] Both scientists and lawyers agree, at the most general level, on the philosophical soundness of a precautionary concept,[122] but opinions diverge largely along disciplinary lines as to interpretation and implementation. Although the associated socio-economic, political, and legal complexities must be fully acknowledged, the actors in MDLBA policy-making processes must put the debate in context by appreciating the relationship between science and the precautionary concept.

The resultant debate concerning the precautionary concept is complex and multi-faceted, but it essentially revolves around (a) scientific uncertainty and the scientific measure of assimilative capacity, and (b) determiners and enablers' perceptions of, or faith in, scientific ability to predict and quantify the assimilative capacity of coastal,

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[119] Gullett, *supra* note 49, p. 54 and Cameron and Abouchar, *supra* note 113, p. 1. Both articles quote from Gro Harlem Brundtland's keynote speech during the Opening Session of the Conference on "Action for a Common Future", Bergen, Norway (8 May 1990), in which she stated, "If we err in our decisions affecting the future of our children and our planet, let us err on the side of caution". Also see Macdonald, *ibid*.

[120] P. Stein, "A Cautious Application of the Precautionary Principle", 2 *Environmental Law Review* 1 (2000).

[121] See Hey, *supra* note 110; Macdonald, *supra* note 112; and McIntyre and Mosedale, *supra* note 112. Two excellent multi-disciplinary texts discussing the relevant issues are Freestone and Hey, *supra* note 113 and T. O'Riordan and J. Cameron (eds.), *Interpreting the Precautionary Principle* (London: Earthscan Publications Ltd., 1994).

[122] J.S. Gray, "Letters: Statistics and the Precautionary Principle – Professor Gray Replies", 21 *Marine Pollution Bulletin* 599 (1990), p. 599.

marine, and other habitats. It is proposed that the debate arises largely because scientific uncertainty and the nature and purpose of the assimilative capacity are misunderstood, primarily by actors in the legal domain.[123] Scientists disturbed by ecologically and economically unsound legal interpretations and applications of the precautionary concept have spoken out, albeit primarily in scientific forums, exposing in full the tension between the scientific and legal domains.[124]

The ensuing debate between scientists and lawyers may prove to be a watershed for the "consilience" of science and law, as the sound philosophy underlying the precautionary concept could unite the two domains. To this end, the following sections review scientific caution in relation to both scientific uncertainty and assimilative capacity, and, finally, its interface with the precautionary concept.

2) *Scientific Uncertainty*

Scientific uncertainty – that which remains unknown or is disputed – drives the debate. It is a fact with which scientists must contend on a daily basis, but for non-scientists the role of scientific uncertainty and the methods through which scientists address it are cloaked in mystery. Uncertainty is inherent in scientific endeavours, and is unlikely to be eliminated in investigations into highly complex systems.[125] Thus, determiners and enablers, and other actors, have little choice but to confront it. How it

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[123] See R.G.V. Boelens, "The London Dumping Convention: Its Development and Significance to Marine Pollution Control", in P.G. Wells and J. Gratwick (eds.), *Canadian Conference on Marine Environmental Quality: Proceedings* (Halifax, Nova Scotia: The International Institute for Transportation and Ocean Policy Studies (IITOPS), 1988), p. 40.

[124] See Appendix 2, The Precautionary Concept, herein.

[125] S.O. Funtowicz and J.R. Ravetz, "Uncertainty, Complexity and Post-normal Science", 13 *Environmental Toxicology and Chemistry* 1881 (1994), p. 1881. Uncertainty can be reduced through additional research, but never eliminated, as there are too many variables that may influence the cause-effect relationship. Also see C. N. Haas, "Editorial: Acting in the Face of Uncertainty", 62 *Research Journal of the Water Pollution Control Federation* 115 (1990).

is confronted may determine the ecological and economic effectiveness of decisions, and the tenor of inter-disciplinary relationships.

Three points may help in understanding scientific uncertainty. First, the fact that investigators articulate scientific uncertainty should be seen as a hallmark of honest science, rather than a sign of poor science.[126] Second, scientific uncertainty is not related to the quality of scientific data, nor does high-quality data imply low levels of scientific uncertainty.[127] Uncertainty is an intrinsic and fundamental property of science. Finally, science is the complete state of knowledge on a subject, including both "knowns" and "unknowns".[128] To understand the present and potential role of science in policy-making, actors need to understand, first, scientific uncertainty and, second, its relationship to both assimilative capacity and the precautionary concept.

Scientific uncertainty gained prominence with the shift in policy emphasis from visible and localised pollution of the 1950-60's to insidious, invisible systemic degradation issues of the 1980-90's.[129] Increased public awareness of environmental issues and pressure on politicians to act highlighted scientific uncertainty at a time when definitive answers were demanded. Scientific uncertainty limited the predictive capability of scientists, who could not provide information on complex ecosystems and certain cause-effect relationships with the same high degree of probability applied to

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[126] Brown, *supra* note 84, p. 19.

[127] S.O. Funtowicz and J.R. Ravetz, "A New Scientific Methodology for Global Environmental Issues", in R. Costanza (ed.), *Ecological Economics: The Science and Management of Sustainability* (New York: Columbia University Press, 1991), p. 141. Lawyers and policy-makers have almost universally ignored issues of quality assurance in the data used for decision-making processes. *Ibid*.

[128] D. Fisk, "Environmental Science and Environmental Law", 10 *Journal of Environmental Law* 3 (1998), pp. 3-4.

[129] R.W. Kates, "Success, Strain, and Surprise", 2 *Issues in Science and Technology* 46 (1985-86), p. 47 and Weinberg, *supra* note 41.

simplistic pollution issues.[130] Actors wishing to take action became baffled by the perceived inability of science to direct them. Although scientific knowledge has grown immensely, scientific uncertainty remains an issue, as does the mistrust of science.

Scientists, through investigation and experimentation, can consciously reduce, but never eliminate, scientific uncertainties. The accumulation of data over time will naturally reduce all types and levels of uncertainty, as ecospheric processes, from sub-cellular to global inter-connections, become better understood. However, new technology and new environmental threats raise new issues that require time and effort to understand in intricate detail. In addition, communication lapses among scientists, poor scientific understanding by determiners and enablers, and the anti-science voices in the mass media often exacerbate confusion over – and help to exaggerate – the degree and relevance of uncertainty surrounding an issue. Scientific uncertainty needs to be kept in perspective to facilitate effective decision-making.

(a) Levels of Scientific Uncertainty

Three levels of uncertainty can be identified in the scientific realm:[131]

(i) *Technical scientific uncertainty* usually stems from experimental statistics (e.g., sample size) and inadequate research techniques. It can be managed through improved methodologies and attention to precision.

(ii) *Methodological scientific uncertainty* occurs more frequently as issues

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130 See generally Ruckelshaus, *supra* note 52; Weinberg, *supra* note 41, p. 60; and Fisk, *supra* note 128. For discussion regarding correlation of causes and effects, see Gullett, *supra* note 49, p. 53; Stebbing, *supra* note 47, p. 292; and R.B. Clark, *supra* note 100, p. 346.

131 See the two articles by Funtowicz and Ravetz, *supra* notes 125 and 127, for a discussion of the three types of uncertainty.

become more complex, and relates to the extent to which theories and information can be deemed reliable. Resolution requires a different, and perhaps more creative methodology that involves professional judgement. Thus, higher professional skills are required to ensure the best judgement is used. This type of uncertainty is common in environmental consultancies (e.g., engineering), where the qualifications of the professional involved become more relevant to the advice.

(iii) *Epistemological scientific uncertainty* arises from lack of knowledge about how the natural world will react in given circumstances. It is the type of uncertainty inherent in many of today's environmental problems and in computer modelling of complex issues. No systematic means of resolving epistemological uncertainty are available, so a way of managing the uncertainties is required. The application of "post-normal" science and adaptive policies are suggested management strategies.[132]

Issues fraught with epistemological uncertainty include coral bleaching, phytoplankton blooms, mass mortality of seals and dolphins, the decline of amphibian populations, and cancer epizootics in fish.[133] All of these are regional, if not global, phenomena, are unprecedented in both scientific experience and ecological understanding, and have unknown causes, although they correlate with widespread pollution. Global climate

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[132] Funtowicz and Ravetz, *supra* note 127, p. 143. The role of post-normal science in policy-making processes is discussed further in Chapter 5, herein. Essentially, post-normal science is applied where epistemological scientific uncertainty is high and environmental or social repercussions are potentially high. Post-normal science involves participation by an extended range of actors to direct actions and policies. Science continues to inform the process, but dialogue, debate, new research, and the evolution of consensus allow sound policies to emerge from a chaotic process.

[133] Cancer epizootics are the widespread occurrence of tumours and other cancers across a population, not unlike cancer "hot spots" among human populations. See N. Myers, "Environmental Unknowns", 269 *Science* 358 (1995), p. 358.

change and the possible endocrine-disrupting effects of POPs are two further examples of issues involving epistemological uncertainty.

In addition to understanding the different *levels* of uncertainty, it is also important to distinguish between two *types* of uncertainties, the "known unknowns" and "unknown unknowns",[134] neither of which is caused by, resulting from, or the fault of scientists or scientific practices.

"Known unknowns" refer to changes, reactions, or processes that scientists recognise are relevant, but are unable to make accurate predictions about due to lack of data, inability to measure, and insufficient knowledge.[135] For example, scientific predictions concerning the impacts of global climate change are hindered by known unknowns such as the heat-absorbing capacity of the ocean, with this capacity being a major influence on the rates and degrees of climate change.[136] Scientists can reduce known unknowns through more research and improved research techniques and computer modelling and by pooling their scientific knowledge with that of other disciplines. They need to articulate for determiners and enablers in a concise way the reliability of their predictions and the limitations posed by known unknowns, and determiners and enablers must work with this information in ways that allow for adjustments as new evidence arises.

"Unknown unknowns" are processes or impacts that cannot be anticipated, due to lack of both basic scientific knowledge and intricate understanding of relevant scientific processes at that point in time.[137] Examples include the thinning of birds' eggshells

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134 C. Garrett, "Oceanographic and Modelling Considerations in Marine Environmental Protection", 25 *Marine Pollution Bulletin* 41 (1992), p. 41.

135 *Ibid*.

136 *Ibid*.

137 *Ibid*.

due to the bioaccumulation of DDT's toxic breakdown product, and, in Minamata, Japan, the metabolic conversion of mercury into its more toxic form of methylmercury. Scientists were shocked by the manifestation of injury in these two cases, as they had had neither the instruments, tools, nor experience to anticipate such outcomes. The number of unknown unknowns decreases as scientists learn from experience, develop improved techniques and instruments, learn more about processes from sub-atomic to ecosystemic levels, and undertake broad-based ecological assessments. Scientists are increasingly able to creatively conceptualise possible unknowns as they understand the scope of ecospheric complexity. However, unknown unknowns will always be a possibility, though not necessarily a probability. Dialogue among scientists and determiners and enablers to dispel unfounded fears of unknown unknowns may restore trust in science as actors acknowledge and accept the limits on scientific knowledge.

(b) Scientific Uncertainty and Other Terms

Scientific uncertainty is often confused with risk, hazard, risk assessment, and risk management.[138] Uncertainty and risk are dissimilar: whereas uncertainty refers to an

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[138] Risk assessment is an objective process that quantifies the probability of an event and inherently accounts for scientific uncertainty through calculated safety margins. Risk management is a social and ethical task that determines an acceptable level of risk and appropriate measures in response to the risk assessment. Hazard assessment is a scientific procedure that utilises the inherent properties of substances to determine potential adverse effects. Risk assessments, undertaken by natural scientists, examine probable exposure in the environment. Social scientists may partake in risk assessment, contributing cultural and social data that may affect the level of risk. For example, the number of kilograms of fish various human populations consume per year. GESAMP, noting that there are no generally accepted definitions of hazard and risk assessments, suggests adoption of its usage of the terms. GESAMP, *Global Strategies for Marine Environmental Protection*, GESAMP Reports and Studies No. 45, 1991, pp. 20-1. Also see Fisk, *supra* note 128, p. 4; B. Fischhoff, "Managing Risk Perception", 2 *Issues in Science and Technology* 83 (1985-86); Ruckelshaus, *supra* note 52; W.F. Allman, "Staying Alive in the 20th Century", *Science 85*, Vol. 6, No. 8, pp. 31-7 (1985); H.A. Latin, "The Significance of Toxic Health Risks: An Essay on Legal Decisionmaking under Uncertainty", 10 *Ecology Law Quarterly* 339 (1982); House Of Commons Standing Committee on Environment and Sustainable Development, *It's About Our Health!: Towards Pollution Prevention – CEPA Revisited* (Ottawa: Government of Canada, June 1995), p. 60; and H. Margolis, *Dealing with Risk: Why the Public and the Experts Disagree on Environmental Issues* (Chicago and London: University of Chicago Press, 1996). For an interesting discussion of the relationship between risk and uncertainty, see S.O. Hansson, "A Philosophical Perspective on Risk", 28 *Ambio* 539 (1999).

event of unknown probability, risk refers to an event with a quantifiable probability.[139] One of the ways scientists deal with uncertainty, for example, is to undertake risk assessments to calculate safety margins. Risk management takes place at the policy/management level and includes mechanisms that should incorporate risk assessment.

Scientists use hazard assessment, a tool that rates and compares a substance's properties, to assess it for bioaccumulation of toxic substances, toxicity, persistence, hormone mimicry, and other deleterious effects. Scientific uncertainty can threaten the usefulness of hazard and risk assessments for risk management purposes. For example, it is a known risk, calculable within a reliable degree of probability, that 100 rems of radiation will double the mutation rate in a large population of mice.[140] However, it is impractical to try to calculate with statistical confidence the probable mutation rate or risk from very low-level exposure to radiation, as millions of mice would be required for such an experiment.[141] Further, the second stage – extrapolating the results to humans – would be rife with uncertainty, as humans are very different from mice.[142] In this example, scientifically sound risk management is possible utilising the 100 rems value, but science cannot accurately predict the probability of harm at significantly lower levels. This type of dilemma pervades contemporary environmental issues, highlighting the need for determiners and enablers to understand hazard and risk assessments and levels of scientific uncertainty, and how these affect management strategies.

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139 Costanza and Cornwell, *supra* note 44, p. 13; J. Hunt, "The Social Construction of Precaution", in T. O'Riordan, and J. Cameron (eds.), *Interpreting the Precautionary Principle* (London: Earthscan Publications Ltd., 1994), pp. 117-19.

140 Weinberg, *supra* note 41, p. 61.

141 *Ibid*.

142 *Ibid*.

(c) Policy Implications of Scientific Uncertainty

A better understanding of the nature of scientific uncertainty will have several positive repercussions for policy and the institutionalisation of a role for science in policy-making. First, those who understand the level and type of uncertainty that pertains to a given discussion will know which types of scientific and policy strategies are appropriate for that situation. Second, and very importantly, they will be able to rationally and logically assess the extent of scientific consensus on core issues and the nuances of debate, clarifying the respective positions of various actors. Third, their confidence in science and scientists should increase, as uncertainty becomes an openly discussed and debated issue. Finally, they may be motivated to create and incorporate policy mechanisms for explicitly recognising and addressing unresolved uncertainty. Understanding offers opportunities for increased transparency.

Determiners and enablers depend on, or should depend on, scientific evidence of degradation to justify regulatory measures, particularly where there is strong opposition by industry or affected parties. For this reason, determiners and enablers face a dilemma where scientific uncertainty is high,[143] as it has been used to justify a "wait and see" approach,[144] and delaying regulatory action until conclusive scientific evidence confirms the need for action, or until degradation escalates to a point at which the public or scientists demand action. However, where there is epistemological

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[143] Ruckelshaus, *supra* note 52 and Weinberg, *supra* note 41.

[144] V. Sebek, "Bridging the Gap Between Environmental Science and Policy-making: Why Policy Often Fails to Reflect Current Scientific Knowledge", 12 *Ambio* 118 (1983), pp. 118-19. Postponing action may result in irreversible harm or excessive restoration costs. *Ibid*., p. 119.

uncertainty, it is particularly unwise to postpone action on a wait-and-see basis, given the potential for serious harm and the possibility of unexpected events.[145]

Debates among scientists regarding scientific uncertainty are frequently reported in the mass media. A problem is that non-mainstream opinions and fringe opinions are often given equal weight, without being adequately, if at all, distinguished from the scientific consensus, which on core issues, is often high. In the resulting confusion, a fearful public react to perceived risk on a subjective and emotional, rather than on an objective and factual, basis.[146] In turn, they pressure determiners and enablers to take action. Responses grounded in public sentiment are often economically unsound, overly stringent, too lenient, or even unnecessary.[147] Overly stringent regulation or policy is a fair option where the costs are scientifically and economically justified, but a hidden cost of stringent regulation is the diversion of attention and financial resources from other issues, which may be ecological priorities.[148] The outcome may be policies that, over time and despite good intentions, result in greater ecological harm overall.[149]

Suppression of issues relating to scientific uncertainty is particularly serious, and arises mainly in one of two ways. First, determiners, enablers, degraders, and influencers

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[145] The risk of ecological discontinuity and synergy must be considered. Ecosystems may suffer stress to the point of collapse, with very little forewarning ("discontinuities"), or there may be an unknown synergy of stresses, the collective impact of which is greater than the sum of individual stresses. See Myers, *supra* note 133.

[146] The public's reaction to environmental risks is only recently being studied. See Kates *supra* note 129; P. Slovic, "Perceived Risk, Trust and Democracy", 13 *Risk Analysis* 675 (1993); H. Kunreuther and P. Slovic, "Science, Values, and Risk", 545 *The Annals of the American Academy of Political and Social Science* 116 (1996); Warren, *supra* note 6; and Wildavsky, *supra* note 59. A practical perspective is offered by W.F. Allman, "We Have Nothing to Fear – But a Few Zillion Things", *Science 85*, Vol. 6, No. 8, pp. 38-41 (1985).

[147] See generally Bewers, *supra* note 80; Gray, *supra* note 47; L.D. Mee, "Scientific Methods and the Precautionary Principle", in D. Freestone and E. Hey (eds.), *The Precautionary Principle in International Law: The Challenge of Implementation* (The Hague, London and Boston: Kluwer Law International, 1996); and M. MacGarvin, "Is the Quality Status Report Reliable?", in J. Andersen, *et al.* (eds), *Scientific Symposium on the North Sea Quality Status Report 1993, 18-21 April 1994, Ebeltoft, Denmark: Proceedings* (Ministry of Environment and Energy, Danish Environmental Protection Agency, 1996), pp. 121-31.

[148] For example, see Gray, *ibid*., p. 142.

[149] Gray, *ibid.* This is discussed more fully in Chapter 4, herein.

either disregard or misunderstand the consequences of ignoring uncertainty, and rely on other factors such as economics, or they rely on scientific evidence as they (mis)perceive it.[150] Second, scientific reports are commonly rewritten by non-scientists, sometimes several times in succession, to make them more comprehensible to laymen.[151] Further, non-scientists frequently draft the executive summaries on which determiners and enablers rely heavily. A common fact repeatedly noted by scientists is that executive summaries and rewritten reports misrepresent the scientific findings and fail to acknowledge the scientific concerns about uncertainty or the caveats and limitations expressed in the original reports.[152]

Uncertainty may be manipulated, interpreted, or exploited by determiners, enablers, degraders, and influencers[153] to advance preferred actions, interests, or agendas. As uncertainty provides an opportunity for scientific debate, biased and skeptical scientists operating on the fringe may further confuse non-scientific actors by advancing conflicting opinions. Some opinions may be sound, but it is often impossible for the less-informed observer to discern the sound from the unsound.

A final implication for policy involves treaty-making and international agreements. The degree of scientific uncertainty in treaty-making processes is often directly correlated with the degree of vagueness of treaty commitments.[154] As scientific uncertainty increases, those who oppose the imposition of measures propose reasons

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150 J.A. Hutchings, C. Walters, and R.L. Haedrich, "Is Scientific Inquiry Incompatible with Government Information Control?", 54 *Canadian Journal of Fisheries and Aquatic Sciences* 1198 (1997).

151 *Ibid*.

152 *Ibid*. A report in which the executive summary is felt to misrepresent the contents is the Intergovernmental Panel on Climate Change, *Climate Change 1995: The Science of Climate Change* (Cambridge: Cambridge University Press, 1996).

153 Latin, *supra* note 138, p. 339; Funtowicz and Ravetz, *supra* note 125, p. 141; and Costanza and Cornwell, *supra* note 44, p. 15.

154 L.S. Susskind, *Environmental Diplomacy: Negotiating More Effective Global Agreements* (New York, Oxford: Oxford University Press, 1994), p. 68.

for dilution, and treaty negotiation often then involves ideology and bargaining in return for some commitment.[155]

The scientist's role is to identify and concisely present uncertainty to determiners and enablers, who need to understand all of its facets[156] to effectively manage and incorporate scientific uncertainty into policy. However, the policy-making process presently lacks a mechanism to recognise, let alone manage, unresolved scientific uncertainty.[157] A solution may be the precautionary concept, if invoked properly. Before discussing the precautionary concept, however, it is essential to understand its relationship to assimilative capacity.

3) Assimilative Capacity and Policy Divergence from Sound Science

Assimilative capacity is defined as the "ability of an aquatic ecosystem to assimilate a substance without degrading or damaging its ecological integrity".[158] The concept is scientifically sound,[159] based on the assumption that, below a certain threshold, most chemicals will not have adverse effects on health or the ecosystem.[160] The question is

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155 The Convention for the Protection of the Ozone Layer, 22 March 1985, 1990 UKTS 1, 26 ILM 1516 (1987), is an example of a treaty in which relatively rapid actions emanated from consensual scientific evidence, and it had public support. Conversely, the United Nations Framework Convention on Climate Change, 9 May 1992, UN Doc. A/Conf.151/26, 31 ILM 849 (1992), has been plagued with debate and opposition to commitment at national and international levels, which is arguable attributable in part to the role of the high level of scientific uncertainty. The GPA is an example of vague commitments and states raising issues of uncertainty. In fact, the science is quite compelling regarding most issues, with uncertainty largely being peripheral to the core issue.

156 See Jamieson, *supra* note 97, for an insightful discussion on the social construction of uncertainty. Discussed are uncertainty, the fallibility of science, and indeterminism.

157 H.P. Green, "The Resolution of Uncertainty", 12 *Natural Resources Journal* 182 (1972), p. 185.

158 J. Cairns Jr., "Aquatic Ecosystem Assimilative Capacity", *Fisheries*, Vol. 2, No. 2, pp. 5-7, 24 (1977), at p. 5. Ecological integrity is defined as the "maintenance of structure and function of characteristics of that locale". *Ibid*. For a very good discussion of the assimilative capacity in science and as a service to be utilised, see A.R.D. Stebbing and R.I. Willows, "Quality Status, Appropriate Monitoring, and Legislation of the North Sea in Relation to the Assimilative Capacity", in W. Salomons, *et al.* (eds.), *Perspectives on Integrated Coastal Management* (Heidelberg: Springer-Verlag, 1999), pp. 152-60.

159 See generally Bewers, *supra* note 80, p. 15; A. Milne, "The Perils of Green Pessimism", *New Scientist,* Vol. 138, No. 1877, pp. 34-7 (1993); E.D. Goldberg, "Our Oceans as Waste Space: The Argument", *Oceanus*, Vol. 24, No. 1, pp. 2-9 (1981); and A.L. Dahl, "Land-based Pollution and Integrated Coastal Management", 17 *Marine Policy* 561 (1993).

160 Cairns, *supra* note 158, p. 6. It should be noted that the determination of the assimilative capacity of the human body underlies societal risk acceptance regarding food additives, automobile exhaust, and numerous other

whether the concept of assimilative capacity has any practical utility in environmental protection and policy-making. The answer is an unambiguous yes, but the misunderstanding of the nature and purpose of the assimilative capacity has given rise to unfortunate misperceptions about the relationship between the precautionary concept and assimilative capacity.[161]

Non-scientists have argued, first, that assimilative capacity is a license to pollute[162] and it has failed the environment[163] and, second, that the precautionary concept rejects and replaces the assimilative capacity as a regulatory strategy.[164] These arguments turn on the perceived inability of scientists to accurately predict the assimilative capacity of the ecosphere.[165]

The irony is that over two decades ago scientists, in discussing the merits of the assimilative capacity as a regulatory strategy, voiced the very concerns about its use that non-scientists now cite as confirmation of its failure. The two seminal points raised by scientists are instructive as they were expressed in 1977, prior to policy-makers considering such as tool for policy-making and they show that scientists are, and have always been, aware of the weaknesses of the assimilative capacity as a regulatory tool. The first concern of scientists was that the assimilative capacity might

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materials, and that the assimilative capacity is the basis for safe exposure standards (which utilise dose-response relationships).

161 Boelens, *supra* note 123, p. 40.

162 Greenpeace International, *supra* note 48, p. 1. Also see V. Pravdic, "Environmental Capacity – Is a New Scientific Concept Acceptable as a Strategy to Combat Marine Pollution?", 16 *Marine Pollution Bulletin* 295 (1985), p. 296. For discussion on how the assimilative capacity has been exploited in the policy-making process, see Dahl, *supra* note 159, p. 563. Cairns, *supra* note 158, p. 6, in outlining the assimilative capacity as a policy tool notes the potential for exploitation.

163 Wynne and Mayer, *supra* note 56, pp. 32-5.

164 T. Jackson and P.J. Taylor, "The Precautionary Principle and the Prevention of Marine Pollution", 7 *Chemistry and Ecology* 123 (1992); Hey, *supra* note 110, p. 305; and McIntyre and Mosedale, *supra* note 112, p. 222. Assimilative capacity is also wrongly perceived to be the foundation of "permissive regulation". See M'Gonigle, *et al*., *supra* note 115.

165 See Jackson and Taylor, *ibid.*; Hey, *ibid*.; and Wynne and Mayer, *supra* note 56.

be interpreted as the legalisation of further environmental assaults, given that industry and society have traditionally favoured economic development over environmental protection.[166] The second insight was that scientists might be arrogant to believe that they could effectively estimate assimilative capacity, given the then state of scientific knowledge.[167]

These two points are at the centre of today's debate over the use of the assimilative capacity (and the precautionary concept). In fact, its evolution as a regulatory strategy, in addition to being a scientific tool, reveals that the assimilative capacity does not oppose, but in fact compliments, the precautionary concept. Understanding the determination of the assimilative capacity as a basic and fundamental scientific tool, accepting how such a tool can assist sound policy formulation, and contextually relating it to scientific uncertainty are positive steps towards the meeting of scientific and legal minds.

(a) Assimilative Capacity in Science and Policy

The seeds of confusion may have been planted by the 1972 Stockholm Declaration, which recommended that the assimilative capacity of the marine environment be used to combat marine pollution.[168] Five years later, a biologist, Dr. Cairns, proposed that assimilative capacity should be incorporated into a comprehensive, holistic marine pollution regulatory strategy.[169] As an alternative to uniform water and emission standards and the chemical-by-chemical approach that regulators favoured at that time, a strategy based on assimilative capacity would capitalise on the absorptive capacity of

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166 Cairns, *supra* note 158, p. 6.

167 *Ibid*.

168 Stockholm Declaration on the Human Environment, 16 June 1972, UN Doc. A/Conf/48/14/REV.1, 11 ILM 1416 (1972), Principle 6. For further discussion, see Bewers, *supra* note 80, pp. 12-15.

169 Cairns, *supra* note 158. Also see Goldberg, *supra* note 159, pp. 8-9.

hardy marine ecosystems and protect those that are vulnerable.[170] It was seen by scientists as a realistic way to optimise ecological integrity in a swiftly degrading ecosphere,[171] and it was philosophically consistent with the then emergent concept of integrated coastal zone management.

This ushered in an era of comprehensive pollution regulation but also led to confusion, as it blurred the distinction between the roles of science and policy. The term "assimilative capacity" was used to refer to both a scientific assessment (in which scientists use a wide range of variables to determine to what extent and in what quantities substances impact on a given ecosystem) and a regulatory strategy. As the proposal was circulated primarily among the scientific community, most non-scientists failed to appreciate it as a sound regulatory tool that required a high level of scientific input and feedback.

Related to the assimilative capacity and precautionary concept debate is the policy of zero discharge, invoked by those unhappy with the assimilative capacity. In his seminal paper, Dr. Cairns discussed this as he countered the environmentalists' utopian calls for "zero discharge" noting that complete treatment of all waste was technologically impossible and, even if it were feasible, to remove the last 5% of contaminants could cost as much as removing the first 95%.[172] He was suggested that the massive amount of energy and processing required to achieve zero discharge would merely displace, not eliminate, environmental effects. Dr. Cairns' words have been echoed in the 1990's as scientists again respond to regulatory calls by reiterating that

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170 Cairns, *ibid*., p. 24.

171 *Ibid*., p. 7.

172 *Ibid*., p. 6.

zero discharge is unnecessary and costly and, second, science can assist in ecological protection with the use of tools, such as the assimilative capacity.[173]

While the concept of zero discharge is untenable, Dr. Cairns proposed that the scientific determination of the assimilative capacity, used properly, offers a sound regulatory strategy.[174] In setting out his proposal for assimilative capacity as a regulatory tool, he articulated clearly and concisely the anticipated scientific obstacles – including ecosystem complexity and knowledge gaps concerning basic ecology and cause-effect relationships – and the means of ensuring an ecosystemic approach.[175] Monitoring was to be an integral component to determine predictive accuracy, *leading to adjustments of policies*, as required. Given limited scientific knowledge, policy reaction to monitoring feedback was to be the key to the successful utilisation of the environment's absorptive ability.[176] Potential socio-political problems Dr. Cairns identified were the real and "usual dangers that regulators will become advocates of the groups they are charged with regulating and that to meet increased demand, positions would be filled with improperly trained personnel".[177] The 1977 paper envisioned an interactive and adaptive regulatory scheme that by definition involved scientific and legal/policy co-operation. It addressed scientific, socio-economic, and political pitfalls and set out a strategy that was fundamentally sound, incorporating the state of scientific knowledge, scientific uncertainty, and the societal emphasis on economic development. He articulated the scientific position with welcome honesty:

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173 Stebbing, *supra* note 47, p. 288.

174 Cairns, *supra* note 158, pp. 6-7.

175 *Ibid*., pp. 6-7 and 24.

176 *Ibid*., p. 24.

177 *Ibid*., at p. 24.

"It is unfortunate that we must act with so much at stake with almost totally inadequate information".[178]

Scientists went on to debate the utility and reliability of the assimilative capacity in pollution regulation, noting the significant lacunae in scientific knowledge and the possibility for unknown unknowns, and proposing ways to obtain sufficiently pessimistic assumptions to ensure an appropriate level of environmental protection.[179] They were exceedingly frank about their limitations and abilities. Most significantly and demonstrating scientific consensus on a core issue, scientists then and now agree that the marine environment does possess a finite capacity to assimilate the impacts of human behaviour.

In 1986, GESAMP endorsed the assimilative capacity as a policy strategy for marine pollution prevention.[180] To paraphrase GESAMP, it is a high-order interactive, adaptive, comprehensive environmental management strategy based on probabilistic assessment of the assimilative capacity of a given environment, *whose success depends on inter-disciplinary co-operation and effective monitoring and feedback.*[181] GESAMP's report was valuable for its clear articulation of the weaknesses in both science and policy that were likely to be encountered, and for which it proposed solutions. The common sense and realism reflected in the scientists' proposal might

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178 *Ibid*., at p. 7.

179 Goldberg, *supra* note 159; Kamlet, *supra* note 14; J.E. Portmann and R. Lloyd, "Safe Use of the Assimilative Capacity of the Marine Environment for Waste Disposal – Is It Feasible?", 18 *Water Science and Technology* 233 (1986); A.R.D. Stebbing, "Assimilative Capacity", 12 *Marine Pollution Bulletin* 362 (1981); Pravdic, *supra* note 162; and M.D. Krom "An Evaluation of the Concept of Assimilative Capacity as Applied to the Marine Waters", 15 *Ambio* 208 (1986). Krom prefers the term "accommodative capacity", as assimilative capacity implies a benefit for the marine environment.

180 GESAMP, *Environmental Capacity: An Approach to Marine Pollution Prevention,* GESAMP Reports and Studies No. 30, 1986. Non-scientists have also endorsed the assimilative capacity as a control strategy for marine pollution. See H. Hirvonen and R.P. Côté, "Control Strategies for the Protection of the Marine Environment", 10 *Marine Policy* 19 (1986). GESAMP preferred the term "environmental capacity" in place of "assimilative capacity". Environmental capacity and "assimilative capacity" are now used interchangeably.

181 GESAMP, *ibid*., p. iv. Italics added as this portion has been so frequently overlooked.

surprise determiners and enablers, who, judging from the dearth of references to the GESAMP report in legal and policy literature, are largely unaware of the proposed policy tool grounded in sound science.

(b) Did Assimilative Capacity Fail the Ecosphere?

Many non-scientists today believe that poor scientific methods, specifically regarding prediction of the assimilative capacity, have resulted in ecological degradation, and thus the assimilative capacity has failed to protect the ecosphere.[182] Whether or not the assimilative capacity "failed the ecosphere" depends on whether it is defined as the strategy envisioned by GESAMP or as the concept in the Stockholm Declaration of an ocean resource to be utilised.

With regard to GESAMP's strategy, a review of the policy applications of scientific knowledge in the last two decades leads to the conclusion that the scientists' comprehensive, scientifically grounded policy strategy was never implemented. For this reason, it cannot be said to have failed.[183] With reference to the Stockholm Declaration, the issue of failure on the part of scientists and science to effectively determine the assimilative capacity is less clear. There is little doubt that, in some cases, scientists have not been pessimistic enough in considering targeted species, pathways, scope of impacted areas, or types of impact[184] and methodology has been criticised by scientists as relying too much on reductionist practices and not enough on systemic thinking in some cases.[185] In the 1980's the concentration of wastes through

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182 Wynne and Mayer, *supra* note 56; Hey, *supra* note 110, pp. 304 and 308; and Greenpeace International, *supra* note 48.

183 Lack of implementation is not surprising, given the complexity and the unprecedented degree of integration and co-operation required, but it is unfortunate that many non-scientists fail to appreciate the mismatch between their perception of the assimilative capacity and the strategy as envisioned by scientists.

184 See Bewers, *supra* note 80; Jackson and Taylor, *supra* note 164; and Goldberg, *supra* note 159.

185 Wynne and Mayer, *supra* note 56, p. 34 and Bewers, *ibid.*

geo-physical processes, often miles from the source, and monitoring, usually site-by-site or waste-by-waste, failed to generate information for ecosystem management.[186] Another factor was that laboratory results so frequently used to set regulatory thresholds often failed to adequately simulate natural conditions and, thus, were not indicative of the actual impacts. Although poor science was partially responsible, more often, external limitations (i.e. mandate and funding conditions) were responsible. This continues today.

In short, the assimilative capacity was misapplied and misunderstood as a policy tool and there were scientific difficulties inherent in its application.[187] However, scientists, defending assimilative capacity against allegations of scientific failure,[188] maintain that although some incorrect assumptions were made, the calculation of sufficiently pessimistic assessments protected human health within established international limits.[189] One example cited as a failure of the assimilative capacity entailed the closure of an industrial plant and the loss of many jobs. As imposing clean technology immediately was not an economically viable option, scientists worked with the policy team to reduce discharges over time for the sake of economic stability.[190] At the same time, scientists protected long-term ecosystem integrity and human health through pessimistic assumptions and adjustments in accordance with a monitoring programme.[191] This was not a failure, but enlightened use of the assimilative capacity.

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[186] V. Dethlefsen, "Marine Pollution Mismanagement: Towards the Precautionary Concept", 17 *Marine Pollution Bulletin* 54 (1986). Also see GESAMP, *supra* note 180, as these issues are addressed in the report on environmental capacity.

[187] Jackson and Taylor, *supra* note 164, p. 125.

[188] *Ibid*., p. 126.

[189] Portmann and Pravdic, *supra* note 80, p. 136. Reading this paper together with Jackson and Taylor, *supra* note 164, provides a broader understanding of the debate.

[190] *Ibid*.

[191] *Ibid*.

Such use appears to be sensible both ecologically and economically, and shows why scientists should participate in policy-making processes.

(c) In Defence of Science

As to the ability, past and present, of scientists to make predictions and incorporate appropriate degrees of scientific caution, several points must be made in defence of scientific findings in previous decades.[192] The rudimentary level of scientific knowledge and lack of sophisticated tools and instruments in the past hampered accurate prediction of ecosystem impacts. Even with sufficient investigators, adequate funding, and open mandates, scientists could not have kept up with the onslaught of ecological issues, range of degraders and generators, new chemicals, the health implications thereof, and basic research necessary to understand human-induced environmental change. Determiners and enablers' sectoral mindset further hampered research by artificially limiting the scientific mandate. In addition, prominent marine scientists discussing four cases that used the assimilative capacity to regulate ongoing contamination note that none of the cases included scientific assessment prior to discharge.[193] They question how many past pollution issues might not have arisen if proper assessment had been conducted beforehand.[194]

Dissatisfaction with the assimilative capacity should be associated not with the scientific tool itself, but with its application as a regulatory tool, and with the use of science by determiners and enablers.[195] Ignoring all[196] or some of the available

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[192] The improvements in scientific capacity and the policy limitations mentioned in this paragraph are discussed more fully in Chapters 4 and 5, herein.

[193] Portmann and Lloyd, *supra* note 179, p. 243.

[194] *Ibid*.

[195] Gray, *supra* note 47, p. 134; Boelens, *supra* note 123, pp. 37-8; and Earll, *supra* note 48.

[196] Gray, *ibid*., p. 134 and Earll, *ibid*., p. 183.

scientific data and processes has resulted in an unnecessarily weak scientific basis for regulation.[197] Favouring other factors over, or to the exclusion of, scientific evidence has also resulted in poor policy decisions, for which scientists are blamed when the ensuing environmental degradation becomes newsworthy. It is not the assimilative capacity that failed the environment, but policy-makers who failed the assimilative capacity.

Although this is discussed in detail in Chapter 4, it is helpful to note here examples of misuse, misinterpretation, and misapplication of science that have directly or indirectly affected the use of assimilative capacity. These include the lack of follow-up monitoring and related policy adjustments, policy-determined constraints for scientific experiments, use of laboratory experiments to the exclusion of field scientists' evidence, suppression and misinterpretation of uncertainty, and misinterpretation of scientific results to suit policy purposes. Other factors beyond scientists' control are the time lags between the scientific danger signal and the policy response, and failure to use effective and available legal and policy tools.[198]

The curious combination of policy requirements and the inherent nature of the scientific endeavour have undermined the concept of assimilative capacity and the *perceived* ability of scientists to accurately predict effects. Traditionally, determiners, pressured by degraders, demanded a high degree of proof of harm before prescribing policy. With the legal emphasis on certainty of an effect existing, scientists and determiners alike focused on ensuring that the effect found did exist (95% certainty in scientific terms) and both disciplines largely overlooked the possibility that a finding

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[197] See Gray, *ibid*. and Stebbing, *supra* note 47, p. 291.

[198] S. Lutter, "Letters: Statistics and the Precautionary Principle", 21 *Marine Pollution Bulletin* 547 (1990), pp. 547-8.

of no effect could be wrong. The policy preoccupation with certainty of correctly finding effects encouraged scientists, particularly those in government and industrial laboratories, to design experiments that increased this certainty. Often, other investigators and influencers, such as ecologists, scientists in the field, environmentalists, and amateur naturalists, sounded alarm bells and questioned scientific capability as effects became apparent. The appropriate response should have been to question scientific methodology, including imposed mandates and funding limitations, and not scientific capacity.

Examining the unfair criticism of scientific capacity, a review of the possible outcomes of experiments is helpful. In determining whether or not there are effects from activities, there are four possible outcomes: (a) correctly conclude there is an effect; (b) correctly conclude there is no effect; (c) wrongly conclude there is an effect (false positive); or (d) wrongly conclude there is no effect (false negative). The last two outcomes are well-understood scientific errors, and they have been statistically incorporated into scientific methodology, known as Type I and Type II errors.

Type I errors are false positives and they cause a scientist to wrongly reject the null hypothesis of "no effects" (finding an effect when there is none). Type II errors are false negatives and cause a scientist to wrongly accept the null hypothesis of no effects (finding no effects when in fact there are). To reduce the occurrence of type I errors and increase the certainty of being correct about finding an effect (the traditional concern of determiners and enablers), scientists have customarily assigned a low value, called alpha (α), of typically 5%, which is the probability that, despite 95% certainty of an effect being present, an observed association is purely due to chance. Type II errors are assigned a beta value (β); the sum of the two values ($\alpha+\beta$) equalling 100%. Thus, a low alpha – a low chance of being wrong about an effect being present – has a corresponding high beta value, and a high chance of concluding that there is no effect when in fact there is.

Thus, claims that the assimilative capacity approach ignores the possibility of effects being present are largely unfair, as scientists have been manoeuvred into focusing almost exclusively on type I errors (false positives), as the policy process demanded certainty that effects were present before action was taken. Given the policy shift towards the precautionary concept, scientists are now responding to this type I error bias with statistical power analysis, a tool used to calculate the degree of certainty of their findings overall.[199] Statistical power analysis examines both the alpha and beta values of experimental procedures, and in this way, the probability of type II (false negative) errors occurring is assessed.[200] Given increasing public calls for precautionary action, statistical power analysis may become an important scientific tool utilised in rational policy-making processes.[201] As the historical review of MDLBA policy in Chapter 3 will indicate, much of the policy use of science has had more to do with non-science interests and demands, and less to do with the capacity of science.

From the start, scientists have been realistic about their capabilities and limitations regarding their predictive abilities and the use of assimilative capacity in policy. Unfortunately, this has not been widely recognised in the policy-making process,

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199 See R.M. Peterman and M. M'Gonigle, "Statistical Power Analysis and the Precautionary Principle", 24 *Marine Pollution Bulletin* 231 (1992) and M'Gonigle, *et al*., *supra* note 115. Unless stated otherwise, information and ideas in this paragraph are drawn from these two papers. Also see J.S. Gray and J.M. Bewers, "Towards a Scientific Definition of the Precautionary Principle", 32 *Marine Pollution Bulletin* 768 (1996) and Bewers, *supra* note 80.

200 See Peterman and M'Gonigle, *ibid.*; M'Gonigle, *et al*., *ibid.*; and Gray and Bewers, *ibid*.

201 See Peterman and M'Gonigle, *ibid*.

making it possibly one of the greatest tragedies directing the evolution of an anti-science interpretation of the precautionary concept.

(d) Assimilative Capacity as a Scientific Tool

A significant misconception among non-scientists is that scientists can dispense with the scientific tool of assimilative capacity entirely, in favour of more "precautionary science". The truth is two-fold: first, determining the assimilative capacity of a given habitat, species, or organism, is the best and only scientific means of determining how much of a given substance or activity generates adverse effects. It is quite simply what natural scientists must do, and it is essentially the same procedure that medical scientists follow when trying to determine optimal doses of medication. No matter what the procedure is called, it is the only precise means of determining at what quantity or dose a reaction is experienced. Most substances or impacts are benign or can be assimilated under a certain dose or quantity. Scientists experiment to find that threshold. There are no alternative methodologies.

Second, scientists inherently incorporate pessimism, or caution, into their predictions. Thus, in science, "precaution" corresponds to "conservatism", and scientists have means of incorporating conservatism into their extrapolations from experimental or observed findings to the broader applications of those findings. This is why feedback monitoring and policy adjustment are necessary to incorporate emerging knowledge and refinement of scientific prediction.

Reflecting on this, scientists seek precision in their quantification processes, incorporating the standard scientific margin of safety (caution). Further, they have the responsibility to articulate the conditions associated with that determination, along with the degrees and types of scientific uncertainty. Policies not grounded in scientific knowledge must be grounded in guesswork and assumption.

4) The Interpretation of the Precautionary Concept

The distrust of scientists, and of the assimilative capacity concept in particular, by determiners and enablers largely precipitated what is alleged herein as unsound interpretations of the precautionary concept, even though initially this legal concept had a sound basis. For this reason, it is relevant to review the evolution of the precautionary concept. Its genesis in relation to the marine environment may be found in the 1972 Stockholm Declaration on the Human Environment, which states that, "States shall take all possible steps to prevent pollution of the seas…".[202] This opened minds to innovative thinking and encouraged the development of creative legal principles and strategies.

In 1977, a marine scientist captured the essence of the precautionary concept. Recognising that there was scant compelling scientific evidence to confirm some insidious contaminants as threats to the global marine ecosystem, Dr. Waldichuk believed that data revealing them as significant local hazards was sufficient to elevate them to a global concern.[203] He advocated precautionary measures, such as the use of best available technology, to reduce (not eliminate) levels of suspicious xenobiotics (substances foreign to ecological systems) until intensive and extensive scientific research could reduce the degree of scientific uncertainty associated with the contaminants in question.[204] This common sense approach, endorsed by scientists and grounded in scientific evidence, is consistent with the original policy definition of the precautionary concept proposed by the Germans the previous year.

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[202] Stockholm Declaration on the Human Environment, *supra* note 168, Principle 7. Also see VanderZwaag, *supra* note 110, p. 13.

[203] M. Waldichuk, "Control of Marine Pollution: An Essay Review", 4 *Ocean Development and International Law* 269 (1977), pp. 280-1.

[204] *Ibid*. and also see Dethlefsen, *supra* note 186.

The precautionary principle, commonly found in contemporary international and domestic policy instruments, is widely accepted as emanating from the German principle of *Vorsorgeprinzip,* usually translated as "the principle of foresight".[205] The *Vorsorgeprinzip* was incorporated into the 1976 German clean air legislation to guide administrators when negotiating with certain polluters.[206] It soon became a cornerstone of German environmental policy as a *Gebot*, a vague legal commandment and, more strongly, a moral requirement.[207]

The Germans, in the 1984 Report from the Government to the Federal Parliament on the Protection of Air Quality, defined *Vorsorge* as follows:

> The principle of precaution commands that the damages done to the natural world (which surrounds us all) should be avoided *in advance* and in accordance with opportunity and possibility. Vorsorge further means the early detection of dangers to health and environment by comprehensive, synchronised (harmonised) research, in particular cause and effect relationships… it also means acting when conclusively ascertained understanding by science is not yet available. Precaution means to develop in all sectors of the economy, technological processes that significantly reduce environmental burdens, especially those brought about by the introduction of harmful substances.[208]

As defined, it embraces government action on four fronts: (a) an increased role for scientists in early stages of policy-making (scientific research is necessary for early warning); (b) action prior to scientific proof of damage where harm is *suspected by scientists*; (c) technological research and development (clean technology) to reduce

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[205] See D. Freestone and E. Hey, "Origins and Development of the Precautionary Principle", in D. Freestone and E. Hey (eds.), *The Precautionary Principle in International Law: The Challenge of Implementation* (The Hague, London and Boston: Kluwer Law International, 1996), pp. 3-18 and Bewers, *supra* note 80. For a detailed history of *Vorsorgeprinzip* in German policy, see S. Boehmer-Christiansen, "The Precautionary Principle in Germany – Enabling Government", in T. O'Riordan and J. Cameron (eds.), *Interpreting the Precautionary Principle* (London: Earthscan Publications Ltd., 1994), pp. 31-61. The roots of the precautionary principle are traced to the socio-legal traditions of Germany in the 1930's and their concept of good household management; the latter entailing a partnership of the state, the individual, and industry to manage change in ways beneficial to the environment and society. The German word *Vorsorge* embraces an element of planning, not just taking care of the here and now, and it goes further conceptually to include risk prevention, ethical responsibilities towards the environment, effective economics, and uncertainty. *Ibid.*

[206] *Ibid.*, p. 36.

[207] *Ibid.*, pp. 36-7.

[208] Federal Interior Ministry (BMI), *Dritter Immissionsschutzbericht,* Drucksache, Bonn 10/1345, 1984, p. 53 (reprinted in Boehmer-Christiansen, *ibid*., pp. 36-7).

and prevent discharge of pollutants; and (d) government participation in the introduction of cleaner processes and technologies into the private sector.[209]

The Germans formally enunciated Vorsorgeprinzip in the 1986 Guidelines on Anticipatory Environmental Protection:

> Environmental protection initially entails averting danger. The State must intervene with protection measures if it is possible to recognise that the input of substances is capable of threatening man and environment. The State must also act if impairment of the natural balance, threat to natural resources or damage to material property is imminent. Protection from environmental burdens of this nature has always been an indispensable constituent of environmental policy. However, not every input of substance poses a threat. The assumption of a risk situation is dependent on the nature and scope of any possible damage as well as on the probability of its occurrence. Active measures will be taken if general experience or scientific findings indicate with sufficient probability that damage will be caused; any remote possibility that damage will be caused is not sufficient.
>
> Furthermore, not every imminent [polluting event] of air, water, or soil and not every impending material threat to plants and animals can be categorised as a risk. Only 'considerable' burdens are of significance in assuming the existence of a risk. Consequently, measures must be taken on the principle of averting dangers to prevent their occurrence as far as humanly possible.[210]

The *Vorsorgeprinzip* is scientifically grounded, and morally, if not legally, binds all actors to heed scientifically-based suspicions of significant risk to the environment. It effectively lessens the burden on scientists, and accommodates scientific uncertainty by not demanding a definitive causal link between the act and ecological damage. Instead, scientists need to provide sound evidence that significant damage is a real possibility.

Under the German version of the precautionary concept, science moved from the periphery of policy-making to become a central and integral component. The essence was to ensure that determiners, enablers, and other actors heed scientific evidence, and forgo the legal requirement of establishing with certainty a causal relationship. Conversely, it required action only where scientific evidence exists to indicate a threat,

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[209] Boehmer-Christiansen, *ibid.*, p. 37.

[210] Reproduced in Bewers, *supra* note 80, at p. 13.

eschewing action based on emotion. It embraced nothing more than basic common sense.[211]

The precautionary concept had its international debut in the 1987 Ministerial Declaration of the Second International Conference on the Protection of the North Sea, where the parties agreed to:

> accept the principle of safeguarding the marine ecosystem of the North Sea by reducing polluting emissions of substances that are persistent, toxic, and liable to bioaccumulate at source by the use of the best available technology and other appropriate measures. This applies especially when there is reason to assume that certain damage or harmful effects on the living resources of the sea are likely to be caused by such substances, *even when there is no scientific evidence to prove a causal link between emissions and effects* (the "principle of precautionary action").[212]

The international legal community has endorsed various forms of this definition, as evidenced by its inclusion in numerous regional and international treaties.[213] However, the soundness of the precautionary concept is jeopardised by legal interpretations and applications that diverge from the scientifically grounded *Vorsorgeprinzip.* Although it is rendered more complex by the schism between the scientific and literary cultures, this divergence has exacerbated existing mistrust of science and scientists to the extent that the precautionary concept is used to justify overlooking or eliminating sound science from policy-making processes.

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[211] Earll, *supra* note 48, p. 182 and Allman, *supra* note 138. Both authors note that humans are "precautionary" by nature, confirming the common-sense nature of the precautionary concept.

[212] Paragraph XVI(1), Ministerial Declaration of the Second International Conference on the Protection of the North Sea, 25 November 1987, reprinted in D. Freestone and T. IJlstra (eds.), *The North Sea: Basic Legal Documents on Regional Environmental Co-operation* (Dordrecht: Graham & Trotman/Martinus Nijhoff, 1991), p. 40. Emphasis added**.**

[213] For international instruments containing the precautionary concept, see the Protocol (to the 1985 Vienna Convention) on Substances that Deplete the Ozone Layer, 16 September 1987, 1990 UKTS 19, 26 ILM 1541 (1987); Convention on Biological Diversity, 5 June 1992, UN Doc. UNEP/Bio. Civ/Conf/L. 2, 31 ILM 818 (1992); United Nations Framework Convention on Climate Change, *supra* note 155; Convention for the Protection of the Marine Environment of the North-east Atlantic, 22 September 1992, 32 ILM 1069 (1993); Convention on the Protection of the Marine Environment of the Baltic Sea Area, 9 April 1992, reprinted in 22 *Law of the Sea Bulletin* 54 (January 1993); Convention on the Protection and Use of Transboundary Watercourses and International Lakes, 17 March 1992, 31 ILM 1312 (1992); Rio Declaration on Environment and Development, 13 June 1992, UN Doc. A/Conf.151/5/Rev. 1, 31 ILM 874 (1992); Agenda 21, 13 June 1992, UN Doc. A/Conf.151/4 (1992); Global Programme of Action for the Protection of the Marine Environment from Land-based Activities, 5 December 1995, UNEP (OCA)/LBA/IG.2/7; and the 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972, 7 November 1996, IMO Doc. LC/SM 1/6, 36 ILM 1 (1997).

5) The Debate

The debate[214] surrounding the precautionary concept and the concept of the assimilative capacity threatens to further undermine the role of science in policy-making. The transnational ethical community, and in particular Greenpeace, are strong advocates of the logical and philosophically sound concept.[215] However, their interpretations include zero-discharge policies and the prohibition of activities even where scientific evidence indicates that prohibition measures are unnecessarily extreme or expensive. Most disturbingly, scientists are precluded from attempting to determine assimilative capacity or degrees or risk of environmental harm. Hence, the precautionary concept is invoked with good intentions, but based on only partially sound logic.

An international example of this is the 1996 Protocol to the London Dumping Convention, which, on the grounds of adopting a precautionary approach, reversed its previous philosophy of prohibiting certain substances from disposal at sea and adopted a "reverse list" of wastes that, subject to other provisions of the Protocol, could be considered for disposal at sea.[216] In effect, this places an *a priori* restriction on what wastes can be considered for disposal at sea. Although banning dumping at sea is philosophically enticing, it may lead to domestic incineration or other types of disposal that may be more "ecologically unfriendly" overall. A focus only on ocean dumping and not on all disposal options may lead to greater degradation of the ecosphere.

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[214] Communication deficiencies between the legal and policy domains have complicated the debate. To aid understanding, see Appendix 2, The Precautionary Concept, herein, which contains publications from both domains on the precautionary concept, assimilative capacity, and scientific uncertainty.

[215] Greenpeace International, *supra* note. 48.

[216] For a review of the Protocol, see R. Coenen, "Dumping of Wastes at Sea: Adoption of the 1996 Protocol to the London Convention 1972", 6 *Review of European Community and International Environmental Law* 54 (1997).

A domestic example is the dumping of an inert substance in Northern European fiords. In this case, a local pressure group encouraged the government in question to dump on land, which is significantly more costly.[217] Two factors not considered by the policy-makers in these cases are, first, the impacts on the terrestrial, freshwater, or coastal environments and, second, increased expenditure that could have been used more effectively to address existing and known serious threats along the coast.[218]

Policies based on assimilative capacity and scientific evidence are at risk of being forsaken in favour of zero-discharge or other economically unsound policies where public and political pressures support drastic action. Although heralded as a choice between risk and caution, such policy decisions are more aptly viewed as a choice between one risk and another.[219]

The precautionary concept has been interpreted as reversing the burden of proof, which effectively changes the balance of reason to favour the environment and place the onus of proving harmlessness on the polluter.[220] This may be ecologically beneficial but scientifically flawed, because scientists cannot prove an activity harmless, as previously noted.[221] Scientists can, however, work with actors in the legal domain to determine what, if any, precautionary or preventative measures are warranted, and what measures will provide the appropriate degree of ecological protection, taking into account social and economic costs.

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[217] J.S. Gray, "Statistics and the Precautionary Principle", 21 *Marine Pollution Bulletin* 174 (1990), pp. 175-6.

[218] See generally, Gray, *ibid*.; Bewers, *supra* note 80; and the Bodansky articles, *supra* notes 48.

[219] Bodansky, *supra* note 112, p. 43 and Clark, *supra* note 100, p. 349.

[220] See Gray, *supra* note 47, p. 136. Also see Coenen, *supra* note 216, pp. 56-7, which discusses reverse listings in place of the traditional black lists. Reverse listing, in essence, reverses the burden of proof.

[221] Gray, *ibid.*, p. 136. Also see Cameron and Abouchar, *supra* note 113, p. 22. The latter article notes that the reversal of the burden of proof puts the onus on the party who wishes to engage in a particular activity that it is harmless, but that the burden of proof is akin to the common law standard of the balance of probabilities. If the best available scientific evidence is used to determine that balance, then this formulation is sound.

6) *Proceeding with Caution*

To summarise, the essence of the precautionary concept debate is the ability to manage scientific uncertainty by scientists, determiners, and enablers. The precautionary concept is inherently a policy tool, which, to avoid ecological and economic misapplication, must be grounded in science. Where scientific evidence indicates that a serious threat may exist, cautious policies may be invoked, including effective monitoring and scientific and policy follow-up, to institutionalise the management of scientific uncertainty while scientists continue their efforts to reduce it. Balance and common sense are called for.

Actors in the legal domain should accept the assimilative capacity as a sound scientific tool for the simple reason that it is what scientists do. The very objective of most scientific enquiry is to determine the point at which contaminants or activities cause adverse effects, which is, in fact, the point at which the concentration of substances or rate of change exceeds the assimilative capacity of the habitat or organism. An analogy is the task of medical scientists to determine, in the case of new drugs, the concentration, or dose, required to produce a benefit, and the point at which toxicity is reached. Precision is the hallmark of good science.

In many cases, the assimilative capacity can be predicted with reliable precision, together with sufficient caution. However, with systemic degradation and complex environmental issues, epistemological scientific uncertainty prevents accurate prediction of the assimilative capacity. It must be remembered that this type of scientific uncertainty is unrelated to sound scientific methodology.

Hence, the assimilative capacity as a policy strategy in the spirit as envisioned by GESAMP and the precautionary principle should be viewed as policy tools to be applied to develop cogent policies, taking into account a continuum of scientific uncertainty. Where low scientific uncertainty permits assessment of the assimilative capacity with reasonable confidence, preventative measures can be invoked.[222] As scientific uncertainty increases along the continuum and the assimilative capacity becomes more unpredictable, hazard assessments and other scientific tools can provide scientifically-grounded reasons for employing precautionary measures and the relevant adaptive strategies to keep precautionary policies current with science. Scientists, of course, rely on the scientific tool of assimilative capacity in all cases to accumulate evidence to add to wealth of scientific knowledge.

The debate surrounding the assimilative capacity and precautionary concept is unfortunate, as the spirit of the latter is to provide determiners and enablers with greater latitude for action, specifically where scientific concerns highlight a significant ecological threat. Rather than demanding scientific certainty prior to taking action, as the previous paradigm required, a new paradigm should utilise science to justify proceeding cautiously. The precautionary concept should not be used to marginalize science, but to incorporate the best scientific evidence possible to realise the best environmental option. It invites common sense and rationality for long-term environmental sustainability, and understanding and co-operation between the scientific and legal domains.

G. Summary

Scientists and lawyers, and, more broadly, actors in the legal domain, are caught in a rip-tide of tension and misunderstanding. Actors in policy-making processes need to understand the reasons for the tension (primarily due to perpetuation of historical divergences), acknowledge the extent of distrust of science (evidenced by the debate

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[222] This is consistent with the environmental principle of preventative action. See Cameron and Wade-Gery, *supra* note 112, pp. 6-8 and VanderZwaag, *supra* note 110, p. 23.

surrounding the precautionary concept), and accept that much of the distrust of science is grounded in misperception and misunderstanding of scientific methods. Actors will then be in a position to put into context the evolution of current policies and come to understand how cultural and social organisation has resulted in widespread scientific illiteracy within the legal domain. The level of scientific literacy is a policy concern as it has culminated in a proliferation of ecologically and economically unsound policies, as chronicled in Chapter 4, herein.

In summary, the rip-tide at the interface of science and law has been a largely unrecognised force in shaping the development, processes, and substance of environmental law and policies. Through better understanding of how scientists operate and appreciation of the divergences and similarities between the two domains, the actors in both domains, through co-operation and improved communication, can move environmental management into "safer waters".[223]

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[223] This is discussed in Chapter 5, herein.

Chapter 3

From Sailing with the Current
to Tacking into the Wind:
The Emerging Global Regime for MDLBA

Part I Introduction

A vessel sailing with the current depends on wind, tides, and currents, as the helmsman attempts to set direction accordingly. Such sailing is reactive, and the helmsman must trim sails and manipulate the rudder as situations arise. Similarly, the regulation of MDLBA-related issues has flowed with the currents of socio-economic conditions, the prevailing ethos, available technologies, and scientific (primarily medical and toxicological) insights, with determiners and enablers, like helmsmen, reacting *ad hoc*. Subsequent to the Stockholm Conference in 1972, environmental regulation became more proactive, just as helmsmen have to plan their tack into the wind. Tacking requires foresight and contemplation of relevant factors to devise a workable strategy to get to the desired destination. This chapter traces the evolution of the regulation of MDLBA issues from a reactive to a proactive approach, relating the underlying ethos and mindset of the actors in the MDLBA policy-making process to policy developments and new laws and principles.

Part I reviews the evolution of the ethos that influences mindset and actions concerning regulation and management of environmental issues today. Part II provides a cursory overview of the historical domestic regulation of sectoral MDLBA issues, which focuses not on the marine environment, but almost exclusively on land-derived pollution. It highlights not specific laws, but how effective regulation was dependent upon technological advances and the availability of alternative behaviour or technology.

Part III focuses largely on the growth of IEL, its interface with LOS, and the changes it precipitated in the MDLBA policy-making process. IEL, evidence of an evolving mindset, encouraged determiners and enablers to move from "sailing with the current" to "tacking into the wind". This is an apt analogy for MDLBA policy-making over the last three decades.

Part II Breezing up: An Evolving Environmental Ethic

A. The Imperial Ethos and Scientism

Ethos may be defined as the characteristic spirit and beliefs of a community, people, system, literary work, or person.[1] It is usually reflected in, and evolves from, socio-economic, political, and legal culture. Mindset, on the other hand, is usually unique to an individual and is drawn from his or her ideals, beliefs, experiences and knowledge, although a collective mindset may exist.[2] Although the terms are often used interchangeably, mindset, which is influenced by external information, is more readily transformed, eventually giving rise to changes in the underlying ethos.[3] Understanding the historical roots of the ethos underlying humankind's relationship with nature

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1 *The Concise Oxford Dictionary,* 7th ed. (Oxford: Oxford University Press, 1984).

2 A common mindset may be attributable to groups of persons, usually those with similar interests. For example, state participants at international diplomatic conferences having common grounds to support or reject proposals often share the same mindset.

3 For example, the evolving environmental mindset was evident at the 1992 UNCED by the majority of nation states endorsing Agenda 21, 13 June 1992, UN Doc. A/Conf.151/4 (1992), even though the dominant global ethos was pro-economic development.

promotes understanding of the many factors that influence contemporary MDLBA policy-making. Ethos is inter-woven with these factors – not only with religious and other values, but also with technology and science and how society chooses to apply them.

Early humans, for example hunter-gatherers, were animists, spiritually connected to the natural environment, venerating gods and goddesses that symbolised the attributes of a forest, stream, or animal, termed the "spirit or genius of the place".[4] Animism gave way to intellectually higher forms of religion and philosophy, and by the time of the Greeks and Romans, the concept of natural law, *jus naturae* or *jus naturale*, prevailed, encompassing biological and natural principles.[5] The third century Roman jurist Ulpian considered that *jus naturale* was not exclusive to the human race, and that nature as a whole commanded the respect of humankind.[6] Between 300 and 500 AD the Roman Empire adopted Christianity, which repressed non-religious philosophy, scientific discovery, and the enlightened ways of the ancient elite, and saw the rise of the Judeo-Christian ethos that humans are superior to nature and that the latter exists solely to improve the human state.[7]

The authority of the Church in Rome was challenged regularly throughout history. The first significant instance was during the Renaissance, a period which witnessed a

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4 R. Dubos, "A Theology of the Earth", in I.G. Barbour (ed.), *Western Man and Environmental Ethics* (Reading, Massachusetts: Addison-Wesley Publishing Company, 1973), p. 45.

5 R.F. Nash, *The Rights of Nature: A History of Environmental Ethics* (Madison: University of Wisconsin Press, 1989), p. 16.

6 *Ibid*., p. 17.

7 L. White Jr., "The Historical Roots of Our Ecological Crisis", in P. Shepard and D. McKinley (eds.), *The Subversive Science: Essays Towards an Ecology of Man* (Boston: Houghton Mifflin Company, 1969), p. 350. Also see D. Worster, *Nature's Economy: A History of Ecological Ideas*, 2nd ed. (Cambridge: Cambridge University Press, 1994), pp. 26-30.

rediscovery of science, medicine, philosophy, and the arts,[8] followed by the periods of the Reformation and the Enlightenment.[9] Although, the Judeo-Christian ethos prevailed throughout,[10] the ruminations of famous natural philosophers, which were frequently construed as challenges to religious authority, laid the foundation for the evolution of an ecological ethic.

Sir Francis Bacon (1561-1626), an influential philosopher on the scientific method, asserted that "the world was made for man, not man for the world",[11] and that science and technology would confer on humankind the dignity and authority over all creatures that were once enjoyed in the Garden of Eden.[12] Many early philosophers, such as Hugo Grotius (1583-16445) and Samuel Pufendorf (1632-1694), argued that natural rights are derived from *human nature*.[13] Thus, laws are not common to humans *and animals*, but are, by definition, anthropogenic rules that incorporate and reflect *only* human interests.[14] The dualism of humanity and nature, as embodied in the Judeo-Christian ethos, became entrenched[15] and gave rise to the imperial, or secularised, ethos that embraced science as the means by which humans could fulfil their destiny: domination of the Earth.[16]

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8 The Renaissance spanned approximately 1350-1650 A.D. Leonardo da Vinci epitomises the intellectual genius of this era.

9 See generally E.O. Wilson, *Consilience: The Unity of Knowledge* (New York: Alfred A. Knopf, Inc., 1998) and Worster, *supra* note 7.

10 White, *supra* note 7, p. 350. Also see Worster, *supra* note 7, pp. 26-30.

11 Worster, *ibid.*, p. 30. Bacon envisioned the use of science and technology to remake nature and improve man's conditions. *Ibid.*

12 *Ibid.*, p. 30.

13 Nash, *supra* note 5, p. 17.

14 *Ibid*. Also see generally, Worster, *supra* note 7 and White, *supra* note 7.

15 White, *supra* note 7, p. 346. René Descartes (1596-1650), a renowned mathematician, physiologist, and psychologist, believed humans' ability to think distinguished them from the rest of nature and that the "objectification" of nature was essential for the progress of science and society. See Nash, *ibid.*, p. 18.

16 Worster, *supra* note 7, pp. 28-30. Although the world is now in a post-Christian era, the modern global community is infused with science, technology, and economic objectives that have their roots in western culture and bear the imprint of the Christian ethic.

Between Nicolaus Copernicus' (1473-1543) scientific observation that the Earth was not at the centre of the universe and Charles Darwin's (1809-1882) theory of evolution in the mid-1800's, the sciences reached new heights in western culture after centuries of repression.[17] Scientists developed experimental and empirical methods, involving the collection of hard data and observation, to prove a carefully reasoned scientific hypothesis.[18] Seeking tangible proof of scientific hypotheses, they embraced the mechanistic view that all life was explainable through physical and chemical laws.[19] However, advocates of ancient authorities, relying on philosophical explanations, disputed the scientific methods, distrusted hard data, and suspected measuring instruments.[20]

The western lifestyle and mindset radically altered after the 1880's, as the free market and individual entrepreneurs had to adapt to the concentration of financial, economic, and political power in the nascent centres of commerce.[21] The limited company supplanted the individual as the market persona; hence the emergence of the "[e]ra of big industry, big finance, and big cities, and an increasing inter-dependence of activities between them".[22] The imperial ethos became entrenched.

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17 W.S. Beck, K.F. Liem, and G.G. Simpson, *Life: An Introduction to Biology*, 3rd ed. (New York: HarperCollins Publishers Inc., 1991), pp. 21-2. Also see A. Bramwell, *Ecology in the 20th Century: A History* (New Haven and London: Yale University Press, 1989), pp. 46-7. The imperialist attitude was challenged first by Copernicus who, with the publication in 1543 of *On the Revolutions of the Heavenly Spheres*, proved through scientific observation that the Earth was not the centre of the universe, but in fact revolved around the sun. This precipitated the rebirth of science. Darwin's work had a similar effect in the field of biology.

18 Beck, *et al.*, *ibid.* These are the roots of the contemporary scientific method.

19 *Ibid.*, p. 26. "Mechanism" displaced "vitalism", which held that "life is intrinsically beyond explanation". *Ibid.*, at p. 26. Also see F.B. Golley, *A History of the Ecosystem Concept in Ecology: More than the Sum of the Parts* (New Haven and London: Yale University Press, 1993), p. 27.

20 Beck, *et al.*, *ibid.*, p. 22. It may be argued that this distrust lingers today among non-scientists.

21 See J.G. Laitos, "Legal Institutions and Pollution: Some Intersections between Law and History", 15 *Natural Resources Journal* 423 (1975), pp. 425-7.

22 *Ibid.*, at p. 426. Also see M.S. Weinstein, *Health in the City: Environmental and Behavioral Influences* (New York: Pergamon Press, 1980), p. 2.

War, famine, and the Great Depression marked the era from 1914 to 1945. The failure of market economics and ecological degradation, although the latter was recognised only in hindsight,[23] triggered these events. This was a period of regulatory stalemate, although new technology reinforced adherence to the imperial ethos.

World War II ended with two nuclear explosions. The concept of such powerful technology inspired further efforts to conquer nature. For the first time in history, the countries with unprecedented power to control pestilence, famine, and war had time to consider more than mere physical and economic survival. Industry, focusing on research and development, achieved breakthroughs in molecular and cellular biology, and discoveries by chemists and physicists further influenced and entrenched the imperial ethos that dominated western civilisation.

With the advent of heightened consumerism came plastics, detergents, synthetic fibres, and chemicals, in place of natural fibres and soaps.[24] The use of disposable packaging flourished.[25] Fertilisers, pesticides, and other synthetic organic compounds were manufactured for commercial use, the best known being the pesticide DDT.[26] These replaced traditional organic agricultural products. The vastly increased production and consumption of consumer goods by a burgeoning population resulted in historically unparalleled ecological degradation, but swelled the social objective of an ever-

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23 Environmental degradation contributed to the "dust-bowl" syndrome in the US Midwest, which left vast tracts of land infertile and pushed thousands of families westward to California.

24 C. Ponting, *A Green History of the World* (London: Sinclair-Stevenson Limited, 1991), p. 370. Phosphate levels in the US, mainly from detergents, rose two and one-half fold between 1910 and 1940 and seven-fold in the ensuing 30 years. *Ibid*.

25 *Ibid*., p. 373. For example, while beer consumption in the US increased 37% between 1950 and 1967, the use of non-returnable beer bottles in this period grew 595%.

26 DDT was discovered in the late 1800's, but its pesticidal qualities were not recognised until the late 1930's.

increasing gross national product,[27] which remains today as the benchmark of success. The imperial ethos transcended western culture to underpin progress on a global level.

This epoch witnessed many environmental disasters. Deaths from the London smog of 1952, smog incidents in the US, and the spontaneous combustion of highly polluted watercourses such as the Cuyahoga River in Cleveland, Ohio placed pollution squarely on the UK and US national agendas. In 1967, the *Torrey Canyon* ran aground off Britain spilling 100,000 tonnes of crude oil into the sea. PCB-contaminated cooking oil caused severe illness in 12,000 Japanese residents in 1968. The Great Lakes on the US-Canada border, and in particular Lake Erie, were virtually biologically dead.[28] Impacts from the toxic dumpsites of the 1940's onwards, and cross-media pollution – the dumping of industrial and toxic wastes as well as sewage sludge into the marine environment – became manifest.[29] Incineration of toxic chemicals at sea became popular in the 1960's. However, marine pollution, far removed from the polluter and largely invisible, did not attract public attention – particularly as the assimilative capacity of the ocean was generally believed to be infinite.

B. Evolution of an Environmental Ethic

The roots of the environmental ethic go as far back as animism, but more recently, it emerged in the 17th-18th centuries in the guise of a conservation ethic. Intellectual,

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[27] A.D. McKnight, P.K. Marstrand, and T.C. Sinclair, *Environmental Pollution Control: Technical, Economic and Legal Aspects* (London: George Allen & Unwin Ltd., 1974), p. 12. From 1945, pollution levels rose more quickly than population and consumption levels.

[28] Ponting, *supra* note 24, p. 375. These lakes were "protected" by a bi-lateral treaty between Canada and the U.S.

[29] Love Canal in the US is, arguably, the most famous toxic dump. Created in the 1940's, it was not declared a disaster zone until 1978. See Ponting, *ibid.*, p. 374. For discussions of cross-media pollution, see H. Hohmann, "Cross-media Pollution and International Environmental Law", 34 *Natural Resources Journal* 535 (1994); L.A. Teclaff and E. Teclaff, "International Control of Cross-media Pollution – An Ecosystem Approach", 27 *Natural Resources Journal* 21 (1987); and L.A. Teclaff and E. Teclaff, "Transfers of Pollution and the Marine Environment Conventions", 31 *Natural Resources Journal* 187 (1991).

aristocratic landowners interested in the natural conservation of their estates,[30] and early naturalists – like vicar Gilbert White, author in 1789 of *The Natural History of Selborne*,[31] a collection of letters on nature and wildlife – encouraged a philosophical kinship with nature.[32] The following century saw the blossoming of the Romantic Movement within the arts, which further encouraged among the educated classes, in particular, an affinity with natural scenery and, later, with wildlife itself.[33] The Romantics embraced an ecological ideology and eloquently rejected both the religious philosophy of human superiority and the values and institutions of expansionary capitalism.[34] Henry David Thoreau (1817-1862) exemplifies this era with his writings, including *Walden*, published in 1852.[35] The environmental ethic evolved, mostly innocuously and on the fringes of mainstream society, while the latter rigorously adhered to the imperial ethic.

1) Confounding Ecology as Science and Ethic

Ecology developed in the 18th century, commingling science, religion, and ethics, but without clearly defining the relationship among them. Ecology has both its scientific and ethical roots, at least partially, in an academic thesis, *The Oeconomy of Nature* by

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30 See M. Nicholson, *The New Environmental Age* (Cambridge: Cambridge University Press, 1987), pp. 24-5. Partially motivated by economic interests and social prestige, conservation management of entire estates as income-earning enterprises catering to sport hunters engendered an intellectual awareness of nature.

31 G. White, *The Illustrated Natural History of Selborn* (London: Macmillan, 1789, 1981). Also see Worster, *supra* note 7, p. 5. Because of its in-depth inquiry and scientific scope, "Selborn" came to be regarded as a seminal work on ecology, although this branch of science was unknown at that time. Worster, *ibid.*, pp. 16-21.

32 The book, one of the first publications on the concept of holism, influenced both natural historians and scientists, and heralded the formation of early natural history societies. See D. Evans, *A History of Nature Conservation in Britain* (London and New York: Routledge, 1992), pp. 34-5.

33 Nicholson, *supra* note 30, p. 25.

34 Worster, *supra* note 7, p. 58.

35 H.D. Thoreau, *Walden, or Life in the Woods* (New York: Signet Classic, 1960). Also see Worster, *supra* note 7, pp. 58-76.

Carolus Linnaeus (1707-1778), a Swedish botanist.[36] Rational, scientific, and pious, he undertook to prove human dominion over nature through scientific endeavour.[37] He concluded that there was a rational order within nature allowing species to co-exist, but ultimately "all things are made for the sake of man" and in enjoying God's bounty, to paraphrase Linnaeus, humans should use nature to pass life conveniently.[38]

The term "oekologie" (ecology) was coined by the German biologist Ernest Haeckel (1834-1919) in 1866 in *Generelle Morphologie der Organismen*.[39] He defined it as "the science of relations between organisms and their environment".[40] Contrary to Linnaeus, Haeckel asserted that humans and nature shared a natural and moral status, and that human society should be reorganised in accordance with scientific observations of the natural world.[41] Haeckel's contributions to ecology transcended science, entering the realms of philosophy and, ultimately, politics.[42] This is the root of confusion regarding ecology as ethic or science.

Charles Darwin (1809-1882) unwittingly engendered a century of dichotomous views on man, nature, and the role of ecology through his book, *Origin of Species by Means of Natural Selection,* published in 1859,[43] in which he proposed a theory of human

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[36] Worster, *supra* note 7, p. 33. See C. Linnaeus, *Carl Linnaeus Systema nature: t.II: Vegetabilia* (New York: Stechert-Hafner, 1759, 1964). Other biologists and naturalists contributed to ecology's growth, including John Ray (1627-1705), Comte de Buffon (1707-1788), Georges Cuvier (1769-1832), and Jean Baptiste Lamarck (1744-1829). See Beck, *et al.*, *supra* note 17, pp. 22 and 28.

[37] Worster, *ibid.,* p. 31.

[38] *Ibid*., pp. 36-7.

[39] Bramwell, *supra* note 17 p. 39.

[40] Quoted from *Generelle Morphologie*, translated and reproduced in Bramwell, *ibid.,* p. 40.

[41] *Ibid.,* pp. 39-45 and Golley, *supra* note 19, p. 27.

[42] See Bramwell, *ibid.,* for a brief overview of the politics of ecology.

[43] C. Darwin, *The Origin of Species by Means of Natural Selection or the Preservation of Favored Races in the Struggle for Life* (New York: Washington Square Press, 1859, 1963).

evolution through "survival of the fittest".[44] This rocked the Church's foundations by offering scientific explanations for humankind's "being" and reducing humans to the status of "animal".[45] By focusing on the origin of species and not on the origin of life, Darwin was silent as to the role of God, religion, and ethics. However, proponents of Darwin's theory garnered from it an ecocentric ethical view of humans as part of nature. More commonly, however, others viewed the theory of evolution as blasphemous, and propounded the ethos of human superiority over nature.[46] The remainder were left to reconcile the origin of species with a literal interpretation of the Bible.

2) The Deepening Schism between Humans and Nature

The Industrial Revolution spiritually and physically divorced humankind from nature through mechanisation of labour.[47] It secularised the religious view of human superiority, alienating any ecocentric ethic, and a schism developed between the intellectual and philosophical conservationists and the materialistic expansionists.[48] As reverence for technology grew, stewardship of the natural world was left to natural historians, poets, and humanitarians.

Scientists were in an unusual situation. Their search for truths about the natural world laid them open to charges of eroding Christian beliefs by providing scientific explanations for natural phenomena. Yet, they largely remained loyal to the Church by

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44 See Bramwell, *supra* note 17, pp. 46-7 and M. Gardner (ed.), *Great Essays in Science* (Oxford: Oxford University Press, 1997), p. 5.

45 Bramwell, *ibid.*

46 See generally, White, *supra* note 7 and Nicholson, *supra* note 30.

47 Evans, *supra* note 32, p. 25.

48 Nicholson, *supra* note 30, p. 25. Ironically, the heirs of conservation-minded landowners were the opportunists of the Industrial Revolution.

adopting a mechanistic view of the operation of nature.[49] Thus, the new discipline of science, emerging in the mid-1800's, gave rise to a new group of individuals who sought truth in a way that was separate from politics or religion, although scientific products (technology) often provided fodder for religious and philosophical debate.

Several key people deepened the schism between humans and nature in the 1800's. First was the natural scientist Thomas Henry Huxley (1825-95), who suggested that nature's laws had replaced God's law, and that the veil of ecological ignorance must be pierced to ensure that humankind would come to live by nature's laws.[50] Similarly, George Perkins Marsh, through his classic book, *Man and Nature,* published in 1864,[51] said that wanton destruction of nature was a reprehensible form of waste, and that humans, as free moral agents, should control and preserve the balance of nature.[52] John Muir, founder of the Sierra Club in 1892, propounded the doctrine of preservation, recognising an intrinsic value in the existence of nature.[53] His ethic contrasted with that of his contemporary, Gifford Pinchot, who recommended the utilitarian perspective of nature conservation to ensure continued existence for future human use.[54] Pinchot's ethic, consistent with the imperial ethos of utilitarian conservation, prevailed throughout the 1900's. Proponents of humankind as part of nature came to be viewed as environmentalists, or ecocentric (ecology-centred)

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49 See Golley, *supra* note 19, pp. 27-8.

50 Bramwell, *supra* note 17, p. 47.

51 G.M. Marsh, *Man and Nature* (Cambridge, Mass.: Harvard University Press, 1864, 1965).

52 *Ibid*. Also see D.M. Johnston, "The Environmental Law of the Sea: Historical Development", in D.M. Johnston (ed.), *The Environmental Law of the Sea* (Berlin: Erich Schmidt Verlag, 1981), pp. 18-19.

53 J.F. O'Neill, *Ecology, Policy and Politics: Human Well-being and the Natural World*, Environmental Philosophies Series (London and New York: Routledge, 1993), pp. 13-15.

54 See R.F. Dasmann, *Environmental Conservation,* 5th ed. (New York: John Wiley & Sons, 1984), pp. 315-16.

ethicists. Consequently, ecology came to be viewed as the philosophical domain of environmentalists.[55]

3) Ecology: Ethicists and Scientists

Meanwhile, the science of ecology developed largely outside the public eye, as most research was of little philosophical interest. Science continued to humble Christian dogma, revealing through scientific methodology that humans were not necessarily superior beings above nature.[56] In 1929, the Russian mineralogist V.I. Vernadsky, with the publication of *La Biosphere*, reaffirmed scientifically the notion of an evolving, complex, interactive system of which humans were a component.[57] Vernadsky detailed the inter-connectedness of organic and inorganic matter, emphasising that living matter can exist only in the thin biospheric envelope (ecosphere) comprising the troposphere (lower atmosphere), the hydrosphere (oceans), and lithosphere (topmost layer of the Earth's mantle), and that humans were consciously and unconsciously changing the ecosphere. Perhaps more concisely than any scientist before, he proclaimed that, "[u]ntil recently the historians, students of the humanities, and to a certain extent even the biologists, consciously failed to reckon with the natural laws of the biosphere".[58] His scientific re-affirmation of humankind's inherent inseparability from the ecosphere and total reliance on it for nutrition and respiration engendered a new respect for Earth and a notion of its vulnerability.

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55 *Ibid.*, pp. 9-10.

56 See L.K. Caldwell, *International Environmental Policy: Emergence and Dimensions*, 2nd ed. (Durham and London: Duke Press Policy Studies and Duke University Press, 1990), pp. 24-8.

57 V.I. Vernadsky, *The Biosphere* (New York: Copernicus/Springer-Verlag, New York, Inc., 1997). Also see Caldwell, *ibid.*, p. 24. The concept of the biosphere has been attributed to Jean Baptiste Lamarck (1744-1829), the renowned French scientist. The term was coined by an Austrian geologist, Edward Suess (1831-1914) in 1875, but Vernadsky through his biogeochemical investigations developed it in its modern context. See E. Suess, *Die Enstchung der Alpen [The Origin of the Alps]* (Vienna: W. Braunmüller, 1875).

58 See Caldwell, *ibid.*, at pp. 24-5.

The work of Vernadsky and other scientists fuelled the arguments of ethicists, who sought support for an evolving environmental ethic. It also encouraged the scientific study of ecology, which remained isolated from the public.[59] Following Raymond Lindeman's groundbreaking scientific article, "The Trophic-Dynamic Aspects of Ecology", published in 1942,[60] Eugene Odum published his landmark text, *Fundamentals of Ecology*, in 1953.[61] The 1950's witnessed attempts to position ecology within mainstream science, and by the early 1960's university courses in the subject were widely offered for the first time.[62] However, ecology was shunned by hard scientists who saw it as "soft", given its inherent inability to meet the rigours of the scientific method.[63]

From its inception, ecology, as the scientific study of inter-relationships, transcended the scientific realm; the social implications of which were recognised by philosophers such as Nietzsche and Bolsch.[64] Philosophical discussions on the rampant ecological deterioration in the 1950-60's cast ecology further into the realm of ethics.[65] Such identification of ecology with an environmental ethic further hindered its ascendance as a respected scientific discipline.

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59 Ecology was advanced when Sir Arthur Tansley (1871-1955), a British plant ecologist, coined the term "ecosystem" in 1935 in relation to plant communities. See A.G. Tansley, "The Use and Abuse of Vegetational Concepts and Terms", 16 *Ecology* 284 (1935). Also see R.P. McIntosh, *The Background of Ecology: Concept and Theory* (Cambridge: Cambridge University Press, 1988), p. 193 and Golley, *supra* note 19, pp. 59-62.

60 McIntosh, *ibid.*, pp. 196-7 and Golley, *ibid.* The article broke new ground because it reduced the complexity of the ecosystem to a mathematical formula, math being the domain of hard sciences.

61 E.P. Odum, *Fundamentals of Ecology* (Philadelphia: W.B. Saunders, 1953). Also see Golley, *ibid.*, pp. 62-9 for a detailed discussion of the book's impact. Odum's text ushered in a generation of ecosystem ecologists, as opposed to plant and animal ecologists. *Ibid*., p. 69.

62 See Golley, *ibid.*, pp. 62-9.

63 Ecology is a soft science insofar as much data is gleaned through observations in the field, where variables cannot be controlled. However, ecology is now accepted as a valid and legitimate scientific endeavour. See generally, Golley, *ibid.*

64 They ruminated on the holistic nature of the environment in relation to humanity's superiority within God's creation. See generally, Bramwell, *supra* note 17 and Nash, *supra* note 5.

65 Although an environmental ethic had existed for more than a century, it was never part of the mainstream. In the 1960's, however, particularly after the publication of *Silent Spring* by Rachel Carson, *infra* note 66, the environmental ethic challenged the mainstream ethos.

Ecology retained a dualistic aspect. On the one hand, it was the very private and largely uninteresting (to the general public) scientific study of organisms and their interaction with one another and their physical environment. On the other hand, it had a very public profile, grounding an environmental ethic adhered to by ethicists and disdained by the majority who advocated the imperial ethos. Although ecology is a respected science today, suspicions linger about ecology's ethical connection.

C. The Evolving Mindset

The mindset of determiners, enablers, and the public underwent a sea change in the early 1970's, challenging the imperial ethos of human superiority and economic development as the benchmark for progress. The shift occurred at both grassroots and international levels, reaching domestic governments from both directions. Although the shift can be partially attributed to environmental awareness and the evolving environmental ethic, many factors converged to influence the collective mindset. Grassroots-level influences included the work of writers like Rachel Carson[66] who interpreted scientific observations and findings in laymen's terms, and the publication of compellingly illustrated large-format "coffee table" books celebrating the wonders of nature. Television programmes on wildlife and ecological disasters brought environmental issues into viewers' homes.[67] Programmes such as *The Undersea World of Jacques Cousteau* inspired ecological awareness on an unprecedented scale.[68] Broadcasts of the Apollo space missions in the late 1960's crystallised the notion of

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[66] R. Carson, *Silent Spring* (New York and Boston: Houghton Mifflin Company, 1962, 1994) and R. Carson, *The Sea Around Us* (Oxford: Oxford University Press, 1950, 1991).

[67] Vivid scenes of animal deaths and environmental damage from oil slicks, for example, did much to raise the awareness of the plight of the oceans. Modern media provided visible access to a new frontier.

[68] The popularity of such programs aided campaigns to save dolphins and other marine species as individuals realised the mystique and beauty of the world beneath the waves. See Nash, *supra* note 5, pp. 172-3.

"spaceship Earth" and brought home to viewers a sense of its fragility and vulnerability.[69]

Additional influence came from print and broadcast media. As the ethicists– primarily environmental NGOs – became more active in the 1960's,[70] the media propagated their ecological perspectives and the concept of the indivisibility of humans from the ecosphere. The public became concerned about food safety, health, and the environment, although for most the driving force was self-concern and not an environmental ethic. Grassroots-level influence on the regulatory mindset came from the fearful public, highly vocal environmental NGOs, and social unrest endemic in the late 1960's.[71]

International agencies and conferences in this time period further influenced the policy mindset. First, the White House Conference on International Co-operation (29 November-1 December 1965), in recognition of the link between international development programmes and ecological degradation, recommended the establishment of several international agencies and programmes for ecological and environmental protection.[72] Second, in 1968 the United Nations Educational, Scientific, and Cultural Organisation ("UNESCO") led the Intergovernmental Conference of Experts on a Scientific Basis for a Rational Use and Conservation of the Resources of the Biosphere ("Biosphere Conference"),[73] which "marked the arrival of the biosphere concept as an

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69 See Beck, *et al.*, *supra* note 17, p. 4.

70 Environmentalists in the 1960's condemned as morally wrong the extinction of species through human activities. See Nash, *supra* note 5, p. 172. Also see A. Leopold, *A Sand County Almanac* (New York: Ballantine Books and Oxford University Press, 1949, 1970), for further discussion.

71 See Bramwell, *supra* note 17.

72 Caldwell, *supra* note 56, p. 47. Also see R.N. Gardner (ed.), *Blueprint for Peace: Being Proposals of Prominent Americans to the White House Conference on International Co-operation* (New York: McGraw Hill, 1966).

73 Paris, September 1968. See Caldwell, *ibid.*, pp. 44-5.

object in international policy deliberations."[74] The emphasis on ecological considerations across a broad spectrum of issues resulted in the adoption of 20 recommendations for action by the participating governments, the UN system, and UNESCO.[75] Noting the historical lack of comprehensive policies for environmental management, the final report of the conference called for bold departures from the past, both internationally and nationally.[76] Third, and most significantly, the UN General Assembly ("UNGA"), making the first major inroad into the century-old ethos of economic development, unanimously adopted Draft Resolution 2398 (XXIII) on 3 December 1968, which called for the convening of an international conference on the problems of the human environment.[77]

The ensuing UN Conference on the Human Environment in June 1972 in Stockholm, ("Stockholm"), one of the first "macro-conferences", secularised environmental awareness and had an immediate and dramatic impact on the policy mindset. Departing from the imperial ethos, it presented a view of humankind as an inherent component of the physical world that must attain a level of ecological harmony for survival.[78]

Ecology, still confounding ethics and science, was among the catalysts of change. Policy-makers and industrialists were forced to acknowledge the ecological insights of

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[74] Caldwell, *ibid.*, at p. 45.

[75] *Ibid*. The act of agreeing on recommendations for environmental protection was itself a bold departure, as previous conferences concerned themselves with merely exchanging views and experiences.

[76] *Ibid*. The seeds of a comprehensive approach were planted in the 1949 UN-sponsored Scientific Conference on the Conservation and Utilisation of Resources, which stressed the broader issues of the cumulative nature of potential threats to humans. *Ibid.*, pp. 42-3. Also see *Proceedings of the United Nations Scientific Conference on the Conservation and Utilisation of Resources*, Lake Success, Newark, 17 August-6 September, 1949, A/Conf.10.7 (1956), pp. 145-66. Also see D.M. Johnston, "International Environmental Law: Recent Developments and Canadian Contributions", in D.M. Johnston, *et al*. (eds.), *Canadian Perspectives on International Law and Organization* (Toronto: University of Toronto Press, 1974), pp. 555-611.

[77] Caldwell, *ibid.*, p. 49.

[78] Caldwell, *supra* note 56, pp. 1-9. Also see generally, H. Skolimowski, "Eco-philosophy versus the Scientific World View", 1 *Ecologist Quarterly* 227 (1978).

ecologists, other scientists, and environmental ethicists, but industrial interests, bound to the imperial ethos, encouraged minimal regulatory intervention while disparaging environmental ethicists as "greenies" on the fringe of society.[79]

However, early evidence of the evolving mindset found environmental issues on the US national agenda even prior to Stockholm, as witnessed by the passage of the National Environmental Policy Act ("NEPA") in 1969.[80] The following year, the US celebrated the inaugural Earth Day.[81] Although NEPA and general environmental awareness precipitated numerous pieces of environmental legislation, this led to a collective mindset that environmental protection was largely a matter for the government and legislation, and that there was little need for individual initiatives.[82] The policy mindset gradually became more ecologically focused over the ensuing decades, particularly following scientific discoveries such as the ozone hole, projections about global climate change, and environmental disasters like the grounding of the *Exxon Valdez*, all of which firmly linked human activity to ecological integrity.

Arguably, at the turn of the millennium, society can be said to be imbued with an environmental ethic. Transnational environmental ethicists have now gained credibility, dispensing with radicalism and issue focussing stunts in favour of professionalism and seeking productive roles in policy-making processes. Boding well for the future, the collective mindset seems to be more balanced and grounded in

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79 In fact, many NGOs undertook radical campaigns, from spray painting seal pups and chaining themselves to trees to dangerous confrontations on the water. Greenpeace was among the best known of these groups.

80 W. B. Honachefsky, *Land Planner's Environmental Handbook* (New Jersey: Noyes Publications, 1991), p. 4.

81 Earth Day is now celebrated annually, on April 22, by many countries.

82 Honachefsky, *supra* note 80, p. 5. For a general overview of its performance, see M.C. Blumm, "The National Environmental Policy Act at Twenty: A Preface", 20 *Environmental Law* 447 (1990).

ecological realism that is slowly eroding the imperial ethos.[83] Despite the progress, ecology remains awash in turbulent seas: widely accepted as a valuable scientific discipline, but still perceived as a tool of environmental ethicists.

Scientists and science have played their part in the evolving mindset. With its emphasis on verifiable facts and objectivity, science has bolstered environmental ethicists' claims through the provision of supporting scientific data, and has offered balance by highlighting exaggerated or unfounded claims. Paradoxically, (inaccurate) perceptions, initially propounded by ethicists, that science and technology are directly responsible for ecospheric degradation, and that scientists are unable to conservatively predict the assimilative capacity of habitats, have contributed to the declining influence of science in policy-making. This has fuelled growth of the environmental ethic as transnational ethicists wield greater influence in the policy-making arena. This dichotomy causes confusion for many.

Understanding the evolving mindset that favours environmental awareness and the tenacity of the underlying imperial ethos puts into context the tension among natural scientists, ecologists, ethicists, and the legal and policy developments that see determiners and enablers moving from "sailing with the current" to "tacking into the wind".

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[83] Much of the Earth's educated population remain committed to the ethos of human superiority, although it is now largely recognised that the Earth has both finite resources and a limited capacity for assimilating pollution. For interesting insights, see generally V. Smil, *Cycles of Life: Civilization and the Biosphere* (New York: Scientific American Library, 1997).

Part III Sailing with the Current: Classical Pollution Regulation

A. History of Reactive Regulation

Historically, regulatory laws were primarily anthropocentric, largely unscientific, concerned only with the immediate vicinity, and focused on symptoms rather than causes. Determiners "sailed with the current" and reacted to pollution issues only when pressured. The effectiveness of pollution laws varied, due to problems such as lack of enforcement, active encouragement of (or failure to prevent) cross-media pollution, the application of ecologically unsound policy (unsurprisingly, as ecology was little understood and was not a consideration in a human-dominated environment), and lack of scientific and medical knowledge. Scientific knowledge, if available, often remained untapped, as regulations targeted "classical pollution", which was largely visible, identifiable, and seen to be localised.[84]

Environmental protection was most commonly a fortuitous by-product or benefit of redressing wrongs against individuals, with pollution regulation being largely based in common law and statutory nuisance, particularly in the latter half of the 19th century.[85] Other legal doctrines, such as riparian rights, gave allegedly injured parties limited access to the courts.[86] Epidemics and industrial pollution in the 1800's resulted in public health measures and industrial regulations that were commonly fragmented across sectors, and, as with nuisance cases, policy action was not viewed as "pollution"

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84 See T. Page, "A Generic View of Toxic Chemicals and Similar Risks", 7 *Ecology Law Quarterly* 207 (1978).

85 Nuisance is premised on the right of an individual to enjoy his or her property without interference from outside activities. Although nuisance actions are useful for rights of individuals, they are inappropriate for preventing ecological degradation and have a limited role in policy-making. For a discussion of nuisance law, see C.H.S. Fifoot, *History and Sources of the Common Law: Tort and Contract* (London: Stevens & Sons Limited, 1949); J.G. Fleming, *The Law of Torts*, 4th ed. (Sydney: The Law Book Company of Australia, 1971); and D. Gardiner, *Outline of Torts* (Sydney: Butterworths, 1992).

86 For a good summary of riparian rights, see L.A. Teclaff, "What You Have Always Wanted to Know About Riparian Rights, But Were Afraid to Ask", 12 *Natural Resources Journal* 30 (1972). Also see W. Whipple Jr., New *Perspectives in Water Supply* (Boca Raton, Florida: CRC Press, Inc., 1994).

regulation. Failure to recognise linkages among or between policy sectors resulted in little inter-sectoral communication, and contradictions and confusion within and between statutes were inevitable.[87] Numerous small and ineffective authorities administered duties, which were distributed in a haphazard way.[88] In short, pollution regulation was chaotic, in the random sense of the word.

Throughout the following discussion of the evolution of an MDLBA regulatory regime, at least four broad observations should be kept in mind:

(i) issues receiving regulatory attention were generally classical pollution issues that affected human health;

(ii) pollution situations that reached unbearable levels or mobilised public pressure (usually because of socially unacceptable human health threats) precipitated reactive regulation;

(iii) technological and engineering solutions to health and pollution problems were usually available prior to regulations being passed (where regulations were most successful); and

(iv) regulatory failure and continued environmental degradation ensued where the law responded to situations, but failed to ensure that viable behavioural or technological alternatives to the polluting activities were available.

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87 See generally, I.G. Davies, *Modern Public Health for Medical Students* (London: Edward Arnold (Publishers) Ltd., 1963).

88 *Ibid*., p. 14.

B. Public Health and Pollution

The concerns of modern public health laws intersect with MDLBA regulation where human welfare is affected by environmental degradation, with the latter addressed under the guise of public health regulation. Understanding historical public health regulation places in context the mindset of the 20th century that valued aspects of public health, but often ignored pollution problems, and most importantly engendered faith in technological fixes

Public health, a relatively new term, was historically concerned with the provision of clean water, the removal of sewage and organic waste, and the instigation of counter-epidemic and quarantine measures.[89] Public health issues were traditionally addressed through law and innovations in engineering. Possibly the world's first written code of hygiene was formulated by the Hebrews in Leviticus about 1,500 BC, and addressed personal and community cleanliness, sanitation of campsites, disposal of excreta and refuse, and protection of water supplies.[90] More than 4,000 years ago engineers addressed problems of water quality and sanitation by developing elaborate water supply conduits and sewage removal systems.[91] The Romans engineered the first of many aqueducts in 312 BC to provide alternatives to water from the River Tiber.[92] These engineering feats, copied by many cities throughout the millennia, arose from an entrenched mindset, which arguably persists today, that addressed the symptoms of

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[89] See J.J. Hanlon and G.E. Pickett, *Public Health: Administration and Practice*, 8th ed. (St. Louis: Times Mirror/Mosby College Publishing, 1984), pp. 22-3 and G. Rosen, *A History of Public Health* (New York: MD Publications, Inc., 1958), pp. 27-8.

[90] Hanlon and Pickett, *ibid.*, pp. 22-3.

[91] Rosen, *supra* note 89, pp. 27-8.

[92] Ponting, *supra* note 24, p. 348. Over a span of 3000 years, Rome relied on nine central water supply systems that extended for a total of 263 miles.

pollution (poor water quality) by building longer aqueducts (better technology), but failed to address the causes (contamination).[93]

From the rise of western civilisation to the middle of the 19th century, personal hygiene and sanitation declined.[94] With no marked progress in sewage disposal,[95] refuse and human wastes amassed around dwellings and slop buckets were emptied into the streets.[96] Watercourses were treated as sewers and waste outlets because it was believed that noxious effluent would be diluted as it was washed downstream.[97] Several cities passed laws to protect water supplies, but most laws failed due to lack of enforcement[98] and an inadequate grasp of the underlying science.[99] Laws to prevent dumping in the streets were largely ineffective, as there were no disposal alternatives.[100]

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93 The City of London built in 1236 its first aqueduct of lead pipes as the Thames was already polluted with human waste. *Ibid.*, p. 348. Other cities piped in water, often using hollow logs or stone. Rosen, *supra* note 89, p. 55.

94 Believing that the Greeks and Romans indulged their bodies to the detriment of their spirit, early Christians thought it immoral even to view one's own body, causing them to ignore personal hygiene and sanitation. See Hanlon and Pickett, *supra* note 89, pp. 23-4.

95 See J.W. Clark, W. Viessman Jr., and M.J. Hammer, *Water Supply and Pollution Control*, 2nd ed. (Scranton, Penn.: International Textbook Company, 1971), p. 4, for a graphic description of poor sanitary conditions.

96 Hanlon and Pickett, *supra* note 89, pp. 23-4. Also see Ponting, *supra* note 24, Chapter 16, "Polluting the World" and M.S. Weinstein, *supra* note 22, p. 18.

97 E.W. Steel, *Water Supply and Sewerage*, 4th ed. (New York: McGraw-Hill Book Company, Inc., 1960), p. 3 and F. McManus, *Environmental Health Law* (London: Blackstone Press Limited, 1994), p. 2. There was at this time an unfounded but fervent belief in the dilution theory.

98 Weinstein, *supra* note 22, p. 16. In Foxton, a typical small village in England, a stream running through the centre was both the sewer and water supply. Legislative failure is illustrated as by-laws for cleaning it up had to be enacted on eight occasions between 1541 and 1698. Additional by-laws preventing the discharge of waste into the stream before 8 p.m. were passed on eight separate occasions between 1562 and 1698. See Ponting, *supra* note 24, p. 347.

99 Had laws been strictly enforced, the problem would have persisted as the contamination was largely due to cesspools, gutter drainage, and other "noisome" sinks that seeped into the watercourses. See Ponting, *ibid.*

100 Grim pollution management in the 13th and 14th centuries included garbage-eating pigs in Sienna's civic centre, government-ordered transfers of carcasses and offal rotting in the streets and streams of Paris to rural streams for waste disposal, and in London, a total of 12 rubbish carts that were tipped into the Thames. *Ibid.*, p. 352.

At the dawn of the 1800's, Jeremy Bentham (1748-1832) propounded the doctrine, "the greatest good for the greatest number"[101] and Edward Jenner developed the vaccination for smallpox.[102] Such progress in ethics and science, and conditions described below set the stage for imminent public health reforms.[103]

Epidemics of cholera and typhoid arose because of the fouled environment.[104] The causes of disease were scientifically unknown, but it became evident that disease was associated with overcrowded, squalid, and unsanitary conditions.[105] Epidemics evoked fear and were "important catalysts in stimulating procrastinating bureaucracies to act".[106] Another catalyst was the mid-19th century squalor of urban centres as labourers migrated from rural areas during the Industrial Revolution.[107]

Amid the squalor, engineers continued to design solutions for water supply problems. Cast iron pipes and cost-effective production and developments in pumping capacity permitted the widespread use of water piped from remote sources.[108] Other

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101 C.F. Brockington, *The Health of the Community: Principles of Public Health for Practitioners and Students* (London: J. and A. Churchill Ltd., 1965), at p. 21. Arguably, Bentham's greatest contribution to the western legal system was his "command and control" theory of law, simplified as "the command of a sovereign backed by a sanction". This typifies legislative action aimed at environmental issues throughout the last two centuries. See H. McCoubrey and N.D. White, *Textbook on Jurisprudence* (London: Blackstone Press Limited, 1993), p. 9.

102 Brockington, *ibid.*, p. 22. Also see C. Singer, *A History of Scientific Ideas* (Oxford: Oxford University Press, 1959, Dorset Press: New York, 1990), p. 468.

103 Brockington, *ibid.*

104 Epidemics were common throughout the Middle Ages, with the most notorious being the bubonic plague of the 14th century. See Weinstein, *supra* note 22, p. 14 and Rosen, *supra* note 89, p. 70.

105 P.F. Basch, *International Health* (Oxford: Oxford University Press, Inc., 1978), p. 70 and Weinstein, *ibid.*, p. 14. The miasmatic (the giving off of "foul gas") theory of illness predominated. The most hygienic and "disease-free" buildings of the early Middle Ages were the large and uniformly planned monasteries, as they tended to have piped water, latrines, and ventilation. These designs influenced sanitation developments in later times. See Rosen, *ibid.*, pp. 53-4

106 Weinstein, *supra* note 22, p. 20.

107 Basch, *supra* note 105, p. 69. The population of London doubled between 1800 and 1841, that of Leeds tripled, and Birmingham's increased ten-fold within 50 years. Some town populations increased 100 times.

108 Steel, *supra* note 97, p. 2.

engineering developments, such as slow sand filters, improved water quality.[109] The ability to maintain a continuing supply of clean water from remote sources obviated any incentive to address the underlying causes of sanitation problems.

Legal and public health reforms to improve urban conditions followed engineering innovations.[110] Engineers designed indoor toilets, and in England after 1815, laws permitted household effluents to be flushed directly into streams. It became *compulsory* to connect a toilet to a stream, where no sewers existed, after 1847.[111] The cumulative effect of various laws was to ensure that streams became open sewers. Few cities had sewerage systems, and some cities that did (most were open drains) prohibited their use for the disposal of household wastes.[112] The watercourses traversing cities and towns, including London, Glasgow, and Edinburgh, were open sewers until well into the 19th century.[113]

The modern approach to public health in England came about in four phases. In 1796, the first Board of Health in England was created in Manchester as a response to widespread fear after a serious typhus epidemic.[114] Then, between 1805 and 1834, two Central Boards of Health for the whole of England were created as a response to epidemics but were subsequently dissolved.[115] The third phase commenced in 1842

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[109] W.G. Smillie, *Public Health: Its Promise for the Future* (New York: The Macmillan Company, 1955), p. 342. The filters were employed to make water clear, rather than to prevent disease.

[110] See generally Steel, *supra* note 97, Chapter 1, therein.

[111] Ponting, *supra* note 24, pp. 354-5.

[112] This was the case in London as late as 1850. See Steel, *supra* note 97, p. 3.

[113] McManus, *supra* note 97, p. 2. Due to the slow-moving estuarial waters of the Thames, rubbish and decaying matter often floated on the tide and unpleasant odours spread over large areas. See Ponting, *supra* note 24, p. 355.

[114] Rosen, *supra* note 89, pp. 158-9 and Brockington, *supra* note 101, p. 20.

[115] See Brockington, *ibid.*, p. 23. The first Central Board of Health was established to advise on the prevention of infection from mainland Europe, and was dissolved 18 months later. In 1831 the threat of cholera, which would ultimately claim 50,000 lives, galvanised the Government into creating the second Central Board of Health, which was also dissolved after the epidemic subsided in 1834.

with a national survey of labourers' sanitary conditions, known as the Chadwick Report.[116] The ensuing Public Health Act of 1848[117] created the third central organisation, the General Board of Health, situated in London.[118] Interestingly, physicians were excluded from the Board, partially due to Chadwick's seminal report, which called for the enlistment of civil engineers in disease prevention.[119]

Three reports instigated lasting sanitation measures as accumulated scientific evidence and public pressure respecting public health issues competed with the socio-economic realities of the Industrial Revolution. They were Chadwick's report; the 1850 report of his US counterpart, Lemuel Shattuck, on behalf of the Sanitary Commission of Massachusetts, that recommended that Boards of Health be established and urban sewerage systems installed;[120] and Dr. John Snow's report in 1854 that clearly linked cholera to "fecalised" water, based on his observations in the famous Broad Street pump experience.[121]

The three reports were initially suppressed. It was a decade before scientists embraced Snow's insights, and four more decades before the public finally accepted the science and discarded the belief that all water free of odour and colour was healthful.[122] Legislators and engineers invoked some health measures in reaction to public pressure

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116 *Ibid*., p. 31. Both Edwin Chadwick, a barrister turned sociologist, and the Commission of which he was a member, noted the economic advantages of preventing disease and improving health. See Davies, *supra* note 87, p. 12.

117 Brockington, *ibid*., p. 32.

118 *Ibid*.

119 Basch, *supra* note 105, p. 71. The Americans, experiencing similar conditions and epidemics, founded the American Medical Association in 1847 and established a hygiene committee the following year. See Smillie, *supra* note 109, pp. 233-4.

120 Smillie, *supra* note 109, p. 347 and Weinstein, *supra* note 22, p. 23.

121 Smillie, *ibid.,* p. 342.

122 People clung to the belief that odourless water was safe and pure, and that running stream water purified itself in the course of seven miles. See Smillie, *ibid*., pp. 342-3 and Weinstein, *supra* note 22, p. 22. This perpetuated false beliefs of the efficiency of stream disposal and justified the release of sewage into streams by up-river communities.

during this period.[123] However, the Public Health Act of 1875 is considered the foundation of modern public health.[124] Americans were slower to respond, as, in 1876, "public hygiene in the United States [was] woefully neglected, except under the stimulus of great epidemics".[125]

The science of modern public health flourished from the 1870's. Advances in medicine and science resulted in the replacement of the miasmatic theory with the germ theory[126] and scientific information, in dispelling old myths, cleared the way for engineering innovations such as modern filtration,[127] chlorination,[128] and bacteriological standards for measuring water quality. Legislatures were mobilised to deal with sanitary issues, as it was conceded that, "[t] he function of the common law begins and ends with the punishments of individuals. It knows nothing of prevention or cure".[129]

High cost, lack of alternative technology, and the belief in dilution perpetuated the use of water bodies as waste sinks.[130] The Americans adopted British tradition of

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[123] Reactively, England passed the first legislative initiatives to suppress infectious disease, the Removal of Nuisances Acts of 1848 and 1856. See McManus, *supra* note 97, p. 233. A cholera epidemic in 1854 that claimed 10,000 lives in London led to passage of an act in 1855 to install an adequate sewerage system for London. Clark, *et al.*, *supra* note 95, p. 5.

[124] R.M. Mersky and J.M. Jacobstein (eds.), *A Century of Law Reform: Twelve Lectures on the Changes on the Law of England During the Nineteenth Century* (London, New York: Macmillan and Co., Ltd., 1901), p. 146.

[125] See H.I. Bowditch, in his address to the International Congress of Medicine, Philadelphia, 1876, quoted in Smillie, *supra* note 109, at p. 6. Also see Clark, *et al.*, *supra* note 95, p. 5.

[126] American Society of Civil Engineers, *Pure and Wholesome: A Collection of Papers on Water and Waste Treatment at the Turn of the Century* (American Society of Civil Engineers, 1982), p. 3. The miasmatic theory claimed that diseases were caused by "foul gas". The germ theory was proposed by Pasteur and conclusively proven by Koch in 1870.

[127] The first filtration plant for the Thames was established in 1869. See Ponting, *supra* note 24, p. 349.

[128] Disinfection was first used in the late 1800's. See Smillie, *supra* note 109, p. 346. Purifying water was more economical than treating raw sewage at the end of the pipe. Also see Honachefsky, *supra* note 80, p. 108.

[129] Mersky and Jacobstein, *supra* note 124, at p. 142. Also see McKnight, *et al*., *supra* note 27, p. 34. Although common law was employed as a means of redress, it was fraught with difficulties and had limited utility.

[130] Ponting, *supra* note 24, pp. 356-7.

disposing of sewage in streams.[131] In 1860, only ten municipal sewer systems existed in the whole of the US, with 200 by 1880, and most of these simply discharged into rivers and lakes.[132] Many cities on both continents used storm drains to transport sewage and waste to nearby watercourses or the sea.[133] While sewers were gradually constructed to carry wastewater exclusively,[134] the problems of tons of horse manure and carcasses fouling the streets, unresolved through legislation, disappeared only with the advent of the automobile.[135]

As early as 1899, some civil engineers shifted their approach from sewage removal from the immediate vicinity, to more holistic ecological thinking.[136] Discussing stream protection in an enlightened fashion, engineers proposed that: (a) laws should prevent the dispersal of untreated sewage into streams;[137] (b) engineers must conform to the laws of nature, or failure would ensue;[138] and (c) the entire drainage area must be under the authority of one trained and knowledgeable official for effective stream pollution control.[139]

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[131] Honachefsky, *supra* note 80, p. 108.

[132] Smillie, *supra* note 109, p. 346. All sewer systems at this time discharged the untreated sewage into lakes, rivers, or the marine environment.

[133] Honachefsky, *supra* note 80, p. 107.

[134] They often drained into the watercourses and seas. See Ponting, *supra* note 24, p. 356.

[135] *Ibid*., pp. 356-8. The horses often remained where they fell dead, scavenged by dogs or other animals.

[136] Attendees at the 1899 annual conference of the American Society of Civil Engineers, in discussing stream pollution, linked the environment to human health. See American Society of Civil Engineers, *supra* note 126, p. 77.

[137] *Ibid*. Another attendee discussing the engineering advances in water filtration commented that "[f]iltration may promise a remedy for defiled waters, but that does not imply that the filtered water would not be better and safer had it not been contaminated". *Ibid*., at p. 77.

[138] *Ibid*., p. 97.

[139] *Ibid*., p. 89. Watershed management today has found international support among ecologists and as a component of ICM.

However, arguments against stream protection prevailed, with claims that the sanitary welfare of the people was the "[u]ltimate and only condition to be insisted upon."[140] Concerns about odour and visible filth in streams that were "[o]bjectionable for aesthetic or sentimental reasons" were dismissed.[141]

Regardless of the lack of support, some engineers, inclined to prevent direct discharge into watercourses, developed various land-based sewage disposal methods.[142] Despite their good intentions, pollution was transferred from one medium to another as sewage leached into the water table and, in turn, contaminated rivers.

Marine pollution was briefly on the agenda at the turn of the 20th century, as the merits of sewage treatment in tidal rivers and estuaries were debated. In the (mistaken) belief that salt killed bacteria, it was argued that cities like New York should disperse raw sewage into tidal areas.[143] The engineering aim was to prevent the spread of typhoid and cholera, not to protect shellfish or the (then unrecognised) ecologically sensitive habitat from contamination. However, the early 1900's saw the first meaningful scientific studies on the impacts of pollution on fish and, to a limited extent, on the marine environment.[144] Recognising that sensitive species were replaced by hardier ones as water quality declined,[145] early marine scientists suggested that key species be

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140 *Ibid.*, at p. 78.

141 *Ibid.*

142 The Imhoff tank was introduced in 1910 in the US. It was a revolutionary way of treating sewage before disposal and is still employed today. *Ibid.*, pp. 14-15.

143 *Ibid.*, p. 93.

144 See generally B. Watermann and H. Kranz, "Pollution and Fish Diseases in the North Sea: Some Historical Aspects", 24 *Marine Pollution Bulletin* 131 (1992). The most frequently studied aquatic environments between 1850 and 1933 were freshwater bodies, estuaries, and coastal areas. Little attention was paid to the open seas. *Ibid.*, p. 137.

145 In the mid-1800's salmon and trout species disappeared from Yorkshire rivers, replaced by hardier species such as whitefish and skate. Ecological changes such as these were accepted in accordance with the mindset that a river's "natural function" was to absorb the effluents and pollution. See Watermann and Kranz, *ibid.*, pp. 132-3.

used as indicators of water purity.[146] This was an opportunity to incorporate science into the regulatory process, but such scientific observations were seldom heeded.

The new era of public health reform continued into the mid-20th century, although its momentum slowed due to the two world wars, the intervening depression, and complacency within more developed countries, which now enjoyed improved sanitary conditions and freedom from common epidemics. Relying on the public health enactments of the late 1800's, England and the US devoted resources to the installation of sewage and water purification systems.[147] Both sides of the Atlantic saw updated public health legislation over the half century.[148] Of note was the Local Government Act, 1933, which recognised the intrinsic role of science and provided for medical officers of health. In 1951, the newly established British Ministry of Housing and Local Government assumed environmental health concerns from the Ministry of Health.[149] Given that regulation of medical officers and sanitary inspectors remained with the Ministry of Health,[150] responsibility was fragmented in a way that has come to dominate contemporary environmental regulation.

As sewage systems became more commonplace, municipal and industrial waste regulation were merged. In practice, the adequacy of sewage systems was often a function of cost-benefit analysis. Although it solved problems in a given vicinity, the

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[146] American Society of Civil Engineers, *supra* note 126, p. 88.

[147] See Watermann and Kranz, *supra* note 144, pp. 131-3, for graphic descriptions of two rivers during this era.

[148] The US federal government, recognising the negative impacts of water pollution, passed the Public Health Services Act of 1912. See M.L. Davis and D.A. Cornwell, *Introduction to Environmental Engineering*, 2nd ed. (New York: McGraw-Hill, Inc., 1991), p. 17. Among other things, it established in Cincinnati the Streams Investigation Station for water pollution research. *Ibid*. The landmark legislation of this period was the Public Health Act, 1936, which repealed much of the 1875 Act and the many amending and related statutes. Later, Parliament passed the National Health Services Act, 1946 with the view to setting up a comprehensive physical (and mental) health regime for England and Wales. See generally F.G. Davies, *Clay's Public Health Inspector's Handbook*, 12th ed. (London: H.K. Lewis & Co. Ltd., 1968), pp. 7-8, and 569.

[149] I.G. Davies, *supra* note 87, p. 20.

[150] F.G. Davies, *supra* note 148, p. 8.

removal of sewage sludge was often a simple matter of transferring it from one medium to another: by dumping it either directly into the ocean, or in landfills where it leached into the water table and, subsequently, into coastal waters. As engineers' mandate was to provide operating sewage treatment facilities, and not to address distant environmental problems, the science of ecology was largely ignored. Generally, the inconvenience of polluted water was preferred to the investment that would have been required to construct treatment facilities.

The marine environment, particularly the coastal waters, became the acceptable sink for waste and sewage disposal, where it was assumed waste would be diluted and assimilated. In larger centres, long pipes were installed to carry sewage waste further from shorelines, or vessels carried sewage offshore for ocean dispersal.

C. Industrial Waste Control – Air and Water Pollution

1) Industrial Water Pollution

Contamination resulted from the discharge of industrial waste into streams.[151] As early as the 1500's, regulations were passed to curb water pollution from the by-products of low-energy industries such as dyeing and sugar refining.[152] The Rivers Pollution Prevention Act 1876 was passed by the English Parliament to protect watercourses from both industrial effluent and sewage discharges.[153] It became an offence to discharge such matter into a stream unless it was done through the proper

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[151] Tanneries, dyeing factories, and paper-mills poured hundreds of thousands of tons of effluent into rivers each year. As with sewage, many of the wastes were organic, consuming available oxygen and leading to eutrophication. Invisible wastes, such as heavy metals were present, but, due to lack of scientific knowledge, went unchecked. Core samples from the North Sea indicate the presence of heavy metals in 1750 and reveal significant increases in concentration between 1850 and 1900. See Watermann and Kranz, *supra* note 144, p. 133.

[152] The Netherlands in 1582 forbade by law the dumping of wastes from linen bleaching into city canals. The English monarchy followed, prohibiting pollution by starch makers in London. See Ponting, *supra* note 24, pp. 360-1.

[153] This Act was repealed by the Rivers (Prevention of Pollution) Act, 1951. See *Halsbury's Laws of England,* 4th ed., Water (Volume 49, paragraphs 201-757, 1984). See paragraph 822, p. 575.

channels (sewers) and the discharger could show that the best practicable means had been employed to render the substance harmless.[154] The law was weak, as action could only be taken by a sanitary authority, required the minister's consent, and restrictions on that consent protected industrial interests.[155] Generally, dilution in watercourses or the marine environment remained the favoured disposal method.

The era between WWI and WWII witnessed devastating water pollution from industrial sources. Biologists reported skin diseases, tumours, and ulceration in fish, and fish kills.[156] Although no conclusive links to industrial pollution and sewage were established, they were suspected.[157] In the 1930's, the industrial production of organochlorines and PCBs began, and residues dating from this period are detectable in marine sediment.[158] Their persistence, toxicity, and capacity to inflict damage across media were not appreciated, due to unsophisticated scientific instrumentation and rudimentary levels of scientific understanding concerning synthetic compounds. The pervasive imperial ethos did not encourage interest in the fate of fish, and connections to human health were unrecognised.

During this era, industrial wastes were discharged indiscriminately for at least two reasons: (a) the "germ killing" ability of industrial waste was recognised and even welcomed (the unwitting discovery of toxicity of industrial waste); and (b) the dominant industries, as notable employers, persuaded municipalities to favour industrial interests.[159] Additionally, courts and legislators looked at isolated situations,

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154 *Ibid*.

155 *Ibid*.

156 Watermann and Kranz, *supra* note 144, pp. 133-6. When compared to fish in the North Atlantic, the incidence of disease was greater.

157 *Ibid*., pp. 133-6.

158 *Ibid*., p. 133.

159 Honachefsky, *supra* note 80, p. 108.

focusing on impacts contained within the proximate area, and ignoring impacts downstream or in distant coastal areas where they were often greatest.[160] American champions of watercourses, lacking relevant legislation, had to rely on creative interpretation of the 1899 Rivers and Harbours Act to extend regulation to the disposal of liquid waste into navigable waters.[161] This Act was originally drafted to prevent interference with vessel traffic by prohibiting solid waste disposal into navigable waters. Although such novel use of the Act was laudable, it illustrates the arbitrary nature of the law because polluters of *non-navigable* waters remained beyond legal purview.

After WWII, a new era in pollution regulation began. As scientific knowledge became available, and events such as the spontaneous combustion of highly polluted watercourses became more widely publicised,[162] governments realised that regulations must address pollution more comprehensively to protect, and not merely regulate, water bodies.

Taking primary responsibility for water pollution control away from state and municipal authorities, the US government passed the first federal statute, the Water Pollution Control Act of 1948.[163] It attempted to regulate most conventional domestic and industrial forms of water pollution. The federal government, accepting the

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[160] Visibility of pollution played an important role in establishing liability, as there was no scientific means of measuring invisible pollutants, or even speculating on their existence or potential toxicity. Nor was it within the purview of the courts to consider a causal link or to look beyond the named defendant, thus limiting cases to the facts presented.

[161] Davis and Cornwell, *supra* note 148, p. 19. Also see N.J. Barker, "Sections 9 and 10 of the Rivers and Harbors Act of 1899: Potent Tools for Environmental Protection", 6 *Ecology Law Quarterly* 109 (1976), pp. 109-59. The Refuse Act of 1899, administered by the US Army Corps of Engineers, made it unlawful to dispose of any refuse matter of any kind into a navigable river in the US. The aim, however, was to prevent impediments to navigation. See A.M. Freeman, "Water Pollution Policy", in P.R. Portney (ed.), *Public Policy for Environmental Protection* (Washington, D.C.: Resources for the Future, 1992), pp. 98-9.

[162] Rivers that have burst into flames as a result of dumped rubbish, oil, and chemicals include the Cuyahoga River in Cleveland (1969), Ganges (1968), and the Volga (1970). See Ponting, *supra* note 24, p. 375.

[163] Davis and Cornwell, *supra* note 148, p. 17.

inevitability of a more active role, passed the Water Pollution Control Act Amendments, 1956.[164] This Act endorsed municipal grants for sewage treatment installations, superseded the 1948 Act by authorising states to establish water quality standards, and enacted federal enforcement procedures against individual polluters.[165] The enforcement procedures fell short of their goal, as agencies had too much discretion and success relied on consensus with the polluter.[166] The subsequent US Water Quality Act of 1965 went further by mandating that states establish ambient water quality criteria and design implementation plans.[167] It shifted the administrative responsibility from the US Public Health Service to the Federal Water Pollution Control Administration.[168] This Act was untenable for various reasons. Among other things, the logistics of establishing limits for interstate water bodies were problematical, states varied in their commitment to enforcement, and it was difficult to establish fault for poor water quality.[169]

The Environmental Protection Agency ("EPA") was established by the US government in 1970 as the environmental watchdog and administrative agency for environmental legislation.[170] Responsible for the new Federal Water Pollution Control Act, 1972, the EPA introduced the now-familiar phrase "best available technology" ("BAT") and "best practicable control technology", now known as "best environmental practice"

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164 *Ibid*.

165 Freeman, *supra* note 161, p. 99.

166 *Ibid*.

167 Davis and Cornwell, *supra* note 148, pp. 17-18.

168 *Ibid*. This responsibility ultimately shifted to the Environmental Protection Agency, established in 1970. *Ibid*.

169 Freeman, *supra* note 161, p. 103.

170 See J.P. Lester, *Environmental Politics and Policy*, 2nd ed. (Durham and London: Duke University Press, 1997), p. 77.

("BEP").[171] Regulation of water pollution was less fragmented and more comprehensive ecologically, commencing a new era in pollution regulation.

2) Air Pollution

In the early Middle Ages, air pollution was localised due to low population density and minimal industry.[172] London was among the first cities to suffer widespread air pollution when a wood shortage prompted coal burning in the 13th century,[173] precipitating the earliest known smoke ordinance in England in 1273.[174] Coal burning in open furnaces was banned in London in 1306-7,[175] but this prohibition was ignored due to the lack of a viable alternative, as wood was scarce, and heating and cooking fuel were required for survival.[176]

Legislation to control the pall of smoke over industrial cities was largely nuisance-based.[177] This entailed legal difficulties, such as establishing a causal connection between the alleged offensive source and either physical harm to property or personal discomfort, and practical difficulties such as reliance upon lethargic authorities for

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[171] *Ibid.*, pp. 248-53. Britain also adopted acts that regulated a broad spectrum of water contaminants, commencing with the Rivers (Prevention of Pollution) Act, 1951, administered by the River Authorities, with the aim of maintaining a high standard of water purity. Attempting an initial holistic approach to environmental pollution, Parliament passed the Control of Pollution Act in 1974. This Act was updated via the Environmental Protection Act 1990. See F.G. Davies, *supra* note 148, p. 583 and McManus, *supra* note 97, p. 6. BAT and BEP are discussed in Chapter 4, herein.

[172] As long ago as the Roman Empire, it is reported that smoke stacks were built higher to keep the immediate area free of ash and harmful by-products. See Ponting, *supra* note 24, p. 360.

[173] *Ibid.*, p. 358.

[174] M.C. Blumm (ed.), *Environmental Law* (New York: New York University Press, 1992), p. xii.

[175] See K.B. Foo, L.H. Lye, and K.L. Koh, "Environmental Protection: The Legal Framework", in G.L. Ooi (ed.), *Environment and the City: Sharing Singapore's Experience and Future Challenges* (Singapore: Times Academic Press, 1995), p. 48 and Ponting, *supra* note 24, p. 358.

[176] Ponting, *ibid.*

[177] McManus, *supra* note 97, p. 33. Nuisance actions at common law were available to a plaintiff, but the cost, difficulty in proving the case, and, often, reliance upon the offender for a livelihood deterred most.

enforcement.[178] Sole reliance upon nuisance law perpetuated the problem well into the 20th century.[179]

Air pollution worsened with the Industrial Revolution due to increased burning of fossil fuels and increased manufacturing.[180] Although some statutes were passed to address air pollution,[181] courts and legislatures were largely supportive of industrialisation until the 1880's.[182] Recognising the market's ineffectiveness in curbing air pollution, the judiciary and legislatures shifted from their roles as market protectors of the early 19th century to market regulators in favour of social welfare.[183]

Cities and municipalities were empowered by the state to pass legislation, which typically adopted one of three forms: (a) a declaration that dense smoke emissions from chimneys and smoke stacks were a public nuisance, punishable by fine; (b) a requirement that polluters install technology to abate smoke pollution; and (c) a prohibition on the use of highly polluting fuel such as soft, high-sulphur, bituminous coal.[184] The legislation often failed due to enforcement problems, investigations into invisible pollutants were discouraged, and polluters challenged the legal threshold of "dense smoke".[185] At its inception, the legislation reflected the extent of scientific

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178 See McManus, *supra* note 97, p. 33. See generally Fifoot, *supra* note 85, *pp.* 21 and Gardiner, *supra* note 85.

179 McManus, *ibid.*

180 Another source of pollution was the thriving chemical industry, resulting in the British Parliament passing in 1906 the Alkali Etc. Works Regulation Act, which persisted until the Environmental Protection Act 1990. *Ibid*., p. 34.

181 For instance, English Parliament passed the Alkali Act 1863 to combat the noxious fumes and emissions from the industrial enterprise. *Ibid*., p. 32.

182 See generally Laitos, *supra* note 21. The first air pollution statutes in the US were established in Chicago and Cincinnati in 1881. See P.R. Portney, "Air Pollution Policy", in P.R. Portney (ed.), *Public Policy for Environmental Protection* (Washington, D.C.: Resources for the Future, 1992), p. 28.

183 Laitos, *ibid*., pp. 424 and 430-2. Courts used the law against the perpetrators and for the first time showed a willingness to slow economic growth by insisting that smoke prevention measures be employed. *Ibid*., p. 432.

184 *Ibid*., p. 434. Such municipal powers were upheld by the courts as constitutional. *Ibid*., p. 424.

185 *Ibid*., p. 435. The phrase "dense smoke" was adopted from judicial precedents. Enforcement of legislation was problematic, as no public officials were appointed to locate and prosecute polluters.

knowledge at the time, but the legal thresholds failed to reflect subsequent improvements in scientific knowledge.

Air quality continued to deteriorate into the 1950's, arguably for two broad reasons.[186] First, the legal process suffered inherent inadequacies; for example, the tendency to address symptoms rather than causes,[187] the under-development of legal institutions, the limited effectiveness of regulations without scientific input, and the lack of channels through which to obtain scientific knowledge.[188] Second, the lack of continuous, informed decision-making processes and scheduled reviews of laws resulted in a policy drift towards favouring the market.[189] Legal measures tended to be aimed at remedial, short-term symptomatic cures rather than prevention, which would require addressing fundamental causes.[190]

In the winter of 1952 in London, copious volumes of coal smoke combined with fog to produce noxious smog, affecting 4,000 people and causing hundreds of deaths in one week.[191] This precipitated the Clean Air Act, 1956, which replaced nuisance-based action with qualitative and quantitative standards.[192] The US experienced a corresponding shift from nuisance-based law and municipal ordinances.[193] The federal

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[186] *Ibid*., pp. 437-50. This article provides a useful overview of, and gives concise insight into, the legal deficiencies with respect to air pollution.

[187] Taller smoke stacks were a favoured solution. See V. Dethlefsen, "Marine Pollution Mismanagement: Towards the Precautionary Concept", 17 *Marine Pollution Bulletin* 54 (1986), p. 55.

[188] Generally, see Laitos, *supra* note 21.

[189] See Laitos, *ibid*., pp. 438-50 for many examples of judicial decisions that favour the market, through default and through fear of creating precedents that would be economically untenable. This permitted questionable practices to continue. *Ibid*.

[190] An example of an ineffective, quick-fix law was the prohibition against short smoke stacks. See Laitos, *ibid*., p. 442.

[191] McManus, *supra* note 97, p. 6.

[192] *Ibid*. This is the genesis of the "command and control" approach that characterises environmental legislation of the 1970's and 1980's.

[193] Davis and Cornwell, *supra* note 148, p. 21. In 1952 Oregon became the first US state to pass comprehensive legislation combating air pollution, controlling, among other things, smoke and soot from furnaces and locomotives. See Portney, *supra* note 182, p. 29.

government passed in 1955 the first national act, the Air Pollution Control Act,[194] followed in 1963 by the Clean Air Act, and the Motor Vehicle Air Pollution Control Act in 1965.[195] The Air Quality Control Act passed in 1967 required state action to establish air quality control standards.[196] The administrative function was transferred to the EPA in 1970, which enacted the Clean Air Act Amendments of 1970. Although it incorporated many of the old grant and research programmes, the EPA reflected a new strategy. This included mandatory national ambient air quality standards, emission standards for select new industries, and auto emission standards.[197] This entrenched the era in industrial pollution legislation often tagged "command and control".

3) Agri-chemical Waste

The most notorious non-point source of pollution is agricultural run-off, consisting of fertilisers, pesticides, eroded soil, and airborne residue. The US Department of Agriculture, encouraged by farmers and industrialists (chemical manufacturers), instigated in 1862 the contemporary reliance on pesticides by funding scientific research into increased productivity and lower cost-per-unit production.[198] These first-

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194 Portney, *ibid.*, p. 29. This Act was amended in 1959 and 1962. The Acts did little more than provide funds for research into air pollution and for training technical and managerial personnel. *Ibid.*

195 *Ibid.*, p. 30. Also see Davis and Cornwell, *supra* note 148, pp. 22-3.

196 Portney, *ibid.* The federal Department of Health, Education, and Welfare was to oversee the Act, publish information on impacts of various pollutants and devise viable control techniques for implementation by the states. This Act reflects many of the principles in the Water Quality Act, under the auspices of the same department. See Davis and Cornwell, *ibid.*, p. 23.

197 Davis and Cornwell, *ibid.*, p. 23.

198 The Department of Agriculture provided state grants for research into improved techniques for farmers. Pest control was one of the more enticing areas of research. See A.A. MacIntyre, "Why Pesticides Received Extensive Use in America: A Political Economy of Agricultural Pest Management to 1970", 27 *Natural Resources Journal* 533 (1987), p. 544.

generation pesticides (primarily insecticides) were based on natural substances such as toxic plant extracts, arsenic, and copper sulphates.[199]

The first widely employed synthetic organic pesticide was DDT, which replaced the first generation pesticides.[200] Used first on a large scale during WWII, the US government concluded that DDT posed little risk to mammals.[201] This precipitated the manufacture and use of second-generation pesticides, a range of synthetic organic compounds, which revolutionised agriculture production globally.[202] Assessment of pesticides was very rudimentary, as bioaccumulation was unperceived, only short-term experiments of high doses were conducted, and the focus was mammals, specifically humans. Lack of time, and the unsophisticated nature of instrumentation and knowledge, discouraged any contemplation of chronic and ecosystemic impacts.

Within a decade, the agri-chemical industry mushroomed into a major US industry with powerful lobbies and significant political influence.[203] Pesticide production favoured broad-spectrum products, as manufacturers had to obtain a large market share to recoup costs and generate funds for further research.[204] In a vicious cycle, genetic resistance by pests forced the development of increasingly potent formulas and the need to generate greater revenues to conduct additional research.[205] Marketing

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[199] *Ibid.*, p. 546.

[200] *Ibid.*

[201] *Ibid.*, p. 549. DDT was assumed to have chemical properties similar to the natural substances it was replacing, when in fact it had new properties, allowing it, or rather its breakdown product, to accumulate in fatty tissue and thus become highly mobile in the food-chain. Such assumptions of safety delayed an in-depth review of DDT's properties for many years. *Ibid.*, pp. 549-51.

[202] See MacIntyre, *ibid.*, pp. 546-7. DDT was first made in the late 1800's, but its pesticidal properties were not recognised at the time. Ostensibly harmless to vertebrates and cheap to produce, it was foremost among second-generation pesticides.

[203] DDT production in the US increased from 10 million pounds (4.5 million kg.) in 1944 to over 100 million pounds (45 million kg.) in 1951. *Ibid.*, p. 547.

[204] *Ibid.*, pp. 547-8.

[205] *Ibid.*, p. 548.

campaigns and direct sales teams encouraged pesticide use even where it was improper or unnecessary, and farmers commonly used more than the recommended doses.[206] The "green revolution" spread to developing countries that struggled to produce crops for rapidly growing populations.[207]

As long as pesticides were effective, they could not be kept from the market.[208] The Food and Drug Administration ("FDA") could only regulate residues on consumer items.[209] Early inquiries into the toxicity of synthetic organic compounds were hindered by inadequate scientific knowledge and instrumentation,[210] but a thousand-fold increase in scientific detection sensitivity allowed the FDA to redefine its standards.[211] The development of toxicology science followed advances in detection technology. Research into toxicology was expensive, and neither farmers, wishing to sell their produce, nor manufacturers, seeking economic returns, had any incentive to conduct research, nor were there laws to compel them.[212]

Suspicion about pesticide safety escalated with reports from amateur naturalists and scientists regarding impacts on birds. In her book, *Silent Spring*,[213] the biochemist Rachel Carson detailed the chronic impacts of pesticide use and its threat to wildlife.

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[206] *Ibid*.

[207] The Green Revolution was heavily dependent on pesticides to keep at bay pests that could decimate mono-culture agriculture.

[208] MacIntyre, *supra* note 198, p. 550.

[209] *Ibid*.

[210] *Ibid*., p. 551. Scientists and wildlife biologists warned of possible toxicological effects, but their protests were ignored, and the enthusiastic and essentially unregulated use of DDT continued for almost two decades. See generally T.R. Dunlap, "DDT: Scientists, Citizens, and Public Policy", from T.R. Dunlap, *DDT: Scientists, Citizens, and Public Policy* (Princeton: Princeton University Press, 1981), and reprinted in R.V. Percival and D.C. Alevizatos (eds.), *Law and the Environment: A Multi-disciplinary Reader* (Philadelphia: Temple University Press, 1997), pp. 291-9.

[211] MacIntyre, *ibid*.

[212] *Ibid*. With hindsight, it may have been reckless of the government to allow extensive use of the new generation of chemical compounds without cautious and in-depth scrutiny. However, rapid technological developments in all sectors, social and economic pressure, lack of scientific knowledge, and the huge success of DDT during the war effort discouraged government intervention. *Ibid*.

[213] Carson, *supra* note 66.

She suggested links to human health not only for those handling pesticides, but also to consumers who ingested residues.[214] The book, a best seller, sobered a nation bent on technology, although it was a decade before the government responded with regulatory measures.

D. Fresh Winds

The 1960's were transition years for environmental policy. Technology put men on the moon and helped to both launch the era of "big science" and shift the mindset from sectoral to ecosystemic concerns.[215] The 1960's witnessed the move to "big science" in the marine environment as scientific disciplines came together to comprehensively explore marine life and the physical environment in which they lived.[216]

By the 1960's, international scientific organisations and programmes had become more established[217] as scientists interested in the natural world began to organise themselves. After WWII, the UN bodies, such as UNESCO, FAO, and the World Health Organisation ("WHO") were the foci for action. Until the mid-1950's, FAO was the only UN agency focused on marine sciences, and that was primarily fisheries research.[218] UNESCO, encouraged by physical oceanographers, formed the

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[214] *Ibid*.

[215] For more details concerning the evolution to "big science", see P.F. Hooper, "Scientists' Attitudes Toward Big Ocean Science", *Oceanus*, Vol. 23, No. 1, pp. 62-7 (1980). Also see Scheiber, *infra* note 216.

[216] For a historical overview of marine science development, see generally W.S. Wooster, "On the Evolution of International Marine Science Institutions", 10 *Ocean Yearbook* 172 (1993); Ritchie-Calder, "Perspectives on the Sciences of the Sea", 1 *Ocean Yearbook* 271 (1978); Hooper, *ibid.*; and V. Pravdic, "International Cooperation in Marine Sciences: The Non-governmental Framework and the Individual Scientist", 5 *Ocean Yearbook* 117 (1985). For a review of an earlier example of large-scale marine ecosystem investigation, see H.N. Scheiber, "From Science to Law to Politics: An Historical View of the Ecosystem Idea and Its Effects on Resource Management", 24 *Ecology Law Quarterly* 631 (1997).

[217] The first international body to undertake marine investigations was ICES, founded in 1902 and having as its focus the north Atlantic.

[218] S.J. Holt, "The Intergovernmental Oceanographic Commission – A Biased History", in L.M. Alexander (ed.), *Proceedings of the Fifth Annual Conference of the Law of the Sea Institute,* 1970 (Kingston, R.I.: The University of Rhode Island, 1971), p. 131.

International Advisory Committee on Marine Science.[219] The oceanographers also created the non-governmental Scientific Committee on Ocean Research ("SCOR"), and pursued the International Indian Ocean Expedition. The Intergovernmental Oceanographic Commission (IOC) arose under the auspices of UNESCO, as it became evident from the SCOR project that intergovernmental ocean research, as well as non-governmental sponsored research, was necessary.[220] Much of the research effort was focused on the physical and chemical attributes of the ocean and ocean floor.[221] The IOC assisted in the co-ordination of several large-scale national projects, while the FAO established research institutes, trained scientists, and assisted developing countries with marine research needs, for example concerning ocean-going vessels.[222] Although the IOC Statutes provided for the establishment of links with other organisations like the FAO, this was seldom done.[223]

A broader, more ecologically inclined mindset is seen in the 1960's as a great deal of exploration was undertaken in this time, although compared to today it was rudimentary inasmuch as oceanic processes were being investigated for the first time. Scientists recognised the global nature of the marine ecosystem and thus the need for expansive data. Instigated in 1966 and sanctioned by UNGA in 1968 was the "Long-term and Expanded Program of Ocean Exploration and Research" ("LEPOR").[224] A component of this was the International Decade of Oceanic Exploration, which

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219 *Ibid*.

220 *Ibid*., pp. 131-2.

221 Oceanography, the scientific study of the oceans, has its formal roots in an 1872 voyage of the vessel, *Challenger*, which circumnavigated the globe over a 3½-year period. On this voyage, measurements and readings resulted in the first map of the physical attributes of the ocean floor. For the ensuing century, oceanography was conducted on a grand scale. See W.J. Broad, *The Universe Below: Discovering the Secrets of the Deep Sea* (New York: Simon & Schuster, 1997), pp. 35-8 and B.L. Gordon, *Man and the Sea: Classic Accounts of Marine Exploration* (Garden City, New York: The Natural History Press, 1970).

222 Holt, *supra* note 218, p. 132. The FAO continued to focus primarily on the fisheries areas.

223 *Ibid*., p. 132.

224 *Ibid*., pp. 132-3. UN General Assembly Resolutions 2414 and 2467.

commenced in 1970.[225] Forward thinking individuals saw the need for independent experts and to this end GESAMP was formed in 1969 by UN agencies as an advisory body of specialised scientists to advise the sponsoring agencies and IOC on marine pollution problems.[226] The UN developed its Man and the Biosphere Programme ("MAB"), which, under the auspices of UNESCO, was to sponsor global forums of scientists, including ecologists, to discuss ecological matters.[227] MAB emanated from the 1968 Biosphere Conference,[228] a year after Expo '67 (held in Montreal) had as its theme, "Man and Nature".

Environmental issues were placed squarely on the international agenda by the late 1960's, and at the same time, there were developments primarily in western states that inter-linked environment and social issues. The year 1968 may be regarded as the year of the "Great Divide", marking both the end of the post-WWII period of rapid industrial expansion and economic growth and the beginning of social unrest and student and counter-culture protests in many countries.[229] As a component of the counter-culture protests, environmental concerns were brought to public attention through media coverage of the protests.[230] This was also a watershed year for the environment, as at this time ECOSOC recommended to UNGA that an international

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225 See E. Wenk Jr., "Genesis of a Marine Policy: The IDOE", *Oceanus* Vol. 23, No. 1, pp. 2-11 (1980) and F.D. Jennings and L.R. King, "The IDOE in the National Science Foundation", *Oceanus*, Vol. 23, No. 1, pp. 12-19 (1980).

226 The sponsoring agencies of GESAMP are: IMO, FAO, UNESCO, WMO, WHO, IAEA, UN, and UNEP. See GESAMP, *Report of the First Session, London, 17-21 March 1969*, UN Doc. GESAMP I/11, 1969. UNEP was not yet founded at the inception of GESAMP. In keeping with environmental knowledge, GESAMP changed its name in the early 1990's to the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection. See GESAMP: http://www.gesamp.imo.org/index.html.

227 See L.K. Caldwell, *Between Two Worlds: Science, the Environmental Movement and Policy Choice* (Cambridge: Cambridge University Press, 1992), pp. 16-17.

228 Paris, September 1968. See Caldwell, *supra* note 56, pp. 44-5.

229 A. King and B. Schneider, *The First Global Revolution: A Report by The Council of The Club of Rome* (London: Simon & Schuster, 1991), p. vii.

230 It is somewhat unfortunate as this deepened the schism between the mainstream and those who became pejoratively known as "greenies" (largely, environmental NGOs). Environmental NGOs are gaining credibility in the international community as the ecological ethic gains ground and the NGOs contributions are necessary.

conference be convened on problems of the human environment.[231] The scientific and legal developments were inter-woven with the evolution of mindset, as discussed previously.

Finally, and most significantly for legal development, in 1969 the Stratton Commission published their report entitled, *Our Nation and the Sea*.[232] It was novel in its approach, as it called for total waste management systems to combat pollution and introduced the concept of ICM. By the 1970's, developments in law, science, and ethics illustrated that "sailing with the current" was no longer acceptable.

Part IV Tacking into the Wind: Addressing Ecological Degradation

A. From Classical Pollution to Risk Management

This Part concerns the regulation of LBA, primarily from the 1970's to the present, within the domains of traditional law of the sea and nascent international environmental law. Emphasised is the unrelenting fact that MDLBA policy-making processes occur within a social context. The social context encompasses the predominant ethos, prevailing and competing mindsets, the conflicting and competing priorities of various actors, scientific knowledge (and *beliefs* about scientific knowledge), available technological and behavioural fixes, and public perception (fears and priorities).

Understanding the social context of the policy-making process is relevant, as *each actor* forms an opinion or determination not merely on the available facts, but also on

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[231] Caldwell, *supra* note 228, p. 49. The recommendation was accepted by the General Assembly, which adopted Draft Resolution 2398 (XXIII) on 3 December 1968 without opposition.

[232] Commission on Marine Science, Engineering and Resources, *Our Nation and the Sea: A Plan for Action* (Washington, D.C.: US Government Printing Offices, January 1969). This is known as the Stratton Commission Report, after its chairman, Julius A. Stratton.

the subjective basis of beliefs, preconceived notions, experiences, and knowledge. Awareness of the social context and its role helps to explain the evolution towards a proactive and integrated approach to environmental protection, and the need for it, particularly as ecological degradation has shifted in nature from classical pollution to systemic degradation and environmental risk management.[233]

The shift from classical pollution is the movement away from sectoral regulation to the concept of ecosystemic or integrated regulation, which requires a very different mindset.[234] Integrated environmental regulation, or management in its most evolved form, naturally follows on from acceptance of the scientific concept that inter-dependent habitats form ecosystems, which together comprise the ecosphere, an enormous, single ecosystem. If only one concept could be chosen to describe environmental protection regimes and the accompanying mindset as they have evolved over the last three decades, it would be "integration".[235] The laws of nature require it. It is hoped that the unifying concept for the coming century will be "consilience", being the complete and actual integration of all relevant knowledge, including natural and social scientific literacy, for rational policy.

B. International Environmental Law (IEL) and Law of the Sea (LOS)

The dualism in mindset, namely pro-environment or pro-development, and the latter's underlying imperial ethos are manifest in the domain of international law concerning

[233] See Page, *supra* note 84, for a discussion on the evolution of risk issues, which are largely invisible, complex, insidious, long-term, regional or global, and often associated with scientific uncertainty. Systemic degradation is another encapsulation of risk issues.

[234] See generally, A. Babich, "Understanding the New Era in Environmental Law", 41 *South Carolina Law Review* 733 (1990), reprinted in M.C. Blumm (ed.), *Environmental Law* (New York: New York University Press, 1992), pp. 361-92.

[235] See Appendix 3, Towards Consilience, herein, for a sampling of articles that illustrate the move towards integration, and ultimately consilience.

pollution and other environmental issues. IEL and LOS, two distinct fields of law, have fundamentally different characteristics that reflect the societal priorities and ethos at the time of their inception. Understanding the differences as they relate to MDLBA helps in analysing MDLBA policy-making processes and understanding some of the endemic confusion.

1) Law of the Sea

The LOS is steeped in 300 years of customary state practice.[236] Historically premised on the notion *Mare Liberum*, freedom of the high seas,[237] LOS focused on a code of conduct for states to allow peaceable navigation and set out basic rules for settling marine boundaries and jurisdictional issues.[238] A sacrosanct and fervently protected principle of LOS is sovereign jurisdiction over domestic matters. Persisting in the 2000's, sovereignty continues to be a barrier to effective environmental management, the latter requiring ecosystemic rather than political boundaries.

Political boundaries, however, are integral to LOS, protecting sovereignty but granting concessions to other states. Fundamental to LOS has been the collective agreement by the international community to abide by negotiated duties, obligations, and rules. Treaties are sought, even if they reflect the "lowest common denominator", as states seek concrete agreement to avoid unnecessary international disputes, and LOS

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[236] See generally R.P Anand, "Changing Concepts of Freedom of the Seas: A Historical Perspective", in J.M. Van Dyke, *et al.* (eds.), *Freedom for the Seas in the 21st Century: Ocean Governance and Environmental Harmony* (Washington, D.C. and Covelo, California: Island Press, 1993), pp. 72-90 and Johnston, *supra* note 52, pp. 17-69.

[237] Freedom of the seas was espoused by the Dutch jurist, Hugo Grotius, in the 17th century, who maintained that the seas, unlike land, were incapable of exhaustion by fishing and navigation. An English jurist, John Selden, held a contrary opinion and claimed *Mare Clausum*, closure of the seas. He asserted that national jurisdiction over coastal waters could be extended to the high seas. Grotius' view prevailed, and to this day Selden's arguments remain unknown to most lawyers. See M. Waldichuk, "Control of Marine Pollution: An Essay Review", 4 *Ocean Development and International Law* 269 (1977), pp. 269-70 and A. D'Amato and J.L. Hargrove, "An Overview of the Problem", in J.L. Hargrove (ed.), *Who Protects the Ocean?* (St. Paul, Minnesota: West Publishing Co., 1975), pp. 1-2. Also see Anand, *ibid*., pp. 72-3.

[238] See the 1982 United Nations Convention on the Law of the Sea, 10 December 1982, UN Doc. A/ .62/122 (1982), 21 ILM 1261 (1982).

essentially concerns state rights and duties. Consequently, LOS conferences have attracted, almost exclusively, foreign affairs lawyers and international diplomats who arrive with pre-determined national mandates.[239]

The most modern LOS instrument is the 1982 LOSC,[240] the product of UNCLOS III, a ten-year negotiating process, which commenced in 1973. More than 20 years after the process began, the LOSC came into force.[241] The impetus for the third conference arose from emerging political and economic realities, scientific developments, and rapid technological advances.[242] A multitude of issues converged, from the technological potential for deep seabed mining to marine environmental concerns, requiring a fresh look by lawyers. Their lofty mandate was to review "[t]he basic approach underlying the existing law, and assess the need to change that approach, together with its accompanying procedures and institutions (or lack of them)".[243]

An intersection with IEL occurred as traditional LOS lawyers had to consider two issues historically outside their purview: (a) non-legal elements, such as the scientific data relating to marine pollution and socio-economic issues; and (b) the novel issue of the type of protection that the marine ecosystem should be afforded at law. These

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239 There have been three LOS conferences, commencing in 1958. The first primarily codified the customary international law in four conventions, namely: Convention on the High Seas, 29 April 1958, 450 UNTS 82, 1964 UKTS 39, 13 UST 2312, TIAS 5200; Convention on Fishing and Conservation of the Living Resources of the High Seas, 29 April 1958, 559 UNTS 285, 1966 UKTS 39, 17 UST 138, TIAS 5969; Convention on the Continental Shelf, 29 April 1958, 499 UNTS 311, 1964 UKTS 39, 15 UST 471, TIAS 5578; and Convention on the Territorial Sea and Contiguous Zone, 29 April 1958, 516 UNTS 205, 1965 UKTS 3, 15 UST 1606, TIAS 5639. Although transboundary pollution is noted, failure to explicitly address land-source pollution is understandable as at the time it was considered a domestic issue.

240 LOSC, *supra* note 238.

241 UNCLOS III was convened by resolution of the UNGA on 17 December 1970. It was to commence in 1973, as it was recognised that careful planning was required and that the work of Stockholm (1972) would further its cause. See United Nations General Assembly, General Assembly Resolution 2750 C, 25 UN GAOR Supp. (No. 28) 26, UN Doc. A/8097 (1971).

242 *Ibid*. Although pollution was on the agenda, a primary focus was to be the negotiation of an equitable regime to govern the sea-bed, subsoil, and ocean floor beyond national jurisdiction. *Ibid.*, paragraph 2. Also see J.L. Hargrove "Environment and the Third Conference on the Law of the Sea", in J.L. Hargrove (ed.), *Who Protects the Ocean?* (St. Paul, Minnesota: West Publishing Co., 1975), pp. 192-3.

243 M. Hardy, "International Control of Marine Pollution", 11 *Natural Resources Journal* 296 (1971), at p. 296.

issues were largely glossed over as politically hot issues such as deep seabed mining dominated the conference. Scientists and organisations such as IUCN were consulted, but they were not invited to participate in the negotiations, a function that was reserved for the diplomatic elite.

The LOSC, a framework treaty, reflects the mindset of the 1970's when it was negotiated. LOSC, Part XII — Marine Environmental Protection, sets out basic principles, duties, and obligations, but fails to establish substantial provisions because in the 1970's the concerns of the negotiators were political and not ecological, which resulted in the lowest common denominator principle dominating the environmental provisions. Regardless, the LOSC is a constitution for the oceans, often cited in IEL soft-law instruments as legal authority for environmental protection commitments.[244]

2) *International Environmental Law*

IEL has its genesis in the early 1970's, arguably a precipitate of a widespread realisation in the 1960's that human activities could jeopardise the long-term integrity of the environment. Driven by public pressure, domestic ecological degradation, and environmental ethicists, IEL evolved to fill a vacant legal niche. It has antecedents in international customary law, particularly state responsibility to prevent transboundary injuries;[245] customary law of equitable utilisation of shared resources;[246] international

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[244] See e.g., Agenda 21 and the GPA, *infra* note 254.

[245] Historically, states have been guided by the maxim *sic utere tuo, ut alienum non laedas*, translated as the principle of good neighbourliness. See P.W. Birnie and A.E. Boyle, *International Law and the Environment* (Oxford: Clarendon Press, 1993), p. 89. This principle was adopted in an environmental context in the *Trail Smelter Arbitration*, 33 AJIL (1939) 182, 35 AJIL (1941) 684. The subsequent *Corfu Channel Case*, ICJ Rep. (1949) 1, entrenched the principle in LOS. The duty to prevent *environmental damage* to "neighbours" was confirmed in the Stockholm Declaration on the Human Environment, *infra* note 255, and is now reiterated in most LOS and IEL treaties and soft-law documents.

[246] Some early international case law unwittingly embraced environmental measures by resolving disputes concerning the equitable utilisation of shared resources through measures that resulted in the establishment of river commissions and fisheries organisations. See *Lac Lanoux Arbitration,* 24 ILR 101 (1957) and the *Bering Sea Fur Seals Arbitration,* 1 Moore's International Arbitration Awards 755 (1898). See also early treaties such

watercourse and river basin law;[247] international public health;[248] conservation of species and habitats; and, of course, LOS.[249] IEL also intersects with other areas of law, such as human rights, gender issues, indigenous peoples, population, poverty, rights of future generations, and trade and commerce. Many practitioners of IEL generally adhere to an ecocentric ethic and possess a mindset that fosters cross-disciplinary and cross-boundary thinking.[250] The objective of IEL is the maintenance of ecological integrity, which is amenable to neither the almost exclusive participation of lawyers and diplomats nor the arbitrarily negotiated rules of conduct. IEL, consistent with ecospheric integrity, focuses more on state duties than sovereign rights.

IEL provoked controversy due to its direct conflict with the politically tuned mindset of traditional LOS practitioners, state sovereignty, and economic interest, which permeate LOS. For example, whereas LOS gave states jurisdiction over the Exclusive Economic Zone ("EEZ"), IEL was, and is, perceived as dictating to states the use of that jurisdiction by requiring them to take measures for, ultimately, global

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as the 1909 Treaty Between the United States and Great Britain Respecting the Boundary Waters Between the United States and Canada, 11 January 1909, 4 AJIL (Suppl.) 239.

[247] International watercourse law has historically focused on allocation and use of shared resources between and among common riparians, with little regard for impacts, such as on coastal states, the international community, and the marine environment. See A.E. Boyle, "The Law of the Sea and International Watercourses: An Emerging Cycle", 14 *Marine Policy* 151 (1990), pp. 155-6. The customary law principles of equitable utilisation of shared resources were codified by the International Law Association's (ILA) informal *Helsinki Rules on the Use of the Waters of International Watercourses*, adopted by the International Law Association at its 52nd Conference in Helsinki in 1966, ILA, *Report of the Fifty-second Conference*, Helsinki, 1967. Also see J. Barros and D.M. Johnston, *The International Law of Pollution* (New York: The Free Press and London: Collier Macmillan Publishers, 1974), p. 77.

[248] Human health issues have influenced the evolution of IEL as the inter-dependence of human well-being and environmental degradation have become more obvious. Scientists working on disease control also focused on causes, many of which involve polluted water or air. The Black Sea and Mediterranean states, concerned about quarantine measures, held the first International Sanitary Conference in Paris in 1851. See I.G. Davies, *supra* note 87, p. 17. Concerned about the spread of communicable diseases, 46 countries agreed to participate in the Office International d'Hygiene Publique established in Paris in 1909, which lead to the establishment in 1932 of the League of Nations Health Organisation. *Ibid*. International public health entered modernity with the establishment in 1948 of the UN World Health Organisation (WHO). *Ibid*. Also see Hanlon and Pickett, *supra* note 89, p. 78.

[249] Generally see Johnston, *supra* note 52 and Birnie and Boyle, *supra* note 245.

[250] See B. Boer, "Social Ecology and Environmental Law", 1 *Environmental and Planning Law Journal* 233 (1985).

environmental protection. The IEL mindset favours the functionality of soft-law instruments that establish goals and optimal standards. IEL practitioners tend to be less formalistic, and view hard-law instruments as fraught with watered-down provisions. The respective mindsets collide as IEL practitioners seek ecological protection by any effective means, whereas LOS remains the domain of international lawyers, who understand international politics and prefer the heft of a binding treaty rather than unenforceable, soft commitments.[251]

The 1972 Stockholm conference is the cornerstone of international environmentalism and IEL. Its emphasis on humans as an integral part of the ecosphere fostered the mindset that persists in IEL. This mindset was evident at the second and third major IEL conferences, being the UN Conference on Environment and Development ("UNCED"), held in Rio de Janeiro in 1992, and the UN Conference on the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities ("UNCGPA"), held in Washington in 1995.

Each of the three conferences was conducted as a macro-conference, attempting a comprehensive approach, inviting governments, NGOs, intergovernmental organisations, scientific organisations, and representatives of interested parties, including multi-national corporations and indigenous peoples.[252] Such an approach was so novel that Stockholm was billed as the conference where science and politics

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[251] See generally D.M. Johnston, "UNCLOS III and UNCED: A Collision of Mind-Sets?", in L.K. Kriwoken, *et al*. (eds.), *Oceans Law and Policy in the Post-UNCED Era: Australian and Canadian Perspectives* (London: Kluwer Law International Ltd., 1996), pp. 11-24; D.M. Johnston, "Marine Pollution Agreements: Successes and Problems", in J.E. Carroll (ed.), *International Environmental Diplomacy* (Cambridge: Cambridge University Press, 1988), pp. 199-206; and D.M. Johnston, "Systemic Environmental Damage: The Challenge to International Law and Organizations", 12 *Syracuse Journal of International Law and Commerce* 255 (1985).

[252] The UNCGPA was not as comprehensive in scope as Stockholm and UNCED, as it was focused specifically on land-based issues, but it is impressive in terms of the level of endorsement by the international community of nations.

meet.[253] Although lawyers were present, most participants were non-lawyers from practical and diverse sectors. Not surprisingly, there was little overlap between the delegates to these conferences and UNCLOS III. Working groups at each of the IEL conferences produced action plans,[254] so-called soft-law documents as their primary output, which are discussed below. High-level political participants endorsed the action plans and morally bound the states to implement them through declarations.[255]

3) Convergence of IEL and LOS

The 1990's witnessed a convergence of IEL and LOS mindsets and process, as diverse actors demanded involvement, and non-traditional actors, particularly transnational ethicists, sought treaties where possible. Two examples of converging mindsets are that the 1996 Protocol to the London Convention,[256] a topic traditionally within LOS, was driven by environmental ethicists; and that, conversely, biodiversity and ozone depletion, both being IEL issues, became the subjects of binding treaties.[257] The convergence will become more pronounced with time, as younger lawyers, brought up

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[253] M.F. Strong, "The Stockholm Conference – Where Science and Politics Meet", 1 *Ambio* 73 (1972). Also see W. Dampier, "Ten Years after Stockholm: A Decade of Environmental Debate", 11 *Ambio* 215 (1982).

[254] The action plans are: Stockholm Action Plan for the Human Environment, A/Conf.48/14/Rev.1 (1973); Agenda 21, 13 June 1992, UN Doc. A/Conf.151/4 (1992); and the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities, 5 December 1995, UNEP (OCA)/LBA/IG.2/7. Action plans have been described as primarily scientific in nature, marshalling scientific consensus on priority environmental issues, and mustering political support in the process. See M.K. Tolba, O.A. El-Kholy, E. El-Hinnawi, M.W. Holdgate, D.F. McMichael, and R.E. Munn (eds.), *The World Environment 1972-1992: Two Decades of Challenge* (London: Chapman & Hall, on behalf of UNEP, 1992), pp. 747-8.

[255] The Stockholm Declaration on the Human Environment, 16 June 1972, UN Doc. A/Conf./48/14/Rev. 1, 11 ILM 1416 (1972); Rio Declaration on Environment and Development, 13 June 1992, UN Doc. A/Conf.151/5/Rev. 1, 31 ILM 874 (1992); and the Washington Declaration on the Protection of the Marine Environment from Land-based Activities, 5 December 1995, UNEP (OCA)/LBA/IG.2/6.

[256] 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972, 7 November 1996, IMO Doc. LC/SM 1/6, 36 ILM 1 (1997). Also see R. Coenen, "Dumping of Wastes at Sea: Adoption of the 1996 Protocol to the London Convention 1972", 6 *Review of European Community and International Environmental Law* 54 (1997), for a review of the Protocol and legal principles, including the precautionary concept, reverse listing, and polluter pays.

[257] Convention on Biological Diversity, 5 June 1992, UN Doc. UNEP/Bio. Civ/Conf/L. 2, 31 ILM 818 (1992); Convention for the Protection of the Ozone Layer, 22 March 1985, 1990 UKTS 1, 26 ILM 1516 (1987); and the Protocol (to the 1985 Vienna Convention) on Substances that Deplete the Ozone Layer, 16 September 1987, 1990 UKTS 19, 26 ILM 1541 (1987).

with environmental issues, are more inclined to have an ecological sensitivity and mindset, if not even consider themselves environmentalists and LOS formalists accept the inevitability of ecospheric protection and its juxtaposition with state sovereignty.

4) MDLBA and International Law

MDLBA is an example of the convergence of IEL and LOS. The 1972 Stockholm Action Plan on the Human Environment ("Stockholm Action Plan")[258] placed LBA on the international agenda. It recommended that governments take early action, including co-operative measures, to adopt effective national measures for the control of all significant sources of marine pollution, including those that are land-based.[259] It further recommended that governments, with the guidance of appropriate UN bodies, and in particular GESAMP, should strengthen national controls over land-based sources, particularly in enclosed and semi-enclosed seas.[260] However, regulation of MDLBA takes its legal authority from the LOSC,[261] which, reflecting the sectoral mindset of the 1970's, lists six sources of marine pollution that states should address, three of which emanate from activities on land: land-based,[262] dumping,[263] and atmospheric.[264] LOS lawyers have addressed MDLBA primarily through regional treaties,[265] largely dismissing the possibility of a global treaty, as states are not ready to

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[258] Stockholm Action Plan, *supra* note 254, pp. 6-28.

[259] *Ibid*., Recommendations 70-94, entitled "Identification and Control of Pollutants of Broad International Significance".

[260] *Ibid*., Recommendation 86 refers specifically to marine pollution.

[261] LOSC, *supra* note 238.

[262] *Ibid*., Article 207. Enforcement provisions are contained in Articles 213-222, inclusive. Most instruments subsequent to LOSC treat land-based and atmospheric pollution as one source, while dumping remains artificially segregated for regulatory purposes.

[263] *Ibid*., Article 210. The three other sources are seabed activities (Article 208), activities in the Area (Article 209), and vessel source (Article 211).

[264] *Ibid*., Article 212.

[265] See e.g., Convention for the Prevention of Marine Pollution from Land-based Sources, 4 June 1974, 1978 UKTS 64, 13 ILM 352 (1974); Convention for the Protection of the Mediterranean Sea Against Pollution, 16 February 1976, 15 ILM 290 (1976); Regional Convention for Co-operation on the Protection of the Marine

commit to binding provisions, given the sheer complexity of MDLBA and the socio-economic and political issues involved.

Lawyers have published surprisingly few papers on the soft-law documents relating to MDLBA, namely the 1985 Montreal Guidelines (MGs)[266] and the GPA, even though, in the case of the GPA, 109 states endorsed it.[267] One possible explanation is that non-LOS lawyers perceive MDLBA as a LOS issue, given its reference to marine degradation, while LOS practitioners view it as having more to do with the IEL field, which popularised soft-law instruments. MDLBA ostensibly falls into the proverbial crack between the two.

MDLBA will likely remain a hybrid issue, as LOS and IEL practitioners slowly recognise that MDLBA transcends all currently recognised sectors of environmental regulation and requires divergent and creative approaches by issue, region, and strategy. Soft-law instruments and formal treaties each play a role. The real focus is human behaviour and LBA, with the marine environment providing a catalyst for regional and global cooperation and commitments. It may be prophetic that the GPA is often referred to merely as the "Global Programme of Action on Land-based

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Environment from Pollution, 23 April 1978, 1140 UNTS 133, 17 ILM 511 (1978); Protocol (to the 1974 Barcelona Convention) for the Protection of the Mediterranean Sea against Pollution from Land-based Sources, 17 May 1980, 19 ILM 869 (1980); Convention for Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region, 23 March 1981, 20 ILM 746 (1981); Convention for the Protection of the Marine Environment and Coastal Area of the South-east Pacific, 12 November 1981, ND (Looseleaf), Doc. J.18; Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment, 14 February 1982, 9 EPL 56 (1982); Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, 24 March 1983, 1988 UKTS 38, 22 ILM 221 (1983); Protocol (to the 1981 Lima Convention) for the Protection of the South-east Pacific Against Pollution from Land-based Sources, 22 July 1983, Burhenne 983: 54; Convention for the Protection of the Marine Environment of the North-east Atlantic, 22 September 1992, 32 ILM 1069 (1993); and the Convention on the Protection of the Marine Environment of the Baltic Sea Area, 9 April 1992, reprinted in 22 *Law of the Sea Bulletin* 54 (January 1993).

[266] Montreal Guidelines for the Protection of the Marine Environment Against Pollution from Land-based Sources, 19 April 1985, Decision 13/18/II of the Governing Council of UNEP, 24 May 1985, reprinted in 14 *Environmental Policy and Law* 77 (1985).

[267] One of the few examples of a recent legal publication on MDLBA is D.L. VanderZwaag, P.G. Wells, and J. Karau, "The Global Programme of Action for the Protection of the Marine Environment from Land-based Activities: A Myriad of Sounds, Will the World Listen?", 13 *Ocean Yearbook* 183 (1998). This is written by an international environmental lawyer, an environmental policy-maker, and a marine scientist.

Activities" or merely the GPA, excluding reference to its stated objective of protection of the marine environment. The evolving mindset seems to recognise that MDLBA infers protection of the ecosphere as a global unit and management of human behaviour as it affects that global unit.

Further encouraging an ecospheric mindset, MDLBA may just be the catalyst for amalgamating LOS and IEL. Applying a contemporary "gloss" to the LOSC, it is reasonable, and beneficial, to construe it as a planetary constitution for ecospheric protection. The LOSC naturally and inherently extends from the marine environment to the entire ecosphere, as it obligates states to protect and preserve the marine environment;[268] take measures to prevent, reduce, and control pollution of the marine environment from all sources,[269] including land-based sources and atmospheric;[270] and, significantly, to not transfer one type of hazard, damage, or pollution into another.[271] Given that virtually all LBA are inter-woven with marine degradation and other environmental issues,[272] marine environmental protection measures ultimately protect the ecosphere. Regarding the authority the be construed as such a sacred text, it is legally binding on the majority of states and its provisions relating to state duty to protect the marine environment are accepted principles of international customary law.

In summary, although present distinctions between LOS and IEL are less relevant now than in the past, it helps to understand that LOS traditionally arises from a strong anthropocentric, politically perceptive mindset, with an affinity for legalistic,

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[268] LOSC, *supra* note 238, Article 192.

[269] *Ibid*., Article 194.

[270] *Ibid*., Article 194(3)(a).

[271] *Ibid*., Article 195.

[272] See GESAMP, *Protecting the Oceans from Land-based Activities: Land-based Sources and Activities Affecting the Quality and Uses of the Marine, Coastal and Associated Freshwater Environment*, GESAMP Reports and Studies No. 71, 2001b, wherein GESAMP discusses many environmental issues that are not traditionally considered in relation to MDLBA. This is discussed in detail in Chapter 1, herein.

formalistic, hard-law instruments to confirm the “rules of the game”. IEL, by contrast, has emerged from an ecocentric mindset,[273] with a functionalist, multi-disciplinary approach to resolving issues for the benefit of the global community and not individual states. This is relevant as mindsets affect the content and types of legal principles that have evolved, their application, and their ecological soundness. Most importantly, mindset affects the actors’ commitment to find effective resolutions for environmental problems and not merely change behaviour in ways that may not have the desired effect.

C. Evolution of Ecocentric Policy-making Processes

Environmental policy-making is a social as much as a legal process. As a new field of endeavour, it has had to incrementally assimilate new knowledge, circumstances, disciplines, actors, and experiences, in essence experimenting with its own progress.[274] Reflecting major events that have spawned contemporary environmental legal principles and norms, the evolving MDLBA regime is set in the context of the interplay and influence of extraneous factors, such as political climate, public fear, scientific debate, evolving mindset, and ecological disasters. Reminiscent of public health and industrial pollution regulation in the 19th and early 20th century, international environmental policies, although now more proactive, largely arose, and continues to arise, from public reactions to environmental degradation and perceived health and environmental risks. What was spread across many sectors in the 19th century has coalesced into a single concern that remains equally chaotic.

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273 An ecocentric mindset implies awareness of the ecological harm humans can inflict on the environment and the importance of taking measures to curb such damage, but does not imply that the underlying ethic is ecocentric. Stockholm is a case in point as the focus was on the human environment, and not the ecosphere generally. UNCED, held in 1992, may be criticised in some sectors as too anthropocentric as it continued to seek a balance between development and environmental protection.

274 Experimenting, by definition, entails controlling some variables (e.g., temperature, age of species, light, and salinity) and testing others.

1) United Nations Conference on the Human Environment 1972[275]

Stockholm, like most international diplomatic endeavours, was a reaction; in this case to global environmental concerns centred on population growth, industrialisation, and newfound materialism.[276] Such concerns were slowly being recognised as the collective responsibility of nations. Perhaps because the need for institutional support at the international level was acknowledged, the time was finally ripe in political terms for an international conference to address environmental issues in a more comprehensive and discerning fashion. The conference evoked a reassessment of society's relationship to the environment, as scientists, still exploring ecological principles, warned of emerging problems.[277]

Although Stockholm was originally intended to be primarily an educational and promotional undertaking to mobilise public opinion, stimulate research, and encourage information exchange across all relevant disciplines, the focus shifted in 1969 when ecological issues permeated the agenda.[278] The UNGA decided that Stockholm should provide guidelines for action by governments and international organisations to protect and improve the *human* environment,[279] by cooperating internationally and by addressing the capacity of developing nations to forestall environmental

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[275] See the UN, Report of the United Nations Conference on the Human Environment, 5-16 June 1972, A/Conf.48/14/Rev.1 (1973).

[276] Johnston, *supra* note 76, p. 561 and Caldwell, *supra* note 56, p. 45.

[277] In 1970, GESAMP enumerated, in addition to oil and radioactive materials, ten major categories of substances actually or potentially hazardous to the marine environment: domestic sewage, pesticides, inorganic wastes (including heavy metals), petrochemicals, organic chemicals, organic wastes, military wastes, detergents, solid waste and dredging spoils. See GESAMP, *Report of the Second Session*, March 1970, Annex V: Review of Harmful Chemical Substances, cited in E.D. Brown, "International Law and Marine Pollution: Radioactive Wastes and "Other Hazardous Substances", 11 *Natural Resources Journal* 221 (1971).

[278] Johnston, *supra* note 76, p. 563.

[279] Although Stockholm may be criticised for its anthropocentric focus on the *human* environment and health and well-being of *humans,* this was appropriate and to be expected in the 1970's, as the concept of the ecosphere was just gaining recognition outside the scientific community.

degradation.[280] The success of Stockholm would depend on the effective interaction of actors across disciplines.

One of the largest UN conferences ever, the preparations for Stockholm were unprecedented in scale.[281] One hundred and thirteen UN member states participated, together with representatives of various UN agencies, specialised bodies, intergovernmental organisations, and NGOs.[282] It featured a mix of political and scientific input, with the latter contributing but overpowered by political interests.[283] Progress was arduous, as the developed and developing states had polarised views and expectations.[284]

Stockholm's greatest legacies are arguably (a) the promotion of environmental awareness and responsibility;[285] (b) recognition of the intrinsic links between the environment and social and economic development;[286] and (c) the institutional

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[280] UNGA Resolution 2581 (xxiv), 18 December 1969, cited in Johnston, *supra* note 76, p. 563.

[281] Johnston, *supra* note 52, p. 47. For a comprehensive synopsis of the preparatory process, see Johnston, *supra* note 76, pp. 561-79; Caldwell, *supra* note 56, pp. 56-71; and L.B. Sohn, "The Stockholm Declaration on the Human Environment", 14 *Harvard International Law Journal* 423 (1973), pp. 423-34. Also see L. Emmelin, "The Stockholm Conferences", 1 *Ambio* 135 (1972).

[282] See UN, *supra* note 275, p. 43. Caldwell, *supra* note 56, p. 57, notes that the remarkable feat of reaching an agreement may have been facilitated by the voluntary absence of the Soviet Union and its East European allies.

[283] See generally Caldwell, *supra* note 56, pp. 55-93. Chapter 3, therein, is dedicated to the legacy of the Stockholm Conference.

[284] The developing countries were highly suspicious of the developed countries, finding it difficult to relate the "disease of the wealthy" to their own experience of under-development and poverty. See United Nations in collaboration with École Pratique des Hautes Études (VI e section), *Development and Environment: Environment and Social Sciences*, Report and Working Papers of a Panel of Experts Convened by the Secretary-General of the United Nations Conference on the Human Environment, Founex, Switzerland, 4-12 June 1971 (Mouton, Paris, The Hague, 1972), p. vix ("Founex Report").

[285] Tolba, *et al.*, *supra* note 254, p. 743 and UN, *supra* note 275, p. 32. One legacy of Stockholm has been the designation of June 5 each year as World Environment Day, when governments and the UN organisations reaffirm their commitment to the environment. *Ibid.* Another legacy is the ecosystemic notion of "not transferring" pollution between media. One disappointment of Stockholm, indicative of the mindset then, was the single focus on "pollution", the input of substances and energy, of the marine environment as the primary threat, to the exclusion of integrated management of human activities. See J.C. Pernetta and D.L. Elder, *Cross-sectoral, Integrated Coastal Area Planning: Guidelines and Principles for Coastal Area Development* (Gland: IUCN, 1993), p. 34.

[286] See the Founex Report, *supra* note 284.

infrastructure in the form of UNEP.[287] Among its tangible legacies are the Declaration on the Human Environment ("Stockholm Declaration"),[288] consisting of 26 principles, and the Stockholm Action Plan,[289] consisting of 109 recommendations.

The legal significance of the "soft" products of Stockholm remains debatable. Some believed that the Declaration was a "first step toward the development of international environmental law";[290] while others claim that it represented the "[f]irst acknowledgement by the community of nations of new principles of behaviour and responsibility which must govern their relationship in the environmental era".[291] Regardless, Stockholm, through its promotion of environmental awareness, altered mindsets and encouraged the development of legal initiatives for ecological protection.

The Stockholm Declaration[292] includes principles that have become fundamental to IEL: (a) humans have the fundamental right to freedom and quality of life in an environment that permits a life of well-being and dignity, with the corollary that humanity's responsibility is to protect and improve the environment;[293] (b) recognition that different standards may be necessary to accommodate states at differing levels of development;[294] (c) co-operation at the regional and global levels;[295] and (d) inter-

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[287] UNEP, permanently housed in Nairobi, was created by UN General Resolution 2997 (XXVII) on 15 December 1972. See Barros and Johnston, *supra* note 247, p. 113. UNEP has supported dozens of environmental initiatives over the ensuing decades, often in concert with other organisations.

[288] Stockholm Declaration, *supra* note 255, pp. 3-5. The principles of the Stockholm Declaration appealed to the governments and peoples of the world and the Stockholm Action Plan provided technical guidelines for action.

[289] Stockholm Action Plan, *supra* note 254, pp. 6-28.

[290] This is the opinion of Canada's representative, J.A. Beesley, quoted in Sohn, *supra* note 281, at p. 431.

[291] Maurice F. Strong, quoted in Sohn, *ibid.*, at p. 432.

[292] Stockholm Declaration, *supra* note 255. For a detailed discussion of the Stockholm Declaration, refer to Sohn, *ibid*.

[293] Stockholm Declaration, *ibid.*, Principle 1.

[294] *Ibid.*, Principle 23. Also see Principles 8-15, which refer to developing countries and their capacity for action.

[295] *Ibid.*, Principles 22 and 24, respectively.

generational equality.[296] Other essential principles noted in Stockholm in 1972 are education,[297] scientific research,[298] the utilisation of science and technology for the common good of humankind,[299] and interaction of international organisations.[300] Although marine pollution from the land was not specifically identified, the Declaration denounced pollution and called on states to take measures to prevent pollution of the seas.[301] Recognising the sovereign right of states to exploit resources, it promoted the corollary responsibility to prevent cross-boundary harm.[302]

The 109 recommendations of the Action Plan can be grouped by function.[303]

- The environmental assessment category, the domain of the scientists and technicians, was to generate neutral, hard data, and scientific conclusions within the processes of evaluation, review, research, monitoring, and information exchange.[304]

- The environmental management category, a social process, was to be inter-linked with the assessment category to form an integrated whole, for the purpose of

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[296] *Ibid*., Principle 2.

[297] *Ibid*., Principle 19.

[298] *Ibid*., Principle 20.

[299] *Ibid*., Principles 20 and 18 respectively.

[300] *Ibid*., Principle 25.

[301] *Ibid*., Principles 6 and 7.

[302] *Ibid*., Principles 21 and 22. Refer to Sohn, *supra* note 281, for further discussion of these two provisions.

[303] B. Gosovic, *The Quest for World Environmental Cooperation: The Case of the UN Global Environment Monitoring System* (London and New York: Routledge, 1992), p. xvi-xvii.

[304] Scientific research was advocated as the need for data relating to all sorts of impacts was recognised. Recommendation 76 recommends the development of monitoring and both epidemiological (disease-related) and experimental research programmes to provide data for, among other things, risks to human health. Pursuant to Recommendation 88, GESAMP was to assume a major role in advising on aspects of marine pollution, particularly those of an inter-disciplinary nature. Recommendations 89 through 91 focused on the interplay of UN agencies, namely IOC, FAO, WMO, IAEA, and WHO, with GESAMP; with the IOC in particular co-operating with both UN and non-UN agencies. Of interest in these provisions are: "appropriate emphasis" to be given to chronic, low-level exposures of priority contaminants (Recommendation 89(c)), and the IOC's role in supporting and initiating the development of an inter-disciplinary and inter-organisational system and an inter-disciplinary marine pollution data base (Recommendations 91(c) and (d)).

goal setting and planning, and international consultation and agreement.[305] Scientific and UN agencies and their priority duties were listed.[306]

- The category of supporting measures, vital to the success of the previous two, consisted of education and training, organisation, financing, and technical co-operation, with much of it aimed at assisting the developing countries.

Although the Action Plan reflected the appropriate mindset and language for the development of an effective marine pollution regime, political issues most likely hindered action. The then rudimentary state of marine science, still in its building phase, could not provide determiners and enablers with the certainty they sought: scientific evidence could confirm the occurrence of marine pollution, but not the full extent of the impact from pollutants, individually or in combination. Conveniently, marine pollution issues were deferred to the imminent UNCLOS III.

2) United Nations Third Law of the Sea Conference 1973-82

By the time UNCLOS III was convened in 1973, several multi-lateral global treaties relating to vessel-source pollution and dumping had been concluded.[307] No regional or global instrument existed for MDLBA,[308] which is not surprising given its low profile

[305] The Stockholm Action Plan includes the recommendation that governments take early action, including co-operative measures, to adopt effective national measures for the control of all *significant* sources of marine pollution, including land-based. Recommendation 86 elaborates on marine pollution and its regulation.

[306] Among other issues, the recommendations addressed government support for research into pollutant sources, pathways, exposures, and risks, UN action to provide early warning of risks to human health, provision of information in a form that is *useful to policy-makers at the national level,* and the international acceptability of procedures for testing pollutants and contaminants (Recommendation 74(d)).

[307] These included: the International Convention on the Prevention of Dumping of Wastes and Other Matter, 2 November 1973, 12 ILM 1319 (1973); the International Convention for the Prevention of Pollution from Ships, 29 December 1972, 26 UST 2403; the International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties, 29 November 1969, 26 UST 765; the International Convention on Civil Liability for Pollution Damage, 29 November 1969, 64 AJIL 481 (1970). The latter two conventions were in response to the *Torrey Canyon* disaster. See A.E. Boyle, “Marine Pollution under the Law of the Sea Convention”, 79 *American Journal of International Law* 347(1985), p. 349.

[308] MDLBA was then referred to as marine pollution from land-based sources, being a much narrower and restrictive formulation compared to MDLBA, as discussed in Chapter 1, herein. For a discussion on the

and the continuing conviction, despite Stockholm, that impacts from LBA were domestic issues. UNCLOS III, however, was concerned not so much with pollution, but with nationalisation of ocean space.[309] Coastal states, becoming technologically capable, asserted claims of sovereignty over adjacent seabed resources, while traditional maritime powers argued freedom of the high seas.[310] It was a formal, diplomatic conference with bargaining, negotiating, lobbying, and formation of state alliances to secure agreement.

The almost ten-year process of UNCLOS III culminated with the 1982 LOSC.[311] The LOSC is a framework convention that contains in Part XII - Protection and Preservation of the Marine Environment, provisions for marine environmental protection. Concluded in 1982, the LOSC reflects the mindset of the 1970's, as previously discussed. Although it might be criticised as a political compromise of watered-down rights and responsibilities, an optimistic view is that it comprises general principles that emanated from protracted negotiations, with some imperfections that may be overcome by interpreting not the provision, but the spirit, of the LOSC. It can be imagined that the drafters recognised the requirement for a "living text" that would adapt to new situations and evolving knowledge. Supporting this is Article 237, which states that state policy regarding marine environmental protection should be consistent with both the general principles and *objectives* of the

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replacement of "pollution" by "degradation", refer to L.A. Kimball, "The United Nations Convention on the Law of the Sea: A Framework for Marine Conservation", in International Union for the Conservation of Nature, *The Law of the Sea: Responsibilities in Implementing the Convention* (Cambridge, U.K. and Gland Switzerland: IUCN Publications Services Unit, 1995), pp. 36 and 57.

[309] National sovereignty clashed with freedom of the seas when coastal states became technologically capable of exploiting the non-living resources of the continental shelf and states realised the economic value of the living resources in what the LOSC deemed the Exclusive Economic Zone (EEZ). The rush to nationalise ocean space was perceived to be the most striking feature of ocean law development in the post-war period. See Hargrove, *supra* note 242, pp. 191-3.

[310] Negotiating a formula for the sharing of deep sea-bed nodules occupied much of UNCLOS III as developing states claimed their share of a common resource that only the developed states could afford to exploit.

[311] LOSC, *supra* note 238.

LOSC.[312] Thus, new environmental law principles such as inter-generational equity, the precautionary principle, sustainable development, polluter pays, and ecosystem-based management, although not part of the 1970's LOS mindset, are consistent with the objectives of the LOSC. The LOSC, which came into force on 16 November 1994, arguably binds all states concerning marine environmental protection, as states that have not ratified it largely accept Part XII as international customary law.[313]

Marine pollution is included in Part XII. Articles are generally stated, often delegating standard setting to other conventions.[314] As previously mentioned, the sectoral mindset of the 1970's is reflected in the way marine pollution in the LOSC comprises six sources: land-based,[315] sea-bed activities,[316] activities in the Area,[317] dumping,[318] vessel-source,[319] and atmospheric.[320] It was pointed out in Chapter 1, herein, that factually, land-based, atmospheric, and dumping are but a single source, as all emanate from human activities on land. The complexity and political sensitivity of land-based sources of pollution is evident in the ambiguous wording of the provisions, as states are compelled to merely "take into account" international standards and to

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[312] *Ibid*., Article 237(2). Also of note is that Article 237(1) states that the LOSC is without prejudice to specific obligations assumed outside the LOSC, both present and future, so long as they are in furtherance of the general principles of the LOSC.

[313] See J.E. Hickey Jr., "Custom and Land-based Pollution of the High Seas", 15 *San Diego Law Review* 409 (1978).

[314] LOSC, *supra* note 238. Article 192 sets forth the general provision that states are obligated to protect and preserve the marine environment. Article 193 reaffirms state sovereignty, subject to a state's duty to protect and preserve the marine environment. To this end, Article 195 articulates the duty not to transfer hazards or transform one type of pollution into another. Article 197 advocates co-operation on a global and regional basis to formulate rules, standards, practices, and procedures for the protection and preservation of the marine environment. Measures to prevent pollution of the marine environment, contained in Article 194, include phrases such as "best practicable means" and "in accordance with their capabilities".

[315] LOSC, *supra* note 238, Article 207. Enforcement provisions are contained in Articles 213-222 inclusive.

[316] *Ibid.,* Article 208.

[317] *Ibid*., Article 209. The "Area" refers to the deep-sea bed, which is considered the common heritage of mankind.

[318] *Ibid*., Article 210.

[319] *Ibid*., Article 211.

[320] *Ibid*., Article 212.

"endeavour" to harmonise policies at a regional level.[321] Article 207(5) does isolate and emphasise the release of toxic, harmful, and noxious substances, particularly those that are persistent. This encompasses PCBs, DDT, and other synthetic chemicals, which were then recognised as emerging environmental problems. Among the most relied-upon provisions for marine environmental protection have been those concerned with conservation and management of living resources of the EEZ[322] and the high seas,[323] and provisions encouraging regional co-operation within states bordering enclosed and semi-enclosed seas.[324] Of note in the LOSC is the lack of ecological language, such as reference to ecosystems, habitats, and holistic measures, and the focus on pollution, not degradation. This must be a reflection of the formalist LOS mindset, as given the timing of UNCLOS III, immediately following Stockholm, a higher degree of ecologically sensitivity is a reasonable expectation.

Improved ecological knowledge and IEL have broadened the application of Part XII. For instance, IEL instruments, namely Agenda 21 and the GPA, extend "marine pollution from land-based sources" to MDLBA.[325] Atmospheric pollution is now encompassed by MDLBA and is no longer considered a separate source. Further, cumulative coastal degradation has placed ICM on the international agenda, and

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[321] See B. Kwiatkowska, "Marine Pollution from Land-based Sources: Current Problems and Prospects", 14 *Ocean Development and International Law* 315 (1984), pp. 318-19. The land-based provisions are minimal in comparison to vessel source provisions. Regarding land-based sources, the LOSC says that states shall adopt rules and regulations taking into account internationally agreed standards, and they shall endeavour to establish global and regional rules, standards, procedures and recommended practices and procedures taking into account factors such as economic capacity of developing states and their need for economic development. See Article 207(1) and (4) and Article 212(1) and (3). Article 212, referring to atmospheric pollution, fails to mention factors to be considered such as capacity of states and need for economic development in developing states. There does not appear to be a good reason for this.

[322] LOSC, *supra* note 238, Part V, Articles 61 to 68, inclusive.

[323] *Ibid.*, Part VII, Articles 116 to 120, inclusive.

[324] *Ibid.*, Part IX, Articles 122 and 123. Of significance is the lack of ecological language in the enclosed and semi-enclosed sea provisions as they are defined utilising geographical and legal terms such as gulf, basin, or sea and "consisting of ... the territorial seas and EEZ of two or more states" (Article 122).

[325] See the GPA, *supra* note 254 and Agenda 21, *supra* note 254.

although not specifically mentioned in the LOSC, instruments referring to ICM draw their legal authority from Part XII, citing state duty to protect and preserve the marine environment.

The LOSC may be interpreted charitably as “[a] fundamental shift from power to duty as the central controlling principle of the legal regime of the marine environment, and a transition from a regime based on obligations of responsibility for damage to one based on obligations of regulation and control.”[326] Part XII of the LOSC is too general to adequately protect the marine environment, but it provides a necessary springboard to more specific action, much of which is found in IEL instruments.

3) Regional Initiatives regarding Land-based Activities

During UNCLOS III negotiations, two regions addressed land-based pollution through treaties: the Baltic[327] and the North-east Atlantic (including the North Sea).[328] Bravely addressing new issues, they became reference points for evolutionary thinking. UNEP, a legacy of Stockholm, identified regional seas as a priority for action, and in 1974, it established the Regional Seas Programme (“RSP”).[329] UNEP’s participation in the Mediterranean arrangements, which resulted in the 1976 Convention for the Protection of the Mediterranean Sea against Pollution (“Barcelona Convention”),[330] successfully

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326 Boyle, *supra* note 307, at p. 370.

327 Convention on the Protection of the Marine Environment of the Baltic Sea Area, 22 March 1974, 13 ILM 13 (1974) and the Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft, 15 February 1972, 11 ILM 262 (1972).

328 Convention for the Prevention of Marine Pollution from Land-based Sources, 4 June 1974, 1978 UKTS 64, 13 ILM 352 (1974).

329 For a brief history and review of the RSP, see P.M. Haas, “Save the Seas: UNEP’s Regional Seas Programme and the Coordination of Regional Pollution Control Efforts”, 9 *Ocean Yearbook* 188 (1991), pp. 188-99; P.C. Schröder, “UNEP’s Regional Seas Programme and the UNCED Future: Aprés Rio”, 18 *Ocean and Coastal Management* 101 (1992); M.A. Jacobson, “The United Nations’ Regional Seas Programme: How Does It Measure Up?”, 23 *Coastal Management* 19 (1995), p. 20; and GESAMP, 2001b, *supra* note 272.

330 Convention for the Protection of the Mediterranean Sea Against Pollution, and the 1980 Protocol (to the 1976 Barcelona Convention) for the Protection of the Mediterranean Sea against Pollution from Land-based Sources, *supra* note 265. Also see the 1996 Protocol for the Protection of the Mediterranean Sea against Pollution from Land-based Sources and Activities, which amends the 1980 Protocol for the Protection of the Mediterranean

launched the RSP.[331] The Mediterranean RSP, involving co-operation among both developing and developed states, inspired other areas to initiate RSPs. Among the early respondents were: West and Central Africa,[332] South-east Pacific,[333] the Red Sea and Gulf of Aden,[334] and the Caribbean.[335] Today, RSPs are in 12 areas, comprising over 140 states and territories.[336] The Baltic and the North-east Atlantic-North Sea are the only regional sea regimes operating outside UNEP's auspices.

The RSP approach to marine environmental protection involves legally binding treaties where possible, and the extensive use of action plans to underpin co-operative efforts to link environmental quality assessment, causes of degradation, and policy responses for management and development.[337]

There is little doubt that the RSPs have been successful, but on what level? It has been said that the real utility of the RSPs have been the transfer of marine science technology to, and capacity building of scientific resources within, developing states.[338] Marine environmental protection has been enhanced through political consensus, international legal instruments, and capacity building, but analyses of the

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Sea against Pollution from Land-based Sources, 7 March 1996, http://www.unep.ch/seas/main/med/ mlbspii. html.

[331] See Jacobson, *supra* note 329, p. 20.

[332] Convention for Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region, *supra* note 265.

[333] Convention for the Protection of the Marine Environment and Coastal Area of the South-east Pacific and the Protocol (to the 1981 Lima Convention) for the Protection of the South-east Pacific against Pollution from Land-based Sources, *supra* note 265.

[334] Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment, *supra* note 265.

[335] Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, *supra* note 265.

[336] See GESAMP, 2001b, *supra* note 272, pp. 159-60. The areas are: Mediterranean, Caribbean, West and Central Africa, Eastern Africa, East Asian Seas, Northwest Pacific, ROPME Sea Area/Kuwait Action Plan Region, South-east Pacific, Red Sea and Gulf of Aden, South Pacific, Black Sea, and South Asian Seas. Negotiations for co-operation in the Upper South-west Atlantic and the Northeast Pacific are under way. *Ibid*.

[337] *Ibid*., p. 159. Also see Jacobson, *supra* note 329, pp. 20-1. Also see UNEP, Guidelines and Principles for the Preparation and Implementation of Comprehensive Action Plans for the Protection and Development of Marine and Coastal Areas of Regional Seas, UNEP Regional Seas Reports and Studies No. 15, 1982.

[338] See Haas, *supra* note 329, p. 212.

RSPs have mostly canvassed financial, administrative, and various programme activities, and have not correlated environmental improvements to policy actions.[339] State-of-the-marine-environment reports indicate the successes or failures as reflected by the health of the habitats, but greater effort can be made to clearly link available scientific knowledge to policy decisions to policy implementation and ultimately, to environmental health.

An in-depth review of almost 30 years of RSPs could be a useful exercise, particularly given the GPA and the focus on marine degradation from a vast range of LBA. It could provide insight into effective means of implementing the GPA, Agenda 21, and existing treaties to attain ecosystemic and economic efficiency. GESAMP, with its 2001 reports, *Protecting the Oceans from Land-based Activities*[340] and *A Sea of Troubles,*[341] have laid a foundation for such a review, as they have looked at regional action plans in relation to LBA.[342] A comprehensive review of the RSPs may reveal lessons that can be shared and costly mistakes that can be avoided in other jurisdictions.

4) 1985 Montreal Guidelines for the Protection of the Marine Environment against Pollution from Land-based Sources (MGs)[343]

Marine pollution from land-based sources was designated as one of three priority areas for environmental law development at a 1981 UNEP *Ad Hoc* Meeting of Senior Government Officials Expert in Environmental Law in Montevideo.[344] As a global

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339 Jacobson, *supra* note 329, p. 32. It is indicated that at the time, 1995, after 20 years of RSP, no concerted attempts to link environmental improvements to specific measures had been undertaken.

340 GESAMP, 2001b, *supra* note 272.

341 GESAMP, *A Sea of Troubles*, GESAMP Reports and Studies No. 70, 2001a.

342 GESAMP, 2001b, *supra* note 272, pp. 56-74.

343 MGs, *supra* note 266.

344 Q.N. Meng, *Land-based Marine Pollution: International Law Development* (London: Graham and Trotman/Martinus Nijhoff, 1987), pp. 163-4. The other two priority areas were protection of the stratospheric

treaty remained politically unfeasible, recommendatory guidelines were a realistic compromise, with participants emphasising their non-binding and flexible nature.[345]

The MGs[346] were unanimously adopted in 1985.[347] Experts nominated by 32 states and six intergovernmental organisations and NGOs were present at the final meeting.[348] The drafting process differed from UNCLOS III and other legal conferences, as the conference objective was a checklist of non-negotiated items. However, it was legalistic in that it retained the legal language from the LOSC and the three regional initiatives referring to land-based sources.

The MGs introduced to the global community at a refreshingly practical level the progressive philosophy of holism and a comprehensive ecosystem approach.[349] The MGs uniquely linked the uses of the environment, scientific understanding of pollutants (including pathways, targets, impacts, and the fate of the agent in the environment),[350] and the choice of control strategies for a comprehensive, ecosystemic framework.[351] Despite the linkages, the MGs lack overall integration of strategies to provide comprehensive management, and instead form a comprehensive checklist for

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ozone layer and the transport, handling, and disposal of toxic and dangerous wastes (UNEP/GC. 10/5/Add.2 and Corr. 1. and 2 and UNEP/WG.92/2, p. 27). See Meng, *ibid.,* for additional details.

345 R.M. M'Gonigle, "'Developing Sustainability' and the Emerging Norms of International Environmental Law: The Case of Land-based Marine Pollution Control", 28 *The Canadian Yearbook of International Law* 169 (1990), p. 192. The MGs were not intended to be a model agreement, but rather a checklist of basic provisions that governments could adapt to their specific needs in developing regional agreements or national legislation. See MGs, *supra* note 266, Introduction.

346 MGs, *ibid.*

347 Meng, *supra* note 344, p. 164. A total of 44 states participated in an *Ad Hoc* Working Group of Experts on the Protection of the Marine Environment against Pollution. For greater discussion on the sessions and the MGs generally, see Meng, *ibid.*, pp. 164-6 and M'Gonigle, *supra* note 345. The MGs were adopted at the 13th Session of the Governing Council of UNEP on 24 May 1985.

348 Meng, *ibid*., p. 167. See fn. 14, therein, for a listing of some of the organisations present.

349 In defining pollution, the MGs substitute the more holistic term "marine ecosystems" for the LOSC formulation of "marine life". See MGs, *supra* note 266, Guideline 1(a).

350 See GESAMP, *The Health of the Oceans*, UNEP Regional Seas Reports and Studies No. 16, 1982, which lists land-based sources as a primary concern in marine environmental protection, was a significant contribution to the drafting of the MGs and in increasing awareness of trans-jurisdictional impacts from land-based sources.

351 See P.G. Wells and R.P. Côté, "Protecting Marine Environmental Quality from Land-based Pollutants: The Strategic Role of Ecotoxicology", 12 *Marine Policy* 9 (1988).

environmental management. An apt analogy is that of environmental regulation as a patchwork quilt: the MGs provided the patches, but did not sew them together.

The MGs, while reiterating the general spirit of the LOSC, do not constitute the international standards referred to in the LOSC, Article 207, as they lack detailed content and were intended only as a menu for choosing strategies for pollution regulation.[352] Neither do they provide a logical scientific framework for protecting and managing the marine environment.[353] They do recommend three pollution control strategies based on (a) marine environment quality standards, (b) emission standards, and (c) environmental planning.[354] Priorities for control may be assessed according to specified criteria, which call for "black" and "grey" listings.[355] The assimilative capacity of the marine environment was recognised, as it was at Stockholm, but its use as a comprehensive management strategy was rejected, as it was perceived by many as a licence to pollute.[356] The MGs advocated the balancing of ecological concerns with anthropocentric needs.[357] Although the strategies provided a management framework, the nature of such a framework was never elucidated.[358] Consequently, lack of

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352 A.E. Boyle " Land-based Sources of Marine Pollution: Current Legal Regime", 16 *Marine Policy* 20 (1992), p. 34.

353 J.S. Gray, D. Calamari, R. Duce, J.E. Portmann, P.G. Wells, and H.L. Windom, "Scientifically Based Strategies for Marine Environmental Protection and Management", 22 *Marine Pollution Bulletin* 432 (1991), p. 435.

354 MGs, *supra* note 266, Annex I, 1.1, 1.2, and 1.3.

355 *Ibid*., Annex II. The recommendation is to eliminate the black-listed substances and strictly regulate the "grey-listed" substances to ensure safe disposal.

356 V. Pravdic, "Environmental Capacity – Is a New Scientific Concept Acceptable as a Strategy to Combat Marine Pollution?", 16 *Marine Pollution Bulletin* 295 (1985), p. 296. The assimilative capacity was proposed as the basis for a comprehensive management strategy, but the European Economic Community nations opposed this, and it was ultimately "lost in the thicket of compromises and trade-offs". *Ibid*.

357 For example, "[i]n controlling marine pollution from land-based sources, an overall approach to the uses and the natural values of the marine environment should be taken", while still considering societal and industrial needs for waste disposal. The stated goal was to protect the marine ecosystem by maintaining its "quality within acceptable levels", such levels to be determined by "scientific, institutional, social and economic factors". See MGs, *supra* note 266, Annex I, Introduction.

358 See R.P. Côté, "Marine Environmental Management: Status and Prospects", 25 *Marine Pollution Bulletin* 18 (1992), in which the nature and elements of a framework are discussed with reference to documents and proposals put forth primarily by scientists.

direction has impeded attempts at implementation and it has provided an excuse for inaction.

The MGs are scientifically flawed for two obvious reasons. The first is that they fail to specify a framework for determining applicable marine quality standards. Thus, design and implementation are left to determiners and enablers who may or may not be science literate. Second, emission standards, the second strategy, are arbitrary and cannot be applied blanket-fashion, as receiving habitats vary in sensitivity and in their ability to assimilate the effects of various activities. As the MGs generally reflected the then-mainstream mindset and remained faithful to familiar strategies, they offered a level of comfort and familiarity that advanced recognition, if not acceptance, among states and provided a basis for communication between scientists and policy-makers. Although the regulatory success of the MGs is debatable, they were an appropriate form of instrument at that point in time. Global environmental awareness soon overtook and outdated the MGs, but their role in the continuing development of an effective global regime for MDLBA should not be underestimated.

5) Our Common Future, 1987

The World Commission on Environment and Development ("WCED") was established after an urgent call by the UNGA for a global agenda for change.[359] The WCED, chaired by Norway's Prime Minister Gro Harlem Brundtland, met for the first time in November 1984 and published their report, *Our Common Future* ("Brundtland Report"), in 1987.[360] WCED's mandate revolved around the critical inter-locking

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[359] WCED, *Our Common Future* (Oxford: Oxford University Press, 1987), p. ix.

[360] *Ibid*. The Brundtland Report has been criticised as perpetuating, through sustainable development, the imperial ethos, with a more eco-friendly mindset, rather than calling for a whole new perspective on environmental management. See D.L. Ray and L.R. Guzzo, *Environmental Overkill: Whatever Happened to Common Sense?* (New York: HarperPerennial, 1993), p. 5 and L.K. Caldwell, s*upra* note 227, pp. 180-1.

issues of environment and development, referred to as "sustainable development".[361] Relying on testimony and deliberations from five continents, WCED foresaw a new path that would sustain humans over the entire planet and into the distant future.[362] WCED called on the UNGA to transform the Brundtland Report into a UN Programme on Sustainable Development.[363] Breaking from old patterns, it could re-orient development through re-directed policies and institutions, and in turn reflect newfound attitudes towards the planet and the means of attaining economic growth.[364] Sustainable development was to become the vessel that would carry the global community away from the rocky shoals of socio-economically induced ecological degradation.

The Brundtland Report articulated the inter-linkages of environmental integrity and anthropocentric development in ways not achieved at Stockholm. It provided an overview of the critical issues facing the global community. The time was ripe socially and politically for a discourse on the marriage of the environment and development, and the international community's mindset was receptive to the juxtaposition of traditionally conflicting issues. In terms of economics, such a

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361 The now fundamental legal principle of sustainable development gained notoriety through the Brundtland Report, but it was mentioned in the MGs, Guideline 5, as a consideration in establishing internationally agreed rules, criteria, standards, and practices. As sustainable development is an amorphous concept with many different meanings, the following articles provide an overview: A.E. Chircop, "The Mediterranean Sea and the Quest for Sustainable Development", 23 *Ocean Development and International Law* 17 (1992); A. Couper and E. Gold (eds.), *The Marine Environment and Sustainable Development: Law, Policy and Science* (Honolulu: University of Hawaii, 1993); C.E. Di Leva, "Environmentally Sustainable Development and the World Bank", *International Business Lawyer* 115 (March 1997); D.L. VanderZwaag, "The Concept and Principles of Sustainable Development: 'Rio-formulating' Common Law Doctrines and Environmental Laws", 13 *Windsor Yearbook of Access to Justice* 39 (1993); D.L. VanderZwaag, *Canada and Marine Environmental Protection: Charting a Legal Course Towards Sustainable Development* (London, The Hague, Boston: Kluwer Law International, 1995); E.D. Gomez, "Coastal Zone Management and Ecosystem Protection", in K.L. Koh, *et al.* (eds.), *Sustainable Development of Coastal Areas in Southeast Asia: Post-Rio Perspectives* (Singapore: National University of Singapore, SEAPOL, and IUCN (CEL), 1995); and D. Sitarz (ed), *Sustainable America: America's Environment, Economy and Society in the 21st Century* (Carbondale, Illinois: EarthPress, 1998).

362 WCED, *supra* note 359, p. 4.

363 *Ibid*., pp. 23 and 343.

364 *Ibid*. The WCED perceives economic growth as an imperative, especially in developing nations, to counteract poverty and ecological degradation.

marriage was perceived as less attractive, although some industries quickly learned, for instance through forced compliance with the Montreal Protocol,[365] that "going green" in some instances yields surprising economic benefits, such as lower capital outlays on production or appeal to ecologically aware consumers.[366]

The Brundtland Report proposed practical actions to abate ecological degradation, most grounded in basic common sense. A relevant proposal is the call for an increased role in informed decision-making for both the scientific community and NGOs.[367] In addition to the substantive concept of sustainable development, the invaluable contribution of the Brundtland Report was to encourage the development of "process". To this end, it recommended that the UN sponsor a Conference on Environment and Development.[368]

6) The 1990 State of the Marine Environment Report

Following their 1982 report on *The Health of the Oceans*,[369] GESAMP published the 1990 *State of the Marine Environment* report.[370] Among the factors contributing to global marine environmental degradation, sewage was identified as a leading cause, and oil and radionuclides, which had driven earlier treaty-making processes and public concern, were assigned lower priorities.[371] The results surprised many determiners and

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[365] Protocol (to the 1985 Vienna Convention) on Substances that Deplete the Ozone Layer, 16 September 1987, 1990 UKTS 19, 26 ILM 1541 (1987).

[366] For example, many computer-related industries discovered cheaper and more effective alternatives to CFCs as cleaning agents, while others revised manufacturing processes to reduce chemical use, recycle water and chemicals, and eliminate waste. Also see L. Scarlett, "Doing More with Less – Unsung Environmental Triumph", in R. Bailey (ed.), *Earth Report 2000: Revisiting the True State of the Planet* (New York: McGraw-Hill, Inc., 2000), pp. 41-62 and M. Suijkerbuijk, "Waste Prevention: Corporate and Environmental Benefits", 9 *Environmental and Planning Law Journal* 258 (1992).

[367] WCED, *supra* note 359, pp. 326-29.

[368] *Ibid.*, p. 343.

[369] GESAMP, 1982, *supra* note 350.

[370] GESAMP, *The State of the Marine Environment*, GESAMP Reports and Studies No. 39, 1990.

[371] *Ibid.*

enablers, and other actors. In another science-law paradox, the priority contaminants identified by scientists globally and regionally gained recognition in the legal domain, but the scientifically grounded suggestions for managing them have been largely overlooked.

7) The 1992 United Nations Conference on Environment and Development

Carrying forward the momentum of the Brundtland Report, 118 heads of state met in Rio de Janeiro from 3-14 June 1992 for the historical "Earth Summit", also known as UNCED. Never before have so many heads of state met to discuss any topic, let alone two topics that have traditionally been so disparate.[372] UNCED made explicit the intricate linkages of human activities and environmental integrity that were first acknowledged at Stockholm 20 years earlier. It is for this inter-linkage that UNCED has been heralded as a success.[373] Additionally, UNCED raised the environmental consciousness of the global community,[374] and evinced a fresh ethic for the management of human activities. Environment and development are integrated themes based on the dualistic proposition that effective environmental management depends on understanding the underlying nature and patterns of development, and that

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[372] See J. Schnoor, "The Rio Earth Summit- What Does it Mean?", 27 *Environmental Science and Technology* 18 (1993).

[373] Although UNCED has its critics, given the enormity of the undertaking and the complexity of environmental and development issues, the fact that UNCED took place and its subsequent impacts on global environmental awareness make it remarkable. See G. Palmer, "The Earth Summit: What Went Wrong at Rio?", 70 *Washington University Law Quarterly* 1005 (1992) for an overview of UNCED achievements, and criticisms. For further commentary on UNCED, see P.H. Sand "UNCED and the Development of International Environmental Law", 3 *Yearbook of International Environmental Law* 3 (1992); C. Flavin, "The Legacy of Rio", in L. Starke (ed.), *State of the World 1997: A Worldwatch Institute Report on Progress Toward a Sustainable Society* (London and New York: W.W. Norton & Company, 1997), pp. 3-22; M. Pallemaerts, "International Environmental Law from Stockholm to Rio: Back to the Future", in P. Sands (ed.), *Greening International Law* (London: Earthscan Publications Limited, 1993), pp. 1-19; I. Porras, "The Rio Declaration: A Basis for International Cooperation", in Sands (ed.), *ibid*., pp. 20-33; Schröder, *supra* note 329; and M.F. Strong, *From Stockholm to Rio: A Journey Down a Generation* (Earth Summit Publication: Number One, UNCED, 1991).

[374] Palmer, *ibid*., p. 1006.

sustainable development relies on the maintenance of environmental integrity, from which a bounty of natural resources and good health emanate.[375]

UNCED followed the Stockholm template, in that the knowledge, experience, and capacity that went into preparations for UNCED were significantly multi-disciplinary, with representations from numerous sectors of governments, intergovernmental organisations, NGOs, scientists, corporate and industrial leaders, trade unionists, educators, and others.[376] There was little overlap between the actors that attended UNCED and the actors that attended the protracted, formalistic negotiations of UNCLOS III.[377]

Concurrent with the main UNCED meetings was the NGO "Global Forum" held several dozen kilometres away. Although such strong NGO representation was welcome, speculation was rampant regarding the intentions, if any, that underlay their isolation from the main forum. It is not known what impact the NGOs had on the negotiation process and outcomes of UNCED, but the international networking that took place should foster the implementation of the UNCED measures at the national level.[378]

UNCED differed from Stockholm, the only other international conference to comprehensively examine a sweeping policy area and to recommend an equivalently

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[375] A. Barcena, "An Overview of the Oceans in Agenda 21 of the United Nations Conference on Environment and Development", 25 *Marine Pollution Bulletin* 107 (1992), p. 107.

[376] *Ibid*. All these actors should have a role in implementing the products of UNCED. For a synopsis of the preparatory process and ensuing negotiations, see B. Cicin-Sain and R.W. Knecht, "Implications of the Earth Summit for Ocean and Coastal Governance", 24 *Ocean Development and International Law* 323 (1993). Also see L.N. Antrim and P. Chesek, "The UNCED Negotiating Process", 18 *Ocean and Coastal Management* 79 (1992).

[377] One exception is Ambassador Tommy Koh of Singapore, who was the Chairman of the UNCED Preparatory Committee process and President of UNCLOS III in its final years. His skill and leadership positively affected the outcome of both conferences. See Cicin-Sain and Knecht, *ibid*., p. 327.

[378] *Ibid*., p. 336.

broad range of actions.[379] First, UNCED, benefiting from 20 years of experience, scientific and socio-economic data, and scientific consensus on many of the global impacts of human activities, was underpinned with scientific knowledge that was absent at Stockholm. Second, UNCED was driven by environmental zealousness and public fear over major global issues, such as ozone depletion and threats of global climate change**.** Reflecting an evolved mindset, UNCED developed greater sophistication than Stockholm's listing of recommendations as it attempted to establish concrete strategies.

The UNCED outputs include two hard-law instruments, the Convention on Biological Diversity[380] and the United Nations Framework Convention on Climate Change,[381] and three soft-law instruments: the Rio Declaration on Environment and Development ("Rio Declaration"),[382] Agenda 21,[383] and the Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forests.[384]

The hard-law instruments, favoured by formalists, legally bind nations and thus, they are seen to have a great impact on international law development. Although no reference is made to MDLBA in either, sound measures pursuant to either treaty should impact favourably on the marine environment. Similarly, measures taken under

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379 *Ibid*., p. 323.

380 Convention on Biological Diversity, *supra* note 257.

381 United Nations Framework Convention on Climate Change, 9 May 1992, UN Doc. A/Conf.151/26, 31 ILM 849 (1992).

382 Rio Declaration, *supra* note 255. One of achievements of UNCED was the establishment of common, but differentiated, responsibilities. Rio Declaration, *ibid.*, Principle 7. Also see L.A. Kimball, "UNCED and the Oceans Agenda: The Process Forward", 17 *Marine Policy* 491 (1993), p. 492 and P.H. Sand, *Lessons Learned in Global Environmental Governance* (Washington: World Resources Institute, 1990).

383 Agenda 21, *supra* note 254.

384 Non-Legally Binding Authoritative Statement of Principles for a Global Consensus on the Management of Conservation and Sustainable Development of All Types of Forests, 13 June 1992, UN Doc. A/Conf.151/6/Rev. 1, 31 ILM 881 (1992).

the Forestry Statement will impact on the oceans, as sustainable deforestation should reduce sediment runoff into fresh and marine water bodies.[385]

Agenda 21, a formidable 40-chapter document, encompasses a vast spectrum of issues with admirable detail.[386] It recommends an anticipatory, integrated, and ecosystemic management approach. MDLBA is specifically addressed in Chapter 17, "Protection of the Oceans and Seas", although it is indirectly addressed in virtually every other chapter in Section II and in other sections, as each chapter refers to an issue that somehow relates to humankind's relationship with and use of the oceans.[387]

Consistent with its ecosystemic mindset, Agenda 21 broadens the conception of land-based sources to MDLBA.[388] The definition is two-pronged, focusing on marine pollution from land-based *sources*, and the associated contaminants,[389] and land-based *activities* that contribute to marine environmental degradation.[390] Such broad conceptualisation invites innovative management schemes to (a) prevent, reduce, and control pollution, and (b) encourage land-use planning to regulate human activities.[391]

Agenda 21 provides an enlightened approach to management of marine degradation, calling for anticipatory and preventative, rather than reactive, approaches.[392] The

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385 The ecological impacts of deforestation are discussed in Chapter 1, herein.

386 Agenda 21, *supra* note 254. Soft-law instruments, due to their non-legally binding nature, usually achieve stronger measures as compared to treaties, in which commitment is ferociously negotiated.

387 Of the 40 chapters in Agenda 21, a few examples of chapters touching on LBA are atmospheric protection (Chapter 9), deforestation (Chapter 11), freshwater quality (Chapter 18), toxic chemicals (Chapter 19), and solid, hazardous, and radioactive wastes (Chapters 19, 20, and 22, respectively), poverty (Chapter 3), changing consumption patterns (Chapter 4), and sustainable human settlements (Chapter 7).

388 *Ibid*., paragraphs 17. 18, 17.19, and 17.24.

389 *Ibid*., paragraph 17.18.

390 *Ibid*., paragraph 17.19. This paragraph highlights activities on land such as human settlements, land-use, construction, agriculture, forestry urban development, tourism, industry, coastal erosion, and siltation. A second source of marine environmental degradation noted in Agenda 21 is shipping and sea-based activities. *Ibid*., paragraph 17.20.

391 Personal communication, John Karau, Chief, Marine Environment Division, Environment Canada, Ottawa, Canada, 18 December 1995.

392 Agenda 21, *supra* note 254, paragraph 17.21.

objectives are noble, with recommended measures spanning the spectrum: environmental impact assessments ("EIAs"), the "polluter pays" principle, improved standards for coastal populations, integrated environmental protection, and socio-economic and development policies.[393]

The provisions relating to MDLBA focus attention, but perhaps they fail to go far enough. The drafters overlooked the conceptual link between ocean-dumped matter and human activities on land, thereby missing an opportunity to revise the mindset that categorises dumping as a separate issue. In a similar way, the chapters on freshwater, toxic chemicals, and hazardous, solid, and radioactive wastes[394] note the links to other chapters and encourage the integrated approach, but they fail to relate them specifically to MDLBA. The integrated approach to environmental management is thus undermined through lack of clearly articulated inter-linkages.

Agenda 21 stresses the inter-connection of science and effective policies. Most chapters suggest areas of research and the type of data required by determiners and enablers. Chapters 31 and 35 are specifically dedicated to strengthening the role of science and utilising science in the implementation phases of Agenda 21. Chapter 31 is ostensibly dedicated to the applied sciences, as among the listed members of the scientific and technological community are engineers, architects, industrial designers, and urban planners.[395] These professionals have key roles in sustainability, but so do natural scientists as investigators and interpreters of nature and the impacts of human activities.

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[393] *Ibid.*, paragraph 17.22.

[394] *Ibid.*, Chapters 18, 19, 20, 21 and 22 respectively.

[395] *Ibid.*, paragraph 31.1.

Chapter 35, entitled *Science for Sustainable Development,* recognises the under-utilisation of natural science, highlighting areas where scientific input is useful, if not essential. The four programme areas in the chapter are (a) strengthening the scientific basis for sustainable management; (b) enhancing scientific understanding; (c) improving long-term scientific assessment; and (d) increasing scientific capacity.[396] It seeks to inject science into the development process and foster communication among scientists and non-scientific actors.[397] Two other chapters relevant to the infusion of sound science into MDLBA policy-making are "Chapter 36: Promoting Education, Public Awareness, and Training" and "Chapter 40: Information for Decision-making". The former refers to activities that range from elevating education priorities within the UN framework and implementing decisions from the UNESCO/UNEP International Environmental Education Programme,[398] to encouraging relevant education of the public and MDLBA actors.[399] Chapter 40 identifies two programme areas, bridging the data gap and improving information availability.[400] Chapters 36 and 40 are pertinent in ensuring that sound decisions emanate from policy-making processes.

Despite Agenda 21's scientific soundness, UNCED itself has been cited as a "signal victory for the foes of scientific progress, knowledge, and economic development".[401] Although this is a strong accusation, one supporting factor is that more than 250 of the world's leading scientists, including 27 Nobel Laureates, released on 1 June 1992 a

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396 *Ibid*., paragraph 35.4.

397 *Ibid*., paragraph 35.5.

398 *Ibid*., paragraph 36.5(g). Also see the Intergovernmental Conference on Environmental Education, *Final Report* (Paris: UNESCO, 1978), Chap./III.

399 *Ibid*., Agenda 21, paragraphs 36.5 (a)-(o).

400 *Ibid*., paragraph 40.1.

401 Ray and Guzzo, *supra* note 360, at p. 7. Also see J.M. Bewers, "The Declining Influence of Science on Marine Environmental Policy", 10 *Chemistry and Ecology* 9 (1995), p. 11, where it is suggested that Agenda 21, while more detailed than Stockholm Action Plan regarding marine environmental protection, is less clear and coherent. This is attributed to "conflicting social philosophies", including the role of the precautionary concept. Bewers, *ibid*., p. 11.

statement, the *Heidelberg Appeal*,[402] directed at the heads of state at Rio.[403] It was noted that in two years of UNCED preparation, the involvement of scientific specialists in relevant issues was insignificant.[404] Underlying the *Heidelberg Appeal* was observations by scientists that decisions affecting the environment were being made in accordance with emotionally driven, public demands and perceptions. Through the *Heidelberg Appeal*, scientists called for scientific input and common sense in policy-making. The *Heidelberg Appeal* was neither acknowledged by the heads of state nor taken into account during the negotiations at UNCED.[405]

8) UNEP Intergovernmental Conference on Protection of the Marine Environment from Land-based Activities, Washington 1995

Pursuant to Agenda 21,[406] the UNEP Governing Council agreed in May 1993 to undertake a comprehensive process that would culminate in the two-week long UNCGPA to adopt a programme of action for MDLBA.[407] After contentious discussions, the 1994 Montreal Meeting of Government Designated Experts on the Protection of the Marine Environment from Land-Based Activities concluded that the MGs should be advisory only in drafting a "Global Programme of Action".[408]

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402 See Bewers, *ibid*., Appendix 1, therein, p. 23. It is reproduced herein as Appendix 4, The Heidelberg Appeal to the Heads of States and Governments. Bewers notes that it was signed by "425 members of the scientific and intellectual community". Also see Ray and Guzzo, *supra* note 360, p. 6.

403 Ray and Guzzo, *ibid.* and see Bewers, *ibid*., p. 21.

404 Ray and Guzzo, *ibid*.

405 *Ibid.*, p. 7.

406 Agenda 21 recommended that states co-operate to update, expand, and strengthen the MGs as appropriate. See Agenda 21, *supra* note 254, paragraph 17.25 (a).

407 Convened pursuant to UNEP's Governing Council decision 17/20 of 21 May 1993, three preparatory meetings were held in 1993, 1994, and 1995. See the UNEP, *Report of the Conference to Adopt a Global Programme of Action for the Protection of the Marine Environment from Land-based Activities*, Washington, D.C., 23 October to 3 November 1995, UNEP(OCA)/LBA/IG.2/6, 5 December 1995. Participants included the 109 states, specialised UN agencies, intergovernmental organisations, and observers (including 29 NGOs).

408 See Environment Canada, *Workshop Report on the 1985 Montreal Guidelines for the Protection of the Marine Environment against Pollution from Land-based Sources* (Ottawa, Canada, 17-21 January 1994), p. 1. The Workshop deemed the MGs outdated and of limited assistance, given Agenda 21 and the then-recent policy developments, and determined to use the MGs only as an aid in drafting a new programme of action. Also see E.J. Norrena and P.G. Wells, "Protection of the Marine Environment from Land-based Pollutants: A Canadian

Preparing and drafting the GPA was largely an informal process, with representations, papers, and recommendations from diverse entities such as governments, NGOs (notably Greenpeace),[409] and scientists.

Senior government representatives attending the final days of the UNCGPA adopted the Washington Declaration on the Protection of Marine Environment from Land-Based Activities ("Washington Declaration").[410] Its preamble and 18 articles reaffirm Agenda 21, Chapters 17, 33, and 34 in particular, and the Rio Declaration.[411] The Washington Declaration highlighted the general inter-dependence of human populations and the coastal and marine environment, and the growing and serious threat of LBA to human health and environmental integrity.[412] Solutions ranged from ecology-based ideas such as ICM and catchment area approaches, to inter-linkages with economic and social development programmes.[413] Recognising the debilitating role of poverty and the need to alleviate it, the developed nations agreed, at least tacitly, to assist developing nations.[414] Substantive issues were supported, such as the processes in progress to address the priority issues of sewage and wastewater treatment

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View of the Montreal Guidelines", a paper delivered to the SEAPOL Workshop on the Control of Land-based Marine Pollution: A Comparative Study of the Canadian and Southeast Asian Experience, SEAPOL Phase II, Project B, Rama Gardens Hotel, Bangkok, Thailand, 7-10 May 1989.

409 Greenpeace was an active participant. See Greenpeace International, "Land-based Sources of Marine Pollution: Sounding the Alarm", prepared for the Meeting of Experts on the Control of Marine Pollution from Land-based Sources, Montreal, Canada, 6-10 June 1994; Greenpeace International, "The Precautionary Approach in the Context of Land-based Sources of Marine Pollution", prepared for the Meeting of Experts on the Control of Marine Pollution from Land-based Sources, Montreal, Canada, 6-10 June 1994 and Greenpeace International, "Annotations by Greenpeace International on UNEP's Draft Global Programme of Action to Protect the Marine Environment from Land Based Activities", prepared for the Meeting of Experts on the Control of Marine Pollution from Land-based Sources, Reykjavik, Iceland, 6-10 March 1995.

410 UNEP, *supra* note 407.

411 Washington Declaration, *supra* note 255, Preamble. Agenda 21, Chapters 17, 33, and 34 refer to protection of the marine environment; financial resources and mechanisms for implementation; and the transfer of technology, co-operation, and capacity building, respectively.

412 Washington Declaration, *ibid*., Preamble.

413 *Ibid*.

414 *Ibid*.

and POPs;[415] the intention to develop and review national action plans within a "few years";[416] implementation of noted programmes; and immediate preventative and remedial action where possible.[417]

(a) The GPA

Through the Washington Declaration, senior government representatives morally bound their governments to the provisions of the GPA,[418] thus imbuing it with a degree of political credibility far surpassing that of its forerunner, the MGs. Adopted by 109 governments and the European Commission,[419] the GPA[420] contains comprehensive conceptual and practical guidance for protection of the marine environment. The GPA's legally non-binding status is consistent with an inclination towards international environmental soft-law instruments, particularly in complex and controversial areas.

The GPA adopts a multi-disciplinary, broad, and systematic approach to the issue of marine protection from LBA. Drawing on UNCED and the ecocentric mindset of the 1990's, its five chapters highlight the reasons for marine environmental protection, inter-linking human health, biodiversity, and productivity of the marine environment,

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[415] *Ibid*., Articles 15, 16, and 17.

[416] *Ibid*., Article 2.

[417] *Ibid*., Articles 3 and 5, respectively.

[418] GPA, *supra* note 254.

[419] The Conference was attended by representatives of 109 states: Antigua and Barbuda, Argentina, Australia, Austria, Bahrain, Bangladesh, Belarus, Belgium, Belize, Benin, Bhutan, Botswana, Brazil, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Chad, Chile, China, Colombia, Comoros, Congo, Costa Rica, Cote d'Ivoire, Croatia, Cuba, Denmark, Dominica, Ecuador, Egypt, Estonia, Ethiopia, Finland, France, Gambia, Georgia, Germany, Ghana, Greece, Honduras, Iceland, India, Indonesia, Israel, Italy, Jamaica, Japan, Jordan, Kazakstan, Kenya, Kiribati, Kuwait, Malawi, Malaysia, Maldives, Malta, Marshall Islands, Mauritius, Mexico, Micronesia (Federated States of), Monaco, Mozambique, Nauru, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Pakistan, Peru, Philippines, Poland, Republic of Korea, Romania, Russian Federation, Rwanda, Saint Lucia, Samoa, Sao Tome and Principe, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Slovenia, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Thailand, Togo, Tunisia, Turkey, Turkmenistan, Uganda, United Kingdom of Great Britain and Northern Ireland, United Republic of Tanzania, United States of America, Uruguay, Vanuatu, Venezuela, Yemen, Zaire, Zambia and Zimbabwe.

[420] GPA, *supra* note 254.

together with coastal habitat degradation.[421] Although ultimate responsibility for action is to be borne by the states, regional co-operation and international institutional support are integral and critical components of the GPA.

The first of its five chapters reviews the international legal duty to protect the marine environment and the interface with national sovereignty, specifically naming the LOSC as legal authority.[422] The aim of the GPA is specified as facilitating the realisation of the legal duty of states to preserve and protect the marine environment and to assist them in taking action individually and jointly.[423] Reflecting the mindset of UNCED, it places this duty "squarely within the context of sustainable development".[424] It reiterates agreement at UNCED to apply preventative, precautionary, and anticipatory approaches; ensure prior assessment of activities; integrate marine environmental protection within the broader development policies; develop economic incentives; and improve living standards of coastal populations.[425] The chapter concludes boldly with the reminder that the GPA is intended for conceptual and practical guidance and that its (and Agenda 21's) implementation requires novel and innovative approaches in all sectors, and new forms of collaboration between and among all actors.[426]

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[421] *Ibid*., Chapter I, paragraph 1.

[422] *Ibid*., paragraphs 4, 5, and 6. Articles 207 and 213, and Parts XII, XIII and XIV of the LOSC are cited. These parts respectively focus on marine environmental protection, scientific research, and technological capacity of developing states. Paragraph 7 embraces several other international instruments that contain duties to protect the marine environment, including dumping, climate change, and biodiversity, and regional seas conventions. The MGs, although legally non-binding, are noted in paragraph 8.

[423] GPA, *ibid*., Chapter I, paragraph 3.

[424] *Ibid*., paragraph 9.

[425] *Ibid*., paragraph 9 (a)-(e), respectively. Paragraphs 10-13 refer to Agenda 21, Chapter 17 provisions regarding financial mechanisms, cleaner technology, and research to assist developing states; as well as links to the Noordwijk Guidelines adopted at the 1993 World Coast Conference, Small Island Developing States, and transfer of technology issues.

[426] *Ibid*., paragraphs 14 and 15.

Chapters II, III, and IV contain bases for action, objectives, and recommended actions at the national, regional, and international levels, respectively. Chapter II establishes a convincing basis for action by linking sustainable ocean use with public health, food security, poverty, economic and social benefits, and ecosystem health.[427] It identifies methodical steps to develop pragmatic and sustainable national action plans, illuminating an integrated and multi-sectoral mindset by calling for the review of diverse elements.[428] It targets global priority sources and activities, namely sewage; POPs; radioactive substances; heavy metals; hydrocarbons; nutrients; sediment mobilisation; litter; physical alteration and destruction of habitats; and sources of degradation (point, non-point, and atmospheric).[429] The objective is to develop comprehensive, continuing, and *adaptive* national programmes of action that reflect state priorities.[430] It also identifies legal measures to be used, such as BAT, BEP, integrated pollution prevention control ("IPPC"), and clean production practices, among other measures that may be adopted as appropriate.[431] The precautionary concept is endorsed, but not defined. Paragraph 24 elaborates on the "precautionary approach", citing conditions for its application, namely where there are threats of serious or irreversible damage, lack of scientific uncertainty should not be used as a reason for postponing cost-effective measures to prevent the degradation of the marine

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[427] *Ibid*., paragraph 16. For further discussion, see Norrena and Wells, *supra* note 408, p. 11.

[428] *Ibid*., paragraph 21. Refer to Appendix 5, The GPA: Integrative Assessment, herein, for the five elements to be assessed. For an interesting discussion, see J.R. McCullagh, "Analysis of UNEP's Global Programme of Action for the Protection of the Marine Environment from Land-based Activities with Respect to Direct Disposal of Carbon Dioxide", Ocean Storage of CO_2 Workshop 4: Practical and Environmental Approaches, IEA Greenhouse Gas R&D Programme, Appendix I, pp. 115-23, Cheltenham, U.K., May 1997.

[429] *Ibid*., paragraph 21(b)(i-viii), (c), and (d)(i-iii).

[430] *Ibid*., paragraph 18. The source and activity categories are listed, and it is indicated that identification and assessment of priorities is a process of combining the five elements previously mentioned. Regarding the policy objective, note the focus on "adaptive", a necessary characteristic to adjust policies to reflect emerging scientific evidence, new technology, and other factors.

[431] *Ibid*., paragraph 26(a)(i). Paragraphs 26(a)(ii)-(iii) and (b)-(f) contain other measures, such as land-use planning, education and awareness, data collection, and institutional arrangements.

environment. This is reminiscent of the use of "precautionary principle" in other instruments. In addition to the call in Chapter I for preventative, precautionary, and anticipatory approaches, Chapter V calls for the "appropriate use of the concept of the precautionary approach".[432]

Chapter III focuses attention on regional aims, objectives, and measures, particularly in enclosed or semi-enclosed seas. Co-operation in all areas and sectors is the dominant theme.[433] It encourages active participation in regional conventions, and the strengthening of existing, and negotiation of new, conventions as necessary.[434] Non-legal initiatives are encouraged, such as networking and involving other actors, for example financial institutions, development banks, local and regional authorities and commissions, and other relevant organisations.[435] Paragraph 33 lists broad and diverse considerations for the development and implementation of regional programmes, including critical habitats, innovative financial mechanisms, inter-linkages with organisations, and capacity building. Its integrated approach encourages upstream land-locked states to join marine environmental protection programmes.[436]

International co-operation and institution building, the focus of Chapter IV, is encouraged for successful and cost-effective implementation of the GPA.[437] "State of the global marine environment" reports are earmarked as crucial, together with the flow of technology and financial resources.[438] Chapter IV also establishes a clearing-

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[432] *Ibid*., paragraphs 9 and 111(a), respectively.

[433] The GPA identifies efficiency and capacity building as attributes of well-executed regional initiatives. See GPA, *ibid*., paragraph 29. This mirrors Agenda 21.

[434] *Ibid*., paragraph 31.

[435] *Ibid*., paragraph 32.

[436] *Ibid*., paragraph 34.

[437] *Ibid*., paragraph 36.

[438] *Ibid*., paragraph 37. To this end, GESAMP has published two recent reports: GESAMP, 2001a, *supra* note 341 and GESAMP, 2001b, *supra* note 272.

house mechanism for the mobilisation and availability of experience and expertise, including facilitating co-operation on scientific, technical, and financial issues.[439]

Chapter V, entitled "Recommended Approaches by Source Category", provides guidance for states taking action at the national, regional, and international levels, in accordance with their capacity, resources, and priorities.[440] The provisions elaborate on the basis for action; objectives/proposed targets; and activities under the source and activity categories listed in Chapter II.[441] Suggested actions, policies, and measures cover a broad spectrum of options and the recommendations draw on the legal principles set out in Chapter I.[442]

The Annex to the GPA focuses on internal and external funding sources and mechanisms. Encouraging the mindset of joint responsibility among nations, this annex suggests innovative and creative financing proposals.[443]

(b) Future of the GPA

The GPA is legally non-binding, focuses on complex and sensitive issues, and directly conflicts with a founding principle of LOS, namely state sovereignty. To a formalist, successful implementation seems remote. To a functionalist, the GPA offers promise, to be judged not in the coming years, but in the coming decades. It is largely scientifically sound, and the text arguably contains sufficient principles, processes, and

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[439] GPA, *ibid*., paragraphs 42-49.

[440] *Ibid*., paragraph 92.

[441] *Ibid*. Refer to paragraph 21(b)(i-viii) and (c) for the source categories.

[442] *Ibid*., Chapter V. For each source category, a range of appropriate measures is suggested. Sewage and POPs are selected as global priorities. Sewage treatment is complex and moving along slowly, but a new treaty concerning POPs has been adopted. See the Stockholm Convention on Persistent Organic Pollutants, 23 May 2001, [2001] ATNIF 7, 40 ILM 532 (2001).

[443] GPA, *ibid*., Annex. Suggested are tax structures, debt for equity (nature) swaps, revolving funds, and others. However, it may be argued that the GPA fails to effectively internalise environmental costs. Also see C. Williams and B. Davis, "Land-based Activities: What Remains to be Done", 29 *Ocean and Coastal Management* 207 (1995).

measures to adequately protect the marine environment and the ecosphere. The obvious hindrance to implementation is not the content or philosophy, but the level of political will and commitment to problem solving. A less obvious implementation problem lies deeper – with the level of scientific literacy of the actors. Without scientific literacy, the adoption of scientifically sound policy-making processes and decisions at the international, regional, and domestic levels is at risk.

9) Stockholm Convention on Persistent Organic Pollutants (“POPs Convention”)

Pursuant to the Washington Declaration, and UNEP’s decision to convene an intergovernmental negotiating committee to draft a treaty on POPs,[444] the POPs Convention was approved at the Conference of Plenipotentiaries for this convention on 22-23 May 2001.[445] The POPs Convention focuses on eliminating and restricting certain POPs,[446] and managing the unintentional production of specified POPs from anthropogenic activities.[447] A group of scientific experts assisted in developing scientifically sound criteria and procedures for identifying potential POPs.[448] The POPs Convention cites as its objective the protection of human health and the environment, noting the relevance of the precautionary approach contained in the Rio Declaration.[449] It further notes the damage to terrestrial and aquatic environments beyond national jurisdiction and the duty of states, in accordance with principles of

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[444] Intergovernmental Negotiating Committee for an International Legally Binding Instrument for Implementing International Action on Certain Organic Pollutants, *Report of the Intergovernmental Negotiating Committee for an International Legally Binding Instrument for Implementing International Action on Certain Organic Pollutants on the Work of Its Fifth Session, 26 December 2000*, UNEP/POPS/INC.5/7, p. 1 (“Report of the Intergovernmental Negotiating Committee”).

[445] POPs Convention, *supra* note 442.

[446] *Ibid.*, Annexes A and B, respectively.

[447] *Ibid.*, Annex C.

[448] Report of the Intergovernmental Negotiating Committee, *supra* note 444, p. 1.

[449] POPs Convention, *supra* note 445, Article 1.

international law (neglecting to provide an authority for those principles), to ensure that activities within their jurisdiction do not harm other states or areas beyond domestic jurisdiction.[450] Unfortunately, the preamble neglects to mention the GPA, or, more importantly, the LOSC. Once again, the language is adequate for effective environmental protection, but success rests on the scientific soundness of implementing law and policies.

10) GESAMP's Report on Protecting the Oceans from Land-based Activities, 2001

Pursuant to the GPA,[451] GESAMP published in 2001 the report, *Protecting the Oceans from Land-based Activities: Land-based Sources and Activities Affecting the Quality and Uses of the Marine, Coastal and Associated Freshwater Environment*.[452] It provides insight into the current state of the marine environment and the LBA that affect it, together with their impacts. The most serious problems affecting the marine and coastal areas noted are (a) alteration and destruction of habitats; (b) sewage; (c) eutrophication; (d) declining fish stocks and other renewable resources; and (e) changes in sediment flow due to hydrological changes.[453]

It is a comprehensive report that largely follows the source categories of the GPA. The explanation of the inter-linkages among issues and source categories, and the ways in which they influence or can be influenced by each other, is useful. A very broad view of MDLBA is adopted, as links to climate change and other issues regulated by

[450] *Ibid*., Preamble.

[451] The report was initiated by UNEP for use at the first intergovernmental review meeting of the GPA's implementation progress. *Ibid*., p. 7.

[452] GESAMP, 2001b, *supra* note 272.

[453] *Ibid*., p. 1, and described in detail in Chapters 2 and 3, therein.

international conventions are noted.[454] GESAMP identifies the root causes of marine degradation from LBA as poverty, poorly managed social and economic development, and unsustainable consumption.[455] Inter-connected with the root causes are institutional failures that reflect governments' lack of commitment to take rational action and to address market failures in resource valuation.[456] Suggested priority strategies for action are improved planning and management frameworks, improved awareness and education, and enhanced implementation of existing mechanisms.[457]

The report was compiled from regional reports collated within the framework of the GPA, and other relevant reports. Significantly, the report was peer reviewed by listed experts.[458] The experts include scientists, social scientists, and policy-makers. Thus, it has a seal of quality assurance from a range of disciplines. It is user-friendly, with a very helpful and educational glossary of scientific and technical terms.

This publication immediately followed GESAMP's publication of *A Sea of Troubles*.[459] The latter provides an educational overview of marine degradation issues, vulnerable habitats and the pressures affecting them, and possible actions for redress. It compliments *Protecting the Oceans*, and, it too, is peer reviewed, giving it credibility and allaying concerns of bias.[460] *A Sea of Troubles* contains less scientific detail, and provides more analysis of marine degradation issues, reasons for policy failure, and means of attaining sound policy.

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[454] *Ibid*. See Chapters 2-4, therein.

[455] *Ibid*., p. 4.

[456] *Ibid*., pp. 116-7.

[457] *Ibid*., p. 3, and Chapters 5 and 6, therein.

[458] *Ibid*., p. 5.

[459] GESAMP, 2001a, *supra* note 341.

[460] It states that it is a peer reviewed document and lists the individuals who participated in the process. This is very helpful to non-scientists as it provides an endorsement of quality and allows more weight to be given to the report.

Not surprisingly, the suggested way forward entails integration, inter-linkages, vertical and horizontal co-ordination, and economically and ecologically sound decisions.[461] Provided is a list of seven wide-ranging failings that impede action.[462] They are insightful, as each could be remedied, at least partially, through scientific literacy. A brief overview of the failures follows:[463]

(i) Poor governance of the marine environment, "including a widespread failure to understand the need to approach their inter-linked environmental problems in an integrated way". The sectoral approach and failure to meaningfully involve a range of actors can often lead to poor allocation of funds.

(ii) Fragmentation and lack of coordination among international programmes and institutions, resulting in poorly defined priorities and inadequate translation of objectives into actions.

(iii) Economic constraints, amplified in part by the failure to recognise the economic value of the natural services provided by the marine environment.

(iv) Deficiencies in national policies and practices that impair participation in international efforts.

(v) Weak scientific infrastructure and lack of scientific involvement in policy-making processes.

(vi) Ineffective communication among scientists (investigators) and policy-makers

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[461] See GESAMP, 2001b, *supra* note 272, pp. 75-126. This report discusses this in detail, whereas GESAMP, 2001a, *supra* note 341, focuses more on the problems and options for resolving them.

[462] GESAMP, 2001a, *supra* note 341, p. 28.

[463] *Ibid*., at p. 28.

(determiners and enablers), and also the public.

(vii) Lack of public awareness about issues and their lack of participation in policy-making processes.

The common thread is the lack of appreciation of the environmental problems, which fundamentally translates into the lack of scientific understanding.

The two GESAMP volumes together provide a very useful overview of weaknesses in current approaches and insightful recommendations for the way forward. Most importantly, both documents are user-friendly for non-scientists. Every MDLBA actor should have a copy of both volumes within easy reach.

Part V Summary: Gusts and Gales

This chapter reviewed the evolution of environmental management from piecemeal, sectoral pollution and human health regulation, to the systemic degradation issues of today. Determiners and enablers have shifted from the reactive approach of "sailing with the current", to being proactive and "tacking into the wind" to reach their objective. Inherently inter-related has been the evolution of the societal and policy-making mindset towards ecological protection, as mindset affects the approach to, and type of, environmental protection measures, given that policy-making processes reflect beliefs, knowledge, and socio-cultural norms. The global community is witnessing the emergence and influence of an ecocentric mindset, and its rivalry with, and slight erosion of, the imperial ethos and economic development mindset. A balance between ecological integrity and economic development is being sought, and the evolving MDLBA regulatory regime is riding the crest of this wave. Evidence of the increasing pervasiveness of an ecologically conscious mindset is IEL's global embrace of ecological philosophy, at least in the conceptualisation of contemporary international and domestic legal principles and policy instruments. This ecological awareness is permeating LOS and domestic forums that have traditionally been strong adherents to the economic development mindset.

In summary, sufficient principles, rules, norms, and other tools currently exist for adequate ecospheric protection strategies, but whether or not they are merged into an effective regime to manage MDLBA largely depends on the ability of actors to interpret and apply them in scientifically (and socially) sound ways. Although the development of new legal principles and other tools should be encouraged, the current emphasis should be on effectively utilising existing instruments and the related tools.

The paradox in this transitional period is that, overall, sound science has not had, nor does it now have, a major role in informing policy-making processes. Ecology has been largely ignored in the international LOS arena, but fiercely embraced by IEL advocates, although more as an ethic than as a science to inform policy. However, many IEL instruments, both hard and soft law, call for a role for science and set out a range of actions and measures. It is now up to the actors to define and incorporate a role for science and act on these in accordance with the prevailing international instruments.

The following chapter investigates the interpretation and implementation of environmental legal principles and related policy, primarily through a telescope fitted only with a scientific lens, to assess their ecological soundness and the degree of wisdom in the allocation of scarce financial and other resources. Although the scientific lens is not the only one that can be applied, understanding the scientific context is fundamental to understanding the many other aspects of environmental issues and necessary to conceptualise a way forward to effective implementation of the numerous agreements that reflect the intentions of the international community.

Chapter 4

Red Sky in the Morning:
Weathering Ecologically Unsound Policy

A. Red Sky in the Morning

Red sky in the morning, a sailor's warning.[1] This is nature's alert to sailors that foul weather is imminent. For MDLBA actors, the "red dawn" is the ecological and economic ineffectiveness of scientifically unsound policy, and the "alert" is that the under-utilisation of the best available scientific knowledge is a major contributor to unsound policy. This chapter chronicles the reasons for under-utilisation, namely: lack and misunderstanding of science, science ignored or disregarded, misplaced blame for ecological degradation, domination of non-scientific issues and actors, and unsound policies due to poor policy processes and policy choices. As the reasons for the under-utilisation of science are inter-woven, many of the examples discussed could fit into several different categories. The objective is not to categorise the misuses, but demonstrate the range and diversity of examples of and opportunities for the misuse of science.

Regarding the reasons for under-utilisation, two points must be made explicit: (a) intentions are irrelevant as many scientifically unsound policies result from well-intentioned determiners and enablers who unwittingly make unsound choices; and (b)

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1 Farmers, who also rely on nature's bounty, have adapted the saying to reflect their interests, "red sky in the morning, farmer's warning". It is interesting how those who live close to the land and sea have developed a great respect for nature and have learned to read her signs.

although it might seem that policy-makers are being unfairly singled out, scientists and science are not without their flaws. However, the scientific disciplines realised their professional inadequacies earlier, and they have begun to revisit the scientific role in environmental policy-making. It is hoped that this chapter will provide an impetus for determiners and enablers, and other actors, to take similar action.

B. The Scientifically Unsound Principles of IEL

As noted in Chapter 3, the evolving principles of IEL are generally philosophically sound, having environmental protection as the goal. Problems arise, however, when IEL principles are applied in scientifically and economically unsound ways. The legal principles most vulnerable to unsound application are the precautionary principle, which was discussed in Chapter 2, BEP, BAT, and clean production practices. These principles are enshrined in the GPA,[2] Agenda 21,[3] and regional agreements, such as the 1992 Baltic Convention,[4] the 1976 Barcelona Convention,[5] and its 1996 Syracusa Protocol.[6] Uniform emission standards and zero-discharge policies are also discussed as they have conceptual flaws from a scientific perspective that may render them costly to invoke.

BAT, BEP, and clean production technologies are socially, legally, and politically appealing, as they are tangible, measurable responses that can be used to reassure a

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2 Global Programme of Action for the Protection of the Marine Environment from Land-based Activities, 5 December 1995, UNEP (OCA)/LBA/IG.2/7. See paragraphs 9(a), 23(i), and 24. Paragraph 26(a)(i)a.-c. contain the remaining principles.

3 Agenda 21, 13 June 1992, UN Doc. A/Conf.151/4 (1992).

4 Convention on the Protection of the Marine Environment of the Baltic Sea Area, 9 April 1992, reprinted in 22 *Law of the Sea Bulletin* 54 (January 1993).

5 Convention for the Protection of the Mediterranean Sea against Pollution, 16 February 1976, 15 ILM 290 (1976).

6 1996 Protocol for the Protection of the Mediterranean Sea against Pollution from Land-based Sources and Activities, which amends the 1980 Protocol for the Protection of the Mediterranean Sea against Pollution from Land-based Sources, 7 March 1996, http://www.unep.ch/seas/main/med/mlbspii.html.

concerned public.[7] However, scientific concerns relate to whether application of the principles provide inadequate protection or, in other situations, overprotection. Regarding the former outcome, this is a significant concern, particularly where the receiving habitats or ecosystems are sensitive or fragile.[8] The Syracusa Protocol is one of the few instruments that explicitly provides for additional measures, should BAT and BEP prove inadequate.[9]

Over-protection of the environment with costly technology that is not scientifically warranted (for instance, because of a high flushing rate of the receiving habitat, high assimilative capacity, or the biodegradability of the discharge)[10] diverts scarce funds that could be applied to other priority concerns. For example, a strict application of technological solutions to meet the amendments to the US water quality standards would cost one-half billion US dollars, but two-thirds of the investment would not produce real ecological returns.[11] An example of BEP is in Norway, where marine dumping of an inert substance was protested by a local NGO.[12] The cost of constructing alternative onshore disposal facilities would be very high, with no net

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7 These principles appear in the GPA, *supra* note 2, paragraph 26(a)(i)a.-c.

8 I.S. Shapiro, "Science and Law", 17 *Jurimetrics Journal* 195 (1977); J.S. Gray and J.M. Bewers, "Towards a Scientific Definition of the Precautionary Principle", 32 *Marine Pollution Bulletin* 768 (1996), pp. 768-9; J.M. Bewers, "The Declining Influence of Science on Marine Environmental Policy", 10 *Chemistry and Ecology* 9 (1995); J.S. Gray, "Integrating Precautionary Scientific Methods into Decision-making", in D. Freestone and E. Hey (eds.), *The Precautionary Principle in International Law: The Challenge of Implementation* (The Hague, London and Boston: Kluwer Law International, 1996), pp. 133-46; and A. Nollkaemper, "Balancing the Protection of Marine Ecosystems with Economic Benefits from Land-based Activities: The Quest for International Legal Barriers", 27 *Ocean Development & International Law* 153 (1996).

9 Syracusa Protocol, *supra* note 6, Annex IV, paragraphs A.4. and 9. Both the Syracusa Protocol and the 1992 Baltic Convention, *supra* note 4, contain BAT, BEP, and clean technology clauses, but neither explicitly addresses the potential waste of financial resources. In the Syracusa Protocol, Article 7.2. notes that economic conditions should be considered in setting standards, including those for BAT and BEP, but it does not reiterate this in Annex IV, which sets out the criteria for BAT and BEP. In the Baltic Convention, see Annex II – Criteria for the Use of BEP and BAT.

10 Gray, 1996, *supra* note 8, p. 136 and also see Gray and Bewers, *supra* note 8. In the North Sea, significant resources are being invested in tertiary sewage treatment whereas scientific data indicates that it is not warranted. See Gray, *ibid*., p. 142.

11 Shapiro, *supra* note 8, pp. 196-7. While this is an example from the 1970's, evidence from the 1990's suggests that the same concerns continue. See generally, the articles mentioned above, *supra* note 8.

12 J.S. Gray, "Statistics and the Precautionary Principle", 21 *Marine Pollution Bulletin* 174 (1990), p. 175.

ecological benefit, and that money could be applied instead to sewage treatment, a real problem further down the coast.[13] Stringent protection is a laudable goal but it is not always logical given the number of priority issues awaiting attention.

Thus, BAT, BEP, and clean production technology are useful where their environmental effectiveness and economic costs are critically assessed, and compared with alternatives. Competing environmental priorities and scarce economic resources should encourage scientists, economists, social scientists, and policy-makers to pool their knowledge to address the most pressing ecological problems for the best social and economic returns.

Due to scientific illiteracy, vital decisions about human conduct are made with only a vague conception of the ecological and social implications.[14] Some of these decisions rely on measures that are inherently ecologically and economically unsound, such as uniform emission standards and uniform targets for reduction, and (entirely hypothetical and intrinsically unachievable) zero-discharge policies. Uniform emission standards and targets are largely ineffective, as the pressures on and conditions in ecosystems and habitats are unique and variable, and thus require tailored management.[15] For example, a given standard for emission or reduction may suffice for one wetland area, but it may be either too stringent or too lenient for another. Uniform standards also ignore geo-physical conditions (i.e., winds and currents) that

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13 *Ibid*.

14 P.E. Allin, "Some Social Aspects of Modern Science: A Point of View", 3 *International Journal of Environment Studies* 49 (1972), p. 50. Also see H. Maij-Weggan, "Foreword", in D. Freestone and T. IJIstra (eds.), *The North Sea: Perspectives on Regional Environmental Co-operation* (London, Dordrecht, Boston: Graham & Trotman/Martinus Nijhoff, 1990), p. *v*.

15 See K.N. Lee, *Compass and Gyroscope: Integrating Science and Politics for the Environment* (Washington, D.C. and Covelco, California: Island Press, 1993), p. 11. Lee refers to the need to avoid conceptual neatness and accept that large ecosystems require what he terms "adaptive management". Also see Mee, *infra* note 24, p. 121, where it discusses "precautionary environmental quality standards" that take into account the receiving habitat.

can concentrate contaminants in specific locations. Uniform standards across arbitrary political boundaries tend to waste valuable economic resources and provide unsatisfactory ecological protection.[16]

Uniform reduction of certain contaminants by coastal states, or agreement to preserve a common percentage of wetlands or reef cover, are common measures for littoral states of semi-enclosed or enclosed seas.[17] In addition to the problem above, uniform standards are often arbitrarily determined in negotiations between determiners without sufficient reference to the scientific basis and practical consequences. A notable case is the negotiation of the 50% reduction of certain contaminants in the North Sea. Scientists unable to reach consensus on a uniform percentage (due to localisation of effects and paucity of reliable data) were asked by the policy-makers to leave the room while the latter arbitrarily agreed to 50% reduction targets.[18] Lacking scientific understanding, these determiners failed to appreciate that the scientists could not reach consensus because of professional concerns regarding the sub-regional/country reports on which the Quality Status Report (the basis for their decisions) was based.[19] Concerns included incompatible data, possible exclusion of information for political reasons, and lack of detailed examination.[20]

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[16] See J.M. Broadus, S. Demisch, K. Gjerde, P. Haas, Y. Kaoru, G. Peet, S. Repetto, and A. Roginko, *Comparative Assessment of Regional International Programs to Control Land-based Marine Pollution: The Baltic, North Sea and Mediterranean* (Woods Hole, Maine, USA: Woods Hole Oceanographic Institution Marine Policy Center, 1993), pp. 87-9.

[17] See Convention for the Protection of the Marine Environment of the North-east Atlantic, 22 September 1992, 32 ILM 1069 (1993) and the Baltic Convention, *supra* note 4.

[18] M. MacGarvin, "Is the Quality Status Report Reliable?", in J. Andersen, *et al*. (eds.), *Scientific Symposium on the North Sea Quality Status Report 1993, 18-21 April 1994, Ebeltoft, Denmark: Proceedings* (Ministry of Environment and Energy, Danish Environmental Protection Agency, 1996), p. 122. In this case, the policy-makers relied on the precautionary principle to justify their actions.

[19] *Ibid.* This article is recommended to appreciate the range, scope, and number of scientific mistakes, misinterpretations and misuse made and perpetuated by policy-makers, who in good conscience believed they were making a difference.

[20] *Ibid.*

The zero-discharge policy, endorsed by the Paris Commission, the Nordic Council's International Conference on Pollution of the Seas, and the Governing Council of UNEP, is inherently unsound.[21] First, zero-discharge policies are scientifically unnecessary and economically wasteful for most substances and habitats, as these policies do not take into account the assimilative capacity of the ecosphere, and second, "zero" discharge is physically unachievable and it is almost always prohibitively expensive.[22] Further, increasingly refined instrumentation permits scientists to measure extremely low but often environmentally insignificant concentrations.[23] This begs the question what is "zero discharge" – is it measured in parts per million, billion, or trillion, or even higher? Thus, referring to "zero-discharge", even for substances whose release should be minimized, or eliminated in some cases, is misleading as there is likely to be traces that science can now measure.[24]

Reversing the burden of proof, or prohibiting release until harmlessness is proven, is often used interchangeably with zero-discharge policies.[25] Reversing the burden is unsound if strictly interpreted, as scientists cannot prove harmlessness of substances.[26] However, if a substance had to be proved harmless "on the balance of probabilities"

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[21] See Bewers, *supra* note 8, p. 14 and Shapiro, *supra* note 8, pp. 196-7.

[22] See J. Cairns Jr., "Aquatic Ecosystem Assimilative Capacity", *Fisheries*, Vol. 2, No. 2, pp. 5-7, 24 (1977).

[23] See Gray, 1996, *supra* note 8, p. 137. Also see A.M. Weinberg, "Science and Its Limits: The Regulator's Dilemma", 2 *Issues in Science and Technology* 59 (1985-6), which discusses the ability of science to predict the impact of increasingly low doses of chemicals on human health.

[24] This can be confusing. In reality, the environment can assimilate low concentrations of most chemicals, including POPs. However, because of POPs' stochastic effects (*risk* of harm is proportional to exposure) and their ability to bioaccumulate in the environment, POPs have been deemed "pollutants", regardless of quantity. For a concise discussion on stochastic effects, see L.D. Mee, "Scientific Methods and the Precautionary Principle", in D. Freestone and E. Hey (eds.), *The Precautionary Principle in International Law: The Challenge of Implementation* (The Hague, London and Boston: Kluwer Law International, 1996), pp. 122-3.

[25] The need to reverse, or modify, the burden of proof is advocated in T. Jackson and P.J. Taylor, "The Precautionary Principle and the Prevention of Marine Pollution", 7 *Chemistry and Ecology* 123 (1992) and refuted in J.E. Portmann and V. Pravdic, "Comment", 7 *Chemistry and Ecology* 135 (1992). That scientists cannot prove harmlessness is discussed in A. Milne, "The Perils of Green Pessimism", *New Scientist,* Vol. 138, No. 1877, pp. 34-7 (1993), p. 36.

[26] See Milne, *ibid*., p. 36 and A.R.D. Stebbing, "Assimilative Capacity", 12 *Marine Pollution Bulletin* 362 (1981).

(the common law standard), or by reference to some flexible standard, it is more tenable. The reality is that it is too onerous a burden to expect industry to test the myriad substances and chemicals in use and coming into use. A procedure must be adopted to accommodate the competing interests between environment and development and acknowledge the need for monitoring and additional scientific information that may indicate the need for policy revision. As will be discussed in Chapter 5, herein, scientists have tools to identify relatively quickly suspect substances using state of the art technology. The actors' will to utilise science techniques for the policy-making can distinguish poor policy from good.

C. A Chronicle of Scientifically Unsound Policy

The prevalence of scientifically (including ecologically) unsound policy, both globally and domestically, is disconcerting. The notion of scientifically unsound policy is not new. In the 1970's, it was recognised by some scientists that determiners, acting on political, emotional, doctrinal, or inertial grounds, made environmental decisions with only a vague conception of the environmental repercussions.[27] Scientists have become more vocal about poor policy choices in recent years, but unfortunately, only a few express their views in a forum regularly accessed by determiners and enablers.[28] The science-law communication gap and the lack of confidence in science remain. Consequently, scientists should be encouraged to publish their views in policy journals to help actors understand *why* many policies fail to meet their ecological objectives.

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[27] M. Waldichuk, "Control of Marine Pollution: An Essay Review", 4 *Ocean Development and International Law* 269 (1977), p. 286 and Allin, *supra* note 14, p. 50. Also see Cairns, *supra* note 22 and R. Carson, *Silent Spring* (New York and Boston: Houghton Mifflin Company, 1962, 1994). The latter alerted the public in 1962 to the failings of policy to use available science, although this message was largely overlooked as the public who, galvanised by fear, focused on the potential impacts of pesticides. Paradoxically, *Silent Spring* became an indictment against science and technology.

[28] Scientists, unfortunately, tend to publish their views on the misuse of science in scientific journals, which few determiners and enablers, or other non-scientific actors read. Scientific advice needs to be shared with non-scientists.

The "why" is complex, as many factors come into play,[29] but science, its misuse, and its under-utilisation are among the key factors. The underlying problem is the lack of understanding of science, or scientific illiteracy, by non-science actors, which is the common theme throughout the following pages.

1) Weakening the Scientific Basis of Policy through Lack of Scientific and Ecological Understanding

Galileo was cross-examined by skeptical church authorities about the validity of his scientific theories, and natural scientists today experience a similar fate in the contemporary policy-making arena, as so few actors are able to comprehend science, and, worse, the lack of comprehension leads to a bias against it – [30] or to indifference, which may be even more difficult to overcome. For example, "[r]egulations are drafted by lawyers and negotiated and put into effect by politicians, with neither group being well placed by background or training to evaluate the technical issues".[31] Most disturbingly, they often fail to seek competent advice, or to recognise good science from poor.

In *Silent Spring*,[32] Carson, a biochemist, sought to denounce, not pesticide technology, but first, the disregard for existing scientific research and second, the unsound application of scientific innovation by society and determiners and enablers.[33]

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29 The failure of policies is the function of a wide range of factors, including lack of commitment to the effective implementation and enforcement of policies, complacency, political convenience, societal mindset, and poor policy choices. Unsound science is only one facet, but it is a major one.

30 A. Stewart, "Environmental Risk Assessment: The Divergent Methodologies of Economists, Lawyers and Scientists", 10 *Environmental and Planning Law Journal* 10 (1993), p. 12. See Chapter 2, herein, for a discussion on societal bias against science.

31 R.B. Clark, "Editorial: Laws of the Sea, 1986", 17 *Marine Pollution Bulletin* 1 (1986), at p. 1. Clark suggests that regulatory action is undertaken to placate the concerned public without relating marine implications to social, economic and other environmental costs.

32 Carson, *supra* note 27.

33 See G. Hardin, *Filters Against Folly: How to Survive Despite Economists, Ecologists and the Merely Eloquent* (New York: Penguin, 1985, 1987), pp. 45-52, which elaborates on human fallibility that leads to poor choices. This is consistent with Carson, *ibid*.

Paradoxically, ethicists transformed the book into a sacred text indicting pesticides. Carson's concern was that although scientific knowledge concerning pesticides was available and ecologists were employed to provide advice, neither their advice nor scientific knowledge were utilised.[34] Carson stated:

> It is not my contention that chemical pesticides must never be used. I do contend that we have put poisonous and biologically potent chemicals indiscriminately into the hands of persons largely or wholly ignorant of their potential for harm.[35]

Essentially, she focuses on the inability of non-scientific actors to distinguish harmful *chemicals* from harmful *doses* of chemicals.[36] *Silent Spring* precipitated public concern and fear that, in turn, led to environmental regulation of pesticides. Illogical and scientifically unsound regulation of pesticides resulted, despite warnings and much effort by scientists to provide input into the policy-making process. Scientists' reputations have suffered, as they are perceived to have given inaccurate advice. This has not been due to scientific failing, but to the non-scientists' misunderstanding of the qualifications, limitations, and uncertainties inherent in scientific evidence and advice.

This illustrates that misunderstanding and misinterpretation of scientists' findings can have dire consequences for the environment, and hinder policy-making processes and environmental law, which can continue for decades. Examined below are the reasons that underlie such misunderstanding. The intention is not to uphold scientists as heroes and decry non-scientists as villains, but to demonstrate why science has not been effectively incorporated into policy-making processes and how mistrust of science is

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34 Carson, *ibid.*, pp. 11-12. This is discussed in Chapter 2, herein.

35 *Ibid.*, at p. 12. Trying to ensure that her contentions are not misunderstood, she makes a similar statement at p. 9, where she refers to the need to gear pest control to reality to ensure that methods employed are ecologically safe.

36 See A. Wildavsky, *But Is It True?: A Citizen's Guide to the Environmental Health and Safety Issues* (Cambridge, Massachusetts and London, England: Harvard University Press, 1997), p. 270. Carson' s 1962 and Wildavsky's 1997 comments remains unheeded. Chemicals and doses of chemicals are discussed in Chapter 2, herein.

largely grounding in misunderstanding. A further note is that the emphasis is on sound science and reference is to competent scientists. Scientists are only human, giving rise to some poor scientists and poor science. Contemporary environmental problems can be attractive to "scientists for hire", and it is considered that it is often, if not always, possible to find a scientist to support any desired or pre-determined political or environmental position. In fact, scientific understanding can help actors to guard against poor science and manipulated science and to thereby identify sound options from which to choose.

(a) Misunderstanding Scientific Processes

The following examples highlight lack of understanding, or misunderstanding, of the scientific method and scientific procedures. The costs to scientists and science of such misunderstanding may be enormous, as policy-makers and other actors, fail to appreciate the risk to both ecospheric integrity and the already bruised and battered faith in science and government to effectively address environmental problems.[37]

(i) Peer Review

Understanding the peer review process is vital for understanding science, determining the relevance of bias, and putting into context apparent conflicts of opinion.[38] The process of peer review and knowledge building is a non-linear process, as scientists incrementally collect data, debate, disagree, and finally agree, and over time move

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37 See W.D. Ruckelshaus, "Risk, Science, and Democracy", 1 *Issues in Science and Technology* 19 (1985). This article discusses actions of policy-makers that result in loss of faith. An example is the unreasonable mandate by Congress to resolve the problem of smog from motor vehicles in Los Angeles within five years, when a realistic timeframe was 25 years. Congress failed to appreciate the issues, and as a result, the public were disillusioned by an unfulfilled promise. *Ibid.*, pp. 30-1. Also see W.D. Ruckelshaus, "Stopping the Pendulum", in R.V. Percival and D.C. Alevizatos (eds.), *Law and the Environment: A Multi-disciplinary Reader* (Philadelphia: Temple University Press, 1997), pp. 397-400.

38 Recall from Chapter 2, herein, that scientific consensus is established through peer review as data, experiments, and observations are debated in dedicated journals and scientists respond based on their own experience, or after replicating the exercise to ascertain the accuracy of the results. It keeps science methodologically honest and the results objective.

scientific knowledge towards consensus. Journalists now follow scientific developments closely as they unfold, presenting to readers and viewers science "in the making", in real time, with all the conflicting opinions that this involves, including the apparent lack of consensus among scientists.

The expectation of the public is, however, almost exactly the opposite of what they see unfolding. In most cases, people expect scientific opinion at any point in time to be consistent, fully formed, conclusive, certain, and unequivocal. Determiners, enablers, and others who fail to grasp the significance and necessity of peer review, becoming confused with many sources of information, may turn to poor science or rely on skeptics or fringe scientists rather than peer-reviewed science.

Skeptic scientists should not be dismissed outright. The opinion of a skeptic that is peer-reviewed should be given due weight, perhaps triggering more cautious policy-making and more feedback mechanisms. It should not pre-empt mainstream opinion merely because it suits policy purposes. However, should the review process solidify the skeptic's position, it could then be used to revise policy decisions. Further, so-called biased scientists who are funded by an interested actor (e.g., degrader or influencer) should not be dismissed without determining whether or not their opinions are peer-reviewed. Where scientific knowledge is not peer-reviewed, less weight should be given to the opinion, and this is especially so for scientists who may not be experts in the specific field being considered, may be biased, or may be paid to merely represent a position (in which case their opinions may be equivalent to those of laymen).[39] Where scientific work is not peer-reviewed, the closer the opinion is to mainstream scientific opinion, the more reliable it is considered, as the mainstream

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[39] See G.E. Brown, "Environmental Science under Siege in the U.S. Congress", *Environment*, Vol. 39, No. 2, pp. 12-31 (1997).

comprises the consensus of many scientists. A process is required to review scientific opinions, rather than adopt or dismiss them too hastily without full understanding.

The US Congress committed a grave error and injustice by opting to accept the opinion of a renowned but non-specialist scientist instead of peer-reviewed science in determining US policy for global climate change.[40] Another arguable "corruption of peer review" is the 1995 report of the IPCC,[41] which is said to be the consensus of 2,500 scientists.[42] In fact, there were approximately 80 authors and most of the contributors agreed to the use of their studies, but without necessarily supporting the Panel's conclusions.[43] Not only is the level of peer review misrepresented, but also the executive summary is misleading. Written by generalists and non-scientists, the summary refers to discernible effects of human activities on the global climate, even though within the body of the report scientists clearly state that the link between global warming and climate change due to human activities is not yet proven.[44] This is particularly damaging and a significant misuse of peer-reviewed science, as a reasonable expectation is that the executive summary reflects the body of science within, and is endorsed by the scientists involved. Such misuse of science is too common at the international, regional, and domestic levels, as non-scientists often

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[40] *Ibid*. A particular scientist, although a climatologist, had not done recent research on climate change and his opinions differed from the peer-reviewed scientists. Although the skeptic scientist may be correct at the end of the day, the more prudent course would be to accept the peer-reviewed science, but recognise that there is uncertainty.

[41] Intergovernmental Panel on Climate Change, *Climate Change 1995: The Science of Climate Change*, (Cambridge: Cambridge University Press, 1996).

[42] Dr. Frederick Seitz, stated in an interview that in more than 60 years as a member of the American scientific community, including service as president of two eminent scientific bodies, he has not seen a more disturbing corruption of the peer review process. See G. Crittenden "The Day the Earth Warmed Up", *The Globe and Mail* (Toronto, Canada, 22 November 1997), pp. D1, D9.

[43] *Ibid.* and Ayres, *infra* note 143, pp. 12-13.

[44] *Ibid.*

prepare the executive summaries. These reports often influence policy, which results in unsound policy.

Government scientists and scientific consultants often render opinions that are not peer-reviewed, often for legitimate reasons. For instance, EIAs are seldom peer-reviewed, leaving open questions as to their quality.[45] While these scientists should not be disregarded, their opinions should be reviewed for some indication as to the degree of consensus between mainstream science and the opinion.

Corruption of the peer review process, both deliberate and inadvertent, is rampant. Given the role of peer review in maintaining scientific honesty and objectivity, the fundamental need to distinguish and incorporate peer-reviewed science into MDLBA policy-making processes cannot be overstated.

(ii) Scientific Terminology

Scientific terminology is very precise, and some words that, to the public, appear to be interchangeable have very distinct scientific meanings. An example is "contamination" and "pollution", as discussed in Chapter 1, herein. These are very distinct concepts in science, but most law and policy instruments fail to distinguish them, and use them interchangeably. Another example is the reference to "global warming". Most scientists refer to "global climate change", as the Earth will not uniformly warm-up – some areas can expect to be wetter and colder. This is very different from the notion of pleasant winters in present temperate climates. Further, "global warming" is a term frequently associated with solely human activities. Scientifically, there is much evidence of global climate change – warming and cooling

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[45] See Stewart, *supra* note 30, p. 15 and Gray, 1996, *supra* note 8, pp. 140-2. Also see S.O. Funtowicz and J.R. Ravetz, "Uncertainty, Complexity and Post-normal Science", 13 *Environmental Toxicology and Chemistry* 1881 (1994), which discusses the issue of peer review and the need to extend the community of reviewers to include other actors, given the complexity of contemporary ecological issues.

– over the Earth's four billion-year history that is clearly independent of human activities. Part of the scientific debate is not denial of globally warmer temperatures, but whether the change is a natural fluctuation or human induced. Another misuse is that of the word "theory", with non-scientists often reducing cornerstones of science, such as the theory of evolution, to mere conjecture. Scientific theory is as close to the truth as science permits, always allowing for the findings of contrary evidence.

Non-scientists sometimes use language that is meant to help convey a concept, but misuse scientific terms in the process. An example is the use of the made-up terms "species pollution" and "living marine pollution".[46] Although such expressions may help readers grasp the concept of "alien species", they are misleading. The publication of such terminology in respected international journals perpetuates ineffective communication among scientists and non-scientific actors.[47]

The results of a survey conducted to discern the differences in thinking between lawyers and scientists reveal much about terminology hindering effective communication.[48] One finding was that lawyers misunderstand or confuse very basic science terms, such as "animal" and "species", and technical terms such as "pollution", "environmental audit", and "environmental assessment".[49]

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[46] C.C. Joyner, "The 1991 Madrid Environmental Protocol: Contributions to Marine Pollution Law", 20 *Marine Policy* 183 (1996), pp. 192-3. Alien species are an environmental concern, as identified in GESAMP, *Protecting the Oceans from Land-based Activities: Land-based Sources and Activities Affecting the Quality and Uses of the Marine, Coastal and Associated Freshwater Environment*, GESAMP Reports and Studies No. 71, 2001b. However, any analogy, however helpful, should be placed in its proper context to prevent confusion or continued misuse of terminology.

[47] An eminent international marine scientist advised that he and others wrote letters to the editor of *Marine Policy* regarding the Joyner article, *ibid*., as scientists were concerned about the misuse of scientific terminology. Joyner was most likely well-intentioned and he probably believed he was creatively describing a concept in a way that non-scientists could understand it.

[48] See L.M. Warren, "The Precautionary Principle: Use with Caution", in K. Milton (ed.), *Environmentalism: The View from Anthropology* (London and New York: Routledge, 1993), pp. 97-111.

[49] *Ibid.*, p. 108. The article concludes that both scientists and lawyers could improve their respective understanding of the other discipline, but in particular, lawyers lacked a basic understanding of science. *Ibid.*, p. 109.

Confusion about terms leads to inaccurate perceptions of environmental problems, and hence inappropriate action. An example mentioned previously is non-scientists' tendency to refer to "toxic chemicals", but it is only accurate to refer to "toxic doses" or "chemical doses that are toxic".[50] This should help alleviate a certain amount of fear among the public, as they realise that unreasonable *doses* of substances – not necessarily the substances themselves – harm health. For example, trace heavy metals like copper are essential to human health, but too much copper can lead to poisoning. Similarly, water is vital to life, but too much can result in drowning.[51]

(iii) Disregarding Scientific Reservations

Scientists should provide the policy process with neutral, objective scientific information, including the facts, reservations (qualifications), and scientific uncertainties.[52] Non-scientists do not always comprehend the significance of the reservations attached, by necessity, to scientific opinion. One example is the failure of the potentially influential North Sea Quality Status Report to include assessments and implications of the statistical, toxicological, and ecological limitations that scientists noted as affecting their ability to accurately predict effects in the North Sea.[53] A senior official involved with the co-ordination and production of the Quality Status Report justified the exclusion of such vital information on the grounds that the report needed

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[50] Wildavsky, *supra* note 36, p. 270.

[51] See J.K. Glassman, "It's in Your Own Home and It's a Real Killer", *International Herald Tribune* (Wednesday, 22 October 1997), p. 9. This newspaper article convincingly illustrates the potential for fear merely through presentation of facts. It describes a substance in all homes as a killer, giving the annual death toll from over-consumption, its daily consumption by millions, and other disturbing facts and statistics. It s not until the reader is quite concerned that the "devastating" substance is revealed as water.

[52] MacGarvin, *supra* note 18, p. 123.

[53] *Ibid*. pp. 123-5. Statistical, toxicological, and ecological deficiencies noted include sampling efforts that are insufficient to provide an accurate picture of contaminants and trends, insufficient monitoring, gross lack of toxicological data on as much as 75% of the chemicals identified in some areas, and the lack of ecological understanding of population dynamics and inter-species relationships. MacGarvin supports his views with scientific studies and articles by numerous marine scientific experts.

to be positive.[54] This not only illustrates the failure to understand and interpret science, but it also damages scientific credibility, as scientists would be wrongly perceived as incompetent, should measures based on such reports prove ineffective.

(b) Failing to Appreciate Natural Processes

Many non-scientific actors fail to appreciate or understand natural processes that forge the inter-linkages among species, habitats, and ecosystems.[55] Significantly, although ecosystem approaches to environmental management are advocated and knowledge of inter-linkages reiterated in most environmental instruments, actors responsible for interpreting and implementing them have disturbingly little understanding of the scientific aspects of ecological inter-dependencies, for example, among wetlands, seagrass beds, and coral reefs, and their link to commercial fisheries.[56] Actors lack understanding of fundamental ecological concepts, such as the cycling of carbon, water, nutrients, and other elements throughout the ecosphere. Yet another example of poor understanding is the role that the transport and concentration of contaminants and marine larvae, by geo-physical processes (i.e., wind and currents), plays in contaminating and populating distant areas. Coral reefs in particular rely on such processes to sustain biodiversity. It has been noted that significant ecological input is required to make rational decisions,[57] but many actors, even if they seek such input, have little understanding of what to do with it.

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[54] *Ibid.*, p. 125.

[55] See F.B. Golley, *A History of the Ecosystem Concept in Ecology: More than the Sum of the Parts* (New Haven and London: Yale University Press, 1993), pp. xi and 200. Also see D.W. Orr, *Ecological Literacy: Education and the Transition to a Postmodern World* (New York: State University of New York Press, 1992); F. Capra, *The Web of Life: A New Scientific Understanding of Living Systems* (New York: Anchor Books, Doubleday, 1996); and E.O. Wilson, *Consilience: The Unity of Knowledge* (New York: Alfred A. Knopf, Inc., 1998).

[56] This is confirmed by the author's discussions with several dozen policy-makers, lawyers, government representatives, international diplomats, professors, and other non-scientists. The high degree of scientific illiteracy encountered precipitated and sustained this thesis.

[57] Allin, *supra* note 14, p. 50.

(c) Lack of Appreciation of the Implications of Misunderstanding Science

Environmental policy, even where it is based on science, is determined, interpreted, and implemented by actors from the policy domain.[58] For example, environmental assessments, such as risk assessment or assimilative capacity determination, are scientifically based, but involve politically or socially derived policy choices to establish safety margins, allowable concentrations, and other policy specifics.[59] Setting safety margins is a political decision, but the degree of safety socially acceptable should be decided in relation to the scientific information, as otherwise the policy may fail for ecological or economic unsoundness.[60] To make rational decisions, actors must be able to understand the repercussions and implications of such choices. It is suggested by many that non-scientists lack an understanding not only of scientific processes and ecology, but also of the extent to which rational policy choices are bound, or should be bound, to science.[61]

(i) Non-scientific Constraints Affecting Scientific Research

Scientists, particularly government-employed, are often criticised for poor scientific practices. Non-scientists fail to appreciate that it is not inept scientists, but rather inappropriate political and other non-science determinations that limit scientific mandates and funding, which consequently affect the scope of research and the ability of the scientist to perform sound procedures.[62] Compromises imposed by non-

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58 Warren, *supra* note 48, pp. 109-10.

59 D.L. Davis, "The 'Shotgun Wedding' of Science and Law: Risk Assessment and Judicial Review", 10 *Columbia Journal of Environmental Law* 67 (1985), p. 99.

60 *Ibid*.

61 To cite a mere sampling, see P.M. Chapman, "The Precautionary Principle and Ecological Quality Standards/Objectives", 34 *Marine Pollution Bulletin* 227 (1997), p. 227; Warren, *supra* note 48; Brown, *supra* note 39; Bewers, *supra* note 8; Wilson, *supra* note 55; and Golley, *supra* note 55.

62 See S.O. Funtowicz, and J.R. Ravetz, "A New Scientific Methodology for Global Environmental Issues", in R. Costanza (ed.), *Ecological Economics: The Science and Management of Sustainability* (New York: Columbia

scientists (e.g., determiners, enablers, and influencers) on experimental design or research strategy result in scientific knowledge that may not be overly useful for, or even answer, policy questions. For example, funding, timing, or limiting mandates may allow only for laboratory or narrowly focused experiments, which cannot measure or accommodate many of the stresses and variables caused by systemic degradation across ecosystems.[63] Scientists should not shoulder responsibility for unsatisfactory results where other actors determine the conditions of enquiry.[64] In fact, policy-making processes and the organisation of government institutions largely dictate the extent to which science is utilised and incorporated into policy.[65] The unfortunate consequence is that only a minimal amount of scientific capacity is effectively employed for environmental protection.[66]

(ii) Ineffective Communication

Dialogue between scientists and determiners and enablers is seldom adequate.[67] This is understandable, given the highly technical nature of science and the high degree of scientific illiteracy. Effective communication was not as vital prior to the 1970's, when regulation addressed visible, localised, and less insidious issues. However, it has

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University Press, 1991), pp. 139-52, p. 139 and W.J. Davis, "The Need for a New Global Ocean Governance System", in J.M. Van Dyke, *et al.* (eds.), *Freedom for the Seas in the 21st Century: Ocean Governance and Environmental Harmony* (Washington, D.C. and Covelo, California: Island Press, 1993), p. 168.

63 M.H. Depledge, "Ecotoxicology: A Science or Management Tool?", 22 *Ambio* 51 (1993), p. 51 and R. Renner, "European Bans on Surfactant Trigger Transatlantic Debate", 31 *Environmental Science & Technology* 316 (1997). Also see Bewers, 1995, *supra* note 8, pp. 12-13 and MacGarvin, *supra* note 18, pp. 123-6.

64 Scientists require sufficient funds and freedom of enquiry to design experiments that will produce results useful to policy. See Bewers, *ibid.*

65 R.G.V. Boelens, "From Policies to Science: Strategies for Marine Environmental Protection", 25 *Marine Pollution Bulletin* 14 (1992), p. 14 and J.S. Gray, "Whose Research Is It Anyway?", *New Scientist*, Vol. 149, No. 2023, p. 48 (1996a). Also see L.A. Kimball, *Treaty Implementation: Scientific and Technical Advice Enters A New Stage*, Studies in Transnational Legal Policy No. 28 (Washington, D.C.: The American Society of International Law, 1996), where a common theme is that the issue is not the availability of scientific knowledge, but its effective presentation to and use by policy-making processes.

66 Boelens, *ibid*., p. 14. Also see GESAMP, *A Sea of Troubles*, GESAMP Reports and Studies No. 70, 2001a, p. 29.

67 *Ibid*.

now become a major concern as risk management associated with systemic degradation replaces classical pollution regulation. Southeast Asian scientists determined, among other things, that the underlying problem contributing to the declining influence of science on policy was the lack of effective communication among scientists and determiners and enablers.[68] For reasons discussed in Chapter 2, herein, this is not surprising, as the mindsets clash.

Common complaints are that scientists fail to provide information in a timely or comprehensible fashion, and that when such information is provided, determiners and enablers do not understand the intricacies and reservations, or why scientific advice requires more funding and an extensive time frame for research. Again, basic terminology is an issue – for instance, scientists speak of "matrices" and non-scientists understand "charts", "tables', and "graphs".[69] This is a serious issue as a listener confused by terminology, even if only by a few words, may consciously or subconsciously disassociate himself from the conversation.

(iii) Choosing Inappropriate Science

As determiners, enablers, and other actors gather scientific knowledge, there is an increasing risk of choosing science that is poor or perhaps reveals only partial truths. As noted above, the US Congress favoured the opinion of scientists whose opinions were not based on peer-reviewed evidence.[70] Preferring empirical data (for example, data regarding temperatures changes and other measurements) to scientific theory and

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68 Workshop on Marine Protected Areas: Conservation, Utilisation, and Management, hosted by the National University of Singapore and the Canadian International Development Agency at the RELC, Singapore, 23-25 August 1995.

69 This example is noted as the author recalls attending a talk on habitat inter-linkages given by a scientist to a mixed audience. The non-scientists were as confused by the term "matrix" as they were by the ecological content.

70 See Brown, *supra* note 39.

models proposed by the experts, Congress failed to understand the need to put empirical data in context by way of theory.[71] Perhaps it was too difficult for them to grasp scientific theory without sufficient scientific literacy, and too tempting to accept, instead data that seemed clear and succinct. Its potential scientific unsoundness most likely was not considered.

It is axiomatic that poorly informed decisions result in poor policy. Determiners and enablers must attempt to understand scientific issues in order to distinguish good (and appropriate) science from poor, pseudo-, or fringe science. Randomly chosen science should not be a basis for policy-making.[72]

Inappropriate science is also chosen in other circumstances. Science may be chosen that supports a political position or appeases public concerns. "Science in black-and-white", reduced to a few lines or charts that can be easily understood, may be chosen over comprehensive science. Policy-makers may use, or mandate, science that is inadequate for making policy, perhaps without even realising its unsoundness. For instance, the US EPA used a study of only *12 individuals* when establishing criteria for carbon monoxide releases.[73] The sample size is scientifically inadequate, thus resulting in suspect regulations. Another side effect of choosing poor science is that scientists bear the public's fury when criteria derived from poor science result in continuing ecospheric degradation.

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[71] *Ibid*., p. 16

[72] See J.M. Bewers and C.J.R. Garrett, "Analysis of the Issues Related to Sea Dumping of Radioactive Wastes", 11 *Marine Policy* 105 (1987), p. 105.

[73] Ruckelshaus, 1985, *supra* note 37.

(iv) Failing to Appreciate the Issue

Contemporary policy-makers may seek scientific input within the spirit of environmental protection, but their misunderstanding of science profoundly affects the choice of science and how they incorporate it into policy. A widespread problem is that policy-makers, needing to make decisions, being pressed for time, and having to consider many factors, prefer simplified science, failing to realise that the over-simplification of science compromises the scientific basis of their decisions.[74] Simplified science can lose its integrity, thus giving determiners and enablers a false impression of simplicity, where it may not exist, and giving them a false sense of having done the right thing. It is unfortunate that determiners and enablers view scientific reservations and uncertainty as irrelevant, and disregard details that may provide a more comprehensive perspective on the ecosystemic or scientific processes in question.

The misunderstanding of science compromises efficiency and output of policy-making processes. This is particularly true in the international arena, where international lawyers, often from the respective country's Ministry of Foreign Affairs and acting on behalf of states, negotiate agreements and legal instruments. Attention can be misdirected. For example, during negotiations for co-operative marine scientific research initiatives in the South China Sea, heated debate ensued over joint research in an area known as the "donut hole", being an area that appealed to governments and lawyers as it is an area legally deemed "high seas" and beyond state jurisdiction.[75] The donut hole in the South China Sea comprises an abyssal plain of little marine scientific interest, whereas other areas in the South China Sea, biologically rich and suffering

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74 Warren, *supra* note 48, pp. 109-10.

75 The author attended this meeting as a rapporteur. The Third Technical Working Group Meeting on Legal Matters for Managing Potential Conflicts in the South China Sea, Pattaya, Thailand, 12-16 October 1998.

degradation, beg for scientific attention and warrant the commitment of scarce financial and human resources. The disagreement over that issue led to postponement of joint research efforts. If the representatives had understood the local ecology or had invited a scientist to brief them, they would not have wasted valuable time in a heated discussion that undermined the co-operative spirit of the meeting. The representatives could have used scientific knowledge to direct their discussions towards co-operation on ecologically and economically rational research that would represent the best value for investment and yield regional environmental integrity. Alternatively, upon notification that scientific research on the abyssal plain was essentially a waste of resources, they could have rationally chosen to redirect the financial and human resources to more productive endeavours that would foster a co-operative spirit.

Scientists must be an integral component of policy-making processes, as only they can discern the type and suitability of research necessary, particularly in a time of tight budgets and minimal resources. It is wiser to make an informed decision to do nothing than to irrationally undertake a project that will usurp resources and fail to produce valuable information. Efficiency of process with useful, high quality results should be a priority.

(v) Masking the Lack of Understanding of Science

Lack of understanding is sometimes masked by other factors. In the early 1970's, the US EPA and other agencies operated under scientific uncertainty and lack of scientific understanding of the issues, not because the science was not available, but because it was not incorporated.[76] However, the US EPA was not castigated, as the lack of scientific understanding was eclipsed by the gross and visible nature of the problems,

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76 Ruckelshaus, 1985, *supra* note 37, pp. 20-2.

and the availability of engineering solutions to address them, such as sewage treatment, industrial end-of-pipe technology, and emission control technology.[77]

In recent years, the precautionary concept has become a popular policy tool that, when invoked, often masks the lack of scientific understanding. The paradox is that many who lack an understanding of science call for the precautionary concept, as they believe, albeit wrongly, that science failed the environment and, consequently, that action must be taken without the benefit of scientific advice.[78] The character of systemic degradation will ensure that any masking of scientific understanding will be revealed in time through the laws of nature.

(vi) Misunderstanding of Scientific Findings

Non-scientists often inaccurately interpret scientific advice. In part, this is attributable to a lack of appreciation of the reservations inherent in scientific opinions.[79] For example, actors may interpret a scientific report of "no effects" to mean "*there are no effects whatsoever*", failing to understand that the "no effects" findings are situational, being limited to the experimental conditions.[80] With all scientific findings, determiners and enablers need to understand that the scientific statement is specific to the study, together with the conditions, variables, and methodology involved, current levels of scientific understanding, and within stated limits of probability.

Thus, a scientific finding of "no effects found" is not evidence that a chemical or activity is *safe*. Conversely, "effects found" pertain to very specific conditions, from

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[77] Ibid.

[78] The precautionary concept is pivotal to the declining influence of science on marine policy-making. It is discussed in detail in Chapters 2 and 5, herein.

[79] L.K. Caldwell, *Between Two Worlds: Science, the Environmental Movement and Policy Choice* (Cambridge: Cambridge University Press, 1992), p. 13.

[80] T. Page, "A Generic View of Toxic Chemicals and Similar Risks", 7 *Ecology Law Quarterly* 207 (1978), p. 231 and Mee, *supra* note 24, pp. 120-1. Also see E. Goldsmith, "Blind Man's Bluff", 1 *Ecologist Quarterly* 2 (1978).

which scientists then make extrapolations. A good scientist will always state the conditions and reservations, and actors in the MDLBA policy-making process must become accustomed to identifying this information in a report or questioning it if it is not apparent.[81] Failure to do so can easily result in unsound policy.

(d) Misplaced Reliance

Discerning sound science is a difficult task, even for those with an adequate degree of scientific literacy. Misplaced reliance comes in the form of choosing poor scientist over sound scientists and peer-reviewed experts and choosing poor science over sound. The reasons for this are many, with some of the main ones described below. As will become apparent, it is necessary to incorporate procedures for checking the scientist's credentials and procedures to ensure that the science chosen is sound. Upon eliminating poor or agenda-bound scientists and unsound science, the choices of scientific opinion available to determiners and enablers may be reasonably straightforward.

(i) Relying on Inappropriate Experts

Relying on inappropriate experts correlates with choosing inappropriate science. Appropriate choices of scientists include peer-reviewed individuals, or those having scientific opinions consistent with mainstream opinions where it is not peer-reviewed. This section focuses on the qualifications of the expert who provide advice on the scientific issue at hand.

Skeptic scientists – those whose opinion go against, or are contrary to, the mainstream body of opinion – require special scrutiny to determine the reason for their contrary

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[81] This information appears in scientific reports, but non-scientists often fail to appreciate it or, often, even read it, and in the redrafting of reports for policy purposes, the qualifications are often omitted.

opinions and how much, if any, weight should be given to their opinions. Skeptic scientists can fall into many categories such good scientists and those offering poor science, such as fringe, pseudo-, and biased scientists.

The most important group of skeptics include scientists who are renowned in their own fields but not experts on the specific issue at hand, or who have left research in the area (i.e., previously an expert in the area) to take up other positions and may now be away from research. The skeptic scientist could also be a peer-reviewed expert in the area who, for reasons emanating from his research and knowledge-building endeavours, holds contrary opinions. These so-called skeptic scientists may be respected experts and their opinions may be found to be correct over time, but the weight given to a contrary opinion should depend on how that opinion converges with mainstream opinion, their level of expertise in the area, and whether the disagreement is on a core or peripheral issue.

It is imprudent to base policy solely on the opinion of a skeptic, even if peer-reviewed, or currently non-practicing experts whose opinion contradicts mainstream, peer-reviewed positions. This is because the integrity of scientific knowledge is grounded in the scientific method, which relies on replication and review by peers and consistency with existing knowledge. Thus, mainstream scientific knowledge cannot and should not, be easily dismissed.

However, as opinions of skeptic scientific experts are scientifically plausible, they signal the need for more cautious and flexible policy-making processes to reflect emerging knowledge and changes in scientific thinking. Practising scientists usually recognise such experts and consider their opinions accordingly, but, unfortunately, non-scientists cannot easily discern the difference, and may need to review the scientist's credentials.[82]

Other experts to be wary of include fringe scientists,[83] pseudo-scientists,[84] biased scientists, with the latter including government scientists who may be ordered to support government policy,[85] scientists representing industry or NGOs who are not peer-reviewed, and scientists "for hire".[86] Fringe and pseudo-scientists frequently have opinions that have little credibility in the scientific community and their opinions often create confusion as non-scientists struggle to make sense of the range of opinions rather than trying to isolate the sound science from the poor. However, potentially biased scientists should be scrutinised to confirm their qualifications, as many are in fact peer-reviewed scientists respected by their colleagues. Biased science is discussed below.

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82 Refer to Brown, *supra* note 39, regarding the need for peer-reviewed science and the problems with relying on non-peer reviewed science. A relatively new journal, *Skeptic*, came about as a means of combating pseudo-science, encouraging individuals to question media reports, and educating users of scientific information to be circumspect.

83 Fringe scientists are those who propose a contrarian view, often in the public media, which does not reflect mainstream thinking or ridicules mainstream scientists without providing a logical argument why the contrarian view is feasible. It often appeals to emotions rather than logic, inciting fear instead of thoughtful reflection. They differ from skeptic scientists in that the latter, despite contrary views, have some rational foundation for their views and may even be peer-reviewed.

84 Pseudo-science falls far short of the rigorous methods of knowledge-building. Often sounding scientific, delving into it reveals speculation, assumption, and, often, underpinning ethical beliefs. An example of pseudo-science is the "science of creationism" or "intelligent design" that is becoming popular in the US, and competes with the scientifically sound theory of evolution. See M. Shermer, "The Gradual Illumination of the Mind", *Scientific American*, Vol. 286, No. 2, p. 25 (2002). Ecology is prone to pseudo-sciencism, as propounded by environmental ethicists.

85 See MacGarvin, *supra* note 18, p. 126 and C. Sheppard, "Not Politically Correct", 24 *Marine Pollution Bulletin* 524 (1992). It is often assumed that scientists formally representing governments are expected, if not ordered, to support government positions. This is certainly true sometimes, but peer-review insulates them from this bias. Where there is no peer-review, one must be more circumspect and ask how the opinion converges with mainstream opinion and if there is political agenda at work.

86 Scientists for hire usually offer science that supports a particular position or objective, whether or not it is sound science. These scientists must be distinguished from paid scientists who are very often peer-reviewed and respected by their colleagues.

(ii) Biased Science

Any scientific bias must be made clear in order to weigh the value of an expert's opinion. It is difficult for the non-scientist to ascertain bias, and the general (incorrect) assumption is that all government-, industry- and NGO-sponsored scientists are biased, due to their affiliations or financial backing.[87] Although some are biased (scientists are, after all, only human), or conform to a pre-determined position, it must be re-emphasised that many are peer-reviewed and respected by their colleagues, regardless of their funding sources or affiliations.[88] Who is paying them might be interesting, but it does not determine the quality of the scientific knowledge offered. Regardless, biases must be identified and the process must "insulate expert advice against bias".[89]

(iii) Reliance on Inappropriate or Insufficient Scientific Studies

Determiners and enablers often rely on scientific reports or studies that are not suitable for the policy purposes at hand. The studies might not necessarily be incorrect, but may not be comprehensive enough to provide full knowledge. Examples of this are diverse, including over-reliance on laboratory tests for lethal and short-term impacts, to the exclusion of tests for chronic impacts and field observations to confirm laboratory

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[87] See MacGarvin, *supra* note 18, pp. 125-6, which discusses the potential bias of government-sponsored science. Some scientists have questioned the possibility of bias of the IPCC, as an intergovernmental panel. For a balanced perspective on the IPCC, see T. Skodvin, *Science-Policy Interaction in the Global Greenhouse,* Center for International Climate and Environmental Research (CICERO) Working Paper 1999:3 (Oslo: CICERO), hhtp://www.cicero.uio.no/Publications/Workingpapers/wp1999-03_introd.html. Others question science sponsored by NGOs. See A. Goddard, "Fighting Science With Science", *Physics World* 57 (July 1997).

[88] J.S. Gray, "Letters: Statistics and the Precautionary Principle – Professor Gray Replies", 21 *Marine Pollution Bulletin* 599 (1990), p. 600, where the author, a respected scientist, tries to pre-empt allegations of bias against environmentalists' interests by noting that oil companies have black-listed him for honest and sound research that goes against their interests. Unfounded allegations of bias are often used to discredit scientists, but peer-review provides quality assurance. Also see L.S. Susskind, *Environmental Diplomacy: Negotiating More Effective Global Agreements* (New York, Oxford: Oxford University Press, 1994), p. 133 and Crittenden, *supra* note 42. Further see Fisk, David, "Environmental Science and Environmental Law", 10 *Journal of Environmental Law* 3 (1998), which discusses types of scientific bias (bias within science) that may affect decisions. Biases do exist and actors should recognise them, and understand how they can be managed.

[89] Kimball, *supra* note 65, at p. 139.

tests.[90] In the case of ocean dumping, other than for radioactive materials, some scientists believe that less than a full account has been taken of marine pathways of transport, exposure, and effects when assessing other disposal options.[91] Ocean dumping of some materials, such as sewage sludge, may be reasonable provided rigorous and holistic monitoring is undertaken.[92] However, reliance is often misplaced as effective monitoring is seldom done, as in many cases only levels of contaminants – not trends and effects – are recorded.[93] Ecologists excluded from participating in the development of ecotoxicological science believe that much-needed ecosystem studies are not being done, in favour of monitoring, primarily by engineers and chemists.[94] Finally, the focus of the investigation, when determined by non-scientists, is often on the wrong contaminants, and even worse, it often neglects the most serious categories.[95]

(iv) Reliance on Outdated Science

The policy-making process involves the weighing and balancing of information from diverse disciplines. Keeping current in each is a challenge for determiners and enablers. For example, in establishing water quality criteria for copper (a heavy metal), the US EPA used laboratory tests utilising the most toxic form of copper, but

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90 See Mee, *supra* note 24, pp. 119-20 and Goldsmith, *supra* note 80. Also see Renner, *supra* note 63 and R.C. Newell, D.R. Clegg, and D.W. Maughan, "Environmental Impact of Liquid Wastes Discharge in Coastal Waters", 16 *Ocean and Shoreline Management* 327 (1991).

91 Bewers, 1995, *supra* note 8, p. 20.

92 J.M. Heap, M. Elliott and T.A. Rheinallt, "The Marine Disposal of Sewage Sludge", 16 *Ocean and Shoreline Management* 291 (1991), p. 311.

93 MacGarvin, *supra* note 18, p. 123 and Gray, 1996, *supra* note 8, p. 138. See J.S. Gray, "Biological and Ecological Effects of Marine Pollutants and Their Detection", 25 *Marine Pollution Bulletin* 48 (1992), for effective monitoring techniques. Also see J.N. Paw (ed.), *Marine Environmental Monitoring*, a dedicated issue of *Tropical Coasts: A Newsletter for Policymakers, Environmental Managers, Scientists and Resource Users*, Vol. 4, No. 2, pp. 1-31 (1997) and Arctic Monitoring Assessment Programme (AMAP), *Arctic Pollution Issues: A State of the Arctic Report* (Oslo: AMAP, 1997).

94 A. Rosemarin, "Ecotoxicology on the Upswing – But Where are the Ecologists?", 17 *Ambio* i (1988), p. i.

95 Mee, *supra* note 24, p. 115.

failed to take into account recent experiments and field data that showed that copper is very seldom present in this form.[96] The result is that the criteria do not relate to actual discharges of copper.[97] Consequently, some US states have ignored EPA copper regulations, despite copper being an algaecide that should be regulated.[98] Improperly grounded regulations, being overly stringent or too permissive, usually result in unnecessary economic or health costs.[99]

(v) Science Outpacing the Legal System

It was noted a few decades ago that the international legal system is ill equipped to address the new ecological order that superseded classical pollution problems.[100] The treaty model of international lawmaking suits specific, narrowly defined issues where a high degree of consensus among states can be achieved, and is not appropriate for systemic degradation issues, as attaining consensus will likely result in weak policies due to compromise and negotiated outcome.[101] The protracted consensus-reaching processes associated with international treaty making and political issues associated with domestic policy-making have caused legal development to lag behind ecological and scientific developments.[102] Additionally, it is often another five to ten years before

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96 J.C. Hall, W.T. Hall, and C.T. Simmons, "Water Quality Criteria for Copper: A Need for Revisions of the National Standard", *Water Environment and Technology*, Vol. 9, No. 6, pp. 45-9 (1997), p. 49.

97 *Ibid*.

98 *Ibid*.

99 *Ibid.* Also see Gray, 1996, *supra* note 8, pp. 136 and 142 and B.S. Dhaliwal, J.V. Ostlund, and C.W. Batts, "Drawbacks of Method Detection Levels: EPA's Approved Measure Can Provide Inappropriate Limits", *Water, Environment and Technology*, Vol. 9, No. 6, pp. 39-43 (1997).

100 See R.L. Friedheim, "Ocean Ecology and the World Political System", in J.L. Hargrove (ed.), *Who Protects the Ocean?* (St. Paul, Minn.: West Publishing Co., 1975), pp. 151-90.

101 W.J. Davis, *supra* note 62, p. 165.

102 World Commission on Environment and Development, *Our Common Future* (Oxford: Oxford University Press, 1987), p. 330 and S. Lutter "Letters: Statistics and the Precautionary Principle", 21 *Marine Pollution Bulletin* 547 (1990), p. 548.

a treaty comes into force.[103] An example is LOSC, which came into force over 20 years after it was set in motion, by which time the land-based pollution provisions were outdated, as the ecocentric mindset evolved to erode the sectoral approach and land-based sources have been broadened to encompass all LBA.

A great failing of treaty- and policy-making processes is the lack of mechanisms to incorporate emergent scientific knowledge and technology. Although the time has not yet arrived for a legally binding agreement on wide-ranging LBA, the two major soft-law instruments, Agenda 21 and the GPA, confirm that the mindset of the international legal community is evolving towards systemic environmental (human) management. New tools, such as common but differentiated standards, are evidence of creative law-making to keep pace with science and technology and environmental degradation.[104]

(vi) Inaccurate Summarisation of Scientific Reports and Manipulation of Data

A disturbing occurrence is the inaccurate summarisation of scientific studies and the inadvertent or blatant manipulation or "massaging" of data to reflect political interests. The projected image is that decisions are made based on sound science, when, in fact, scientists have not endorsed the manipulated version.

The written results of scientific investigations by scientific consultants, or government scientists employed for policy/management purposes, often go through several phases

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[103] D.M. Johnston, "Marine Pollution Agreements: Successes and Problems", in J.E. Carroll (ed.), *International Environmental Diplomacy* (Cambridge: Cambridge University Press, 1988), p. 203.

[104] See P.H. Sand, *Lessons Learned in Global Environmental Governance* (World Resources Institute, 1990). This publication contains several ideas, most of which have proven effective, for facilitating effective treaty-making, by accommodating the interests of various states, particularly of those less developed. Also see Agenda 21, which advocates common, but differentiated standards. See generally, D. M. Johnston, *Consent and Commitment in the World Community: The Classification and Analysis of International Instruments* (Irvington-on-Hudson, New York: Transnational Publishers, Inc., 1997).

of redrafting and summarisation before reaching determiners and enablers.[105] A common scenario is that the investigation recorded by the scientist, with its inherent limitations, assumptions, statistical probabilities, qualifications, and uncertainties made explicit, is redrafted into a report that eliminates technical terminology to make it more understandable to non-scientists. The report may be redrafted further to distil it for determiners and enablers who seek only the salient points or an executive summary, often prepared by non-scientists, may be added.

Policy-makers, pressed for time and lacking scientific knowledge to understand the report itself, often rely on the executive summary alone. Depending on the qualifications of those involved in the editing and redrafting processes, the final product often reflects scientific findings very different from the original report, or omits to mention the reservations and limitations that scientists regard as vital.[106] The IPCC report,[107] widely disseminated and influential, has been criticised for its misleading executive summary.[108] In such cases, environmental decisions are not being made on sound science, despite sound science being provided by scientists.

A related problem is the control and manipulation by some countries as to what information and data appear in country/sub-regional reports and are reported at workshops, meetings, and conferences.[109] This problem appears to be endemic within

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[105] See Stewart, *supra* note 30, pp. 14-15 and J.A. Hutchings, C.W., and R.L. Haedrich, "Is Scientific Inquiry Incompatible with Government Information Control?", 54 *Canadian Journal of Fisheries and Aquatic Sciences* 1198 (1997).

[106] See Stewart, *ibid*. and Warren, *supra* note 48, p. 108. Many scientists have voiced their concerns about this issue.

[107] IPCC, *supra* note 41.

[108] Wildavsky, *supra* note 36, pp. 344-5. Also see Crittenden, *supra* note 42.

[109] MacGarvin, *supra* note 18, p. 126.

most regions, including highly developed regions such as the North Sea.[110] Again, the IPCC report has been criticised for bias due to suspicions that, as an intergovernmental endeavour, some scientists might have been instructed by their governments to ensure that data put forward was consistent with government interests.[111] Such manipulation of scientific information is a problem of transparency of process. Neither the science relied upon, nor other factors influencing the policy decision, are made public. When policies prove ineffective, too frequently the assumption is that scientists are at fault for providing poor scientific advice. The review of the executive summary by one or more of the contributing scientists to ensure consistency with the main body should be incorporated as part of the reporting process.

(e) Funding Affecting Scientific Research

Murky waters surround the allocation of funding for scientific research. Research cannot be undertaken without funding, but non-science influences on funding decisions affect the depth, priority, and quality of research.[112] Studies show that public spending on scientific research is declining in many countries,[113] and funding is withheld if research is perceived to conflict with economic growth.[114] The public is seen to drive much of research funding allocation, as public concerns become government priorities.[115]

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[110] Regarding the North Sea, see MacGarvin, *ibid.* With respect to the general poor use and control of data, see generally, Sheppard, *supra* note 85. This article refers to the concealing and censorship of data by governments and the "massage of original conclusions". Such use of data is particularly rampant in less developed states, often for reasons of politics and funding.

[111] Susskind, *supra* note 88, p. 133.

[112] Funding is an enduring complaint of scientists, many of whom feel that their work and reputation are compromised by poor funding decisions. For a few examples taken from an ocean, see Gray, 1996a, *supra* note 65; Rosemarin, *supra* note 94; D.A. Wright, "Chesapeake Bay: Pollution and Politics", 16 *Marine Pollution Bulletin* 299 (1985); and Goldsmith, *supra* note 80.

[113] See T. Theocharis and M. Psimopoulos, "Where Science Has Gone Wrong", 329 *Nature* 595 (1987), p. 595.

[114] See generally, Goldsmith, *supra* note 80.

[115] Caldwell, *supra* note 79, p. 13.

The setting of research priorities, which can affect research for many decades, is especially controversial. One issue is that the upper echelons of determiners and enablers often establish priorities without consulting the scientists involved in research on the ground.[116] This top-down process of prioritising has been an issue in Europe, despite its advanced systems of government.[117] The impact on science, and on the environment, is that funding of the non-scientifically identified priorities may be wasted, as they may not be ecological priorities.

The allocation of funding for scientific research is quite abysmal, arguably because determiners lack scientific understanding and are therefore more influenced by non-scientific factors and in particular, socio-political concerns. Poor allocation of funding for environmental protection is a concern, even in environmentally aware and politically sophisticated nations. A US example involves Chesapeake Bay, an ecologically rich area that supports economically vital commercial fisheries.[118] Scientific baseline data on the Bay and surrounding land are lamentably inadequate, yet such data are necessary to isolate and understand environmental changes. Politics is the major problem, as funding for monitoring programmes lasts only as long as the political party in power, and priorities and funding are re-established with each election.[119] In this environmental protection programme, which is hailed as a political

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[116] Gray, 1996a, *supra* note 65.

[117] *Ibid.* This article notes that research priorities must emanate from the researchers, or from the bottom up. It notes poor decisions by the European Science Foundation, which largely involving individuals removed from marine research and who are involved with priority setting for funding purposes. The ICSU's International Geosphere-Biosphere Programme (IGBP) provides an excellent example of bottom-up collaboration on the establishment of priorities. *Ibid.* For more information on the IGBP, see Caldwell, *supra* note 79.

[118] See Wright, *supra* note 112, for a detailed description of the Chesapeake Bay programme and the problems with political and general misuse of science.

[119] *Ibid*., p. 299. Also see J. Kusler, "Wetlands Delineation: An Issue of Science or Politics?", *Environment*, Vol. 34, No. 2, pp. 7-11, 29-37 (1992), for a discussion regarding the politicisation of boundary determination of wetlands, where science, and specifically ecology, were excluded. For a discussion on the failure of American marine policy, see R.J. Wilder, "Is This Holistic Ecology or Just Muddling Through?: The Theory and Practice of Marine Policy", 21 *Coastal Management* 209 (1993), p. 219.

success, less than 0.1% of funding is spent on developing scientific knowledge.[120] If scientific data were used to ground policy decisions, the other 99.9% of the funds could be spent more efficiently and effectively.

Governments naturally seek immediate and tangible results-oriented projects to demonstrate that public funds are well used.[121] Two results are notable. First, fewer funds are being directed towards pure (i.e., curiosity-driven) scientific research, which often takes years to reap benefits but remains a necessary and beneficial scientific endeavour.[122] Second, governments prefer instead to direct scientific research funds at economic problems, as opposed to the ecological effects of such problems. For example, the US Congress allocated funds, not for studying the effects of pesticides, but for developing new pest controls for pests other than those targeted by existing pesticides (i.e., not necessarily more ecologically friendly pesticides).[123] An example of this is the transfer of a scientist studying the effects of DDT to a new project concerning chemical communication in foxes, in the hope of developing a product that farmers could use to deter foxes preying on livestock.[124] In this particular case, the repercussions are two-fold: first, economic spin-offs immediately ensue for industries that manufacture the new controls; and second, through no fault of science, the chronic impacts of pesticides remain inadequately understood, even though pesticides remain in use. The impression is that research funds are spent where they will contribute to

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[120] Wright, *supra* note 112, p. 300.

[121] Goldsmith, *supra* note 80.

[122] See Gray, 1996a, *supra* note 65. The knowledge gained from pure scientific research becomes part of a growing data bank available to other researchers. The spin-offs for science, and society, such as new scientific techniques, greater understanding of various scientific processes (from sub-atomic to ecospheric), and advanced technology, usually justify expenditure on pure research. It is a long-term investment as scientific knowledge is accretionary. The difference between pure and applied science is described in Funtowicz and Ravetz, 1994, *supra* note 45, pp. 1882-3. They are terms with increasingly fuzzy boundaries as pure science is now so quickly used in applications, or applied science.

[123] Goldsmith, *supra* note 80, p. 3.

[124] *Ibid*.

the current world-view of economic progress.[125] Some may argue that this view has changed somewhat as public pressure demands ecological safeguards. However, financial investment in ecological research, establishment of baseline data, effective monitoring, and identification of causal effects has not increased.

Another disconcerting trend is investment in "green science", where a particular environmental effect is sought; or, more accurately, the scientific method is inverted to prove, rather than disprove, that an effect exists.[126] An example is huge government investment in tertiary sewage treatment in the North Sea, where there is no significant scientific data to justify such expenditure, but it is assumed that the sea is being saved from eutrophication.[127] This epitomises the unwise allocation of scarce financial resources.

2) Science Ignored or Disregarded

There is increasing evidence that determiners and enablers are ignoring science. Examples are legion, but solid evidence of this belief is the Heidelberg Appeal presented to the Heads of State at UNCED, as discussed in Chapter 3, herein.[128] Identifying concerns about the irrational and emotional basis of policy-making to the exclusion of science, it was a plea for common sense and sustainable, ecologically effective policy-making grounded in *sound* science. During preparations for UNCED, scientists' involvement was minimal, and experts were not consulted.[129] The lack of effective and reliable scientific input into UNCED, and the lack of acknowledgement

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[125] Editorial, "Why We Only Accept a Policy if We Know It Will Not Work", 1 *Ecologist Quarterly* 266 (1978), p. 268.

[126] Gray, 1996, *supra* note 8, p. 142.

[127] *Ibid*.

[128] The Heidelberg Appeal is attached herein as Appendix 4 and reproduced in Bewers, *supra* note 8, p. 23.

[129] D.L. Ray and L.R. Guzzo, *Environmental Overkill: Whatever Happened to Common Sense?* (New York: HarperPerennial, 1993), p. 7.

of the Heidelberg Appeal, and have lead some to cast it as "represent[ing] a signal victory for the foes of scientific progress, knowledge, and economic development".[130]

(a) Science and Scientists Disregarded

Many writers, both scientists and non-scientists, have commented on the lack of scientific input into policy-making processes.[131] Science has not been infused into policy; even where sound scientific information has been available.[132] "In practice, science and its processes have often been totally ignored when development decisions have been taken."[133] Science has had a minimal role in international treaties, including issue definition, fact-finding, bargaining, and regime strengthening.[134] Science was used in acid rain, ozone depletion, and biodiversity negotiations, but it has been considered irrelevant or only secondary in other international negotiations, including whaling, hazardous waste transport and trade, tropical deforestation, arctic mineral exploration, ocean dumping, world heritage sites, wetlands and migratory species protection, and law of the sea.[135] A common sentiment is that only a fraction of

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[130] *Ibid.*, at p. 8. The previous chapter notes that Agenda 21 is largely scientifically sound. To clarify, this relates primarily to the incorporation of the ecosystem approach and philosophically sound principles. Scientists' concerns relate to the use of science in interpreting and applying principles and the frequent lack of scientific input into policy-making processes.

[131] Susskind, *supra* note 88, p. 63. Written in the 1990's, Susskind noted that science has played a surprisingly small role in policy-making processes since 1972. Also see G. Porter and J.W. Brown, *Global Environmental Politics,* 2nd ed. (Boulder, Colorado and Oxford, UK: Westview Press, Inc., 1996), p. 21 and generally Kimball, *supra* note 65. Bewers, *supra* note 8, describes the declining influence of science on marine policy-making from a scientist's perspective. Most citations in Chapter 4, herein, (this chapter) contain one or more incidents of disregard for science.

[132] See Caldwell, *supra* note 79, p. 23 and Mee, *supra* note 24, p. 110.

[133] R.C. Earll, "Commonsense and the Precautionary Principle: An Environmentalist's Perspective", 24 *Marine Pollution Bulletin* 182 (1992), at p. 183.

[134] Susskind, *supra* note 88, p. 63. Chapter 4, therein, is insightful as it details the limited use of science in international treaties, with recommended readings for additional insights. Porter and Brown, *supra* note 131, p. 21, echo the minimal contribution that scientists have in regime formation and strengthening. Also see Kimball, *supra* note 65, and Caldwell, *supra* note 79.

[135] Susskind, *ibid.*, p. 63 and Porter and Brown, *ibid.*, p. 21.

scientific capability is utilised for policy-making, and that the dialogue between scientists and determiners and enablers is usually inadequate.[136]

(b) Neglect of Science by Government Agencies

In the 1970's, the natural sciences were easily neglected because "classical pollution", such as car emissions, untreated sewage, and industrial effluents, were addressed through technology.[137] When natural science is used, it is often poor quality or comes from irrelevant scientific experiments. Examples of this include the US EPA's aforementioned study of 12 individuals to establish a safety standard for carbon monoxide exposure;[138] government agencies conducting laboratory tests that used non-sensitive species, for example freshwater trout, to detect hydrocarbon effects in marine organisms,[139] or bioassays of 96 hours to detect lethal doses, and 30 days to determine chronic effects.[140] Compounding the problems with reliance on such laboratory science, determiners and enablers commonly ignore the data and informed opinions of scientists conducting field experiments whose data contradicts laboratory findings.[141] Scientists have been excluded from assessing management options to regulate degradation, and this continues despite the fact that environmental issues have evolved into risk management issues that require feedback monitoring and policy adjustments to reflect emerging scientific knowledge.[142]

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[136] Boelens, *supra* note 65, p. 14.

[137] Ruckelshaus, 1985, *supra* note 37, p. 25.

[138] *Ibid.*, p. 22.

[139] This is one example of the many offered by scientists to the author. Also see MacGarvin, *supra* note 18, p. 125.

[140] See Mee, *supra* note 24, pp. 119-20. Neither of the lab tests provide sufficient information on which to base exposure levels for general populations.

[141] This has been verbally confirmed by many scientists.

[142] Mee, *supra* note 24, p. 110. See generally, Kimball, *supra* note 65; Bewers and Garrett, *supra* note 72; and J.M. Bewers and P.G. Wells, "Challenges for Improved Marine Environmental Protection", 25 *Marine Pollution Bulletin* 112 (1992), for concordant opinions.

(c) Adequacy of Scientific Knowledge

(i) Scientific Uncertainty

Scientific uncertainty is discussed in detail in Chapters 2 and 5, herein, as it is a pivotal issue at the interface of science and law. The nature of contemporary systemic degradation issues makes understanding scientific uncertainty increasingly relevant to determiners and enablers, as uncertainty must be explicitly addressed and managed through the policy-making process. To re-emphasis, a crucial point is that the quality of sound science is unrelated to scientific uncertainty and that, despite some uncertainty, scientists usually have sufficient understanding to provide useful advice. Scientific uncertainty should not be used as an excuse to postpone action or condone unsound action, this being the essence of the original formulation of the precautionary concept.

(ii) Science Sufficient, But Disregarded

In many cases, sound and tested science is disregarded. Scientists warned in 1899 that irrigation in California would result in agricultural collapse, yet irrigation continues in much the same form, despite very good scientific understanding of the issue, much evidence of salt accumulation, and the knowledge that almost identical conditions contributed to the collapse of the ancient Sumerian civilisation.[143] Scientists warned over 100 years ago of the phenomenon of acid rain and its potential for devastation, yet no action was taken until forests and lakes suffered great damage.[144]

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143 D. Ludwig, R. Hilborn, and C. Walters, "Uncertainty, Resource Exploitation, and Conservation: Lessons from History", 260 *Science* 17 (1993), p. 36. Early examples include the demise of the ancient Sumerian civilisation, due in part to destructive agriculture practices, particularly the irrigation of arid soil that led to crop-inhibiting salt deposits. Also see E. Ayres, *God's Last Offer: Negotiating for a Sustainable Future* (New York, London: Four Walls Eight Windows, 1999), pp. 127-8.

144 N. Myers, "Environmental Unknowns", 269 *Science* 358 (1995), p. 358.

A more relevant example is that of the collapse of the anchovy fishery offshore California, in the early 1950's.[145] In this case, scientists, adopting the ecosystem approach, accumulated over several decades, excellent data and knowledge of both the fishery and the marine ecosystem.[146] Despite superior scientific knowledge, the lack of rational policy resulted in the fishery collapse, with catches dropping from nearly 590,000 tons in 1941-42 to 5,700 tons in 1952-53.[147]

A more recent example concerns scientific knowledge about the safe marine disposal of low-level radioactive waste. Current knowledge is adequate for the assessment of the impacts and regulation, yet suspicion lingers among non-scientific actors, and international agreement was delayed due to misrepresentation of the status of scientific understanding.[148] Another example is the 75 years from the time leaded gasoline was recognised as hazard to the conversion to lead-free gas.[149]

Adequate science is also disregarded in favour of technological fixes. For example, science is very clear about the effects of clearing ground cover, which leads to erosion and flooding. Yet flood plains and riverbanks have been developed with the belief that technology can somehow control water flows, masking the risks to inhabitants and their properties.[150]

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[145] H.N. Scheiber, "From Science to Law to Politics: An Historical View of the Ecosystem Idea and Its Effects on Resource Management", 24 *Ecology Law Quarterly* 631 (1997), p. 644.

[146] *Ibid*.

[147] *Ibid*.

[148] Bewers and Garrett, *supra* note 72, pp. 121-3.

[149] See N. Robinson, "Legal Systems, Decisionmaking, and the Science of Earth's Systems: Procedural Missing Links", 27 *Ecology Law Quarterly* 1077 (2000).

[150] R.W. Kates "Success, Strain, and Surprise", 2 *Issues in Science and Technology* 46 (1985-86), p. 52. China and other developing states have experienced floods first hand over the last five years with billions of dollars of damage and loss of life. See Ayres, *supra* note 143, pp. 48-9.

In other cases, pollution problems identified and adequately understood by scientists are ignored. The wastes from sewage, mining, food and beverage industries, pulp and paper mills, and many other industrial processes are subject to ineffective regulations and policies, or they continue to be released unabated.[151] Deforestation (including events like the annual fires in Indonesia), conversion of mangroves to shrimp farms, destruction of coral reefs, and global over-exploitation of fisheries are part of the growing list, even though these practices are known to be unsustainable and disrupt the valuable natural services that such ecosystems perform.

3) Misplaced Blame for Continuing Ecological Degradation

It is common to hear among policy circles and in the public domain that scientists are at fault for the state of environmental affairs today – acid rain, ozone depletion, global warming, and a myriad of other issues exist because scientists failed in their responsibilities. This section seeks to reveal the sources of failure that are never acknowledged, if even contemplated.

(a) Ignoring Science Unfairly Affects Scientists

Listed in the previous section are a few examples of science ignored in policy-making processes. Another common example is the official sanctioning of or "turning a blind eye" to degrading activities in the name of short-term economic gain. Solid science indicating a contrary position and long-term sustainability are ignored. Then, when ecological problems arise or continue unabated, the cry, "Why didn't scientists predict

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[151] See Bewers and Wells, *supra* note 142, p. 113; GESAMP, 2001b, *supra* note 46; GESAMP, 2001a, *supra* note 66; E.D. Gomez, *et al*., *State of the Marine Environment in the East Asian Seas Region*, UNEP Regional Seas Reports and Studies No. 126, 1990; L.C.C. Koe and M.A. Aziz, *Regional Programme of Action on Land-based Activities Affecting the Coastal and Marine Areas in the East Asian Seas*, RCU/EAS Technical Reports Series No. 5, 1995; H. Yap, "Marine Environmental Problems: Experiences of Developing Regions", 25 *Marine Pollution Bulletin* 37 (1992); G.B.K Baines and R.J. Morrison, "Marine Pollution from Land Use in the Pacific Islands Region", 21 *Marine Pollution Bulletin* 506 (1990); D. Hinrichsen, *Our Common Seas: Coasts in Crisis* (London: Earthscan Publications Limited, 1990). These are but a few of the numerous publications detailing the continuing acts of contamination, despite scientifically understood causal relationships.

this?", reinforces the inaccurate impression that scientists are inept, or worse, culpable.[152] The policy-making process is cloaked in mystery, leaving the public unaware of contributors, information, the use to which any information is put, and finally the determination process.

(b) Lack of Transparency

The misuse of scientific information, whether due to blatant abuse or good intentions gone wrong, is a major problem for society as it leads to poor decisions. The lack of transparency in the policy-making process encourages misuse of science, as it is ignored or used to rationalise *post hoc* policy/management decisions or preferences that are determined by other factors.[153] These other factors, such as socio-economic and political issues, and most importantly today, ethical grounds must be accounted for in the policy-making processes, but truthfulness and openness must prevail as to the basis on which decisions are made. Science must continue to inform such decisions, but not be used to justify a decision where, for instance ethical considerations prevail.

(c) Conditions Outside of Science Affecting Perceptions

Scientists may be blamed for poor policy results because of non-scientific inadequacies within the policy-process. For example, the US Congress has been known to impose unrealistic time frames for performance by regulatory agencies.[154] The ensuing non-performance, or poor results, undermines public confidence in both scientists and

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[152] The public's lack of confidence in science and scientists was the precipitating factor in the scientifically unsound interpretation of the precautionary concept. See Chapter 2, herein, for a discussion on the precautionary concept.

[153] See L.C. Hempel, *Environmental Governance: The Global Challenge* (Washington D.C. and Covelo, California: Island Press, 1996), p. 122 and W.J. Davis, *supra* note 62. The latter discusses the misuse of science under the London Convention. It notes that this has been partially addressed by the 1996 Protocol to the London Convention as it recognises that science can inform choices, but human values are intricately involved in decision-making.

[154] Ruckelshaus, 1985, *supra* note 37, pp. 30-1. One example is that Congress allotted five years to address the Los Angeles smog issue, despite 25 years being a realistic assessment. Also see Ruckelshaus, 1997, *supra* note 37.

determiners and enablers. Examples of past (non)performance are often used to justify current courses of action that circumvent science.[155] This is dangerous, as past policy-making processes are seldom analysed to determine the actual reasons for poor performance.

(d) Negotiated Outcomes and Standards

Convoluted and complex environmental issues driven by diverse interests – industrial, political, economic, and ecological – usually result in outcomes and standards that are negotiated, often to the exclusion of sound science. Examples include: the priorities on the disposal of radioactive wastes being usurped by various social values and political interests;[156] the *Quality Status Report on the North Sea* which was compromised as government officials negotiated to the lowest common denominator, effectively burying scientific concerns and controlling the research agenda;[157] and regulations based on scientific standards which are viewed as a starting point for negotiations between degraders and determiners.[158] Regulatory agencies charged with enforcement (enablers) have frequently negotiated compliance levels with industry.[159] Negotiated outcomes and standards have contributed to the *perceived* failure of both the assimilative capacity as a regulatory strategy and scientists generally.

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155 The precautionary concept is the best example of this. See Bewers, 1995, *supra* note 8.

156 J. Spiller and C. Hayden, "Radwaste at Sea: A New Era of Polarization or a New Basis for Consensus?", 19 *Ocean Development and International Law* 345 (1988).

157 MacGarvin, *supra* note 18, p. 126. This article provides an excellent overview of why the Report on the North Sea is unreliable, and relates its unreliability in large part to the misunderstanding of science by policy-makers and government officials. See generally, J. Andersen, H. Karup, and U.B. Nielson (eds.), *Scientific Symposium on the North Sea Quality Status Report 1993, 18-21 April 1994, Ebeltoft, Denmark: Proceedings* (Ministry of Environment and Energy, Danish Environmental Protection Agency, 1996).

158 R.M. M'Gonigle, T.L. Jamieson, M.K. McAllister, and R.M. Peterman, "Taking Uncertainty Seriously: From Permissive Regulation to Preventative Design in Environmental Decision Making", 32 *Osgoode Hall Law Journal* 99 (1994), p. 135. The authors note that the courts' failure to understand the intricacies of science encourages regulatory agencies to negotiate with polluters to avoid the hardship of meeting the onerous legal burden of proof in pollution cases. Courts often demand definitive answers to scientific questions and judges often fail to realise, or acknowledge, scientific opinions require explanations and qualifications.

159 *Ibid.*, pp. 135-6.

As discussed previously, international agreements are the product of political bargaining.[160] The complex of sovereign interests makes such negotiations inevitable. Therefore, transparency would benefit the treaty-making process and the outcomes could then be recognised as compromises. Inaccurate assumptions or beliefs about the role of sound science could be isolated and dispelled, and it could be acknowledged that the negotiated outcomes may not provide adequate environmental protection, or in this current era, costly over-protection pursuant to vociferous public pressure.

(e) Implementation Problems

Generating sound policy is merely the first step towards effective ecological management. Implementation and enforcement are both essential, but these elements of the policy-making process are very weak. Even classical domestic pollution management schemes are seldom implemented as intended. For example, priorities for control and remedial action are often determined without full scientific assessment.[161] A classic example of implementation problems is the policy use of the assimilative capacity, as discussed in Chapter 2, herein. Although scientists discussed its pitfalls and GESAMP mapped out a sound programme, the assimilative capacity was seldom implemented or used by policy-makers in accordance with scientific dictates, with the result that scientists have been unfairly blamed for its *perceived* lack of success. While this is at the root of the debate over the precautionary concept, in fact, lack of success can be more properly attributed to poor implementation.[162]

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[160] See Waldichuk, *supra* note 27, p. 286. This article was written in the 1970's, and the situation has not changed today.

[161] Mee, *supra* note 24, p. 110.

[162] See Chapters 2 and 5, herein, for a detailed discussion of the assimilative capacity and its relationship to the precautionary concept.

International environmental agreements often encounter implementation failures, often due to the lack of enforcement mechanisms and a reluctance to take offending states to international courts or tribunals. One glaring example is that of the Mediterranean Sea, which suffers from ineffective scientific monitoring and state reporting, resulting in minimal compliance.[163] Furthermore, the compliance control section of the 1976 Barcelona Convention has never been implemented.[164] Such non-implementation and non-enforcement leads to unfair criticism of science.

(f) Failure to Implement an Ecosystemic Perspective

Many regulatory agencies adopted broad-based policies subsequent to Stockholm to reflect the fact that the ecosphere is an intricately inter-linked system of living and non-living entities bound by the continual cycling of nutrients, elements, and the flow of energy. However, surveys indicate that these policies are seldom implemented. The US EPA in the early 1970's was organised around ecological unity, but this was not practised until the mid-1980's.[165] The Canadian cod fishery collapse in the 1990's has been attributed in part to the failure of the Canadian Department of Fisheries and Oceans ("DFO") to implement an ecosystem approach.[166] It provides a stark warning that unless ecosystem approaches are adopted in fisheries management,[167] most

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[163] Broadus, *et al.*, *supra* note 16, p. 102. Also see V. Sebek, "Bridging the Gap Between Environmental Science and Policy-making: Why Policy Often Fails to Reflect Current Scientific Knowledge", 12 *Ambio* 118 (1983).

[164] Ibid.

[165] Ruckelshaus, 1985, *supra* note 37, p. 22.

[166] See D.G. Cook, "Editorial", 54 *Canadian Journal of Fisheries and Aquatic Sciences* iii (1997) and Hutchings, *et al.*, *supra* note 105.

[167] It must be clarified that the ecosystem approach must be adopted by policy and management strategies, not just science. A case on point is the sardine fishery in California in the 1950's where the science was extensive, multi-disciplinary and systemic, but it was ignored by policy processes, which resulted in complete collapse of the fishery. Many scientists would argue that the cod fishery in the North Atlantic suffered the same fate. See Scheiber, *supra* note 145.

fisheries face a bleak future.[168] In the international arena, if the London Convention were in fact to reflect a true ecosystemic perspective, full account would have to be taken of all pathways, transport media, effects, and target species.[169] In the Philippines, a uni-sectoral approach has been adopted to the exclusion of ICM, as foreign and local investors insist on conditions that benefit their developments.[170]

Although many non-scientists advocate an ecosystemic approach, they fail to understand its complexity or scope, and continue to adopt ecological policies that are sectoral or inconsistent with maintaining ecospheric integrity.

(g) Unjust Treatment of Scientists and Misuse of Scientific Data and Knowledge

There are several ways in which actors in the policy-making process treat scientists unjustly and misuse scientific knowledge. The first involves treating scientific knowledge as conclusive, despite reservations and limitations provided. Scientific knowledge is the *process* of accruing information that fits coherently together to build understanding of the large picture; it is not a *product* or a final packet of information, as discussed in Chapter 2. Non-scientists do not always comprehend the accretionary nature of scientific knowledge often mistreat scientists and misuse data, often without realising it. They treat the scientific input as a final product, and overlook the process of gathering scientific information, with its inherent limitations and uncertainties.

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[168] S.R. Kerr and R.A. Ryder, "The Laurentian Great Lakes Experience: A Prognosis for the Fisheries of Atlantic Canada", 54 *Canadian Journal of Fisheries and Aquatic Sciences* 1190 (1997). It surprises many to think of an advanced nation like Canada overlooking an ecosystem approach to managing its valuable cod fishery, but evidence suggests that this is the case. See Hutchings, *et al.*, *supra* note 105. Note that the US EPA is not immune from ignoring the ecosystem approach, as although it was organised around concepts of ecology and unity of nature, it was a decade before it was put into practice. See Ruckelshaus, 1985, *supra* note 37, p. 22. Note that Hall, *et al.*, *supra* note 96, suggest that the US EPA is still lacking, as it adheres to outdated scientific data. Also see Ruckelshaus, 1997, *supra* note 37.

[169] See Bewers, 1995, *supra* note 8, pp. 19-20; Bewers and Garrett, *supra* note 72, p. 119; and Heap, *et al.*, *supra* note 92, p. 311.

[170] E.D. Gomez, "Jumping Onto International Bandwagons Without Really Meaning It", 30 *Marine Pollution Bulletin* 98 (1995), p. 98.

The systemic nature of current ecological degradation means that the calculation of long-term risks of exposure to contaminants is inherently difficult and that the calculation of changes in global processes (i.e. climate, oceanic currents, greenhouse effect, and many others) due to human activities is very much scientifically informed projection. Scientists are studying complex systemic issues for the first time, and like doctors using acquired information to determine the origins and cures for cancer, scientists use their professional training and accumulated knowledge to predict outcomes. Determiners and enablers, innocently or otherwise, without appreciating the associated statistical probabilities and other limitations, often misuse scientific input by treating it as definitive and final.[171] Compounding the injury, scientists are often unfairly blamed by actors and the public for continuing degradation and policy failure.

A second unjust treatment of scientists and science involves the suppression of scientific information by actors involved with the policy-making process. Although many scientists can provide examples of scientific results being suppressed, an article by three fisheries scientists with the Canadian DFO is telling. In a well documented article, they contend that DFO ignored scientific fact and opinion where these failed to conform to department orthodoxy or political expediency, based on their personal experience with fish stocks in Canada's EEZ.[172] The editorial in the prestigious journal in which the article was published detailed other examples of policy/political interference with science, noting the increasing pervasiveness of social, political, and

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[171] Chapman, *supra* note 61.

[172] Hutchings, *et al.*, *supra* note 105. DFO publicly reacted to the allegations, with suggestions that libel cases would be filed against the fisheries scientists. Also see S. Strauss, "Ottawa to Reopen Cod Fishery: Scientists Condemn Plan as Political, See No Clear Sign Number of Fish is Recovering", *The Globe and Mail* (Toronto, Canada, Wednesday, 16 April 1997), pp. A1 and A6; A. DePalma, "Newfoundland to Ease Ban on Fishing; Some Say It's Too Soon", *The New York Times International* (New York, Friday, 18 April 1997), p. A7; E. Anderssen, "Bureaucrats Sabotage Scientists" *Ottawa Citizen* (Ottawa, Canada, 21 June 1997), pp. A1 and A2; and C. Enman, "DFO Scientists Decry 'Dishonesty'", *Ottawa Citizen* (Ottawa, Canada, Saturday, 5 July 1997), pp. A1 and A2.

bureaucratic influences on scientific endeavour.[173] Although the same accusation might be made of most governments, this example is significant, as the scientists involved were sufficiently concerned to speak out directly and explicitly. The collapse of the Canadian cod fishery raised questions of responsibility, and scientists received an unfair proportion of the blame.

A third type of misuse involves the manipulation of scientific information for policy ends. Worse than disregard of science is the use of scientific information to defend actions taken when in fact the scientific data were ignored and do not support the policy choice. An example was the decision of the International Whaling Commission to continue the moratorium on the whaling of some species, despite scientific data indicating that the species numbers were such that they could withstand regulated culling. "Science" was said to support the moratorium, but it was in fact political and ethical opinions that dictated the outcome, as public pressure is great to save whales.[174]

It seems that the global community is not yet ready to invoke policies on ethical grounds alone, particularly where there are strong objections from a minority, such as Japan and Norway in the case of whaling. More robust justification, such as science, is sought, but it must be sound science and it must truly support the policy. It makes a mockery of science to manipulate scientific information in this way. As effective conservation and protection policies remove species and habitats from scientifically endorsed "endangered" lists and parties seek to exploit the surplus, ethical concerns and intrinsic values of the species or habitats are likely to enter policy debates with increasing frequency. While justifying policies on ethical grounds is perfectly

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[173] Cook, *supra* note 166, p. iii.

[174] For more details, see W. Aron, W. Burke, and M. Freeman, "Flouting the Convention", *Atlantic Monthly*, Vol. 283, No. 5, pp. 22-9 (1999) and W. Aron, W. Burke, and M. Freeman, "The Whaling Issue", 24 *Marine Policy* 179 (2000).

acceptable and rational, in accordance with societal desires, and political objectives (where greater ecological harm will not be incurred), such grounds must be made transparent and science must not be manipulated.

A fourth abuse of scientific information by determiners and enablers involves the misuse of current scientific understanding as an excuse to delay action or agreement, particularly where political, economic, or social issues are in question.[175] An example relates to the lack of an international treaty relating to the disposal of radioactive wastes, despite the state of scientific knowledge regarding radioactive waste being more than adequate to form the basis of an international agreement.[176] It is suggested that actors in the policy-making process have justified policy inaction by misrepresenting the advanced state of scientific understanding, when in fact, the real reasons for inaction are political, social, and other problems associated with such an agreement.[177]

The tragedy with such misuse of science is that the public and other actors, such as international lawyers involved in other issues, most frequently get information from the policy side or hear (wrongly) that scientists cannot agree on the state of scientific information. The actors come to unjustly believe that science and scientists are inept at providing useful information to policy-making processes. This serves to widen the schism between scientists and other actors.

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[175] See Bewers and Garrett, *supra* note 72, p. 123. Also see Sheppard, *supra* note 85 and Sebek, *supra* note 164.

[176] Bewers and Garrett, *ibid.*

[177] *Ibid.*

(h) Lack of Resources for Gathering Baseline Data and Useful Measurements

The lack of relevant and useful data and measurements is a concern for scientists as such information is vital for quality output and it should be a concern for other actors as they seek the best available science. It is frustrating for scientists as more wisely allocated resources could improve the quantity and quality of scientific research. Access to reliable baseline data is a problem for many reasons, although a few are: their collection is seldom seen as a priority for those funding research; data exists, but the quality is questionable; or comparability of data within or across regions is compromised if instruments are not calibrated and measurements are not harmonised.

The calibration is particularly necessary among regional laboratories studying a common sea or other habitat.[178] The regional policy regimes in the North, Baltic, and Mediterranean Seas suffered from the lack of reliable and useful data.[179] Poor data makes for poor policies, and poor policies raise questions of fault when environmental quality objectives are unfulfilled. Unfortunately, the causes are seldom explored and, once again, scientists are blamed without considering the facts.

Scientific illiteracy fosters such assumptions of blame and, in a vicious cycle, these assumptions reinforce the lack of faith in science. Sadly and dangerously, the declining influence of science becomes further entrenched.

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[178] Quality assurance regarding data is seldom addressed. See Funtowicz and Ravetz, 1991, *supra* note 62, pp. 141-3; GESAMP, *Long-term Consequences of Low-level Marine Contamination: An Analytical Approach*, UNEP Regional Reports and Studies No. 18, 1990, pp. 11-12; and Bewers and Wells, *supra* note 142, p. 113. See generally G. Topping, “The Role and Application of Quality Assurance in Marine Environmental Protection”, 25 *Marine Pollution Bulletin* 61 (1992).

[179] Broadus, *et al.*, *supra* note 16, p. 61.

4) Non-science Issues Hindering the Effective Infusion of Science into the Policy-making Process

Contemporary environmental policy-making is largely – and rightfully – a comprehensive, multi-disciplinary, multi-sectoral, value-driven process comprising a diverse complex of actors. The question in a necessarily inclusive process is how to weigh and balance the data, information, interests, and values, and still attain ecologically sound policies. Historically and currently, certain issues (e.g., outsider interests, politics, economics, and public pressure) have overwhelmed the policy-making processes, largely to the exclusion of science.[180] Due to a lack of transparency, non-scientists, and in particularly the public, are largely oblivious to the fact that science is not adequately infused into the process. Although there are many examples of science being lost in the process, a cross-section is provided below.

(a) When Science Lacks Consensus, Outsiders Dominate

The study of systemic risk issues requires time to accumulate data and test models and projections to address scientific uncertainties. Scientific experts engaged in knowledge-building exercises debate existing knowledge, reservations, cause-effect relationships, and trends, and the relevance of existing knowledge to models and projections about future impacts. Any lack of scientific consensus, real or imagined, harms the credibility of sound science and encourages the domination of other interests. One observation has been that where "insiders" (scientists) disagree, "outsiders" come to dominate the environmental agenda, whether they be politicians,

[180] It must be noted here that other disciplines, particularly the social sciences, may have ample grounds for similar arguments. Policy-making processes have traditionally limited participation, and have seen little need to include, or take account of, knowledge from other disciplines, psychological reactions, religious beliefs, cultural factors, or other non-traditional factors.

the public, NGOs, journalists, lawyers, activists, legislators, or policy-makers.[181] "Outsiders" dominate the policy-making process as politicians respond to public pressure, and science is eclipsed at a time when the systemic nature of degradation urgently requires scientific input.[182] Other actors, instead of trying to work with scientists to formulate policies that reflect the level of consensus among peer-reviewed experts (which is often quite high on core issues), often end up ignoring science, selecting opinions that suit their own agenda, or trying to discredit or marginalise science.

(b) Other Actors Dominating the Process

(i) Determiners

Politicians and decision-makers, in particular, eclipse scientists in many ways, some of which have been noted previously. A common scenario is the selection of scientific information to validate leadership positions and respond to political coalitions.[183] For example, politicians determined the definition of "wetlands" in US federal regulation, which resulted in decreasing levels of scientific input into the delineation criteria, the adoption of scientifically unsound criteria that failed to protect wetlands, and unnecessary costs and confusion for landowners and developers.[184]

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[181] Funtowicz and Ravetz, 1991, *supra* note 62, pp. 148-9. Also see Funtowicz and Ravetz, 1994, *supra* note 45 and Sebek, *supra* note 164. See also E.D. Miles, *et al*. (eds.) *Environmental Regime Effectivenss: Confronting Theory with Evidence* (Cambridge, Massachusetts and London: MIT Press, 2002), pp. 469-70.

[182] For example, sovereignty and national issues hamper marine scientific research and the infusion of science, often due to scepticism and suspicion, particularly as between developed and developing states. The long-term benefits of incorporating science are lost where there is no link between scientific knowledge and political power. See R. Winner, "Science, Sovereignty, and the Third Law of the Sea Conference", 4 *Ocean Development and International Law* 297 (1977), p. 299.

[183] Hempel, *supra* note 153, p. 139.

[184] Kusler, *supra* note 119, p. 7. Also see Wright, *supra* note 112, which discusses the political success, but ecological failure, of protective measures in Chesapeake Bay.

Science is often subsumed in the international political arena, as agreements are reached through political bargaining, not scientific reasoning.[185] Many agreements fail to effectively address the ecological problem because sovereignty (i.e., political) issues dominate.[186] Politics affects science input into both international and domestic instruments, as the political will driving the process is directed by public opinion or strong lobbies, which in turn are often emotionally or interest driven.[187] It is increasingly recognised that the greatest barrier to effective environmental management is not the limitations of science or other knowledge, *but failure of political will to formulate effective policies based on that knowledge*.[188]

Even worse are determiners usurping the role of science. An example concerns the US Congress and its decision to support an act to repeal a ban on CFCs, as it concluded that the scientific basis of the ban had been politically distorted.[189] It is noteworthy that the case for the effects of CFCs on the ozone layer was scientifically well founded, convincing, and widely accepted within the scientific community. The sad irony is that the science on which Congress relied was not the peer-reviewed science that was presented to them, but the opinions of a few skeptic scientists.[190] At least one of the skeptics was an eminent and respected scientist with many credentials and accolades, but who was not involved currently in research or the peer-review process, and

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185 This was noted in the 1970's. See Waldichuk, *supra* note 27, p. 286. Unfortunately, the observation remains valid today as the process of negotiation in treaty-making processes involves trade-offs that obscure the scientific positions.

186 See Friedheim, *supra* note 100.

187 R.B. Clark, "Assessing Marine Pollution and Its Remedies", 10 *South African Journal of Marine Science* 341 (1991).

188 See A. Johnels, "Conference on Environmental Research and Management Priorities for the 1980's", 12 *Ambio* 58 (1983), p. 58 and Kimball, *supra* note 65, p. 177. The latter refers to the problem as being a lack of organisation of scientific input into the policy-making process. This problem emanates from political/policy domination and ineffective communication on behalf of scientists.

189 Brown, *supra* note 39, p. 13.

190 *Ibid*.

therefore had little first-hand knowledge of this highly specialised field.[191] This scientist is neither a fringe nor a pseudo-scientist, and his opinion may be proven accurate in time. However, his opinion, being contrary to the mainstream peer-reviewed body of scientific evidence and not grounded in current and focused research, was an unwise choice to adopt as the basis for policy.[192] Had the members of Congress been more scientifically literate, they could have taken steps to confirm the soundness of the science offered, rather than making an uninformed determination and, in essence, usurping the role of science. Further, transparency of process is necessary so that choices can be scrutinised to ensure that they are not made for political or other reasons.

(ii) Economists and Political Scientists (i.e., Investigators)

Environmental decision-making and regulation continues to be dominated by lawyers and economists.[193] Economic factors continue to prevail over ecological considerations, as the worldview continues to be grounded in economic development and the empirical ethos.[194] Traditional economic models are poorly adapted for resolving ecological problems,[195] but there is a move towards "green economics" as economists now are trained to work ecological considerations into economic models and attempt to quantify the economic worth of services provided by natural systems.[196]

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191 *Ibid.*

192 *Ibid.*

193 Stewart, *supra* note 30, p. 10.

194 For concurring opinions, see Waldichuk, *supra* note 27, p. 227; Clark, 1991, *supra* note 187, p. 343; D.A. Caponera, "Towards a New Methodological Approach in Environmental Law", 12 *Natural Resources Journal* 133 (1972), p. 134; C. Ray, "Ecology, Law and the Marine Revolution", in E. Young and Lord Ritchie-Calder (eds.), *Pacem In Maribus*: *The Ocean Environment*, Volume V (Malta: The Royal University of Malta Press, 1971), pp. 99-115; Sebek, *supra* note 164; and Boelens, *supra* note 65.

195 See Stewart, *supra* note 30, pp. 10-11.

196 See R. Costanza, R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O'Neill, J. Paruelo, R.G. Raskin, P. Sutton, and M. van den Belt, "The Value of the World's Ecosystem Services and Natural Capital", 387 *Nature* 253 (1997). Also see J.N. Abramovitz, "Valuing Nature's Services",

A concern is the use of science, by the often well-intentioned actors in these disciplines.

An example is the recent Cambridge University Press publication of *The Skeptical Environmentalist*, by Bjørn Lomborg, a political scientist.[197] His intention is sound: to dispel fear-mongering and scientifically unsound perceptions of environmental issues, and advocate the use of science for knowledgeable decision-making. His method is the analysis of statistics, his field of expertise. Unfortunately, he demonstrates his own lack of scientific understanding of environmental issues, provoking many scientists to disavow it.[198] *Scientific American*, a respected journal, dedicated a section entitled "Misleading Math about the Earth: Science Defends Itself against *The Skeptical Environmentalist*".[199] *Scientific American* sums up the concerns of many scientists as to the use of incomplete data, or a misunderstanding of the underlying science that leads to misinterpretation even where the data it uses are correct and complete.[200] The titles of four essays in this section, contributed by top experts in their respective fields, identify the main problems: "Global Warming: Neglecting the Complexities",[201] "Energy: Asking the Wrong Questions",[202] "Population: Ignoring Its Impact",[203] and

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in L. Starke (ed.), *State of the World 1997: A Worldwatch Institute Report on Progress Toward a Sustainable Society* (London and New York: W.W. Norton & Company, 1997), pp. 95-114.

197 B. Lomborg, *The Skeptical Environmentalist: Measuring the Real State of the World*, (Cambridge University Press: Cambridge, U.K. and New York, 2001). Originally published in Danish as *Verdens Sande Tilstand*, 1998.

198 The book is widely publicised, available through popular retailers, and commands respect merely because of its publisher, Cambridge University Press. Economists and political scientists have endorsed the book for what they (wrongly) perceive to be a balanced perspective. Scientists, who were expected to welcome it, have spoken out against its poor and misleading use of science.

199 See *Scientific American*, Vol. 286, No. 1, pp. 59-69, 2002, which contains an introduction and four essays, *infra* notes 200-204, respectively, which highlight the many mistakes and types of mistakes commonly made by non-scientists.

200 J. Rennie, "Misleading Math about the Earth", *Scientific American*, Vol. 286, No. 1, p. 59 (2002).

201 S. Schneider, "Global Warming: Neglecting the Complexities", *Scientific American*, Vol. 286, No. 1, pp. 60-3, 2002.

202 J.P. Holdren, "Energy: Asking the Wrong Questions", *Scientific American*, Vol. 286, No. 1, pp. 63-5, 2002.

203 J. Bongaarts, "Population: Ignoring Its Impact", *Scientific American*, Vol. 286, No. 1, pp. 65-7, 2002.

"Biodiversity: Dismissing Scientific Process".[204] The depth of misunderstanding discussed by these articles is helpful for non-scientists as Lomborg, despite seemingly good intentions, commits common mistakes made by many non-scientist.

(iii) Lawyers, Judges, and Expert Witnesses

The historical battle of experts played out in courtrooms around the globe is relevant to sound scientific input into legal and policy processes. In the US, from 1923 until recently, the standard for the admissibility of expert opinion regarding scientific evidence in court was the rule in *Frye v United States*.[205] This case established that admissibility hinged on the basic scientific principle in question being generally accepted within the scientific community; but the actual opinion rendered by the expert did not have to be generally accepted within the community, thus allowing for manipulation of science.[206]

This opened the courtrooms to flagrant abuse by parties who often sought experts without appropriate qualifications, or even those regarded as poor or questionable scientists within the scientific community, and left it to the judge or jury, untrained in science, to ascertain the validity of the scientific evidence. This remains a widespread phenomenon, occurring whenever scientific experts testify before decision-makers, congressional hearings, politicians, and other determiners.[207] Such practices undermine the professional integrity of good scientists and support the public

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[204] T. Lovejoy, "Biodiversity: Dismissing Scientific Process", *Scientific American*, Vol. 286, No. 1, pp. 67-9, 2002.

[205] *Frye v United States*, 293 F 1013 (DC Cir 1923).

[206] See S.M. Solomon and E.J. Hackett, "Setting Boundaries Between Science and Law: Lessons Learned from *Daubert v. Merrell Dow Pharmaceuticals, Inc*", 21 *Science, Technology and Human Values* 131 (1996) and L. Loevinger, "Science as Evidence", 35 *Jurimetrics Journal* 153 (1995), p. 156.

[207] See H.A. Latin, "The Significance of Toxic Health Risks: An Essay on Legal Decisionmaking under Uncertainty", 10 *Ecology Law Quarterly* 339 (1982), which describes a poor decision reached by a US court. Also see H.E. Longino, *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry* (Princeton, New Jersey: Princeton University Press, 1990). Also see Brown, *supra* note 39, concerning the US Congress and its misuse of science in determining global climate change policy.

perception of "scientists for hire" –a scientist with a favourable opinion is always available, providing the price is right.

Fortunately, the 1993 US decision of *Daubert v. Merrell Dow Pharmaceuticals, Inc.*[208] has tempered *Frye*. In this landmark decision, the judges, recognising that scientific validity is neither simplistic nor certain, established new standards that include allowing the court to appoint neutral scientific experts to assist judges in the evaluation of the scientific methodology that an expert might have used to determine the validity of the scientific evidence.[209] *Daubert* is a clarion call for judges and lawyers to learn not only the basic principles of science, but also to accommodate scientific uncertainty, become familiar with modern science, and accept only authentic and valid scientific evidence.[210] *Daubert* "may eventually acquire totemic significance".[211]

Incidents of the legal process misusing science are abundant, but the following examples illustrate problems that arise when judicial investigators and lawyers, who most frequently dominate legal processes, are unfamiliar with basic scientific processes and terminology.[212] One such example, the Terania Rainforest Inquiry in Australia outraged scientists, as a retired judge and an ecologically illiterate Queen's Counsel decided ecological issues while the evidence of a world-renowned scientific authority on rainforests received little merit because his necessarily qualified answers

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208 *Daubert v. Merrell Dow Pharmaceuticals, Inc*., 113 S Ct 2786 (1993).

209 See Solomon and Hackett *supra* note 206 and Loevinger, *supra* note 206. Both articles discuss the abuses of science within the court process and how *Daubert* is a first step to rectifying this.

210 Loevinger, *ibid.*, pp. 178-81 and 189-90.

211 *Ibid*., at p. 178.

212 Loevinger has written much on this topic, from as early as 1966 to the present. Also see L. Loevinger, "Law and Science as Rival Systems", 8 *Jurimetrics Journal* 63 (1966); L. Loevinger, "Science, Technology and Law in Modern Society", 26 *Jurimetrics Journal* 1 (1985); and L. Loevinger, "Standards of Proof in Law and Science", 32 *Jurimetrics Journal* 323 (1992). Over a thirty-year period, the same concerns regarding the interface of science and law are identified, suggesting that progress is slow in both educating non-scientists and infusing effective science into the policy-making process.

were manipulated and interpreted to be inconsistent and contradictory.[213] In another example, the chairman of the Environmental Assessment Board of Canada concluded that the judicial system, composed of neither scientists nor technocrats, was more suited than boards of scientists and experts to determine fair and impartial resolutions to applications, as scientists were often biased.[214] Legal personalities will always dominate court proceedings, and so they should, but what needs to be asked is what duty do they owe the parties involved, and the system, regarding scientific literacy and the need to use impartial, sound science.

Regarding examples of courts misusing science, in *Industrial Union Department, AFL-CIO v American Petroleum Institute*[215] the US Supreme Court, misunderstanding scientific uncertainty, invalidated an Occupational Safety and Health Administration regulation protecting workers from exposure to benzene. Not only did they fail to take notice of the intent of the regulation, they also committed two scientific misinterpretations that may have long-term implications for workers and for other judicial proceedings involving scientific standards.[216] It must be remembered that the legal system is established largely as an adversarial system, limited to resolving issues as presented by the parties to the action. Its very nature endorses "an ascientific commitment to victory, rather than truth".[217]

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[213] Stewart, *supra* note 30, pp. 12-13. This is an excellent article, containing cross-references to other articles on the misuse of science in legal processes.

[214] M.I. Jeffery, "Appropriateness of Judicial and Non-judicial Determination of Environmental Issues", 5 *Environmental Planning Law Journal* 265 (1988). This article is cited and discussed in Stewart, *ibid.*, p. 13.

[215] *Industrial Union Department, AFL-CIO v American Petroleum Institute,* 448 US 607 (1980).

[216] Latin, *supra* note 207, p. 394.

[217] K.R. Hammond and L. Adelman, "Science, Values, and Human Judgement", 17 *Jurimetrics Journal* 253 (1977), at p. 269.

(iv) The Media, the Public, and Ethicists: Misdirected Public Pressure

As influencers, the public's scientific (mis)perceptions have a direct impact on policy-making.[218] Public opinion should influence policy-decisions, but such opinion must be scientifically informed to prevent the waste of economic and ecological resources, and accordingly, enable the policy options to meet the policy objectives. More importantly, ecological priorities are often overlooked in favour of the public's perception of priorities.[219] Two examples are the public focus on heavy metals, radionuclides, and oil, in contrast with scientifically established ecological priorities of sewage, nutrients and synthetic organics (POPs) and black lists (lists of banned substances) that contain items that are present due to public pressure, contrary to the results of stringent scientific testing.[220]

Many people base their view of reality and the world in general on what they gather from the media. This is true even for some policy-makers. For this reason, unbalanced reporting on environmental issues is detrimental to long-term ecological integrity, as it leads the public to formulate unbalanced opinions and to influence determiners to further the adoption of those opinions.[221] Studies have shown that many media reports are based on assumed harm, with less than half of reporters relying on science,[222] and that journalists often convey a perspective that differs from scientific

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218 Caldwell, *supra* note 79, p. 13; H. Kunreuther and P. Slovic, "Science, Values, and Risk", 545 *The Annals of the American Academy of Political and Social Science* 116 (1996), p. 117; Clark, *supra* note 187, p. 343; Caponera, *supra* note 194, pp. 148-50; Stewart, *supra* note 30, p. 16; Funtowicz and Ravetz, 1991, *supra* note 62, p. 149; and H.L. Windom, "Contamination of the Marine Environment from Land-based Sources", 25 *Marine Pollution Bulletin*: 32 (1992).

219 See Bewers, 1995, *supra* note 8, p. 18. Also see Sebek, *supra* note 164 and W.F. Allman, "Staying Alive in the 20th Century", *Science 85*, Vol. 6, No. 8, pp. 31-7 (1985).

220 Bewers, *ibid*., p. 10.

221 See Lee, *supra* note 15, p. 93.

222 Wildavsky, *supra* note 36, p. 390. Also see H.A. Cohl, *Are We Scaring Ourselves to Death?: How Pessimism, Paranoia, and a Misguided Media are Leading Us Toward Disaster* (New York: St. Martin's Griffin Press, 1997); L. Margulis and D. Sagan, *Slanted Truths: Essays on Gaia, Symbiosis, and Evolution* (New York:

opinions.[223] To sell news, the media often employ "scare words",[224] and seek controversial opinions from scientists who may not be experts, leaving the public fearful and confused, or with an incorrect or partial perspective on an issue.[225]

The media both help and harm the scientific cause. On the one hand, they reach the masses and have the potential to inform an interested and educated public, explain environmental complexities, and utilise opinions from experts in the field. However, the media's predominant focus on catastrophic events and fear-inspiring contaminants engrosses the public for the short-term, and encourages an attention span that, with respect to ecological issues, is limited to the period in which a given topic is newsworthy.[226]

An observation is that fringe scientists are more often willing to interact with the media than are mainstream experts, the latter being busily engaged in research, more circumspect in their comments, or generally more media-shy. The media fails in its public service to discern reliable experts and sound scientific opinion from impostors, expound on issues such as scientific reservations and uncertainty, and dispel confusion by explaining divergent opinions. The media and environmental ethicists often seem to have a natural affinity that spawns unsound reporting, as NGOs seek publicity through the media, but their opinions, often reported as scientific, may not be grounded in objective scientific opinion. Two points need to be made. First, as noted previously, more decisions may be made on ethical and social grounds; for example, as

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Copernicus/Springer-Verlag New York, Inc., 1997); and M. Allaby, *Facing the Future: The Case for Science* (London: Bloomsbury, 1995, 1996).

223 Wildavsky, *ibid*., pp. 372-4.

224 Ray and Guzzo, *supra* note 129, p. 183.

225 See Cohl, *supra* note 222, p. 149; Wildavsky, *supra* note 36, p. 384; and Clark, 1991, *supra* note 187, p. 344.

226 Lee, *supra* note 15, p. 93.

the public seeks protection of species and habitats for their intrinsic value and ecological issues become increasingly intertwined with social issues. Thus, ethicists and other influencers must have open access to the media to have their opinions expressed, providing commentary is presented as opinion and not as science. Second, some NGO's and industry have their own laboratories with peer-reviewed scientists, and these scientists' opinions must be distinguished as emanating from a scientific investigator and not merely opinion from influencers.

The media further undermines science by publishing research results prior to the conclusion of the messy, but essential, process of peer review. Instead of helping the public become informed, such reporting may evoke unfounded fear or complacency. More often than not, it confuses the public and deepens distrust of science, as debate among scientists is perceived as incompetence rather than as constituting a part of a process necessary to reach consensus. Increased scientific literacy among non-scientists would allow the media to present the information as early in the peer-review process and the public could follow its path to acceptance (or rejection) within the scientific community.

5) Mindset Contributing to Unsound Policies

The mindset of the actors greatly affects the type of policies favoured and their perspective on policy-making processes, including expectations for effectiveness. The mindset affects the use, or misuse, of science, particularly as the contemporary mindset continues to have a bias against science, but an inclination towards an environmental ethic. Mindset underlies thinking processes, and its influence is seldom contemplated. Noted below are a few examples of conduct or belief that is unquestioned and arises from the current mindset that neglects science in policy-making processes.

(a) Fixation with Technological Solutions

It has been stated that humans accept only policies that they know will not work.[227] Although this is an exaggeration, the point is that many policies are technologically focused, blindly utilising available technology rather than assessing whether the technology offers adequate or excessive ecological protection, or whether there are other options, such as behavioural adjustments, that may work better.[228] The mindset that focuses on technological fixes to the exclusion of other options lacks comprehensive understanding of the issue, including natural and social sciences and the ability of science to inform policy and fails to appreciate the cause of the problem, human behaviour.

(b) Asking the Wrong Questions

Actors often thwart the effective management of activities affecting health and environment, and misuse or under-utilise science in the process, simply by asking – and thus seeking answers to – the wrong questions.[229] For example, the appropriate focus for questions about systemic degradation issues is not whether the activity or compound is harmful in itself, but what is the associated *risk* of harm. For example, where actors look for *pollution*, scientists seek to identify and reasonably quantify *risk posed by contaminants*. Asking the wrong questions may engender unreasonable expectations or mandate inappropriate scientific enquiry;[230] or lead to the failure to discern scientific reservations, establish the degree of scientific uncertainty, or canvass

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[227] See Editorial, *supra* note 125.

[228] *Ibid.* Also see Kates, *supra* note 150.

[229] A.C. Flournoy, "Legislating Inaction: Asking the Wrong Questions in Protective Environmental Decisionmaking", 15 *Harvard Environmental Law Review* 327 (1991).

[230] See Ruckelshaus, 1985, *supra* note 37.

sound options for proceeding.[231] Inadvertently asking the wrong question is very common, given the complexity of contemporary environmental issues and lack of scientific literacy among actors.[232] Actors who advocate ecosystemic management may be particularly prone to this, as they have a broad concept of ecological inter-linkages, but lack critical understanding of the underlying science.

(c) Misperceiving Their Own Lack of Understanding

Many environmental and health decisions now rely on science, but the actors involved fail to grasp that they do not understand the science; worse, they often understand just enough to feel (falsely) confident. Unsound policy may ensue. Dubbed the "worst example of how disregard of an intrinsic limit of science can lead to bad policy by overenthusiastic politicians",[233] the 1958 Delaney clause in the US Federal Food, Drug, and Cosmetic Act prohibits the use of any food additive that has induced cancer in humans and animals in the laboratory.[234] This is overly cautious, as humans would have to ingest kilograms of most additives to arrive at doses equivalent to those used in most laboratory tests performed on animals.[235] The dose-response relationship is ignored, as there is no specific evidence that low doses of many food additives are harmful. Contemporary examples, driven by a pro-ecology mindset and good intentions, include the zero-discharge policy and the reverse onus clause.[236] As discussed previously, these are, most often, scientifically unjustified and impossible to

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231 Flournoy, *supra* note 229.

232 See Holdren, *supra* note 202 and Flourney, *ibid*.

233 Weinberg, *supra* note 23, at p. 66.

234 *Ibid*. and Wildavsky, *supra* note 36, pp. 8, 12, 33-5, 237, 240-1, 248-52, 270-1, and 421-2.

235 Weinberg, *ibid.*, p. 66 and Wildavsky, *ibid.*, pp. 33-5 and 421-2.

236 See Stebbings, *supra* note 26 and Gray, 1996, *supra* note 8. It is an axiom of science that a substance cannot be proved harmless.

enforce. Actors need to know enough to ask the right questions and to understand the answers.

(d) Chaotic and Slow Response to Science

A great frustration with the policy-making process is the vast time lag between scientific warnings and policy response, even where a high degree of consensus exists among scientific experts.[237] The policy response is often chaotic and uncoordinated, resulting in ecological compromise. An example of a slow and chaotic policy response to scientific warnings involves organohalogens (a class of POPs), which as a class of contaminants affect marine and terrestrial biota. Determiners responded to individual substances such as DDT or PCBs, neglecting to systematically deal with whole classes of chemicals.[238] In the case of DDT, the response time was more than 20 years, similar to the response time with mercury poisoning in the Minamata incident.[239] Even with CFCs and their role in ozone depletion, it took 15 years from initial scientific warnings to attract international legal attention.[240] The truth is that scientists are seldom heeded when they sound alarms.

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[237] Lutter, *supra* note 102, p. 547. Also see Caldwell, *supra* note 79, p. 27 and D.L. VanderZwaag, *Canada and Marine Environmental Protection: Charting a Legal Course Towards Sustainable Development* (London, The Hague, Boston: Kluwer Law International, 1995), p. 40. A political scientist and an environmental lawyer, respectively, both lament the slow pace of policy and legal development compared to the rate of development of ecological issues and scientific knowledge regarding those issues. The WCED, *supra* note 102, p. 330 also highlights this problem.

[238] Lutter, *ibid.*, pp. 547-8. This article suggests dealing with the problem at the source, i.e., chlorine production. Again, caution and clarity is required as not all chlorine products are harmful.

[239] E.D. Goldberg, "Our Oceans as Waste Space: The Argument", *Oceanus*, Vol. 24, No. 1, pp. 2-9 (1981), p. 7. Goldberg's thesis in this paper is that humans should use the absorptive capacity of the oceans and not ascribe unbalanced protection to them as compared to other components of the ecosphere. This remains a valid argument.

[240] J.B. Skjærseth, "The 'Successful' Ozone-layer Negotiations", 2 *Global Environmental Change* 292 (1992), p. 295. He notes that it took this long as inaction prevailed until the scientists could provide certainty of evidence for legal guidance, which was the banning of CFCs. Fear then became a motivating factor for the quick international legal action.

Traditionally, determiners and enablers have adopted a "wait and see" attitude to justify political inaction when a knowledge gap is encountered.[241] Waiting allows the problem to progress to levels that can become costly to resolve or result in irreparable harm. Law may lose the capability to shape events if it awaits scientific or ecological developments to completely fill in such a knowledge gap.[242] The precautionary concept, which advocates action prior to definitive scientific evidence, counters this mindset. Paradoxically, both mindsets have a bias against scientific inclusion. The result in both cases is often that the content and logic of law and policy are often inconsistent with current scientific principles and knowledge.[243]

(e) Inflexibility

Related to time lag is the inflexibility of the legal and policy system, and the related difficulties, in adjusting legally enforceable environmental quality standards or discharge limits. Experience suggests that, once set, policies that are too stringent, too lax, or are being applied inappropriately are unlikely to be changed even where clear scientific evidence indicates need for adjustment.[244] The mindset is such that, once policies are established, there is little need to revisit them. This mindset is largely successful in other legal disciplines, but is dangerous in systemic degradation issues where the original science, if considered, was incomplete and new science emerges continually.[245]

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241 Sebek, *supra* note 164, pp. 118-9.

242 Ray, *supra* note 194, p. 110.

243 Caldwell, *supra* note 79, p. 27.

244 Chapman, *supra* note 61, p. 227. Also see Hall, *et al.*, *supra* note 96.

245 Milne, *supra* note 25, pp. 35-6.

(f) Lack of Scientific Assessment of Policy Options

It is easy to imagine that a reasonable person, recognising scientists as the interpreters of nature, would assume that policy decisions and management options regarding the environment would be assessed for ecological soundness. In reality, scientists traditionally have had only peripheral involvement, and they are seldom engaged to assess options.[246] Considering that the mindset is evolving to embrace systemic environmental management, it is disheartening that scientists, who have so much to offer and whose involvement is so critical, are the one group of actors that have a declining influence on policy.

D. Insights from the Use of Science in Policy-making Processes

This chronicle of the under-utilisation of natural science offers several insights. First, it highlights that past policy failures and the current state of the ecosphere have little to do with inadequacies in natural scientific knowledge. The focus for resolution is not science, but scientific illiteracy among non-scientific actors that leads to the failure to discern sound science and good scientists from poor and, equally important, the application of poor science or, worse, no science. Non-scientific actors have been shown to have little critical understanding of science processes, ecology, and ecospheric-sociological inter-relationships. Second, it illustrates that the proper utilisation of sound science is necessary for effective environmental policy. Philosophically sound legal principles, rules, and policy will founder if grounded in poor science. The real cost of ineffective policy are continuing ecospheric degradation or unsound economic investment, both of which have repercussions for the general public. Third, there are many opportunities for science to be under-utilised and

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[246] Mee, *supra* note 24, p. 110.

misused, both innocently and intentionally, with only a sample discussed in this chapter. This suggests the need for rigorous analysis of policy-making processes to ensure transparency, sound input from all scientific disciplines (natural and social), policy objectives are met, and the actors are contributing within their role and not usurping other roles (beware of influencers usurping the role of investigators). Drawing on these lessons, actors may revise their mindsets to seek ecologically and economically sound policies through the rational integration of good science into policy-making processes.

E. Summary

Sailors have lived and died by the adage, "red sky in the morning, a sailor's warning", largely according to their ability to interpret nature's warning. "Old salts" survive by having a critical understanding of the factors that affect their options. They have to rationally think, plan, and prepare so they can react quickly and effectively to changes. It is hoped that by understanding the varied and many ways in which policy can be scientifically (and economically) unsound, more determiners and enablers will become "old salts" who will utilise science to strengthen their vessel – the policy-making process –to ensure that policies are sufficiently sound to weather the inevitable "stormy seas" of degradation from land-based activities.

Chapter 5

Red Sky at Night: Prospects for Consilience of Law and Science for Effective Policy-making

Part I Introduction

A. Red Sky at Night

"Red sky at night, sailors' delight." Seafarers over the centuries have trusted a ruddy sunset as nature's forecast for fair seas and fine sailing. MDLBA policy-making is in a phase of metaphorical red skies that hold promise for an effective regime as the pieces of information are present and available, but require processes and mechanisms to bring them together in a coherent and useful way. "Consilience" offers such a means of co-ordination to facilitate integration of the requisite information and the potential to chart a truly sustainable course.

There has been a general move, pursuant to the legal principle of integration, towards "consilience" as policy-making accommodates more actors from diverse disciplines and more information from the natural and social sciences is available to inform policy. The current process of integration is gaining momentum at all levels of policy-making, but it lacks direction as actors incorporate parcels of information from various disciplines on a rather *ad hoc*, or chaotic, basis, and as noted frequently without a full appreciation of the information or the issue to which it is applied. To this end, "consilience" embodies integration at all levels, but particularly at the most basic level, which is the integration of all knowledge and information necessary for critical understanding on which to build an effective environmental regime. “Consilience” is conceptually useful as it reminds actors that they must sufficiently understand the many facets of an issue to resolve it.

B. Winds of Change

Although “consilience” is the unity of all relevant knowledge from many disciplines and domains, the previous chapters have highlighted one facet of consilience that is critical to the effectiveness of environmental policy. This is the transparent and effective infusion of sound natural science into the MDLBA policy-making process, in conjunction with increased scientific literacy. Scientific assessment can provide the rational basis against which all other factors can be effectively assessed, and policy decisions must be grounded in sound science, whether or not they are ultimately taken for ethical, economic or political reasons.

This chapter looks at methods and intervention points for fundamental and philosophical changes necessary to combat misperceptions and dispel widespread mistrust of science, and the unsound policy choices that result, as discussed in previous chapters. Part II, “Crewing the Vessel”, discusses ways to increase non-scientists’ appreciation of the need for scientific and ecological literacy (“eco-literacy”). This is addressed through: (a) education, and (b) improving confidence in science and scientists. Part III, “Sailing on Open Water”, prescribes a role for science, suggests institutional changes to embrace sound science, and, most importantly, proposes a new ethic and mindset that not only incorporates the best available scientific evidence, but also encourages transparency, flexibility, and understanding.

Part IV, “Becoming Master Mariners” proposes two strategies to encourage determiners and enablers, the captains of the policy vessel, to move towards “consilience” of law and science. The first is the practical strategy of a study, which could be undertaken by GESAMP, to determine the informational requirements for scientific understanding among actors involved in the management of MDLBA and to propose a framework for a scientific literacy programme. The second strategy relates to recent evidence confirming ineffectiveness of regimes to solve environmental problems, despite positive behavioural changes in actors. Suggested is a diplomatic strategy to encourage critical understanding of the factors, many of which are non-legal, that contribute to or influence regime (and policy) effectiveness.

Part II Crewing the Vessel

Seafarers require unique and diverse knowledge, as they must be both specialists and generalists, with the ability to operate, often spontaneously and creatively, in the isolation of a vessel upon a capricious sea. Like sailors, actors in the MDLBA policy-making process must learn to trust and respect their "shipmates", and one another's specialised knowledge, in order to anticipate and manage the scientific and socio-economic outcome of human actions on the ecosphere. A knowledgeable and cohesive crew pulling together often determines a vessel's survival in unpredictable conditions.

As previously discussed, the policy-making vessel is currently traversing rocky shoals. Most actors, lacking scientific and ecological knowledge, cannot set effective bearings due to confusion as to which scientists and what science to believe, or they are influenced by other factors to the exclusion or marginalisation of science. Policy-makers need to crew the policy-vessel with all relevant disciplines, each member well trained in a particular area of expertise *and* versed in the rudiments of science (and other disciplines) and open to consulting scientists. Why science? Understanding science, including ecology, is as much the key to long-term survival as an understanding of the geophysics of wind and waves is to seafarers' survival.

A. Swabbing the Decks: Education for Scientific Literacy

Swabbing a vessel's decks is necessary, but it is seldom a sailor's favourite task. Similarly, becoming science literate holds little immediate appeal for non-scientists, but greater understanding can dispel complacency and generate the will, and commitment, to change.[1]

Actors in the MDLBA policy-making process are locked, for the most part, in a cycle of uninformed policy-making. Most actors have emerged scientifically illiterate from schools and tertiary educational institutions, as few institutions require that students have even minimal scientific exposure.[2] Although in recent years environmental issues have entered educational curricula, the focus is primarily on sociological aspects, based on information most frequently provided by environmental NGOs. While NGOs have a valid role to play as influencers and educators, they often have a bias, as is reasonable given their role as advocates of environmental interests.[3] They do not always provide a balanced view or a scientific basis for validating the state of knowledge and explaining scientific concerns and uncertainties.[4] Thus continues the science-deficient cycle and the confusion with conflicting science from other sources, some of which are not science at all, as discussed. Students graduate and become actors in the MDLBA policy-making process as taxpayers, community members, or key actors. In the media, journalists from the same education system report events

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1 One of the major constraints to attaining scientific literacy, and hence the "consilience" of science and policy is the lack of motivation to change.

2 See D.W. Orr, *Ecological Literacy: Education and the Transition to a Postmodern World* (New York: State University of New York Press, 1992), pp. *x-xii*.

3 Regarding their role, see M.J. Peterson, "International Organizations and the Implementation of Environmental Regimes", in O.R. Young (ed.), *Global Governance: Drawing Insights from the Environmental Experience* (Cambridge, Massachusetts and London, England: The MIT Press, 1997), pp. 115-51.

4 For a discussion of environmental education in the US, see D.L. Ray and L.R. Guzzo, *Environmental Overkill: Whatever Happened to Common Sense?* (New York: HarperPerennial, 1993), pp. 172-3.

without due regard to their role as educators or influencers.[5] In turn, the general public, largely uninformed, emotionally driven, eco-illiterate, and spurred on by the media, influence policy choices and decisions.[6] Policy-makers make decisions from an ill-informed position, given their own education and the influence exerted by uninformed and fearful citizens, powerful lobbies, and other influencers.

The intervention point to convert this cycle to a rational policy-making process is scientific education at all levels of society, particularly targeting school children, but also offering educational opportunities to, first, the key actors and, second, the general public. Scientific education, encompassing ecology, helps to change perceptions and behaviour and provides awareness, knowledge, and skills for living within the laws of nature.[7] Ecological degradation issues require broad knowledge input, as a lack of insight today has the potential to exact a high toll in the future. With the transition from classical pollution to the latent issues of risk management today, actors must be educated and intellectually prepared to function effectively in an anticipatory and adaptive policy-making process. Although knowledge from humanities and arts must be incorporated, the fundamental knowledge base for environmental policy-making lies in the sciences. Education is required to attain the following social goals:

(i) ecological literacy – the understanding of ecology, ecospheric inter-linkages, and the relationship between human activities and the physical environment;

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[5] L.S. Susskind, *Environmental Diplomacy: Negotiating More Effective Global Agreements* (New York, Oxford: Oxford University Press), 1994, p. 136.

[6] Ray and Guzzo, *supra* note 4, pp. 171-87. The authors provide examples of policies that have been driven by emotional public opinion, and not sound science. A few noted are: electromagnetic fields, chlorine, asbestos, lead poisoning, population growth, and cancer scares related to POPs.

[7] E.W. Weidner, "Educational Aspects of Environmental Issues", 2 *International Journal of Environmental Studies* 301 (1972), p. 108. For a discussion on the need for behavioural fixes in addition to technological fixes, see R.W. Kates, "Success, Strain, and Surprise", 2 *Issues in Science and Technology* 46 (1985-86).

(ii) scientific literacy – the understanding of science and scientists' mode of operation in interpreting the physical environment and the way users of science understand scientific information; and

(iii) knowledge-based determinations – understanding the respective roles of hazard assessment, risk assessment, and risk management, and the interplay of expert knowledge with societal responsibilities.

1) Ecological Literacy

Eco-literacy entails an understanding of the rudiments of ecology.[8] It does not require detailed or expert knowledge of ecology, but, at the very least, an intellectual appreciation of basic ecological terminology, types of habitats, and inter-linkages between and among habitats and species. Understanding at least five of the basic principles of ecological organisation, discussed below, can help to put scientific opinion in context.[9]

The first principle, *inter-dependence*, requires understanding life as a network of multiple and intricate non-linear relationships,[10] in which the behaviour of an organism depends on the behaviour of many others, and the success of the community of mixed species depends on the success of its individual members.[11] Most significantly, for actors, it means appreciating that any given disturbance may manifest itself in a non-linear spreading pattern, with the original disturbance often masked by the complexity

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8 For a basic understanding, see GESAMP, *Protecting the Oceans from Land-based Activities: Land-based Sources and Activities Affecting the Quality and Uses of the Marine, Coastal and Associated Freshwater Environment*, GESAMP Reports and Studies No. 71, 2001b and E.P. Odum, *Ecology and Our Endangered Life-support System*, 2nd ed. (Sunderland, Massachusetts: Sinauer Associates, Inc., 1993).

9 F. Capra, *The Web of Life: A New Scientific Understanding of Living Systems* (New York: Anchor Books, Doubleday, 1996), pp. 298-304. Capra, a physicist, has written extensively on the philosophical implications of science for modern life. He advocates the adoption of the five ecological principles of organisation by humans for a sustainable future.

10 *Ibid.*, p. 298.

11 *Ibid.*

of interactions and reactions.[12] Linear thinking – that cause A results in effect B – is overly simplistic. A shift is required to thinking in terms of relationships. Two examples of the need for relationship thinking are the unanticipated effects of DDT sprayed on crops (the effect is eggshell thinning in fish-eating birds species) and volatile freons on the stratospheric ozone balance (the effect is ozone depletion).[13] Relationship thinking would help determiners and enablers to anticipate links between seemingly unrelated issues, such as deforestation and distant commercial fish species.[14]

The second principle is the *cyclic flow, or recycling, of resources and energy* through the ecosystem.[15] Water, nutrients, air, and waste products (waste of one species is utilised by another) are perpetually recycled,[16] involving processes such as feedback loops and biochemical and geo-physical mechanisms that help maintain ecosystem equilibrium.

The third principle, *partnership*, is based on co-operation and co-dependencies among organisms to ensure efficient use of resources and species survival. For example, vultures and hyenas scavenge the carcass of a lion's kill, benefiting from the lion's expenditure of energy.[17] In natural systems, there are no leftovers. Through inter-linkages and co-reliance on food resources, organisms develop niche specialisation that

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[12] *Ibid*., p. 299.

[13] Both of these cases, for example, demonstrate that thinking beyond the expected pathways and targets is required. These situations are proof that more science is required, and not less, to allow scientists to learn from accumulated data and design comprehensive research programmes in order to inform policy.

[14] Often when scientists understand and can predict effects, other actors fail to heed the scientific warnings or advice, as they do not see the "big picture" of inter-connections or understand the advice.

[15] See Capra, *supra* note 9, pp. 299-300.

[16] For example, the air molecules inhaled today are the same as those once inhaled by dinosaurs, Egyptian pharaohs, and Roman emperors.

[17] See Capra, *supra* note 9, pp. 299-301 for a discussion on partnership and co-operation.

fosters co-habitation and directs competition.[18] Such partnerships ensure each organism has a role and an interest in maintaining the overall health of the community.

As ecosystems are fluctuating, dynamic networks of energy and resource flow, the fourth principle concerns ecosystem *flexibility* required to maintain a sustainable equilibrium.[19] Flexibility is the ability of communities to adapt to changes and stresses, whether natural or human-induced, via feedback loops.[20] Two examples from Australia of systems out of equilibrium due to lack of a feedback mechanism (predators in this case) are the explosive growth of rabbit populations and crown of thorn starfish, which destroy coral.[21] An ecosystem will collapse when fluctuations or stresses exceed tolerance limits, and higher tolerance is characteristic of dynamic, biologically diversified, and healthy habitats.

This leads to the fifth principle, *biological diversity* (biodiversity). Biodiversity builds options into a system for maintaining equilibrium and keeping fluctuations within tolerance limits.[22] The greater the biodiversity, the greater the resilience of a system, as the greater number of species allows for more overlapping ecological functions among species; which in turn allows the role of a destroyed species to be partially

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[18] For example, wetland bird species have evolved leg length and beak shape so as to feed at different water depths to maximise available resources and reduce inter-species competition.

[19] Capra, *supra* note 9, p. 302.

[20] *Ibid*.

[21] Usually, via feedback mechanisms, excessive prey populations would decline in response to increasing numbers of predators (due to abundant prey) feeding on them, and in turn, the decline in prey would check the growth in predators. In Australia, lack of predators, combined with abundant food supplies, allowed the alien species to multiply. It is interesting to note that the introduction of alien species is of sufficient concern that GESAMP included it in their recent study of *Protecting the Oceans from Land-based Activities, supra* note 8, pp. 33-5. Alien species have not traditionally been within the rubric of LBA.

[22] Capra, *supra* note 9, p. 303. Biological diversity is discussed in Chapter 1, herein.

fulfilled by another, thus permitting reorganisation of the network structure for continued sustainability.[23]

Revision of the education and training of actors to include the rudiments of ecological organisation should be a priority to ensure at least a minimal level of eco-literacy – at least enough to recognise the need to consult scientists for advice. Eco-literacy allows actors to understand scientific advise, identify priority issues, and consequently seek wise allocation of human and financial resources, rather than have actors commit scarce resources to issues driven only by public concern, or worse, fear.

2) Scientific Literacy

Scientific literacy by definition includes eco-literacy, given ecology's home within the natural sciences. Eco-literacy was discussed separately to stress its importance for non-scientific actors. Scientific literacy is much broader, comprising at least two educational areas. First, the wide range of scientists, from physics, chemistry, biology and mathematics,[24] who investigate the natural world and human impact on it, must be appreciated not only to garner an understanding of the diverse expertise required to fathom the natural world, but also to provide insight as to whose participation may be required for policy-making processes. Second, it is important to understand how scientists and science operate, and the relevance of scientific methodology (including peer-review processes, scientific uncertainty, statistical power analysis, inherent limitations, and other aspects of scientific endeavour, including the concepts and

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23 *Ibid*.

24 Appreciating the range of scientific disciplines, i.e., biochemists, geo-physicists, molecular biologists, molecular physicists, marine biologists, meteorologists, terrestrial ecologists, marine ecologists, physical oceanographer, and chemical oceanographer (to name a few only), helps put scientific advice in perspective. On complex issues, the number of scientists qualified to give specific and sound advice may in fact be quite limited.

assessments of hazard and risk.[25] As with eco-literacy, the objective is to provide the basics necessary to comprehend the issues and communicate effectively with scientists.

The aim of scientific literacy is to generate sophisticated and informed *users* of science who can ask relevant questions and avoid the pitfalls that have led to unsound policy.[26] Actors, the users of science, must also determine whether the science used is sound. To this end, actors should explore three key questions when communicating with scientists or reading scientific reports: (1) "Who is saying it?" (2) "Where (or why) is it being said?"; and (3) "What is the scientist saying about the issue?". When exploring these questions, there is some overlap among the sub-questions as, for instance, publication in peer-reviewed journals relates to the credibility of the scientist and the soundness of the information.

With respect to question 1, in establishing whether the individual is a credible scientist regarding the issue at hand and to ensure that the best science available is applied in the policy-making process, actors need to ask the following questions about the person or persons who are presenting the scientific knowledge.

a) *Is the provider of information a scientist?* Is the individual a scientist, or a planner, manager, or other actor with some scientific knowledge, or is he posing as a scientist?

b) *Is the appropriate expert providing the scientific information?* Is the scientist an expert in the area, an expert in another area, or a respected scientist whose research may be significantly outdated?

c) *Is the scientific information merely an opinion, or is the information based on*

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25 These concepts are just a few from the wide range of topics necessary for actors, not to become scientists, but to understand and appreciate issues and scientific needs and limitations.

26 Sophisticated users of science is a term defined and used by Faigman, *infra* note 31.

research? Mere opinion from a scientist who has no research experience on a given issue may be no more relevant than that of a layman.

d) *Is the scientist a skeptic/contrarian?* Is the research peer-reviewed, and is the scientist considered by peers to be an expert in the area? If the rigorous scientific methodology of peer review supports the view of a skeptic scientist, the latter should be given some weight. However, policies should not be determined solely on the research of a skeptic, particularly where it contradicts or conflicts with a persuasive body of mainstream science.

e) *Is the scientific opinion peer-reviewed?* Peer review provides quality assurance for actors.

f) *Is it pseudo-scientific research?* Merely sounding scientific is not sufficient evidence of sound science.

g) *Is the scientific advice/report influenced by bias, and how should such bias be accommodated?*[27] Research is not necessarily tainted because it is industry-, NGO-, or government-funded. Peer review of the scientific method employed can allay most concerns of bias, and circumspect questions by sophisticated users of science can help detect bias.

h) *Is there motivation other than providing scientific information, or a hidden agenda?* This is related to bias, but as scientists are only human or perhaps their employers dictate what is said, it is wise to contemplate the possibility of hidden agendas.

i) *Is the scientist providing sound scientific knowledge in the degree of detail and*

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[27] For recommendations for protecting scientific advice from bias, particularly in the international arena, see L.A. Kimball, *Treaty Implementation: Scientific and Technical Advice Enters A New Stage*, Studies in Transnational Legal Policy No. 28 (Washington, D.C.: The American Society of International Law, 1996), pp. 139-148.

with the clarity that is required for policy-making purposes? Does the actor need to ask more questions?

Regarding question 2, where (or why) the opinion or knowledge is stated, questions should include:

a) *Is it from a peer-reviewed scientific journal?*

b) *Is it from a scientific report?* If so, is the report peer-reviewed?

c) *Is it from a publication sponsored or funded by and influencer?* Influencers can be expected to have a biased view.

d) *If from a publication/report, is it the work of a body of scientists (some evidence of consensus) or a lone scientist?* Was the work undertaken by a reputable scientific institution? Is it consistent with mainstream scientific opinion?

e) *Was it drawn from a magazine article, conversation, or other source?* Is it being given proper weight, considering the source?

Regarding question 3, as to what the scientist is saying about the issue, actors should ask at least the following questions:

a) *Was the scientific method rigorously applied?* Although actors need not, and likely should not, become the judges of what is good science, they can ask probing questions, such as adequacy of the sample size, statistical power analysis (type I and type II errors), adequacy of the range of targeted species, or consideration of all pathways; seek confirmation from other scientists; or follow scientific debate on issues. Good scientific methods equate with quality knowledge, and an accurate assessment of uncertainty and other limitations. Poor methods produce unreliable science.

b) *What do the numbers (statistics) really mean?* What is the probability of a false positive or a false negative? By definition, statistics indicate the *probability*, not certainty, of an event occurring under the given conditions.

c) *What scientific reservations and limitations are expressed by the scientist?* Are there reservations in the main report that are not reiterated in the executive summary?

d) *Is the scientific uncertainty fully detailed by the scientist?* What is the degree and type of scientific uncertainty?

e) *What are the known unknowns?* Are the qualifications/reservations explicitly stated, and can scientists somehow reduce the known unknowns given the state of scientific knowledge on the issue?

f) *What is the probability of unknown unknowns, and can the probability be minimised?* The probability of an unexpected impact increases with spatial, temporal, biochemical, and geo-physical complexity, particularly where numerous factors intersect to create interactions, which can increase uncertainty.

g) *What scientific uncertainties can be reduced? At what cost? And is the investment scientifically and socially warranted?* Science is mandated by the laws of nature to reduce uncertainty, and thus provide policy-makers with a scientific comfort zone in which to ground policy.[28] What policy measures, including feedback loops and scientific monitoring programmes, are suggested/available to decrease scientific uncertainty?

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[28] I.S. Shapiro, "Science and Law", 17 *Jurimetrics Journal* 195 (1977), p. 198.

h) *Is the quality of the science proffered being confused with the degree of scientific uncertainty*?[29] The very best science may yield a high degree of uncertainty if the issue is complex or if little research has accumulated on the issue.

i) *How well do scientists understand the issue?* Has a high-profile issue moved the scientific knowledge-making process (scientific debates and peer review process) into the public arena, causing confusion about the state of scientific knowledge?

j) *Does any apparent lack of scientific cohesion result from equally sound science processes, or are uninformed or pseudo-scientists or the media misdirecting the consumers of science?* Where the scientific knowledge-making process is forced into the public arena, usually when the popular media publish summaries of the latest scientific article, scientists lack time in which to present a cohesive opinion to an anxious public.

k) *Is the scientific evaluation consistent with or contrary to the mainstream science on the issue?* This is particularly relevant where the science offered is not peer-reviewed. It is always wise to follow the mainstream peer-reviewed science, and incorporate mechanisms for policy adjustment in light of new information.

l) *Is any scientific disagreement merely peripheral to the core ecological issue or is the disagreement about the fundamentals of the issue?* The degree and substance of conflict can significantly influence the degree of caution that

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[29] Warren discusses the need within policy-making processes to test the quality of science proffered. See L.M. Warren, "The Precautionary Principle: Use with Caution", in K. Milton (ed.), *Environmentalism: The View from Anthropology* (London and New York: Routledge, 1993), pp. 97-111.

policy-makers should adopt.

m) *Is the scientific report/opinion ecologically broad enough to consider direct or indirect effects on other habitats/species and/or regional and global issues?*

n) *Does the executive summary reflect the science in the main body?* Who wrote the executive summary and has it been reviewed by the contributing scientists?

o) *Have the scientists or any parties relying on the science oversimplified it?*[30] Over-simplification can result in the poor use of good science, with possible repercussions for the ecosphere, society, and scientists when policy objectives are not met.

p) *Is the best available science being utilised to formulate policy options?* What mechanisms or checks can be employed throughout the policy-making process to ensure quality science is provided?

Scientific literacy does not entail turning actors from the legal domain into scientists, or turning policy-making into a science-dominated process. Science must inform policy, but not to the extent of dictating, usurping, or hijacking the process. Science provides options, not determinations, for policy-makers. Scientists decide, "what *is*" (factual findings), and society through the policy-making process, using these factual findings, decides "what *ought* to be", given "what is" (value and fact combination).[31]

A final point about scientific literacy involves clarity of vocabulary. Science is factual, and it would benefit everyone if actors used language that reflected facts. A good

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[30] *Ibid*.

[31] D.L. Faigman, *Legal Alchemy: The Use and Misuse of Science in Law* (New York: W.H. Freeman and Company, 1999, 2000), p. 33 and P. Castro and M.E. Huber, *Marine Biology*, 2nd ed. (Dubuque, Iowa: Wm. C. Brown Publishers, 1997), pp. 14-16.

example of diplomatic relations obscuring facts is the thick, choking smoke from burning rainforests in Indonesia that has blanketed Southeast Asia in recent years – which is politely called "haze". Equally misleading are the terms "waste" and "disposable".[32] Waste and "disposable" articles (i.e. fast food packaging) largely remain in the ecosphere in one form or another (whether after burial, incineration, or even recycling) and will eventually resurface, given time and/or quantity.[33] "Pesticides" target the pest, but they are in fact "biocides" that kill indiscriminately.[34] Pollution has a scientific and a legal definition, the former factual, and the latter based on potential eventuality.[35] How can scientists and lawyers effectively communicate when the same word means two different things? These are just a few examples that demonstrate the need for clear and concise definitions and clarity for improved communication.

3) Hazard and Risk Assessments and Risk Management

Today's MDLBA issues relate more to risk management, than elimination of an environmental problem. Understanding this is the first step towards rational policy, and towards eliminating scientifically and economically untenable policies such as zero discharge.[36] Accepting humankind's continuing impact on the ecosphere, actors must consider options for managing LBA from a perspective of managing risks. Such

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32 G. Hardin, *Filters Against Folly: How to Survive Despite Economists, Ecologists and the Merely Eloquent* (New York: Penguin, 1987), p. 67. This book is highly recommended for anybody involved with environmental management.

33 *Ibid.*

34 *Ibid.*

35 This scientific definition requires the consequence of deleterious effects. Legal instruments tend to use wording to define words that covers the greatest range of situations, and thus that incorporates "fact" and "potentiality", such as with pollution, it "results in or is likely to result in…".

36 See R.B. Clark "Assessing Marine Pollution and Its Remedies", 10 *South African Journal of Marine Science* 341 (1991), p. 350.

management must also be ecologically sustainable in the long-term and economically and socially rational. Although challenging, effort can produce positive results.

Most, if not all, MDLBA actors overlook two distinctive, yet inter-related, aspects of risk management that inherently involve science. The first is the substantive role of scientists in risk management. The second concerns individuals' psychological perceptions of risk and risk-taking.

The substantive role of scientists does not include making determinations about risk acceptance. Society, through public debate and the policy-making process, should determine what is an acceptable risk and then attempt risk management through policy (the "what ought to be").[37] Scientists undertake *hazard assessments* and *risk assessments*, which in turn, can be used by actors to *manage* risk. "Hazard assessment identifies the potentially adverse effects of substances on the basis of their inherent properties".[38] Risk assessment predicts the damage to organisms and habitats, based on the probability of exposure to hazardous substances or activities.[39] While hazard assessments are the domain of natural scientists, natural and social scientists may co-operate on risk assessment.

Actors in the MDLBA policy-making process should engage scientific hazard and risk assessments to tailor policy/management efforts, to ensure adequate ecological protection while still accommodating social and economic factors. For instance, to protect local economies, an ecologically viable option may be to gradually phase out the use of a hazardous substance over a specific period of time. However, where the

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37 See generally B. Fischhoff, S. Lichtenstein, P. Slovic, S.L. Derby, and R.L. Keeney, *Acceptable Risk* (Cambridge: University of Cambridge Press, 1981, 1993).

38 GESAMP recommended the use of hazard assessments in the early 1990's. See GESAMP, *Global Strategies for Marine Environmental Protection,* GESAMP Reports and Studies No. 45, 1991, at p. 21.

39 *Ibid.*

receiving environment is fragile, such as a coral reef, the risk assessment may show that it is necessary to immediately cease the activity in question. Risk assessors (investigators) and risk managers (determiners and enablers) working together can provide rational and sound protection strategies and ensure that precious financial resources are utilised effectively. Risk assessment should also underpin negotiations concerning environmental measures to ensure that the negotiated outcome is sound both ecologically and economically. Science can be used to establish a range of options and or confirm the viability of suggested options.

To foster a close working relationship among risk assessors and risk managers, the second overlooked aspect, risk perception, must be addressed. How the public perceives various risks – a highly complex area of study by social scientists – is relevant to policy-making, as the public often drive the policy-process, voicing concern about what ecological issues are addressed and how they ought to be managed. Further, perception of risk impinges on public trust in both policy-makers and scientists, as the public must be satisfied with both the agenda and policy solutions.

Social scientists are becoming more vocal about the need for determiners and enablers to understand how and why people react to risks, as they note how some trivial risks generate outrage, while risks that are more serious might be essentially ignored.[40] Research shows that the public respond with the "outrage effect" to two types of risks. The first is the unknown, where the problem is unobservable by individuals, not fully understood scientifically, and generates fear, as the impacts are potentially serious and

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[40] See G. Fisher, *Mindsets: The Role of Culture and Perception in International Relations,* (Yarmouth, Maine, USA: Intercultural Press, Inc., 1988); P. Slovic, "Perceived Risk, Trust and Democracy", 13 *Risk Analysis* 675 (1993); H. Kunreuther and P. Slovic, "Science, Values, and Risk", 545 *The Annals of the American Academy of Political and Social Science* 116 (1996); B. Fischhoff, "Managing Risk Perception", 2 *Issues in Science and Technology* 83 (1985-86); N. Stanley, "Public Concern: The Decision-makers' Dilemma", [1998] *Journal of Planning Law* 919; and Kates, *supra* note 7.

difficult to assess (e.g., global climate change).[41] The second is the dread risk, where there is little personal control and catastrophic potential exists for harm to humans, the environment, and/or future generations (e.g., nuclear power).[42]

These two examples of the outrage effect have resulted in politicians yielding to public pressure with resultant ecological and economic costs. The abhorrence of nuclear power, one of the safest and cleanest fuels (provided plants are properly maintained and safeguards to protect against human error are in place) has resulted in the continued reliance on fossil fuels. Fossil fuels are a major contributor to global climate change and have other ecological impacts. The second, global climate change, has resulted in agreements for massive expenditure to reduce greenhouse gases; and this expenditure, which will have huge economic impacts on many economies, may not resolve the problem.[43] Two other examples of dread and fear driving the ecological agenda are public over-reaction to oil spills and heavy metals. Fear, emanating from an uninformed perspective, results in an irrational demand for action, which in these cases may represent huge expenditure on scientifically assessed low-risk issues.[44]

Actors, who understand that people are predisposed to reasoning and perceiving information in certain ways,[45] can anticipate, explain, and address emotional reactions, allaying irrational concerns and fears. This is important, as even when scientists

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41 Stanley, *ibid.*, pp. 925-6.

42 *Ibid*.

43 Kyoto Protocol to the United Nations Framework Convention on Climate Change, 10 December 1997, 37 ILM 32 (1998), W.E. Burhenne International Environmental Law: Multilateral Treaties 992:35/A. (1997). Also see S. Schneider, "Global Warming: Neglecting the Complexities", *Scientific American*, Vol. 286, No. 1, pp. 60-3 (2002) and E. Ayres, *God's Last Offer: Negotiating for a Sustainable Future* (New York, London: Four Walls Eight Windows, 1999), p. 13.

44 Kunreuther and Slovic, *supra* note 40, pp. 222-3.

45 Fisher, *supra* note 40, p. 1.

provide completely accurate information, individuals hear only the “dread” words, like cancer, and not the reservations, conditions, or probabilities.[46] Common sense gives way to emotions, which in turn drive ecological priority setting and the policy-making processes.

Related to this is the tendency for people to simplify complex issues.[47] The risk is that science, particularly complex science laden with reservations and uncertainty, is compromised, because laymen cannot absorb the reservations or appreciate the sheer complexity of both ecology and the scientific endeavour. Science-literate actors can grasp at least the weight of the complexities.

Informing actors, including the public, about science, ecology, and the various roles in the assessment and management of risk will influence the policy-making process. First, understanding the issues will precipitate reasoned thinking, which can replace fear.[48] Second, an empowered and educated public will be able to participate in reasoned debate, supplanting emotional and emotive participation. Third, rational policy will replace unsound policy, as actors will be more capable of making informed, intelligent, and scientifically grounded decisions.[49]

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[46] Social scientists have found that humans have a psychological tendency to focus on and be influenced by negative events. See Slovic, *supra* note 40, p. 679. A vicious cycle is created as the media also focuses on the negative, and particularly catastrophic potential to attract an audience.

[47] Fischhoff, *supra* note 40, pp. 86-7.

[48] See W.D. Ruckelshaus, “Risk, Science, and Democracy”, 1 *Issues in Science and Technology* 19 (1985), p. 38; Kunreuther and Slovic, *supra* note 40, pp. 222-3; and Kates, *supra* note 7. Also see W.F. Allman, “Staying Alive in the 20th Century”, *Science 85*, Vol. 6, No. 8, pp. 31-7 (1985), which in discussing polls of the general public and risk analysis experts, illustrates how uninformed the public is about risks, and their often irrational reaction to risks, even after they have the facts.

[49] See W.K. Reilly, “The Future of Environmental Law”, 6 *Yale Journal on Regulation* 351 (1989), reprinted in M.C. Blumm (ed.), *Environmental Law* (New York: New York University Press, 1992), p. 353. Reilly speaks about the three fundamental changes for a sustainable future: sophisticated environmental education, building an environmental ethic, and changing human behaviour. The latter two will flow from education. Also see Kates, *supra* note 7 and Allman, *ibid*.

4) Educating the Actors in the MDLBA Policy-making Process

Improving the scientific literacy of actors is challenging, given the present mistrust of science and the actor's diverse backgrounds, experience, and education. Innovative and creative methods will have to be devised to ensure that future generations grow up scientifically literate, and meanwhile, special programmes will need to be established to educate the current MDLBA actors, at least until the public education system catches up.[50]

Scientific education should start at an early age in the public education system and carry through to university level.[51] Redesigning and reorganising the present education system to infuse science into a system that suffers from a universal anti-science bias is possible, but challenging. School children, having absorbent minds and unprecedented exposure to ecological issues, hold promise for science-literate graduates within the next few generations, providing schools respond.

Earth Day, celebrated in the US and other countries, and UN-sponsored World Environment Day provide opportunities for schools to introduce, discuss, and respond to ecological issues in meaningful ways. Essays or projects for subjects such as English, geography, or political science may focus on environmental issues, as these are social issues at their core. Ecological and scientific literacy need not be restricted to science lessons, and in fact, science should be taught in a broad framework to ensure

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50 The utility of environmental education has been widely recognised. See generally D.P. Pereira (ed.), *Focus on Environment* (Singapore: Select Books on behalf of the Institute of Education Academic Staff Association, 1979); R.H.K. Wong, "Education for Responsibility and Accountability: Nothing is for Free", in Pereira (ed.), *ibid.*, pp. 67-78; W.A. Thomas, "A Report from the Workshop on Cross Education of Lawyers and Scientists", 19 *Jurimetrics Journal* 92 (1978); H. Schneider, "Concepts and Issues", in OECD, *Environmental Education: An Approach to Sustainable Development*, Prepared under the OECD Development Centre's Research Programme on Coping with Environmental Threats in Developing Countries (Paris: OECD, 1992), pp. 25-33; J. Vinke, "Actors and Approaches in Environmental Education in Developing Countries", in OECD, *ibid*., pp. 39-73; and O.S. Dijksterhuis, "Environmental Education: A Tool for Coastal Management? A Study of the Caribbean Region", 24 *Coastal Management* 339 (1996).

51 See generally S. Tomkins, "Science for the Earth Starts at School", in T. Wakeford and M. Walters (eds.), *Science for the Earth: Can Science Make the World a Better Place?* (Chichester, England: John Wiley & Sons, 1995), pp. 257-76.

that students understand the relevance of science to their daily lives and a sustainable future. The prevalence of environmental issues in the media and on political agendas is helping to set the stage for educational changes.

University offers students intense study in chosen fields, and post-educational employment opportunities reward specialisation. Thus, non-scientists might never encounter science, and, curiously, science students often learn the facts of their discipline without learning the history or philosophy of science (and the scientific method). Universities must consider broadening the scientific component for both science and non-science majors. Introducing multi-disciplinary courses and degrees, and encouraging students from one faculty to take courses from other faculties, are starting points.[52]

Law faculties should integrate basic science into environmental law courses, or, even better, co-ordinate with the science faculty for a basic science course suitable for non-scientists, which will attract students from law, public administration, policy, and other faculties.[53] A basic science course should be a prerequisite to environmental law courses, or at the very least, introductory environmental law courses should have a science literacy component discussed preferably in the first few weeks of term. This will help students understand environmental issues and put environmental law and policy-making into perspective.

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[52] Multi-disciplinary degrees are becoming more common in the environmental area, particularly in coastal zone management and marine affairs. While this is promising, it continues to limit scientific education to a select, albeit important, few. Dalhousie University, Halifax, Canada offers a Master's in Marine Management, which is a highly regarded multi-disciplinary degree and attracts students from around the globe.

[53] See Warren, *supra* note 29. For suggestions for generally improving environmental law courses, see H.G. Robertson, "Methods for Teaching Environmental Law: Some Thoughts on Providing Access to the Environmental Law System", 23 *Columbia Journal of Environmental Law* 237 (1998).

Regarding science faculties, the university system of tenure rewards professors for scientific discovery through promotion, grants, and recognition. There are no professional rewards for teaching introductory science or philosophy courses to students. Task forces need to attack the various issues associated with university education with some haste, as ecological issues require educated, rational, and broad-minded problem solvers *now*.

Actors influential in policy-making should become informed through dedicated programmes that foster a deeper, broader ecological understanding as well as a basic understanding of science as discussed above. Policy-makers, bureaucrats, lawyers, and other government employees involved in environmental management (the determiners an enablers) should be encouraged, if not required, to take a scientific literacy exam, or enrol in a government-sponsored scientific literacy course with accreditation given for those who upgrade their skills. A precedent for this is the requirement for French proficiency within some sectors of the Canadian federal civil service, with language training for those who require it. Politicians, political appointees, ministers, cabinet members, and other government officials should have access to science-literate advisors, and be expected, if not required, to consult them. This brings with it a degree of accountability for actions. Of all the actors, it is essential that the ones in decision-making positions are able to cut through emotionally charged issues and are empowered with the best available science.[54]

Determiners and enablers are most likely to have followed an arts/business stream in education, and hence largely escaped exposure to science. Learning the necessary rudiments of science will take motivation and dedication. A motivational tool is a

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[54] See J.S. Gray and J.M. Bewers, "Towards a Scientific Definition of the Precautionary Principle", 32 *Marine Pollution Bulletin* 768 (1996), p. 771.

twelve-step self-help programme similar in design and philosophy to Alcoholics Anonymous and other such self-help models.[55] The twelve steps, attached as Appendix 6, herein, commences with the admission of scientific illiteracy, acknowledges the need for scientific literacy to fulfil professional obligations, commits to seeking sound scientific advice, and concludes that by following the steps the participant will become a sophisticated consumer of science.[56] The programme may sound somewhat pedantic, but upon consideration, it holds promise as a tool to focus actors and encourage them to improve their own level of scientific understanding and to incorporate science into policy-making. Should an actor not seek to improve his own knowledge, he should at least be more receptive of the need to consult others who may offer advice or opinions and others to counsel him with respect to discerning sound advice.

Another major group of actors deserving special and immediate education is the media. In addition to its role as influencer, the media should assume the vital role of educator, educating the public with ecological facts and providing them with the tools to discern the best available science from fringe, pseudo-, and poor science and to assess issues for the purpose of action. The media is the most immediate and direct route to the general public, who have few means or opportunities to become science literate.[57] In this role, the media can provide society with information to help shape their environment, either directly through individual actions and choice of products, or indirectly through pressure exerted on politicians.

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55 Faigman, *supra* note 31, p. 198. The twelve steps are reproduced and attached as Appendix 6, Becoming a Sophisticated Consumer of Science, herein.

56 *Ibid*.

57 As it is unreasonable to expect even a significant portion of the general public to enrol in scientific literacy courses, future generations of the general public will have to rely on the public education system to become science literate.

As influencers and educators, the media must revise its reporting methods. First, reporters should undergo scientific "enlightenment", perhaps endorsing the twelve-step programme described above, and ensuring that they understand the scientific components of given issues. Second, they must aspire to responsible reporting that is objective, informative, and balanced. Third, they should provide credentials of the scientist interviewed or quoted, and indicate the status of the scientific knowledge – is it an established area of knowledge, such as low-level radioactivity; or an area in the midst of the peer-review process as the reporter writes, such as global climate change? Fourth, reporters should strive to report the best science available and not portray contrarian opinions as part of the mainstream. Fifth, scientific uncertainty and reservations of the scientist, or scientific community, must be communicated for an accurate account, to prevent confusion, and help explain contrary opinions. Sixth, reporters must acknowledge their role in influencing public opinion on very important and long-term issues. Seventh, they should dispense with sensationalism and views that are meant to sell copy, particularly in issues such as global climate change, where the science is contemporaneously presented to the public and scientific peers.

There is a move towards responsible and balanced reporting, particularly as bodies such as the Union for Concerned Scientists, based in the US, speak out against inaccurate or misleading science reporting on environmental issues.[58] The contrarian reports and open debates in the media must continue, and they should be encouraged. However, calling for honesty and sincerity, reporters must fully inform the public to assist them in making rational choices. Clarity needs to replace chaos.

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[58] The Union for Concerned Scientists started in the 1960's in response to concerns about the social uses of scientific discovery, with specific regard to nuclear bombs. Over the decades, their members, primarily research scientists in various sectors, have focused on popular and publicly debated environmental concerns, such as global climate change, to try to ensure that the science used is sound and it is used soundly. UCS is based in the United States. See the Union for Concerned Scientists homepage on the Internet at: http://www.ucsusa.org/ucs-home.html.

Finally, building scientific literacy in all quarters requires multi-disciplinary task forces to conceptualise, design, and implement novel ways of infusing science, making it less daunting and more interesting for non-science learners, who generally have an inherent and perhaps personally unacknowledged bias against numbers and scientific terminology. Designing such task forces requires multi-disciplinary participation by numerous actors. Most vital are social scientists and psychologists who understand patterns and variations in human thought processes – how and why people think, and consequently act and react – and understand how and why individuals learn in different ways.[59] Different learning styles and their potentially profound effect on communication and mutual understanding are only now becoming known.[60]

Garrett Hardin, author of the famous 1968 article, "Tragedy of the Commons",[61] suggests that humans tend to view the world through "literate", "numerate", and "ecolate" filters, with selected groups relying heavily on one filter to the exclusion of the others.[62] Most lawyers, policy-makers, and non-scientists have a bias towards the "literate" filter. Educated non-scientists are often adept at fine-tuning word choices and distinguishing subtleties.[63] The thought process of the "literate" focuses on the most appropriate words to describe or convey a given thought.[64] Language, through clever word choice and eloquence, is used to create irony, beauty, outrage, awe, emphasis, and poetry, generally sensitising the reader or listener's emotions. The heart

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59 For example, see D. Goleman, *Emotional Intelligence* (New York: Bantam Books, 1995) and S. Pinker, *How the Mind Works* (New York: W.W. Norton, 1997).

60 See H. Gardner, *Multiple Intelligences: The Theory in Practice* (New York: BasicBooks, 1993); Pinker, *ibid.*; and I. Aleksander, *Impossible Minds* (London: Imperial College Press, 1997). Scientists are discovering organic reasons, including genes, brain chemistry, and brain circuitry, for thinking and processing information. Evidence seems to indicate that certain professions may attract certain thinking styles.

61 G. Hardin, "Tragedy of the Commons", 162 *Science* 1243 (1968), reprinted in G. Hardin and J. Baden (eds.), *Managing the Commons* (San Francisco: W.H. Freeman and Company, 1977), pp. 16-30.

62 Hardin, 1987, *supra* note 32. Discussion of the three filters, herein, is largely summarised from Hardin's book.

63 *Ibid.*, p. 22.

64 *Ibid.*

of the issue is often eclipsed by eloquence, and the use of words that summon clear images, often with under- and over- statement to achieve the desired effect. Non-quantifiable and innumerate words such as “infinite”, “never”, “non-negotiable”, and “forever” are preferred over definitive, but less descriptive choices.[65]

Through the literate filter, an idea is often conveyed effectively, but at the expense of accuracy. Innumerate thinking has given rise to arbitrary standards, such as safe and unsafe categories of pollutants, with the call for zero-tolerance laws a prime example. “ ‘Safe’ and ‘unsafe’ are literate distinctions; nature is numerate. Everything is dangerous at *some level”*.[66] Literacy ignores numbers, but it acknowledges the practical need to set standards for conduct. This is contrary to science, where precision is fundamental.

“Numeracy” adherents are scientists, as numbers, or at least quantities, rates of change, proportions, correlations, ratios, duration, and dimensions dominate science.[67] Scientists focus on conveying accurate information that reflects natural truths. Numeracy recognises the need for measuring contamination on a continuum, not black and white categories of safe and unsafe pollutants. Numeracy relies on very precise language, but its subtleties are lost after processing through the literate filter. Understandably, literacy adherents often find science writing tedious, uninspiring, and unclear, as numbers, rates and quantities in scientific language have no relevant context for such persons. Recognising the two diverse filters helps promote understanding of some of the communication difficulties.

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[65] *Ibid*., p. 33. For instance, the literate filter arguably contributed to the “permissive regulation” mindset through belief in an *infinite* capacity of the ocean to assimilate pollution. The truth is that this capacity is high, but *it is finite* – a point easily lost. Such language also fails to recognise that certain marine habitats have a significantly lower capacity than the “ocean”.

[66] *Ibid*., at p. 43. Emphasis added.

[67] *Ibid*., pp. 22 and 41.

The third filter, "ecolacy", is employed primarily by ecologists. "Ecolacy", mandating caution, humility, and prudence, asks, "And then what?"[68] The need for the "ecolate" filter is shown by Hardin's example of the literate and numerate filters alone to predict resistance to many phenomena, such as antibacterial drugs and pesticides.[69] Neither the literate nor numerate filter revealed that the continued application would result in mutations that give rise to resistance, but the ecolate filter, asking, "And then what?", anticipates the unexpected by allowing for the passage of time to reveal consequences.[70]

Traditionally, non-scientists used the literate filter ("Which word?") and scientists used numeracy ("What numbers?").[71] The use of the ecolate filter ("And then what?") has its foundations in the late 20th century, as insidious and unexpected impacts prompted scientists (frequently ecologists) to ask, "And then what?" Spring boarding from Hardin's concept of "And then what?" vis-à-vis ecology to MDLBA policy-making, ecolacy arguably embodies the philosophy of the precautionary concept, namely, that of proceeding with prudence and caution.

The three filters used together are necessary for a realistic understanding of the ecosphere and the human impact on it. Literacy provides grace and eloquence for effective and meaningful communication, provided it is tempered with numeracy for succinctness, accuracy, and perspective. Ecolacy, asking, "And then what?" offers a chance to assess and choose policy options on a rational basis so that problems can be

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68 *Ibid*., pp. 24-5.

69 *Ibid*., pp. 22-3. Antibacterial drugs and pesticides, by definition, kill the target, so from a literate perspective, application of these should resolve the problem. Applying the numerate filter would show the actual percentage killed at each application, demonstrating that perhaps two or more applications may be necessary.

70 *Ibid*., p. 24.

71 *Ibid*., p. 22. Hardin likens the two filters to Snow's two cultures. See Chapter 2, herein, for a discussion of the latter.

addressed wisely and insightfully, and actors are more receptive to emerging evidence and the need for adaptive policies.

The three filters are a practical way to analyse and then synthesise rational options to address environmental issues. The integration of literacy, numeracy, and ecolacy embodies "consilience" as they require conscious and interdisciplinary assessment of information and coherent input into the process of policy-making, and confirmation that information available is sound, logical, and comprehensive. Equally important, the filters encourage individuals to understand their own and others' filtration preferences, and to understand how different filters may affect communication and means of attaining common goals. Educating the actors in the use, and personal preferences, of the three filters should be imperative, as they can change the mindset of the actors, encouraging the use of caution, balance of perspective, and comprehensive input of information. Significantly, the three filters require the input of science and all other disciplines relevant to MDLBA issues.

B. Caulking the Seams: Building Confidence in Scientific Capacity

"Caulking the seams" of public confidence, by showing why high confidence in science is warranted, may keep myths and misunderstanding about science and scientists from seeping into the policy-making process. The policy vessel should remain watertight if, first, sound science is utilised to its fullest, and, second, if scientists and the media contribute to "caulking the seams" as discussed below.

1) Superior Scientific Capacity

Much of the present lack of confidence in scientific ability stems from the *perceived* failures of science in the 1960-70's.[72] If scientists then had possessed the accumulated knowledge or technology of today to predict impacts, public confidence in scientists today might be much higher than it is. Scientists' ability to predict and determine ecological repercussions has significantly improved in the recent decades, as their present knowledge-building approach combines reductionist and "consilience"-based methodology to understand biological, physical, and chemical processes from the sub-cellular, to the global, and even universal, level. Some of the more relevant improvements in scientific capacity follow.

(a) Superior Technological Capacity

Instrumentation and tools available to scientists largely determine the degree to which they can experimentally fathom natural processes and accurately measure change.[73] Fortunately, the last 30 years, and particularly the last decade, have witnessed unprecedented technological improvement in both improved versions of existing instruments and wholly new instruments.[74] Just a few examples are that (a) contaminants are now measured in nanograms (and even picograms) whereas a few years ago they were measured in milligrams;[75] (b) advances in analytical techniques

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72 Failure from negligence or oversight must be distinguished from inability to predict. See J.M. Bewers, "The Declining Influence of Science on Marine Environmental Policy", 10 *Chemistry and Ecology* 9 (1995), where it discusses support for comprehensive experimental design to help counteract surprise effects.

73 An interesting point to note is that technology is a barrier to testing hypotheses and theories, but not to constructing hypotheses and theories.

74 Computers, robotics, innovative materials, and satellites are sophisticated and precise tools that give access to, to name a few, new types of data, remote locations, more frequently recorded data, insights into biochemical changes, and improved methods of chemical analysis.

75 J.S. Gray "Integrating Precautionary Scientific Methods into Decision-making", in D. Freestone and E. Hey (eds.), *The Precautionary Principle in International Law: The Challenge of Implementation* (The Hague, London and Boston: Kluwer Law International, 1996), p. 137.

have made possible more accurate hazard assessments;[76] and (c) remotely operated submersibles and technologies, such as cameras or data recorders attached to wild animals provide access to previously inaccessible habitats, species, and data collection opportunities.

(b) Scientific Progress: Knowledge, Techniques, and Methodologies

Employing accumulated, diverse, and improved knowledge, scientists have developed diverse techniques and methodologies that provide improved predictive capacity and accurate ecological assessments, and generally reduce scientific uncertainty (both "known unknowns" and "unknown unknowns").[77] Subtle changes in biota and the physical environment can be assessed for anticipated impacts, or monitored for early signs of degradation or potentially adverse changes in the community structure. In many cases, scientists are able to provide actors with a range of expected impacts at specific doses/quantities for many contaminants, classes of contaminants, or activities.

Scientists are also now able to detect biological effects at the sub-cellular and molecular levels, thanks to several new techniques, often developed within novel disciplines of scientific investigation.[78] A new discipline, ecotoxicology, concerned

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[76] GESAMP, *Review of Potentially Harmful Substances: Choosing Priority Organochlorines for Marine Hazard Assessment*, GESAMP Reports and Studies No. 42, 1990, p. 6.

[77] Scientific advances are vast and varied. For a general appreciation of improved capacity, see generally P.M. Chapman, "Is Bioaccumulation Useful for Predicting Impacts", 34 *Marine Pollution Bulletin* 282 (1997); L.W. Aarssen, "On the Progress of Ecology", 80 *Oikos* 177 (1997); G. Kullenberg, "Capacity Building in Marine Research and Ocean Observations: A Perspective on Why and How", 22 *Marine Policy* 185 (1998); J.H. Stel, "Editorial – Marine Capacity Building in a Changing Global Setting", 22 *Marine Policy* 175 (1998); E. Okemwa, "The Intergovernmental Oceanographic Commission of UNESCO and Regional Capacity Building", 22 *Marine Policy* 197 (1998); T. Wakeford and M. Walters (eds.), *Science for the Earth: Can Science Make the World a Better Place?* (Chichester, England: John Wiley & Sons, 1995); R. Bailey (ed.), *Earth Report 2000: Revisiting the True State of the Planet* (New York: McGraw-Hill, Inc., 2000); and GESAMP, 1991, *supra* note 38.

[78] For improvements in capacity for assessment and predictions, see Health of the Ocean (HOTO) Panel of the Joint Scientific and Technical Committee for the Global Ocean Observing System (GOOS), *A Strategic Plan for the Assessment and Prediction of the Health of the Ocean: A Module of the Global Ocean Observing System*, Doc. IOC/INF-1044 (Paris: UNESCO, 26 August 1996); N.R. Andersen, "An Early Warning System

with the relationship between contaminant concentration and biota response, provides indispensable information for policy-making.[79] For example, this information can contribute to meaningful water quality criteria for effective regulation.

A technique used in ecotoxicology to predict the toxicity and rates of bioaccumulation of thousands of chemicals on the market, without extensive and expensive testing of each specific chemical, is quantitative structural-activity relationships ("QSARs").[80] QSARs utilise physical and chemical properties and the molecular structure of well-understood chemicals to predict the properties of similarly structured chemicals.[81] QSARs are also key components in hazard assessments, the latter being further evidence of progress in scientific techniques.[82]

Scientific advances, particularly in molecular biology, are resulting in new biological early warning systems that utilise biological indicators ("biomarkers") to reveal sensitivity to either a specific class of contaminant or general ecological stresses.[83] In comparison with past methods, biomarkers provide early warning, as they reveal subtle changes at the biochemical or molecular levels,[84] or they show community structural

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for the Health of the Oceans", 10 *Oceanography* 14 (1997); Chapman, *ibid*.; and GESAMP, 1991, *supra* note 38.

[79] See GESAMP, 1991, *ibid.*, pp. 22-3; M.H. Depledge, "Ecotoxicology: A Science or Management Tool?", 22 *Ambio* 51 (1993); and A. Rosemarin, "Ecotoxicology on the Upswing - But Where are the Ecologists?", 17 *Ambio* i (1988).

[80] Gray, 1996, *supra* note 75, p. 137; A.R.D. Stebbing, "Environmental Capacity and the Precautionary Principle", 24 *Marine Pollution Bulletin* 287 (1992); and GESAMP, 1991, *supra* note 38, p. 22.

[81] Gray, 1996, *ibid*., p. 137 and GESAMP, 1991, *ibid.*, p. 22. QSAR investigations have also shown that chemicals with similar QSARs have additive effects and thus this can be taken into account when setting environmental quality criteria for such substances. See GESAMP, 1991, *ibid*., p. 23.

[82] See GESAMP, 1991, *ibid*.

[83] See HOTO Panel, *supra* note 78, pp. 18-21; Gray, 1996, *ibid*., pp. 137-8; Stebbing, *supra* note 79, p. 292; L.D. Mee, "Scientific Methods and the Precautionary Principle", in D. Freestone and E. Hey (eds.), *The Precautionary Principle in International Law: The Challenge of Implementation* (The Hague, London and Boston: Kluwer Law International, 1996), pp. 127-8; and GESAMP, *Biological Indicators and Their Use in the Measurement of the Conditions of the Marine Environment*, Report of Working Group 33, 1994.

[84] Stebbing, *ibid*., p. 292.

changes that indicate an imbalance in the ecosystem.[85] Three examples of recorded impacts utilising biomarkers are genetic damage in plankton due to increased UVB radiation, changes in the cytochrome P-450 enzyme levels in fish exposed to PAHs, and the growth patterns in some molluscs (shellfish) affected by a variety of ecological stressors.[86] It is hoped that biomarkers, in time, will become the natural scientists' version of the medical profession's antigens and anti-bodies.[87]

Generally, exponential growth in basic knowledge within all scientific disciplines has led to improved experimental design, for example in choosing key species as indicators of change, more precise experimental conditions, and more comprehensive pathways and targets for investigation of impacts. The possibility of chronic and inter-generational impacts and phenomena such as bioaccumulation are considered as a matter of course. Another example of progressive science is the move away from a focus on toxicity, persistence, and bioaccumulation, to the more comprehensive hazard assessment-based approaches.[88]

Methodology has improved, particularly in relation to monitoring, modelling, and statistical analysis. Monitoring is a necessary and worthwhile scientific endeavour, providing its design is appropriate to the information sought.[89] The capacity for

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85 Mee, *supra* note 83, p. 127.

86 Gray, 1996, *supra* note 75, pp. 137-8.

87 Stebbing, *supra* note 79, p. 292. Stebbing notes that at the turn of the 20th century medical doctors were just beginning work that would lead to today's relatively simple tests for anti-bodies and antigens as indicators of diseases. A century later, natural scientists are making similar progress in relation to contaminants in living organisms as they locate more biomarkers.

88 For discussions on hazard assessments, see P.M. Chapman, "The Precautionary Principle and Ecological Quality Standards/Objectives", 34 *Marine Pollution Bulletin* 227 (1997), p. 227; Mee, *supra* note 83, pp. 130-1; and GESAMP, 1990, *supra* note 76, pp. 2-4. For the advantages of hazard assessments, see Gray and Bewers, *supra* note 54, p. 768.

89 Past monitoring efforts and some contemporary monitoring programmes often have failed to produce useful results as inappropriate aspects were monitored, the policy-makers' needs were insufficiently communicated to scientists, scientists did not heed the policy-makers' requests, funding was not available to establish appropriate programmes, or non-scientists dictated the parameters for programmes. For an array of comments on monitoring, see J.B. Skjærseth, "Towards the End of Dumping in the North Sea", 16 *Marine Policy* 130 (1992),

effective monitoring is improving, as scientists are able to monitor biological, chemical, and physical changes, and isolate *trends* (more useful for long-term predictions) in addition to levels and effects of contaminants.[90] The monitoring process is evolving as scientists and policy-makers communicate to ensure that necessary information will result from the intended monitoring programme and funds are directed to effective ends.[91] International and global monitoring programmes such as the Global Ocean Observing System ("GOOS") undertaken by the IOC, UNEP, WMO, and ICSU should provide global, routine, cost-effective, readily accessible, long-term monitoring programmes with the intended effect of creating an early warning system for the health of the oceans.[92]

Modelling, largely computer-driven, has benefited from the progressive sophistication of both hardware and software. In addition to the technology, predictive models relating to ecological change/impacts have benefited from improved data in terms of quality, quantity, and capacity to include more variables.[93] These improvements allow

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p. 137; Andersen, *supra* note 78, p. 14; R.G.V. Boelens, "The London Dumping Convention: Its Development and Significance to Marine Pollution Control", in P.G. Wells and J. Gratwick (eds.), *Canadian Conference on Marine Environmental Quality: Proceedings* (Halifax, Nova Scotia: The International Institute for Transportation and Ocean Policy Studies (IITOPS), 1988), p. 40; M.A. Jacobson, "The United Nations' Regional Seas Programme: How Does It Measure Up?", 23 *Coastal Management* 19 (1995), p. 31; and GESAMP, 2001b, *supra* note 8.

90 GESAMP, 1991, *supra* note 38, pp. 23-4. Also see J.S. Gray, "Biological and Ecological Effects of Marine Pollutants and Their Detection", 25 *Marine Pollution Bulletin* 48 (1992). Mee, *supra* note 83, p. 123, notes that it is not enough to monitor what chemicals are present, but their impacts (i.e., type, range, and severity) are vital data required for effective and anticipatory policy. For review of pitfalls and improvements, see GESAMP, *Monitoring the Ecological Effects of Coastal Aquaculture Wastes*, GESAMP Reports and Studies No. 57, 1996 and UNEP/AIMS, *Monitoring Coral Reefs for Global Change*, Reference Methods for Marine Pollution Studies No. 61, 1993.

91 See GESAMP, 2001b, *supra* note 8, pp. 108-9 and GESAMP, *A Sea of Troubles*, GESAMP Reports and Studies No. 70, 2001a, p. 29. Funding of scientific research can compromise knowledge building if funds are (a) directed to non-priority issues, (b) insufficient for the requisite study, or (c) come with attached conditions.

92 HOTO Panel, *supra* note 78; Andersen, *supra* note 78; J. Woods, "The Global Ocean Observing System", 18 *Marine Policy* 445 (1994); and H.L. Windom, "What Does GOOS/HOTO Mean, and What Will It Offer, to the Marine Scientist?", 10 *Oceanography* 15 (1997). HOTO is a component of GOOS.

93 See generally J.L. Casti, *Would-be Worlds: How Simulation is Changing the Frontiers of Science* (New York: John Wiley and Sons, Inc., 1997); C. Garrett, "Oceanographic and Modelling Considerations in Marine Environmental Protection", 25 *Marine Pollution Bulletin* 41 (1992); and GESAMP, *Coastal Modelling*, GESAMP Reports and Studies No. 43, 1991.

scientists to more accurately test models against factual happenings to confirm reliability of the predictive capacity. Scientists use models as *predictive* tools, not generators of facts, as some actors assume. As predictive tools, models are useful for policy purposes because they provide a range of ecological outcomes with varying degrees of probability of occurrence, which can be used to assess policy options and formulate science-based policy. Policies relying heavily on models must have adaptive mechanisms to incorporate emerging science.

Some scientists are promoting the use of statistical power analysis, as mentioned in Chapter 2, which assesses the probability of the occurrence of both type I and type II errors, in place of the traditional emphasis solely on type I errors for policy purposes.[94] Monitoring programmes in particular can benefit from the incorporation of statistical power analysis, as the latter indicates specific design requirements for detecting change within the sampling process.[95] Power analysis helps confirm the accuracy of scientific findings and allows scientists to more effectively incorporate pessimism (caution) into their predictions.[96]

(c) Data Quality Assurance

A reliable, relevant, and accessible database is imperative for the accurate accumulation of scientific knowledge and predictions, and consequently for bolstering actors' faith in scientific advice. Quality assurance is crucial, particularly now with global access to data on the Internet – a phenomenal resource, but one that is largely

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94 See Gray and Bewers, *supra* note 54, p. 771; R.M. M'Gonigle, T.L. Jamieson, M.K. McAllister, and R.M. Peterman, "Taking Uncertainty Seriously: From Permissive Regulation to Preventative Design in Environmental Decision-making", 32 *Osgoode Hall Law Journal* 99 (1994); and R.M. Peterman, and R.M. M'Gonigle, "Statistical Power Analysis and the Precautionary Principle", 24 *Marine Pollution Bulletin* 231 (1992).

95 *Ibid*.

96 Gray and Bewers, *supra* note 54, p. 771.

un-policed.[97] Poor quality data – resulting from poor experimental and monitoring design, carelessness, ignorance, or merely lack of access to current knowledge and technology (the latter is rampant in developing states) – are available on the Internet, and to the untrained eye may be indistinguishable from quality data.

Scientists are working among themselves, and with other actors, towards superior data collection and access that will support effective science-based policy-making processes.[98] Various means of improving data quality assurance include encouraging scientifically meaningful and precise data collection,[99] promoting the use of inter-calibrated instrumentation to foster meaningful comparison, especially within a region, and ensuring that data banks contain only reliable and validated data, particularly within widely utilised national and international banks.[100] To this end, publications such as GESAMP reports provide scientists with access to recommended methodologies and means of conducting scientifically sound research.[101] International and regional programmes are being established with the hope that actors will turn to

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97 For an interesting article generally about scientific information, which touches on the use of the Internet, see C.S. Lalwani and T. Stojanovic, "The Development of Marine Information Systems in the UK", 23 *Marine Policy* 427 (1999). The Internet contains information or provides access to sources of data, studies, researchers, institutes, and publications including journals and global and regional environmental reports. Electronic communication, which allows for ease of transmission and distribution, enhances the global body of baseline data, providing users can confirm its reliability.

98 For a sample of papers relating to improved scientific data and monitoring processes, see T. Munn, A. Whyte, and P. Timmerman, "Emerging Environmental Issues: A Global Perspective of SCOPE", *Ambio,* Vol. 28, No. 6, pp. 464-71 (1999); Chapman, *supra* note 77; L. Landner, "Hazardous Chemicals in the Environment – Some New Approaches to Advanced Assessment", 17 *Ambio* 360 (1988); S. Edwards, "Coastal Electronic Information Systems – Conference Report", 18 *Marine Policy* 357 (1994); J.N. Paw (ed.), *Marine Environmental Monitoring,* a dedicated issue of *Tropical Coasts: A Newsletter for Policymakers, Environmental Managers, Scientists and Resource Users,* Vol. 4, No. 2, pp. 1-31 (1997); and Casti, *supra* note 93.

99 Developing countries in particular suffer from poor data collection as resources for appropriate methodologies and sufficiently trained scientists are often scarce.

100 Scientists in 1985 encouraged the formation of data validation teams to ensure that data particularly in banks used for decision-making purposes were reliable and accurate. See E.D. Goldberg and J.K. Taylor, "The VD Conspiracy", 16 *Marine Pollution Bulletin* 1 (1985) and G. Topping, "The Role and Application of Quality Assurance in Marine Environmental Protection", 25 *Marine Pollution Bulletin* 61 (1992). Quality assurance remains an issue, particularly as environmental issues become more complex. See Funtowicz and Ravetz, 1991 and 1994, *infra* note 153.

101 GESAMP reports are available from its sponsoring agencies.

these data banks. A global example is the integrated data management system and biological distress signal detection programme being implemented by GOOS and one of its modules, Health of the Oceans ("HOTO").[102] It will ensure cost-effective, long-term, routine, multi-purpose, relevant, and reliable data collection that is globally accessible and useful to scientists, determiners, and enablers.

(d) "Consilience" of the Natural Sciences

Scientific knowledge is derived from the accumulation of time-tested observations from different disciplines that support scientific theories. The depth of scientific understanding and speed of attaining that understanding are accelerated as scientists draw on the existing body of reliable information. Scientific knowledge emanating from narrowly focused (reductionist) research, such as propulsion systems in squid or chemical communication in ants,[103] becomes strands in the web that scientists weave in their quest to understand actions, reactions, and interactions from sub-atomic to ecospheric levels. Hence, the network of scientists investigating how natural systems function is as complex as the ecological web.

New scientific disciplines such as biochemistry, molecular biology, biophysics, and on a grander scale, ecology, and oceanography have evolved, evidencing true "consilience". Scientists can draw on the accumulated knowledge to gain insights into their research and, consequently, to relate it to a broader context. The "consilience" of the natural sciences is providing today's scientists with the knowledge and

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[102] Andersen, *supra* note 78 and Windom, *supra* note 92.

[103] The renowned world-class biologist, Edward O. Wilson, has spent close to half a century studying ants, ant colonies, and ant communication, all over the globe. He is concerned about the place of science in society and society's neglect of biological inter-dependencies. Among his popular and insightful publications are *Sociobiology: The New Synthesis* (Cambridge: Belknap Press of Harvard University Press, 1975); *The Diversity of Life* (New York: W.W. Norton and Company, Inc., 1992); *Biophilia* (Cambridge, Massachusetts and London: Harvard University Press, 1984); *In search of Nature* (Washington, D.C. and Covelo, California: Island Press, 1996); and *The Future of Life* (New York: Alfred A. Knopf, 2002).

understanding necessary at the system, community, and organism levels to predict, with reasonable reliability, emerging ecological issues[104] and the impacts of existing issues. Hence, confidence in the ability of science and scientists should be high, providing actors can discern sound science from unsound science.

2) Scientific Uncertainty is a Certainty

Scientific uncertainty is inherent in the scientific process and must not be ignored or understated, as it can be reduced but never eliminated. Scientists have the tools and knowledge to incorporate sufficient pessimism (conservatism) into predictions and opinions, and good scientists routinely do this. Clarity about the presence of scientific uncertainty is a sign of thoroughness, not sloppiness.

The key is to *manage* scientific uncertainty through scientific and policy processes.[105] Management strategies vary depending on the degree and type of uncertainty involved and it requires forethought, planning, and open communication among actors.

Communication among actors and scientists regarding uncertainty has at least four purposes: (a) to allow actors to support or make decisions that overtly incorporate scientific uncertainty issues; (b) to encourage the incorporation of mechanisms to trigger a review of policy for effectiveness and to adapt to changes in scientific knowledge; (c) to help actors choose sound science, and (d) to appropriately and responsibly direct scientific funding. Only through understanding can science-literate actors become instrumental in reducing scientific uncertainty.

In summary, explicitly *institutionalising* scientific uncertainty in the policy-making process is imperative. Instead of using scientific uncertainty to justify inaction, actors

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[104] See Munn, *et al.*, *supra* note 98.

[105] See generally D. Jamieson, "Scientific Uncertainty and the Political Process", 545 *The Annals of the American Academy of Political and Social Science* 35 (1996).

must acknowledge its presence, ensure that the best available science is used throughout, and tailor policy accordingly.

3) Responsibility of Scientists

Scientists have a significant role to assume in integrating science into the policy-making process, encouraging its proper use by actors, and educating actors. Scientists, in fact, have been working on three areas for "consilience" of science and policy.

First, scientists recognise the need to involve other actors in planning and designing scientific research to accommodate policy needs.[106] This includes the generation, timely delivery, and communication of information that is both relevant and in a useable form, and communicating opinions that might not have attained the traditional 95% confidence level (i.e., less than complete information).[107] Actors must realise that the latter is difficult for scientists, as their reputation rests on the accuracy of their advice, which requires time and funds. Conversely, scientists must appreciate other actors' inability to await more certain information. A successful relationship requires clear and concise two-way communication, and science-literate actors who can understand the intricacies of scientific opinions, including both the capabilities possessed by and the investigative handicaps challenging the scientist.

The second and related area of focus is communication. Scientists, notorious for speaking in "foreign tongues", need to overcome the traditionally insular approach to science and ensure that actors have access to useful and useable scientific information. This may entail applying the "literacy filter" to provide illustrations or analogies to

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[106] GESAMP, 2001a, *supra* note 91, p. 29.

[107] *Ibid*. Note that the precautionary concept can be invoked where information is incomplete and scientists have reason for suspicion of harmful effects. Communication is key so that policy-makers understand the status of scientific information and the uncertainties and limitations associated with the current level of knowledge.

make data more comprehensible. Non-scientists require a context. Scientists and science bodies realise this, and many now consciously address the need to make their reports less technical and more comprehensible for policy-makers.[108]

A third and vital area is education by scientists of other actors about the importance of the scientific method and peer-review processes,[109] as well as natural science. Education may take many forms. For example, respected scientists increasingly publish popular science books,[110] write for newspapers and magazines, and publicly respond to situations in which actors rely on poor science or misuse science. The Union for Concerned Scientists is particularly active in the US, responding to poor science in the media and to that used for policy processes.[111] Scientists are starting to address the civic component of their duty as interpreters of nature, but more pro-activity is welcomed.

4) Responsible Reporting by the Media

The influential power of the mass media should be harnessed to promote confidence in the capacity of science. The mass media should be encouraged to assume the role of

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[108] One example is ICES, the oldest intergovernmental scientific marine body. See J. Wettestad, "Science, Politics and Institutional Design: The Case of the North-east Atlantic Land-based Pollution Regime", 18 *Marine Policy* 219 (1994), pp. 227-32. GESAMP also recognises the need for user-friendly reports. See GESAMP, 2001a, *supra* note 91.

[109] G.E. Brown, "Environmental Science under Siege in the U.S. Congress", *Environment*, Vol. 39, No. 2, pp. 12-31 (1997), p. 29.

[110] For example, see E.O. Wilson, *supra* note 103; C. Sagan, *The Demon-Haunted World: Science as a Candle in the Dark* (New York: Random House, 1995); L. Margulis and D. Sagan, *Slanted Truths: Essays on Gaia, Symbiosis, and Evolution* (New York: Copernicus/Springer-Verlag New York, Inc., 1997); P. Levi, *Other People's Trades*, translated by Raymond Rosenthal (London: Abacus Books, 1990). D. Suzuki, *The Sacred Balance: Rediscovering our Place in Nature* (Vancouver, Toronto: Greystone Books, 1997); Capra, *supra* note 9; S.A. Earle, *Sea Change: A Message of the Oceans* (New York: Fawcett Columbine, 1995); W.J. Broad, *The Universe Below: Discovering the Secrets of the Deep Sea* (New York: Simon & Schuster, 1997); J.L. Casti, *Searching for Uncertainty: What Scientists can Know about the Future* (London: Abacus Books, 1991); and Casti, *supra* note 93. Also see Appendix 1, The Paradox of Science, herein.

[111] For more information about the Union for Concerned Scientists, see the Internet: http://www.ucsusa.org/ucs-home.html. The Union for Concerned Scientists issued a Warning to Humanity in November 1992, putting society on notice of the need to change patterns of consumption and take steps to protect the ecosphere. Unfortunately, the press in the US and Canada did not find it newsworthy and it was ignored or downplayed. See Suzuki, *ibid*., p. 5.

educator of the public, with the goal of empowering laymen to make rational decisions about their environment, or at the very least, pose intelligent questions for determiners and enablers, and even scientists and other investigators.[112] Conversely, laymen who understand the need for sound science can demand fair reporting of the facts, issues, controversies, and uncertainties, and discourage the reporting of just sensational events or contrarian opinions.[113]

Reporters must assume some responsibility for differentiating pseudo-science, fringe science, and mainstream science. Balanced reporting and greater dedication to explaining the reasons for differences in scientific opinion will alleviate confusion that arises from conflicting reports. The professional qualifications of cited scientists, not the bias of the given reporter or publication, should determine the degree of public confidence. To this end, the educated public should support and encourage balanced and scientifically sound reporting. Public debate of the many facets of environmental issues is healthy and necessary, but attention must be paid to ensuring relevant, factual, and complete information is presented.

Part III Sailing on Open Water

MDLBA policy-making is not unlike sailing on the open ocean, where the navigational choices are vast and varied and no single course guarantees that the desired destination will be reached. A course must be plotted and headings adjusted according to winds, currents, the weather, other vessels, and even marine life. To reach port without being blown off course requires foresight, planning, a steady hand on the tiller, and a

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[112] See Susskind, *supra* note 5, pp. 136-7; S. Rothman and S.R. Lichter, "Is Environmental Cancer a Political Disease?", in P.R. Gross, *et al*. (eds.), *The Flight from Science and Reason* (New York: New York Academy of Sciences, 1996).

[113] Susskind, *ibid*.

discerning eye to ensure that the process ends at port, and not in disaster. MDLBA policy-making is also a process that requires flexibility to adjust to on-going change and new information. This section examines ways to incorporate science to ensure that actors do not remained stalled in the plotting phase, but move through the process to the end result of an effective environmental regime.

Three factors for the successful and systematic infusion of science into the policy-making process are: (a) the two-fold role that science should assume in each stage of the policy-making process; (b) suggested collaborative efforts and institutionalised mechanisms to respond to evolving conditions and thereby support adaptive and flexible policy; and (c) a "star to steer her by", namely the precautionary concept as an ethic that instils common sense into the policy-making process.

A. Ballast: A Role for Science

Sound science is ballast for effective environmental policies. As a ship without ballast is at risk of capsizing, sound science can help prevent the capitulation of MDLBA policy. Policy-making comprises several stages, discussed below, and science is vital to each one. The ideal contribution of science to each stage of the policy-making process is two-fold.

The first role is scientific, being the interpretation of the natural world and investigation of human impacts through objective and peer-reviewed scientific endeavour. Scientists, natural and social, and other actors should work together to define realistic and specific research objectives, establish arrangements to direct research so that management issues are met, and employ quality science.[114] The twist

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[114] GESAMP, *The Contributions of Science to Integrated Coastal Management*, GESAMP Reports and Studies No. 61, 1996, pp. 5-12 and 20-1. Also see L.C. Hempel, *Environmental Governance: The Global Challenge* (Washington D.C. and Covelo, California: Island Press, 1996), pp. 134-47.

on traditional science is the requirement for co-operation with determiners, enablers, and other actors to establish research priorities and projects.[115]

The second role is educational, involving communication and confidence building, as discussed above. Scientists throughout each stage must seek opportunities to educate, direct, guide, advise, challenge, or support actors in an effort to foster sound policy and discourage or eliminate misperceptions, myths, prejudices, abuse, neglect, misunderstanding, and confusion. Scientists and other actors (particularly determiners and enablers) must learn to work together throughout the relevant stages to recognise and use mechanisms that alleviate tension between the science and legal domains, develop ways to co-operate, and foster consensus. The goal is an on-going relationship among all actors, whereby each is accountable and respects the needs, limitations, and interests of fellow actors.[116]

GESAMP has detailed a role for science through five consecutive stages of an iterative, feedback-enhanced process for ICM.[117] Scientific contributions to an ICM programme are equally applicable to the MDLBA policy-making process, as the former is a facet of MDLBA, and both involve complex systems of inter-relationships.[118] Adapting GESAMP's stages and drawing on their role formulated from experience, a two-fold role for science at each stage of policy-making follows.[119]

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115 See Susskind, *supra* note 5, pp. 76-8. Susskind describes five scientific roles, namely trend spotters, theory-builders, theory-testers, communicators, and policy analysts.

116 *Ibid.*, p. 78.

117 GESAMP, 1996, *supra* note 114, pp. 20-1.

118 Policy-making must be viewed as an ongoing, multi-jurisdictional, multi-disciplinary process that is capable, through premeditated mechanisms, of responding and adapting to new information and changing morals, socio-economic, and other factors. A comprehensive MDLBA policy-making process should include an ICM programme, but it would also have to include management programmes for individual issue, with an overseeing body or integrative mechanism to ensure cohesiveness and comprehensive coverage. Any management programme should provide feedback to the policy-process to trigger policy review and revision.

119 For more details on the policy-making stages and the related role for science, see GESAMP, 1996, *supra* note 114, pp. 5-12. The issue is discussed only briefly herein to indicate the general role of science at each stage.

1) Stage 1: Issue Identification and Assessment

At this stage, science should collect and provide sufficient information to guide a multi-disciplinary team in subsequent stages of policy-making. Throughout this stage, social and natural scientists and other relevant actors would take the first step towards "consilience", as economic, social (e.g., values and interests), and ecological information establishes a basis for goal- and priority-setting. It entails compiling, integrating, and prioritising information to identify and assess ecological and social issues, and developmental, institutional, cultural, and other relevant contexts in which policy must operate.[120] Degraders, influencers, and investigators dominate this space.

Natural scientists must assume scientific and educational roles in roughly equal measure in this stage. They must identify the scientific priorities (e.g., ecological and research), trends, linkages, gaps in scientific knowledge, and scientific uncertainty, and consider the implications of their findings.[121] The role as educators is fundamental to the initial stage, as it is here that misperceptions, prejudices, biases, illiteracy, and other kinds of misunderstanding foment, particularly where influencers and degraders are encouraged to participate.[122]

2) Stage 2: Planning (Programme Preparation in GESAMP's Terms)

This organisational stage utilises information from the assessment stage as a basis for consultation and planning of a detailed strategy for action and policy. Programme

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Discussion of a detailed role is not possible herein, as each stage must be designed by a multi-disciplinary team focused on specific issues. Some issues are very well researched and it may be a matter of bringing together diverse data rather than embarking on new research. Refer to Hempel, *supra* note 114, for a very insightful discussion of each stage of the policy-making process, complete with pitfalls, constraints, and needs. Hempel discusses policy vehicles such as hard law (i.e. treaties), soft law (i.e. guidelines and declarations), and voluntary action plans (i.e. the GPA). *Ibid*., pp. 140-1.

120 GESAMP, 1996, *ibid*., p. 5.

121 *Ibid*., p. 7.

122 *Ibid*., p. 21. GESAMP also highlights other roles for science in this stage, such as identifying opportunities for the cost-effective use of existing data in place of new studies, the use of local scientists as opposed to foreign experts, and the role of cost-saving technologies.

objectives, desired environmental quality objectives, and competing values must be articulated in a concise way, together with the basis for involving other actors, where necessary.[123] The economic, ecological, and social costs of various options must be analysed and debated. The participation of diverse disciplines and actors and acknowledgment of the sincere interests of all are fundamental for the long-term integrity of any programme/policy. Investigators, determiners, and enablers dominate, although other actors would be represented when it would assist engendering acceptance of the strategy.

The scientific role in this stage includes research, monitoring, identifying characteristics or conditions of concern, elaborating on natural and anthropocentric influences, and collecting and providing the necessary scientific information to the relevant actors.[124] Co-operation between scientists and other actors to formulate specific questions for scientific investigation greatly enhances probability of success.[125] Together they must define the ecological objectives, define what is to be investigated, and why, and establish methodologies, including logistics such as required personnel and technology.

Scientists in the role of educator in the planning stage are vital to ensure that policy is grounded in sound science. Scientists can highlight alternatives to the most ecologically sound option where social, economic, or other conditions require. By explaining ecological priorities, scientists can work with other actors to tailor policy options that will provide sufficient environmental protection without undue economic or social costs. Scientists should identify decisions taken for reasons other than

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[123] *Ibid.*, p. 7.

[124] *Ibid.*, pp. 7-9.

[125] *Ibid.*, p. 9.

science, to avoid misconceptions of scientific endorsement and explain the issues to ensure that actors are clear on the scientific aspects, and potential economic implications of scientifically unnecessary strategies. Adopting strategies for ethical or other reasons is perfectly valid, but it is wrong to manipulate science or utilise poor/pseudo-science to mask the true basis of the decision.

Scientists, capitalising on an opportunity to educate and enhance policy effectiveness, can explain the need for and encourage the policy use of scientific feedback mechanisms to indicate whether the stated environmental quality objectives are being met and the desired level of environmental protection secured via the chosen policy and management strategies. Strategies may be diverse and innovative, including phase-in/phase-out periods for technology, practices, or substances, or monitoring for thresholds that will trigger pre-determined action.

3) Stage 3: Adoption and Funding

This is a crucial political stage, as policy choices must be marketed to politicians (most often ministers, heads of agencies, or even the head of government), funding agencies, and the public.[126] A well-organised, explicit, scientifically sound, accurate proposal with a detailed and substantiated budget for each stage will attract interest and encourage constructive dialogue among the broadened range of actors. Regardless of how soundly science was applied at the initial stages, this stage presents the greatest risk of neglect or failure to incorporate sound science – this is because this stage, more than any other, is one of negotiation, bargaining, and accommodation of interests that involves most actors.[127]

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[126] *Ibid.*

[127] *Ibid.*

The focus for scientists in this stage should be to educate, identify, explain, and if necessary, defend the policies as scientifically sound and cost-effective.[128] As issues are debated, scientists need to clarify and advise on repercussions of a range of actions, or inaction, ensuring that the scientific/ecological issues are understood and not overlooked in negotiations and that the pros and cons of various policy options are understood. Scientists must ensure that the best available scientific expertise is utilised, and point out any proposals based on unsound science.[129] Scientists should explain any divergences in scientific opinion, including whether they are superficial or peripheral to the main issue, or whether the experts disagree on fundamentals. Informed actors can then more effectively tailor strategies. Negotiation and accommodation are legitimate and necessary, as society must set priorities. Of utmost importance is that such a process has a sound scientific footing and the actors are conscious of the need for ecologically and economically rational policy. Scientists can be facilitators and ecological information can be a common basis for action.

4) Stage 4: Implementation

Having already adopted policies, interested parties should commit themselves to operationalising them. Controls, regulations, incentives, monitoring programmes, enforcement, and institutional arrangements are facets of an implementation strategy.[130] Possible issues to be addressed both before and during implementation, as lessons are learned, are conflict resolution, inter-agency co-ordination, *infra*structure

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[128] *Ibid*., p. 10. As nature's interpreters and recognising ecological complexity, scientists are not only the best, but the only actors competent to explain and clarify scientific aspects and ecological implications of management options.

[129] See Gray, *supra* note 75, p. 146.

[130] GESAMP, 1996, *supra* note 114, p. 10.

construction, development actions, public education, personnel training, and contemplation of new areas or problems.[131]

The scientific role entails continuous assessment of policy performance, revision and adaptation of techniques, experimental designs, monitoring programmes, and related scientific endeavours.[132] Scientists' designs and methodologies must produce results that are reliable, comparable to baseline data, and useful in relation to policy objectives.[133] Mechanisms must be incorporated to keep scientists involved, with freedom to revise scientific endeavours for effective results.

The scientist's role of educator is essential also in this stage. As a policy becomes operational, more actors become active in the process, increasing the risk of poor use of scientific resources, perpetuation of misperceptions, and inappropriate on-going priority setting.

Scientists, together with interested actors, must fully integrate themselves into the process to ensure effective implementation and operation of agreed strategies. Actors must remain flexible, reacting to new ecological, social, or other issues. When dealing with complex issues it is helpful to view this stage as a learning process, or in scientific terms, as an experiment. It promotes the mindset in actors that adaptation, revision, adjustment, and even revolutionary adjustment or new strategies, as required, are necessary and valid steps for the long-term integrity of the policy-making process and the environment. In place of inaction based on a "wait and see" mindset, scientists can provide the best available scientific evidence to justify rational action, or inaction, as required.

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[131] *Ibid.*, p. 10.

[132] *Ibid.*

[133] *Ibid.*

5) Stage 5: Review/Evaluation and Adjustment/Adaptation

Common sense dictates that evaluation of policy performance should be a standard procedure. How can learning, correction, or adaptation occur otherwise? Paradoxically, this stage is the one most often omitted or poorly addressed in environmental policy-making.[134] This is particularly true of scientific input. Effort spent developing this stage to review policies from all perspectives will highlight inefficiencies, ineffectiveness, "over-effectiveness", and successes.

Drawing on the previously defined objectives, baseline data, and identified indicators of progress, two primary questions arise from a proper evaluation: (a) "Should the next generation of the programme be revised, adapted, or refocused, given the findings of the review?" and (b) "Have the contextual boundaries changed since the initial assessment stage?"[135] Contextual boundaries may include priority issues, emerging issues, additional interested parties, breakthrough technology, newly available scientific information, or evolving social, ethical, or political interests. Policy-making is cyclical, or at least should be, and addressing these questions triggers a return to Stage 1 (assessment), initiating the five-stage process to promote flexible and adaptive policies and strategies as dictated by the evaluation.[136]

As noted by GESAMP, the scientific roles in this fifth stage are, first, to evaluate the scientific information generated by both research and monitoring for reliability, cost-effectiveness, and relevance to programme objectives; and second, to attribute – to the

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[134] *Ibid*. It is noted that this stage is either omitted or superficially addressed in ICM. Conventions seldom have provisions relating to mandatory, detailed reviews and, generally, domestic policy equally lacks such mechanisms. If proper evaluation of policy performance were undertaken, the perpetuation of unsound environmental policies would be reduced.

[135] *Ibid*., p. 11.

[136] *Ibid*. and K.N. Lee, *Compass and Gyroscope: Integrating Science and Politics for the Environment* (Washington, D.C. and Covelco, California: Island Press, 1993), pp. 51-86. Lee refers to the strategy of *adaptive management*, which is discussed in detail therein, with examples of both its successes and difficulties. His text is highly recommended.

extent possible – observed changes in baseline data to programme initiatives or to unmanaged factors.[137] Regardless of other interests, the primary objective is environmental and human protection, the effectiveness of which only scientists can determine. The role as educator is equally important here, as scientists need to interact with other actors to evaluate performance on a multi-disciplinary plane and plot the course for subsequent generations of the process.

B. All Hands on Deck: Institutional Transformation

The previous discussion set out why and how to incorporate science for rational MDLBA policy. Having said that, science should not dominate the process. As very well respected scientists noted almost four decades ago, it is not merely more science that is needed, but it is necessary to include specialists in political science, sociology, economics, and public administration to develop policies that recognise the role of humans in the ecosystem.[138] Despite the complexity that comes with cultural, social, political, and economic diversity, the actors in MDLBA policy-making must overcome their differences and *work together*, for a democratic process that produces workable solutions.[139] Debate, negotiation, compromise, bargaining, and accommodation should be accommodated in the policy-making process.[140] Although negotiation and accommodation dominated traditional policy-making, rarely was the process formally

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[137] GESAMP, 1996, *ibid*., p. 11.

[138] H.N. Scheiber, "From Science to Law to Politics: An Historical View of the Ecosystem Idea and Its Effects on Resource Management", 24 *Ecology Law Quarterly* 631 (1997), p. 646. For an integrative approach, also see P.M. Haas, "Prospects for Marine Governance in the NW Pacific Region", 24 *Marine Policy* 341 (2000).

[139] S. Rampton and J. Stauber, *Trust Us, We're Experts!: How Industry Manipulates Science and Gambles with Your Future* (New York: Jeremy P. Tarcher/Putnam and the Center for Media and Democracy, 2001), p. 301.

[140] *Ibid*., p. 301 and GESAMP, 1996, *supra* note 114, p. 9.

instituted to ensure all interests were represented and that it proceeded from a rational (scientific) basis.[141]

Following are suggestions to rationally address diverse concerns, to enhance flexible policy-making, and, in particular, to ensure that sound science is incorporated. They are also examples of "consilience" of policy and science. It is also hoped that these suggestions will enhance actors' willingness to commit themselves to rational policy-making processes and overcome complacency by reducing the sense of overwhelming intractability.

1) Epistemic Communities

An environmental epistemic community is a network of individuals with expertise or competence in a specific domain or sector, who, sharing a common outlook, are positioned to influence policy-making processes.[142] Epistemic communities may guide policy in ways that lobby groups or NGOs cannot, as members of the epistemic community possess technical and scientific knowledge useful to determiners and enablers, particularly where the issue is complex or information ostensibly conflicts.[143] "Consilience" via an epistemic community is evident in the case of the Mediterranean Regional Seas Programme, in which the experts involved were from interested countries and various disciplines, such as engineering, physics, oceanography,

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141 Social science, values, cultural concerns, and all other valid interests must be formally incorporated for a process that allows for rational debate.

142 P.M. Haas, "Do Regimes Matter?: Epistemic Communities and Mediterranean Pollution Control", 43 *International Organizations* 377 (1989); P.M. Haas (ed.), *Knowledge, Power, and International Policy Coordination*, 46 *International Organizations* (Special Issue) (1992); P.M. Haas, "Introduction: Epistemic Communities and International Policy Coordination", 46 *International Organizations* (Special Issue) 1 (1992); H. Breitmeier, "International Organizations and the Creation of Environmental Regimes", in O.R. Young (ed.), *Global Governance: Drawing Insights from the Environmental Experience* (Cambridge, Massachusetts and London, England: The MIT Press, 1997), pp. 90-2; O.S. Stokke, "Regimes as Governance Systems", in O.R. Young (ed.), *ibid.*, pp. 57-8; M. Valiante, P. Muldoon, and L. Botts, "Ecosystem Governance: Lessons from the Great Lakes", in O.R. Young (ed.), *ibid.*, pp. 197-225; and Hempel, *supra* note 114, pp. 124-8.

143 Epistemic communities are not limited to scientific or ecological issues, but may occur whenever experts come together.

microbiology, urban planning, and diplomacy.[144] In the Mediterranean, transnational members worked with domestic members, and together they were able to inform foreign ministry officials of the need to regulate specific pollutants and recommend solutions.[145] Scientists were invited to participate in their individual capacities, rather than as representatives of their governments, thus increasing professional autonomy.[146] Epistemic communities are most successful where they offer science-based consensual knowledge on priority issues and effective control measures. Their effectiveness comes from individual members influencing the mindset of other actors to encourage policy changes, rather than organising as a formal body.[147]

Commonality binds an epistemic community, but epistemic communities are not common. The level of consensus must be quite high to positively influence policy and, as discussed before, with systemic ecological issues scientific consensus may be elusive. However, other examples in which epistemic communities have influenced policy are the 1987 Montreal Ozone Protocol, the 1979 Convention on Long-range Transboundary Air Pollution,[148] and the management regime for the Great Lakes boundary waters between Canada and the US.[149] A more contemporary example is the agreement among the Parliamentarians of the Arctic Region to formally address ecological issues.[150] Scientists within these epistemic communities were successful, as

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[144] Haas, 1989, *supra* note 142, pp. 384-5.

[145] *Ibid*., pp. 396-7. In Mediterranean countries where the epistemic community consolidated its power, pollution control measures were the strongest, most effective and integrated with economics through sophisticated environmental policies, EIAs, and economic plans. *Ibid*., p. 397.

[146] *Ibid*., p. 387.

[147] Breitmeier, *supra* note 142, p. 91.

[148] Haas, 1989, *supra* note 142, p. 402.

[149] Valiante, *et al.*, *supra* note 142, pp. 218 and 224-5.

[150] See Minister of Public Works and Government Services Canada, *Report of the Second Conference of Parliamentarians of the Arctic Region, Yellowknife*, Northwest Territories, Canada, 13-14 March 1996 (Ottawa: Minister of Public Works and Government Services Canada, 1996).

they gained access to decision-makers where public concern and scientific knowledge signalled the need for scientific consultation.[151]

Actors in MDLBA policy-making should learn from environmental epistemic communities that have contributed to sound environmental management. Consensual knowledge within the epistemic community will inspire rational policy by giving determiners and enablers confidence in the knowledge they have been given. Solutions to the apparent intractability of land-based issues can flow from the confluence of information and scientific opinion.

Scientists can augment their role by consciously working to establish epistemic communities. By recognising that epistemic communities are most likely to arise where there is significant consensus on the core issue, scientists can consciously counteract *perceptions* of low consensus by explaining clearly the state of scientific knowledge – for instance, that conflicting opinions concern only peripheral aspects of a core issue. This "new-generation" epistemic community must unite to present a technologically and scientifically common position on which actors can rely, with clearly defined areas of consensus, and clarification of both scientific uncertainty and divergent scientific opinion.[152] Scientists must consolidate to provide sound advice and minimise confusion.

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[151] Haas, 1989, *supra* note 142, pp. 402-3. The power of the epistemic community spreads as members communicate with fellow members similarly committed to the issue in other states. The Mediterranean is the best example of the consolidated power of an epistemic community and its ability to direct regional policy despite social, cultural, and economic barriers and disparities among states.

[152] While the developers of the epistemic community concept may feel that the essence of their concept grounded in common outlook is lost where scientists debate scientific uncertainty, the argument is that the spirit of an epistemic community is vital in systemic ecological issues, as scientific discourse must promote clarity about consensus and uncertainty. Scientists must be able to say that, "we agree on a, b, and c, but differing opinions about x, w, and z result in a range of possible impacts…". The spirit of the epistemic community concept, namely the bond of commonality, remains.

2) Post-normal Science

"Post-normal science" refers to an extended version of the normal scientific methodology, or to "second-order science", that is applicable where scientific uncertainty is high, facts (and impacts) are uncertain, societal values are in dispute, ecological/health stakes are high, and policy decisions are urgent.[153] This is relevant today, as high uncertainty and/or potentially high stakes characterise many of the global and systemic issues that challenge MDLBA actors.[154] Where an issue spans cultures and values, and includes temporal and spatial aspects, post-normal science addresses the limitations of traditional (normal) science through a dynamic and revised approach to science input.[155] It incorporates traditional science, which remains fundamental, but also provides options for selecting scientific problem-solving methods appropriate to the level of uncertainty associated with the issue.[156]

In essence, as scientific uncertainty and the stakes increase, post-normal science extends the peer community of scientists to include other actors, and moves science away from almost sole reliance on traditional deductive methods towards interactive dialogue in the broader context of other scientific disciplines and society itself.[157] The primary aim is to articulate and manage uncertainty in *science and values* with clarity

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[153] S.O. Funtowicz and J.R. Ravetz, "A New Scientific Methodology for Global Environmental Issues", in R. Costanza (ed.), *Ecological Economics: The Science and Management of Sustainability* (New York: Columbia University Press, 1991), p. 139 and S.O. Funtowicz and J.R. Ravetz, "Uncertainty, Complexity and Post-normal Science", 13 *Environmental Toxicology and Chemistry* 1881 (1994).

[154] High stakes refer to potentially catastrophic or irreversible impacts. For example, global climate change falls into the "high stakes, high uncertainty" scenario, as the worst possible scientific scenario is catastrophe. .

[155] Funtowicz and Ravetz, 1994, *supra* note 153, p. 1881. The authors describe three types of science and their applicability to certain situations. Traditional research is sufficient for policy purposes where certainty is low and decision stakes are low. The second type is professional consultancy, where the decision stakes and uncertainty are moderate to severe, and the issue is beyond traditional ecological concerns. For example, the consultant, i.e., engineer, must consider human safety in relation to the consultant's client and the broader community. Finally, in post-normal science, the decision stakes and uncertainty are severe, and the issue involves the global community and ecospheric integrity. See *ibid*., pp. 144-8.

[156] *Ibid*., p. 1882.

[157] J.R. Ravetz, *Scientific Knowledge and Its Social Problems* (Middlesex, England: Penguin University Books, 1973), p. 17, and Funtowicz and Ravetz, *ibid*., p. 1881.

and transparency. It embodies the philosophy underlying "consilience", bringing together all knowledge.

The extended peer community should perform at least two vital functions: quality assurance and access to "extended facts".[158] Extended facts have always been available, but have been largely untapped by scientists and determiners and enablers alike. Actors who may be in possession of extended facts include investigative journalists, the public, school children performing monitoring tasks, indigenous and local people, commercial fishermen, birdwatchers, amateur naturalists, industry, NGOs, and others with relevant local or empirical knowledge. Extended facts do not have much relevance to traditional or "normal" science, which is concerned with traditional, rigorous scientific research methods. However, they may serve as a quality assurance check for post-normal science. Extended facts contribute to quality assurance of data, as local and practical knowledge can be used to confirm the accuracy of scientific predictions, assumptions, biases, and models.

Access to the extended facts is relevant in uncertain and complex issues, as the extended facts include not only ecological information, but also the beliefs and feelings of people affected by a particular decision. "Fact extension" solves two problems: first, it gives scientists more information with which to resolve scientific questions and reduce uncertainties; and second, it forestalls alienation and fosters trust through inclusion.[159]

Post-normal science has emerged in response to the high degree of uncertainty inherent in complex, dynamic, contemporary environmental issues that allows scientist to

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[158] Funtowitz and Ravetz, 1994, *ibid*., pp. 1883-5 and Funtowitz and Ravetz, 1991, *supra* note 153, pp. 148-50.

[159] Funtowitz and Ravetz, 1991, *ibid*., pp. 149-50.

predict a range, and not specific, outcomes – a type of uncertainty that has been termed "epistemological".[160] To paraphrase the authors, epistemological uncertainty requires an extended peer community to help manage it for the common good and overcome the false assumption that uncertainty can be ignored or conquered.[161] The success of post-normal science will partially depend on its mobilisation from within the scientific community. It will also depend on other actors' willingness to concede that scientific uncertainty is inherent in science, that many questions are simply unanswerable at this time, and that questions must be recast to derive meaningful information for policy purposes.[162]

Although post-normal science extends scientific endeavour to meet the challenges of contemporary environmental problems, it does not replace the need for or use of "normal" science in policy-making. It should not be a surprise to learn that ICM, systemic approaches to environmental issues, sustainable development, and many contemporary legal principles already embody the spirit of post-normal science. The concept of post-normal science legitimises and clarifies roles for diverse actors, while infusing quality science into the policy-making process. Post-normal science embraces "consilience" by incorporating an extended peer community to manage uncertainty through participation of actors with various values, interests, and knowledge in contemporary MDLBA issues.

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160 Funtowitz and Ravetz discuss in detail three types of uncertainty: technical (inexactness), methodological (unreliable), and epistemological (bordering on ignorance). They refer to three types of problem-solving methods, ranging from applied science (mission-oriented), to professional consultancy to post-normal science. See Funtowitz and Ravetz, 1991, *ibid*., pp. 141-8.

161 *Ibid*., at p. 146.

162 A.M. Weinberg, "Science and Its Limits: The Regulator's Dilemma", 2 *Issues in Science and Technology* 59 (1985-6), pp. 67-8.

3) Independent International Scientific Advisory Body

An international body of independent scientific advisors drawn from all professional sectors is suggested as an option to ensure that sound science informs policy-making processes. Independence is crucial to freedom of opinion, and dispels concerns about bias.[163] It would be redundant to form an independent body solely for MDLBA, given the extensive work of GESAMP in the area of marine affairs, including land-based issues that incorporate coastal and freshwater environments.[164]

GESAMP is ecologically progressive, as reflected by its name change in 1994 – from the Joint Group of Experts on the Scientific Aspects of *Marine Pollution*, to the Joint Group of Experts on Scientific Aspects of *Marine Environmental Protection*.[165] GESAMP is an advisory body of mostly independent scientists, which provides scientific advice primarily to its sponsoring UN agencies on prevention, reduction, and control of marine environmental degradation.[166] GESAMP does not undertake scientific research, but instead collects data and assesses methodology, determines priority issues, and advises on or recommends scientific, management, and policy strategies. By mandate, GESAMP's focus is the marine environment. In practice, however, it is broader, as evidenced by at least two of its reports, which include LBA and their impact on fresh water[167] and deforestation, farming, urbanisation, dams, and

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[163] For instance, the IPCC has suffered from allegations of bias because of its status as an intergovernmental body. The independence allowed the government scientists and the degree of political interference in the drafting of the report has been raised.

[164] See GESAMP 2001b, *supra* note 8 and GESAMP 2001a, *supra* note 91.

[165] See GESAMP's homepage on the Internet at: http://www.gesamp.imo.org/index.html. Emphasis added.

[166] GESAMP's role is articulated on the inside cover of most of their publications. Its sponsoring agencies are IMO, FAO, UNESCO, IOC, WMO, WHO, IAEA, UN, and UNEP. GESAMP members act in their individual capacity and their views are independent of their respective employers.

[167] GESAMP, 2001b, *supra* note 8.

mining.[168] As the marine environment has been an effective catalyst for regional and global action on LBA, it also provides a legitimate basis for GESAMP to extend their mandate to land-based issues.

Perhaps GESAMP and its sponsoring agencies should consider formally extending GESAMP's mandate to encompass land-based issues. Already terrestrial ecologists, meteorologists, and a host of other scientists participate in GESAMP projects, although its core membership remains marine experts. Furthermore, social scientists and other non-scientists often collaborate with GESAMP and, consequently, its reports offer comprehensive policy suggestions.[169] GESAMP might consider extending membership to other disciplines, both scientific and non-scientific. Alternatively, GESAMP may establish formal ties to scientific advisory bodies on other MDLBA issues, or encourage reports by independent scientists, as required. Endorsement by GESAMP would lend credibility and reliability, boosting the confidence of actors who may otherwise question the degree of scientific soundness.

Regarding users, GESAMP members and sponsoring agencies should be encouraged to extend its primary mandate beyond advice to the sponsoring agencies. Distribution of reports to domestic agencies, policy-makers, environmental lawyers, and other non-scientific actors should be a priority. Regular reference to GESAMP reports offers actors two primary benefits, namely enhancing their understanding of scientific issues and, second, providing scientifically and economically sound recommendations as a basis for rational discussion. Scientists, including GESAMP members, do not wish to

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[168] GESAMP, *Anthropogenic Influences on Sediment Discharge to the Coastal Zone and the Environmental Consequences*, GESAMP Reports and Studies No. 52, 1994.

[169] One example of many is the *Report of the Second Meeting of the Working Group on Marine Environmental Assessments of the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP)*, Geneva, 25 April 1998, 6 May 1998, where a list of reviewers proposed for the draft of the report on LBA (now published as GESAMP, 2001b, *supra* note 8) includes numerous non-scientists.

usurp or hijack decision-making processes, but rather adopt a role to inform determiners and enablers for the formulation of sound policy.

GESAMP is a model for an independent body of scientists whose work can inform environmental policy-making processes.[170] If GESAMP does not respond to the call to extend their range of users[171] or their membership to include more disciplines, perhaps epistemic communities could be developed to fulfil the need for independent scientific advice.

Independent scientific evidence is required to inform policy, and dispense with the common practice of seeking science to support a pre-determined position. Such independent science exists, but is largely untapped by MDLBA actors. Examples include HOTO and GOOS globally, and their regional counterparts. Co-ordination and greater visibility of these bodies and their work are required to ensure reliance on these valuable resources. Ways of increasing visibility of both GESAMP and other responsible science bodies and initiatives are numerous, with one effective and relatively inexpensive option being the creation of an Internet website that lists and links the bodies, and is then widely advertised through Internet Bulletin Boards, UN bodies, journal notices, notification to government and NGO offices, and other sources tapped by actors.[172] Scientists would have to manage such a site to ensure that only sound science was linked.

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[170] If this is not feasible, it is suggested that an umbrella organisation be formed that will review and compile scientific works, including GESAMP reports, to ensure that actors have access to sound science.

[171] Many non-science actors, if aware of GESAMP, often overlook GESAMP's work as purely marine science. More frequently, they are not even aware of GESAMP or its reports. GESAMP and its sponsoring agencies need to become more involved in marketing GESAMP's work and products.

[172] This web site would require more than updating by an existing, overworked secretariat. To be useful and reliable, it must be maintained with the equivalent of scientific rigour.

4) International Bodies to Oversee MDLBA

(a) Co-ordinating Body for MDLBA Issues

The notion of creating an international body exclusively to oversee MDLBA is as intractable and controversial as MDLBA itself. However, as the shortcomings of the present, treaty-focused global regulatory system are becoming more apparent, there are more calls for ecospheric, anticipatory, co-ordinated regulatory models that reject the compartmentalisation and fragmentation of issues.[173] As the entrenched nature of the treaty system, sovereignty issues, and economic costs preclude the creation of a wholly new system of governance, a possibility would be the restructuring of existing relevant UN organisations to reflect the inter-connectedness of ecosystems.[174] Another option to consider would be assigning a new function to an existing body to co-ordinate the ongoing work of current treaty and action plan secretariats. Formalists and functionalists must unite.

The ideal would be to establish an international co-ordinating body to foster ecospheric integrity and encourage "consilience" of science, law, economics, and other disciplines, and thereby contribute to rational and sound global, regional, and domestic policy. A co-ordinating body for MDLBA should encompass virtually all land- and sea-based issues, consistent with the broad and all-encompassing definition of MDLBA and to ensure comprehensive coverage. In effect, MDLBA would be the

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[173] W.J. Davis, "The Need for a New Global Ocean Governance System", in J.M. Van Dyke, *et al* (eds.), *Freedom for the Seas in the 21st Century: Ocean Governance and Environmental Harmony* (Washington, D.C. and Covelo, California: Island Press, 1993), pp. 147-70. Also see A. Yankov and M. Ruivo, "An Ocean Assembly", in P.B. Payoyo (ed.), *Ocean Governance* (Tokyo, New York and Paris: United Nations University Press, 1994), pp. 330-49 and E.Mann Borgese, "Sustainable Development in the Oceans", 27 *Environmental Policy and Law* 203 (1997).

[174] G. Palmer, "New Ways to Make International Environmental Law", 86 *American Journal of International Law* 259 (1992) and M.F. Strong, *Where on Earth are We Going?* (Toronto: Alfred A. Knopf Canada, 2000), pp. 287-343.

catalyst for ecospheric coverage, just as the LOSC is a constitution for Earth, not just the oceans.

The mandate of the body and its composition would require careful consideration by a multi-disciplinary task force. Its primary characteristics could include multi-disciplinary membership, links to treaty and action plan secretariats, formal mechanisms for the infusion of science, and links to GESAMP and other scientific bodies, NGOs, and other associations of actors, including social scientists. Such a body could advise international negotiations to ensure consistency among treaties and other regulatory instruments, and ensure that the best environmental options are adopted, not just the best option for the specific issue at hand. It could advise on policy soundness. Without having to fundamentally reorganise the present infrastructure, a co-ordinating body could foster enlightened thinking about long-term ecospheric protection.

(b) A Global Environmental Think-tank

An environmental think-tank could prove invaluable, as the global community of policy-makers are in relatively calm seas after three decades of attending conferences, drafting treaties and other instruments, and making international environmental law. Policy-makers have addressed ecological concerns much as sailors do boat repairs at sea: do what is necessary to keep the forward momentum. As most environmental issues are now subject to some regulatory measures or strategy, actors now have an opportunity to consider overhauling the policy-making process to improve efficiency and effectiveness. This opportunity is welcome, as the emergent ecological issues are chronic, systemic, invisible, characterised by degrees of risk, and permeated by ethics and values.[175] They require careful consideration as there is no single correct solution, but there are many inappropriate ones. An environmental think-tank with multi-disciplinary membership could consider and integrate all factors – including social and psychological – and link strands of inter-connectedness. It could develop sound strategies and options for environmental management, including scientific roles, policy measures, legal principles, and social action.[176] It is time to revisit current policies, including the legal principles and strategies, and plan and design improvements where necessary that are consistent with consilience of information.

5) Emergence of a New Discipline at the Interface of Law and Science

The introduction of facilitators into the policy-making process is recommended. Facilitators must be "specialised generalists" who have a broad understanding of all disciplinary concerns, or, at least, appreciate the inter-linkages among disciplines in order to seek out the proper information as needed.[177] They should be tuned to identify confusion or misconceptions and set them right or seek clarification: many times actors agree in essence, but disciplinary differences terminology or expression mask this, and they talk at cross purposes. The aim is to facilitate communication to ensure that action taken, or not taken, is sound for the resources invested, and that real, not just

[175] Environmental treaties have addressed many acute problems, although socio-economic and political issues, rather than law or science, perpetuate some problems, with examples including rainforest and mangrove preservation and desertification. The developed world confronts environmental degradation issues that are chronic and primarily related to lifestyle. The price to pay for old-growth forests, global climate change, clean air versus acceptable air, water quality issues, and other such issues are largely a matter of social values and choices. Conversely, the developing world struggles with the cost of remedying environmentally degrading practices that are at the heart of human survival.

[176] For direction, see E. Mann Borgese, "The Process of Creating an International Ocean Regime to Protect the Ocean's Resources", in J.M. Van Dyke, *et al.* (eds.), *Freedom for the Seas in the 21st Century: Ocean Governance and Environmental Harmony* (Washington, D.C. and Covelo, California: Island Press, 1993), pp. 23-37.

[177] The facilitator need not understand the intricacies of all disciplines, but have an appreciation of them. For example, he need not know social science theories, but his level of understanding must be such that he can appreciate when a social scientist may be able to assist in issue resolution.

public-focus, priorities are addressed. Such a role is emerging at the interface of science and law.[178]

New multi-disciplinary programmes such as Masters studies in marine affairs or ICM acknowledge the need for cross-disciplinary understanding and training, although the formal organisation of a distinct discipline to train facilitators remains elusive. Holding promise for the future, some actors see the need for and are now informally assuming the role of facilitators, or synthesisers of knowledge. The emerging group of actors who perform this function on an *ad hoc* basis are not presently associated with any particular discipline, but have certain characteristics in common. They are multi-disciplinary by training or self-education (must have a diverse knowledge base), good communicators (in particular, they are good listeners), problem solvers, lateral thinkers, open-minded, visionary, people-oriented, science literate, and grounded in common sense.

At present, facilitators/synthesisers participate in the policy-making process on an *ad hoc* basis, with individuals mostly unconsciously assuming such a role. However, the *role* assumed remains largely unrecognised, as other actors note the helpful individual but no thought is given to institutionalising the role.[179] The facilitators' value lies in their broad understanding of all issues, acceptance of the validity of each actor's interests, and an awareness of what information is useful when and who has access (and who *should have* access) to it.[180] They can facilitate the regulation of MDLBA by

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178 T. Justice and D.W. Jamieson, *The Facilitator's Handbook* (New York: American Management Association, 1999).

179 Other actors tend to view individuals as helpful, rather than recognising that the role as facilitator/synthesiser is useful in many instances and perhaps should be institutionalised.

180 For instance, a good facilitator would know instinctively when an engineer, biochemist, reef specialist, geographer or other discipline should be consulted or may have constructive information to contribute to the process.

bringing actors together in a meaningful way, helping articulate each actor's interests, encouraging transparency and clarity of thought, discouraging secret agendas, highlighting ecological bases for action, and seeking satisfactory compromises for conflicts.[181]

The overarching role of facilitators/synthesisers is to ensure co-ordination and meaningful inclusion of the various actors and activities in the policy-making process. Conscious recognition and formal institution of such a category of actors in the environmental policy-making process would promote effective action and accountability; the latter two elements being conspicuously absent from the present policy-making process.

C. "And a Star to Steer Her By":[182] The Precautionary Concept

As sailors once used stars to help chart their course, so do policy-makers today. The "stars" are many, from legal principles and legally binding instruments, to management strategies and action plans. However, like sailors using the North Star for reference, policy-makers may have one guiding star, if they wish to use it – the precautionary concept.

1) The Precautionary Concept

Just as the precautionary concept's popularity emanated from the breakdown of trust in scientists and science, it can be used to rebuild that trust and to convince actors and the public that science is necessary for effective environmental policy.[183] The

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181 Many international diplomats are particularly adept at this.

182 This line is taken from a poem by John Masefield, "Sea Fever", in M. Harrison and C. Stuart-Clark (eds.), *The New Oxford Treasury of Children's Poems* (London: Oxford University Press, 1995), p. 88.

183 For an insightful discussion on the role of trust and the public perception and acceptance of risk, see Slovic, *supra* note 40.

precautionary concept is undoubtedly accepted as a legitimate principle of international environmental law, and is a fundamental and valuable one when it is used in a scientifically sound way.

The philosophical soundness of the precautionary concept is attractive. At its simplest, it calls for a rational approach to environmental policy-making, which is to ensure that policy is ecologically sound and that the economic and social costs of action, or inaction, are justified. Sound interpretation demands the participation of scientists to provide opinions, explain uncertainties, and co-ordinate with other actors to tailor policy as previously discussed. Scientists should not be excluded simply because they may lack full knowledge about an issue, but rather scientists should be included to share their knowledge (including what is known and unknown) and to explain the implications of such knowledge.

In fact, as precautionary concept is so fundamental to "steering" policy-making processes, it is proposed it be viewed as an *ethic*, as well as a legal principle. Instinctive self-preservation leads most individuals to live by a precautionary ethic, so it is not a great leap to extend personal security concerns to the environment. As an ethic, it could transform policy-making processes, as actors would automatically proceed thoughtfully and rationally regardless of the environmental issue at hand. Science-literate actors who understand both ecological concerns and the mechanisms of science would find it easiest to cultivate the precautionary ethic. Conversely, the precautionary ethic would encourage less literate actors to consult scientists and other disciplines as they rationally ponder issues. The precautionary concept should be seen as institutionalising common sense, advocating the age-old philosophy of "looking before leaping".

2) New Mindset: A Global Experiment

The precautionary concept as an ethic institutionalises a new mindset for actors. In addition to the requisite common sense, it encourages all actors to exhibit some of the curiosity common to scientists by partaking in a grand experiment. Managing large-scale ecosystems, central to addressing MDLBA, is little different from a scientific experiment, and thus requires the same tactics. The actors must be quick to adapt policy to new information and environmental or social changes and adjust their actions accordingly, being flexible, objective, analytical, creative, skeptical (cautious), integrative, persevering (following up inconsistencies), and thoughtful, seeking the truth and not merely expedient resolutions.[184]

By adopting the mindset that environmental management is a global experiment, and that knowledge and truths will be discerned throughout an on-going, knowledge-building process, unsuccessful strategies, inaccurate assumptions, the emergence of unexpected phenomena, misstated values, and any other "missteps" can be used to inform the policy-making process and trigger rational responses, preferably through a pre-determined mechanism or procedure. Expectations, and definitions, of success change as actors accept the long-term nature of their endeavour and the need for adaptive management.[185]

Part IV Becoming Master Mariners

Master mariners are able, multi-disciplined, seasoned sailors who captain their vessels with skill and wisdom, inspiring the trust of the crews and vessel owners. A master mariner prides himself on making informed decisions, taking into account the safety of

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[184] See Lee, *supra* note 136, pp. 51-86. Adaptive management is a very appealing strategy that advocates common sense. It is a central theme in his text, and is recommended reading.

[185] *Ibid*.

vessel and crew, and the need to smartly reach port to satisfy the owners. He seeks weather reports from government agencies, checks his own navigational equipment, and, finally, checks by eye the conditions outside the wheelhouse. The knowledge required encompasses vessel mechanics, the physics of floating objects, and geo-physical forces, all of which could be crucial to survival in stormy seas or hazardous waters. An understanding of basic psychology is important to anticipate the crew's reactions under various conditions. If any chances are to be taken, the options and risks are well considered, as the master mariner knows that he alone is accountable for the vessel's safety.

The mandate of MDLBA determiners is not so different from that of the master mariners – both must safely deliver their cargo (habitats, in the case of determiners), despite uncertain conditions and unanticipated events. The shipping industry will not settle for incompetent captains; why should the global community accept inept actors leading policy-making processes? Determiners are not accountable to the same degree as captains, and societal arrangement have not produced, demanded, or even encouraged informed policy-making. To this end, two suggestions are made that could foster knowledge-based policy-making and move determiners to the rank of master mariner. The first is a practical recommendation that GESAMP be assigned a "navigational" role in an endeavour to increase the scientific literacy of determiners and enablers in particular. The second recommendation is a diplomatic strategy to facilitate the infusion of science into policy-making, with the ultimate aim of creating an effective environmental regime for regulating and managing human activities on land.

A. GESAMP: Assuming a Navigational Role

It has been shown that a large proportion of civil society,[186] particularly determiners and enablers, lack the level of scientific literacy necessary for informed, or knowledge-based, policy-making. Immediate action should be taken to develop and design a scientific literacy programme for those who have direct and immediate impact on policy-making processes; most notably the enablers and determiners, together with influencers, such as NGOs and funding agencies, and non-scientific investigators.

As the programme must address many issues outside of substantive science, it requires significant forethought to make it operationally sensible and successful. Actors must be enticed to dedicate time from already hectic schedules. Materials must be comprehensive without being overwhelming, and designed to be reference sources useful to the actors and, optimally, their colleagues, in carrying out their duties. The science must be understandable to laymen, ecological inter-connectivity detailed, and links within environmental issues and to non-environmental factors clearly demonstrated. The "how and why" of science must be clear and concise. It is not an easy mandate.

Designing an *effective* scientific literacy programme is a challenge for the international community, and for scientists who must be the core designers, but work with non-scientists to establish the appropriate content and method for imparting the knowledge. The concept, in outline, is to tackle the problem in four phases. The first phase is investigative and involves identifying the actors who would benefit from such a programme and their areas of deficiency; outlining the general contents of a

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[186] "Civil society" is a term that is becoming increasingly popular to refer to "that aspect of social organisation that is not governmental". See J. Ayling, "Serving Many Voices: Progressing Calls for an International Environmental Organization", 9 *Journal of Environmental Law* 243 (1997), p. 258. Two components of civil society noted are NGOs and epistemic communities. *Ibid*., pp. 258-60.

programme and preparing material; and investigating the various options for teaching it. The second phase involves designing the specifics of the programme and preparing the materials. Phase 3 involves implementing the programme. Of course, a subsequent phase (or phases) should involve review of the programme and its successes, improvement of materials and methods, and implementation of any recommended changes. The first phase is of primary concern here.

Although the first phase could be undertaken by various entities or organisations, GESAMP is the recommended body, for several reasons. GESAMP is an international body, primarily comprising scientists, although it involves a broader spectrum of disciplines in its activities. Its members are particularly suited for this as they are accustomed to operating in the international community. As it has been providing scientific advice on marine environmental issues to its sponsoring agency since its inception in 1969, GESAMP has vast experience with many types of policy issues, and its members know first-hand the specific scientific (il)literacy problems experienced by non-scientists.

Consequently, its members understand types and areas of information deficiency and perhaps have insight into ways and means of most effectively imparting scientific information. Its members come from all career paths, for example the civil service, academia, NGOs, and industrial research. They bring a wealth of experience based on the frustrations and knowledge deficits in their own domestic and regional work. Members also emanate from a wide range of scientific disciplines, with specialisations in many aspects of environmental issues. They are geographically and culturally diverse, and because of their work with GESAMP, and often other agencies and organisations, the members are well connected within regional and global networks.

Organisationally, GESAMP offers benefits as well. The networks often extend beyond scientists to include non-scientific actors, particularly where a GESAMP member is also part of an epistemic community, or perhaps a regional seas organisation or ICM initiative. Further, GESAMP is generally recognised as an independent body of scientists, whose scientific opinions may not reflect those of the respective employers. GESAMP members have a grasp of policy issues and strategies for environmental management, as evidenced by the many reports that include specific policy advice or recommend strategies for policy purposes.[187] Finally, GESAMP's placement within the UN system of organisations and its sponsorship by numerous agencies provides access to people, resources, and data from many disciplines, geographic locations, and environmental and non-environmental issues that few other organisations can match. It provides an opportunity to mobilise some of GESAMP's retired members and senior scientists who have witnessed the changes in science, law, and policy and in their interface over the three decades of environmental regulation. Their experience and wisdom is needed to help institutionalise science in policy-making processes.

The above describes GESAMP's general suitability. Specifically, its operational history is appealing, as advice given has related to methodology and management options. Thus, members are accustomed to collecting and analysing information from relevant sources around the globe, noting substantive and organisational deficiencies and benefits. Additionally, GESAMP's ecological focus on marine environmental protection has broadened to encompass LBA, freshwater issues, and relevant aspects of other environmental issues such as global climate change, as evidenced by its recent

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[187] See GESAMP, *Environmental Capacity: An Approach to Marine Pollution Prevention*, GESAMP Reports and Studies No. 30, 1986; GESAMP, *The State of the Marine Environment*, GESAMP Reports and Studies No. 39, 1990; GESAMP, 1991, *supra* note 38; GESAMP, *Guidelines for Marine Environmental Assessments*, GESAMP Reports and Studies No. 54, 1994; GESAMP, 1996, *supra* note 114; GESAMP, 2001b, *supra* note 8; and GESAMP, 2001a, *supra* note 91.

reports.[188] Although it maintains the reference to the marine environment in its name, GESAMP is an ecologically integrative body.

Countering GESAMP's suitability are a few factors that must be considered, although they can be overcome. The first is GESAMP's reliance on its sponsoring agencies to set its agenda. Second, as GESAMP members are generally employed full-time, their available hours to perform GESAMP duties are limited. A third factor is financial concerns, as GESAMP is funded by its sponsoring agencies and resources are tight. Such details should be resolvable, providing there is commitment to the programme. Should GESAMP, or, more realistically, its sponsoring agencies, decline involvement, support for a scientific literacy programme can be sought among organisations such as private foundations, NGOs, and academia. In this case, given GESAMP's ideal suitability to such a programme, perhaps it could assume a consultancy role to a primary organisation. To neglect GESAMP's wealth of expertise and experience would be folly.

While such a study is among the first of its kind, it is reasonably straightforward, being the first step in a process that should ultimately see the implementation of a scientific literacy programme.[189] Assuming the study is undertaken under the auspices of GESAMP, the study committee should comprise both GESAMP (or GESAMP-recommended) scientists and non-scientific actors, preferably from several different disciplines. The recommended product is a report roughly in the format of current GESAMP reports. The objective is to elaborate on the need for and general

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[188] GESAMP, 2001b, *ibid*. and GESAMP, 2001a, *ibid*.

[189] GESAMP's or GESAMP-recommended scientists should be involved in the second phase, designing a programme, which will require innovative thought and creative methods, although this is merely scoped out in a general way in the first phase, with a detailed curriculum to be developed subsequently. It would be ideal if GESAMP could remain involved throughout.

description of a scientific literacy programme for targeted actors in the MDLBA policy-making process.[190] This should include prioritising actors by category, disciplines, or role, on a "*need* to understand science" basis. For example, it is expected that any survey would reveal that determiners and enablers are a top priority for scientific literacy education, perhaps followed by investigators from disciplines other than the natural sciences, followed by influencers, with the media targeted as the prime concern. Following this should be an overview or summary of the critical deficiencies experienced by the actors or particular groups of actors and a framework of topics that should be taught. The logistics of imparting the information to the targeted actors and the format of the material should also be discussed.

Having as its ultimate goal the implementation of a science literacy programme, one goal of the study would be to ensure that the initial report provides detail, scope, and information sufficient to inform the second phase, the programme design. With this in mind, the study committee, drawing on collective and individual experience and expertise, are in the position to determine the scope of the study and issues to be addressed. It is expected that non-scientists (the actors who will ultimately take the literacy course) would be consulted or polled.

Without usurping the study committee's mandate, it is appropriate to envision here some broad aims of the study. The first aim is to elaborate on the need for such a programme, and in so doing evaluate the needs of the various actors. The needs vis-à-vis various categories of actors should be examined, including geographic and political distribution. For example, it has been the author's very general observation that

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[190] The actors targeted should be those involved in regulating and managing human behaviour that results in ecospheric degradation. It must not be restricted to only those involved in marine issues. Having said that, it may be that a pilot project involving one particular sector of actors may be deemed the most sensible initial step.

determiners (including international lawyers) from developing states require more persuasion to even consider scientific aspects, as economic and sovereignty issues dominate in their home countries; whereas determiners from developed states more often embrace ecological, but not broader scientific, considerations. The latter often *believe* they are acting ecologically responsibly, but their poor understanding of science leads to poor decisions. This is an important distinction, as the two mindsets – "Prove to me that science is important!" and "I am ecologically sensitive, so what more do I need to know?" – demonstrate that needs are not uniform across categories of actors. Thus, in evaluating the need for scientific literacy, identifying the specific need is as relevant as who has the need.

The second aim could be to identify the challenges, and avenues for overcoming them, for each phase of the scientific literacy project, from this initial study to implementation of the literacy programme. The most obvious challenges are financial and institutional. Financial concerns transcend all three phases – who should pay for each phase? Answers to this will partially depend on the chosen means and methodology of implementation.

Decisions regarding implementation may be interlinked with available sources of funding and willingness to participate. For example, it may be decided that a pilot project focussing on an existing regional seas programme area may be the most appropriate first foray as benefits can be measured within the area, all actors can be targeted, and a particular region is keen to learn and willing to provide some or all funding. Another possibility could be that determiners and enablers within UN agencies either globally or within a region will become the target participants. The study committee will have to canvass jurisdictions and institutions for enthusiasm and commitment. Other challenges relate to educational, intellectual, and pedagogical issues, which are primarily relevant to the design and implementation phases.

Vitally important, but often overlooked, are challenges involving administration and logistics. For example, who will draft the programme materials – should it be contracted to an institution, or should GESAMP-recommended scientists and others work on specific chapters, with an editor? Who will collate the material if it is contracted out and review it for flow and consistency? Who will finance the scientists and non-scientists collecting the materials and doing the drafting, as well as organise publication and distribution. Answers to these questions are contingent on answers to other considerations, encouraging a broad review of options and possibilities. It is important to identify all challenges, even if they are not resolved in this phase.

The third aim relates to the design of the programme. The committee's mandate should include the determination of the broad programme outline, without delving into the detailed curriculum. This includes very concise clarification of the programme objectives. For example, the author believes that conveying an understanding of the scientific method and scientific capacity – both capabilities and limitations – is as important as, if not more important than, understanding ecological principles and inter-connectivity. Only through scientific literacy will actors understand ecological options and be in a position to communicate effectively with scientists.

A substantial and detailed manual, complete with index, is recommended, as actors could greatly benefit by having on their desks a GESAMP-endorsed, user-friendly guide to science and environmental issues. Ideally, it should constitute part of the core materials. Such an extensive manual may be considered separately from the literacy programme, for distribution to (or purchase by) whomever may find it useful. For example, sensible ideas would be to sell the manual at university bookstores, particularly where environmental management or law programmes are offered, and offer it for sale (or free, should funding permit) on the Internet and through UN offices. This would provide many actors access to sound science.

To this end, the study committee could scope out an outline of the manual, at least in relation to the programme. Recommended inclusions are: scientific methodology, a role for science in policy-making, discerning sound science from poor and pseudo-science, ecological principles, environmental issues and their inter-connectivity, areas that commonly confuse or mislead non-scientists, and examples of ecologically and economically unsound policy as a result of ignoring or choosing inappropriate science. In short, the study committee can design a manual in this phase, leaving preparation of actual materials to a subsequent phase and group.

The fourth aim concerns the implementation phase. In addition to the challenges described above, the study committee could be charged with canvassing options for implementation. Having identified the priority categories of actors and their needs, it may be decided to bring together the targeted individuals in a given region for an intensive course. Alternatively, an existing regional programme could be targeted, bringing together teams of actors that span more than one category. For example, bringing together determiners, enablers, and influencers will foster bonding and networking among the various actors, which in turn will facilitate the emergence of an epistemic community or an extended peer community in accordance with post-normal science. It might be most efficient to send a scientist or small team on a global circuit of various centres to impart knowledge and maintain quality assurance.

On the other hand, it may be decided that it would be more important to bring scientists from each region to a central location, familiarising them with the material and objectives and having those individuals conduct seminars in their respective regions. This option has the benefit of familiarising participants with a scientific focal point in the region, and the regional scientist may be more sensitive to cultural issues or particular scientific deficiencies in their jurisdiction. Internet-based learning long-distance learning is another option to be explored.

Optimal implementation is inter-linked with the other aims, and can only be determined after the committee has completed data collection and review. It may even be determined that different regions would benefit from different approaches, with the possibility of incorporating literacy sessions into other regional gatherings of various actors, given the cost-effective and networking benefits of such a tactic. Both design and implementation require innovative and creative thinking to encourage participation, cost effectiveness, and success.

The final aim then may be how to market the programme to the identified actors. Incentives, enticements, approaches to senior ministers or heads or chairs of regional seas initiatives, and other inducements to participate will have to be included in the mandate. Attracting participation may be the major challenge.

As a first step to navigating strong currents of resistance, it is recommended that scientists now commence publishing articles in policy journals that address some of the confusion surrounding scientific roles, and its implications, in helpful and meaningful ways, and expound on the role, utility, and capacity of science to inform policy. For instance, a series of articles over several months by scientists and non-scientists in *Marine Policy*, or other respected international legal or policy journal, will initiate dialogue among the disciplines. Such dialogue could either commence or conclude with a special issue dedicated to science in policy-making processes. It would also be a useful way to solicit views from key actors, international lawyers, and other enablers and determiners, which could direct, or be incorporated into, the design and implementation of a scientific literacy programme. It would be beneficial if GESAMP members and other scientists who interface with non-scientists could make heightened visibility of scientific literacy issues a mission.

GESAMP seems to be uniquely suited for the navigational role of initiating and mapping the course to scientific literacy.[191] An appropriate entity must be chosen to ensure serious commitment, as it can be imagined that failure to meet scientific literacy objectives of this suggested programme would be used as justification for avoiding calls for scientific literacy in the future. GESAMP has the intellectual capacity and experience, although administrative and financial capacity requires some thought. From GESAMP's perspective, involvement would give it higher visibility within the policy community, and foster expansion of the user community of its valuable reports, as more actors will become familiar with its endeavours.

In summary, it is recommended that GESAMP assume the challenge of improving scientific literacy among key actors involved with ecospheric degradation issues. GESAMP is one of the few bodies with global coverage and significant experience interfacing with actors in the law and policy domain. Although GESAMP's full participation is desirable in the outlined programme, any involvement in a lesser capacity is welcome.

[191] At its 32nd Session (5-10 May 2002, London), GESAMP members were informed of the main finding of this thesis that there is a need to improve scientific literacy among marine policy-makers and those responsible for legal instruments and agreements for the protection of the marine environment. There was general agreement within GESAMP that this is a matter that warrants serious attention and the Group would consider what actions it might take to improve the situation as part of its future work programme.

B. Regime Development: A Port of Call

1) Assessing Regime Effectiveness

Reflecting on the milestones in environmental policy – namely Stockholm (1972), UNLOSC III (1972-82), UNCED (1992), and the UNCGPA (1995) – and the instruments they generated, and acknowledging the shift in mindset towards ecological concerns, soft-law approaches, and sustainable development, it is apparent that the global community is attempting to chart a course towards environmental sustainability and management of human activities. In pondering this, it becomes equally apparent that the lack of scientific understanding can hinder regime development regarding MDLBA, or conceptually more accurate – degradation from human activities.

A regime in this context is essentially a cooperative arrangement comprising outputs (e.g., laws, principles, norms, rules, and policies) and the related institutional arrangements to design, implement, and comply with the output.[192] Effective regimes are evidence of "consilience", as a regime is the coming together of people and knowledge to generate and implement sound policies through various initiatives and institutions. Policy-making processes occur, or should occur, in the broader context of a regime.

A recent seminal study reviewed the effectiveness of 14 environmental regimes,[193] assessing objectives, issues, questions, and concerns in significant detail. The results of the study are instructive in moving from chaos to "consilience" of MDLBA policy-making processes, as the factors that foster and hinder regime effectiveness are identified.

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[192] See Ayling, *supra* note 186, p. 247 and A. Underdal, "One Question, Two Answers", in E.L. Miles, *et al*. (eds.), *infra* note 193, pp. 5-16.

[193] E.L. Miles, A. Underdal, S. Andresen, J. Wettestad, J.B. Skjærseth, and E.M. Carlin (eds.), *Environmental Regime Effectiveness: Confronting Theory with Evidence* (Cambridge, Massachusetts and London: MIT Press, 2002).

Two aspects of regulatory regimes that can be used to gauge the effectiveness of regimes are outcomes (changes in the actor's behaviour) and impacts on the environment, whether improvements, continuing degradation or no change.[194] Outcomes (changes in actors' behaviour) are the most common measure of regime effectiveness, and there seems to be a belief that changed behaviour in accordance with the output of the regime results in regime effectiveness. The second measure is less common, but equally or even more relevant. This is the measure of the environmental impact that the output and outcome combined have on the environment; or, more concisely, whether or not the environmental problem that the regime was intended to address is actually resolved as an effect of the relevant strategies.[195] The two measures, outcomes and impacts, are distinct, as changes in behaviour do not necessarily correlate with an improvement in environmental quality, and in most regimes studied positive changes in behaviour did not produce corresponding environmental improvements.[196] In fact, in over 50% of the regimes studied, there were significant behavioural changes in the actors in the intended direction,[197] but nearly 60% of the regimes scored low in environmental problem-solving effectiveness.[198]

The study's findings support the proposition, herein, that greater scientific literacy is necessary, as environmental improvement should have been found if the policies that resulted in changed behaviour were ecologically sound. Although other factors are also relevant, the study also confirmed the direct correlation between the degree of

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194 Underdal, *ibid*., pp. 6-7.

195 *Ibid*.

196 This is clear from discussions in Chapter 4, herein, and also the point is made by the study. See Underdal, *ibid*.

197 A. Underdal, "Conclusions", in Miles, *et al*. (eds.), *supra* note 193, p. 435.

198 *Ibid*.

consensus on knowledge and regime effectiveness, whereby a lack of consensus resulted in less effective problem solving.[199]

These findings may be interpreted to suggest that a diplomatic strategy that increases the capacity to reach consensus and encourages scientific literacy will foster overall problem-solving effectiveness and help ensure that measures that result in changed behaviour should also result in environmental problem-solving. In developing such a strategy, a summary of the study's finding is necessary to place the suggested strategy in a useful context:

- There are two main determinants of regime effectiveness. The first is the *characterisation of the problem* on a continuum from "benign" to "malignant".[200] Factors that increase problem malignancy include intellectual complexity and intricacy, and the degree of political malignancy ("conceived of primarily as a function of the configuration of actor interests and preferences that it generates").[201] MDLBA, overall, is considered a complex and malignant problem,[202] although some issues within it may lie nearer the centre of the benign-malignant continuum, and others towards benign.

- The second determinant is *problem-solving capacity* within the regime (and its member states) to address the problem, wherever it falls along the characterisation continuum.[203] The three main determinants of problem-solving

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199 See Miles, *et al*. (eds.), *supra* note 193, Epilogue.

200 Underdal, *supra* note 192, p. 13.

201 *Ibid*., at 15. Thus, a benign political problem should have harmonious interests and preferences. *Ibid*. Note that the study primarily concerns political aspects, but intellectual aspects (encompassing science) are discussed as they interface with political considerations. *Ibid*., p. 16.

202 J.B. Skjærseth, "Cleaning up the North Sea: The Case of Land-based Pollution Control", in Miles, *et al.* (eds.), *supra* note 193, pp. 175-95 and J.B. Skjærseth, "The Effectiveness of the Mediterranean Action Plan", in Miles, *et al.* (eds.), *ibid*., pp. 311-30.

203 Underdal, *supra* note 192, p. 13.

capacity are identified as: "(a) the institutional setting (the rules of the game); (b) the distribution of power among the actors involved; (c) and the skill and energy available for the political engineering of cooperative solutions".[204]

- Where substantive measures are elusive, the actors should concentrate on improving problem-solving capacity, as such increased capacity fosters substantive measures over time. Additionally, increasing institutional capacity improves effectiveness, with an example in the North Sea being the introduction of ministerial meetings – these meetings cemented political commitment.[205]

- Noting that MDLBA is a malignant problem, it concluded that the problem-solving effectiveness for malignant problems was low, but given the complexity of such problems, the study concludes there was still "a fair amount of success" in this area.[206] It was noted that strong malignancy combined with a high uncertain state of knowledge "could be lethal" to effectiveness, and that the state of knowledge is an important factor in its own right, as it impinges on effectiveness.[207]

- The key to resolving malignant problems is the presence of a consensual knowledge base, or basic agreement as to the seriousness, causes, and impacts of the problem.[208]

- It was noted that in malignant problems the chance of a specific measure being

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[204] *Ibid*., at p. 23.

[205] Underdal, *supra* note 197, p. 472.

[206] *Ibid*.

[207] *Ibid*., p. 443 and Miles, *et al*., *supra* note 193, pp. 469-70.

[208] Miles, *et al*., *ibid*., p. 470. Noted are two situations where increased knowledge is counter-productive, namely where knowledge prevents the parties from determining the winners and losers and, second, where there is a conflict over basic values.

adopted increases if it favours the interests and values of powerful actors.[209] Capacity building also helps to offset the effects of powerful actors.

- The North Sea and the Mediterranean were studied with regard to regimes for LBA.[210] Three important points are: (a) that policies were less successful when there was no basis for concerted action, but effectiveness improved when there was basic agreement; (b) changing the "rules of the game", such as introducing high-level ministerial conferences, improved effectiveness, as it provided the necessary region-wide political commitment; and (c) political commitment at the regional level does not necessarily induce behavioural changes at the domestic level.[211]

- Several points drawn from the regime studies are noteworthy.

    - The improved state of scientific knowledge induced positive behavioural changes in the actors.[212]

    - Hard- and soft-law measures had a symbiotic effect,[213] showing that both are of value and should be used to the best effect.

    - The introduction of BAT, BEP, and the precautionary concept induced positive behavioural changes, yet the effectiveness of the regime remains mixed and the environmental problems have not been solved.[214]

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[209] *Ibid*., p. 473.

[210] See the two Skjærseth articles, *supra* note 202.

[211] Skjærseth, "The North Sea", *ibid*.

[212] *Ibid*., p. 177.

[213] *Ibid.*, p. 193.

[214] *Ibid*., pp. 177 and 183-6.

- The “mismatch” between the regional determiners and domestic enablers was largely responsible for poor problem solving, as those having to implement the decisions were not party to making them.[215]

- The study acknowledges that its measures of effectiveness do not include efficiency. This is important, as greater use of science (knowledge-building) can inform actors to chose the best ecological and economical options.

- The actors, including domestic actors who must implement the commitments, need to be brought together in a meaningful way to improve co-operation generally, as the study found that the greater the degree of co-operation, generally the more effective the regime.[216] Thus, co-operation among actors and a consensual knowledge base were among the essential keys to concerted action.

Although scientific literacy was not specifically addressed, it underlies many of the findings. It is not a panacea, but scientific literacy can improve regime effectiveness, particularly contributing to the environmental problem-solving capacity. By improving understanding of the environmental problem and reduction of scientific uncertainty, especially in malignant problems, it improves the knowledge base, which in turn promotes consensus on the issues, and contributes to the basis for concerted action. Institutional settings and rules can reflect sound science for efficiency and effectiveness, and understanding the problem can make the issues less intractable.[217]

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215 *Ibid.,* p. 193.

216 Miles, *et al*., *supra* note 193, p. 467.

217 *Ibid*., pp. 467-8 and 470-1.

2) Regime Development and the GPA

Regarding implementation of the GPA, a cornucopia of operationally sensible strategies consistent with the findings of the study, such as the importance of having a consensual knowledge base and concerted action, can be pursued. At the global level, the LOSC provides legal authority and sectoral and regional conventions and soft-law arrangements, including Agenda 21 and the GPA, arguably provide sufficient principles, norms, direction, and guidance for effective management of human activities on land. However, application of these have induced changes in actors' behaviour, but in most of the regimes studied, the environmental problem remained unsolved.

It is suggested that *more* substantive law and principles will not be significant factors in either *effectively* implementing the GPA or solving environmental problems, given the lack of scientific understanding. The international diplomatic community should turn its attention to making existing regimes and policies more effective. In doing so, regime effectiveness should be measured by the degree of improvement in environmental quality, given that problem to be solved was environmental degradation.

Behavioural changes, or the outcome of a regime, should be measured and monitored. Their utility is not as a determinant of effectiveness, but as a means of linking the policy to changes in environmental quality. Strategies that change behaviour, but do not improve environmental quality, signal a problem and must be revisited for adjustment, or perhaps in severe situations, refocus on an entirely different strategy.

The concern is not the strategies themselves, but the capacity (and mindset) to wisely choose and implement strategies that have positive impacts on environmental quality. Although individual actors make decisions, they usually operate within an institutional setting or framework. Most contemporary institutions have not yet been adapted (or overhauled where necessary) to reflect the new legal order,[218] the participatory demands of civil society,[219] or the superior capacity of science to inform policy-making processes. A rational expenditure of human and financial resources may involve reviewing institutional design and problem-solving capacity to effectively implement the existing principles, norms, rules, and strategies.[220]

In determining how to effectively implement the GPA via global, regional, and domestic commitments, actors, particularly determiners and enablers, should embark upon an exploration of the critical understanding of environmental issues and the reasons underlying ineffectiveness. The regime effectiveness study, previously mentioned, identifies many issues that can be further analysed for critical understanding. Some issues may be straightforward with relatively easy solutions, such as remedying "mismatches" of actors to allow participation in policy-making by those affected. Others may require peeling away layers to gain critical understanding, with an example being reconciliation of different values – why does an individual have the values he has, are they generally based in belief or knowledge, is the knowledge accurate or the understanding of it sufficient, and what compromises or changes are reasonable? This is a quest to analyse the "why" of today's policies and determine what novel, creative, or other action can increase the knowledge base, improve

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[218] Mann Borgese, *supra* note 173, pp. 204-7.

[219] See generally K. Raustiala, "The 'Participatory Revolution' in International Environmental Law", 21 *Harvard Environmental Law Review* 537 (1997); R.S. Pomeroy, "Community-based and Co-management Institutions for Sustainable Fisheries Management in Southeast Asia", 27 *Ocean and Coastal Management* 143 (1995); and A. Hurrell and B. Kingsbury (eds.), *The International Politics of the Environment: Actors, Interests, and Institutions* (New York and Oxford: Oxford University Press, 1992).

[220] For insightful discussions along these lines, see generally N. Yost, "Environmental Regulation – Are there Better Ways?", 25 *Ecology Law Quarterly* 564 (1998) and N. Robinson, "Legal Systems, Decisionmaking, and the Science of Earth's Systems: Procedural Missing Links", 27 *Ecology Law Quarterly* 1077 (2000).

problem-solving capacity, effect a basis for concerted action, or solve the issue at hand.

3) A Diplomatic Strategy

The product of such a quest could be an international declaration endorsed by states (determiners and enablers), and other actors such as NGOs and funding institutions. Noting in the preamble the need to improve regime and policy effectiveness and the prevalence of ecologically and economically unsound policy, its primary purpose would be to acknowledge that accomplishing regime effectiveness requires novel efforts. Options should be proposed that de-emphasise substantive legal principles and strategies and target critical understanding, with the expectation that greater understanding of the issue will foster wiser decisions and knowledge-based policies.

Roughly, a declaration could incorporate the conclusions of the regime effectiveness study. Examples include the need for consensus, the positive role of a consensual knowledge base, the detrimental effect of high uncertainty and malignant (complex) problems, inclusion of an array of actors, the need for problem-solving capacity, and the focus on building problem-solving capacity where substantive commitments are not forthcoming. In identifying the criteria for effectiveness, the underlying factors should be included. For instance the need for knowledge contributions by many disciplines, clarity of objectives to foster consensus, investment in scientific research to reduce uncertainty, and other behavioural, political, and intellectual factors that must be pursued in the quest for the best environmental strategy.[221] Scientific literacy should figure prominently, but not dominate, as the study conclusions are instructive as concrete steps for effectiveness. Whereas existing instruments call for objectives such

[221] The best environmental strategy for an ecologically and economically sound decision includes the weighing and balancing of factors within all ecosystem components.

as transparency, clarity, integration, cooperation, and relevant participation, this declaration delves below the surface, targeting the processes and methods to attain the stated objectives.

A set of guidelines may be appropriate in addition to the declaration. Whereas the declaration crystallises political support, the guidelines provide direction so that the declaration does not become yet another instrument that languishes for lack of action. It is an educational and capacity-building exercise, as it will contribute to trans-national learning by providing guidance on some of the issues that detract from effectiveness and sharing the experiences of, and lessons learned within, many regimes.

Three decades ago, at Stockholm, there were global calls for protection and preservation of the environment. This broad reference transformed over time into calls for sustainable development, ICM, BAT, BEP, the precautionary concept, and other principles and norms. Now, that call for protection and preservation of the environment is taken to the next logical step of elaborating on the underlying logistical aspects of how to attain effective implementation of the substantive strategies. In essence, it is acknowledging the role of mindsets and critical knowledge, neither having been explored to any depth within the international diplomatic arena, at least in the context of environmental regulation. Opposition by some states may be expected, as the contents of the declaration and guidelines may be perceived as dictating strategies and governing conduct. Hopefully, with a little informed persuasion, actors can see beyond this, as the objective is enlightenment about psychological, political, intellectual, and other non-legal reasons contributing to regime ineffectiveness and poor policy choices.

Investigating and drafting a declaration and guidelines will require a specialised body or group of individuals. Any of the authors of the regime study would be ideal organisers of such a working group. Participants should include other disciplines (e.g., natural and social science, psychology, anthropology, economics, law, and philosophy), as well as representatives of the major actors. A review of the GPA process may highlight states that were particularly active or committed, and perhaps may be interested in such an endeavour. Canada comes to mind as a potential leader of such a process.

The working group should be small enough to reach a consensus to foster the drafting of documents that can be distributed to a wider audience for feedback and subsequent revision. However, it should be large enough that it can accommodate a broad mix of backgrounds. Working group members should be empanelled only if they are personally committed, but at the same time recognising that the instruments are unlikely to garner significant international support. The international diplomatic community generally, and government officials in particular, take time to warm to new ideas, delaying commitment until they get a feel for the level of support domestically and internationally.

The declaration and guidelines for understanding science and other relevant issues could serve a similar purpose to the MGs, whose value was in, first, the exposure to management options via circulation of the MGs within the international community and, second, their subsequent use in drafting the GPA. While they were not widely adopted, state-wide familiarity with the MGs helped acclimatise actors to the inevitability of commitments regarding LBA, and thus facilitated consensus building at the time of the drafting of the GPA. At the most rudimentary level, the MGs *helped shift mindsets*. It can be envisioned that a declaration and guidelines for "behaviour mechanics" for improving regime effectiveness may have a similar fate as the MGs in terms of the latter's limited regulatory success. However, it is argued that exposure to mere discussion of such issues, the educational benefits to be gleaned from the circulation of a declaration and guidelines through governments and educational institutions, and the opportunity to encourage and facilitate a shift in mindsets justifies the exercise.

Environmental problem-solving is a long-term proposition, and the mere discussion of an issue among actors, particularly the higher level actors who would be involved in the discussing the relevance of, and hopefully the ultimate drafting of a declaration, contributes to trans-national learning. Education improves capacity, which in turn can operate to reduce real and perceived intractability of complex issues. Perhaps a functionalist would interpret an instrument having this effect as successful. As the MGs were the bridge between the reluctance to address LBA in the 1970's to the international communities' overwhelming endorsement of the GPA in the 1990's, such a declaration and guidelines combination may be viewed as a bridge between the reluctance to embrace science today and an effective regime grounded in science in the hopefully not to distant future.

Every effective regime has a core concept or "generative vision" that binds or "integrates its components into a coherent package" and acts "to structure the discourse in terms of which participants discuss its operation".[222] A declaration and guidelines on improving effectiveness of environmental regimes would help actors

[222] O.R. Young, "Arctic Governance: Meeting Challenges of Cooperation in the High Latitudes", in the *Report of the Second Conference of Parliamentarians of the Arctic Region, Yellowknife, Northwest Territories, Canada, 13-14 March 1996* (Ottawa: Minister of Public Works and Government Services Canada, 1996), p. 122.

identify a “generative vision” that could contribute to solving the environmental problem for which the regime was designed.

Part V Summary

The actors involved in MDLBA policy-making processes have good reason to be optimistic about the future. Most importantly, the knowledge, capacity, and strategies are currently available within the various disciplines to adequately manage human activities to maintain ecospheric integrity. The challenge for the actors is to seek a level of co-operation that is conducive to bringing together sound information and allowing them to rationally use it to further their policy objectives. Two fundamental pre-conditions to attaining this level of co-operation are the empowerment of all actors through scientific literacy and the infusion of science into the policy-making process. With these, actors, particularly determiners and enablers, can consciously and rationally consider all knowledge from other investigators, the technological possibilities, and consider the positions and interests of influencers and degraders, to determine the most effective ecospheric option in an informed policy-making process.

Chapter 6

Conclusions: Land Ahoy!

A. View from the Crow's Nest

Actors involved in the management of MDLBA can anticipate calls of "land ahoy", as possibilities for effective environmental regimes hover on the policy horizon after several decades of planning, negotiating, and implementing environmental policy and management strategies. However, as is true for mariners, there are many shoals on which the policy vessel may founder prior to reaching its destination, unless skill and care continue to be incorporated and applied to sound policy-making process in order to seek ecological and economic soundness. Following are the conclusions regarding the ability to navigate towards an effective regime for the management of MDLBA.

B. Prospects for Consilience

Evidence accumulated in the early chapters herein demonstrates the chaotic nature of the process of traditional policy-making for marine and LBA issues, with random, sectoral, piecemeal, and reactive being apt adjectives. The ongoing paradigm shift towards ecological (holistic) management, which commenced with the 1972 Stockholm Conference, and gave rise to IEL and its ensuing principles, has been equally chaotic.

Regarding MDLBA issues, several factors contribute to the chaos. First, a shift in the character of environmental issues from visible and local pollution to systemic degradation has removed policy-making from the "command and control" era into a new era of risk management. Second, poor understanding of contemporary environmental issues as exercises in risk management hinders the designing of effective strategies, as actors largely acknowledge present and future needs, but operate from outdated perceptions of policy-making processes. Third, and further confounding policy-making processes and confirming MDLBA as a social issue, are the demands for participation by non-traditional actors. Many of these actors have legitimate interests in both environmental integrity (including human health) and policy constraints affecting their behaviour. Competing values and interests of these actors need to be incorporated into policy-making processes in a forthright and transparent way that allows meaningful debate and balanced decision-making. Fourth and finally, policy chaos of MDLBA is epitomised by the contest between competing mindsets, namely the traditional mindset embracing sovereign rights and economic development as against the evolving environmental mindset.

Like the global community itself, policy-making is caught between two paradigms – the result is environmental management that is chaotic in its randomness and lack of full and informed integration. Calls for clear and organised thinking abound, but actors have yet to seek the appropriate information in which to ground the thinking and the ultimate direction of regime development. Determiners today have the opportunity to direct regime development, but they require wisdom to apply the information available and lessons from the past.

It is appropriate to consider effective regime development as an example of consilience. To rephrase it, consilience, the bringing together of relevant information, encapsulates the operating paradigm of an effective regime. Only through co-operative efforts of all actors can the problem be understood in a way that will generate effective solutions.

The evidence suggests that actors in the management of MDLBA issues have realised that they must choose either to continue in a chaotic fashion, in which case the destination will remain elusive, or to chart a new course to effective environmental management, albeit through waters riddled with shoals of complexity. Charting the new course requires reliance on the LOSC as a constitution for the planet, not merely the oceans, and effective use of the principles of IEL, and other available and existing tools and strategies, together with innovative ideas. A diverse array of actors, both individual and institutional, is required, as previously discussed. As regimes have specific objectives to be fulfilled, consilience should be considered a vital component for regime effectiveness as it can bring actors and knowledge together in a meaningful way.

The prospects for consilience are good. The legal authority, policy tools, management strategies, and knowledge are available. It merely requires the international community to take up the challenge. Consilience has been subtly injecting itself into policy-making processes since Stockholm, and more obviously in the last decade. Every discipline has been calling for consilience, without labelling it as such, as illustrated by the publications from numerous disciplines on integrating issues, institutions, disciplines, actors, and knowledge.[1] Legal principles, such as sustainable development, the precautionary concept, inter-generational equity, integration, ICM, IPPC, cradle to grave approaches, and extended participation (i.e., women, children, indigenous peoples, NGO's, and contributory and affected states) all embody the philosophy underpinning consilience. Together they bring to the policy process a

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[1] See Appendix 3, Towards Consilience, herein, for a list of articles that discuss the philosophy underlying consilience, concepts consistent with consilience, and indications of the international communities move towards consilience.

broader knowledge base as well as factors, considerations, and participants beyond that traditionally included in policy-making. Further evidence of consilience is found in Agenda 21 and the GPA, which, by inter-linking issues, are significant indicators of the acknowledgement that there must be unity of knowledge for effective environmental management.

The actors intellectually and philosophically appreciate that integration is required, but as evidence suggests, this understanding of a need to move towards concerted cooperative action has yet to be consistently translated into *effective* action. This is not to detract from successes and improvements, but to note that the degree of effectiveness could be improved.

To assist in analysing the historical, current, and proposed processes, the emphasis is partially shifted from the consequences of the act to the act itself and actors involved. MDLBA is the product, or symptom, of human actions, and human actors. Human actors create the problems and human actors must address them. This acknowledgement becomes particularly meaningful if the actors are classified according to the role they assume, or can assume, in environmental-problem creation and solution. For example, the actors are classified as degraders (generators of waste and disruptors of habitats), determiners (makers of policy), enablers (implementers of policy), investigators (possessors of informed opinions and objective knowledge), technologists (providers of physical solutions), influencers (interest or value-driven actors and those who may legitimately influence policy, although through opinion more than objective knowledge), and educators (distributors of knowledge). The greatest utility of identifying roles from the standpoint of consilience is that it segregates sound knowledge and informed opinion from less qualified opinion, which is particularly relevant as input from influencers and investigators have often been given the same weight. It is important to remember that the same actor can occupy different roles in different situations, and it is vital to identify the role in each time to maintain quality-assured information and determine values. This exercise encourages the adoption of policy that effectively and efficiently addresses deleterious effects and their causes and seeks to put in place solutions that, by recognising values and other factors and working with those actors while grounding decisions in sound science, provide the best chance of success.

The general public supports consilience as global public opinion polls suggest that individuals around the world are aware of the importance of ecological integrity, and that they perceive environmental quality to be on the decline.[2] Individuals indicate the existence of a willingness to assume responsibility rather than blame others, and they tend to support both national governmental involvement and input from international agencies on trans-national issues.[3] This suggests that the barriers to promoting environmental quality may not be as intractable or as formidable as they once were thought to be.[4]

Consilience, the confluence of knowledge from diverse, but relevant disciplines must be translated into an operational paradigm. Questions arise about workable criteria and intellectual and logistical complexity. To address this, the quest herein has been to isolate and discuss a key component in the chronicled failure of domestic, regional, and global collective action to solve environmental problems, despite available philosophically sound legal principles, holistic legal instruments, and wide acknowledgement of MDLBA issues as global concerns. Among the myriad of

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2 D.E. Bloom, "International Public Opinion on the Environment", 269 *Science* 354 (1995), p. 357.

3 *Ibid*.

4 *Ibid*.

components contributing to such policy ineffectiveness, science, and its present and potential role stand out.

C. The Role for Science

Evidence indicates that science is having a declining influence on MDLBA policy, even where the mindset favours environmental protection. Too many policies are either ecologically unsound or economically inefficient, usurping limited resources that could be otherwise applied to priority issues. The importance of science informing environmental policy-making cannot be overstated. Failure to effectively incorporate science can have unforeseen effects on policy. For example, evidence has shown that when science is equivocal, social and political concerns frequently dominate, often leading to compromises or unsound policy. Understanding, however, allows for wise choices. Actors who understand basic ecological principles and scientific methods are better placed to appreciate a science-based rationale for action and bring pressure to bear on powerful, but perhaps resistant, actors, particularly where substantial scientific uncertainty exists. Working within a science-based framework can help maintain negotiations and bargaining within sound ecological and economic boundaries and provide a means of focussing issues.

Two additional factors make science a key component in effective policy-making. First, scientific investigation is at the core of identifying environmental *problems* and only scientists can effectively investigate cause-effect relationships and interpret the impacts of human activities on the natural environment. Scientific capacity to provide accurate and sufficiently conservative advice is growing as databases of knowledge, new hybrid sciences (products of consilience), and technological innovations allow for broader and deeper scientific investigation. Without science, including its uncertainties, humans would not be equipped to recognise systemic degradation issues, which are largely invisible and insidious.

Second, science is necessary to interface with other disciplines. Although environmental decisions must be informed by science, science cannot (and should not) *solve* the problems. Solving environmental issues is a socio-political endeavour involving values, interests, feelings, beliefs, economics, and a host of other factors that are beyond the scope of the scientific endeavour.[5] Thus, non-science actors, particularly determiners and enablers, who are those responsible for negotiating, drafting, determining, and implementing policies, require a critical understanding of science (including ecology) to permit evaluation of the technical issues.[6] Becoming science literate and using science to ground policy evinces common sense.

D. Constraints on Attaining Consilience

Actors can embrace the prospects for consilience of law and science regarding MDLBA policy-making processes or they can allow the intractability to overwhelm them. Observations of human nature suggests that only a few may embrace the challenges of change, while an expected reaction from many is resistance to any review of policy-making processes that involves questioning motivation, commitment, roles, strategies, participants, human and financial resources, responsibility, accountability, and numerous other facets not commonly analysed in traditional environmental policy-making processes. Opposition may be expected to learning scientific nomenclature, to enlisting scientists to act more closely in the decision-making process, and to the dilution of sovereignty, to offer a few examples. The

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5 P. Castro and M.E. Huber, *Marine Biology,* 2nd ed. (Dubuque, Iowa: Wm. C. Brown Publishers, 1997), p. 16.

6 R.B. Clark, "Editorial: Laws of the Sea, 1986", 17 *Marine Pollution Bulletin* 1 (1986), p. 1.

comprehensive scope for gains from consilience equals the scope for opposition and criticism, not to mention the inertia element of human nature – a resistance to new concepts that will affect the *status quo*.

Evidence supports the claim that the greatest impediment to consilience of law and science (and other disciplines) is the societal mindset in general and the policy mindset in particular. Existing policy-making processes are entrenched in preconceived perceptions of solutions to environmental problems. Manifestations of this are complacency, lack of will power to infuse science into policy-making processes, and lack of political commitment to solve environmental problems (as contrasted with merely changing behaviour).

All actors, but especially determiners and enablers, need to break free of the restrictive mindset reflected in traditional legal strategies and allow the process of moving from chaos to consilience to embrace innovative and creative thinking. This process is underway, with proof being the emergent novel legal principles and strategies such as the preponderance of soft-law documents (particularly action plans) and common but differentiated standards. However, the focus must turn to the critical process of applying available measures effectively.

While consilience is a challenge, it is possible, and the benefits justify the effort. Consilience is an on-going process, just as knowledge building and policy-making are ongoing processes. As noted, evidence indicates that consilience has been ongoing for sometime as a slow, incremental process. Regardless of whether it is formally adopted, the jumping together of knowledge from various disciplines will continue, with predictions of increased momentum as critical thresholds are passed and benefits of collaboration fully realised. The contemporary focus on the legal principle of integration in its various forms is consilience at work. The reality is that integration cannot be stopped. Faced with a choice between letting integration continue chaotically under its own momentum, as it is now, or consciously directing that momentum to ensure effective and efficient policy-making processes and outcomes, the latter seems to be the only rational option.

Actors can become sophisticated users of knowledge from science and other disciplines. They can consciously foster consilience, and direct and monitor the jumping together of knowledge for a comprehensive and useful knowledge base. The alternative is accumulating knowledge in a random and inefficient fashion, as evidence indicates is now happening. In short, the global community needs to decide if it sincerely *wants* to effectively address MDLBA. If the answer is in the affirmative, science, law, economics, and other disciplines can provide the knowledge and the tools. There are no intractable impediments to consilience, only challenges.[7]

E. Conclusions: Points on the Compass Rose

A compass rose is the rendition of a compass, usually found on a lower corner of a map, which indicates directional layout of the map. Ranging from an arrow pointing north to an intricate figure that resemble a flower, and hence the name, it commonly shows eight compass points. A compass rose is an apt analogy for the conclusions drawn from the previous chapters as they fall into eight points, and like those on a compass, they are inter-related as parts of a whole, but provide valuable guidance in different directions. The eight concluding points are:

(i) Understanding the precautionary concept, and its relationship to science is paramount, given its high profile as an emergent and fundamental legal principle.

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[7] Generally see W.W. Harmon, *Global Mind Change: The Promise of the 21st Century* (San Francisco and Sausalito: Berrett-Koehler Publishers, Inc. and the Institute of Noetic Sciences, 1998).

The precautionary concept is philosophically sound, and it should be viewed as an ethic to guide actors generally, and policy-making and the sound application of legal principles specifically. By adopting a precautionary ethic, actors acknowledge that chaotic activities have wrought ecological degradation and that long-term ecospheric integrity requires that potentially destructive activities be managed with the skill, care, review, and forethought of a scientist conducting an experiment.

The relationship between science and the precautionary concept needs to be understood to eradicate the *inaccurate perception* that the precautionary concept is invariably applicable, as a counter to scientific incapacity, in the protection of the environment. Scientists and assimilative capacity did not fail the environment, particularly as the latter was never properly implemented as a policy tool. Further, understanding scientific uncertainty is imperative for rational application of the precautionary concept, which requires scientific evidence indicating a concern, or probability, of a problem that may warrant intervention prior to obtaining scientific confirmation.

(ii) Learning from policy choices, including both the mistakes and successes, is crucial. To this end, the effectiveness of policies and regimes should be referenced directly to environmental problem-solving and environmental improvements (or lack thereof), with a review of policy performance triggered by feedback mechanisms and mechanisms for adaptive management embedded in the policy-making process. Cycles of poor policy can be prevented and effective policies promoted. Environmental protection and regime functioning are cyclic processes that require review, adaptation, adjustment, and flexibility to incorporate emerging knowledge and evidence, particularly where consilience is at work.

(iii) MDLBA is not a single environmental issue, but an aggregation of environmental issues, many of which are already on the international agenda as sectoral issues. As ecology is the embodiment of the integration of all scientific disciplines,[8] MDLBA is the embodiment of the integration of all human activities on land. Thus, MDLBA is not just “another environmental problem”. In fact, MDLBA is a *symptom* of the impacts of human conduct on any habitat, with the marine environment providing a catalyst for regional and global cooperation. The GPA can profitably be viewed as fostering recognition of the need for a comprehensive and integrated approach to *managing human activities* for long-term sustainability. Indignant claims of infringements to sovereignty are being replaced by hesitant commitments to address MDLBA as regional degradation from cumulative LBA is acknowledged.

While it is necessary to acknowledge the aggregation of issues, focusing on specific issues (usually sectorally) reduces the intractability, but only if management of that “part” is interwoven into the ecological and socio-economic context of the whole. It is a matter of adopting a mindset that seeks resolution of environmental issues and, consequently, seeks to reduce and manage the complexities by drawing on the knowledge and experience of others.

(iv) The role of consensus cannot be understated. Policies are more effective where

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[8] See L.W. Aarssen, “On the Progress of Ecology”, 80 *Oikos* 177 (1997), p. 178.

there is at least basic consensus.[9] Consensus concerns both scientific information and values. Referring to the former, scientific consensus plays a significant role in policymaking.[10] It inspires the confidence of non-scientific actors and provides a solid basis for action. Conversely, scientific uncertainty (which can generate a lack of consensus) can thwart policy effectiveness if it allows powerful actors to influence policy towards their interests, if it is used as justification for non-action such as "wait and see", or if it waters down commitments to the lowest common denominator. This is particularly true where the issue is complex, as is MDLBA. In such situations where agreement on meaningful substantive measures and strategies is difficult to secure, the best strategy is to define the boundaries of consensus to determine whether there is agreement on the core issues, and to build on the consensus accordingly. Action on co-operative endeavours to increase problem-solving capacity has merits, which remain largely unrecognised. Simple advice is to revise the mindset to ask not, "What are the conflicts and constraints complicating resolution?", but to ask, "What are the areas of consensus?". Actors may be surprised by the responses.

Consensus on values and philosophy is important as it can establish a concerted basis for action; and conversely, a lack of consensus on values and philosophy can impede policy-making even where scientific consensus is high. A caveat is that high consensus on values and interests can lead to emotionally driven

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9 See E.D. Miles, A. Underdal, S. Andresen, J. Wettestad, J.B. Skjærseth, and E.M. Carlin (eds.) *Environmental Regime Effectiveness: Confronting Theory with Evidence* (Cambridge, Massachusetts and London: MIT Press, 2002), pp. 468-73.

10 *Ibid*.

standards, which can be more stringent than the scientific consensus indicates is scientifically and economically warranted. In this process, science must not be misused to "justify" ethical or social choices. The latter must be justified on their own merits, and in fact, most laws, e.g., family, municipal, corporate, and criminal, reflect ethical beliefs and social desires. While there is nothing wrong with environmental policies being influenced by ethics and social interests, it remains critical that these policies concurrently protect ecological integrity and do not usurp scarce economic resources.

(v) Knowledge-based policy-making processes[11] for MDLBA should be the ultimate goal of any regime or policy exercise. The knowledge base must be broad, integrating diverse disciplines (i.e., it must be developed through consilience). Knowledge and consensus compliment each other but are not always co-existent. For example, a significant consensus may believe that the high costs of BAT, BEP, and clean technology are ethically or morally justified. However, without scientific grounding, such strategies may not provide adequate ecological protection, or they may usurp resources that could be applied to scientifically evaluated priorities. Scientists and other investigators possessing relevant knowledge must have a means of integrating it and infusing it into the policy-making process as uninformed consensus among actors can lead to poor choices.

Building and relying on a broad knowledge base reflects common sense. It fosters efficient use of scarce financial and intellectual resources and provides a

[11] H. Breitmeier, "International Organizations and the Creation of Environmental Regimes", in O.R. Young (ed.), *Global Governance: Drawing Insights from the Environmental Experience* (Cambridge, Massachusetts and London, England: The MIT Press, 1997), pp. 87-114.

logical, value-free basis for negotiation, upon which actors can advance their interests. As well as recommending that every policy decision be grounded in science as a matter of course, a knowledge base should be available to integrate factors such as social perceptions of risk and counter-intuitive reactions to scientific information so that the risks to be managed are comprehensively understood. Knowledge-based policy-making epitomises rationality.

(vi) Policies and decisions must be scientifically assessed prior to adoption to ensure they are sensible in the context and to determine expectations in terms of behavioural changes and environmental problem solving. Feedback mechanisms must be incorporated into policy-making processes to trigger reviews to evaluate expected results against actual results as a measure of effectiveness. Flexibility and adaptability must be institutionalised to allow for revision of policies in light of the review and any emerging scientific knowledge and evidence. This is particularly important for policies relating to risk management issues and leading to systemic degradation. This is realistic as the relevant body of science is growing rapidly as a result of improved technologies and capacity, increased understanding of bio-chemical, geo-physical, and other processes, and consilience of scientific (natural and social) disciplines.

As many contemporary issues are characterised by high uncertainty and potentially high stakes, resource use must be wise and a sound strategy must be devised to comprehensively inter-link strategies and policies for consistency and efficiency. Laws, policies, and rules must be interpreted, applied, and implemented in the most ecologically and economically sound fashion. A process that reflects reason, patience, and review is required as environmental policy-making is an exercise that can be equated with a grand experiment.

(vii) Actors in the MDLBA policy-making process must analyse facts, strategies, and issues to seek the intervention point that balances ecological results and investment. Finding an appropriate intervention point may involve creative thinking beyond the traditional concepts of policy-making. This requires an adjustment of mindset away from pollutant-by-pollutant or medium-by-medium regulation, towards systemic thinking. Lawyers, traditionally trained to intervene where the system is most susceptible to manipulations must be reprogrammed to seek intervention points that will capitalise on actors' goodwill, maximise returns on financial and other investment, encourage co-operation, improve problem-solving capacity, and build confidence and consensus.

This may not involve treaties or other hard law instruments, policies, or rules, but instead strategies such as ministerial declarations, joint scientific research, and cradle-to-grave (or preferably, cradle-to-cradle) analysis as appropriate. Other intervention points may involve unilateral action, such as the issuance of government subsidised appliances to the public (e.g., composting bins or water-conserving shower heads); government sponsored school contests or environment-related activities (e.g., beach cleaning events or Earth Day celebrations); or the universal availability of basic scientific literacy courses for civil servants involved in environmental policy-making. The available intervention points are only be limited by the imagination.

(viii) Education is the fulcrum for change. Actors directly involved in the management of MDLBA require a basic level of scientific literacy to ensure that the laws, policies, rules, and other management actions are sound. In addition to science, actors need to become better versed in the rudiments of other disciplines in order to gain a comprehensive understanding of the issues and public reaction to them. There is little sense in having an extensive knowledge base and striving for consensus and problem-solving capacity if many of the actors do not have sufficient critical understanding to analyse technical issues and endorse sound options. Civil society should demand this of environmental determiners and enablers, just as a reasonable man, to use the common law standard, can expect those entrusted with healthcare to be trained appropriately. Further, civil society, as influencers, would benefit from scientific literacy.

Literacy in natural sciences is targeted as the educational priority. This is because society generally has a poor understanding of scientific methods, the range of scientific disciplines (and how they come together to build scientific knowledge), and ecological principles and ecosystem functioning, which are central to environmental management. Scientific education of the public may take many forms. The media's increased environmental coverage over the last decade has spawned environmental concern, if not an environmental conscience or consciousness, laying a foundation for, or at least opening minds to ecological learning. To this end, journalists should take seriously their responsibility to educate the public with balanced reporting, sound science, accurate encapsulation of environmental priorities, and meaningful identification of sources to help gauge the quality of the opinion or information offered. This may require reporters improving their own level of scientific literacy to effectively communicate with the public. Over the long-term, public school systems and tertiary institutions will have to respond to society's needs, by producing well-rounded graduates and dispelling the bias against science. A public empowered with scientific literacy should turn from fear-motivated responses to understanding the essence of issues and offering meaningful input.

Immediate scientific education is a priority for actors directly involved in MDLBA policy-making processes. A study, preferably by GESAMP, is recommended to analyse the need for such and scope out the design and general syllabus. Governments must undertake to enhance the scientific literacy of all relevant civil servant actors. Innovative and creative means of educating the actors are necessary as the material, particularly scientific methodology, is foreign to the majority. Professional schools should incorporate basic science into their environmental law and policy courses. The quest for scientific literacy may provide an opportunity to focus on the presently junior actors, as they are likely to be more amenable to such concepts, having largely grown up with exposure to environmental issues.

Attaining a science-literate status is a challenge for actors in the MDLBA policy-making process and the international community in general. It is a component of the larger challenge of consilience as it will meld critical understanding of scientific knowledge with the actors' own specialised and general knowledge for positive ecological results.

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Science, law, or politics may dictate or direct policy decisions. However, the evidence suggests that acting alone, none is sufficient for environmental problem solving, particularly where the problem is an amalgam of conflicting and diverse issues and actors. All three are necessary, as a largely scientific knowledge base must inform the application of principles, policies, and rules in the social and political context of interests and values. Emphasis must be placed on finding solutions that work by rationally addressing the environmental problem, utilising economic and human resources wisely, and considering social issues when determining management options. It helps to remember that MDLBA is a symptom of human activities. Addressing it becomes a social exercise on the scale of a grand experiment that must be well informed by diverse knowledge from diverse disciplines, with scientific literacy and the infusion of science being fundamental to the process.

Effective environmental management through consilience is a significant challenge for determiners and enablers, and the global community of actors. However, we owe ourselves, our neighbours, and our children no less. Fortunately, the ecosphere is more resilient than many had believed, and the actors, within their appropriate roles, can apply the skills and knowledge that they individually and collectively possess to convert actions into learning opportunities, which can productively direct current integration exercises. The actors, with committed and informed leadership, have the capacity to move the MDLBA policy-making process from chaos to consilience.

Appendix 1

The Paradox of Science

The following publications, from both professional journals and the popular media, provide insight into the paradox of science and how and why is it losing influence at a time when it is most urgent for science to be used by actors to address contemporary environmental issues. Many of the publications in Appendix 2, which focuses on the precautionary concept, are relevant to discussions on the paradox of science.

A. Key Articles and Books

Allaby, Michael. *Facing the Future: The Case for Science*. 1996.

Bewers, J. Michael. "The Declining Influence of Science on Marine Environmental Policy." 1995.

Brown, George E. "Environmental Science under Siege in the U.S. Congress." 1997.

Caldwell, Lynton Keith. *Between Two Worlds: Science, the Environmental Movement and Policy Choice.* 1992.

Cohl, H. Aaron. *Are We Scaring Ourselves to Death?: How Pessimism, Paranoia, and a Misguided Media are Leading Us Toward Disaster.* 1997.

Editorial. "Why We Only Accept a Policy if We Know It Will Not Work." 1978.

Ehrlich, Paul R. and Anne H. Ehrlich. *Betrayal of Science and Reason: How Anti-Environmental Rhetoric Threatens Our Future*. 1996.

Faigman, David Laurence. *Legal Alchemy: The Use and Misuse of Science in Law.* 2000.

Fisk, David. "Environmental Science and Environmental Law." 1998.

Friedheim, Robert L. "Ocean Ecology and the World Political System." 1975.

Gray, John S. "Whose Research Is It Anyway?" 1996.

Hardin, G. *Filters Against Folly: How to Survive Despite Economists, Ecologists and the Merely Eloquent.* 1987.

Hutchings, Jeffery A., Carl Walters, and Richard L. Haedrich. "Is Scientific Inquiry Incompatible with Government Information Control?" 1997.

Jackson, Thomas C. and Diana Reische (eds.). *Coast Alert: Scientists Speak Out*. 1981.

Lee, Kai N. *Compass and Gyroscope: Integrating Science and Politics for the Environment.* 1993.

M'Gonigle, R. Michael, T. Lynne Jamieson, Murdoch K. McAllister, and Randall M. Peterman. "Taking Uncertainty Seriously: From Permissive Regulation to Preventative Design in Environmental Decision Making." 1994.

Ray, Carleton. "Ecology, Law and the Marine Revolution." 1971.

Ruckelshaus, William D. "Stopping the Pendulum." 1997.

Sagan, Carl. *The Demon-Haunted World: Science as a Candle in the Dark.* 1995.

Scheiber, Harry N. "From Science to Law to Politics: An Historical View of the Ecosystem Idea and Its Effects on Resource Management." 1997.

Sebek, Viktor. "Bridging the Gap Between Environmental Science and Policy-Making: Why Policy Often Fails to Reflect Current Scientific Knowledge." 1983.

Shapiro, Irving S. "Science and Law." 1977.

Snow, C.P. *Two Cultures and the Scientific Revolution.* 1959.

Waldichuk, Michael. “Control of Marine Pollution: An Essay Review.” 1977.

Wakeford, Tom and Martin Walters (eds.). *Science for the Earth: Can Science Make the World a Better Place?* 1995.

Wali, Mohan K. and Robert L. Burgess. “The Interface of Ecology and Law: Science, the Legal Obligation, and Public Policy.” 1985.

Weinberg, Alvin M. “Science and Its Limits: The Regulator’s Dilemma.” 1985-6.

Wildavsky, Aaron. *But Is It True?: A Citizen’s Guide to the Environmental Health and Safety Issues*. 1997.

Wilson, Edward O. *Consilience: The Unity of Knowledge*. 1998.

B. General Articles

Borgese, Elizabeth Mann. “Sustainable Development in the Oceans.” 1997.

Casti, John L. *Searching for Uncertainty: What Scientists Can Know About the Future.* 1991.

Clark, R.B. “Editorial: Laws of the Sea. 1986.” 1986.

Cook, David G. “Editorial” (on Canadian fishing policy and science). 1997.

Cuber, John F. “Ecotactics: The Critical Link (An Analysis of Values in Conflict.” 1972.

Dahl, Arthur Lyon. *The Eco Principle: Ecology and Economics in Symbiosis.* 1996.

Davis, Devra Lee. “The ‘Shotgun Wedding’ of Science and Law: Risk Assessment and Judicial Review.” 1985.

Dixon, Bernard. *What is Science For?* 1976.

Dunbar, Robin. *The Trouble with Science.* 1995.

Dunlap, Thomas R. “DDT: Scientists, Citizens, and Public Policy.” 1981.

Ehrlich, Paul R. and Edward O. Wilson. “Biodiversity Studies: Science and Policy.” 1991.

Flournoy, Alyson C. “Legislating Inaction: Asking the Wrong Questions in Protective Environmental Decisionmaking.” 1991.

Fumento, Michael. *Science under Siege: How the Environmental Misinformation Campaign is Affecting Our Laws, Taxes, and Our Daily Life*. 1993.

Gaines, Sanford E. “Science, Politics, and the Management of Toxic Risks Through Law.” 1990.

Goddard, Alison. “Fighting Science With Science.” 1997.

Goldsmith, Edward. “Blind Man’s Bluff.” 1978.

Goodstein, David. “Conduct and Misconduct in Science.” 1996.

Gray, John S., D. Calamari, R. Duce, J.E. Portmann, P.G. Wells, and H.L. Windom. “Scientifically Based Strategies for Marine Environmental Protection and Management.” 1991.

Gross, Paul R. “The Icarian Impulse.” 1998.

Gross, Paul R., Norman Levitt, and Martin W. Lewis (eds.). *The Flight from Science and Reason*. 1996.

Hammond, Kenneth R. and Leonard Adelman. “Science, Values, and Human Judgement.” 1977.

Hansson, Sven Ove. “A Philosophical Perspective on Risk.” 1999.

Hawking, Stephen. “Foreword.” (in *Science for the Earth: Can Science Make the World a Better Place?* 1995.

Holdren, John P. “Energy: Asking the Wrong Questions.” 2002.

Hollander, Jack M. “Scientists and the Environment: New Responsibilities.” 1972.

Horgan, John. *The End of Science: Facing the Limits of Knowledge in the Twilight of the Scientific Age.*

1997.

Jamieson, Dale. “Scientific Uncertainty and the Political Process.” 1996.

Jasanoff, Sheila. *Science at the Bar: Law, Science, and Technology in America.* 1995.

Jeffery, Michael I. “Appropriateness of Judicial and Non-judicial Determination of Environmental Issues.” 1988.

Jeftic, L. “The Role of Science in Marine Environmental Protection of Regional Seas and Their Coastal Areas: The Experience of the Mediterranean Action Plan.” 1992.

Jones, Harry W. *Law and the Social Role of Science.* 1966.

Kates, R.W. “Success, Strain, and Surprise.” 1985-86.

Kaye, D.H. “Proof in Law and Science.” 1992.

Kimball, Lee A. *Treaty Implementation: Scientific and Technical Advice Enters A New Stage*. 1996.

Kunreuther, Howard and Paul Slovic. “Science, Values, and Risk.” 1996.

Kusler, Jon. “Wetlands Delineation: An Issue of Science or Politics?” 1992.

Latin, Howard A. “The Significance of Toxic Health Risks: An Essay on Legal Decisionmaking under Uncertainty.” 1982.

Levi, Primo. *Other People’s Trades*. 1990.

Loevinger, Lee. “Law and Science as Rival Systems.” 1966.

Margolis, Howard. *Dealing with Risk: Why the Public and the Experts Disagree on Environmental Issues.* 1996.

Munn, Ted, Anne Whyte, and Peter Timmerman. “Emerging Environmental Issues: A Global Perspective of SCOPE.” 1999.

Odum, Eugene P. “Great Ideas in Ecology for the 1990s.” 1992.

Odum, Eugene P. “The Emergence of Ecology as a New Integrative Discipline.” 1977.

Orr, David W. *Ecological Literacy: Education and the Transition to a Postmodern World.* 1992.

Pool, Robert. “Science Literacy: The Enemy is Us.” 1991.

Rampton, Sheldon and John Stauber. *Trust Us, We’re Experts!: How Industry Manipulates Science and Gambles with Your Future.* 2001.

Ravetz, Jerome R. *Scientific Knowledge and Its Social Problems.* 1973.

Ray, Dixy Lee and Louis R. Guzzo. *Environmental Overkill: Whatever Happened to Common Sense?* 1993.

Raymo, Chet. *The Virgin and the Mousetrap: Essays in Search of the Soul of Science.* 1991.

Rennie, John, “Misleading Math about the Earth.” 2002.

Rosemarin, Arno. “Ecotoxicology on the Upswing – But Where are the Ecologists?” 1988.

Rothman, Stanley, and S. Robert Lichter. “Is Environmental Cancer a Political Disease?” 1996.

Shepard, Paul, and Daniel McKinley (eds.). *The Subversive Science: Essays Towards an Ecology of Man.*1969.

Shermer, Michael. “The Gradual Illumination of the Mind.” 2002.

Solomon, Shana M. and Edward J. Hackett. “Setting Boundaries Between Science and Law: Lessons Learned from *Daubert v. Merrell Dow Pharmaceuticals, Inc*.” 1996.

Stewart, Alan. “Environmental Risk Assessment: The Divergent Methodologies of Economists, Lawyers and Scientists.” 1993.

Stone, Christopher D. *The Gnat is Older Than Man: Global Environment and Human Agenda.* 1993.

Switzer, Jacqueline Vaughn. *Green Backlash: The History and Politics of Environmental Opposition in the U.S.* 1997.

Theocharis, T. and M. Psimopoulos. “Where Science Has Gone Wrong.” 1987.

Tomkins, Stephen. “Science for the Earth Starts at School.” 1995.

von Moltke, K. “The Relationship between Policy, Science, Technology, Economics and Law in the Implementation of the Precautionary Principle.” 1996.

Wettestad, Jørgen and Steinar Andresen. “Science and North Sea Policy-Making: Organization and Communication.” 1990.

Wettestad, Jørgen. “Science, Politics and Institutional Design: The Case of the North-east Atlantic Land-Based Pollution Regime.” 1994.

White, Lynn, Jr. “The Historical Roots of Our Ecological Crisis.” 1969.

Winner, Russ. “Science, Sovereignty, and the Third Law of the Sea Conference.” 1977.

Yearley, Steven. “Standing in for Nature: The Practicalities of Environmental Organizations’ Use of Science.” 1993.

Appendix 2

The Precautionary Concept

The following articles have been selected to provide an understanding of the history of the precautionary concept and how it relates to both science and law. Articles on the assimilative capacity provide insight into how scientists intended the assimilative capacity be used as a policy tool. Articles on scientific uncertainty discuss, or illuminate, the relationship among it, the assimilative capacity, and the precautionary concept. Risk management is inter-related as a means of internalising uncertainty in policy-making processes. The key section below is, "C. Precautionary Concept, Science, and Law", containing articles representing both sides of the debate over the use of science in the application of the precautionary concept. Recommended publications are marked with an "".*

C. Precautionary Concept in Law

*Boehmer-Christiansen, Sonja. "The Precautionary Principle in Germany – Enabling Government." 1994.

Cameron, James and Juli Abouchar. "The Precautionary Principle: A Fundamental Principle of Law and Policy for the Protection of the Global Environment." 1991.

Cameron, James. "The Status of the Precautionary Principle in International Law." 1994.

Freestone, David and Ellen Hey. "Origins and Development of the Precautionary Principle." 1996.

Gündling, Lothar. "The Status in International Law of the Principle of Precautionary Action." 1990.

Hey, Ellen. "The Precautionary Approach: Implications of the Revision of the Oslo and Paris Convention." 1991.

McIntyre, Owen and Thomas Mosedale. "The Precautionary Principle as a Norm of Customary International Law." 1997.

Nollkaemper, André. "The Precautionary Principle in International Law: What's New Under the Sun?" 1991.

D. Assimilative Capacity

*Cairns, John, Jr. "Aquatic Ecosystem Assimilative Capacity." 1977.

*GESAMP. *Environmental Capacity: An Approach to Marine Pollution Prevention*. 1986.

*Goldberg, Edward D. "Our Oceans as Waste Space: The Argument." 1981.

Kamlet, Kenneth S. "Our Oceans as Waste Space: The Rebuttal." 1981.

Krom, Michael D. "An Evaluation of the Concept of Assimilative Capacity as Applied to the Marine Waters." 1986.

Kullenberg, Gunnar. "Capacity Building in Marine Research and Ocean Observations: A Perspective on Why and How." 1998.

Portmann, John E. and R. Lloyd. "Safe Use of the Assimilative Capacity of the Marine Environment for Waste Disposal – Is It Feasible?" 1986.

Pravdic, Velimir. "Environmental Capacity – Is a New Scientific Concept Acceptable as a Strategy to Combat Marine Pollution?" 1985.

*Stebbing, A.R.D. "Assimilative Capacity." 1981.

*Stebbing, A.R.D. "Environmental Capacity and the Precautionary Principle." 1992.

E. Precautionary Concept, Science, and Law

*Bewers, J. Michael. “The Declining Influence of Science on Marine Environmental Policy.” 1995.

Bodansky, Daniel. “Commentary: The Precautionary Principle.” 1992.

Broadus, James M. “Creature Feature Too: *Principus precautionarium*.” 1992-3.

Chapman, Peter M. “The Precautionary Principle and Ecological Quality Standards/Objectives.” 1997.

*Dethlefsen, Volkert. “Marine Pollution Mismanagement: Towards the Precautionary Concept.” 1986.

Fisk, David. “Environmental Science and Environmental Law.” 1998.

*Gray, John S. “Integrating Precautionary Scientific Methods into Decision-Making.” 1996.

*Gray, John S. and J. Michael Bewers. “Towards a Scientific Definition of the Precautionary Principle.” 1996.

*Gray, John S., D. Calamari, R. Duce, J.E. Portmann, P.G. Wells, and H.L. Windom. “Scientifically Based Strategies for Marine Environmental Protection and Management.” 1991.

*Gray, John S. “Statistics and the Precautionary Principle.” 1990.

Gray, John S. “Letters: Statistics and the Precautionary Principle - Professor Gray Replies.” 1990.

Hey, Ellen. “The Precautionary Principle.” 1993.

Hey, Ellen. “The Precautionary Concept in Environmental Policy and Law: Institutionalizing Caution.” 1992.

Jackson, Tim and Peter J. Taylor. “The Precautionary Principle and the Prevention of Marine Pollution.” 1992.

Johnston, Paul and Mark Simmonds. “Letters: Precautionary Principle.” 1990.

Josefson, Alf B. “Letters: Statistics and the Precautionary Principle.” 1990.

Lindsay, Richard. “Galloping Gertie and the Precautionary Principle: How is Environmental Impact Assessed?” 1995.

Lutter, Stephan. “Letters: Statistics and the Precautionary Principle.” 1990.

MacGarvin, Malcolm. “Precaution, Science and the Sin of Hubris.” 1994.

*Mee, Laurence David. “Scientific Methods and the Precautionary Principle.” 1996.

Peterman, Randall M. and Michael M’Gonigle. “Statistical Power Analysis and the Precautionary Principle.” 1992.

Raffensperger, C. and J. Tickner. *Protecting Human Health and the Environment: Implementing the Precautionary Principle*. 1999.

Ruckelshaus, William D. “Stopping the Pendulum.” 1997.

Stein, Paul. “A Cautious Application of the Precautionary Principle.” 2000.

Thorne-Miller, Boyce. “The LDC, the Precautionary Approach, and the Assessment of Wastes for Sea-Disposal.” 1992.

von Moltke, Konrad. “Commentary: The Precautionary Principle.” 1992.

von Moltke, Konrad. “The Relationship between Policy, Science, Technology, Economics and Law in the Implementation of the Precautionary Principle.” 1996.

*Warren, Lynda M. “The Precautionary Principle: Use with Caution.” 1993.

Weinberg, Alvin M. “Science and Its Limits: The Regulator’s Dilemma.” 1985-6.

Weintraub, Bernard A. “Science, International Environmental Regulation, and the Precautionary Principle: Setting Standards and Defining Terms.” 1992.

F. Uncertainty

*Bodansky, Daniel. "Scientific Uncertainty and the Precautionary Principle." 1991.

*Costanza, Robert and Laura Cornwell. "The 4P Approach to Dealing with Scientific Uncertainty." 1992.

*Funtowicz, Silvio O. and Jerome R. Ravetz. "Uncertainty, Complexity and Post-Normal Science." 1994.

Green, Harold P. "The Resolution of Uncertainty." 1972.

Gullett, Warwick. "Environmental Protection and the 'Precautionary Principle': A Response to Scientific Uncertainty in Environmental Management." 1997.

Haas, Charles N. "Editorial: Acting in the Face of Uncertainty." 1990.

Jamieson, Dale. "Scientific Uncertainty and the Political Process." 1996.

Ludwig, Donald, Ray Hilborn, and Carl Walters. "Uncertainty, Resource Exploitation, and Conservation: Lessons from History." 1993.

*M'Gonigle, R. Michael, T. Lynne Jamieson, Murdoch K. McAllister, and Randall M. Peterman. "Taking Uncertainty Seriously: From Permissive Regulation to Preventative Design in Environmental Decision Making." 1994.

Myers, Norman. "Environmental Unknowns." 1995.

Shelton, Dinah. "The Impact of Scientific Uncertainty on Environmental Law and Policy in the United States." 1996.

G. Risk

Fischhoff, Baruch, Sarah Lichtenstein, Paul Slovic, Stephen L. Derby, and Ralph L. Keeney. *Acceptable Risk.* 1981.

Fischhoff, Baruch. "Managing Risk Perception." 1985-86.

Gaines, Sanford E. "Science, Politics, and the Management of Toxic Risks Through Law." 1990.

Margolis, Howard. *Dealing with Risk: Why the Public and the Experts Disagree on Environmental Issues*. 1996.

Stewart, Alan. "Environmental Risk Assessment: The Divergent Methodologies of Economists, Lawyers and Scientists." 1993.

H. Mindset and Social Aspects of Precaution

Allman, William F. "We Have Nothing to Fear – But a Few Zillion Things." 1985.

Gupta, Joyeeta. "Glocalization: The Precautionary Principle and Public Participation." 1996.

Hunt, Jane. "The Social Construction of Precaution." 1994.

Lave, Lester B. and Hadi Dowlatabadi. "Climate Change: The Effects of Personal Beliefs and Scientific Uncertainty." 1993.

*Macdonald, John M. "Appreciating the Precautionary Principle as an Ethical Evolution in Ocean Management." 1995.

Stanley, Neil. "Public Concern: The Decision-makers' Dilemma." 1998.

Suzuki, David. "Blinded by Our Minds." 1995.

Appendix 3

Towards Consilience

The following publications provide evidence of integration within and across disciplines, representing a chaotic, but progressive movement towards consilience of knowledge for environmental protection. The selection is a small sampling of those available, particularly from the last decade. They are presented in chronological order to confirm that consilience is not a new concept.

1789	White, Gilbert. *The Illustrated Natural History of Selborn.*
1840	Whewell, William. *The Philosophy of Inductive Sciences*.
1859	Darwin, Charles. *On the Origin of Species by Means of Natural Selection.*
1864	Marsh, George Perkins. *Man and Nature*.
1926	Vernadsky, Vladimir I. *The Biosphere.*
1949	Leopold, Aldo. *A Sand County Almanac.*
1968	Hardin, Garrett. “Tragedy of the Commons.”
1969	Commission on Marine Science, Engineering and Resources. *Our Nation and the Sea: A Plan for National Action*.
1969	Shepard, Paul and Daniel McKinley (eds.). *The Subversive Science: Essays Toward an Ecology Of Man.*
1970	Caldwell, Lynton Keith. *Environment: A Challenge to Modern Society*.
1971	Ray, Carleton. “Ecology, Law and the Marine Revolution.”
1972	Caponera, Dante A. “Towards a New Methodological Approach in Environmental Law.”
1972	Edwards, R.W. and Gordon G. Goodman. “Pollution of Air, Soil, Freshwater and the Sea.”
1975	Friedheim, Robert L. “Ocean Ecology and the World Political System.”
1977	Baden, John. “A Primer for the Management of Common Pool Resources.”
1977	Odum, Eugene P. “The Emergence of Ecology as a New Integrative Discipline.”
1977	Stever, H. Guyford. “Science, Technology, and Law – A Growing Partnership.”
1977	Tinbergen, Jan (ed.). *RIO- Reshaping the International Order: A Report to the Club of Rome.*
1978	Giarini, Orio. “Economics, Ecology and Welfare.”
1978	Wilkowski, Jean Mary. “Law, Science and Diplomacy: An Introduction to a Workshop on Cross Education of Lawyers and Scientists.”
1979	Lovelock, James. *Gaia: A New Look at Life on Earth.*
1980	Underdal, Arild. “Integrated Marine Policy: What? Why? How?”
1981	Goldberg, Edward D. “Our Oceans as Waste Space: The Argument.”
1985	Loevinger, Lee. “Science, Technology and Law in Modern Society.”
1985	Johnston, Douglas M. “Systemic Environmental Damage: The Challenge to International Law and Organizations.”
1985	Wali, Mohan K. and Robert L. Burgess. “The Interface of Ecology and Law: Science, the Legal Obligation, and Public Policy.”
1985	Hardin, Garrett. *Filters Against Folly: How to Survive Despite Economists, Ecologists and the Merely Eloquent*.

1986 Boczek, Boleslaw Adam. "The Concept of Regime and the Protection and Preservation of the Marine Environment."

1986 Borgese, Elisabeth Mann. *The Future of the Oceans: A Report to the Club of Rome*.

1987 Kelly, David, Raymond P. Côté, Brian Nicholls and Peter Ricketts. "Developing a Strategic Assessment and Planning Framework for the Marine Environment."

1987 Nicholson, Max. *The New Environmental Age*.

1987 Teclaff, Ludwik A. and Eileen Teclaff. "International Control of Cross-Media Pollution – An Ecosystem Approach."

1988 Underwood, A.J. and C.H. Peterson. "Towards an Ecological Framework for Investigating Pollution."

1989 Malone, Thomas F. "A New Dimension of International and Interdisciplinary Cooperation."

1990 Alexander, Lewis M. "The Cooperative Approach to Ocean Affairs: Twenty Years Later."

1990 Gaines, Sanford E. "Science, Politics, and the Management of Toxic Risks Through Law."

1990 M'Gonigle, R. Michael. "'Developing Sustainability' and the Emerging Norms of International Environmental Law: The Case of Land-Based Marine Pollution Control."

1991 Costanza, Robert, Herman E. Daly and Joy A. Bartholomew. "Goals, Agenda, and Policy Recommendations for Ecological Economics."

1991 Irwin, Frances H. "An Integrated Framework for Preventing Pollution and Protecting the Environment."

1991 Krier, James E. and Mark Brownstein. "On Integrated Pollution Control."

1992 Gore, Al. *Earth in the Balance: Forging a New Common Purpose*.

1992 Odum, Eugene P. "Great Ideas in Ecology for the 1990s."

1992 Caldwell, Lynton Keith. *Between Two Worlds: Science, the Environmental Movement and Policy Choice*.

1993 Couper, Alistair and Edgar Gold (eds.). *The Marine Environment and Sustainable Development: Law, Policy and Science*.

1993 Dahl, Arthur Lyon. "Land-Based Pollution and Integrated Coastal Management."

1993 Davis, W. Jackson. "The Need for a New Global Ocean Governance System."

1993 Lee, Kai N. *Compass and Gyroscope: Integrating Science and Politics for the Environment*.

1994 Yankov, Alexander and Mário Ruivo. "An Ocean Assembly."

1994 Brunnée, Jutta and Stephen J. Toope. "Environmental Security and Freshwater Resources: A Case for International Ecosystem Law."

1994 Hohmann, Harald. "Cross-media Pollution and International Environmental Law."

1995 Kimball, Lee A. "An International Regime for Managing Land-Based Activities that Degrade Marine and Coastal Environments."

1995 Macdonald, John M. "Appreciating the Precautionary Principle as an Ethical Evolution in Ocean Management."

1996 Dahl, Arthur Lyon. *The Eco Principle: Ecology and Economics in Symbiosis*.

1996 Gupta, Joyeeta. "Glocalization: The Precautionary Principle and Public Participation."

1996 Howard, Eric S. "Pollution Prevention in the Watershed: Protect the Land to Protect the River."

1996 Kunreuther, Howard and Paul Slovic. "Science, Values, and Risk."

1997 Ayling, Julie. "Serving Many Voices: Progressing Calls for an International Environmental Organization."

1997 Borgese, Elizabeth Mann. "Sustainable Development in the Oceans."

1997 Percival, Robert V. and Dorothy C. Alevizatos (eds.). *Law and the Environment: A Multi-Disciplinary Reader.*

1997 Scheiber, Harry N. "From Science to Law to Politics: An Historical View of the Ecosystem Idea and Its Effects on Resource Management."

1997 Young, Oran R. (ed.). *Global Governance: Drawing Insights from the Environmental Experience*.

1998 VanderZwaag, David L., Peter G. Wells and John Karau. "The Global Programme of Action for the Protection of the Marine Environment from Land-based Activities: A Myriad of Sounds, Will the World Listen?"

1998 Yost, Nicholas. "Environmental Regulation – Are there Better Ways?"

1998 Wilson, Edward O. *Consilience: The Unity of Knowledge*.

1999 Munn, Ted, Anne Whyte, and Peter Timmerman. "Emerging Environmental Issues: A Global Perspective of SCOPE."

1999 Salomons, Wim, R. Kerry Turner, Luiz Drude de Lacerda, and S. Ramachandran (eds.). *Perspectives on Integrated Coastal Management.*

1999 Turner, R. Kerry, Kenneth J. Button, and Peter Nijcamp (eds.). *Ecosystems and Nature: Economics, Science, and Policy.*

2000 Faigman, David Laurence. *Legal Alchemy: The Use and Misuse of Science in Law*.

2000 Robinson, Nicholas. "Legal Systems, Decisionmaking, and the Science of Earth's Systems: Procedural Missing Links."

2000 Howarth, William. "Economics, Ethics and Water Pollution Control."

2001 GESAMP. *A Sea of Troubles*.

2001 GESAMP. *Protecting the Oceans from Land-based Activities: Land-based Sources and Activities Affecting the Quality and Uses of the Marine, Coastal and Associated Freshwater Environment*.

2001 Goldberg, Edward D. "Emerging Problems in the Coastal Zone for the Twenty-first Century."

2002 Lutzenhiser, Loren. "Environmental Sociology: The Very Idea."

2002 White, Alan T., Catherine A. Courtney, and Albert Salamanca. "Experience with Marine Protected Area Planning and Management in the Philippines."

2002 Miles, Edward L., Arild Underdal, Steiner Andresen, Jørgen Wettestad, Jon Birger Skjærseth, and Elaine M. Carlin (eds.). *Environmental Regime Effectivenss: Confronting Theory with Evidence.*

2002 Wilson, Edward O. *The Future of Life.*

Appendix 4

Heidelberg Appeal to the Heads of States and Governments

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

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

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

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

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

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

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

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

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

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

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

From J.M. Bewers, "The Declining Influence of Science on Marine Environmental Policy", 10 *Chemistry and Ecology* 9 (1995), p. 23.

Appendix 5

The GPA: Integrative Assessment

The GPA is integrative in that it attempts comprehensive analysis of problems and it attempts to bring information together in a way consistent with consilience. Paragraph 21 identifies five elements to be systematically assessed when addressing problems. They are the type of problem, the contaminants involved, the sources, the type or range of impacts, and any special features of the receiving environment. The list is not exhaustive and States must decide their own priorities, with guidance from the GPA. Paragraph 21 is reproduced below.

21. The identification and assessment of problems is a process of combining five elements:

a) Identification of the nature and severity of problems in relation to:

(i) Food security and poverty alleviation;

(ii) Public health;

(iii) Coastal and marine resources and ecosystem health, including biological diversity.

(iv) Economic and social benefits and uses, including cultural values;

b) Contaminants: (not listed in order of priority)

(i) Sewage;

(ii) Persistent organic pollutants;

(iii) Radioactive substances;

(iv) Heavy metals;

(v) Oils (hydrocarbons);

(vi) Nutrients;

(vii) Sediment mobilisation;

(viii) Litter;

c) Physical alteration, including habitat modification and destruction in areas of concern;

d) Sources of degradation:

(i) Point sources (coastal and upstream), such as:

a. Waste-water treatment facilities;

b. Industrial facilities;

c. Power plants;

d. Military installations;

e. Recreational/tourism facilities;

f. Construction works (e.g., dams, coastal structures, harbour works, and urban expansion);

g. Coastal mining (e.g., sand and gravel);

h. Research centres;

i. Aquaculture;

j. Habitat modification (e.g., dredging, filling of wetlands, or clearing of mangrove areas);

k. Introduction of evasive species;

(ii) Non-point (diffuse) sources (coastal and upstream), such as: (not listed in priority)

a. Urban run-off;

b. Agricultural and horticultural run-off;

c. Forestry run-off;

d. Mining waste run-off;

e. Construction run-off;

f. Landfills and hazardous waste sites;

g. Erosion as a result of physical modification of coastal features;

(iii) Atmospheric deposition caused by:

a. Transportation (e.g., vehicle emissions);

b. Power plant and industrial facilities;

c. Incinerators

d. Agricultural operations;

e) Areas of concern (what areas are affected or vulnerable): (not listed in order of priority)

(i) Critical habitats, including coral reefs, wetlands, seagrass beds, coastal lagoons, and mangrove forests;

(ii) Habitats of endangered species;

(iii) Ecosystem components, including spawning areas, nursery areas, feeding grounds, and adult areas;

(iv) Shorelines;

(v) Coastal watersheds;

(vi) Estuaries and drainage basins;

(vii) Specially protected marine and coastal areas; and

(viii) Small islands.

Appendix 6

Becoming a Sophisticated Consumer of Science

Following are the 12 steps to be taken to become a sophisticated consumer of science.

1. I am an innumerate.
2. The law needs the best science available or that could be made available.
3. As a / an ___________________ (insert one: practicing attorney, professor, judge, administrator, legislator, or others), it behooves me to become familiar with science and the scientific culture in order to fulfil my professional obligations.
4. I don’t have to be a scientist to understand the rudiments of science.
5. I have the ability and motivation to learn about science.
6. Science is deeply fascinating and genuinely fun.
7. I am not afraid to seek help from bona fide experts in relevant fields, but I will not abdicate my responsibility to them.
8. I am willing to attend continuing education programs to help me, and if necessary and when relevant and useful, I will read published reference materials on science.
9. I will not label something “science” when it is merely the product of advocacy and has not been tested.
10. I will endeavour to understand the nuts and bolts of the scientific method and not simply the conclusory testaments offered by scientists or those pretending to that title.
11. I will call on all experts to provide the best information that their methods or methods that could be employed can deliver.
12. I am now a sophisticated consumer of science.

From D.L. Faigman, *Legal Alchemy: The Use and Misuse of Science in Law* (New York: W.H. Freeman and Company, 2000), p. 198.

Bibliography

A. Books and Articles

Aarssen, Lonnie W. "On the Progress of Ecology." 80 *Oikos* 177 (1997).

Abramovitz, Janet N. "Valuing Nature's Services." In Linda Starke, ed., *State of the World 1997: A Worldwatch Institute Report on Progress Toward a Sustainable Society* (London and New York: W.W. Norton & Company, 1997), pp. 95-114.

Aleksander, Igor. *Impossible Minds*. London: Imperial College Press, 1997.

Alexander, Lewis M. "The Cooperative Approach to Ocean Affairs: Twenty Years Later." 21 *Ocean Development and International Law* 105 (1990).

Alhéritière, Dominique. "Marine Pollution Control Regulation." 6 *Marine Policy* 162 (1982).

Allaby, Michael. *Facing the Future: The Case for Science*. London: Bloomsbury, 1996.

Allin, P.E. "Some Social Aspects of Modern Science: A Point of View." 3 *International Journal of Environment Studies* 49 (1972).

Allman, William F. "Pesticides: An Unhealthy Dependence?" *Science 85*, Vol. 6, No. 8, p. 14 (1985).

Allman, William F. "Staying Alive in the 20th Century." *Science 85*, Vol. 6, No. 8, pp. 31-7 (1985).

Allman, William F. "We Have Nothing to Fear – But a Few Zillion Things." *Science 85*, Vol. 6, No. 8, pp. 38-41 (1985).

American Society of Civil Engineers. *Pure and Wholesome: A Collection of Papers on Water and Waste Treatment at the Turn of the Century*. American Society of Civil Engineers, 1982.

Anand, R.P. "Changing Concepts of Freedom of the Seas: A Historical Perspective." In Jon M. Van Dyke, Durwood Zaelke, and Grant Hewison, eds., *Freedom for the Seas in the 21st Century: Ocean Governance and Environmental Harmony* (Washington, D.C. and Covelo, California: Island Press, 1993), pp. 72-90.

Andersen, Neil R. "An Early Warning System for the Health of the Oceans." 10 *Oceanography* 14 (1997).

Anderson, Stanley H., Ronald E. Beiswenger, and P. Walton Purdom. *Environmental Science.* New York: Macmillan Publishing Company, 1993.

Anonymous. "Pesticides Blamed for Absence of Alligators in Florida Lake." 9 *Water, Environment and Technology* 12 (1997).

Aron, William, William Burke, and Milton Freeman. "Flouting the Convention." *Atlantic Monthly*, Vol. 283, No. 5, pp. 22-9 (1999).

Aron, William, William Burke, and Milton Freeman. "The Whaling Issue." 24 *Marine Policy* 179 (2000).

Antrim, Lance N. and Pamela Chesek. "The UNCED Negotiating Process." 18 *Ocean and Coastal Management* 79 (1992).

Ayres, Ed. *God's Last Offer: Negotiating for a Sustainable Future.* New York, London: Four Walls Eight Windows, 1999.

Ayling, Julie. "Serving Many Voices: Progressing Calls for an International Environmental Organization." 9 *Journal of Environmental Law* 243 (1997).

Babich, Adam. "Understanding the New Era in Environmental Law." 41 *South Carolina Law Review* 733 (1990). Reprinted in Michael C. Blumm, ed., *Environmental Law* (New York: New York University Press, 1992), pp. 361-92.

Bailey, Ronald, ed. *Earth Report 2000: Revisiting the True State of the Planet.* New York: McGraw-Hill, Inc., 2000.

Baines, G.B.K. and R.J. Morrison. "Marine Pollution from Land Use in the Pacific Islands Region." 21 *Marine Pollution Bulletin* 506 (1990).

Ballschmiter, K.H., O. Froescheis, W.M. Jarman, and G. Caillet. "Contamination of the Deep-sea." 34 *Marine Pollution Bulletin* 288 (1997).

Barbour, Ian G., ed. *Western Man and Environmental Ethics.* Reading, Massachusetts: Addison-Wesley Publishing Company, 1973.

Barcena, Alicia. "An Overview of the Oceans in Agenda 21 of the United Nations Conference on Environment and Development." 25 *Marine Pollution Bulletin* 107 (1992).

Barcena, Alicia. "Some Reflections on a New Approach to Ocean and Coastal Management." In Alistair Couper and Edgar Gold, eds., *The Marine Environment and Sustainable Development: Law, Policy and Science* (Honolulu: University of Hawaii, 1993), pp. 21-55.

Barker, Neil J. "Sections 9 and 10 of the Rivers and Harbors Act of 1899: Potent Tools for Environmental Protection." 6 *Ecology Law Quarterly* 109 (1976).

Barros, James and Douglas M. Johnston. *The International Law of Pollution*. New York: The Free Press and London: Collier Macmillan Publishers, 1974.

Barton, Ronald. "The Helsinki Convention (1992): New Approaches." 22 *Ocean and Coastal Management* 249 (1994).

Basch, Paul F. *International Health*. Oxford: Oxford University Press, Inc., 1978.

Beanlands, G.E. "Research Demands of Marine Environmental Impact Assessments." 25 M*arine Pollution Bulletin* 104 (1992).

Beck, William S., Karel F. Liem, and George Gayford Simpson. *Life: An Introduction to Biology*, 3rd ed. New York: HarperCollins Publishers Inc., 1991.

Bernard, H. Russell and Peter D. Killworth. "Scientists as Others See Them." 4 *Ocean Development and International Law* 261 (1977).

Bewers, J. Michael. "The Declining Influence of Science on Marine Environmental Policy." 10 *Chemistry and Ecology* 9 (1995).

Bewers, J. Michael and C.J.R. Garrett. "Analysis of the Issues Related to Sea Dumping of Radioactive Wastes." 11 *Marine Policy* 105 (1987).

Bewers, J. Michael and Peter G. Wells. "Challenges for Improved Marine Environmental Protection." 25 *Marine Pollution Bulletin* 112 (1992).

Birnie, Patricia W. and Alan E. Boyle. *International Law and the Environment.* Oxford: Clarendon Press, 1993.

Blomquist, Robert F. "The EPA Science Advisory Board's Report on 'Reducing Risk': Some Overarching Observations Regarding the Public Interest." 22 *Environmental Law* 149 (1991).

Bloom, Allan David. *The Closing of the American Mind: How Higher Education has Failed Democracy and Impoverished the Souls of Today's Students.* New York: Simon and Schuster, 1987.

Bloom, David E. "International Public Opinion on the Environment." 269 *Science* 354 (1995).

Blumm, Michael C. "The National Environmental Policy Act at Twenty: A Preface." 20 *Environmental Law* 447 (1990).

Blumm, Michael C., ed. *Environmental Law*. New York: New York University Press, 1992.

Boczek, Boleslaw Adam. "Global and Regional Approaches to the Protection and Preservation of the Marine Environment." 16 *Case Western Reserve Journal of International Law* 39 (1984).

Boczek, Boleslaw Adam. "The Concept of Regime and the Protection and Preservation of the Marine Environment." 6 *Ocean Yearbook* 271 (1986).

Bodansky, Daniel. "Scientific Uncertainty and the Precautionary Principle." *Environment,* Vol. 33, No. 7, pp. 4-5, 43-45 (1991).

Bodansky, Daniel. "Commentary: The Precautionary Principle." *Environment*, Vol. 34, No. 3, pp. 4-5 (1992).

Bodansky, Daniel. “The Precautionary Principle in US Environmental Law.” In Timothy O’Riordan and James Cameron, eds., *Interpreting the Precautionary Principle* (London: Earthscan Publications Ltd., 1994), pp. 203-28.

Boehmer-Christiansen, Sonia. “Marine Pollution Control in Europe: Regional Approaches, 1972-80.” 8 *Marine Policy* 44 (1994).

Boehmer-Christiansen, Sonja. “The Precautionary Principle in Germany – Enabling Government.” In Timothy O’Riordan and James Cameron, eds., *Interpreting the Precautionary Principle* (London: Earthscan Publications Ltd., 1994), pp. 31-61.

Boelens, R.G.V. “From Policies to Science: Strategies for Marine Environmental Protection.” 25 *Marine Pollution Bulletin* 14 (1992).

Boer, Ben. “Social Ecology and Environmental Law.” 1 *Environmental and Planning Law Journal* 233 (1985).

Bongaarts, John. “Population: Ignoring Its Impact.” *Scientific American*, Vol. 286, No. 1, pp. 65-7 (2002).

Bookchin, Murray. *Remaking Society: Pathways to a Green Future*. Boston: South End Press, 1990.

Borgese, Elisabeth Mann. *The Future of the Oceans: A Report to the Club of Rome.* Montreal: Harvest House, 1986.

Borgese, Elisabeth Mann. “The Process of Creating an International Ocean Regime to Protect the Ocean’s Resources.” In Jon M. Van Dyke, Durwood Zaelke, and Grant Hewison, eds., *Freedom for the Seas in the 21st Century: Ocean Governance and Environmental Harmony* (Washington, D.C. and Covelo, California: Island Press, 1993), pp. 23-37.

Borgese, Elisabeth Mann. “*Pacem in Maribus* XXI.” 24 *Environmental Policy and Law* 19 (1994).

Borgese, Elizabeth Mann. “Sustainable Development in the Oceans.” 27 *Environmental Policy and Law* 203 (1997).

Boulding, Kenneth E. “What Do We Want To Sustain? Environmentalism and Human Evaluations.” In Robert Costanza, ed., *Ecological Economics: The Science and Management of Sustainability* (New York: Columbia University Press, 1991), pp. 21-31.

Bowler, Peter J. *The Norton History of the Environmental Sciences*. New York and London: W.W. Norton & Company, 1992.

Boyle, Alan E. “Marine Pollution Under the Law of the Sea Convention.” 79 *American Journal of International Law* 347(1985).

Boyle, Alan E. “The Law of the Sea and International Watercourses: An Emerging Cycle.” 14 *Marine Policy* 151 (1990).

Boyle, Alan E. “Land-based Sources of Marine Pollution.” 16 *Marine Policy* 20 (1992).

Boyle, Alan E. “Protecting the Marine Environment: Some Problems and Developments in the Law of the Sea.” 16 *Marine Policy* 79 (1992).

Bramwell, Anna. *Ecology in the 20th Century: A History*. New Haven and London: Yale University Press, 1989.

Breitmeier, Helmut. “International Organizations and the Creation of Environmental Regimes.” In Oran R. Young, ed., *Global Governance: Drawing Insights from the Environmental Experience* (Cambridge, Massachusetts and London, England: The MIT Press, 1997), pp. 87-114.

Bright, Chris. “Tracking the Ecology of Climate Change.” In Linda Starke, ed., *State of the World 1997: A Worldwatch Institute Report on Progress Toward a Sustainable Society* (London and New York: W.W. Norton & Company, 1997), pp. 78-94.

Broad, William J. *The Universe Below: Discovering the Secrets of the Deep Sea*. New York: Simon & Schuster, 1997.

Broadus, James M. “Creature Feature Too: *Principus precautionarium*.” *Oceanus*, Vol. 35, No. 1, pp. 6-7 (1992-3).

Brockington, C. Fraser. *The Health of the Community: Principles of Public Health for Practitioners and Students*. London: J. and A. Churchill Ltd., 1965.

Brown, E.D. "International Law and Marine Pollution: Radioactive Waste and Other Hazardous Substances." 11 *Natural Resources Journal* 221 (1971).

Brown, George E. "Environmental Science under Siege in the U.S. Congress." *Environment*, Vol. 39, No. 2, pp. 12-31 (1997).

Brown, Paul. *Global Warming: Can Civilisation Survive?* London: Blandford Books, 1996.

Brunnée, Jutta and Stephen J. Toope. "Environmental Security and Freshwater Resources: A Case for International Ecosystem Law." 5 *Yearbook of International Environmental Law* 42 (1994).

Cairns, John Jr. "Aquatic Ecosystem Assimilative Capacity." *Fisheries*, Vol. 2, No. 2, pp. 5-7, 24 (1977).

Cairns, John Jr. "Healing the World's Ecological Wounds." 8 *International Journal of Sustainable Development and World Ecology* 185 (2001).

Caldwell, Lynton Keith. *Environment: A Challenge to Modern Society*. New York: American Museum of Natural History, The Natural History Press, 1970.

Caldwell, Lynton Keith. "The Changing Structure of International Policy: Needs and Alternatives." 12 *Natural Resources Journal* 153 (1972).

Caldwell, Lynton Keith. *International Environmental Policy: Emergence and Dimensions*, 2nd ed. Durham and London: Duke Press Policy Studies and Duke University Press, 1990.

Caldwell, Lynton Keith. *Between Two Worlds: Science, the Environmental Movement and Policy Choice*. Cambridge: Cambridge University Press, 1992.

Cameron, James. "The Status of the Precautionary Principle in International Law." In Timothy O'Riordan and James Cameron, eds., *Interpreting the Precautionary Principle* (London: Earthscan Publications Ltd., 1994), pp. 262-89.

Cameron, James and Juli Abouchar. "The Precautionary Principle: A Fundamental Principle of Law and Policy for the Protection of the Global Environment." 14 *Boston College International and Comparative Law Review* 1 (1991).

Camp, William G. and Roy L. Donahue. *Environmental Science for Agriculture and Life Sciences.* Albany, New York: Delmar Publishers, Inc., 1994.

Caponera, Dante A. "Towards a New Methodological Approach in Environmental Law." 12 *Natural Resources Journal* 133 (1972).

Capra, Fritjof. *The Web of Life: A New Scientific Understanding of Living Systems*. New York: Anchor Books, Doubleday, 1996.

Carley, Michael and Ian Christie. *Managing Sustainable Development*. Minneapolis: University of Minnesota Press and London: Earthscan Publications Limited, 1993.

Carroll, John E., ed. *International Environmental Diplomacy*. Cambridge: Cambridge University Press, 1988.

Carson, Rachel L. *The Sea Around Us.* Oxford: Oxford University Press, 1950, 1989.

Carson, Rachel L. *Silent Spring*. New York and Boston: Houghton Mifflin Company, 1962, 1994.

Casti, John L. *Searching for Uncertainty: What Scientists Can Know About the Future*. London: Abacus Books, 1991.

Casti, John L. *Would-be Worlds: How Simulation is Changing the Frontiers of Science*. New York: John Wiley and Sons, Inc., 1997.

Castro, Peter and Michael E. Huber. *Marine Biology,* 2nd ed. Dubuque, Iowa: Wm. C. Brown Publishers, 1997.

Chapman, Peter M. "Is Bioaccumulation Useful for Predicting Impacts." 34 *Marine Pollution Bulletin* 282 (1997).

Chapman, Peter M. "The Precautionary Principle and Ecological Quality Standards/Objectives." 34 *Marine Pollution Bulletin* 227 (1997).

Charney, Jonathan I. "Universal International Law." 87 *American Journal of International Law* 529 (1993).

Chia Lin Sien and Ausafur Rahman. "Marine Pollution from Land-based Sources with Special Reference to Southeast Asia." In Mochtar Kusuma-Atmadja, Thomas A. Mensah and Bernard H. Oxman, eds., *Sustainable Development and Preservation of the Oceans: The Challenges of UNCLOS and Agenda 21* (Honolulu: University of Hawaii, 1997), pp. 316-47.

Chircop, Aldo E. "The Mediterranean Sea and the Quest for Sustainable Development." 23 *Ocean Development and International Law* 17 (1992).

Christie, Edward. "The Eternal Triangle: The Biodiversity Convention, Endangered Species Legislation and the Precautionary Principle." 10 *Environmental and Planning Law Journal* 470 (1993).

Chua Thia-Eng. "Essential Elements of Integrated Coastal Zone Management." 21 *Ocean and Coastal Management* 81 (1993).

Cicin-Sain, Biliana. "Sustainable Development and Integrated Coastal Management." 21 *Ocean and Coastal Management* 11 (1993).

Cicin-Sain, Biliana and Robert W. Knecht. "Implications of the Earth Summit for Ocean and Coastal Governance." 24 *Ocean Development and International Law* 323 (1993).

Clark, John William, Warren Viessman Jr., and Mark J. Hammer. *Water Supply and Pollution Control*, 2nd ed. Scranton, Penn.: International Textbook Company, 1971.

Clark, R.B. "Editorial: Laws of the Sea, 1986." 17 *Marine Pollution Bulletin* 1 (1986).

Clark, R.B. "Assessing Marine Pollution and Its Remedies." 10 *South African Journal of Marine Science* 341 (1991).

Clingan, Thomas A. Jr. "The Law of the Sea Convention: International Obligations and Stewardship Responsibilities of Coastal Nations." 17 *Ocean and Coastal Management* 201 (1992).

Collins, H.M. "Cooperation and the Two Cultures: Response to Labinger." 25 *Social Studies of Science* 306 (1995).

Coenen, René. "Dumping of Wastes at Sea: Adoption of the 1996 Protocol to the London Convention 1972." 6 *Review of European Community and International Environmental Law* 54 (1997).

Cohen, Steven and Sheldon Kamieniecki. *Environmental Regulation Through Strategic Planning*. Boulder, San Francisco, Oxford: Westview Press, 1991.

Cohl, H. Aaron. *Are We Scaring Ourselves to Death?: How Pessimism, Paranoia, and a Misguided Media are Leading Us Toward Disaster*. New York: St. Martin's Griffin Press, 1997.

Colborn, Theo, Dianne Dumanoski, and John Peterson Myers. *Our Stolen Future*. London: Abacus, 1997.

Connell, Joseph H. "Man's Effect on the Stability of Oceanic Systems." In Elizabeth Young and Lord Ritchie-Calder, eds., *Pacem In Maribus*: *The Ocean Environment*, Volume V (Malta: The Royal University of Malta Press, 1971), pp. 17-20.

Cook, David G. "Editorial." 54 *Canadian Journal of Fisheries and Aquatic Sciences* iii (1997).

Cormack, Douglas. "Scientific and Technical Background." 16 *Marine Policy* 5 (1992).

Costanza, Robert, ed. *Ecological Economics: The Science and Management of Sustainability*. New York: Columbia University Press, 1991.

Costanza, Robert, Herman E. Daly, and Joy A. Bartholomew. "Goals, Agenda, and Policy Recommendations for Ecological Economics." In Robert Costanza, ed., *Ecological Economics: The Science and Management of Sustainability* (New York: Columbia University Press, 1991), pp. 1-20.

Costanza, Robert and Laura Cornwell. "The 4P Approach to Dealing with Scientific Uncertainty." *Environment*, Vol. 34, No. 9, pp. 12-20 (1992).

Costanza, Robert, Ralph d'Arge, Rudolf de Groot, Stephen Farber, Monica Grasso, Bruce Hannon, Karin Limburg, Shahid Naeem, Robert V. O'Neill, Jose Paruelo, Robert G. Raskin, Paul Sutton, and Marjan van den Belt. "The Value of the World's Ecosystem Services and Natural Capital." 387 *Nature* 253 (1997).

Côté, Raymond P. "Marine Environmental Management: Status and Prospects." 25 *Marine Pollution Bulletin* 18 (1992).

Council of Environmental Advisers. "In Pursuit of Sustainable Environmentally Sound Development: Fundamentals of Environmental Ethics." Extracts from the 1994 Environmental Report of the German Council of Environmental Advisers (Der Rat von Sachverstandigen fur Umweltfragen). Translated and reprinted in 25 *Environmental Policy and Law* 90 (1995).

Crawford, Brian R., J. Stanley Cobb, and Abigail Friedman. "Building Capacity for Integrated Management in Developing Countries." 21 *Ocean and Coastal Management* 311 (1993).

Couper, Alistair and Edgar Gold, eds. *The Marine Environment and Sustainable Development: Law, Policy and Science.* Honolulu: University of Hawaii, 1993.

Cournand, André. "The Code of the Scientist and Its Relationship to Ethics." 18 *Jurimetrics Journal* 225 (1978).

Cox, George W. *Conservation Ecology: Biosphere and Biosurvival.* Dubuque, Iowa, USA; Wm. C. Brown Publishers, 1993.

Cuber, John F. "Ecotactics: The Critical Link (An Analysis of Values in Conflict)." 3 *International Journal of Environmental Studies* 23 (1972).

D'Amato, Anthony and John Lawrence Hargrove. "An Overview of the Problem." In John Lawrence Hargrove, ed., *Who Protects the Ocean?* (St. Paul, Minn.: West Publishing Co., 1975, published under the auspices of the American Society of International Law), pp. 1-35.

Dahl, Arthur Lyon. "Land-based Pollution and Integrated Coastal Management." 17 *Marine Policy* 561 (1993).

Dahl, Arthur Lyon. *The Eco Principle: Ecology and Economics in Symbiosis.* Oxford, London and New Jersey: George Ronald, Publisher and Zed Books Ltd., 1996.

Daily, Gretchen C. and Paul R. Ehrlich. "Population, Sustainability, and Earth's Carrying Capacity." In Fred B. Samson and Fritz L. Knopf, eds., *Ecosystem Management: Selected Readings* (New York: Springer-Verlag New York, Inc., 1996), pp. 435-50.

Dampier, William. "Ten Years after Stockholm: A Decade of Environmental Debate." 11 *Ambio* 215 (1982).

Darwin, Charles. *The Origin of Species by Means of Natural Selection or the Preservation of Favored Races in the Struggle for Life*. New York: Washington Square Press, 1859, 1963.

Dasmann, Raymond F. *Environmental Conservation,* 5th ed. New York: John Wiley & Sons, 1984.

Davies, F.G. *Clay's Public Health Inspector's Handbook*, 12th ed. London: H.K. Lewis & Co. Ltd., 1968.

Davies, I.G. *Modern Public Health for Medical Students*. London: Edward Arnold (Publishers) Ltd., 1963.

Davis, Devra Lee. "The 'Shotgun Wedding' of Science and Law: Risk Assessment and Judicial Review." 10 *Columbia Journal of Environmental Law* 67 (1985).

Davis, Mackenzie Leo and David A. Cornwell. *Introduction to Environmental Engineering*, 2nd ed. New York: McGraw-Hill, Inc., 1991.

Davis, W. Jackson. "Global Aspects of Marine Pollution Policy." 14 *Marine Policy* 191 (1990).

Davis, W. Jackson. "The Need for a New Global Ocean Governance System." In Jon M. Van Dyke Durwood Zaelke, and Grant Hewison, eds., *Freedom for the Seas in the 21st Century: Ocean Governance and Environmental Harmony* (Washington, D.C. and Covelo, California: Island Press, 1993), pp. 147-70.

Davos, C.A. "Sustaining Co-operation for Coastal Sustainability." 52 *Journal of Environmental Management* 379 (1998).

De Bono, Edward. *The Six Thinking Hats*. London: Penguin, 1985, 1990.

de Laet, Christian and Susan Singh. "The Individual and the Environment." 12 *Natural Resources Journal* 211 (1972).

Depledge, Michael H. "Ecotoxicology: A Science or Management Tool?" 22 *Ambio* 51 (1993).

Dethlefsen, Volkert. "Marine Pollution Mismanagement: Towards the Precautionary Concept." 17 *Marine Pollution Bulletin* 54 (1986).

Dhaliwal, Bhupinder S., Jonalea V. Ostlund, and Charles W. Batts. "Drawbacks of Method Detection Levels: EPA's Approved Measure Can Provide Inappropriate Limits." *Water, Environment and Technology*, Vol. 9, No. 6, pp. 39-43 (1997).

Dijksterhuis, Oda S. "Environmental Education: A Tool for Coastal Management? A Study of the Caribbean Region." 24 *Coastal Management* 339 (1996).

Di Leva, Charles E. "Environmentally Sustainable Development and the World Bank." *International Business Lawyer* 115 (March 1997).

Dixon, Bernard. *What is Science For?* Middlesex, England: Pelican Books, 1976.

Dubos, René. "A Theology of the Earth." In Ian G. Barbour, ed., *Western Man and Environmental Ethics* (Reading, Massachusetts: Addison-Wesley Publishing Company, 1973), pp. 43-54.

Duce, Robert. "Introduction." In Lewis M. Alexander, Scott Allen, and Lynne Carter Hanson, *New Developments in Marine Science and Technology: Economic, Legal and Political Aspects of Change* (Honolulu: University of Hawaii, 1989), pp. 15-6.

Dunbar, Robin. *The Trouble with Science.* Cambridge, Massachusetts: Harvard University Press, 1995.

Dunlap, Thomas R. "DDT: Scientists, Citizens, and Public Policy." From Dunlap, Thomas R. *DDT: Scientists, Citizens, and Public Policy* (Princeton: Princeton University Press, 1981), and reprinted in Robert V. Percival and Dorothy C. Alevizatos, eds., *Law and the Environment: A Multi-disciplinary Reader* (Philadelphia: Temple University Press, 1997), pp. 291-99.

Dzidzornu, David M. "Four Principles in Marine Environment Protection: A Comparative Analysis." 29 *Ocean Development and International Law* 91 (1998).

Earle, Sylvia Alice. *Sea Change: A Message of the Oceans.* New York: Fawcett Columbine, 1995.

Earll, R.C. "Commonsense and the Precautionary Principle: An Environmentalist's Perspective." 24 *Marine Pollution Bulletin* 182 (1992).

Eckholm, Erik P. *Down to Earth: Environment and Human Needs*. A report prepared in commemoration of the tenth anniversary of the historic Stockholm Conference on the Human Environment. New York and London: W.W. Norton & Company, 1982.

Editorial. "Why We Only Accept a Policy if We Know It Will Not Work." 1 *Ecologist Quarterly* 266 (1978).

Editorial. "§ 17: The Way Ahead for Hazardous Substances." *North Sea Monitor,* Vol. 15, No. 2, p. 3 (1997).

Edwards, David. "Review of the Status of Implementation and Development of Regional Arrangements on Cooperation in Combatting Marine Pollution." In John E. Carroll, ed., *International Environmental Diplomacy* (Cambridge: Cambridge University Press, 1988), pp. 229-72.

Edwards, R.W. and Gordon G. Goodman. "Pollution of Air, Soil, Freshwater and the Sea." 2 *International Journal of Environmental Studies* 263 (1972).

Edwards, Simon. "Coastal Electronic Information Systems – Conference Report." 18 *Marine Policy* 357 (1994).

Ehlers, Peter. "The Helsinki Convention, 1992: Improving the Baltic Sea Environment." 8 *The International Journal of Marine and Coastal Law* 191 (1993).

Ehrlich, Paul R. and Edward O. Wilson. “Biodiversity Studies: Science and Policy.” 253 *Science* 758 (1991).

Ehrlich, Paul R. and Anne H. Ehrlich. *Betrayal of Science and Reason: How Anti-environmental Rhetoric Threatens Our Future*. Washington, D.C.; Covelo, California: Island Press, 1996.

Ekstrand, Lars H. and Rita Ray. “Chaos and Complexity in Development.” 8 *International Journal of Sustainable Development and World Ecology* 127 (2001).

Elder, Danny L. “International Union for the Conservation of Nature and Natural Resources.” In Alistair Couper and Edgar Gold, eds., *The Marine Environment and Sustainable Development: Law, Policy and Science* (Honolulu: University of Hawaii, 1993), pp. 56-89.

Emmelin, Lars. “The Stockholm Conferences.” 1 *Ambio* 135 (1972).

Engelbert, Ernest A. “Political Parties and Natural Resources Policies: An Historical Evaluation.” 1 *Natural Resources Journal* 224 (1961).

Enger, Eldon D. and Bradley F. Smith. *Environmental Science: A Study of Interrelationships*, 5th ed. Dubuque, Iowa, USA; Wm. C. Brown Publishers, 1995.

Evans, David. *A History of Nature Conservation in Britain*. London and New York: Routledge, 1992.

Evans, Shelley M. “Control of Marine Pollution Generated by Offshore Oil and Gas Exploration and Exploitation: The Scotian Shelf.” 10 *Marine Policy* 258 (1986).

Evans, S.M., M. Dawson, J. Day, C.J.L. Frid, M.E. Gill, L.A. Pattisina, and J. Porter. “Domestic Waste and TBT Pollution in the Coastal Areas of Ambon Island (Eastern Indonesia).” 30 *Marine Pollution Bulletin* 109 (1995).

Fabbri, Paolo, ed. *Ocean Management in Global Change*. London and New York: Elsevier Science Publishers Ltd., 1992.

Faigman, David Laurence. *Legal Alchemy: The Use and Misuse of Science in Law*. New York: W.H. Freeman and Company, 1999, 2000.

Federal Interior Ministry (BMI). *Dritter Immissionsschutzbericht.* Drucksache, Bonn 10/1345, 1984, p. 53. Cited in Boehmer-Christiansen, Sonja. “The Precautionary Principle in Germany – Enabling Government”, in Timothy O’Riordan and James Cameron, eds., *Interpreting the Precautionary Principle* (London: Earthscan Publications Ltd., 1994), pp. 31-61.

Feynman, Richard P. *The Meaning of It All: Thoughts of a Citizen Scientist*. Reading, Massachusetts: Helix Books/Perseus Books, 1998.

Field, Barry C. *Environmental Economics: An Introduction*. New York: McGraw-Hill, Co., 1994.

Fifoot, C.H.S. *History and Sources of the Common Law: Tort and Contract*. London: Stevens & Sons Limited, 1949.

Fischhoff, Baruch. “Managing Risk Perception.” 2 *Issues in Science and Technology* 83 (1985-86).

Fischhoff, Baruch, Sarah Lichtenstein, Paul Slovic, Stephen L. Derby, and Ralph L. Keeney. *Acceptable Risk.* Cambridge: University of Cambridge Press, 1981, 1993.

Fisher, Glen. *Mindsets: The Role of Culture and Perception in International Relations*. Yarmouth, Maine, USA: Intercultural Press, Inc., 1988.

Fisher, Roger and William Ury. *Getting to Yes: Negotiating Agreements without Giving In*. London: Arrow Books Limited, 1981, 1987.

Fisk, David. “Environmental Science and Environmental Law.” 10 *Journal of Environmental Law* 3 (1998).

Flavin, Christopher. “The Legacy of Rio.” In Linda Starke, ed., *State of the World 1997: A Worldwatch Institute Report on Progress Toward a Sustainable Society* (London and New York: W.W. Norton & Company, 1997), pp. 3-22.

Fleming, David. “The Economics of Taking Care: An Evaluation of the Precautionary Principle.” In David Freestone and Ellen Hey, eds., *The Precautionary Principle in International Law: The Challenge of Implementation* (The Hague, London and Boston: Kluwer Law International, 1996), pp. 147-70.

Fleming, John G. *The Law of Torts*, 4th ed. Sydney: The Law Book Company of Australia, 1971.

Flournoy, Alyson C. "Legislating Inaction: Asking the Wrong Questions in Protective Environmental Decisionmaking." 15 *Harvard Environmental Law Review* 327 (1991).

Foo Kim Boon, Lye Lin Heng, and Koh Kheng Lian. "Environmental Protection: The Legal Framework." In Ooi Giok Ling, ed., *Environment and the City: Sharing Singapore's Experience and Future Challenges* (Singapore: Times Academic Press, 1995), pp. 47-99.

Fortes, Miguel D. "Seagrass-Mangrove Ecosystems Management: A Key to Marine Coastal Conservation in the ASEAN Region." 23 *Marine Pollution Bulletin* 113 (1991).

Fouéré, Erwan. "Emerging Trends in International Environmental Agreements." In John E. Carroll, ed., *International Environmental Diplomacy* (Cambridge: Cambridge University Press, 1988), pp. 29-44.

Freeman, A. Myrick. "Water Pollution Policy." In Paul R. Portney, ed., *Public Policy for Environmental Protection* (Washington, D.C.: Resources for the Future, 1992), pp. 97-149.

Freestone, David and Ellen Hey, eds. *The Precautionary Principle in International Law: The Challenge of Implementation.* The Hague, London and Boston: Kluwer Law International, 1996.

Freestone, David and Ellen Hey. "Origins and Development of the Precautionary Principle." In David Freestone and Ellen Hey, eds., *The Precautionary Principle in International Law: The Challenge of Implementation* (The Hague, London and Boston: Kluwer Law International, 1996), pp. 3-18.

Freestone, David and Ellen Hey. "Implementing the Precautionary Principle: Challenges and Opportunities." In David Freestone and Ellen Hey, eds., *The Precautionary Principle in International Law: The Challenge of Implementation* (The Hague, London and Boston: Kluwer Law International, 1996), pp. 249-68.

Freestone, David and Ton IJIstra, eds. *The North Sea: Perspectives on Regional Environmental Co-operation.* Special Issue of the International Journal of Estuarine and Coastal Law. London, Dordrecht, Boston: Graham & Trotman/Martinus Nijhoff, 1990.

French, Hilary F. "Learning from the Ozone Experience." In Linda Starke, ed., *State of the World 1997: A Worldwatch Institute Report on Progress Toward a Sustainable Society* (London and New York: W.W. Norton & Company, 1997), pp. 151-71.

Friedheim, Robert L. "Ocean Ecology and the World Political System." In John Lawrence Hargrove, ed., *Who Protects the Ocean?* (St. Paul, Minn.: West Publishing Co., 1975, published under the auspices of the American Society of International Law), pp. 151-90.

Friedheim, Robert L. "Managing the Second Phase of Enclosure." 17 *Ocean and Coastal Management* 217 (1992).

Fumento, Michael. *Science under Siege: How the Environmental Misinformation Campaign is Affecting Our Laws, Taxes, and Our Daily Life*. New York: Quill/William Morrow and Company, Inc., 1993.

Funtowicz, Silvio O. and Jerome R. Ravetz. "A New Scientific Methodology for Global Environmental Issues." In Robert Costanza, ed., *Ecological Economics: The Science and Management of Sustainability* (New York: Columbia University Press, 1991), pp. 139-52.

Funtowicz, Silvio O. and Jerome R. Ravetz. "Uncertainty, Complexity and Post-normal Science." 13 *Environmental Toxicology and Chemistry* 1881 (1994).

Gaines, Sanford E. "Science, Politics, and the Management of Toxic Risks Through Law." 30 *Jurimetrics Journal* 271 (1990).

Gamble, John King Jr., ed. *Law of the Sea: Neglected Issues*. Honolulu: University of Hawaii, 1979.

Gardiner, David. *Outline of Torts*. Sydney: Butterworths, 1992.

Gardner, Alex. "Federal Intergovernmental Cooperation on Environmental Management: A Comparison of Developments in Australia and Canada." 11 *Environmental and Planning Law Journal* 104 (1994).

Gardner, Howard. *Multiple Intelligences: The Theory in Practice*. New York: BasicBooks, 1993.

Gardner, Martin, ed. *Great Essays in Science.* Oxford: Oxford University Press, 1997.

Gardner, Richard N., ed. *Blueprint for Peace: Being Proposals of Prominent Americans to the White House Conference on International Co-operation*. New York: McGraw Hill, 1966.

Gardner, Richard N. *Negotiating Survival: Four Priorities After Rio.* New York: Council on Foreign Relations Press, 1992.

Garrett, Chris. "Oceanographic and Modelling Considerations in Marine Environmental Protection." 25 *Marine Pollution Bulletin* 41 (1992).

Garrett, Laurie. *The Coming Plague: Newly Emerging Diseases in a World Out of Balance*. New York: Farrar, Straus and Giroux, 1994.

Gascoigne, Robert. "The Historical Demography of the Scientific Community, 1450-1900." 22 *Social Studies of Science* 545 (1992).

Giarini, Orio. "Economics, Ecology and Welfare." 1 *Ecologist Quarterly* 249 (1978).

Ginsberg, Norton. "The Lure of Tidewater: The Problem of the Interface between the Land and Sea." In Elizabeth Young and Lord Ritchie-Calder, eds., *Pacem In Maribus*: *The Ocean Environment*, Volume V (Malta: The Royal University of Malta Press, 1971), pp. 59-65.

Ginsberg, Norton. "On the Nature of a Model Global Maritime Research Organization." 5 *Ocean Yearbook* 109 (1985).

Gleick, James. *Chaos: Making New Science*. New York and London: Penguin Books, 1987.

Goddard, Alison. "Fighting Science With Science." *Physics World* 57 (July 1997).

Goldberg, Edward D. "Our Oceans as Waste Space: The Argument." *Oceanus,* Vol. 24, No. 1, pp. 2-9 (1981).

Goldberg, Edward D. and John K. Taylor. "The VD Conspiracy." 16 *Marine Pollution Bulletin* 1 (1985).

Goldberg, Edward D. "Emerging Problems in the Coastal Zone for the Twenty-first Century." In R. Kerry Turner and Ian J. Bateman, eds., *Water Resources and Coastal Management* (Northhampton, Mass.: Edward Elgar Publishers, 2001), pp. 46-53.

Goldberg, Edward D. and David Menzel. "Oceanic Pollution." In John Lawrence Hargrove, ed., *Who Protects the Ocean?* (St. Paul, Minn.: West Publishing Co., 1975, published under the auspices of the American Society of International Law), pp. 37-61.

Goldsmith, Edward. "Blind Man's Bluff." 1 *Ecologist Quarterly* 2 (1978).

Goleman, Daniel. *Emotional Intelligence.* New York: Bantam Books, 1995.

Golley, Frank Benjamin. *A History of the Ecosystem Concept in Ecology: More than the Sum of the Parts*. New Haven and London: Yale University Press, 1993.

Gomez, Edgardo. "The Elements of Success in Project Implementation in a Developing Region." 24 *Marine Pollution Bulletin* 426 (1992).

Gomez, Edgardo. "Jumping Onto International Bandwagons Without Really Meaning It." 30 *Marine Pollution Bulletin* 98 (1995).

Gomez, Edgardo. "Coastal Zone Management and Ecosystem Protection." In K.L. Koh, R.C. Beckman and L.S. Chia (eds.), *Sustainable Development of Coastal Areas in Southeast Asia: Post-Rio Perspectives.* Singapore: National University of Singapore, SEAPOL and IUCN (CEL), 1995.

Goodstein, David. "Conduct and Misconduct in Science." In Paul R. Gross, Norman Levitt, and Martin W. Lewis, eds. *The Flight from Science and Reason*. New York: New York Academy of Sciences, 1996, pp. 31-38.

Gorden, Morton and Marsha Gorden. *Environmental Management: Science and Politics*. Boston: Allyn and Bacon, Inc. (1972).

Gordon, Bernard L. *Man and the Sea: Classic Accounts of Marine Exploration.* Garden City, New York: The Natural History Press, 1970.

Gore, Al. *Earth in the Balance: Forging a New Common Purpose*. London: Earthscan, 1992.

Gosovic, Branislav. *The Quest for World Environmental Cooperation: The Case of the UN Global Environment Monitoring System*. London and New York: Routledge, 1992.

Gray, John S. "Statistics and the Precautionary Principle." 21 *Marine Pollution Bulletin* 174 (1990).

Gray, John S. "Letters: Statistics and the Precautionary Principle – Professor Gray Replies." 21 *Marine Pollution Bulletin* 599 (1990).

Gray, John S. "Biological and Ecological Effects of Marine Pollutants and Their Detection." 25 *Marine Pollution Bulletin* 48 (1992).

Gray, John S. "Integrating Precautionary Scientific Methods into Decision-making." In David Freestone and Ellen Hey, eds., *The Precautionary Principle in International Law: The Challenge of Implementation* (The Hague, London and Boston: Kluwer Law International, 1996a), pp. 133-46.

Gray, John S. "Whose Research Is It Anyway?" *New Scientist*, Vol. 149, No. 2023, p. 48 (1996b).

Gray, John S., D. Calamari, R. Duce, J.E. Portmann, P.G. Wells, and H.L. Windom. "Scientifically Based Strategies for Marine Environmental Protection and Management." 22 *Marine Pollution Bulletin* 432 (1991).

Gray, John S. and J. Michael Bewers. "Towards a Scientific Definition of the Precautionary Principle." 32 *Marine Pollution Bulletin* 768 (1996).

Green, Harold P. "The Resolution of Uncertainty." 12 *Natural Resources Journal* 182 (1972).

Grinnell, Frederick. *The Scientific Attitude*, 2nd ed. New York and London: The Guilford Press, 1992.

Gross, Paul R. "The Icarian Impulse." 22 *The Wilson Quarterly* 39 (1998).

Gross, Paul R., Norman Levitt, and Martin W. Lewis, eds. *The Flight from Science and Reason*. New York: New York Academy of Sciences, 1996.

Gullett, Warwick. "Environmental Protection and the 'Precautionary Principle': A Response to Scientific Uncertainty in Environmental Management." 14 *Environmental and Planning Law Journal* 52 (1997).

Gündling, Lothar. "The Status in International Law of the Principle of Precautionary Action." In David Freestone and Ton IJIstra, eds., *The North Sea: Perspectives on Regional Environmental Co-operation*, Special Issue of the International Journal of Estuarine and Coastal Law (London, Dordrecht, Boston: Graham & Trotman/Martinus Nijhoff, 1990), pp. 23-30.

Gupta, Joyeeta. "Glocalization: The Precautionary Principle and Public Participation." In David Freestone and Ellen Hey, eds., *The Precautionary Principle in International Law: The Challenge of Implementation* (The Hague, London and Boston: Kluwer Law International, 1996), pp. 231-46.

Haas, Charles N. "Editorial: Acting in the Face of Uncertainty." 62 *Research Journal of the Water Pollution Control Federation* 115 (1990).

Haas, Peter M. "Do Regimes Matter?: Epistemic Communities and Mediterranean Pollution Control." 43 *International Organizations* 377 (1989).

Haas, Peter M. "Save the Seas: UNEP's Regional Seas Programme and the Coordination of Regional Pollution Control Efforts." 9 *Ocean Yearbook* 188 (1991).

Haas, Peter M., ed. *Knowledge, Power, and International Policy Coordination.* 46 *International Organizations(Special Issue)* (1992).

Haas, Peter M. "Introduction: Epistemic Communities and International Policy Coordination." 46 *International Organizations* (Special Issue) 1 (1992).

Haas, Peter M. "Prospects for Marine Governance in the NW Pacific Region." 24 *Marine Policy* 341 (2000).

Habermas, Jürgen. *Between Facts and Norms: Contributions to a Discourse Theory of Law and Democracy*. Translated by William Rehg. Cambridge, U.K.: Polity Press, 1996.

Haigh, Nigel and Frances Irwin, eds. *Integrated Pollution Control in Europe and North America*. Dexter, Michigan: Thomson-Shore, Inc., 1990.

Haigh, Nigel. “The Introduction of the Precautionary Principle into the UK.” In Timothy O’Riordan and James Cameron, eds., *Interpreting the Precautionary Principle* (London: Earthscan Publications Ltd., 1994), pp. 229-51.

Hall, John C., William T. Hall, and Charles T. Simmons. “Water Quality Criteria for Copper: A Need for Revisions of the National Standard.” *Water Environment and Technology*, Vol. 9, No. 6, pp. 45-9 (1997).

Halsbury’s Laws of England, 4th ed. Water. Volume 49, paragraphs 201-757, 1984.

Hammond, Kenneth R. and Leonard Adelman. “Science, Values, and Human Judgement.” 17 *Jurimetrics Journal* 253 (1977).

Handl, Günther. “Environmental Security and Global Change: The Challenge to International Law.” 1 *Yearbook of International Environmental Law* 3 (1990).

Hanlon, John J. and George E. Pickett. *Public Health: Administration and Practice*, 8th ed. St. Louis: Times Mirror/Mosby College Publishing, 1984.

Hansson, Sven Ove. “A Philosophical Perspective on Risk.” 28 *Ambio* 539 (1999).

Hardin, Garrett and John Baden, eds. *Managing the Commons*. San Francisco: W.H. Freeman and Company, 1977.

Hardin, Garrett. “Tragedy of the Commons.” 162 *Science* 1243 (1968). Reprinted in Garrett Hardin and John Baden, eds., *Managing the Commons* (San Francisco: W.H. Freeman and Company, 1977), pp. 16-30.

Hardin, Garrett. *Filters Against Folly: How to Survive Despite Economists, Ecologists and the Merely Eloquent*. New York: Penguin, 1985, 1987.

Hardy, Michael. “International Control of Marine Pollution.” 11 *Natural Resources Journal* 296 (1971).

Hare, Tony, ed. *Habitats*. New York: Macmillan, Inc., 1994.

Hargrove, John Lawrence, ed. *Who Protects the Ocean?*. St. Paul, Minn.: West Publishing Co., 1975. Published under the auspices of the American Society of International Law.

Hargrove, John Lawrence. “Environment and the Third Conference on the Law of the Sea.” In John Lawrence Hargrove, ed., *Who Protects the Ocean?* (St. Paul, Minn.: West Publishing Co., 1975, published under the auspices of the American Society of International Law), pp. 191-222.

Harmon, Willis W. *Global Mind Change: The Promise of the 21st Century.* San Francisco and Sausalito: Berrett-Koehler Publishers, Inc. and the Institute of Noetic Sciences, 1998.

Harrison, Paul. *The Third Revolution: Population, Environment and a Sustainable World*. London: Penguin, 1993.

Hawking, Stephen. “Foreword.” In Tom Wakeford and Martin Walters, eds., *Science for the Earth: Can Science Make the World a Better Place?* (Chichester, England: John Wiley & Sons, 1995), pp. ix-x.

Heap, J.M., M. Elliott, and T. Ap Rheinallt. “The Marine Disposal of Sewage Sludge.” 16 *Ocean and Shoreline Management* 291 (1991).

Heimlich, Ralph E., Keith D. Wiebe, Roger Claassen, and Robert M. House. “Recent Evolution of Environmental Policy: Lessons from Wetlands.” 52 *Journal of Soil and Water Conservation* 157 (1997).

Hempel, Lamont C. *Environmental Governance: The Global Challenge*. Washington D.C. and Covelo, California: Island Press, 1996.

Herschbach, Dudley R. “Imaginary Gardens with Real Toads.” In Paul R. Gross, Norman Levitt, and Martin W. Lewis, eds. *The Flight from Science and Reason*. New York: New York Academy of Sciences, 1996, pp. 11-30.

Hey, Ellen. “The Precautionary Approach: Implications of the Revision of the Oslo and Paris Convention.” 15 *Marine Policy* 244 (1991).

Hey, Ellen. “The Precautionary Concept in Environmental Policy and Law: Institutionalizing Caution.” 4 *Georgetown International Law Review* 303 (1992).

Hey, Ellen. "The Precautionary Principle." 26 *Marine Pollution Bulletin* 53 (1993).

Hey, Ellen, Ton IJIstra and André Nollkaemper. "The 1992 Paris Convention for the Protection of the Marine Environment of the North-east Atlantic: A Critical Analysis." 8 *International Journal of Marine and Coastal Law* 1 (1993).

Hickey, James E. Jr. "Custom and Land-based Pollution of the High Seas." 15 *San Diego Law Review* 409 (1978).

Hildebrand, Lawrence P. and Edward J. Norrena. "Approaches and Progress Toward Effective Integrated Coastal Zone Management." 25 *Marine Pollution Bulletin* 94 (1992).

Hinds, Lennox O. and G.B. Bacon. "CIDA Regional Ocean Initiative Workshop: Lessons Learned." 22 *Marine Policy* 539 (1998).

Hinrichsen, Don. *Our Common Seas: Coasts in Crisis*. London: Earthscan Publications Limited, 1990.

Hirvonen, H. and Raymond P. Côté. "Control Strategies for the Protection of the Marine Environment." 10 *Marine Policy* 19 (1986).

Hohmann, Harald. "Cross-media Pollution and International Environmental Law." 34 *Natural Resources Journal* 535 (1994).

Holdren, John P. "Energy: Asking the Wrong Questions." *Scientific American*, Vol. 286, No. 1, pp. 63-5 (2002).

Hollander, Jack M. "Scientists and the Environment: New Responsibilities." 3 *Ambio* 116 (1972).

Honachefsky, William B. *Land Planner's Environmental Handbook*. New Jersey: Noyes Publications, 1991.

Hooper, Peter Francis. "Scientists' Attitudes Toward Big Ocean Science." *Oceanus*, Vol. 23, No. 1, pp. 62-7 (1980).

Horgan, John. *The End of Science: Facing the Limits of Knowledge in the Twilight of the Scientific Age.* New York: Broadway Books, 1997.

Houck, Oliver A. "Are Humans Part of the Ecosystem?" 28 *Environmental Law* 1 (1998).

Howard, Eric S. "Pollution Prevention in the Watershed: Protect the Land to Protect the River." 5 *Review of European Community and International Environmental Law* 116 (1996).

Howarth, William. "Economics, Ethics and Water Pollution Control." 2 *Environmental Law Review* 131 (2000).

Hunt, Jane. "The Social Construction of Precaution." In Timothy O'Riordan and James Cameron, eds., *Interpreting the Precautionary Principle* (London: Earthscan Publications Ltd., 1994), pp. 117-25.

Hurrell, Andrew and Benedict Kingsbury, eds. *The International Politics of the Environment: Actors, Interests, and Institutions.* New York and Oxford: Oxford University Press, 1992.

Hutchings, Jeffery A., Carl Walters, and Richard L. Haedrich. "Is Scientific Inquiry Incompatible with Government Information Control?" 54 *Canadian Journal of Fisheries and Aquatic Sciences* 1198 (1997).

International Council of Scientific Unions. "IGBP International Geosphere-Biosphere Programme: A Study of Global Change." 17 *Ambio* 410 (1988).

International Union for the Conservation of Nature. *The Law of the Sea: Responsibilities in Implementing the Convention.* Cambridge, U.K. and Gland Switzerland: IUCN Publications Services Unit, 1995.

Irwin, Frances H. "Introduction to Integrated Pollution Control." In Nigel Haigh and Frances Irwin, eds., *Integrated Pollution Control in Europe and North America* (Dexter, Michigan: Thomson-Shore, Inc., 1990), pp. 3-30.

Irwin, Frances H. "An Integrated Framework for Preventing Pollution and Protecting the Environment." 22 *Environmental Law* 1 (1991).

Jackson, Thomas C. and Diana Reische, eds. *Coast Alert: Scientists Speak Out*. San Francisco: Friends of the Earth Publications, 1981.

Jackson, Tim and Peter J. Taylor. “The Precautionary Principle and the Prevention of Marine Pollution.” 7 *Chemistry and Ecology* 123 (1992).

Jacobson, Michael A. “The United Nations’ Regional Seas Programme: How Does It Measure Up?” 23 *Coastal Management* 19 (1995).

Jamieson, Dale. “Scientific Uncertainty and the Political Process.” 545 *The Annals of the American Academy of Political and Social Science* 35 (1996).

Jasanoff, Sheila. “What Judges Should Know About the Sociology of Science.” 32 *Jurimetrics Journal* 345 (1992).

Jasanoff, Sheila. *Science at the Bar: Law, Science, and Technology in America.* Cambridge, Massachusetts and London, England: Harvard University Press, 1995.

Jeffery, Michael I. “Appropriateness of Judicial and Non-judicial Determination of Environmental Issues.” 5 *Environmental Planning Law Journal* 265 (1988).

Jeftic, L. “The Role of Science in Marine Environmental Protection of Regional Seas and Their Coastal Areas: The Experience of the Mediterranean Action Plan.” 25 *Marine Pollution Bulletin* 66 (1992).

Jennings, Feenan D. and Lauriston R. King. “The IDOE in the National Science Foundation.” *Oceanus*, Vol. 23, No. 1, pp. 12-19 (1980).

Johnels, Alf. “Conference on Environmental Research and Management Priorities for the 1980s.” 12 *Ambio* 58 (1983).

Johnston, Douglas M. “International Environmental Law: Recent Developments and Canadian Contributions.” In Douglas M. Johnston, Ronald St. J. Macdonald, and Gerald L. Morris, eds., *Canadian Perspectives on International Law and Organization* (Toronto: University of Toronto Press, 1974), pp. 555-611.

Johnston, Douglas M., ed. *The Environmental Law of the Sea.* Berlin: Erich Schmidt Verlag, 1981.

Johnston, Douglas M. “The Environmental Law of the Sea: Historical Development.” In Douglas M. Johnston, ed., *The Environmental Law of the Sea* (Berlin: Erich Schmidt Verlag, 1981), pp. 17-69.

Johnston, Douglas M. “Systemic Environmental Damage: The Challenge to International Law and Organizations.” 12 *Syracuse Journal of International Law and Commerce* 255 (1985).

Johnston, Douglas M. “Marine Pollution Agreements: Successes and Problems.” In John E. Carroll, ed., *International Environmental Diplomacy* (Cambridge: Cambridge University Press, 1988), pp. 199-206.

Johnston, Douglas M. “UNCLOS III and UNCED: A Collision of Mind-sets?” In Lorne K. Kriwoken, Marcus Haward, David VanderZwaag, and Bruce Davis, eds., *Oceans Law and Policy in the Post-UNCED Era: Australian and Canadian Perspectives* (London: Kluwer Law International Ltd., 1996), pp. 11-24.

Johnston, Douglas M. *Consent and Commitment in the World Community: The Classification and Analysis of International Instruments*. Irvington-on-Hudson, New York: Transnational Publishers, Inc., 1997.

Johnston, Douglas M., Ronald St.J. Macdonald, and G.L. Morris, eds. *Canadian Perspectives on International Law and Organization.* Toronto: University of Toronto Press, 1974.

Johnston, Paul and Mark Simmonds. “Letters: Precautionary Principle.” 21 *Marine Pollution Bulletin* 402 (1990).

Jones, Harry W. *Law and the Social Role of Science.* New York: Rockefeller University Press, 1966.

Josefson, Alf B. “Letters: Statistics and the Precautionary Principle.” 21 *Marine Pollution Bulletin* 598 (1990).

Joyner, Christopher C. “The 1991 Madrid Environmental Protocol: Contributions to Marine Pollution Law.” 20 *Marine Policy* 183 (1996).

Justice, Tom and David W. Jamieson. *The Facilitator’s Handbook.* New York: American Management Association, 1999.

Kamlet, Kenneth S. “Our Oceans as Waste Space: The Rebuttal.” *Oceanus*, Vol. 24, No. 1, pp. 10-17 (1981).

Kamminga, Harmke. “Interpreting the World, Changing the World, and Living in the World: Is a ‘Science for the People’ Possible?” In Tom Wakeford and Martin Walters, eds., *Science for the Earth: Can Science Make the World a Better Place?* (Chichester, England: John Wiley & Sons, 1995), pp. 321-46.

Kant, I. *Universal Natural History and Theory of the Heavens.* Edinburgh: Scottish Academic Press, 1755, 1981.

Karau, John. “The Control of Land-based Sources of Marine Pollution: Recent International Initiatives and Prospects.” 25 *Marine Pollution Bulletin* 80 (1992).

Kates, Robert W. “Success, Strain, and Surprise.” 2 *Issues in Science and Technology* 46 (1985-86).

Kato, Ichiro, Nobuo Kumamoto, William H. Matthews, and Ariffin Suhaimi, eds. *Environmental Protection and Coastal Zone Management in Asia and the Pacific*. Tokyo: University of Tokyo Press, 1985.

Kaye, D.H. “Proof in Law and Science.” 32 *Jurimetrics Journal* 315 (1992).

Kerr, S.R. and R.A. Ryder. “The Laurentian Great Lakes Experience: A Prognosis for the Fisheries of Atlantic Canada.” 54 *Canadian Journal of Fisheries and Aquatic Sciences* 1190 (1997).

Kimball, Lee A. “UNCED and the Oceans Agenda: The Process Forward.” 17 *Marine Policy* 491 (1993).

Kimball, Lee A. “The United Nations Convention on the Law of the Sea: A Framework for Marine Conservation.” In IUCN, *The Law of the Sea: Responsibilities in Implementing the Convention* (Cambridge, U.K. and Gland Switzerland: IUCN Publications Services Unit, 1995), pp. 5-119.

Kimball, Lee A. “An International Regime for Managing Land-based Activities that Degrade Marine and Coastal Environments.” 29 *Ocean and Coastal Management* 187 (1995).

Kimball, Lee A. *Treaty Implementation: Scientific and Technical Advice Enters A New Stage*. Studies in Transnational Legal Policy No. 28. Washington, D.C.: The American Society of International Law, 1996.

King, Alexander and Bertrand Schneider. *The First Global Revolution: A Report by The Council of The Club of Rome*. London: Simon & Schuster, 1991.

Koechlin, Dominik and Kaspar Muller. *Green Business Opportunities*. London: Pitman Publishing, 1992.

Koh, K.L., R.C. Beckman, and Chia Lin Sien, eds. *Sustainable Development of Coastal and Ocean Areas in Southeast Asia: Post-Rio Perspectives.* SEAPOL Singapore Conference on Sustainable Development of Coastal and Ocean Areas in Southeast Asia: Post-Rio Perspectives, Singapore, 26-28 May 1994.

Kohl, Daniel H. “The Environmental Movement: What Might It Be?” 15 *Natural Resources Journal* 328 (1975).

Krier, James E. “The Pollution Problem and Legal Institutions: A Conceptual Overview.” 18 *UCLA Law Review* 429 (1971). Reprinted in Michael C. Blumm, ed., *Environmental Law* (New York: New York University Press, 1992), pp. 181-229.

Krier, James E. and Mark Brownstein. “On Integrated Pollution Control.” 22 *Environmental Law* 119 (1991).

Krom, Michael D. “An Evaluation of the Concept of Assimilative Capacity as Applied to the Marine Waters.” 15 *Ambio* 208 (1986).

Kuhn, Thomas S. *The Structure of Scientific Revolutions,* 3rd ed. Chicago and London: University of Chicago Press, 1962, 1970, 1996.

Kullenberg, Gunnar. “Capacity Building in Marine Research and Ocean Observations: A Perspective on Why and How.” 22 *Marine Policy* 185 (1998).

Kunreuther, Howard and Paul Slovic. "Preface." 545 The Annals of the American Academy of Political and Social Science 8 (1996).

Kunreuther, Howard and Paul Slovic. "Science, Values, and Risk." 545 *The Annals of the American Academy of Political and Social Science* 116 (1996).

Kurlansky, Mark. *Cod: A Biography of the Fish that Changed the World.* London: Vintage/Random House, 1999.

Kusler, Jon. "Wetlands Delineation: An Issue of Science or Politics?" *Environment*, Vol. 34, No. 2, pp. 7-11, 29-37 (1992).

Kusuma-Atmadja, Mochtar, Thomas A. Mensah, and Bernard H. Oxman, eds. *Sustainable Development and Preservation of the Oceans: The Challenges of UNCLOS and Agenda 21*. Honolulu: University of Hawaii, 1997.

Kütting, Gabriela. "Mediterranean Pollution: International Cooperation and the Control of Pollution from Land-based Sources." 18 *Marine Policy* 233 (1994).

Kwiatkowska, Barbara. "Marine Pollution from Land-based Sources: Current Problems and Prospects." 14 *Ocean Development and International Law* 315 (1984).

Labinger, Jay A. "Science as Culture: A View from the Petri Dish." 25 *Social Studies of Science* 285 (1995).

Laitos, Jan G. "Legal Institutions and Pollution: Some Intersections between Law and History." 15 *Natural Resources Journal* 423 (1975).

Lalwani, C.S. and T. Stojanovic. "The Development of Marine Information Systems in the UK." 23 *Marine Policy* 427 (1999).

Landner, Lars. "Hazardous Chemicals in the Environment – Some New Approaches to Advanced Assessment." 17 *Ambio* 360 (1988).

Lasswell, Harold D. and Myers S. McDougall. *Jurisprudence for a Free Society: Studies in Law, Science and Policy*. New Haven, Boston, London, and Dordrecht: New Haven Press and Martinus Nijhoff Publishers, 1992.

Latin, Howard A. "The Significance of Toxic Health Risks: An Essay on Legal Decisionmaking under Uncertainty." 10 *Ecology Law Quarterly* 339 (1982).

Lave, Lester B. and Hadi Dowlatabadi. "Climate Change: The Effects of Personal Beliefs and Scientific Uncertainty." 27 *Environmental Science and Technology* 1962 (1993).

Lawrence, John and David Taylor. "Letters: Statistics and the Precautionary Principle." 21 *Marine Pollution Bulletin* 598 (1990).

Lee, Kai N. *Compass and Gyroscope: Integrating Science and Politics for the Environment*. Washington, D.C. and Covelco, California: Island Press, 1993.

Leopold, Aldo. *A Sand County Almanac*. New York: Ballantine Books and Oxford University Press, 1949, 1970.

Lester, James P. *Environmental Politics and Policy,* 2nd ed. Durham and London: Duke University Press, 1997.

Levi, Primo. *Other People's Trades*. Translated by Raymond Rosenthal. London: Abacus Books, 1990.

Lindsay, Richard. "Galloping Gertie and the Precautionary Principle: How is Environmental Impact Assessed?" In Tom Wakeford and Martin Walters, eds., *Science for the Earth: Can Science Make the World a Better Place?* (Chichester, England: John Wiley & Sons, 1995), pp. 197-236.

Linnaeus, Carl. *Carl Linnaeus Systema nature: t.II: Vegetabilia.* New York: Stechert-Hafner, 1759, 1964.

List, Martin and Volker Rittberger. "Regime Theory and International Environmental Management." In Andrew Hurrell and Benedict Kingsbury, eds., *The International Politics of the Environment: Actors, Interests, and Institutions* (New York and Oxford: Oxford University Press, 1992), pp. 85-109.

Loevinger, Lee. "Law and Science as Rival Systems." 8 *Jurimetrics Journal* 63 (1966).

Loevinger, Lee. “Science, Technology and Law in Modern Society.” 26 *Jurimetrics Journal* 1 (1985).

Loevinger, Lee. “Standards of Proof in Law and Science.” 32 *Jurimetrics Journal* 323 (1992).

Loevinger, Lee. “Science as Evidence.” 35 *Jurimetrics Journal* 153 (1995).

Lomborg, Bjørn, *The Skeptical Environmentalist: Measuring the Real State of the World*, Cambridge University Press: Cambridge, U.K. and New York, 2001. Originally published in Danish as *Verdens Sande Tilstand,* 1998.

Longino, Helen E. *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry*. Princeton, New Jersey: Princeton University Press, 1990.

Lovejoy, Thomas, “Biodiversity: Dismissing Scientific Process.” *Scientific American*, Vol. 286, No. 1, pp. 67-9 (2002).

Lovelock, James. *Gaia: A New Look at Life on Earth.* Oxford and New York: Oxford University Press, 1979, 1995.

Lovelock, James. “The Greening of Science.” In Tom Wakeford and Martin Walters, eds., *Science for the Earth: Can Science Make the World a Better Place?* (Chichester, England: John Wiley & Sons, 1995), pp. 39-63.

Ludwig, Donald, Ray Hilborn, and Carl Walters. “Uncertainty, Resource Exploitation, and Conservation: Lessons from History.” 260 *Science* 17 (1993).

Luke, Timothy W. *Ecocritique: Contesting the Politics of Nature, Economy, and Culture*. Minneapolis and London: University of Minnesota Press, 1997.

Lundholm, Bengt. “The Oceans: Their Production and Pollution with the Baltic as a Case Study.” In Elizabeth Young and Lord Ritchie-Calder, eds., *Pacem In Maribus*: *The Ocean Environment*, Volume V (Malta: The Royal University of Malta Press, 1971), pp. 50-8.

Lutter, Stephan. “Letters: Statistics and the Precautionary Principle.” 21 *Marine Pollution Bulletin* 547 (1990).

Lutzenhiser, Loren. “Environmental Sociology: The Very Idea.” 15 *Organisation and Environment* 5 (2002).

M’Gonigle, R. Michael. “‘Developing Sustainability’ and the Emerging Norms of International Environmental Law: The Case of Land-based Marine Pollution Control.” 28 *The Canadian Yearbook of International Law* 169 (1990).

M’Gonigle, R. Michael, T. Lynne Jamieson, Murdoch K. McAllister, and Randall M. Peterman. “Taking Uncertainty Seriously: From Permissive Regulation to Preventative Design in Environmental Decision Making.” 32 *Osgoode Hall Law Journal* 99 (1994).

Macdonald, John M. “Appreciating the Precautionary Principle as an Ethical Evolution in Ocean Management.” 26 *Ocean Development and International Law* 255 (1995).

MacGarvin, Malcolm. “Is the Quality Status Report Reliable?” In Jesper Andersen, Henning Karup, and Ulla B. Nielson (eds), *Scientific Symposium on the North Sea Quality Status Report 1993, 18-21 April 1994, Ebeltoft, Denmark: Proceedings* (Ministry of Environment and Energy, Danish Environmental Protection Agency, 1996), pp. 121-31.

MacGarvin, Malcolm. “Precaution, Science and the Sin of Hubris.” In Timothy O’Riordan and James Cameron, eds., *Interpreting the Precautionary Principle* (London: Earthscan Publications Ltd., 1994), pp. 69-101.

MacIntyre, Angus A. “Why Pesticides Received Extensive Use in America: A Political Economy of Agricultural Pest Management to 1970.” 27 *Natural Resources Journal* 533 (1987).

Maij-Weggan, Hanja. “Foreword.” In David Freestone and Ton IJIstra, eds., *The North Sea: Perspectives on Regional Environmental Co-operation*, Special Issue of the International Journal of Estuarine and Coastal Law (London, Dordrecht, Boston: Graham & Trotman/Martinus Nijhoff, 1990), p. *v*.

Maltby, Edward. *Waterlogged Wealth*. London: Earthscan, 1986.

Margalef, Ramon. “Some Remarks from the Point of View of a General Ecologist.” In Elizabeth Young and Lord Ritchie-Calder, eds., *Pacem In Maribus*: *The Ocean Environment,* Volume V (Malta: The Royal University of Malta Press, 1971), pp. 13-17.

Margolis, Howard. *Dealing with Risk: Why the Public and the Experts Disagree on Environmental Issues*. Chicago and London: University of Chicago Press, 1996.

Margulis, Lynn and Dorion Sagan. *Slanted Truths: Essays on Gaia, Symbiosis, and Evolution*. New York: Copernicus/Springer-Verlag New York, Inc., 1997.

Marsh, George Perkins. *Man and Nature.* Cambridge Mass.: Harvard University Press, 1864, 1965.

Masefield, John. “Sea Fever.” In Michael Harrison and Christopher Stuart-Clark, eds. *The New Oxford Treasury of Children’s Poems.* (London: Oxford University Press, 1995), p. 88.

Mayr, Ernst. *This is Biology: The Science of the Living World*. Cambridge, Massachusetts and London: Belknap Press of Harvard University Press, 1997.

McCoubrey, Hilaire and Nigel D. White. *Textbook on Jurisprudence.* London: Blackstone Press Limited, 1993.

McGinn, Anne Platt. “Preventing Chronic Disease in Developing Countries.” In Linda Starke, ed., *State of the World 1997: A Worldwatch Institute Report on Progress Toward a Sustainable Society* (London and New York: W.W. Norton & Company, 1997), pp. 60-77.

McHale, John. *The Ecological Context*. London: Studio Vista Limited, 1971.

McIntosh, Robert P. *The Background of Ecology: Concept and Theory*. Cambridge: Cambridge University Press, 1988.

McIntyre, Owen and Thomas Mosedale. “The Precautionary Principle as a Norm of Customary International Law.” 9 *Journal of Environmental Law* 221 (1997).

McKnight, Allan D., Pauline K. Marstrand, and T. Craig Sinclair. *Environmental Pollution Control: Technical, Economic and Legal Aspects*. London: George Allen & Unwin Ltd., 1974.

McManus, Francis. *Environmental Health Law*. London: Blackstone Press Limited, 1994.

Meadows, Donella H., Dennis L. Meadows, and Jørgen Randers. *Beyond the Limits: Global Collapse or a Sustainable Future*. London: Earthscan, 1992.

Mee, Laurence David. “Scientific Methods and the Precautionary Principle.” In David Freestone and Ellen Hey, eds., *The Precautionary Principle in International Law: The Challenge of Implementation* (The Hague, London and Boston: Kluwer Law International, 1996), pp. 109-32.

Meng Qing-Nan. *Land-based Marine Pollution: International Law Development*. London: Graham and Trotman/Martinus Nijhoff, 1987.

Mersky, Roy M. and J. Myron Jacobstein, eds. *A Century of Law Reform: Twelve Lectures on the Changes on the Law of England During the Nineteenth Century*. London, New York: Macmillan and Co., Ltd., 1901.

Meyers, Charles J. “An Introduction to Environmental Thought: Some Sources and Some Criticisms.” 50 *Indiana Law Journal* 426 (1975). Reprinted in Michael C. Blumm, ed., *Environmental Law* (New York: New York University Press, 1992), pp. 3-30.

Miles, Edward L. “Concepts, Approaches, and Applications in Sea Use Planning and Management.” 20 *Ocean Development and International Law* 213 (1989).

Miles, Edward L., Arild Underdal, Steiner Andresen, Jørgen Wettestad, Jon Birger Skjærseth, and Elaine M. Carlin, eds. *Environmental Regime Effectiveness: Confronting Theory with Evidence.* Cambridge, Massachusetts and London: MIT Press, 2002.

Miller, G. Tyler Jr. *Environmental Science: Working with the Earth,* 6th ed. Belmont, California: Wadsworth Publishing Company, 1997.

Miller, Marc L. and Jerome Kirk. “Marine Environmental Ethics.” 17 *Ocean and Coastal Management* 237 (1992).

Milne, Alex. “The Perils of Green Pessimism.” *New Scientist,* Vol. 138, No. 1877, pp. 34-7 (1993).

Milton, Kay, ed. *Environmentalism: The View from Anthropology*. London and New York: Routledge, 1993.

Mowbray, David L. "Pesticide Control in the South Pacific." 15 *Ambio* 22 (1986).

Muller-Karger, Frank E. "Remote Sensing of Marine Pollution: A Challenge for the 1990s." 25 *Marine Pollution Bulletin* 54 (1992).

Munn, Ted, Anne Whyte, and Peter Timmerman. "Emerging Environmental Issues: A Global Perspective of SCOPE." *Ambio*, Vol. 28, No. 6, pp. 464-71 (1999).

Myers, Douglas. "Classroom Science." *Policy Options*, Vol. 6, No. 3, pp. 9-10 (1985).

Myers, Norman. "Biodiversity and the Precautionary Principle." 22 *Ambio* 74 (1993).

Myers, Norman. "Environmental Unknowns." 269 *Science* 358 (1995).

Nalven, Joseph. "Transboundary Environmental Problem Solving: Social Process, Cultural Perception." 26 *Natural Resources Journal* 793 (1986).

Nash, Roderick Frazier. *The Rights of Nature: A History of Environmental Ethics*. Madison: University of Wisconsin Press, 1989.

Nature Conservancy. "Coral Calamity." *Environment*, Vol. 39, No. 2, pp. 23-4 (1997).

Newell, R.C., D.R. Clegg, and D.W. Maughan. "Environmental Impact of Liquid Wastes Discharge in Coastal Waters." 16 *Ocean and Shoreline Management* 327 (1991).

Newton, Roger G. *The Truth of Science: Physical Theories and Reality*. Cambridge Massachusetts and London, England: Harvard University Press, 1997.

Nicholson, Max. *The Environmental Revolution: A Guide for the New Masters of the World*. London: Readers Union and Hodder and Stoughton, 1971.

Nicholson, Max. *The New Environmental Age*. Cambridge: Cambridge University Press, 1987.

Nollkaemper, André. "The Precautionary Principle in International Law: What's New Under the Sun?" 22 *Marine Pollution Bulletin* 107 (1991).

Nollkaemper, André. "Marine Pollution from Land-based Sources: Towards a Global Approach." 24 *Marine Pollution Bulletin* 8 (1992).

Nollkaemper, André. "Legal Protection of the Marine Environment from Pollution of International Watercourses: Recent Developments." 26 *Marine Pollution Bulletin* 298 (1993).

Nollkaemper, André. "Balancing the Protection of Marine Ecosystems with Economic Benefits From Land-based Activities: The Quest for International Legal Barriers." 27 *Ocean Development & International Law* 153 (1996).

Nurmi, Satu. "Issues and Problems in the Protection of the Marine Environment." In John E. Carroll, ed., *International Environmental Diplomacy* (Cambridge: Cambridge University Press, 1988), pp. 208-27.

O'Neill, John Francis. *Ecology, Policy and Politics: Human Well-being and the Natural World*. (Environmental Philosophies Series.) London and New York: Routledge, 1993.

O'Riordan, Timothy and James Cameron, eds. *Interpreting the Precautionary Principle*. London: Earthscan Publications Ltd., 1994.

Odum, Eugene P. *Fundamentals of Ecology*. Philadelphia: W.B. Saunders, 1953.

Odum, Eugene P. "The Emergence of Ecology as a New Integrative Discipline." 195 *Science* 1289 (1977).

Odum, Eugene. "A New Ecology for the Coast." In Thomas C. Jackson and Diana Reische, eds., *Coast Alert: Scientists Speak Out* (San Francisco: Friends of the Earth Publications, 1981), pp. 146-65.

Odum, Eugene P. *Ecology and Our Endangered Life-support System*, 2nd ed. Sunderland, Massachusetts: Sinauer Associates, Inc., 1993.

Odum, Eugene P. "Great Ideas in Ecology for the 1990s." 42 *Bioscience* 452 (1992). Reprinted in Fred B. Samson and Fritz L. Knopf, eds., *Ecosystem Management: Selected Readings* (New York: Springer-Verlag New York, Inc., 1996), pp. 279-84.

OECD. *Market and Government Failures in Environmental Management.* Paris: OECD, 1992.

Okemwa, Ezekiel. "The Intergovernmental Oceanographic Commission of UNESCO and Regional Capacity Building." 22 *Marine Policy* 197 (1998).

Ooi Giok Ling, ed. *Environment and the City: Sharing Singapore's Experience and Future Challenges*. Singapore: Times Academic Press, 1995.

Orr, David W. *Ecological Literacy: Education and the Transition to a Postmodern World*. New York: State University of New York Press, 1992.

Page, Talbot. "A Generic View of Toxic Chemicals and Similar Risks." 7 *Ecology Law Quarterly* 207 (1978).

Pallemaerts, Marc. "International Environmental Law from Stockholm to Rio: Back to the Future." In Philippe Sands, ed., *Greening International Law* (London: Earthscan Publications Limited, 1993), pp. 1-19.

Palmer, Geoffrey. "New Ways to Make International Environmental Law." 86 *American Journal of International Law* 259 (1992).

Palmer, Geoffrey. "The Earth Summit: What Went Wrong at Rio?" 70 *Washington University Law Quarterly* 1005 (1992).

Pardo, Arvid. "Perspectives on Ocean Governance." In Jon M. Van Dyke Durwood Zaelke, and Grant Hewison, eds., *Freedom for the Seas in the 21st Century: Ocean Governance and Environmental Harmony* (Washington, D.C. and Covelo, California: Island Press, 1993), pp. 38-40.

Parsons, T.R. "The Removal of Marine Predators by Fisheries and the Impact on Trophic Structure." 25 *Marine Pollution Bulletin* 51 (1992).

Paw, James N., ed. *Marine Environmental Monitoring, a dedicated issue of Tropical Coasts: A Newsletter for Policymakers, Environmental Managers, Scientists and Resource Users*, Vol. 4, No. 2, pp. 1-31 (1997).

Paw James N. and T.E. Chua. "Climate Changes and Sea Level Rise: Implications on Coastal Area Utilization and Management in South-east Asia." 15 *Ocean and Shoreline Management* 205 (1991).

Payoyo, Peter Bautista, ed. *Ocean Governance.* Tokyo, New York and Paris: United Nations University Press, 1994.

Pearce, David, ed. *Blueprint 2: Greening the World Economy*. London: Earthscan, 1991.

Pearce, David, Anil Markandya, and Edward B. Barbier. *Blueprint for a Green Economy*. London: Earthscan, 1990.

Peet, Gerard. "The Role of (Environmental) Non-governmental Organizations at the Marine Protection Committee (MEPC) of the International Maritime Organization (IMO), and at the London Dumping Convention (LDC)." 22 *Ocean and Coastal Management* 3 (1994).

Percival, Robert V. and Dorothy C. Alevizatos, eds. *Law and the Environment: A Multi-disciplinary Reader*. Philadelphia: Temple University Press, 1997.

Pereira, D.P., ed. *Focus on Environment.* Papers presented at the Symposium on Education for the Environment: Implications for the Future Development of Singapore, 1978. Singapore: Select Books on behalf of the Institute of Education Academic Staff Association, 1979.

Pernetta, John C. and Danny L. Elder. *Cross-sectoral, Integrated Coastal Area Planning: Guidelines and Principles for Coastal Area Development*. Gland: IUCN, 1993.

Perrings, Charles. "Reserved Rationality and the Precautionary Principle: Technological Change, Time and Uncertainty in Environmental Decision Making." In Robert Costanza, ed., *Ecological Economics: The Science and Management of Sustainability* (New York: Columbia University Press, 1991), pp. 153-66.

Peterson, M.J. “International Organizations and the Implementation of Environmental Regimes.” In Oran R. Young, ed., *Global Governance: Drawing Insights from the Environmental Experience* (Cambridge, Massachusetts and London, England: The MIT Press, 1997), pp. 115-51.

Peterman, Randall M. and Michael M’Gonigle. “Statistical Power Analysis and the Precautionary Principle.” 24 *Marine Pollution Bulletin* 231 (1992).

Philander, S. George. *Is the Temperature Rising?: The Uncertain Science of Global Warming*. Princeton: Princeton University Press, 1998.

Pimm, Stuart L. *The World According to Pimm: A Scientist Audits the Earth*. New York: McGraw-Hill, 2001.

Pinker, Steven. *How the Mind Works.* New York: W.W. Norton, 1997.

Pojman, Louis P., ed. *Environmental Ethics: Readings in Theory and Application.* Boston, London, Singapore: Jones and Bartlett Publishers, 1994.

Pomeroy, Robert S. “Community-based and Co-management Institutions for Sustainable Fisheries Management in Southeast Asia.” 27 *Ocean and Coastal Management* 143 (1995).

Ponting, Clive. *A Green History of the World*. London: Sinclair-Stevenson Limited, 1991.

Pool, Robert. “Science Literacy: The Enemy is Us.” 251 *Science* 266 (1991).

Popper, Karl R. *The Logic of Scientific Discovery*. New York: Harper & Row Publishers, Incorporated, 1959.

Porras, Ileana. “The Rio Declaration: A Basis for International Cooperation.” In Philippe Sands, ed., *Greening International Law* (London: Earthscan Publications Limited, 1993), pp. 20-33.

Porter, Gareth and Janet Welsh Brown. *Global Environmental Politics*, 2nd ed. Boulder, Colorado and Oxford, UK: Westview Press, Inc., 1996.

Portmann, John E. and R. Lloyd. “Safe Use of the Assimilative Capacity of the Marine Environment for Waste Disposal – Is It Feasible?” 18 *Water Science and Technology* 233 (1986).

Portmann, John E. and Velimir Pravdic. “Comment.” 7 *Chemistry and Ecology* 135 (1992).

Portney, Paul R., ed. *Public Policies for Environmental Protection.* Washington, D.C.: Resources for the Future, 1992.

Portney, Paul R. “Air Pollution Policy.” In Paul R. Portney, ed., *Public Policy for Environmental Protection* (Washington, D.C.: Resources for the Future, 1992), pp. 27-96.

Pravdic, Velimir. “Environmental Capacity – Is a New Scientific Concept Acceptable as a Strategy to Combat Marine Pollution?” 16 *Marine Pollution Bulletin* 295 (1985).

Pravdic, Velimir. “International Cooperation in Marine Sciences: The Non-governmental Framework and the Individual Scientist.” 5 *Ocean Yearbook* 117 (1985).

Raffensperger, C. and J. Tickner. *Protecting Human Health and the Environment: Implementing the Precautionary Principle*. Washington, D.C.: Island Press, 1999.

Rampton, Sheldon and John Stauber. *Trust Us, We’re Experts!: How Industry Manipulates Science and Gambles with Your Future.* New York: Jeremy P. Tarcher/Putnam and the Center for Media and Democracy, 2001.

Ramsey, Ross and Gerard C. Rowe. *Environmental Law and Policy in Australia*. Sydney: Butterworths, 1995.

Raustiala, Kal. “The ‘Participatory Revolution’ in International Environmental Law.” 21 *Harvard Environmental Law Review* 537 (1997).

Ravetz, Jerome R. *Scientific Knowledge and Its Social Problems.* Middlesex, England: Penguin University Books, 1973.

Ray, Carleton. “Ecology, Law and the Marine Revolution.” In Elizabeth Young and Lord Ritchie-Calder, eds., *Pacem In Maribus*: *The Ocean Environment*, Volume V (Malta: The Royal University of Malta Press, 1971), pp. 99-115.

Ray, Dixy Lee and Louis R. Guzzo. *Environmental Overkill: Whatever Happened to Common Sense?* New York: HarperPerennial, 1993.

Raymo, Chet. *The Virgin and the Mousetrap: Essays in Search of the Soul of Science*. New York: Viking Penguin, 1991.

Reed, David. "The Global Environment Facility and Non-governmental Organizations." 9 *American University Journal of International Law and Policy* 191 (1993).

Rees, William E. and Mathis Wackernagel. "Ecological Footprints and Appropriated Carrying Capacity: Measuring the Natural Capital Requirements of the Human Economy." In AnnMari Jansson, *et al.*, eds., *Investing in Natural Capital: The Ecological Economics Approach to Sustainability* (Washington, D.C.: Island Press, 1994), pp. 362-90.

Reilly, William K. "The Future of Environmental Law." 6 *Yale Journal on Regulation* 351 (1989). Reprinted in Michael C. Blumm, ed., *Environmental Law* (New York: New York University Press, 1992), pp. 467-71.

Rémond-Gouilloud, Martine. "Land-based Pollution." In Douglas M. Johnston, ed., *The Environmental Law of the Sea* (Berlin: Erich Schmidt Verlag, 1981), pp. 230-245.

Rennie, John. "Misleading Math about the Earth." *Scientific American*, Vol. 286, No. 1, p. 59 (2002).

Renner, Rebecca. "European Bans on Surfactant Trigger Transatlantic Debate." 31 *Environmental Science & Technology* 316 (1997).

Revelle, Roger. "The Need for International Cooperation in Marine Science and Technology." 5 *Ocean Yearbook* 130 (1985).

Revelle, Roger. "The Scripps Institution of Oceanography, California." 10 *Ocean Yearbook* 153 (1993).

Richman, Michael. "Environmentalists Impatient with EPA over Antidegradation Policies." 9 *Water, Environment and Technology* 15 (1997).

Risser, Paul G. "Biodiversity and Ecosystem Function." In Fred B. Samson and Fritz L. Knopf, eds., *Ecosystem Management: Selected Readings* (New York: Springer-Verlag New York, Inc., 1996), pp. 451-55.

Ritchie-Calder, Lord. "Perspectives on the Sciences of the Sea." 1 *Ocean Yearbook* 271 (1978).

Robertson, Heidi Gorovitz. "Methods for Teaching Environmental Law: Some Thoughts on Providing Access to the Environmental Law System." 23 *Columbia Journal of Environmental Law* 237 (1998).

Robinson, Nicholas. "Legal Systems, Decisionmaking, and the Science of Earth's Systems: Procedural Missing Links." 27 *Ecology Law Quarterly* 1077 (2000).

Rorty, Richard. "Against Unity." 22 *The Wilson Quarterly* 28 (1998).

Rose, J. "Anniversary Editorials." 37 *International Journal of Environmental Studies* 1 (1991).

Rose, J. "Foreword." 1 *International Journal of Environmental Studies* 1 (1970).

Rosemarin, Arno. "Global Change: A New Focus for International Environmental Science." 15 *Ambio* 370 (1986).

Rosemarin, Arno. "Ecotoxicology on the Upswing – But Where are the Ecologists?" 17 *Ambio* i (1988).

Rosen, George. *A History of Public Health*. New York: MD Publications, Inc., 1958.

Rothman, Stanley, and S. Robert Lichter. "Is Environmental Cancer a Political Disease?" In Paul R. Gross, Norman Levitt, and Martin W. Lewis, eds. *The Flight from Science and Reason*. New York: New York Academy of Sciences, 1996, pp. 231-45.

Ruckelshaus, William D. "Risk, Science, and Democracy." 1 *Issues in Science and Technology* 19 (1985).

Ruckelshaus, William D. "Stopping the Pendulum." In Robert V. Percival and Dorothy C. Alevizatos, eds., *Law and the Environment: A Multi-disciplinary Reader* (Philadelphia: Temple University Press, 1997), pp. 397-400.

Safe, Stephen. “Endocrine Disruptors: New Toxic Menace?” In Ronald Bailey, ed., *Earth Report 2000: Revisiting the True State of the Planet* (New York: McGraw-Hill, Inc., 2000), pp. 189-202.

Sagan, Carl. *The Demon-Haunted World: Science as a Candle in the Dark*. New York: Random House, 1995.

Salomons, Wim, R. Kerry Turner, Luiz Drude de Lacerda, and S. Ramachandran, eds. *Perspectives on Integrated Coastal Management.* Heidelberg: Springer-Verlag, 1999.

Sand, Peter H. *Lessons Learned in Global Environmental Governance.* Washington: World Resources Institute, 1990.

Sand, Peter H. “UNCED and the Development of International Environmental Law.” 3 *Yearbook of International Environmental Law* 3 (1992).

Sands, Philippe, ed. *Greening International Law*. London: Earthscan Publications Limited, 1993.

Scarlett, Lynn. “Doing More with Less – Unsung Environmental Triumph.” In Ronald Bailey, ed., *Earth Report 2000: Revisiting the True State of the Planet.* New York: McGraw-Hill, Inc., 2000, pp. 41-62.

Scheiber, Harry N. “From Science to Law to Politics: An Historical View of the Ecosystem Idea and Its Effects on Resource Management.” 24 *Ecology Law Quarterly* 631 (1997).

Schneider, Jan. *World Public Order of the Environment: Towards an International Ecological Law and Organization*. London: Stevens & Sons, 1979.

Schneider, Stephen, “Global Warming: Neglecting the Complexities.” *Scientific American*, Vol. 286, No. 1, pp. 60-3 (2002).

Schnoor, Jerald. “The Rio Earth Summit – What Does it Mean?” 27 *Environmental Science and Technology* 18 (1993).

Schröder, Peter C. “UNEP’s Regional Seas Programme and the UNCED Future: Aprés Rio.” 18 *Ocean and Coastal Management* 101 (1992).

Schumacher, E.F. *Small is Beautiful: A Study of Economics as if People Mattered.* London: Vintage, 1973, 1993.

Sebek, Viktor. “Bridging the Gap Between Environmental Science and Policy-making: Why Policy Often Fails to Reflect Current Scientific Knowledge.” 12 *Ambio* 118 (1983).

Shaikh, Rashid A. and Joanne K. Nichols. “The International Management of Chemicals.” 13 *Ambio* 88 (1984).

Shapiro, Irving S. “Science and Law.” 17 *Jurimetrics Journal* 195 (1977).

Shelton, Dinah. “The Impact of Scientific Uncertainty on Environmental Law and Policy in the United States.” In David Freestone and Ellen Hey, eds., *The Precautionary Principle in International Law: The Challenge of Implementation* (The Hague, London and Boston: Kluwer Law International, 1996), pp. 209-29.

Shepard, Paul and Daniel McKinley, eds. *The Subversive Science: Essays Toward An Ecology Of Man*. Boston: Houghton Mifflin Company, 1969.

Sheppard, Charles. “Not Politically Correct.” 24 *Marine Pollution Bulletin* 524 (1992).

Shermer, Michael. “The Gradual Illumination of the Mind.” *Scientific American*, Vol. 286, No. 2, p. 25 (2002).

Singer, Charles. *A History of Scientific Ideas*. Oxford: Oxford University Press: 1959; Dorset Press: New York, 1990.

Singer, S. Fred. *Hot Talk, Cold Science: Global Warming’s Unfinished Debate*, 2nd ed. Oakland, California: The Independent Institute, 1999.

Sitarz, Daniel, ed. *Sustainable America: America’s Environment, Economy and Society in the 21st Century.* Produced in Co-operation with the President’s Council on Sustainable Development and the Global Research Institute. Carbondale, Illinois: EarthPress, 1998.

Skjærseth, Jon Birger. "The 'Successful' Ozone-layer Negotiations." 2 *Global Environmental Change* 292 (1992).

Skjærseth, Jon Birger. "Towards the End of Dumping in the North Sea." 16 *Marine Policy* 130 (1992).

Skjærseth, Jon Birger. "Cleaning up the North Sea: The Case of Land-based Pollution Control." In Edward L. Miles, Arild Underdal, Steiner Andresen, Jørgen Wettestad, Jon Birger Skjærseth, and Elaine M. Carlin, eds., *Environmental Regime Effectiveness: Confronting Theory with Evidence* (Cambridge, Massachusetts and London: MIT Press, 2002), pp. 175-95.

Skjærseth, Jon Birger. "The Effectiveness of the Mediterranean Action Plan." In Edward L. Miles, Arild Underdal, Steiner Andresen, Jørgen Wettestad, Jon Birger Skjærseth, and Elaine M. Carlin, eds., *Environmental Regime Effectiveness: Confronting Theory with Evidence* (Cambridge, Massachusetts and London: MIT Press, 2002), pp. 311-30.

Skolimowski, Henryk. "Eco-philosophy versus the Scientific World View." 1 *Ecologist Quarterly* 227 (1978).

Slovic, Paul. "Perceived Risk, Trust and Democracy." 13 *Risk Analysis* 675 (1993).

Smil, V. *Cycles of Life: Civilization and the Biosphere.* New York: Scientific American Library, 1997.

Smillie, Wilson G. *Public Health: Its Promise for the Future*. New York: The Macmillan Company, 1955.

Smith, S.C. "How Law Hides Risk." In Gunther Teubner, Lindsay Farmer, and Declan Murphy, eds., *Environmental Law and Ecological Responsibility: The Concept and Practice of Ecological Self-organization* (Chichester, England: John Wiley & Sons, 1994), pp. 117-44.

Snow, C.P. *Two Cultures and the Scientific Revolution.* New York: Cambridge University Press, 1959.

Sohn, Louis B. "The Stockholm Declaration on the Human Environment." 14 *Harvard International Law Journal* 423 (1973).

Solomon, Shana M. and Edward J. Hackett. "Setting Boundaries Between Science and Law: Lessons Learned from *Daubert v. Merrell Dow Pharmaceuticals, Inc*." 21 *Science, Technology and Human Values* 131 (1996).

Spiller, Judith and Cynthia Hayden. "Radwaste at Sea: A New Era of Polarization or a New Basis for Consensus?" 19 *Ocean Development and International Law* 345 (1988).

Springer, Allen L. "Towards a Meaningful Concept of Pollution in International Law." 26 *International and Comparative Law Quarterly* 531 (1977).

Stairs, Kevin and Peter Taylor. "Non-governmental Organizations and the Legal Protection of the Oceans: A Case study. In Andrew Hurrell and Benedict Kingsbury, eds., *The International Politics of the Environment: Actors, Interests, and Institutions* (New York and Oxford: Oxford University Press, 1992), pp. 110-41.

Stanley, Neil. "Public Concern: The Decision-makers' Dilemma." [1998] *Journal of Planning Law* 919.

Starke, Linda, ed. *State of the World 1997: A Worldwatch Institute Report on Progress Toward a Sustainable Society*. London and New York: W.W. Norton & Company, 1997.

Starke, Linda, ed. *Vital Signs 1998: Environmental Trends that are Shaping Our Future.* New York and London: W.W. Norton & Company, and Washington: Worldwatch Institute, 1998.

Stebbing, A.R.D. "Assimilative Capacity." 12 *Marine Pollution Bulletin* 362 (1981).

Stebbing, A.R.D. "Environmental Capacity and the Precautionary Principle." 24 *Marine Pollution Bulletin* 287 (1992).

Stebbing, A.R.D. and R.I Willows. "Quality Status, Appropriate Monitoring, and Legislation of the North Sea in Relation to the Assimilative Capacity." In Wim Salomons, R. Kerry Turner, Luiz Drude de Lacerda, and S. Ramachandran, eds., *Perspectives on Integrated Coastal Management* (Heidelberg: Springer-Verlag, 1999), pp. 145-82.

Steel, Ernest W. *Water Supply and Sewerage*, 4th ed. New York: McGraw-Hill Book Company, Inc., 1960.

Stein, Paul. "A Cautious Application of the Precautionary Principle." 2 *Environmental Law Review* 1 (2000).

Steiner, Rick. "Government, Industry and Public Management of the Seas in the 21st Century." 17 *Marine Policy* 399 (1993).

Stel, Jan H. "Editorial – Marine Capacity Building in a Changing Global Setting." 22 *Marine Policy* 175 (1998).

Stel, Jan H., ed. *A Special Issue on Marine Capacity Building in a Global Setting*. 22 *Marine Policy* (1998).

Stever, H. Guyford. "Science, Technology, and Law – A Growing Partnership." 17 *Jurimetrics Journal* 189 (1977).

Stewart, Alan. "Environmental Risk Assessment: The Divergent Methodologies of Economists, Lawyers and Scientists." 10 *Environmental and Planning Law Journal* 10 (1993).

Stokke, Olav Schram. "Regimes as Governance Systems." In Oran R. Young, ed., *Global Governance: Drawing Insights from the Environmental Experience* (Cambridge, Massachusetts and London, England: The MIT Press, 1997), pp. 27-63.

Stone, Christopher D. *The Gnat is Older Than Man: Global Environment and Human Agenda.* New Jersey: Princeton University Press, 1993.

Stone, Christopher D. "Mending the Seas Through a Global Commons Trust Fund." In Jon M. Van Dyke Durwood Zaelke, and Grant Hewison, eds., *Freedom for the Seas in the 21st Century: Ocean Governance and Environmental Harmony* (Washington, D.C. and Covelo, California: Island Press, 1993), pp. 171-86.

Strong, Maurice F. "The Stockholm Conference – Where Science and Politics Meet." 1 *Ambio* 73 (1972).

Strong, Maurice F. *From Stockholm to Rio: A Journey Down a Generation.* An Earth Summit Publication: Number One, UNCED, 1991.

Strong, Maurice F. *Where on Earth are We Going?* Toronto: Alfred A. Knopf Canada, 2000.

Suess, E. *Die Enstchung der Alpen [The Origin of the Alps].* Vienna: W. Braunmüller, 1875.

Suijkerbuijk, Michael. "Waste Prevention: Corporate and Environmental Benefits." 9 *Environmental and Planning Law Journal* 258 (1992).

Sumich, James L. *Introduction to the Biology of Marine Life,* 5th ed. Dubuque, Iowa, U.S.A.: Wm. C. Brown Publishers, 1992.

Susskind, Lawrence S. *Environmental Diplomacy: Negotiating More Effective Global Agreements*. New York, Oxford: Oxford University Press, 1994.

Susskind, Lawrence and Connie Ozawa. "Negotiating More Effective International Agreements." In Andrew Hurrell and Benedict Kingsbury, eds., *The International Politics of the Environment: Actors, Interests, and Institutions* (New York and Oxford: Oxford University Press, 1992), pp. 142-65.

Suzuki, David. "Blinded by Our Minds." In Tom Wakeford and Martin Walters, eds., *Science for the Earth: Can Science Make the World a Better Place?* (Chichester, England: John Wiley & Sons, 1995), pp. 3-17.

Suzuki, David. *The Sacred Balance: Rediscovering our Place in Nature*. Vancouver, Toronto: Greystone Books, 1997.

Switzer, Jacqueline Vaughn. *Green Backlash: The History and Politics of Environmental Opposition in the U.S.* Boulder and London: Lynne Rienner Publishers, Inc., 1997.

Tansley, Arthur G. "The Use and Abuse of Vegetational Concepts and Terms." 16 *Ecology* 284 (1935).

Taylor, Peter. "The State of the Marine Environment: A Critique of the Work and Role of the Joint Group of Experts on Scientific Aspects of Marine Pollution (GESAMP)." 26 *Marine Pollution Bulletin* 120 (1993).

Teclaff, Ludwik A. "What You Have Always Wanted to Know About Riparian Rights, But Were Afraid to Ask." 12 *Natural Resources Journal* 30 (1972).

Teclaff, Ludwik A. and Albert E. Utton, eds. *International Environmental Law.* New York/London: Praeger Publishers, 1975.

Teclaff, Ludwik A. "International Law and the Protection of the Oceans from Pollution." In Ludwik A. Teclaff and Albert E. Utton, eds., *International Environmental Law* (New York/London: Praeger Publishers, 1975), pp. 104-39.

Teclaff, Ludwik A. "Fiat or Custom: The Checkered Development of International Water Law." 31 *Natural Resources Journal* 45 (1991).

Teclaff, Ludwik A. and Eileen Teclaff. "International Control of Cross-media Pollution – An Ecosystem Approach." 27 *Natural Resources Journal* 21 (1987).

Teclaff, Ludwik A. and Eileen Teclaff. "Transfers of Pollution and the Marine Environment Conventions." 31 *Natural Resources Journal* 187 (1991).

The Concise Oxford Dictionary, 7th ed. Oxford: Oxford University Press, 1984.

The Concise Oxford Dictionary of Ecology. Oxford and New York: Oxford University Press, 1994.

Theocharis, T. and M. Psimopoulos. "Where Science Has Gone Wrong." 329 *Nature* 595 (1987).

Thomas, Lewis. *The Lives of a Cell: Notes of a Biology Watcher.* New York and London: Penguin Books, 1974, 1978.

Thomas, Patricia, ed. *Water Pollution Law and Liability.* London: Graham and Trotman, 1993.

Thomas, William A. "A Report from the Workshop on Cross Education of Lawyers and Scientists." 19 *Jurimetrics Journal* 92 (1978).

Thomashow, Mitchell. *Ecological Identity: Becoming a Reflective Environmentalist*. Cambridge Massachusetts and London: The MIT Press, 1996.

Thompson, Andrew R. "Legal Responses to Pollution Problems – Their Strengths and Weaknesses." 12 *Natural Resources Journal* 227 (1972).

Thoreau, Henry David. *Walden, or, Life in the Woods.* New York: Signet Classic, 1960.

Thorne-Miller, Boyce. "The LDC, the Precautionary Approach, and the Assessment of Wastes for Sea-disposal." 24 *Marine Pollution Bulletin* 335 (1992).

Thrupp, Lori Ann. "Entrapment and Escape from Fruitless Insecticide Use: Lessons from the Banana Sector of Costa Rica." 36 *International Journal of Environmental Studies* 173 (1990).

Tinbergen, Jan, ed. *RIO-Reshaping the International Order: A Report to the Club of Rome.* Winnipeg, Canada: The New American Library of Canada Limited, 1977.

Tolba, Mostafa K., Osama A. El-Kholy, E. El-Hinnawi, M.W. Holdgate, D.F. McMichael, and R.E. Munn, eds. *The World Environment 1972-1992: Two Decades of Challenge*. London: Chapman & Hall (on behalf of UNEP), 1992.

Tomczak, M. Jr. "Defining Marine Pollution: A Comparison of Definitions Used by International Conventions." 8 *Marine Policy* 311 (1984).

Tomkins, Stephen. "Science for the Earth Starts at School." In Tom Wakeford and Martin Walters, eds., *Science for the Earth: Can Science Make the World a Better Place?* (Chichester, England: John Wiley & Sons, 1995), pp. 257-76.

Turner, R. Kerry. "Policy Failures in Managing Wetlands." In OECD, *Market and Government Failures in Environmental Management* (Paris: OECD, 1992), pp. 9-43.

Turner, R. Kerry, W.N. Adger, S. Crooks, I. Lorenzoni, and L. Ledoux. "Sustainable Coastal Resources Management: Principles and Practices." 23 *Natural Resources Forum* 275 (1999).

Turner, R. Kerry, Kenneth J. Button, and Peter Nijcamp, eds. *Ecosystems and Nature: Economics, Science, and Policy.* Cheltenham, UK; Northhampton, Mass.: Edward Elgar Publications, 1999.

Turner, R. Kerry and Ian J. Bateman, eds. *Water Resources and Coastal Management*. Cheltenham, UK; Northhampton, Mass.: Edward Elgar Publications, 2001.

Topping, Graham. “The Role and Application of Quality Assurance in Marine Environmental Protection.” 25 *Marine Pollution Bulletin* 61 (1992).

Underdal, Arild. “Integrated Marine Policy: What? Why? How?” 4 *Marine Policy* 159 (1980).

Underdal, Arild. “One Question, Two Answers.” In Edward L. Miles, Arild Underdal, Steiner Andresen, Jørgen Wettestad, Jon Birger Skjærseth, and Elaine M. Carlin, eds., *Environmental Regime Effectiveness: Confronting Theory with Evidence* (Cambridge, Massachusetts and London: MIT Press, 2002), pp. 3-45.

Underdal, Arild. “Conclusions.” In Edward L. Miles, Arild Underdal, Steiner Andresen, Jørgen Wettestad, Jon Birger Skjærseth, and Elaine M. Carlin, eds., *Environmental Regime Effectiveness: Confronting Theory with Evidence* (Cambridge, Massachusetts and London: MIT Press, 2002), pp. 433-65.

Underwood, A.J. and C.H. Peterson. “Towards an Ecological Framework for Investigating Pollution.” 46 *Marine Ecology – Progress Series* 227 (1988).

United Nations Environment Programme. *Global Environmental Outlook*. New York and Oxford: Oxford University Press, 1997.

Valiante, Marcia, Paul Muldoon, and Lee Botts. “Ecosystem Governance: Lessons from the Great Lakes.” In Oran R. Young, ed. *Global Governance: Drawing Insights from the Environmental Experience*. Cambridge, Massachusetts and London, England: The MIT Press, 1997, pp. 197-225.

Vallega, Adalberto. “A Conceptual Approach to Integrated Coastal Management.” 21 *Ocean and Coastal Management* 149 (1993).

Vallentyne, J.R. “First Direction, Then Velocity.” 17 *Ambio* 409 (1988).

Van Dyke, Jon M., Durwood Zaelke, and Grant Hewison, eds. *Freedom for the Seas in the 21st Century: Ocean Governance and Environmental Harmony*. Washington, D.C. and Covelo, California: Island Press, 1993.

VanderZwaag, David L. “The Concept and Principles of Sustainable Development: ‘Rio-formulating’ Common Law Doctrines and Environmental Laws.” 13 *Windsor Yearbook of Access to Justice* 39 (1993).

VanderZwaag, David L. *Canada and Marine Environmental Protection: Charting a Legal Course Towards Sustainable Development*. London, The Hague, Boston: Kluwer Law International, 1995.

VanderZwaag, David L. “International Law and Arctic Marine Conservation and Protection: A Slushy, Shifting Seascape.” 9 *The Georgetown International Environmental Law Review* 303 (1997).

VanderZwaag, David L., Peter G. Wells, and John Karau. “The Global Programme of Action for the Protection of the Marine Environment from Land-based Activities: A Myriad of Sounds, Will the World Listen?” 13 *Ocean Yearbook* 183 (1998).

Vernadsky, Vladimir I. *The Biosphere*. New York: Copernicus/Springer-Verlag, New York, Inc., 1997. (*Biosfera*. Leningrad: Nauka, 1926. *La Biosphère*. Paris: Félix Alcan, 1929.)

Vernadsky, Vladimir I. “The Biosphere and the Noösphere.” 33 *American Scientist* 1 (1945).

von Moltke, Konrad. “Commentary: The Precautionary Principle.” *Environment*, Vol. 34, No. 3, pp. 3 (1992).

von Moltke, Konrad. “The Relationship between Policy, Science, Technology, Economics and Law in the Implementation of the Precautionary Principle.” In David Freestone and Ellen Hey, eds., *The Precautionary Principle in International Law: The Challenge of Implementation* (The Hague, London and Boston: Kluwer Law International, 1996), pp. 97-108.

Wakeford, Tom. “Bringing Science Down to Earth.” In Tom Wakeford and Martin Walters, eds., *Science for the Earth: Can Science Make the World a Better Place?* (Chichester, England: John Wiley & Sons, 1995), pp. 349-63.

Wakeford, Tom and Martin Walters, eds. *Science for the Earth: Can Science Make the World a Better Place?* Chichester, England: John Wiley & Sons, 1995.

Waldichuk, Michael. “Control of Marine Pollution: An Essay Review.” 4 *Ocean Development and International Law* 269 (1977).

Waldichuk, Michael. “Sustainable Development in the Marine Context.” 22 *Marine Pollution Bulletin* 110 (1991).

Wali, Mohan K. and Robert L. Burgess. “The Interface of Ecology and Law: Science, the Legal Obligation, and Public Policy.” 12 *Syracuse Journal of International Law and Commerce* 221 (1985).

Walker, D.I. and A.J. McComb. “Seagrass Degradation in Australian Coastal Waters.” 25 *Marine Pollution Bulletin* 191 (1992).

Warren, Lynda M. “The Precautionary Principle: Use with Caution.” In Kay Milton, ed., *Environmentalism: The View from Anthropology* (London and New York: Routledge, 1993), pp. 97-111.

Watermann, B. and H. Kranz. “Pollution and Fish Diseases in the North Sea: Some Historical Aspects.” 24 *Marine Pollution Bulletin* 131 (1992).

Weidner, Edward W. “Educational Aspects of Environmental Issues.” 2 *International Journal of Environmental Studies* 301 (1972).

Weinberg, Alvin M. “Science and Its Limits: The Regulator’s Dilemma.” 2 *Issues in Science and Technology* 59 (1985-6).

Weinstein, Malcolm S. *Health in the City: Environmental and Behavioral Influences*. New York: Pergamon Press, 1980.

Weintraub, Bernard A. “Science, International Environmental Regulation, and the Precautionary Principle: Setting Standards and Defining Terms.” 1 *New York University Environmental Law Journal* 173 (1992).

Weiss, Edith Brown, ed. *Environmental Change and International Law: New Challenges and Dimensions.* Tokyo, New York and Paris: United Nations University Press, 1992.

Wells, Peter G. and Raymond P. Côté. “Protecting Marine Environmental Quality from Land-based Pollutants: The Strategic Role of Ecotoxicology.” 12 *Marine Policy* 9 (1988).

Wenk, Edward Jr. “Genesis of a Marine Policy: The IDOE.” *Oceanus* Vol. 23, No. 1, pp. 2-11 (1980).

Wettestad, Jørgen and Steinar Andresen. “Science and North Sea Policy-making: Organization and Communication.” In David Freestone and Ton IJIstra, eds., *The North Sea: Perspectives on Regional Environmental Co-operation*, Special Issue of the International Journal of Estuarine and Coastal Law (London, Dordrecht, Boston: Graham & Trotman/Martinus Nijhoff, 1990), pp. 111-22.

Wettestad, Jørgen. “Science, Politics and Institutional Design: The Case of the North-east Atlantic Land-based Pollution Regime.” 18 *Marine Policy* 219 (1994).

Whipple, William Jr. *New Perspectives in Water Supply*. Boca Raton, Florida: CRC Press, Inc., 1994.

White, Alan T., Catherine A. Courtney, and Albert Salamanca. “Experience with Marine Protected Area Planning and Management in the Philippines.” 30 *Coastal Management* 1 (2002).

White, Gilbert. *The Illustrated Natural History of Selborn.* London: Macmillan, 1789, 1981.

White, Lynn Jr. “The Historical Roots of Our Ecological Crisis.” In Paul Shepard and Daniel McKinley, eds., *The Subversive Science: Essays Towards an Ecology of Man* (Boston: Houghton Mifflin Company, 1969), pp. 341-50.

Wildavsky, Aaron. *But Is It True?: A Citizen’s Guide to the Environmental Health and Safety Issues*. Cambridge, Massachusetts and London, England: Harvard University Press, 1997.

Wilder, Robert J. “Is This Holistic Ecology or Just Muddling Through?: The Theory and Practice of Marine Policy.” 21 *Coastal Management* 209 (1993).

Wilkowski, Jean Mary. “Law, Science and Diplomacy: An Introduction to a Workshop on Cross Education of Lawyers and Scientists.” 19 *Jurimetrics Journal* 89 (1978).

Williams, Caroline and Bruce Davis. “Land-based Activities: What Remains to be Done.” 29 *Ocean and Coastal Management* 207 (1995).

Wilson, Edward O. *Sociobiology: The New Synthesis*. Cambridge: Belknap Press of Harvard University Press, 1975.

Wilson, Edward O. *Biophilia.* Cambridge, Massachusetts and London: Harvard University Press, 1984.

Wilson, Edward O. *The Diversity of Life.* New York: W.W. Norton & Company, 1992.

Wilson, Edward O. *In Search of Nature.* Washington, D.C. and Covelo, California: Island Press, 1996.

Wilson, Edward O. "Resuming the Enlightenment Quest." 22 *The Wilson Quarterly* 16 (1998).

Wilson, Edward O. *Consilience: The Unity of Knowledge*. New York: Alfred A. Knopf, Inc., 1998.

Wilson, Edward O. "Consilience among the Great Branches of Learning." In Peter Galison, Stephen R. Graubard, and Everett Mendelsohn, eds. *Science in Culture* (New Brunswick, N.J.: Transaction Publishers, 2001), pp. 131-50.

Wilson, Edward O. *The Future of Life.* New York: Alfred A. Knopf, 2002.

Windom, Herbert L. "Contamination of the Marine Environment from Land-based Sources." 25 *Marine Pollution Bulletin*: 32 (1992).

Windom, Herbert L. "What Does GOOS/HOTO Mean, and What Will It Offer, to the Marine Scientist?" 10 *Oceanography* 15 (1997).

Winner, Russ. "Science, Sovereignty, and the Third Law of the Sea Conference." 4 *Ocean Development and International Law* 297 (1977).

Wong, Ruth H.K. "Education for Responsibility and Accountability: Nothing is for Free." In D.P. Pereira, ed., *Focus on Environment* (Singapore: Select Books on behalf of the Institute of Education Academic Staff Association, 1979), pp. 67-78.

Woods, John. "The Global Ocean Observing System." 18 *Marine Policy* 445 (1994).

Wood-Thomas, B.C. "Land-based Marine Pollution and Coastal Zone Management: Role of State and Local Government in the U.S.A." 18 *Marine Policy* 165 (1994).

Wooster, Warren S. "International Cooperation in Marine Science." 5 *Ocean Yearbook* 123 (1985).

Wooster, Warren S. "On the Evolution of International Marine Science Institutions." 10 *Ocean Yearbook* 172 (1993).

World Bank. *World Bank Development Report 2000/2001: Attacking Poverty*. Oxford: Oxford University Press, 2001.

World Commission on Environment and Development. *Our Common Future*. Oxford: Oxford University Press, 1987.

Worster, Donald. *Nature's Economy: A History of Ecological Ideas*, 2nd ed. Cambridge: Cambridge University Press, 1994.

Wright, D.A. "Chesapeake Bay: Pollution and Politics." 16 *Marine Pollution Bulletin* 299 (1985).

Wynne, Brian and Sue Mayer. "How Science Fails the Environment." *New Scientist*, Vol. 138, No. 1876, pp. 32-5 (1993).

Yankov, Alexander and Mário Ruivo. "An Ocean Assembly." In Peter Bautista Payoyo, ed., *Ocean Governance* (Tokyo, New York and Paris: United Nations University Press, 1994), pp. 330-49.

Yap, Helen. "Marine Environmental Problems: Experiences of Developing Regions." 25 *Marine Pollution Bulletin* 37 (1992).

Yearley, Steven. "Standing in for Nature: The Practicalities of Environmental Organizations' Use of Science." In Kay Milton, ed., *Environmentalism: The View from Anthropology* (London and New York: Routledge, 1993), pp. 59-72.

Yost, Nicholas. "Environmental Regulation – Are there Better Ways?" 25 *Ecology Law Quarterly* 564 (1998).

Young, Elizabeth and Lord Ritchie Calder, eds. *Pacem In Maribus*: *The Ocean Environment*. Volume V. Malta: The Royal University of Malta Press, 1971.

Young, Oran R., ed. *Global Governance: Drawing Insights from the Environmental Experience*. Cambridge, Massachusetts and London, England: The MIT Press, 1997.

B. Treaties and Other International Instruments

1909 Treaty Between the United States and Great Britain Respecting the Boundary Waters Between the United States and Canada. 11 January 1909. 4 AJIL (Suppl.) 239 (1909).

Charter of the United Nations. 1 UNTS xvi; 1946 UKTS 67; 39 AJIL Supp. 190 (1945).

Convention on the Territorial Sea and Contiguous Zone. 29 April 1958. 516 UNTS 205; 1965 UKTS 3; 15 UST 1606; TIAS 5639.

Convention on the High Seas. 29 April 1958. 450 UNTS 82; 1963 Austl. TS No. 12; 1964 UNTS 39; 13 UST 2312; TIAS 5200.

Convention on Fishing and Conservation of the Living Resources of the High Seas. 29 April 1958. 559 UNTS 285; 1963 Austl. T.S. No. 12; 1966 UKTS 39; 17 UST 138; TIAS 5969.

Convention on the Continental Shelf. 29 April 1958. 499 UNTS 311; 1964 UKTS 39; 15 UST 471; TIAS 5578.

International Convention on Civil Liability for Pollution Damage. 29 November 1969. 64 AJIL 481 (1970).

Convention on Wetlands of International Importance Especially as Waterfowl Habitat. 2 February 1971. 996 UNTS 245, 11 ILM 963 (1972).

Stockholm Declaration on the Human Environment. 16 June 1972. UN Doc. A/Conf./48/14/Rev.1; 11 ILM 1416 (1972).

Stockholm Action Plan for the Human Environment. A/Conf.48/14/Rev.1 (1973).

International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties. 29 November 1969. 26 UST 765; 4 New Directions in the Law of the Sea 451 (1973).

Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter. 29 December 1972. 1976 UKTS 43; 26 UST 2403; TIAS 8165; 11 ILM 1294 (1972).

Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft. 15 February 1972. 11 ILM 262 (1972).

International Convention for the Prevention of Pollution from Ships. 2 November 1973. 1340 UNTS 184; 1983 UKTS 27; 12 ILM 1319 (1973).

Convention for the Prevention of Marine Pollution from Land-based Sources. 4 June 1974. 1978 UKTS 64; 13 ILM 352 (1974).

Convention on the Protection of the Marine Environment of the Baltic Sea Area. 22 March 1974. 13 ILM 13 (1974).

Convention for the Protection of the Mediterranean Sea Against Pollution. 16 February 1976. 15 ILM 290 (1976).

Regional Convention for Co-operation on the Protection of the Marine Environment from Pollution. 23 April 1978. 1140 UNTS 133; 17 ILM 511 (1978).

Protocol (to MARPOL) Relating to the Convention for the Prevention of Pollution from Ships. 17 February 1978. 1340 UNTS 61, 17 ILM 546 (1978).

Convention on Long-range Transboundary Air Pollution. 1983 UKTS 57; TIAS 10541; 18 ILM 1442 (1979).

Protocol (to the 1976 Barcelona Convention) for the Protection of the Mediterranean Sea against Pollution from Land-based Sources. 17 May 1980. 19 ILM 869 (1980).

Convention for Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region. 23 March 1981. 20 ILM 746 (1981).

Convention for the Protection of the Marine Environment and Coastal Area of the South-east Pacific. 12 November 1981. ND (Looseleaf), Doc. J.18 (1981).

United Nations Convention on the Law of the Sea. 10 December 1982. UN Doc. A/Conf.62/122 (1982); 21 ILM 1261 (1982).

Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment. 14 February 1982. 9 EPL 56 (1982).

World Charter for Nature. 28 October 1982. UNGA Res. 37/7; UN Doc. A/37/51 (1982); 22 ILM 455 (1983).

Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region. 24 March 1983. 1988 UKTS 38; 22 ILM 221 (1983).

Protocol (to the 1981 Lima Convention) for the Protection of the South-east Pacific Against Pollution from Land-based Sources. 22 July 1983. Burhenne 983: 54 (1983).

Convention for the Protection of the Ozone Layer. 22 March 1985. 1990 UKTS 1; 26 ILM 1516 (1987).

Montreal Guidelines for the Protection of the Marine Environment Against Pollution from Land-based Sources. 19 April 1985. Decision 13/18/II of the Governing Council of UNEP, 24 May 1985. Reprinted in 14 *Environmental Policy and Law* 77 (1985).

Convention for the Protection of the Natural Resources and Environment of the South Pacific Region. 26 ILM 38 (1987).

Protocol (to the 1985 Vienna Convention) on Substances that Deplete the Ozone Layer. 16 September 1987. 1990 UKTS 19; 26 ILM 1541 (1987).

Ministerial Declaration of the Second International Conference on the Protection of the North Sea. 25 November 1987. Reprinted in David Freestone and Ton IJlstra, eds., *The North Sea: Basic Legal Documents on Regional Environmental Co-operation* (Dordrecht: Graham & Trotman/Martinus Nijhoff, 1991), p. 3.

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal. 22 March 1989. Canada Treaty Series (1992). No. 19; 28 ILM 657 (1989).

Ministerial Declaration of the Third International Conference on the Protection of the North Sea. (The Hague) 8 March 1990. Reprinted in David Freestone and Ton IJlstra, eds., *The North Sea: Basic Legal Documents on Regional Environmental Co-operation* (Dordrecht: Graham & Trotman/Martinus Nijhoff, 1991), p. 40.

Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa. 30 January 1991. 30 ILM 773 (1991).

Convention on Environmental Impact Assessment in a Transboundary Context. 25 February 1991. 30 ILM 802 (1991).

Protocol to the 1979 Convention on Long-range Transboundary Air Pollution Concerning the Control of Emissions of Volatile Organic Compounds or Their Transboundary Fluxes. 18 November 1991. 31 ILM 849 (1992).

United Nations Framework Convention on Climate Change. 9 May 1992. UN Doc. A/Conf.151/26; 31 ILM 849 (1992).

Convention on Biological Diversity. 5 June 1992. UN Doc. UNEP/Bio. Civ/Conf/L. 2; 31 ILM 818 (1992).

Convention on the Protection and Use of Transboundary Watercourses and International Lakes. 17 March 1992. 31 ILM 1312 (1992).

Convention on the Protection of the Marine Environment of the Baltic Sea Area. 9 April 1992. Reprinted in 22 *Law of the Sea Bulletin* 54 (January 1993).

Non-legally Binding Authoritative Statement of Principles for a Global Consensus on the Management of Conservation and Sustainable Development of All Types of Forests. 13 June 1992. UN Doc. A/Conf.151/6/Rev. 1; 31 ILM 881 (1992).

Rio Declaration on Environment and Development. 13 June 1992. UN Doc. A/Conf.151/5/Rev. 1; 31 ILM 874 (1992).

Agenda 21. 13 June 1992. UN Doc. A/Conf.151/4 (1992).

Convention for the Protection of the Marine Environment of the North-east Atlantic. 22 September 1992. 32 ILM 1069 (1993).

Global Programme of Action for the Protection of the Marine Environment from Land-based Activities. 5 December 1995, UNEP (OCA)/LBA/IG.2/7 (1995).

Washington Declaration on the Protection of the Marine Environment from Land-based Activities. 5 December 1995, UNEP (OCA)/LBA/IG.2/6 (1995).

1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972. 7 November 1996. IMO Doc. LC/SM 1/6; 36 ILM 1 (1997).

1996 Protocol for the Protection of the Mediterranean Sea against Pollution from Land-based Sources and Activities, which amends the 1980 Protocol for the Protection of the Mediterranean Sea against Pollution from Land-based Sources. 7 March 1996. http://www.unep.ch/seas/main/med/mlbspii. html.

Kyoto Protocol to the United Nations Framework Convention on Climate Change. 10 December 1997. 37 ILM 32 (1998); W.E. Burhenne International Environmental Law: Multilateral Treaties 992:35/A. (1997).

Stockholm Convention on Persistent Organic Pollutants. 23 May 2001. [2001] ATNIF 7; 40 ILM 532 (2001).

C. United Nations, Intergovernmental Agency, and Miscellaneous Documents, Reports, and Papers

Advisory Committee on Protection of the Sea (ACOPS). “The Legal Regime of Land-based Sources of Marine Pollution.” A study prepared for the Inter-governmental Meeting of Experts on Land-based Sources of Marine Pollution. Halifax, Nova Scotia, Canada, 6-10 May 1991.

Alexander, Lewis M., ed. *Proceedings of the Fifth Annual Conference of the Law of the Sea Institute, 1970.* Kingston, R.I.: The University of Rhode Island, 1971.

Andersen, Jesper, Henning Karup, and Ulla B. Nielsen, eds. *Scientific Symposium on the Quality and Status Report 1993: Proceedings.* 18-21 April 1994, Ebeltoft, Denmark. Copenhagen: Ministry of Environment and Energy, Danish Environmental Protection Agency, 1996.

Arctic Monitoring Assessment Programme (AMAP). *Arctic Pollution Issues: A State of the Arctic Report*, Oslo: AMAP, 1997.

Bewers, J. Michael and R.G. Boelens. “Options for the Revision of the GESAMP Definition of Marine Pollution.” Paper dated 17 January 1991 and submitted to the International Maritime Organization for the 21st Session of GESAMP, 18-22 February 1991.

Bewers, J. Michael. “Marine Environmental Protection Initiatives in Europe: Steps to Emulate and Steps to Avoid.” In V. Konrad, S.Ballard, R. Erb, and A. Morin, eds., *Proceedings of an International Conference on the Gulf of Maine: Sustaining our Common Heritage* (Portland, Maine, USA: Maine State Planning Office and University of Maine, 1989), pp. 177-202.

Boelens, R.G.V. “The London Dumping Convention: Its Development and Significance to Marine Pollution Control.” In Peter G. Wells and John Gratwick, eds., *Canadian Conference on Marine Environmental Quality: Proceedings* (Halifax, Nova Scotia: The International Institute for Transportation and Ocean Policy Studies (IITOPS), 1988), pp. 35-46.

Broadus, James M., Suzanne Demisch, Kristina Gjerde, Peter Haas, Yoshiaki Kaoru, Gerard Peet, Sarah Repetto, and Alexei Roginko. *Comparative Assessment of Regional International Programs to Control Land-based Marine Pollution: The Baltic, North Sea and Mediterranean.* Woods Hole, Maine, USA: Woods Hole Oceanographic Institution Marine Policy Center, 1993.

Cameron, James and Will Wade-Gery. “Addressing Uncertainty: Law, Policy and the Development of the Precautionary Principle.” CSERGE Working Paper GEC 92-43. Centre for Social and Economic Research on the Global Environment, University of East Anglia and University College London, 1992.

Commission on Marine Science, Engineering and Resources. *Our Nation and the Sea: A Plan for National Action*. Washington, D.C.: United States Government Printing Office, 1969.

Environment Canada. *Workshop Report on the 1985 Montreal Guidelines for the Protection of the Marine Environment against Pollution from Land-based Sources*. Ottawa, Canada, 17-21 January 1994.

GESAMP. *Report of the First Session, London, 17-21 March 1969*. UN Doc. GESAMP I/11, 1969.

GESAMP. *The Health of the Oceans*. UNEP Regional Seas Reports and Studies No. 16, 1982.

GESAMP. *Environmental Capacity: An Approach to Marine Pollution Prevention*. GESAMP Reports and Studies No. 30, 1986.

GESAMP. *The State of the Marine Environment*. GESAMP Reports and Studies No. 39, 1990.

GESAMP. *Review of Potentially Harmful Substances: Choosing Priority Organochlorines for Marine Hazard Assessment*. GESAMP Reports and Studies No. 42, 1990.

GESAMP. *Long-term Consequences of Low-level Marine Contamination: An Analytical Approach*. UNEP Regional Reports and Studies No. 18, 1990.

GESAMP. *Coastal Modelling*. GESAMP Reports and Studies No. 43, 1991.

GESAMP. *Global Strategies for Marine Environmental Protection*. GESAMP Reports and Studies No. 45, 1991.

GESAMP. *Report of the 21st Session, London, 18-22 February 1991*. GESAMP Report and Studies No. 44, 1991.

GESAMP. *Review of Potentially Harmful Substances: Carcinogens*. GESAMP Reports and Studies No. 46, 1991.

GESAMP. *Impact of Oil and Related Chemicals and Wastes on the Marine Environment*. GESAMP Reports and Studies No. 50, 1993.

GESAMP. *Anthropogenic Influences on Sediment Discharge to the Coastal Zone and the Environmental Consequences*. GESAMP Reports and Studies No. 52, 1994.

GESAMP. *Guidelines for Marine Environmental Assessments.* GESAMP Reports and Studies No. 54, 1994.

GESAMP. *Biological Indicators and Their Use in the Measurement of the Conditions of the Marine Environment*. Report of Working Group 33, 1994.

GESAMP. *Monitoring the Ecological Effects of Coastal Aquaculture Wastes*. GESAMP Reports and Studies No. 57, 1996.

GESAMP. *Report of the Twenty-sixth Session of GESAMP, Paris, 25-29 March 1996*. GESAMP Reports and Studies No. 60, 1996.

GESAMP. *The Contributions of Science to Integrated Coastal Management*. GESAMP Reports and Studies No. 61, 1996.

GESAMP. *Report of the Twenty-seventh Session of GESAMP, Nairobi, Kenya, 14-18 April 1997*. GESAMP Reports and Studies No. 63, 1997.

GESAMP. *Report of the Second Meeting of the Working Group on Marine Environmental Assessments of the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP)*. Geneva, 25 April 1998. 6 May 1998.

GESAMP. *A Sea of Troubles.* GESAMP Reports and Studies No. 70, 2001a.

GESAMP. *Protecting the Oceans from Land-based Activities: Land-based Sources and Activities Affecting the Quality and Uses of the Marine, Coastal and Associated Freshwater Environment.* GESAMP Reports and Studies No. 71, 2001b.

Gomez, Edgardo D., E. Deocadiz, M. Hungspreugs, A.A. Jothy, Kuan Kwee Jee, A. Soegiarto, and R.S.S. Wu. *State of the Marine Environment in the East Asian Seas Region.* UNEP Regional Seas Reports and Studies No. 126, 1990.

Greenpeace International. “Annotations by Greenpeace International on UNEP’s Draft Global Programme of Action to Protect the Marine Environment from Land Based Activities.” Prepared for the Meeting of Experts on the Control of Marine Pollution from Land-based Sources, Reykjavik, Iceland, 6-10 March 1995.

Greenpeace International. “Land-based Sources of Marine Pollution: Sounding the Alarm.” Paper submitted to the Meeting of Experts on the Control of Marine Pollution from Land-based Sources, Montreal, Canada, 6-10 June 1994.

Greenpeace International. “Marine Pollution Prevention Strategies.” Paper submitted to the Second Session of the Preparatory Committee for the UN Conference on Environment and Development, 18 March-5 April 1991.

Greenpeace International. “The Precautionary Approach in the Context of Land-based Sources of Marine Pollution.” Paper submitted to the Meeting of Experts on the Control of Marine Pollution from Land-based Sources, Montreal, Canada, 6-10 June 1994.

Health of the Ocean (HOTO) Panel of the Joint Scientific and Technical Committee for the Global Ocean Observing System (GOOS). *A Strategic Plan for the Assessment and Prediction of the Health of the Ocean: A Module of the Global Ocean Observing System.* Doc. IOC/INF-1044, Paris: UNESCO, 26 August 1996.

Holt, Sydney J. “The Intergovernmental Oceanographic Commission – A Biased History.” In Lewis M. Alexander, ed., *Proceedings of the Fifth Annual Conference of the Law of the Sea Institute, 1970* (Kingston, R.I.: The University of Rhode Island, 1971), pp. 131-42.

House of Commons Standing Committee on Environment and Sustainable Development. *It’s About Our Health!: Towards Pollution Prevention – CEPA Revisited*. Report of the House of Commons Standing Committee on Environment and Sustainable Development. Ottawa: Government of Canada, June 1995.

Intergovernmental Conference on Environmental Education: *Final Report* Chap./III., Paris: UNESCO, 1978.

Intergovernmental Negotiating Committee for an International Legally Binding Instrument for Implementing International Action on Certain Organic Pollutants. *Report of the Intergovernmental Negotiating Committee for an International Legally Binding Instrument for Implementing International Action on Certain Organic Pollutants on the Work of Its Fifth Session.* UNEP/POPS/INC.5/7, 26 December 2000.

Intergovernmental Oceanographic Commission. *IOC/WESTPAC Workshop on River Input of Nutrients to the Marine Environment in the Western Pacific.* Penang, Malaysia, 26-29 November 1991. IOC Workshop Report No. 79, 1991.

Intergovernmental Oceanographic Commission. *Ocean Science for the Year 2000.* A Report on an Inquiry by the Scientific Committee on Oceanic Research and the Advisory Committee on Marine Resources Research for the Intergovernmental Oceanographic Committee and UNESCO, Paris: UNESCO, 1984.

Intergovernmental Panel on Climate Change. *Climate Change 1995: The Science of Climate Change.* Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press, 1996.

IUCN/UNEP. *Management and Conservation of Renewable Marine Resources in the East Asian Seas Region*. UNEP Regional Seas Reports and Studies No. 65, 1985.

Jeftic, L. “UNEP Guidelines for the Protection of the Marine Environment against Pollution from Land-based Sources: Their Implementation in the Mediterranean.” In Peter G. Wells and John Gratwick, eds., *Canadian Conference on Marine Environmental Quality: Proceedings* (Halifax, Nova Scotia: The International Institute for Transportation and Ocean Policy Studies (IITOPS), 1988), pp. 9-34.

Johnston, Douglas M., ed. *Regionalization of the Law of the Sea.* Proceedings of the Eleventh Annual Conference of the Law of the Sea Institute, 1977. Cambridge, Massachusetts: Ballinger Publishing Company, 1978.

Koe, Lawrence C.C. and M.A. Aziz. *Regional Programme of Action on Land-based Activities Affecting the Coastal and Marine Areas in the East Asian Seas.* RCU/EAS Technical Reports Series No. 5, 1995.

McCullagh, James R. “Analysis of UNEP’s Global Programme of Action for the Protection of the Marine Environment from Land-based Activities with Respect to Direct Disposal of Carbon Dioxide.” Ocean Storage of CO_2 Workshop 4: Practical and Environmental Approaches, IEA Greenhouse Gas R&D Programme, Cheltenham, U.K., May 1997, pp. 115-23.

Milliman, John D., Christine Rutkowski, and Michel Meybeck. *River Discharge to the Sea: A Global River Index (GLORI)*. A core project of the International Geosphere Biosphere Programme: A Study of Global Change (IBGP). Land-Ocean Interactions in the Coastal Zone (LOICZ) Reports and Studies, April 1995.

Minister of Public Works and Government Services Canada. *Report of the Second Conference of Parliamentarians of the Arctic Region, Yellowknife, Northwest Territories, Canada, 13-14 March 1996.* Ottawa: Minister of Public Works and Government Services Canada, 1996.

Norrena, Edward J. and Peter G. Wells. "Protection of the Marine Environment from Land-based Pollutants: A Canadian View of the Montreal Guidelines." A paper delivered to the SEAPOL Workshop on the Control of Land-based Marine Pollution: A Comparative Study of the Canadian and Southeast Asian Experience, Rama Gardens Hotel, Bangkok, Thailand, 7-10 May 1989.

OECD. *Environmental Education: An Approach to Sustainable Development*. Prepared under the OECD Development Centre's Research Programme on Coping with Environmental Threats in Developing Countries. Paris: OECD, 1992.

Penning-Rowsell, E.C. "Introduction." In OECD, *Coastal Zone Management: Selected Case Studies* (Paris: OECD, 1993), pp. 15-23.

Rummel-Bulska, Iwona. "Implementation of and Reaction to the Montreal Guidelines for the Protection of the Marine Environment Against Pollution from Land-based Sources (1985) by the International Community – A Progress Report." In Peter G. Wells and John Gratwick, eds., *Canadian Conference on Marine Environmental Quality: Proceedings* (Halifax, Nova Scotia: The International Institute for Transportation and Ocean Policy Studies (IITOPS), 1988), pp. 289-95.

Schneider, Hartmut. "Concepts and Issues." In OECD, *Environmental Education: An Approach to Sustainable Development*. Prepared under the OECD Development Centre's Research Programme on Coping with Environmental Threats in Developing Countries. (Paris: OECD, 1992), pp. 25-33.

Strand, Per, Mikhail Balonov, Asker Aarkrog, J. Michael Bewers, Brenda Howard, Anneli Salo, and Yuri Tsaturov. *Arctic Pollution Issues: Radioactive Contamination.* A Report from an International Expert Group to the Arctic Monitoring and Assessment Programme. Østerås: Norwegian Radiation Protection Authority, 1997.

Study of Critical Environmental Problems (SCEP) Panel. *Man's Impact on the Global Environment*. The Report of the Study of Critical Environmental Problems (SCEP). Cambridge, Massachusetts and London: The MIT Press, 1970.

UN. *Proceedings of the UN Scientific Conference on the Conservation and Utilisation of Resources. Lake Success, Newark, 17 August -6 September 1949*. A/Conf.10.7, 1956.

UN. *Report of the United Nations Conference on the Human Environment.* Stockholm, 5-16 June 1972. A/Conf.48/14/Rev.1, 1973.

UNEP. *Draft Global Programme of Action to Protect the Marine Environment from Land-based Activities.* Submitted by UNEP to the Preparatory Meeting for the United Nations Environment Programme Intergovernmental Meeting on the Protection of the Marine Environment from Land-based Activities, Reykjavik, Iceland, 6-10 March 1995. UNEP/ ICL/IG/1/2, 19 January 1995.

UNEP. *Guidelines and Principles for the Preparation and Implementation of Comprehensive Action Plans for the Protection and Development of Marine and Coastal Areas of Regional Seas*. UNEP Regional Seas Reports and Studies No. 15, 1982.

UNEP. *Report of the Conference to Adopt a Global Programme of Action for the Protection of the Marine Environment from Land-based Activities. Washington, D.C., 23 October to 3 November 1995*. UNEP(OCA)/LBA/IG.2/6, 5 December 1995.

UNEP/AIMS. *Monitoring Coral Reefs for Global Change.* Reference Methods for Marine Pollution Studies No. 61, 1993.

United Nations General Assembly. *General Assembly Resolution 2750 C, 25.* UNGA OR Supp. (No. 28) at 26, UN Doc. A/8097, 1971.

United Nations in collaboration with École Pratique des Hautes Études (VI e section). *Development and Environment: Environment and Social Sciences*. Report and Working Papers of a Panel of Experts Convened by the Secretary-General of the United Nations Conference on the Human Environment. Founex, Switzerland, 4-12 June 1971. Mouton, Paris, The Hague: UN, 1972.

Vinke, Jacoline. "Actors and Approaches in Environmental Education in Developing Countries." In OECD, *Environmental Education: An Approach to Sustainable Development*. Prepared under the OECD Development Centre's Research Programme on Coping with Environmental Threats in Developing Countries (Paris: OECD, 1992), pp. 39-73.

Ward, Barbara and René Dubos. *Only One Earth: The Care and Maintenance of a Small Planet.* An Unofficial Report Commissioned by the Secretary-General of the United Nations Conference on the Human Environment. Prepared with the Assistance of a 152-Member Committee of Corresponding Consultants in 58 Countries. New York: W.W. Norton & Company, 1972.

Wells, Peter G. and John Gratwick, eds. *Canadian Conference on Marine Environmental Quality: Proceedings*. Halifax, Nova Scotia: The International Institute for Transportation and Ocean Policy Studies (IITOPS), 1988.

Windom, Herbert L. "Land Based Sources of Marine Pollution and the State of the Marine Environment." Paper presented at the Intergovernmental Meeting of Experts on Land-based Sources if Marine Pollution, Halifax, Canada, 6-10 May 1991.

Young, Oran R. "Arctic Governance: Meeting Challenges of Cooperation in the High Latitudes." In the *Report of the Second Conference of Parliamentarians of the Arctic Region, Yellowknife, Northwest Territories, Canada, 13-14 March 1996* (Ottawa: Minister of Public Works and Government Services Canada, 1996), pp. 115-32.

D. Newspaper Articles and Popular Periodicals

Anderssen, Erin. "Bureaucrats Sabotage Scientists." *Ottawa Citizen*, Ottawa, Canada, 21 June 1997, pp. A1 and A2.

Anonymous. "Unscientific Readers of Science." Moreover Section, *The Economist.* 9 May 1998, pp. 97-8.

Cousteau, Jacques. "Our Oceans are Dying." *New York Times*. 14 November 1971, p. 13, col. 3.

Crittenden, Guy. "The Day the Earth Warmed Up." *The Globe and Mail*. Toronto, Canada, 22 November 1997, pp. D1, D9.

DePalma, Anthony. "Newfoundland to Ease Ban on Fishing; Some Say It's Too Soon." *The New York Times International*. New York, Friday, 18 April 1997, p. A7.

Enman, Charles. "DFO Scientists Decry 'Dishonesty'." *Ottawa Citizen*. Ottawa, Canada, Saturday, 5 July 1997, pp. A1 and A2.

Glassman, James K. "It's in Your Own Home and It's a Real Killer." *International Herald Tribune*. Washington, Wednesday, 22 October 1997, p. 9.

Mobil Corporation. "Climate Change: A Prudent Approach." *Asian Wall Street Journal*, 4 December 1997, p. 4.

Park, Robert L. "Values, Not Science, Spur Global Warming Debate." *International Herald Tribune*. 5 May 1998, p. 9.

Safe, Stephen. "Another Enviro-Scare Debunked." *Asian Wall Street Journal*. 25 August 1997, p. 6.

Strauss, Stephen. "Ottawa to Reopen Cod Fishery: Scientists Condemn Plan as Political, See No Clear Sign Number of Fish is Recovering." *The Globe and Mail.* Toronto, Canada, Wednesday, 16 April 1997, pp. A1 and A6.

E. Cases

Bering Sea Fur Seals Arbitration. 1 Moore's International Arbitration Awards 755 (1898).

Corfu Channel Case. ICJ Rep. 1 (1949).

Daubert v Merrell Dow Pharmaceuticals. 113 S Ct 2786 (1993).

Frye v United States. 293 F 1013 (DC Cir 1923).

Lac Lanoux Arbitration. 24 ILR 101 (1957).

Trail Smelter Arbitration. 33 AJIL 182 (1939); 35 AJIL 684 (1941).

F. Personal Communication

Bewers, J. Michael. Department of Fisheries and Oceans, Government of Canada. Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada (now retired). Member of GESAMP. (Via e-mail). 5 January 1998.

Karau, John. Chief, Marine Environment Division, Environment Canada. Ottawa, Canada, 18 December 1995.

G. Web Cites

Union for Concerned Scientists: http://www.ucsusa.org/ucs-home.html.

GESAMP: http://www.gesamp.imo.org/index.html.

Global Programme of Action Home Page: http://www.unep.org/unep/gpa/home.html.

Skodvin, Tora. *Science-Policy Interaction in the Global Greenhouse.* Center for International Climate and Environmental Research (CICERO) Working Paper 1999:3. Oslo: CICERO. hhttp://www.cicero.uio.no/Publications/Workingpapers/wp1999-03_introd.html.