Global aspects of marine pollution policy

The need for a new international convention

W. Jackson Davis

The source and fate of marine pollutants are discussed in overview and exemplified with the case of radioactive wastes dumped at sea. Only 10% of marine pollutants originate with deliberate dumping; the other 90% come from land-based sources. Remarkably, there is no international convention regulating pollution from all sources, including land-based. The London Dumping Convention (LDC) is the chief international treaty for regulating and limiting dumping at sea. The LDC is moving away from regulation, however, and toward prohibition of most forms of dumping at sea. A new international 'Convention for the Protection of the Oceans from Pollution' (CPOP) is now needed, incorporating new waste management principles and having jurisdiction over all sources of marine pollution, including those from land-based sources. Such a convention could foster international cooperation in the prevention of marine pollution by serving as a clearing house for the exchange of technologies in the area of toxic waste source reduction and abatement. Possible hurdles to the formation of such an international instrument are discussed along with possible solutions.

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Nearly 71% of the earth's surface, and 90% of its biosphere, is oceanic. Salt concentrations in ocean waters are the same as in human blood, reflecting our evolutionary debt to the seas. Humanity still depends upon the oceans for food, oxygen,[1] minerals and energy, transportation, military purposes, recreation and waste management. The oceans are also coupled to other ecosystems on which humans depend for survival, eg the atmosphere and terrestrial environments. The health of the oceans is directly tied to planetary health.

Despite the importance of the oceans to human survival, certain areas of the world's oceans have been polluted beyond their capacity to support life forms. Nations have been motivated to externalize the costs of toxic waste production by overusing the ocean option, because they then receive the benefits of such overuse while the costs are shared with other states – consistent with Garet Hardin's thesis of the 'tragedy of the commons'.[2] Assuming that national behaviour is motivated by self-interest, workable solutions to marine pollution must confer benefits upon the potential polluters; and these benefits must outweight the costs. Here I summarize some problems of marine pollution, and sketch the outlines of possible solutions that meet the self-interest criterion.

The environmental and technical framework

Wastes generated on land eventually reach the sea by deliberate or accidental dumping[3] (approximately 10% of wastes entering the oceans), or from land-based sources (90%). The principal wastes include dredged materials, sewage sludge (typically contaminated with radioactive and/or industrial wastes), hydrocarbon-related waste substances,[4] industrial wastes (notably toxic chemicals), heavy metals (cadmium, mercury – typically components of contaminated sewage sludge or industrial wastes), radionuclides, and worn-out vessels (military and civilian).

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conventions, notably the London Dumping Convention (LDC), where he has been instrumental in establishing the LDC's present global moratorium on radioactive waste dumping at sea.

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[1]It is estimated that between one third and one half of atmospheric oxygen is generated by phytoplankton in the upper layers of the oceans.

[2]G. Hardin, 'The tragedy of the commons', *Science*, Vol 162, 1968, pp 1243–1248.

[3]For most waste forms, discharge from transportation accidents represents but a small fraction of the total quantity of waste introduced into the seas.

[4]Such substances are defined broadly here to include not only oil and closely related products, but also derived products such as plastics, pesticides and herbicides, as well as decommissioned oil platforms.

[5]These figures are based upon data from the International Maritime Organization of the United Nations, on the basis of dumping reports made by Contracting Parties to the London Dumping Convention (eg document LDC 12/8, 3 October 1989, p 6).

[6]W. M. Arkin and J. Handler, 'Naval accidents 1945–1988', *Neptune Papers*, No 3, Greenpeace/Institute for Policy Studies, Washington, DC, 1989, p 7.

[7]The total inventory of radioactivity represented by these five lost submarines is approximately 8.64E6 TBq (2.33E8 Ci). This figure was calculated as follows. Of the five lost submarines, three were Soviet vessels, each powered by two nuclear propulsion reactors; and two were US vessels (the *Scorpion* and the *Thresher*), each powered by a single reactor (See Ref 6). Eight fully fuelled nuclear propulsion reactors were therefore lost accidentally at sea. The radioactive inventory of each reactor was calculated using the ORIGEN computer code, under the following assumptions: 1) the power capacity of each lost reactor was 100 MW (thermal); 2) each lost reactor was fuelled with enriched (93%) uranium; 3) the average burn time of each vessel was 8 years (approximately one-half to two-thirds the estimated interval between refuellings); 4) each reactor was operated over its lifetime at 25% capacity factor; and 5) all radionuclides with a half-life less than one day were ignored. Under these assumptions, each lost nuclear reactor would contain approximately 1.08E6 TBq (2.92E7 Ci) of radioactivity in the form of mixed fission products.

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Of materials deliberately dumped at sea, dredged materials constitute approximately 86% of the total tonnage, with sewage sludge (7%) and industrial waste (6%) comprising most of the remainder.[5] Dumping of radioactive wastes was curtailed by a 1983 moratorium of the London Dumping Convention (LDC), renewed indefinitely in 1985, although the moratorium is temporary and is not technically binding on Contracting Parties to the Convention. Incineration at sea of hazardous, organic liquid wastes is likewise being phased out by both the LDC and the Oslo Commission (OSCOM). Similarly, a phase-out of industrial waste dumping at sea has been implemented for the North Sea by OSCOM, and is on the agenda for consideration by the LDC in 1990.

Of materials entering the sea from land sources, toxic industrial chemicals and hydrocarbon-related products may be the most significant from an environmental viewpoint. The former are introduced through the atmosphere or rivers, while the latter (notably herbicides and pesticides) are typically carried into the sea by inadvertent runoff from land. Radionuclides continue to enter the sea mainly from land sources (reprocessing plants and nuclear reactors), although the military discharges small amounts of radioactive cooling water from nuclear vessels. More significantly, five nuclear powered submarines have been lost at sea by the USA and USSR,[6] with an estimated total radioactive content equivalent to 212 times greater than all known radioactive wastes dumped deliberately at sea.[7] Dumping of decommissioned nuclear vessels at sea is also under consideration by certain nations,[8] as is sub-seabed emplacement of high-level nuclear wastes.[9]

Once waste substances are introduced into the seas, their fate cannot be predicted with precision owing to large gaps in our knowledge of ocean processes. As a broad generality, nature operates in coupled cycles, such as the water cycle, mineral cycles, etc. Materials of all kinds, including wastes, flow through these cycles repeatedly, driven mainly by solar energy. Pollutants enter and alter these cycles; the seriousness of a pollutant's effect can be measured by the degree to which it interferes with these natural cycles. Some practical technical guidelines are provided by GESAMP (the United Nations Joint Group of Experts on the Scientific Aspects of Marine Pollution).[10]

A case study

These generalities are well exemplified by the specific case of radionuclides. Packaged radioactive wastes dumped at sea in the Pacific and Atlantic Oceans have escaped their original containment and become adsorbed to nearby bottom sediments[11] and probably to particles suspended in the benthic boundary layer.[12] Bottom-dwelling organisms and sessile filter feeders ingest the sediments and the attached radioactivity, incorporating the wastes into the oceanic food web.[13] It is likely that radioactive wastes are also incorporated by abundant benthic bacteria, although this has not been documented. The availability of the released wastes to living forms, or *bioavailability*, varies depending on the radionuclide.[14] Radionuclides that are readily incorporated concentrate in the cells and tissues of ocean organisms, in a process termed *bioaccumulation*.

Movement of the wastes over long distances in the ocean occurs by physical movement of contaminated particles (physical mass transport[15]), and, potentially, also by the movement of contaminated organisms (biological mass transport[16]), notably bacteria, although the possibility of bacterial transport of dumped radionuclides has not been investigated. As the wastes move to higher trophic levels in the food web, they become concentrated through the process of *biomagnification*, because the same quantity of radionuclides are now fixed in a smaller total biomass. The radioactive materials produce particles and rays that are toxic to living animals, especially juvenile forms,[17] causing damage to the genetic material on which life is based. The radionuclides originally 'disposed' at sea can thus return to humans in seafood, by the operation of closed cycles of which humans are an integral component.

All natural cycles are linked by 'transfer functions' of variable strength. In any complex ecosystem, therefore, everything is ultimately connected with everything else. Because these couplings are not fully understood, it is impossible to foresee fully the impacts of introducing any toxic materials into oceans. Radionuclides dumped at sea in large quantities, for example, could theoretically have an impact on the life cycle of phytoplankton which converts carbon dioxide to atmospheric oxygen. The difficulty of understanding these complex ecosystem interactions contributes to enormous scientific uncertainty regarding the impacts of wastes entering the oceans.

The evolution of marine pollution policy

The oceans have always been used as a waste repository by human societies. In pre-industrial times, total toxic waste generation was small in comparison with global limits, and wastes were managed under the permissive 'dilute and disperse' philosophy. Corollary concepts included the idea that wastes could be permanently 'disposed' of in the seas, and the idea that the oceans have an 'assimilative capacity' for toxic wastes. The economic incentive for such ideas was externalization of costs to waste-producing nations. Use of the ocean option was believed to bestow economic advantage upon the producing nation, while minimizing costs by distributing them more broadly. The political motive was equally simple; waste-producing nations are motivated to use the ocean because hazardous wastes threaten the health and well-being of their domestic populations, creating pressures for exportation. The legal onus of proof was placed upon potential victims of pollution; a particular waste management practice was deemed acceptable unless proven dangerous.

Now, however, toxic waste generation is large in relation to planetary limits, and the earlier policy rationale requires re-thinking for at least four reasons. First, the fate of toxic wastes entering the seas is not fully understood, and therefore the risks cannot be assessed confidently. Second, some wastes persist for long periods – up to hundreds of human generations – and contemporary human institutions are not designed to deal with such long-term impacts.[18] Third, the impact of some waste forms can be so great as to threaten life on earth, and there is no precedent in the human experience for coping with impacts of such magnitude. Fourth, there is an increasing realization that all ecosystems are intimately interconnected. The seas bathe all shores, including those of the polluter.

These realizations are prompting the evolution of new waste management principles, including source reduction, the 'isolate and contain' philosophy, and the related 'precautionary principle'. It is

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The total inventory from eight lost reactors (8.64E6 TBq) is equivalent to 212 times the approximately 4.07E4 TBq (1.1E6 Ci) dumped deliberately at sea in past radioactive waste sea dumping programmes, but is still small in comparison with inputs of radioactivity to the sea associated with atmospheric fallout from nuclear weapons testing.

8 W. J. Davis and J. Van Dyke, 'Dumping of decommissioned nuclear submarines at sea: a technical and legal analysis', Paper submitted to the Twelth Consultative Meeting of the London Dumping Convention. *Document LDC 12/6*, International Maritime Organization, London, 1989.

9 Nuclear Energy Agency (of the Organization for Economic Co-operation and Development) *Feasibility of Disposal of High-level Radioactive Waste into the Seabed*, Nuclear Energy Agency, Paris, 1988 (8 volumes; available from OECD Publications Service, 2 rue Andre-Pascal, 75775 Paris CEDEX 16, France).

10 GESAMP (the United Nations Joint Group of Experts on the Scientific Aspects of Marine Pollution), 'The evaluation of the hazards of harmful substances carried by ships: revision of GESAMP *Reports and Studies* No 17', *Reports and Studies*, No 35, International Maritime Organization, London, 1989.

11 V. T. Bowen and H. D. Livingston, 'Radionuclide distributions in sediment cores retrieved from maritime radioactive waste dump-sites', in *Impacts of Radionuclide Releases into the Marine Environment*, Proceedings of Vienna Symposium 8–10 October 1980, IAEA/NEA (STI/PUB/565), International Atomic Energy Agency, Vienna, pp 33–62; R. Dayal, A. Okuba, I. W. Duedal and A. Ramamoorthy, 'Radionuclide redistribution mechanisms at the 2800 meter Atlantic nuclear waste disposal site', *Deep Sea Research*, Vol 26A, 1979, pp 1329–1345; E. K. Duursma and D. Eisma 'Theoretical, experimental and field studies concerning reactions of radiosotopes with sediments and suspended particles of the sea. Part C: applications to field studies', *Netherlands Journal of Sea Research*, Vol 6, 1973, pp 265–324; S Hirano and T. Koyanagi, 'Study on the chemical forms of radionuclides in sea water. I. Chloride sulfate hydroxide complexes of ^{144}Ce', *Journal of the Oceanographic Society of Japan*, Vol 34, 1978, pp 269–275; W. R. Schell and S. Sugai, 'Radionuclides at the US radioactive waste disposal site near the Farallon Islands', *Health Physics*, Vol 39, 1978, pp 475–496.

12 E. K. Duursma and D. Eisma, *op cit*. Ref 11.

13 W. R. Schell and S. Sugai, *op cit*, Ref 11; W. Feldt, G. Kanish and R. Lauer, 'Radioactive contamination of the NEA dumping sites', in *Impacts of Radionuclide Releases into the Marine Environment, op cit*, Ref 11, pp 456–480; T. Koyanagi,

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'Effect of sediment-bound radionuclides on marine organisms', in Egami, Ed, *Radiation Effects on Aquatic Organisms*, Japan Scientific Societies Press, Tokyo, 1980, pp 27–37; W. R. Schell and A. Nevessi, *Radionuclides at the US Radioactive Waste Disposal Site in the Hudson Canyon, 350 km off New York City*, Final Report, Contract, No 68–01–4838, January 1980, US Environmental Protection Agency Office of Radiation Protection, Washington, DC, 1980.

[14]Plutonium, for example, is not readily absorbed by the gut and hence mostly passes through the organism. Plutonium therefore exhibits limited bioavailabilty through the ingestive pathway. In contrast, other radionuclides are chemically similar to elements normally used in living processes. Strontium-90, for example, is chemically similar to calcium, and hence cellular mechanisms exist to transport it across cell membranes and incorporate it into the internal machinery of the cell.

[15]B. C. Heezen, 'Photographic reconnaissance of continental slope and upper continental rise', in *May 1974 Baseline Investigation of Deepwater Dumpsite 206*, National Oceanic and Atmospheric Administration Dumpsite Evaluation Report 75–1, National Oceanic and Atmospheric Administration, Rockville, MD, 1975, pp 105–140; B. C. Heezen, E. D. Schneider, O. H. Pilkey, 'Sediment transport by the Antarctic Bottom Current on Bermuda Rise', *Nature*, Vol 211, 1966, pp 611–612; E. J. W. Jones, M. Ewig, J. I. Ewing and S. L. Eittrem, 'Influences of Norwegian Sea overflow water on sedimentation in the northern North Atlantic and Labrador Sea', *Journal of Geophysical Research*, Vol 75, 1970, pp 1655–1680.

[16]J. A. Musick and K. J. Sulack, 'Characterization of the demersal fish community of a deep-sea radioactive dump site,' (results of cruise E. P. A. – 7801, RV ADVANCE II, 21–27 June 1978), available from the US Environmental Protection Agency, Office of Radiation Programs.

[17]G. G. Polikarpov, *Radioecology of Aquatic Organisms*, Reinhold, New York, 1966.

[18]The Republic of Nauru has argued before the London Dumping Convention that the uncertainty and long time scales render dumping at sea intrinsically inequitable, inasmuch as the effects across space and time cannot be accurately foreseen and compensated.

[19]This evolution in international legal thinking has taken place mainly within the London Dumping Convention, and mainly in regards to radioactive waste dumping at sea. See K. A. Gourlay, *Poisoners of the Seas*, Zed Books, London, 1988.

[20]J. Spiller and C. Hayden 'Radwaste at sea: a new era of polarization or a new basis for consensus?' *Ocean Development and International Law*, Vol 19, No 5, 1988, 345–357.

[21]K. A. Gourley, *op cit*, Ref 19.

recognized increasingly that wastes introduced into the seas are not 'assimilated' but recirculated, and that 'disposal' in a closed system is a misnomer. In economic terms, increasing scarcity of the resource – in this case the common property of the oceans' capacity to absorb wastes – has created a common property externality and the consequent incentive for regulation of the resource. Economic advantage may not in fact accrue to nations that exercise the ocean option, however, for three reasons. First, use of the option encourages other nations to do likewise, reducing the advantage to each and increasing the net detriment to all. Second, use of the ocean option creates a disincentive for source reduction. And third, use of the ocean option discourages development of economic land-based alternatives. Political resistance to the use of the ocean in national waste management practices has arisen in international fora, where the majority of nations have joined forces to forestall use of the ocean option. Legal history has been made by a shift in the onus of proof, which rests increasingly upon potential polluters; increasingly, a particular waste management practice is deemed unacceptable unless it is first proven safe.[19]

The signs of such change in global marine pollution policy include the recent formation of the Basle Convention for the Transboundary Movement of Wastes and their Disposal, which attempts to impose at least minimal regulatory standards on the export of hazardous wastes from producing nations; and the rapid evolution of the LDC from a regulatory role to an increasingly effective body for prevention of dumping at sea, in which social, political, economic and ethical considerations are taken into account in international waste management decisions.

It has been suggested that these events represent a weakening of the 'scientific' basis of international waste management.[20] An alternative view, however, is that events within the LDC have not affected its scientific basis, but simply affirmed in the international context what has been practised domestically for years, namely, that science cannot alone form the basis of the value judgements that ultimately underlie waste management practices. Prior to the evolution of the LDC, scientific arguments were frequently used as *post hoc* rationalizations for waste management policies that were motivated, in the first instance, by domestic economic and political pressures. The present posture of the LDC recognizes that science can inform choices, but human beings guided by value judgements must make them. This position is more consistent with the scientific uncertainty that characterizes ocean processes.

The international policy framework

The uncertainty, longevity, magnitude and interconnectedness of toxic waste impacts have collaborated to create, in this century, nearly two dozen regional and global treaties and conventions for the regulation of the marine environment.[21] The pre-eminent international convention regulating dumping of wastes into the oceans is the LDC, which entered into force in 1972. As noted above, the LDC deals only with deliberate dumping at sea, which it is increasingly prohibiting. In any case, the authority of the LDC is presently restricted to the 10% of wastes that are introduced deliberately by dumping into the marine environment, and most of these wastes are dredge spoils. Remarkably, there is no international convention regulating the other 90% of wastes introduced into the seas – wastes from land-based sources – although regional conventions and protocols address land-based sources to some extent.[22]

The recent history of international conventions illustrates that the new principles of waste management and reduction have not yet been fully incorporated into the international policies of all the nations of the world. Some of the major waste-producing nations, whose domestic waste management practices are most informed and restrictive, pursue international policies that are much more permissive. The consequence has been an impasse, reflected, for example, in the LDC, the Basle Convention, etc, in which this small group of nations has regularly opposed the precautionary approach to international waste management policy advocated by the majority of nations. It is an impasse that must be resolved before effective and concerted international marine protection policies can be implemented.

A Convention for the Protection of the Oceans from Pollution

The LDC was formed in part to ensure international standards for the regulation of ocean dumping. There is an even greater need for international standards to protect the oceans from land-based sources of pollution. The Law of the Sea (LOS) Convention provides conceptual guidance to such a process, by acknowledging the obligation of nations to protect and preserve the marine environment (Articles 192–196), based on existing standards of appropriate international organizations (Articles 197–201). The LOS does not, however, create such standards or organizations, nor does it specify mechanisms for their implementation.

There is a pressing need for the formation of a new international Convention for the Protection of the Oceans from Pollution (CPOP). The broader role of CPOP would be to establish international standards to prevent all ocean pollution, both from deliberate dumping at sea and from land-based sources, on the basis of the precautionary principle. The Convention could achieve this goal by linking the export of production technologies to the export of appropriate waste reduction and management technologies; by implementing the exchange of source reduction and waste abatement technologies; and by facilitating global adoption of clean production technologies. CPOP would thus serve in part as an international clearing-house for technological exchange aimed at reducing waste generation where feasible, and coupling unavoidable waste production with the best available abatement technologies. The resultant technology transfers would necessarily be mainly from the industrial to the developing countries – simultaneously protecting both from further degradation of the marine environment.

To establish an effective CPOP, several key problems must be addressed. First, a scientific and technical basis for establishing international standards must be built. The existing work of GESAMP provides a helpful beginning. But it is also necessary to establish the source of ocean pollution from land-based sources (atmospheric and terrestrial) in order to regulate these sources effectively.

Second, a legal framework for CPOP must be agreed. Existing international Conventions, notably the LDC and LOS, furnish a sound beginning. Existing regional Conventions (OSCOM, the Helsinki Convention, the Paris Convention), as well as UNEP's Regional Seas

[22]The Paris Convention, for example, is a regional treaty that plays such a role but is, however, restricted to the European region.

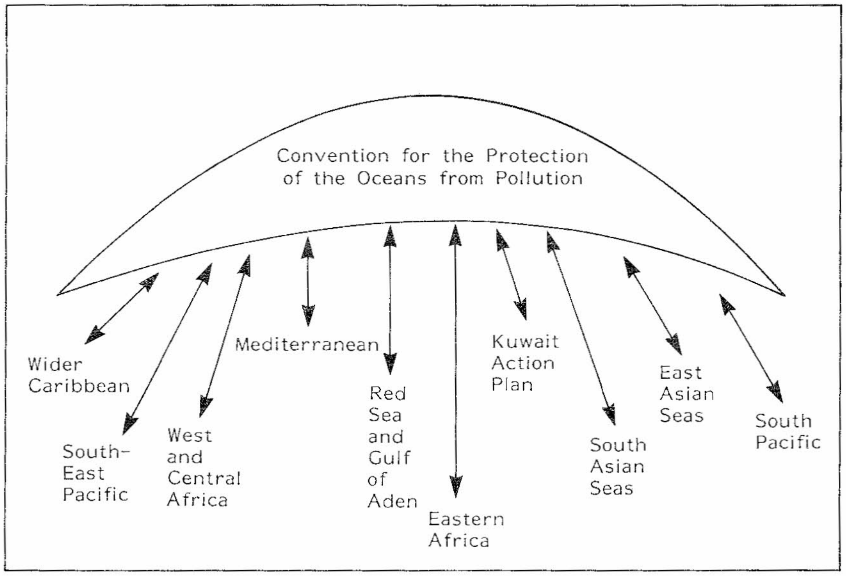

Figure 1. Possible conceptual organization for a global oceans convention.

Note: This conceptual organization incorporates the existing Regional Seas Programme of the United Nations Environment Programme (UNEP). Arrows signify enforcement and cooperation in the exchange of information and technology. See text for commentary.

Conventions (Figure 1), provide useful precedents and preview the problems that will have to be solved in creating a CPOP. A chief hurdle requiring solution is the problem of national sovereignty over the land-based sources that introduce national wastes into the international commons of the oceans.

Third, viable solutions to ocean pollution require that the economic benefits outweigh the cost. Protection of the oceans from pollution must be made profitable, either by increasing the costs of pollution, or by increasing the benefits of non-polluting alternatives. These aims can be pursued by both political and economic mechanisms (eg a 'polluter's tax'), and by technical means (eg development of alternative technologies that will eventually become economic). Such a marriage of ecology with economics could prove to be the most significant environmental milestone of the 20th century.

Fourth, an administrative mechanism for CPOP must be developed; precisely how and where the Convention might be situated are matters in need of further consideration. One possibility is expansion of the existing LDC, which is currently under consideration by Contracting Parties. A second possibility (not mutually exclusive with the first) involves the Regional Seas Programme of the United Nations Environment Programme. In this case, the proposed CPOP would represent a global 'umbrella' organization that establishes common standards, and provides for coordination, enforcement and technological exchange between the Regional Seas programmes (Figure 1). Yet a third possibility is the formation *de novo* of a new UN agency designed specifically for the protection of the oceans, with its own independent directorate. Whatever the forum, its funding must be substantial, stable and divorced from politics.

Fifth, international consensus on the need for such a convention must be achieved. According to one view, regulation of land-based sources of marine pollution is best achieved at the regional level, since inter-regional differences are profound. While there is merit to this view, ocean pollution is a global problem requiring global solutions. There is substantial inter-regional transfer of ocean pollutants, and enforcement and effective technology exchange require inter-regional communications links that can be provided most effectively by a global convention of the kind described above.

Finally, and perhaps most important, the aforementioned impasse must be resolved. This can occur only when all nations come to understand their capacity for environmental degradation, and the consequent need for implementing the precautionary principle. A change in national behaviour is required, such that national interests are defined in terms of the global imperative for a sustainable biosphere. As the Chairman of the London Dumping Convention, Mr Geoff Holland of Canada, has written:[23]

> The recognition that the planet Earth is one entity, and that anthropogenic activities are capable of threatening the world environment as we know it, automatically leads to the conclusion that all countries must work together for mutual gain.

Conclusions

Humanity has developed an unprecedented capacity to destroy the biosphere with its toxic waste products. As a consequence, previous principles of waste management have become outmoded, and new principles are required. As many have noted, the survival of our species depends upon our recognition of our capacity to destroy the biosphere, and upon our will to counter it effectively. Recent case studies challenge the thesis of the 'tragedy of the commons' by showing that group self-goverance can allow the maintenance of stable, harvested ecosystems,[24] but whether this can be accomplished on a global scale rapidly enough to avert catastrophic degradation of the biosphere is an open question. Establishing an effective international Convention for the Protection of the Oceans from Pollution would represent a significant step in this direction.

[23] Twelfth Consultative Meeting of the London Dumping Convention. *Document LDC 12/2/2*, p 9, International Maritime Organization, London.

[24] F. Berkes, D. Feeny, B. J. McCay and J. M. Acheson, 'The benefits of the commons', *Nature*, Vol 340, 1989, pp 91–93.