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—A. D. McINTYRE

## MARINE POLLUTION CONVENTION

Negotiations of the International Convention for the Prevention of Pollution from Ships in 1973 and its fully integrated protocol in 1978 (together known as MARPOL 73/78) constituted efforts to develop a comprehensive regime for ship-generated marine pollutants. Prompted in part by several dramatic oil tanker accidents, MARPOL built on several earlier intergovernmental treaties for marine pollution control, including the 1954 International Convention for Prevention of Pollution of the Sea by Oil (1954), the International Convention on Civil Liability for Oil Pollution Damage (1969), the International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (1969), the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (1971), and the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (1972). Primarily concerned with nonaccidental pollution, MARPOL established five pollutant-specific annexes regulating oil, liquid chemicals, harmful packaged substances, sewage, and garbage discharged by ships. The United Nations International Maritime Organization (IMO) has since negotiated protocols and amendments to most of the above-mentioned agreements, as well as producing the International Convention on Oil Pollution Preparedness, Response and Co-operation (1990) and the International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea (1996). Recent negotiations under the auspices of IMO have sought to add regulations to MARPOL to address various ship-generated air pollutants (including sulfur dioxide, nitrogen oxides, and ozone-depleting substances).

Taken together, these conventions have produced a global regime composed of a vast network of regulations covering most intentional and accidental pollution of the ocean from ships. These conventions, *inter alia*, ban or limit the amounts and rates of discharge of various pollutants, establish financial liability for polluting accidents, require installation of equipment that precludes such discharges, and require the provision of shore facilities to receive various pollutants. Numerous regional agreements as well as many countries' domestic laws provide additional marine environmental protection by establishing further regulations regarding regional seas and land-based sources of marine pollution. National efforts to facilitate compliance with these regulations while detecting noncompliance have been bolstered by regional agreements in Europe, Latin America, the Asia–Pacific region, the Caribbean, the Mediterranean, the Indian Ocean, West and Central Africa, the Black Sea, and the Persian Gulf, which coordinate inport inspections and marine surveillance efforts. Ship-classification societies, insurance agencies, and shipbuilders have also played important roles in altering the institutional environment in ways that decrease the opportunities and incentives for shipowners to pollute the ocean.

As with many environmental problems, numerous obstacles prevent confident evaluation of the impact that these agreements have had on polluting behavior or on marine environmental quality. What evidence does exist suggests that the nations and ships of the world have become more conscientious in their treatment of the ocean, even though none of these pollutants has yet been eliminated from the marine environment. Both intentional discharges and accidental spills of oil appear to have decreased in size and frequency, and similar trends are evident for most of the other pollutants regulated under these agreements. At present, remaining obstacles to marine environmental protection appear to arise more from the absence of proper implementation and compliance than from the absence of appropriate regulations.

[*See also* Law of the Sea; London Convention of 1972; Ocean Disposal; *and* Petroleum Hydrocarbons in the Ocean.]

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—RONALD B. MITCHELL

## MARKET MECHANISMS

Although many environmental regulations over the past three decades have been effective in improving environmental quality, they have often done so at a relatively high cost to society. The unduly high cost stems from the reliance of regulators on direct regulations that provide little flexibility to firms in meeting environmental goals. This command and control approach often specifies a uniform level of pollution reduction that all firms must achieve, or a particular technology that must be installed. On the other hand, policies that create economic incentives for firms to reduce pollution, rather than a rigid mandate, provide firms with the flexibility to choose the most cost-effective method to achieve an environmental goal. Moreover, they encourage innovation by providing firms with an incentive to find or develop cleaner and less expensive technologies and production methods. Thus, policies that use market mechanisms such as environmental taxes or marketable permit schemes can meet an aggregate level of pollution reduction at lower overall costs.

**Market-Based Approaches.** Two major types of market-oriented policy that have been implemented are pollution charges and marketable-permit systems. A pollution charge system levies a fee or tax per unit of pollution. Under a charge system, firms face the same incentive to control at the margin, so that a firm will reduce its pollution up to the point at which the marginal cost of control just equals the tax. The result is that the total costs of pollution control are minimized compared with other allocations of the pollution-control burden across firms (Bohm and Russell, 1985). One problem with a charge system is that the regulators do not know in advance what level of cleanup will result from any given charge. Marketable-permit systems, on the other hand, can achieve the same cost-minimizing allocation of the pollution-control burden as a charge scheme in a way that avoids the problem of uncertain responses by firms (Hahn and Noll, 1982; Coase, 1960). A marketable-permit system typically limits pollution by establishing an overall level of permits and then allocating those permits to firms. Those that keep emission levels below the allotted level can sell or lease their surplus permits to other firms, or use them to offset excess emissions in other parts of their own facilities.

In addition to allowing greater levels of environmental protection for any given aggregate cost of control, market-oriented policies can provide powerful incentives for the development of new pollution-control technologies by the private sector. Because investments in pollution control can enhance profits under incentive-based systems, these policies can encourage firms to adopt new pollution-control technologies. The opportunity to profit creates incentives for firms to carry out research and development on cheaper and better pollution-abatement techniques.

In theory, the use of these mechanisms has the potential to achieve environmental objectives at the lowest cost. Many economic studies have projected substantial cost savings from replacing the traditional command-and-control regulations with more flexible incentive-based regulations. A review of *ex ante* empirical studies on cost savings from achieving least-cost air pollution control shows significant potential gains from incentive-based policies (Tietenberg, 1990). The ratio of costs from the traditional command-and-control approach to the least-cost policy for the eleven studies reviewed ranged from 1.07 to 22.00, with an average of 6.13. These *ex ante* simulations assume that incentive-based mechanisms achieve the optimal result. This is rarely the case in practice. Political obstacles frequently lead to markets that have high transaction costs and institutional barriers that reduce the potential for cost savings.

**Market-Based Mechanisms in Practice.** A broad array of incentive-based mechanisms have been used in the United States, but perhaps best known in terms of their potential for achieving cost savings are marketable permits, whose use has steadily increased over time. The primary application of this mechanism has been federal programs such as the Emissions Trading Program, the nationwide phasedown of lead in gasoline, the phaseout of some ozone-depleting chemicals, and the market in sulfur dioxide allowance trading for reducing acid rain. In addition, there are several programs at the regional level, such as Southern California's Regional Emissions Clean Air Incentives Market (RECLAIM), which allows polluters to trade emissions allowances to achieve air pollution goals.

The first U.S. experiment with marketable permits was the Emissions Trading Program implemented in 1974 to reduce the cost of meeting air pollution regulation. Hahn and Hester (1989b) produced the only comprehensive study of costs savings based on actual trades. They estimated that the program achieved savings on the order of U.S.$1.4–19 billion over the first fourteen years. These savings come mainly from internal trading and, although substantial, do not represent the full extent of potential cost savings that could have been gained from external trading. The program generally failed to create an active market for emission-reduction credits, and did little to change the level of emissions. The program has not been widely used for several reasons. For example, the states that actually

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