5

Prevention Rather Than Cure

An ounce of prevention is worth a pound of cure.

Poor Richard's Almanac

CONSIDER THE MOST SENSIBLE path ahead for ocean governance, and a new principle readily suggests itself. The precautionary ideal embraces a more integrative and conservationist perspective—something wiser than traditionally divisive boundaries like a three- or twelve-mile jurisdictional limit. Not surprisingly, then, this new thinking is increasingly cited in international accords, since it is an attractive means to improve marine policy. At its heart, the principle is based on the conviction that it is no longer valid to assume that the sea has a vast capacity to absorb a variety of harms.[1]

Precautionary action seeks to prevent pollution from land-based sources, thereby reassessing the thicket of pollution controls that operate at the "end of the pipe."[2] Unlike most current policies, precautionary action would *prevent* ecological harm before it occurs. For instance, it would avoid discharges into the marine environment and prevent damage from overfishing. Likewise, it would minimize the destruction of wetlands or other essen-

tial fish habitats that serve as breeding grounds. On a legal front, it would shift the burden of proof off nature and onto those who are proposing significantly harmful activities.[3]

The United States brims with exciting opportunities for preventing pollution. Money-saving options run a wide gamut from new manufacturing processes that replace toxic substances with benign (and often less expensive) substitutes[4] to educating consumers on nontoxic and organic household cleaning agents.[5] There are an array of economically sensible ways of pursuing these ends. However, such prevention-based goals will not be easily achieved because of the vast inertia surrounding most environmental regulations.

The direction taken in U.S. environmental laws is instructive. The core environmental legislation that began in the late 1960s at first represented a challenge to the power of traditional government. Rapid change was precipitated by opposition to the Vietnam War and efforts to raise public consciousness such as Rachel Carson's *Silent Spring* (1962), which alerted the public to the damage caused by pesticides, the Santa Barbara oil spill of 1969, and a broadening realization that the global ecosystem needed protection. These events and others grabbed the public's attention and thus the notice of politicians. In the space of a few years, sixteen major environmental laws (albeit narrowly defined and usually single-purpose) were enacted in the United States.

Countless regulations spawned by these basic laws have built businesses in areas like pollution control and waste management. Meanwhile, the rising number of consulting firms attests to the profits that can be realized by after-the-fact pollution monitoring and cleanup. The immense sums that are spent in attempting to clean up toxic waste sites illustrate this institutional mind set.

Yet there is a flaw woven into these laws, policies, and regulations: most environmental statutes rely on end-of-pipe control strategies. The assumption that the natural environment has an almost limitless capacity to absorb pollution has prevailed for so long that it goes unexamined. Starting from this assumption, most regulatory efforts focus on after-the-fact pollution controls, while ignoring prevention.

Control techniques have made impressive strides, as illustrated by new sophisticated filtering technologies. Catalytic converters used globally in

automobiles are a case in point. They have caused a sharp decine in pollutants from exhausts of individual cars. Nonetheless, this case also demonstrates a problem with control strategies: although pollution from each car has dropped, the total number of cars on the road has increased exponentially, far outstripping any initial declines in pollution levels. Similarly, the growth of many industrial activities means that after initial declines, many pollutants are again defying all control efforts. After early encouraging signs, the measured totals of numerous pollutants are now dropping only modestly, if at all, and in many cases are worsening. Meanwhile, a broader loss of ecological integrity continues.[6]

Hence, despite a few successes to the contrary, the goal of these laws—to "save the environment"—still remains elusive. This has happened largely because environmental laws have emerged in startlingly piecemeal fashion; they are not integrated so as to wisely prevent harm, nor do they address the causes of ecological harm at the source. Because regulations have not yet recognized that prevention is far more successful than remediation after harm is done, control strategies have stayed locked in place. Thus the dominant paradigm is still to dilute pollutants, such as by releasing them into coastal seas, or secreting wastes away in the depths of the ocean. But those short-term responses will in time come back to haunt us: merely diluting or hiding waste is not the answer.[7]

On the other hand, if pollution is regarded as a form of inefficiency, which in fact it really is, then new attention to upstream preventive measures makes great sense.[8] Why then is prevention overlooked? Part of the explanation is inertia. The *Economist* observes that when a smart, inexpensive technology was introduced to enable certain industries to reduce pollutants while also operating on 30 percent less electricity, the one source selling this novel technology generally met with stubborn resistance to its product. Only a few companies were willing to switch operations immediately. "To understand why [the] technology spread relatively slowly despite promising such huge savings, think in terms of work psychology. Big companies are conservative; engineers are hard-put to believe that their traditional approach to design can be bettered so easily."[9] Oftentimes large firms seemed to assume that if alternative "greener" technologies really were so much cheaper and better, we would all be using them by now.[10]

Resistance to new preventive technology includes a sentiment that

government intrusion in manufacturing choices is tantamount to "command-and-control" economics, reminiscent of Soviet-era communism. Clearly, governments in a free-market economy should not be in the business of picking winning technologies. Nonetheless, where new subsidies or "green" taxes make ecological and economic sense, they ought to be considered. For although government-industry partnerships (made for "green" ends) are often painted as un-American, many industries like coal, petroleum, and nuclear power already enjoy a host of subsidies, tax relief, and other indirect government aid. Those many incentives, created before the environmental protection ethic entered the national consciousness, ought to be reconsidered.

Yet another reason why pollution prevention strategies are so far disregarded is that the economic benefits may accrue over the long term and thus do not show up immediately in ledger books. Economic incentives currently work against prevention because under generally accepted accounting practices, it is typically cheaper to create ecological harms (pollution) and then to disperse the costs so that the broader community bears the burden. If environmentally harmful activities are borne by the commons and if producers can shrug off ecological responsibility, there is undeniably an economic incentive to do so. A result is that inefficiencies (pollution) are shifted from the polluter to the public, and the cost of cleanup falls to future generations.

Another reason for precautionary measures stems from the fact that our scientific understanding of marine ecosystems is still rudimentary and hindered by a host of factors.[11] Recently, for example, genetic studies of a common mussel species off the shores of southern California underscores how little is known about marine ecology. For many years a species of mussel was thought to be among the better-studied marine organisms. This was because it inhabited the waters adjacent to marine science laboratories. Yet scientists recently discovered that this particular species may have sharply declined in numbers decades ago, when its original populations were replaced by a nonendemic (foreign) species, a subtly different invader from the Mediterranean.[12] Without our realizing it, a mussel species may have crashed, and right under our noses. Given such levels of uncertainty, precautionary action encourages a restraint to protect marine biodiversity.

A core element of this principle is proved by the few successful cases in

which pollutants have been most effectively reduced, as with airborne lead, DDT, mercury in surface waters, and radioactive fallout from atomic bomb tests—these successes were owed to the *elimination* of the offending substance or activity at its *source*.[13] Precaution thus means avoiding or minimizing an offending activity upstream, or finding new means to replace a harmful substance or activity with more benign substitutes. Both the precautionary principle and pollution prevention look upstream to avoid the use of dangerous substances like organochlorines.[14] They are not intended to replace all end-of-pipe control technologies, but rather to provide efficient concepts for better protecting the marine environment. Both precaution and prevention would offer more than the old shell game of just shifting pollutants from one environmental medium to another.

Precaution also responds to a vexing problem: how should environmental policy be made in the face of scientific uncertainty? The sciences rightly engage in rigorous objective studies in order to better understand the workings of nature.[15] And yet that academic, time-consuming process of seeking scientific agreement is rarely available to policy makers, who are under pressure to make rapid decisions.[16] Without a common yardstick for "good" governance, the swift extraction of nature's resources may be regarded as a preferable goal (nice economic miracle—shame about the environmental costs). Given the exigencies of making policy under such conditions, government leaders tend to ignore preventive strategies and leave it to the environment to assimilate damage. The precautionary principle would respond to this dilemma by encouraging *conservative* decisions in the truest sense of the word.

A Case Study in Pollution Prevention

The economic possibilities of pollution prevention is seen in the case of Dydee Diaper Service, once the largest cloth diaper service in New England, with eighty-five employees.[17] In a typical week Dydee washed about 200,000 pounds of soiled baby linen and diapers. To act in an environmentally conscious fashion and to conserve water, Dydee used a special eighteen-chamber continuous-batch tunnel washer that required only 20–25 percent

of the water used by a conventional washer. However, a major drawback to this conservation effort was that contaminants in the waste water were more concentrated. Ironically, by using less water, Dydee Diaper found it more difficult to meet effluent guidelines.

Soon the effluent exceeded the maximum of 1 part per million (ppm) for zinc set by the Massachusetts state water resources authority. In January 1992, Dydee was cited for exceeding zinc discharge limits, a violation widely reported in the local news. Concerned customers, many of whom had chosen to use cloth diapers rather than disposables, were outraged and many canceled their accounts.

Dydee Diaper was puzzled by this effluent problem, since the company did not use zinc in any of its cleaning processes. Tests showed no zinc in its cleaning chemicals or water supply. It was discovered that the zinc came from the diapers themselves, from the zinc oxide–based baby ointments commonly used to treat diaper rash. Zinc was also an ingredient in various baby skin creams.

Dydee's president next considered three alternatives to resolve this zinc problem. The conventional answer, a classic control approach, would be to purchase a water treatment system, costing about $150,000 for purchase and installation and another $30,000 per year for chemicals. Additional expenses were required to pay a licensed operator. The second alternative was to purchase "closed-loop ozone activated" laundering machines. Dydee's president was impressed by the concept of closed-system technology, which can almost eliminate water discharge altogether, but applications of this new technology to diapers were still being developed. Because that option might be adaptable for Dydee's special needs in several years' time, the company was reluctant to spend over $150,000 up front for the more conventional waste water treatment system.

The third option was the most unconventional—and the one Dydee chose. In a pioneering decision, Dydee opted to try to reduce the problem at its source by convincing its customers to voluntarily alter habits at home. The main question was whether its customers would do so. In an unconventional route for U.S. business, Dydee reached out to customers, informed them of an environmental problem, and provided them with education and assistance to make the solution work. Dydee sent out a letter explaining the problem and asking customers to use zinc-free ointments. It

offered to pay customers $1 per container for their zinc-based ointments and to sell them zinc-free products—such as diaper rash ointment and baby skin cream—at about half the retail cost. Customers were sent free samples of zinc-free products and the zinc-free campaign was promoted in a monthly newsletter, "Bottoms Up."

The results were highly positive. The company immediately witnessed a substantial reduction in total zinc discharge. Before this outreach campaign began in 1992, zinc concentrations typically ranged between 2 and 4.5 ppm. Following the campaign, its zinc discharge was consistently held below the 1 ppm limit. In this way, Dydee was able to comply with zinc discharge regulations, and even save money, by preventing pollution.

The benefits exceeded the costs. Dydee spent about $1,000 to buy back zinc ointments and another $7,000 for 20,000 samples of zinc-free products. It sold some 2,000 containers of zinc-free ointments and creams and larger zinc-free containers at a loss, costing Dydee $250. This total campaign cost less than $10,000. On the other hand, the education effort saved Dydee Diaper from spending about $150,000 in start-up costs for a treatment system plus $30,000 per year for treatment chemicals, sludge disposal fees, and an operator. Through prevention the company was able to realize substantial savings.

This example suggests that if more companies actively considered prevention, the results could be not only cost savings but also reductions in global environmental problems. Yet current U.S. campaigns for advancing pollution prevention and precaution are only at an embryonic beginning.[18] And although we rarely think of such upstream activities as related to the state of the seas, there is a direct connection. Pollution prevention will be rewarded by better protection of the ecological integrity of the sea.

The Precautionary Principle in International Law

While clean production strategies will grow more popular as industry discovers that new techniques can lower costs while reducing pollution, there are at present strong disincentives that must be overcome. Perhaps most daunting is that humanity has grown accustomed to assuming that the ocean is endlessly capable of absorbing the land's wastes. But in recent

multinational accords for protecting the environment, the precautionary principle (and thus prevention) is receiving increasing attention from industrialized nations. Initially put forward in an international setting at a First Ministerial Conference on North Sea Pollution in 1984, the precautionary principle was strengthened in London at a Second North Sea Conference in 1987 and reinterpreted at a Third Conference in 1990.[19]

The principle has since provoked a variety of responses from the industrialized nations. Views currently range from cautious resistance, as in a case of Britain, to much more sympathy toward precaution, as shown by Germany and the Scandinavian nations.[20] Hence the concept is at a crossroads, and a meaningful question is whether the nascent principle will be embraced in future international agreements. Recent trends suggest that precautionary action may slowly become more mainstream thinking. References to this concept are on the increase.[21]

The principle, for example, is noted approvingly in the 1991 Bamako Convention for Regulation of Pesticides and Hazardous Wastes (Africa), in Principle 15 of the Rio Declaration (UN Conference on the Environment and Development, 1992), and also in Article 2 of the Convention for Protection of the Marine Environment of the Northeast Atlantic (OSLO and Paris Commission, 1992).[22] Other key instances of precautionary action include the 1987 Montreal Protocol on Substances That Deplete the Ozone Layer, the moratorium against whaling, and suspension of disposal of low-level radioactive wastes at sea without approval of the consultative parties to the London Dumping Convention.[23] A UN resolution against drift netting on the high seas, together with a vigorous policy statement on this resolution, are likewise precautionary, since they shift the burden of proof.[24]

These resolutions suggest that the precautionary principle is moving toward acceptance in international law. But closer examination of this principle as implemented reveals a different picture. Precautionary thinking seemed to have found some early consensus in 1987 at the conclusion of the Second North Sea Conference, when success injecting the principle was regarded by many within the environmental movement as a breakthrough. The progressive northern European and Nordic nations appeared to be seriously grappling with the vexing problems of North Sea pollution and genuine, forceful precautionary policy seemed about to be implemented.

Since that time, however, there has been a notable absence of robust new policies. Irresolute efforts to instill precaution have fallen short of environmentalists' expectations. A shadow report by an environmental group argues that efforts among nations represented at the Second North Sea Conference still shy away from precautionary measures.[25] This resistance might be explained by certain common characteristics of the northern European nations. Divided by dissimilar customs, they all have mature market economies and are linked by competitive free trade. Although a spur to economic development, that competition as currently framed may cause people to undervalue the costs to the earth of economic activity.

Industrial nations have understandably resisted making economic sacrifices to avoid harm to the environment, for fear of allowing others a comparative advantage. It is difficult even for the "greener" Nordic nations to lead the cause of environmental protection because of the "lowest common denominator" factor in international negotiations, whereby a single unenthusiastic nation can stymie agreement on progressive treaty goals. In the aggregate, this is a collective free-rider problem with the health of the global environment at stake. As a result, opponents of precautionary action can claim that to expect more aggressive measures from Second North Sea Conference nations is romantic but unrealistic.[26]

Although the United States often sets an example for environmental regulation, it usually resists the precautionary approach. Such resistance was evident in U.S. opposition to the 1990 Bergen Conference and again at the 1990 Second World Climate Conference.[27] This opposition of course is articulated in the best light possible. In the words of James Baker, secretary of state under President George Bush, "While the U.S. continues to support scientific research into the greenhouse effect, [we] are prepared to take actions that are fully justified in their own right and have the added advantage of coping with greenhouse gases. They're precisely the policies [the United States] will never have cause to regret."[28]

This "no regrets" position seems reasonable and beyond reproach. It even seems to support government incentives to encourage industries to use more efficient production methods that will produce fewer environmental harms—a key aim of the precautionary principle. Yet paradoxically, the United States adopted a unique version of this "no regrets" position that defends policies still rooted in the assumption that nature can assimilate

pollution.[29] Despite its increasing favor, one of the major criticisms leveled at the precautionary concept by opponents, including the U.S. government, is that the principle is just too idealistic. They claim that this principle—at least, as they envision it—cannot be applied in real-world situations in which some risk in exploitation of resources is inevitable.[30]

But precautionary action need not be taken to extremes. The principle can be applied in various degrees. The rigor with which it is applied can depend on the danger of some proposed action. Indeed, just such a scaled approach is commonly used, for instance, for interpreting the constitutional protections written into the Bill of Rights. The degree to which an individual is shielded from discrimination will vary according to just how fundamental is the right that is being protected.

Critics further complain that ecological harms are not always foreseeable and therefore it is impossible to guard against them. That criticism carries substantial weight. Many substances or activities now recognized as harmful had once seemed to pose no risk. Seemingly benign chemicals like chlorofluorocarbons (CFCs) are an example. Despite their inert nature (or more accurately because of that quality), the release of CFCs into the atmosphere has led to a thinning of stratospheric ozone. Other unexpected outcomes have resulted from the spraying of DDT, marine habitat destruction, or overprescribing antibiotics, which in turn hastens the rise of resistant strains of bacteria.

To be sure, precautionary action cannot prevent all dangerous activities, and ecological damage is not always foreseeable. Yet that argument does not discredit the concept. Rather, on closer inspection, it reemphasizes the opposing view: with rapid changes to come in the twenty-first century, there is a growing need for precaution. For instance, machine-driven meat production in Britain has led to a fear that "mad cow disease" could jump across the species barrier. Indeed, bovine spongiform encephalopathy (BSE) may now be transmissible to humans, as manifested by Creutzfeldt-Jakob disease. It is often prudent to take readily available, economically sensible steps that reduce risk.

Another criticism of precautionary action is that the principle is still such an ambiguous legal concept that it cannot bind nations.[31] However, the principle may be given more concrete form as it is increasingly applied

and thus evolves. Yet it can be interpreted in unintended ways. Some make the case that most environmental policies are already precautionary at base. That is a tactic meant to define away precaution. At this early stage in defining what the precautionary principle should mean, some may prefer interpretations that weaken the concept. A variety of nations and nongovernmental organizations have thus "decided that the best approach is to try to undermine it while ostensibly endorsing it." By capitalizing on the lack of legal definitions for the precautionary principle, they may derail recent momentum for establishing this concept.[32]

Finally, the precautionary principle has been criticized for its simplicity, but—as with the U.S. Constitution—its strength lies in brevity and simplicity. Precaution is like the First Amendment, for example, which holds that Congress shall make no law abridging the freedom of the press. For more than two centuries, that one pithy line has had an impact out of proportion to its size; the free-press principle has built a wall against censorship. The precautionary principle can similarly inform our thinking. An abstraction may be fleshed out by interpretive rulings over time. Thus the vagueness of current definitions of the precautionary principle is not a fatal flaw; what is required is greater consensus on what the principle entails.

This discussion will review a wide assortment of U.S. environmental regimes as to their capacity for precautionary action. Where the idea of precaution is absent, ways are suggested for introducing it. As is shown, current U.S. policy does not emphasize the prevention of harm. Precautionary action requires the greater application of science in policy making and prefers prevention to cure.[33] As a matter of efficiency, it shifts the burden of proof toward improved environmental protection.[34] By exploring some ways in which precaution could inform our thinking, I will suggest what a second-generation precautionary regime should look like.[35]

The National Environmental Policy Act

The National Environmental Policy Act of 1970 (42 U.S.C. Sec. 4332 [2][C][1976]), commonly known as NEPA, was a milestone in the early history of U.S. environmental law.[36] It is one of the least understood yet most

important environmental laws. NEPA clearly forged new paths by creating novel protections for the biosphere, including the oceans. As currently interpreted, NEPA is a "stop and think" statute, mandating that environmental assessments be written in cases of any proposed major federal actions that would significantly affect the environment.[37]

The authors of NEPA intended that federal agencies should for the first time be required to proactively consider the environmental consequences of their activities before they sent bulldozers into action. Its unique action-forcing requirement of an environmental assessment was born of the reasonable fear that because of inertia, once a bureaucracy decided to move ahead with a project such as a dam, a superhighway, or a toxic waste dump, the project was unstoppable. Among other things, NEPA was meant to nip ecologically unwise ideas in the bud.

That wisdom of considering environmental impacts before a project is begun is now taken for granted. Yet until NEPA was passed, few agencies had thought it necessary to think in ecological terms. For instance, immediately after the act was passed, an unyielding Atomic Energy Commission (AEC) vigorously challenged this requirement in court, arguing that NEPA did not apply to the construction of nuclear plants. In the first major interpretation of NEPA, Judge Skelly Wright ruled that the AEC's crabbed view was a clear violation of the statute and that NEPA bore a rigorous stop-and-think purpose.[38] That ruling set up many basic criteria for interpreting NEPA that still exist today.

But just as important was what Judge Wright chose not to do. He did not interpret other NEPA language that went beyond its procedural stop-and-think function. Remarkable language in NEPA went beyond the requirement to list the impact of proposed action; in addition, it implied that project planners should also favor an ecologically superior course of action.[39] If more attention had been given to this substantive function in judicial interpretations of the act, NEPA would have a far broader scope today. Thus Judge Wright's decision gave NEPA considerable force by fortifying its environmental assessment provisions, but if he had gone further and fleshed out NEPA's aspirational language, his decision would have provided broad stimulus for substantively "green" decision making.

The door had been opened for substantive interpretations of NEPA, but

it was soon shut. For example, the law states in Sections 101 (a) and (b) that it is U.S. policy to "maintain, wherever possible, an environment which supports [biological] diversity."[40] Although NEPA could have been interpreted by the courts to mandate substantive review, and therefore projects should be shown to be environmentally sensible before they were allowed to proceed, a hostile Supreme Court in two crucial decisions (*Vermont Yankee* and *Strycker's Bay*) summarily held that federal agencies do not have to promote environmental concerns.[41] The law was emasculated, enforcing only a duty to stop and think.[42]

In theory, NEPA could be reinterpreted by the Supreme Court to give it more power, to create a regulatory regime akin to precautionary action. Yet that is highly unlikely. Alternately, it might be amended by Congress to mandate a substantive review of the ecological impacts of proposed projects, but neither is likely in the present political climate. As it stands, NEPA sets up a series of time-consuming hoops that agencies must jump through on the way to approving a given enterprise. To be sure, the jumping has not been easy. Environmental assessments are often exceptionally voluminous and detailed to avoid litigation over errors or omissions. That problem was corrected to some degree, but these reports are so complex that the public rarely hears of them. Impact statements fail to be the concise interdisciplinary reports suitable for public consumption, as intended.[43]

Moreover, NEPA as implemented is not precautionary in nature because it addresses only the narrow issues, such as whether to build an individual nuclear plant or new superhighway. It does not require any substantive large-scale review of policy making with an eye to precaution in general or pollution prevention. If it did, this law could then fill an important new role. For instance, NEPA might require planners to consider whether it might be preferable to find alternatives to reduce traffic than to build another superhighway. Yet NEPA as now interpreted allows many unwise policies to emerge from a tyranny of small decisions. This need not be so. Lynton Caldwell, who played a major role in drafting NEPA, argues that the law does authorize consideration of substantive policy alternatives like precautionary action, pollution prevention, reduction of pollution at the source, and clean production strategies, but this goal has not been met.[44]

Thus, as Caldwell points out, NEPA has been misinterpreted. He be-

lieves it was not meant to be a regulatory or procedural statute, but rather a declaration of ecological policy that includes an action-forcing provision. However, unlike U.S. civil rights laws that are backed by constitutional mandate, courts are often reluctant to rigorously interpret environmental laws or overturn executive decisions regarding the environment. Caldwell observes, "No law is more effective than the will to enforce it," and NEPA has thus far had very weak support in the executive and legislative branches.[45] Were this statute given a broad new element requiring federal proposals to consider new opportunities for precaution or pollution prevention in the first place, then NEPA could offer much. But because such expansion is unlikely in the present political climate, NEPA promises little for instilling precaution in domestic policy.

The Magnuson-Stevens Fishery Conservation and Management Act

Unlike the broad brush of NEPA that can apply to many actions on land and sea, the Fisheries Conservation and Management Act of 1976 is devoted exclusively to fisheries management.[46] Now known as the Magnuson-Stevens Act (see chapter 3), this law has been a failure from most perspectives. It was originally a response to foreign fishing off U.S. shores. Thus the law codified what became a 200-mile exclusive economic zone (EEZ).[47] Most important, the act served to oust foreign vessels and favored the small domestic fleet, which greatly increased in size.

Over twenty years after passage, the Magnuson-Stevens Act is most notable for what it is not doing—it is failing to conserve fishery resources. A so-called fishery conservation zone has proved to be anything but: it has brought about neither effective conservation of valuable stocks nor significant reductions in the total fishing effort. Instead, it has merely replaced overfishing by foreign vessels with a clearly home-grown problem.

Immediately following the passage of this act, foreign fishing within 200 miles of the United States declined precipitously from 3.8 billion tons in 1977, or 71 percent of the total catch, to just 12 million tons in 1991, or 0.2 percent. Meanwhile domestic fishing capacity increased dramatically. The U.S. catch jumped from 1.56 billion tons in 1977 to more than 5.78

billion tons in 1991. Foreign boats were allowed to capture fish only when U.S. boats failed to reach the total allowable catch.[48] Despite the new U.S. management scheme, an alarming percentage of fish stocks have fallen to depleted levels over the same period. According to the U.S. National Marine Fisheries Service (NMFS), the agency charged with monitoring the nation's 200-mile zone, fully 45 percent of fisheries whose status is known are in danger. Some stocks plummeted to less than 10 percent of optimum size.[49]

In a worrisome sign of things to come, the once abundant stocks of haddock and cod off New England have crashed. This is forcing New England fishermen, with their overcapitalized fishing fleets, to switch their efforts toward the less desirable species that have come to dominate altered marine ecosystems. As a result, the ecosystems on the northwest Atlantic continental shelf are being transformed by overfishing. Relatively valuable fish like mackerel and herring are in decline, while commercially less desirable sand lance take their place.[50] Desirable haddock and cod are threatened, which allows "trash fish" like dogfish and skate to proliferate.

Several broad factors responsible for the act's failure are listed in chapter 3. But in light of goals of precautionary action, some other points are notable as well. At the outset, this act is failing because it is being driven by short-term economic interests that fail to put the health of the resource first. It functions as a development regime, not the conservationist regime that it should be and is demanded by the precautionary principle.

Precaution is ignored partly because of the makeup of the eight regional fisheries management councils (FMCs).[51] These councils were established by the act to peg allowable fishing efforts. Yet council members represent the same fishing industry this law regulates. At NMFS, well-meaning scientists attempt to forecast maximum sustained yield, a difficult task in its own right. But when presented with various possible scenarios (scientists must draw up various estimates because of uncertainty), too often councils attempt to wring from the data the highest take possible. It is too much an instance of the fox watching the henhouse. Keen observers of ocean management like Sylvia Earle conclude that the councils have been a failure in theory and practice.[52]

Such problems with U.S. fisheries management are hidden from the

public because declines in domestic stocks are masked by imported products. Fish and other seafood are abundant in local markets. Moreover, a lack of popular concern for the plight of crashing stocks may be explained. Fish simply do not inspire sentimental identification like other species. They are usually rather small, cold-blooded, scaly creatures, unlike "cuter" air-breathing marine mammals such as seals, whose very countenance seems to beg for human empathy. Moreover, they care not a whit for their young: many species release eggs by the million to be fertilized at random and eat their own young fry. Finally, the threat of commercial depletion is rather different from extinction; people are not alarmed.

Nonetheless, the tragedy of overfishing is now beginning to catch the public eye. Critics of the act are at last starting to be heard. Even a few FMC members say the councils are becoming their own worst enemies by institutionalizing overfishing. A front-page story in the *New York Times* notes that "overharvesting has helped to bring about the fishing industry's drastic decline."[53] One solution is clear: membership on fisheries councils should be more diversified so that they are not dominated by the fishing industry whose short-term interests lie in overharvesting the resource.[54]

Action must be taken soon. Worldwide total marine fish catch peaked at 86 million tons in 1989 and has since gone into decline; thirteen of the seventeen major global fisheries are now in serious trouble.[55] The causes are complex and will be nettlesome to resolve. One problem is pollution. Others stem from devastatingly effective fishing methods. Vessels that produce large bycatches (unintended catch of species not targeted) or that cause habitat destruction are tremendously wasteful over the long term, although this fact seems unacknowledged, given their ongoing use. So declines in many stocks will continue for many reasons, including deference to national sovereignty, a "tragedy of the commons," and the unceasing world demand for protein.[56]

Although wise ocean governance requires extensive knowledge of marine ecosystems, scientific understanding is still rudimentary. Only a few decades ago, it was widely assumed that most marine ecosystems were characterized by a balance of nature. Biotic communities and individual fish stocks were conceived as though centering on some ascertainable, knowable equilibrium. As recently as the mid-1970s, some scientists still

regarded marine ecosystems as stable, closed, internally regulated, deterministic, and fathomable.[57]

The optimistic assumption that fisheries were not exceptionally complex systems led to the idea that a targeted species of fish (such as coho salmon) could be readily managed to produce its maximum sustained yield. It was believed that regulators could obtain the greatest possible take of salmon, for instance, by simply manipulating fishing pressures alone. Fish populations were seen as tending toward a steady-state equilibrium, and so susceptible to predictive modeling techniques.

Today the management of resources is undergoing radical revision. As that static "balance of nature" idea fell into disfavor, another school of thought has arisen that portrays the marine environment as characterized by change and turmoil. As noted by G. Carleton Ray, marine ecosystems are now seen as in a chaotic state of disturbance and fluctuation. Instead of stability, there are discontinuities and synergisms that "are devilishly difficult to predict."[58] This paradigm sees marine ecosystems as open and in constant flux, affected by both human and natural factors often originating far outside the ecosystem.

Given this revolution in attitudes, the classic aim of maintaining fisheries at very high levels of exploration, supporting large numbers of fishing boats from year to year, becomes all but impossible. Our very way of thinking is shifting. The assumption of a closed "symmetrical predator-prey relationship and bumper fish population become transient conditions at best, even in the absence of human intervention."[59] We have just begun to recognize that it is impractical to manage a fish stock as if it exists in isolation; it is folly to ignore the effects of fishing pressures on related stocks and the complex and cascading impacts of marine pollution. Precautionary action is essential.

How can the Magnuson-Stevens Act be altered so that it works toward the goal of precautionary action? This is admittedly pioneering work, for "to date there is no generally accepted definition of what elements should characterize a precautionary approach in the context of fisheries."[60] However, it is now clear that we should begin by identifying the stocks under the most grave pressure and by mandating reductions in total catch efforts. Because so little is known about marine stock fluctuations, a precautionary

approach requires more conservative governance than is currently the norm. A report by the UN Food and Agricultural Organization recognizes that errors may be rife in fishery management: there are (1) measurement errors in basic fishery data used for analysis such as for catch, efforts, and sizes landed; (2) errors in estimation of stocks; (c) process errors caused by imperfect understanding of the interactions between elements of the ecosystem; (d) modeling errors; (e) decision errors; and (f) errors in implementation.[61]

That errors are rife throughout fisheries management ought to have significance. It should mean that "for modest levels of catch relatively little information is needed to ensure that the risks to a stock are held below a given level, but the required amount of information escalates rapidly when the resource is pushed to its limits."[62] Injecting the precautionary principle into the Magnuson Act would mean mandating types of fishing gear and methods least disturbing to marine ecosystems and strictly regulating or banning destructive practices.[63] (See figure 8.)

Precautionary action also mandates strenuous efforts to prevent the inefficient loss of nontarget species, known as bycatch.[64] Large numbers of unwanted fish, birds, marine mammals, and other creatures are simply thrown over the side dead and dying. Such bycatch can induce stress that radiates throughout an ecosystem. Other animals too are destroyed outside the nets. This ecological disaster occurs in part because there are no economic incentives to prevent it: bycatch is regarded as a mere externality outside cost-benefit calculations. Precautionary action would follow from the recognition that high bycatch is actually costly because it is degrading to the long-term health of an ecosystem.

Excessive catch levels will have to be defined, and fishermen must have reason to avoid them. This can be accomplished by selective means. For instance, the few ultramodern vessels that can stay at sea for long periods and bring in a huge catch should be prohibited, as should the most destructive fishing methods, if stocks are to be restored. Trade magazines like *National Fisherman* now exhibit a heartening willingness to consider boat buybacks and retraining of crews. Only a few years ago, these measures were regarded as unacceptable.[65]

Moreover, productive marine habitat must be set aside as protected re-

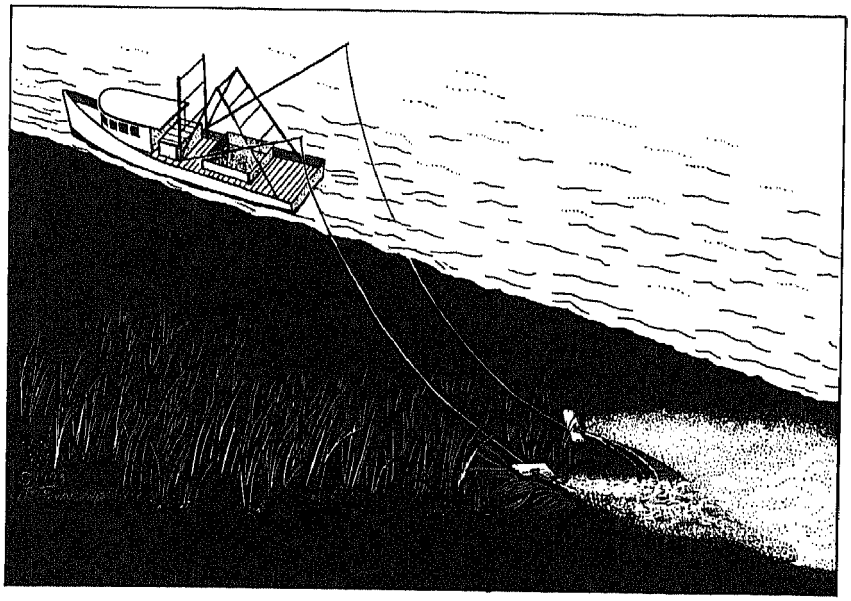

Figure 8. Trawling can obliterate bottom habitat necessary for many marine species, yet large areas may be trawled between two and ten times per year. *Artist: Jill Townsend*

serves. This is necessary to encourage the essential recruitment of new year classes and to maintain critical biological diversity. Carefully delineated and strictly enforced harvest refugia, where fishing would not be allowed, are an idea whose time has come. Yet so far amazingly few areas have been set aside. Off the California coast, with its 220,000 square miles of state and federal ocean, only 14 square miles, or just .006 percent, have been set aside as marine protected areas off-limits to fishing. By contrast, of 156,000 square land miles that make up terrestrial California, fully 6,109 square miles, or 6 percent of the total, is protected park land.[66]

Few of the existing marine sanctuaries or reserves are genuinely protected areas off-limits to fishing. Instead, because of political pressures from commercial and sport fishing interests, fishing is generally allowed even in national marine sanctuaries and state marine reserves in California. Indeed, even the idea of small test refugia has met with vitriolic opposition from commercial fishermen. When citizens of Monterey tried to create a tiny marine refuge less than a half mile in size off Cannery Row in the late 1990s,

the combined opposition from sport and commercial interests were enough to defeat the proposal. Even though this area was not even being fished, local fishermen were organized in their rejection of any harvest refugia, which translated into opposition by local officials. Fearing an expansion should the refugia idea prove to be popular, and already facing declining catches, they saw little reason to support the proposal.

Nonetheless, this concept of harvest refugia will likely gather increasing support. Potential sites for harvest refugia include an area off of Malibu that has lately been proposed as a new "no-take" sanctuary. More such proposals will follow. It will take many years of effort, and much consensus building with the assorted fishing interests, naturally wary of losing any fishing grounds, but it can and should be done.[67]

Sport fishing should receive more attention also. Once of relatively minor impact, recreational fishing now entails unprecedented new technology for finding fish. As with commercial fishing interests, the concordance of sport fishermen is necessary for long-term conservation. And environmental groups should not demonize sport or commercial fishing, which are both honorable, age-old pursuits. But because of new technology, fishing pressures are making it difficult to maintain a fishery such as squid off the California coast at optimum levels; serious restrictions or even short-term moratoria are needed to protect the long-term health of stocks.

At heart, management of fisheries means managing fishermen themselves, which is where the difficulty arises.[68] A fishing community on the brink of precipitous decline has substantial political leverage. Environmentalists should learn a lesson from the vicious spotted owl controversy: the support of loggers themselves is needed to truly conserve forests. Conservationists will have to find incentives to get fishermen to support their aims, as difficult as that may be.

The precautionary principle is moreover a useful means to increase funding for scientific studies because of the considerable importance it attaches to high levels of confidence in fisheries data. Under precautionary action, the total allowable catch of a given species must be lower when data are sparse; larger catches should be permitted only if there is better information and thus greater certainty about stock levels. Hence, there are eco-

nomic and political incentives for the government to improve the state of marine sciences. Such a marked turnaround in thinking toward ocean governance ought to open a door for better data collection. This includes new programs financed by the large-scale resource users, since sparse data becomes relevant to total allowable commercial catches set by government.[69]

The Outer Continental Shelf Lands Act

Just as the Magnuson Act misses the boat with respect to the precautionary principle, so too has the important Outer Continental Shelf Lands Act (OCSLA) failed to embody the thinking called for. Simply put, OCSLA is devoid of precautionary action. Yet it was given a significant task: to establish national goals for the exploration and production of oil and gas on the federal outer continental shelf extending 3–200 miles offshore.[70]

OCSLA in 1953 had little to recommend it from a standpoint of good governance. It initiated a closed-door process behind which industry and federal officials charted the course of offshore development. Critics of such development were to have almost no voice. After the oil shocks of the 1970s, Congress rushed to reform this statute. Amendments to OCSLA in 1978 attempted to correct the law's many defects.[71] But they only muddied the planning process. While the changes permitted somewhat greater involvement by the opponents of drilling (mainly coastal states), they were also designed to expedite new offshore oil exploration and development. The result is a contradictory mess dominated by resort to OCS moratoria. Greater consistency is needed to reconcile the two goals of rationalized energy policy and giving the coastal states an equal voice in the planning process.

One way to do this is to amend OCSLA again—but this time to embody clearly precautionary ideals. For instance, the statute should not enable new offshore oil drilling to "trump" all ecological concerns. Instead of giving priority to drilling, the law should make it clear that when a new leasing program is prepared, protecting coastal resources should be given as much weight as the recovery of hydrocarbons.[72] Precaution means that

federal officials should listen to objections from state governors opposed to offshore drilling.[73]

The present emphasis on expanding new oil production also ignores compelling arguments for reducing the demand for energy.[74] Eco-businesses and technologies to improve fuel efficiency are being pursued vigorously in Japan and the Nordic nations. Reflecting this, a Japanese poll revealed that the two highest expectations for science and technology in Japan were preservation of the environment (68 percent) and development of more efficient sources of energy (62 percent).[75]

The catalytic converter exemplifies traditional thinking toward energy use, pollution, and the power of the natural world to assimilate harm. Converters do filter out much pollution, but the benefits of this end-of-pipe device are more than offset by a broad array of government subsidies that have encouraged the aggregate reliance on internal combustion engines.[76] Rather than investing in cleaner technologies, our policy is sisyphean. It is similar to the "taller smokestacks" response to acute air pollution: simplistically "fixing" the problem by dispersing atmospheric contamination over a wider area.

Injecting precautionary action into OCSLA means that new offshore drilling should not be undertaken until significant efforts have been made to reduce energy demand.[77] In sum, OCSLA fails to reflect the precautionary approach in two basic ways. First, it does not give the coastal states an effective voice in governing ocean resources. Second, it fails to address what can be done by conservation and working toward fuel efficiency.[78] However, some domestic laws have begun to be fashioned in ways that incorporate the principle of precaution.

Antecedents to the Precautionary Principle

THE ENDANGERED SPECIES ACT

The Endangered Species Act of 1973 (ESA) broke with the permissive thinking of the past. The act seeks to save from extinction certain forms of life that are disappearing at a rate comparable to what fossil records show occurred only during catastrophic events in the earth's history. The act

helps to protect marine biodiversity by emphasizing caution and foresight. During the congressional debate on the bill, an advocate observed, "Sheer self-interest impels us to be cautious. It is institutionalization of that caution that lies at the heart of [this law]."[79] The act attacks the assumption that the environment is infinitely capable of absorbing harmful influences; it cannot, for human actions are destroying a diversity of flora and fauna. It asserts that the extinction of any species is alarming and rejects the idea that there is a surplus of life on our planet that can be depleted without harm to all living creatures.

The Endangered Species Act incorporates precaution by mandating substantive protections for animals and plants on the brink of extinction. The act's requirements are laid out in absolute terms. When a commerce or interior secretary determines that a species is in danger of becoming extinct, given the best scientific data, that species is "listed." Its critical habitat is defined and a recovery plan is devised. Unlike the National Environmental Policy Act (interpreted as only procedural), ESA provides substantive protections, although only for those unfortunate members of species clearly threatened with extinction.

The act prohibits actions that harass, harm, or kill a listed species in the United States and extends to persons subject to U.S. jurisdiction anywhere at sea. However, its precautionary elements are somewhat narrow. First, it aids only those species listed by federal officials. The current political climate is palpably hostile to the act, so species that appear undesirable to us (regardless of their ecological service) may find little support for listing. The Endangered Species Act continues to be a lightning rod for intense political opposition.[80] Section 7, which provides judicial review for federal actions that jeopardize the existence of a species, has been subject to innumerable attacks. Moreover, opponents have succeeded in curtailing the necessary discretion to list species; in an effort to hobble the act, extensive language was added so that this section grew from the original two sentences to ten pages of statutory text.[81]

In the first year of the unsympathetic Reagan administration, the listing process ground to a halt. Only two species were listed as endangered in 1981: a Texas orchid and a crustacean (Hay Springs amphipod) found only in the National Zoo.[82] Perennial political opposition and severe lack

of funding for the Interior Department has since crippled the act. Interior has been able to process only about fifty listing decisions a year, yet it has identified 3,600 U.S. species that it believes should be listed. The Nature Conservancy estimates that up to 9,000 species should be listed, just in the United States.[83] Nonetheless, plans to list some 2,000 new species were dropped because it would have been impossible to satisfy the new listing procedures established by Congress. If the act is to forestall what Harvard biologist E. O. Wilson calls a global crisis of extinction, the law falls badly short. Wilson estimates that some 1,000 species are lost per year as a result of human activities.[84]

The Endangered Species Act does contain precautionary thinking, since it seeks to slow currently disastrous rates of extinction. This law has halted some development plans that would otherwise have pushed threatened species over the edge, although it often seems that the act itself is most endangered. The fact that it is partly based on science has helped to overcome politically motivated pressures to permit activities that threaten the fragile balance of nature.

THE CLEAN WATER ACT

The Clean Water Act of 1972 shows how an idealistic and aspirational environmental law can founder on the rocky shoals of implementation.[85] The law set up breathtakingly ambitious goals. It sought to virtually eliminate water pollution in the United States, regardless of cost. It aimed to make U.S. waters fishable and swimmable wherever possible by 1983—and to greatly reduce all discharges of pollutants into U.S. waters by 1985. To achieve such ambitious goals, the Clean Water Act built on a rigorous standard: that the best available technology (BAT) economically achievable should be applied to reduce pollution at the source. Proponents of this standard hoped it would lead to preventing pollution throughout U.S. industry. Their belief was that to attain the act's stringent no-discharge goals it would be necessary to avoid pollution in the first place.[86]

To be sure, the act has led to many marked improvements in U.S. surface water quality.[87] But far more improvement was expected. The law was designed to provide uniform standards for industrial effluent categories based on BAT. Yet after only a few years of attempted implementation, it was clear to EPA administrators that as a new agency with limited resources,

the EPA could not meet statutory deadlines for issuing guidelines on categories of pollutants. Since that original failure, implementation has been blocked by extensive litigation, missed deadlines, court orders, and in the end, lowered expectations. As a result, tough BAT standards are repeatedly pushed back. The EPA is not able to promulgate effluent guidelines as fast as necessary and those that have been issued are far from comprehensive.[88] Nearly 80 percent of toxic industrial discharges are still not covered by a rigorous BAT standard. In *Natural Resources Defense Council v. Reilly* (1991), it was pointed out that of 74,525 discharges, 59,338 were not covered.[89]

There was notable progress at the beginning. As a result of a 1976 consent decree, the EPA sought to list criteria for ambient water quality and specifically identified numerous pollutants known to harm human health. These were designated toxic pollutants under the act's Section 307, and 126 of these key chemicals or classes were given priority status. Yet there has been little success since that time. Because of limited funds, the EPA has established necessary human health criteria for just 70 percent of these 126 priority pollutants. Criteria have been established for less than one-quarter of these priority pollutants to protect aquatic life—and most criteria that do exist are based on studies over thirteen years old. The EPA clearly faces an enormous task and is hampered by a severe lack of funding. About 1,100 nonpriority pollutants are thought to be entering the nation's surface waters; meanwhile, an underfunded EPA still has to establish the "required" standards for 126 pollutants listed as priority contaminants.[90]

Difficulties arise partly from the sheer number of chemicals, old and new, being used and produced by industry. Methodological problems also stem from inadequate risk management techniques.[91] Classic risk-benefit analysis often does a poor job of predicting environmental (nonhuman) risks.[92] Furthermore, in extrapolating from limited data there is often an exaggerated emphasis on cancer risk to humans. This can cause regulators to overlook non-negligible harms associated with sublethal stress. The EPA places a great emphasis on chemical carcinogens, but often for reasons related more to politics than to science, so that "current risk assessment practices do not adequately account for diseases other than cancers."[93] This is true despite the fact that new attention is being paid to emerging issues like endocrine disrupters.

The EPA has experienced similar pitfalls in meeting its mandate to

oversee the manufacture of potentially harmful chemicals under the Toxic Substances Control Act (TSCA). Unable to test every one of the tens of thousands of new chemicals marketed, the EPA relies on a "structure activity relationships analysis" that depends on test data derived from chemicals of similar molecular structure. Yet the General Accounting Office notes that this methodology is unreliable and often inaccurate regarding the characteristics of new chemicals. When the EPA did begin chemical review testing in 1979, some 62,000 (86 percent) of roughly 72,000 chemicals in the TSCA inventory were already in commerce; therefore they have not been given priority review as new chemicals. EPA has since reviewed only about 1,200 (or 2 percent) of existing chemicals. The outcome is clearly a permissive regime in which the EPA has been able to issue regulations for only a handful of chemicals under the TSCA.[94]

These issues illuminate many of the problems faced in implementing the Clean Water Act. An early BAT mandate was replaced by weaker standards like best conventional pollutant control technology (BCT), which focuses on end-of-pipe controls without advancing to a rigorous BAT requirement.[95] Enforcement efforts thus continue to favor "what industry is prepared to give, rather than what the environment needs."[96] Because of such a backward drift, this law is largely devoid of the demanding technology-forcing language that achieves real progress.[97]

Finally, with its focus on human health rather than a broader concern with the total environment, the EPA still fails to protect freshwater and marine ecosystems from harms caused by nonpoint sources of pollution (for example, runoff from farms laden with pesticides or the oily runoff from roads). EPA's excessively narrow focus looks only to a few specified pollutants, rather than the actual diffuse causes of ecosystem degradation.[98] To satisfy the precautionary principle, then, both the CWA and EPA should again apply demanding technology-forcing standards, establish a system for broad ecosystems protection, and provide incentives for clean industrial production strategies.

THE OIL POLLUTION ACT

The Oil Pollution Act of 1990 (OPA) entails precautionary action in several ways. First, it envisions an eventual switch from single-hull to double-hull oil tankers. In this alone, OPA departs from the status quo

ante.[99] Other precautionary elements include a broadened and more realistic regime that holds ship owners and operators liable in the event of an accident. These parties are now responsible for removing oil after a spill, as well as for damage to the environment. This goes a long way toward preventing contamination in the first place by instilling greater reason for caution. By internalizing what had been externalized costs to the earth from an oil spill, OPA has taken a genuinely precautionary step.

Many benefits are already easy to spot. Immediately following passage of OPA, "only" 55,000 gallons of oil and petroleum products were spilled by oil tankers in 1991—the lowest level in fourteen years.[100] An industry-sponsored study documented better procedures, improved safety provisions, and more inspection routines among tanker operators (raising the question of whether standards were adequate before). The law has also had global consequences: the International Maritime Organization has looked into a double-hull requirement for international routes. In general, the law, which has had positive global ramifications, represents a much-needed step in the right direction.[101]

THE MARINE PROTECTION, RESEARCH, AND SANCTUARIES ACT

Another first step toward precautionary ocean governance is the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA), sometimes known as the Ocean Dumping Act.[102] A string of amendments have been added that reflect the ongoing need for regulatory action. For instance, MPRSA was amended in 1974 to bring the United States into conformity with international law as promulgated by the London Dumping Convention of 1972 (LDC). Although neither MPRSA nor its progeny have stopped all types of ocean dumping, their intent is to bring private and public dumping under a regulatory regime.

And regulation is clearly needed. In 1968 about 48 million tons of waste was dumped off the coasts of the United States. Eleven years later, and remarkably over a period when MPRSA was in force, the figure had grown to more than 100 million tons.[103] As the figures suggest, the law is not intended to ban all dumping at sea. Indeed, the economic rationale for dumping is hard to resist: it moves pollutants from land to sea where disposal is virtually cost-free.[104] It is arguably the moral responsibility of the United

States, as the world's leading ocean dumper, to take a lead in minimizing this harmful practice. (Between 1977 and 1982, over 400 million tons of wastes were dumped annually by parties to the London Dumping Convention.)[105] MPRSA does limit the dumping of radioactive materials, biological and chemical warfare agents, persistent plastics, toxic organics, and metals, yet the problem of dumping has not been solved.[106]

Dumping still continues in the United States, but under a regulatory regime like that administered by the Army Corps of Engineers (COE), and EPA. The Corps oversees the dumping of dredge spoils removed from river and harbor bottoms to maintain channels for navigation. Because of the need to keep navigational arteries open and the zest of the COE in this endeavor, by the 1980s dumping had grown fortyfold compared to fifteen years earlier.[107] Yet scientists are now finding that dumping the dredge spoils, even in deep ocean waters, may have far-reaching impacts on marine ecosystems.[108] Dumping sediments such as alluvial sand, clay, silt, or sludge can smother entire benthic communities. In more egregious cases there may be toxic contamination of the dredge spoils, which causes significant chemical or biological change and sublethal stress.[109]

A study of a dump site 115 miles off the New Jersey coast is illustrative. Contaminants dumped far offshore were discovered to be entering the marine food chain, beginning with bottom-dwelling organisms. Elevated levels of sewage sludge were found in worms, sea urchins, and sea cucumbers at a depth of 8,000 feet. Even organisms tested some forty-five miles away were found to be contaminated—although at lower levels than those nearer the dump site.[110]

Such pollution of the vasty depths by human activities has generally been ignored since it was assumed to be without consequence. But during the late 1980s many of the deleterious effects of dumping were unavoidably brought ashore when medical waste and fish washed up along the New York and New Jersey shores, costing taxpayers billions of dollars in cleanup and lost tourist revenues. In response to mounting political pressures, the Ocean Dumping Ban Act of 1988 strengthened the Marine Protection, Research, and Sanctuaries Act by giving renewed rigor to dumping deadlines.[111] Later, in an international setting, the so-called Yablokov report startled the world in 1993 when it revealed that the Soviet Union had

clandestinely dumped 2.5 million curies of nuclear waste in violation of its obligations under the London Dumping Convention. The Clinton administration successfully pushed afterward for a worldwide ban on further dumping of radioactive wastes at sea.[112] Whether this latest obligation that exists on paper will actually be heeded remains to be seen.

Is the present U.S. regime on dumping as precautionary as it could be? To the extent that it has stemmed an earlier rush to dump at sea, it does satisfy a core element of precaution, but disturbing problems remain. The Corps of Engineers can issue a permit to dump once a proponent meets the (lenient) standard that their activity will not "unreasonably degrade" the marine environment.[113] The definition of *unreasonably* may be only weak protection when interpreted by an agency determined to view dumping permissively. The precautionary principle would instead shift the onus onto the produmping parties to show their actions would not adversely affect the environment.

A conflict of interest also hinders its implementation. Under the Marine Protection Act, the Army Corps of Engineers is responsible for issuing permits for dumping; meanwhile the Corps is also responsible for generating almost 90 percent of the dredged materials to be dumped at sea. This dual role of chief dumper and also regulator renders the decisions made by the Corps suspect—such as its finding that only 3 percent of the dredged material is highly contaminated. Last, the act is poorly enforced.[114] While some regulation of dumping is obviously preferable to what went on before, this regime can do more to prevent contamination of the seas.

If a key aim of ocean governance is to prevent further deterioration and maintain ecological integrity, then current regimes also reflect the sin of ignorance. In what should be a very significant finding, recent investigations by marine scientists have made it clearer than ever that land-based sources far outstrip dumping at sea as the chief source of marine pollution.[115] Yet environmental regimes still fail to recognize that most marine pollution comes from land-based sources. Listening to the sea largely requires action onshore.

It is now understood that roughly three-fourths of ocean pollution is caused by land-based human activities. This includes both point sources and nonpoint sources of pollution, as well as precipitation of contaminants

from the atmosphere.[116] Ocean contamination that occurs at sea totals about 12 percent of marine pollution; this mainly consists of accidental spills and intentional operational discharges in transport activities, while another 10 percent of marine pollution comes from ocean dumping. These percentages are given by weight, which can be deceiving; measuring by weight, for instance, will mask the disastrous effects of only a few grams of plutonium. Nonetheless, the numbers reveal that most ocean pollution comes from activities on land.[117]

Wiser governance of the marine environment therefore requires a more holistic approach: land-based pollution sources must be addressed if the vexing problem of ocean pollution is to be solved. Current ocean dumping policies, like other regimes that make up ocean governance, have ignored the multiplicity of pathways by which pollution actually enters the marine environment. Thus the precautionary principle forces us to look upstream to minimize at the source many land-based sources of contamination.

UNITED NATIONS CONVENTION ON THE LAW OF THE SEA

The 1982 United Nations Convention on the Law of the Sea (UNCLOS III) has played a major role in establishing new norms and principles in international law. But given the great need for precautionary action, the near absence of that principle from UNCLOS III is troubling.[118] The evolution from the first UNCLOS regime to the third is instructive. As noted in chapter 3, UNCLOS I, signed in 1958, consisted of four parts. Only one, entitled Fishing and Conservation of Living Resources of the High Seas, imposed a responsibility to conserve marine life.[119] The breadth of the territorial sea was then a key focus of attention.

The conservation obligations of that agreement were put forth in simplistic terms. Management was not informed by holistic ecological factors such as complex and cascading human impacts; instead, its chief aim was to maximize the available catch for coastal nations. Fish were not distinguished from marine mammals, nor from desired migratory species, which left a real potential for overexploitation. From a conservationist perspective, the problems were legion: distant-water fishing nations like Japan and Russia never joined; scientific recommendations for desirable catch levels could be modified by political and economic considerations—usu-

ally toward overfishing; enforcement of its conservationist aims was lacking and international inspections were rare; the procedures for dispute settlement were seldom activated; and nations typically viewed the already weak conservation goals of UNCLOS I as a moral code they preferred to meet but were prepared to violate if the need was felt.[120] In sum, the chief aim of UNCLOS I and II was not genuine resource conservation.

UNCLOS III (1982) is the latest attempt at ocean resources management. The existence of UNCLOS III is a milestone, for the convention sets out norms that could bind the international community, including the United States.[121] But does it display robust precautionary thinking? No, for it still functions much like its predecessors. It was negotiated as a package deal, so its most thorny conservatory questions—those that were unlikely to achieve consensus—were finessed by the use of vague and ambiguous language. Instead of expressly allocating specific levels of total allowable catch, or agreeing on robust conservationist definitions for maximum sustainable yield, the convention left these matters to the discretion of individual nations or to be resolved in later treaties.[122]

The treaty contains no mechanisms to coordinate its assorted jurisdictional regimes. However, such coordination is essential to protect marine ecosystems and habitat (although Articles 61 and 94 go partway toward this goal). Linkages such as between Parts 5 and 7 on fisheries, and Part 12 on pollution can acknowledge the interrelationships between marine pollution and the long-term vitality of fish stocks.[123] Its many provisions on protecting marine environments are themselves hortatory and nonbinding, more aspirational than operational. It lacks the definitive standards that would limit toxic discharges and stress pollution prevention or clean production strategies.[124]

Yet UNCLOS III contains some elements of precaution. For instance, by creating 200-mile exclusive economic zones, the regime permits individual nations to take rigorous new steps toward conservation. They can protect their own domestic waters from overfishing by rigorous national laws and regulations. On the other hand, the poor record of achievement is disheartening. UNCLOS III can do more to foster precautionary action. Most critically, it should be implemented to require that catch efforts be reduced in proportion to uncertainty about a stock's status. That uncer-

tainty is pervasive in the data used to guide fisheries management *ought* to be recognized in decision making.[125] Governments worldwide must begin to actually conserve stocks, regulate fishing gear and methods so as to minimize disturbances to essential habitat, and prevent bycatch.[126]

There is scope within UNCLOS III for precautionary implementation. And experience with the Magnuson-Stevens Act indicates that nations are just beginning to go down this path, as indicated by its 1996 amendments. But tensions will continue to flare and ecosystems will become yet more degraded before appropriately cooperative action is undertaken. Expect debates, for instance, between China and the Philippines over the oil near the Spratly "Islands" (no more than rocks, really);[127] Canada may clash again with Spain or the United States over valuable fisheries of the North Atlantic or North Pacific. The free-for-all aspect of the high seas exacerbates this problem. Nonetheless, as Sylvia Earle notes, "one thing is for sure: 'freedom of the seas' is no longer an acceptable doctrine."[128] Given a new political willpower, UNCLOS III is there as a vehicle for creating a conservationist stewardship of the seas.

THE STRADDLING STOCKS CONFERENCE AND OTHER MULTILATERAL AGREEMENTS

Many narrowly tailored international agreements have lately begun to supplement UNCLOS III as a global edifice of marine protection. These agreements not only exist in the context of UNCLOS III but also go beyond it.[129] Notable both for explicitly adopting precautionary action and for having U.S. support is the 1995 UN Agreement on Straddling and Highly Migratory Fish Stocks. By addressing straddling stocks, it is moving to manage stocks that can be found in both EEZs and ungoverned high seas. Already signed by more than forty nations, this treaty emphasizes (1) the precautionary principle, (2) conservation of marine biodiversity, and (3) sustainable use of fisheries. Its main elements include an ecosystems approach to governance that takes into account dependent or associated species, as well as robust enforcement of conservation measures through effective monitoring. This agreement on straddling stocks is designed to work closely with the FAO Code of Conduct for Responsible Fisheries, thus strengthening both.[130]

Among the significant events in creating multilateral protections for ma-

rine ecosystems was the 1946 International Convention for the Regulation of Whaling. That regime has evolved dramatically in the last few decades from resource extraction to conservation. A major treaty from the 1970s was the International Convention on the Prevention of Pollution from Ships. In 1987 there was a Montreal Protocol on Substances That Deplete the Ozone Layer. This is not an atmospheric issue only; depletion of the ozone layer poses large risks for the health of marine ecosystems as well.[131]

Another important milestone was Agenda 21, signed at a 1992 UN Conference on Environment and Development. Of special importance are chapters 13, chiding nations for their slowness to compensate for extraterritorial environmental damage, and 15, on the precautionary principle.[132] Also created in the 1990s was the UN General Assembly Drift-Net Resolution banning drift nets longer than 2.5 kilometers from the high seas, although this ban is reportedly being violated.[133] A United Nations Environment Program Conference was held in 1995 on protecting the marine environment from land-based activities. And talks that concluded in Kyoto, Japan, in 1997 have somewhat strengthened the Framework Convention on Climate Change. As with the impact of ozone depletion for marine environments, rising emissions of greenhouse gases can harm the integrity of marine ecosystems by fostering global changes that produce instability.[134]

THE INTERNATIONAL JOINT COMMISSION ON THE GREAT LAKES

The above sampling makes it clear that comprehensive, multilateral undertakings like the UNCLOS III extravaganza are not the only avenues to action. Recently Canada and the United States have made the Great Lakes, on their common border, a topic of bilateral discussion through the International Joint Commission on Great Lakes Water Quality (IJC). Interestingly enough, the IJC explicitly adopts the precautionary principle.[135] A 1994 report states, "Persistent toxic substances are too dangerous to the biosphere and to humans to permit their release in any quantity," and "All persistent toxic substances are dangerous to the environment, deleterious to the human condition, and can no longer be tolerated in the ecosystem, whether or not unassailable scientific proof of acute or chronic damage is universally accepted."[136]

This is a bold response to the Great Lakes' dire situation.[137] It is also a

major departure from traditional permissive policies toward the Great Lakes that permitted releasing a variety of pollutants.[138] As in the UN Straddling Stocks agreement, in this case the United States is now an advocate for precautionary action. While the IJC statement of principles has been criticized as lacking force, it should be recognized as a genuine vote of confidence and an endorsement of cooperative stewardship for the marine environment.

THE POLLUTION PREVENTION ACT

A major first step toward precaution and prevention in domestic environmental law is the Pollution Prevention Act of 1990 (PPA).[139] What is unusual is that the act was created in conference committee when enabling language was inserted in the Omnibus Budget Reconciliation Act of 1990. Thus the PPA did not appear in House or Senate budget bills.[140] The forward-looking PPA explicitly establishes a four-level ranking for preventing pollution. Source reduction (or pollution prevention) is clearly listed in the act as the most desirable option. Failing that, the PPA lists waste recycling as next best option. Waste treatment follows when recycling is unworkable. Finally, waste disposal is seen as a last resort.[141] And thus the environmentally popular option of recycling is also recognized as inferior to either eliminating or reducing waste at the source. The act intentionally leaves the initiative for pollution prevention with the states to take advantage of local knowledge. Indeed, "States have been at the forefront of the pollution prevention movement . . . [with] programs occasionally serving as a model for federal programs."[142]

Making prevention the number one priority is a novel idea. It is also common sense; it can be more economical than command-and-control methods that for decades mandated end-of-pipe thinking. Thus engineers and scientists are increasingly being asked to find clever means to avoid waste in the first place. An earlier attempt at source reduction was the Resource Conservation and Recovery Act of 1976, amended by the Hazardous and Solid Waste Amendments of 1984. However, it has been more narrowly interpreted than PPA and has generally had little success.[143] But times change. As reported in *Science*, a chemist at the Environmental Protection Agency was "tired of being an environmental cop." Rather than track the "hundreds of known toxic and carcinogenic substances released into

the environment each year as they move from air to water to land and back again, he would rather replace his police uniform with a lab coat, and promote research into ways chemists can redesign existing compounds to render them harmless to humans and the environment."[144]

Engineering environmentally safer substitutes for current methods and products is clearly possible but too rarely tried. A new mind set can facilitate innovative thinking and enable the redesign of substances like dyes, paints, solvents, pesticides, weed killers, and other chemicals. In just this fashion, a safer way was found to manufacture quinoic acid, used in photographic agents and other chemicals; bacteria are incorporated in making the acid so that it releases sugars in place of benzene.[145] In another industrial setting, the commercially important polymer polytrimethylene terephthalate (3GT) is now being made without heavy metals, petroleum, or toxics. Instead it is produced using glucose from cornstarch, which is cheaper to boot. And all the liquid effluent in its production is now biodegradable. Further, this 3GT polymer can easily undergo methanolysis to reduce polyesters to original monomers, for indefinite recycling.

A strikingly different and yet ultimately similar strategy is seen in the Toxic Diet Project promoted by Save the Bay of Rhode Island.[146] Here the emerging aims of pollution prevention are being achieved by a combination of waste-water monitoring, together with education to encourage individuals to buy less toxic products for home use. It shows that a more sensible alternative to water contamination, and thus to costly sewage treatment, is to voluntarily reduce toxins at their source. Ideas like the Toxic Diet are an exciting, low-cost, and rational means to prevent pollution among the broad public.

Yet few federal dollars earmarked for the environment are being spent on prevention. In 1990, roughly $115 billion went toward all pollution control efforts in the United States, an immense figure that will rise to $170 billion by the year 2000. Yet, according to a GAO report, the EPA spends "less than 1 percent of the agency's annual budget for source reduction activities."[147] While hundreds of billions of dollars have initiated much eco-business for environmental cleanup or treatment, these dollars typically are directed to remediating damage after it has occurred.

Prevention has not been embraced more strongly in part because of problems in implementing the Pollution Prevention Act. According to a report

from the General Accounting Office that evaluated PPA programs nationwide, the primary goals of the act are not being met. While some state antipollution programs created by the PPA are properly focused on source reduction, many of them wrongly emphasize recycling, waste treatment, and even waste disposal. A curious result is that some state programs are awarded federal funds for pollution control but have neglected to ascertain if prevention is possible—an outcome inconsistent with the goals of the act.[148]

Another potential issue is that some 80 percent of the state PPA programs are nonregulatory, volunteer efforts. While this voluntary (nonmandatory) feature might be the smartest approach to prevention, without strong financial support the goals of PPA could be too easily overlooked. An information base for industry was created to disseminate knowledge on ways to prevent pollution at its source. The results included a Pollution Prevention Office and a Source Reduction Clearinghouse, and the GAO report notes that these should be expanded. Prevention must be strengthened by new outreach efforts if pollution prevention, reduction at the source, is to develop any momentum. And some way of assessing current PPA efforts will be necessary to ascertain which state prevention programs are working and which are not, and exactly why.[149] The EPA notes in its defense that stronger goals are not part of its mandate under PPA, which requires only that states "promote" reduction at the source.[150]

Realistically, preventing pollution is a daunting task. While the dollars are there for after-the-fact cleanup, no infrastructure or constituency truly supports pollution prevention. Moreover, for political reasons, PPA targets for voluntary action are deliberately vague to avoid entanglements with manufacturers who resist any limitation on their business decisions. Nonetheless, fiscal incentives and market tools to eliminate or reduce harms at the source ought to be considered. These include "green" subsidies and taxes. For instance, a levy on manufacturers that use virgin materials in making paper, plastics, glass, aluminum, and metal products can promote greater efficiency and recycling.[151] Carefully tailored "green" taxes can be incentives for prevention and reduce currently externalized environmental burdens. Revenues generated from "green" taxes should then be earmarked for new PPA action, creating a self-sustaining process.

Other attempts at source reduction should encourage industry to voluntarily reduce the use of problematic chemicals. The EPA's 33/50 program is one example. The program, begun during the Bush administration, sought to reduce releases of seventeen specified chemicals by 33 percent in 1992 and 50 percent in 1995. Generally speaking, the program has been a success as far as it attempted to go. But several issues still need to be solved. For example, because it relies on data from the toxics release inventory as the sole means to measure reductions, it is difficult to ascertain the true success rate because the inventory does not indicate specifically how reductions were made. While it shows changes in the total weight of chemicals released or transferred, it does not give good data on whether these were a result of closing a facility, of paperwork changes like new methods for calculating estimates, of transfers offsite such as for incineration or recycling, or of true source reduction.[152] Toxic release inventory data show that even though the reported release of certain chemicals into the environment has been dropping, the total amount of waste generated by industry continues to rise.[153] Nonetheless, the 33/50 program is a worthy first step.

During the 1990s the EPA began other new programs for incorporating pollution prevention into business, industrial, and consumer decision making. These include the Green Lights Project, which promotes the idea that more efficient practices can cut the use of electricity for lighting by 50–75 percent.[154] Other pollution prevention projects include the Energy Star Computers, which draw on less power when inactive, since 25–40 percent of computers are left on overnight, and the Water Alliances for Voluntary Efficiency, in which participants seek to reduce their water usage by some 2.25 billion gallons per year. This is a purposeful effort to move away from sector-specific, command-and-control regulations that had characterized earlier EPA actions.[155]

Looking Ahead: Industrial Ecology and Design for the Environment

The preceding discussion shows that the design phase is crucial to reducing waste and pollution in manufacturing. According to the National Research Council, roughly 70 percent of the costs associated with a prod-

uct's development, manufacture, and use are determined at the outset—during the product's initial design stage.[156] More relevant here is that design decisions deeply influence a product's ecological impacts—from cradle to grave. At the design stage there is greatest flexibility to determine what materials to use, to choose benign manufacturing techniques, to consider ecological risks, and to determine the characteristics of waste streams.[157] The design phase is the best moment to apply new concepts of industrial ecology and design for the environment.[158]

In 1989 Robert Frosh and Nicholas Gallopoulos introduced the idea of industrial ecology to the public.[159] The aims of industrial ecology are to advance a more cyclical approach toward manufacturing design in which natural resources are used and reused as efficiently as possible. "This contrasts with the traditional linear model of manufacturing, in which materials are extracted, used in production, and then discarded."[160] Industrial ecology strives to emulate the cyclical processes found in ecosystems, since natural systems abhor waste. In nature one organism's waste is another's sustenance. In fact, many technological advances have been made by imitating patterns found in nature; dragonflies once served as a model for improving helicopter designs.[161]

The objective is to "network" industrial plants so that they work more like biological systems. A network of interrelationships could take the unwanted effluents from one plant, or "organism" (such as heat, waste water, surplus gas, steam, organic debris), and use them as input for other processes. By design, the by-products of metabolism (manufacturing) can be coordinated so that effluents support a much larger system. Although the biological metaphor is not perfect, the current state of industrial production could be compared to a stage of primitive life on earth when there was very little recycling of material and toxic wastes accumulated to the point where they presented problems for survival.[162] Microorganisms evolved over time to become consumers of other organisms' wastes. Once evolved from a primitive anaerobic to an aerobic metabolism, thus able to exploit what had been poisonous oxygen, the web of living systems grew more integrated and stronger because of its biological diversity.

A manifestation of the efficient ecosystems approach is design for the environment (DfE), an adaptation of the "Design for X" idea (DfX) in man-

ufacturing. "In DfX, a desired product characteristic (such as safety or durability) is integrated as a goal into the design process. In DfE initiatives, environmental considerations become an integral part of the design of a product."[163] Like nature, DfE has many faces. In Germany, for instance, legislative initiatives have led to new product designs that incorporate ease of disassembly, recyclability, and pollution prevention into original specifications. More broadly, German law is beginning to require companies to check their production processes to identify by-products (waste) that may be used by other industries.[164] Such technology forcing is bound to improve ecological efficiency. Thus an enzymatic process was found to reduce wastes from one industrial process by about 90 percent while also making the remaining waste nontoxic.

On a larger scale, the DfE idea may be applied to the eco-industrial park. Here zoning is applied not only to set aside space for manufacturing but also to prevent pollution by initiating more sophisticated and interconnected business relationships. Industrial systems are viewed through a prism of biological systems using (where feasible) ecological ideas like materials flows, carrying capacity, resilience, and connectivity. Outputs from one plant are raw inputs for other plants in a process that both increases profits and minimizes wastes.[165]

There are many potential avenues for achieving environmental efficiency, materials recycling, and gaining ecological wisdom—all in a spirit of DfE. Possibilities include integrated pest management and aggressively designing houses and whole communities for greater energy conservation. In the fertile Salinas Valley of California, a smart new company has developed one such business that reflects DfE thinking.[166] A large agribusiness there had been processing several tons of lettuce daily for packaging, discarding unwanted vegetable pieces as waste. In an entrepreneurial fashion, this company now takes the excess and converts it into compost, which is then sold to farmers. This composting business supplants potentially harmful chemical fertilizers and reuses organic materials that otherwise would be wasted (by being thrown away in landfills). Any action that productively returns a product to the soil is the greatest recycling act of all.

Another example of the application of industrial symbiosis is a Danish biotech company named Novo Nordisk and the interrelationships among

industrial plants in the small city of Kalundborg, Denmark. It cost an estimated $60 million to build this complex system, which has returned some $10–12 million per year, for a $120 million payback so far. The web of interrelationships works like this: a local oil refinery sells its waste—cooling water, waste water, and surplus gas and steam—to a local power plant. The power plant sells its waste, including heat, to some 5,000 homes; it sells gypsum to a plaster board factory; and it sells heated water to a fish farm. Waste in the form of steam is sold to the Novo Nordisk biotech company. At the same time, Novo Nordisk sells to farmers a nitrogen-rich biomass from its enzyme fermentation vats. Surplus yeast from Novo Nordisk's insulin production goes to farmers as fodder to feed animals.[167] This cooperation not only is commercially sound but also makes common sense.

Conclusion

In sum, present U.S. laws are just beginning to exhibit precautionary action. However, the government has started to play a needed catalytic role, as seen in the Design for the Environment program at the U.S. Environmental Protection Agency.[168] This voluntary DfE program offers selected industries information on ways to prevent pollution while also increasing profits by designing products and/or processes with an awareness of ecological consequences. That thinking is establishing cooperative government-industry partnerships for both precautionary action and pollution prevention. These are sophisticated, multifaceted approaches to solving the problem by going to the source of pollution.[169]