and would not have initiated such open discussions," Schell remarks.

The SRI group, in its attempts to behave responsibly, had hoped to keep the news of the computer network vulnerability confined to manufacturers and users who had a legitimate need to know. But a reporter for a computer trade newsletter, *InfoWorld*, found out about the method and 2 months ago told the SRI group that he planned to publish a report on the discovery. Parker and Wood dissuaded him from publishing specific details, but now it may be too late to stop the method from being widely known.

The *InfoWorld* story appeared on 11 January. Already, computer hacks, communicating on electronic bulletin boards—widely available computerized message centers—are speculating on what the method may be and are passing on to each other weaknesses in various computer systems. Once it is known that a simple method exists that allows one user to masquerade as another in a time-sharing system, it is only a matter of time until someone finds the method.

So here is a situation in which everyone involved made every attempt to find the right thing to do, and in which the end result will most likely be the one that everyone was trying to avoid. "I just want you to ask your readers," Wood said to *Science*, "what should we have done?"—GINA KOLATA

U.S. Considers Ocean Dumping of Radwastes

EPA is revising its regulations on ocean dumping; critics charge this may pave the way for dumping low-level waste

After a pause of almost two decades, the United States could soon resume dumping radioactive materials into the oceans. The Navy has already expressed an interest in getting rid of the radioactive reactors of old nuclear submarines by scuttling the vessels in deep water, and the Department of Energy (DOE) is looking to the seas as a potential repository for thousands of tons of slightly contaminated soil from the cleanup of disused atomic weapons facilities. And the nuclear industry, which is facing mounting political difficulties in dumping low-level wastes onshore, is watching these government plans with interest, for they could ease the way for a resumption of marine disposal of waste material from commercial operations.

These possibilities have begun to stir up opposition from environmentalist groups, and an intense debate over the potential hazards of dumping radwaste into the oceans is expected to develop in the next few months. At the center of the turmoil will be the Environmental Protection Agency (EPA), which is responsible for regulating ocean dumping. EPA is now in the throes of drafting new regulations governing all ocean dumping activities, including marine disposal of radwastes, and it is expected to publish its proposals in the next few weeks.

Although there are currently plans to dump only limited amounts and types of radwaste from government programs, opponents are concerned that if these plans are allowed to go ahead, they may be a prelude to more extensive dumping. In particular, they are worried that any resumption of dumping low-level wastes may eventually lead to the disposal of high-level wastes in or under the sea floor. Moreover, the critics point out, European countries, especially Britain, are already dumping thousands of barrels of low-level wastes each year in the Atlantic, and Japan has plans to begin dumping in the Pacific next year. Instead of adding its radioactive garbage to this growing pile, opponents argue, the United States should be urging restraint on its allies.

In response to these criticisms, advocates of ocean dumping contend that there is no evidence that the radwastes already disposed of in the oceans have resulted in environmental or health hazards. A controversial report, published last year by the General Accounting Office (GAO), supports this contention. It concluded that "Congressional and public concern about this issue has been over-emphasized," and recommended that EPA should get on with drafting regulations governing future ocean dumping.

The United States virtually abandoned dumping low-level wastes in the oceans in the early 1960's, although a few barrels a year were dumped until 1970. It is generally assumed that public concern over safety was responsible for bringing the practice to an end, but economics played an equally important role. Burial sites on land opened up in the early 1960's, and they offered a much cheaper alternative to marine disposal. Recently, however, the cost of onshore burial has increased sharply, and public opposition has surfaced in the two states (South Carolina and Washington) that have commercial burial sites in operation. This explains the renewed interest in dumping low-level wastes into the ocean and the attention being given to EPA's attempts to write new marine disposal regulations. The new rules will determine the conditions, if any, under which ocean dumping can be resumed.

EPA inherited responsibility for marine disposal of radwastes from the Atomic Energy Commission (AEC) in 1970. At that time, a de facto moratorium on dumping radioactive material was in effect. AEC stopped issuing dumping permits in 1960, but it allowed existing permits to be renewed, and the practice gradually petered out when renewal applications stopped coming in.

In 1972, 2 years after the last consignment of radwaste was shipped, Congress passed the Marine Protection, Research, and Sanctuaries Act (generally known as the ocean dumping act) which directed EPA to write new regulations governing all ocean dumping. The act prohibited marine disposal of high-level radioactive wastes but gave EPA authority to set rules for dumping low-level material.

EPA's regulations, which were published in 1977 and are still in force, make it difficult to dump anything into the oceans. In essence, they allow dumping permits to be issued only when no alternative means of disposal exists; they thus virtually preclude weighing the costs and benefits of ocean dumping against those of dumping on land. As for radioactive wastes, the regulations specify that, in addition to satisfying the requirement that no other means of disposal is available, they must be packaged

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in containers that will remain intact at least until the radioactivity has decayed to innocuous levels. These stringent requirements all but rule out the disposal of radwastes in the oceans.

But these rules may soon be relaxed, for EPA is rewriting the regulations. According to an early draft of the proposed revisions, the new rules will "incorporate and present a major shift in EPA ocean dumping policy toward making ocean dumping a viable option for waste disposal." In short, ocean dumping would not necessarily be ruled out even if disposal on land were an available alternative. This would remove one regulatory barrier to a resumption of marine disposal of radwastes and many other types of material.

The revisions, according to one EPA official who asked to remain anonymous, are based on the principle that ocean dumping, like other actions that affect the environment, should be governed by cost-benefit analysis—an approach that the Reagan Administration has been trying to incorporate into environmental policy-making. This approach can now be applied to ocean dumping, the official argued, because there is sufficient scientific understanding of the impact of many pollutants on the marine environment to assess the hazards of ocean dumping. Since the ocean dumping act was passed, he said, "we now know more about what the oceans can assimilate."

The revisions were also prompted by the desire to bring U.S. policy into line with international law, in this case the so-called London Dumping Convention (LDC), which sets standards for the disposal of a variety of waste materials, including radwastes. And finally, shortly after EPA began working on the new rules, the old regulations were successfully challenged in court by New York City, which was facing a ban on dumping its sewage sludge. EPA decided not to appeal the court ruling in view of its own change of policy.

EPA's new rules will cover a wide range of waste material. But the provisions governing radwastes are likely to arouse the most controversy, even though they would still place severe restrictions on dumping most types of radioactive garbage into the oceans. One reason for the controversy is that the dumping that took place during the postwar years was, in retrospect, so sloppy that it has left a lasting residue of public disquiet. Opponents of resuming dumping also argue that there is insufficient knowledge of the behavior of radionuclides in the marine environment to permit any more radwastes to be dumped. "Even thinking of resuming dumping is negligent," says Wendy Schnelker of Bridge the Gap, a Los Angeles–based environmental group.

Some 90,000 drums of radwaste were dumped between 1946 and 1970 by U.S. vessels. Most of it was disposed of at two sites, one near the Farallon Islands 30 to 50 miles off San Francisco, and the other about 130 miles off Sandy Hook, New Jersey. The wastes, which were mostly packaged in concrete-lined 55-gallon drums, consisted of such items as contaminated laboratory glassware, tools, chemicals, and animal carcasses. They came mostly from weapons laboratories operated by the AEC, but some also originated in commercial and medical facilities.

The exact composition of the wastes and the location of some of the dump sites are, however, unknown, for the AEC did not require detailed records to be kept. Moreover, until recently, virtually no monitoring was conducted even at the primary dump sites. Thus there is scant knowledge of what has happened to the radionuclides in the marine environment.

Surveys conducted by EPA and the National Oceanic and Atmospheric Administration in the past few years have turned up some interesting findings, however. First, the drums were difficult to find. A look at the Farallon Islands site with a submersible turned up fewer than 200 of the 47,000 barrels that were supposed to have been dumped there, for example. It also appeared that about one-fourth of the drums had imploded and several of them had leaked their contents.

> "The ocean just isn't a good place to put radwaste; if you put it there, you can't get it back. . . ."

Exactly what happened to the radionuclides is uncertain, however, for the amounts involved are generally so small that they are difficult to separate from background radiation and from isotopes generated by nuclear weapons testing. But sediment samples retrieved from close to some drums did indicate higher than expected levels of some long-lived isotopes such as those of plutonium, cesium, and americium. This indicates that these isotopes are held in the silt rather than dispersed in the ocean waters, a fact that critics claim could lead to a buildup of radioactivity in the marine environment immediately surrounding dump sites. So far, however, there is little evidence, even if this occurs, that the radioisotopes will enter the marine food chain. But, as a recent report by the Rand Corporation points out, "the most significant transport pathways for radionuclides are not fully known. Also, the small amounts of radionuclides that may escape make it difficult to detect transport and to assess its effect on the marine environment."

Most observers agree, however, that the hazards from past U.S. dumping activities are small, because the total radioactivity in the wastes was relatively low. In the 25 years during which dumping took place, less than 100,000 curies of radioactivity was disposed of, according to EPA estimates. In contrast, European countries are dumping about 100,000 curies each year at a site in the northeast Atlantic about 550 miles off the tip of Land's End, England, and Japan is planning to dump similar quantities in the Pacific at a point roughly midway between Japan and the Mariana Islands. Even these amounts, moreover, fall well short of the total radioactivity entering the oceans from natural sources and from power plants and other facilities. The Windscale reprocessing plant in Britain alone releases more than 100,000 curies per year into the sea.

Nevertheless, the lack of demonstrated impact from past dumping should not be used as the basis for allowing the practice to be resumed, critics charge. "The ocean just isn't a good place to put radwaste; if you put it there, you can't get it back later if you find there is a problem," says W. Jackson Davis, a biologist from the University of California at Santa Cruz who has been among the most outspoken opponents of ocean dumping.

EPA is not about to open the door wide to a resumption of marine disposal of radioactive material, however. A draft of its revised regulations, which is still subject to change, states, for example, that permits for dumping most radwastes "will be issued only under the most pressing of circumstances and . . . the applicant would be required to make a most compelling demonstration of need before an application would be considered complete." A thorough analysis of the anticipated impact on the marine environment would also be required.

The chief thrust of the proposed regulations is to incorporate the LDC ocean dumping rules into U.S. law. One impor-

tant result would be to change the way that low-level wastes are defined for the purposes of ocean dumping. At present, radioactive wastes are classified in the United States according to how they are generated (high-level wastes are derived from spent fuel, transuranic wastes contain high levels of transuranic elements, and low-level wastes are everything else). The LDC regulations classify radwastes according to their curie content, the type of radiation emitted, and the half-lives of the radionuclides they contain. This classification correlates more closely with expected radiation hazards.*

The LDC rules also specify in general which types of radwastes can be dumped without first being packaged in concrete-lined steel drums. It so happens that the two types of waste that the Navy and DOE are hoping to dispose of—the reactors of old nuclear submarines and contaminated soils—may fall into this category.

The Navy announced in the *Federal Register* on 14 January that it will soon prepare an environmental impact statement on the disposal of decommissioned nuclear submarines. Even after the fuel elements have been removed from the vessels, their reactors remain intensely radioactive because radionuclides are formed in steel components exposed to neutron bombardment. There are two options for disposing of the reactors: either they can be cut out of the submarines, shipped to a disposal site, and buried, or the entire submarine can be towed to deep water and scuttled. The Navy is thought to favor the latter option because it is far cheaper (*Science*, 26 September 1980, p. 1495).

The *Federal Register* notice states that the Navy will eventually need to dispose of three or four nuclear submarines per year over the next 30 years. Since each will contain up to 50,000 curies of radioactivity, scuttling them would result in the dumping of more radioactivity in the oceans each year than the United States dumped between 1946 and 1970.

Even if the Navy does decide to scuttle the vessels, it would have to obtain a permit from EPA, and considerable monitoring of potential sites would be required before approval could be given. During that time, opposition is sure to grow. Already, Barry Keene, a California state senator, has introduced a resolution into the state legislature opposing any resumption of ocean dumping of radwaste.

EPA's planned change of its marine dumping regulations will, however, have an important bearing on the plan. The LDC rules state that radionuclides that are part of a solid matrix need not be packaged and shielded before dumping. That is the case with irradiated reactor steels.

The other type of radioactive waste that is now under consideration for marine disposal may also fall under the packaging exemptions in the LDC rules. DOE now has some 30,000 tons of soil, contaminated with trace amounts of naturally occurring radionuclides, stored at a federal site near Middlesex, New Jersey. The radioactivity comes from uranium ore that was crushed in a plant near Middlesex in 1942 and used to fuel Enrico Fermi's nuclear pile in Chicago. Waste material from the operation was used as landfill and ended up in people's backyards, where it emitted radiation well above normal background levels. During the past few years, DOE has scraped up the contaminated soils as part of a major effort to clean up the residues of old weapons-making activities. It is now faced with the problem of what to do with the stuff.

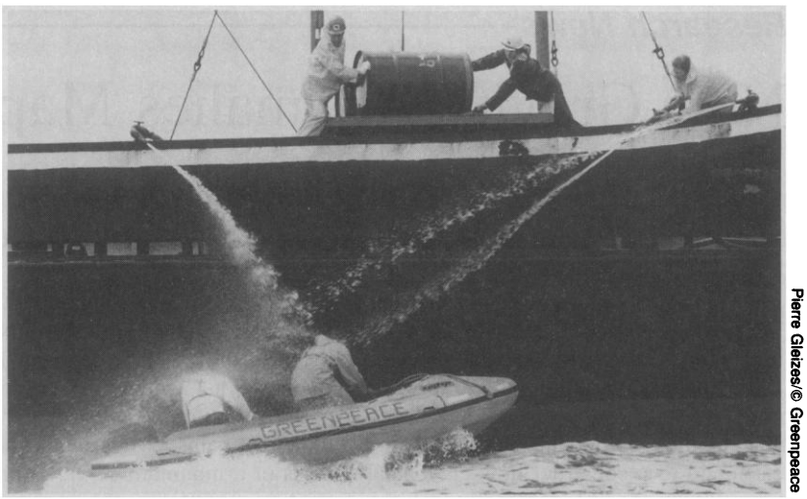
According to Bob Ramsey, who is in charge of the cleanup operations at DOE, dumping the material into the ocean may be the best and cheapest way of getting rid of it. "I just don't see why the federal government should have to permanently monitor a pile of dirt," he says.

It would not be possible to dump the soil at sea under EPA's current regulations, but the proposed revisions may open up that option. The LDC rules permit wastes contaminated with trace amounts of naturally occurring radionuclides to be dumped under a general permit without first being packaged. EPA officials say they are aware of DOE's plans, but stress that they have not yet analyzed the material to determine whether it would come under the LDC definition of trace contamination.

The nuclear industry has not yet expressed a formal interest in resuming ocean dumping, but EPA officials say they have recently had several inquiries in response to press reports about the new ocean dumping rules. "In view of the closure of [land burial] sites and the increasing costs of burial [onshore], this is raising a good deal of interest," says one official. The GAO also noted in a report last year that the costs of land burial and ocean dumping "are approaching parity—particularly for high-volume, low-activity wastes being disposed of in shallow land burial repositories—and there is increasing interest in the ocean disposal option by both the government and some commercial organizations."

EPA's new ocean dumping regulations are therefore sure to attract a good deal of interest and controversy. Any resumption of dumping low-level wastes is sure to engender a major battle, however. "The oceans may seem to be politically attractive receptacles for our wastes because there are no voters in the ocean, but the Reagan Administration is mistaken if it believes it can resume ocean dumping without a fight," warns Schnelker of Bridge the Gap.

—COLIN NORMAN



Pierre Gleizes/© Greenpeace

Nuclear confrontation

Greenpeace last year tried to block the dumping of radwaste from a British ship. The attempt was repelled, but it drew attention to Britain's dumping policy.

*The LDC rules specify the following limits on ocean dumping of radwastes: (i) One curie per metric ton for alpha emitters but limited to 0.1 curie per ton for radium-226 and polonium-210. (ii) One hundred curies per metric ton for beta/gamma emitters with half-lives of at least 0.5 year (excluding tritium) and mixtures of beta/gamma emitters of unknown half-lives. (iii) One million curies per metric ton for tritium and beta/gamma emitters with half-lives less than 0.5 year. The activity concentrations shall be averaged over a gross mass not exceeding 1000 metric tons, and no more than 100,000 metric tons per year can be dumped at a single site.