INTRODUCTION

In March 1990 *the* Office of Technology Assessment (OTA) published *Coping With an Oiled Sea: An Analysis of Oil Spill Response Technologies. The* study was prompted in part by the alarm and concern that followed the Nation's largest oil spill to date, the n-million-gallon spill in Prince William Sound, Alaska, caused by the grounding of the *Exxon Valdez.* OTA concluded that if the damage *from* such pollution incidents is to be minimized in the future, major improvements are required in the organization and the technologies employed to fight oil spills. OTA evaluated the state-of-the-art and the potential for improvement of the most widespread technologies-mechanical containment and cleanup methods-and assessed what appeared to be the most promising alternatives to mechanical methods-in particular, the use of chemical dispersants and in situ burning.

One "new" technology about which OTA had little to say in its initial study was bioremediation—the use of microorganisms to accelerate the degradation of oil or other environmental contaminants (box A). Degradation of oil by microorganisms is one of the most important long-term *natural processes* for removal of oil from the marine environment.[1] Given enough time-at least several years, for example, for oil stranded on beaches-some microorganisms are capable of at least partially cleaning environments polluted with oil. Because bioremediation is a potentially significant method for mitigating the damage caused by marine oil spills,[2] techniques to accelerate and improve the efficiency of this natural process have had a number of proponents over the past two decades. Although considerable research has been conducted in the last 10 years on the development of bioremediation techniques, imporant questions remain about their effectiveness, possible unintended side effects of their use, and their importance in comparison with more conventional oil spill response technologies. Research concerning these issues has been given new momentum, in large part because the *Exxon Valdez* accident stimulated a general search for more effective methods to fight oil spills. Consequently, the data that those directly responsible for fighting oil spills--e. g., on-scene coordinators-will need before they are willing or able to include biological techniques in their arsenal of countermeasures are beginning to be developed.

This study examines the potential of bioremediation technologies to clean up marine oil spills and to minimize the damage they cause. Thus, the study evaluates a small, but highly visible, subset of the many possible applications of bioremediation technologies to environmental problems. Among the other applications for which bioremediation is being considered or is currently in use are: 1) treatment of nontoxic liquid and solid wastes, 2) treatment of toxic or hazardous wastes, 3) treatment of contaminated groundwater, and 4) grease decomposition.[3] Although recent marine oil spills and bioremediation efforts have called attention to the potential of bioremediation as an oil spill response technology, some of these other applications, in particular the treatment of hazardous waste, appear to have greater potential. Officials at approximately 135 hazardous waste sites, for example, are now either considering, planning, or **operating** full-scale bioremediation systems.[4]

Consideration of the applicability of bioremediation to oil spills is not new. Investigation of microbial degradation of oil dates to at least 1942, when the American Petroleum Institute began to subsidize research on the topic.[5] Considerable basic knowledge about factors that affect *natural* biodegradation, about the kinds of hydrocarbons capable of being degraded, and about the species and distribu-

[1] National Research Council, *Oil in the Sea: Inputs, Fates, and Effects* (Washington DC: National Academy Press, 1985), P. 290.

[2] The term "marine oil spills" is here defined to include spills at sea, in bays and estuaries, on beaches, and in environments such as salt marshes in contact with the sea.

[3] Several OTA studies have addressed various aspects of these topics. See, for example, *Commercial Biotechnology: An International* Analysis, OTA-BA-218 (Washington DC: U.S. Government Printing Office, 1984); *New Developments in Biotechnology, OTA-BA-360 (Washington* DC: U.S. Government Printing Office, July 1988); *Coming Clean: Superfund Problems Can Be Solved,* OTA-ITE-433 (Washington DC: U.S. Government Printing Office, October 1989); *and Biotechnology in a Global Economy* (Washington, DC: U.S. Government Printing Office, expected publication date mid-1991).

[4] U.S. Environmental Protection Agency, bioremediation Action Committee, Summary of Nov. 7, 1990 meeting.

[5] C.E. Zobell, "Microbial Degradation of Oil: Present Status, Problems, and Perspectives," in *The Microbial Degradation of Oil Pollutants (proceedings* of a workshop at Georgia State University, Atlanta, December 1972), D.G. Ahearn and S.P. Meyers (eds.), 1973.