Chapter 2
Findings

The Exxon *Valdez* accident was the largest spill (about 10.8 million gallons or 35,000 tons) in U.S. history. Not since the Santa Barbara oil spill 20 years earlier has as much public concern been voiced about the inability of government and industry to respond effectively to large oil spills. Although such spills have occurred worldwide at the rate of 3 to 5 per year since the *Torrey Canyon* accident off England in 1967, many of these (table 2-1) have escaped U.S. attention. This OTA study is *not* directed at an evaluation of what went wrong with the *Exxon Valdez* but is focused on the response capabilities (or lack thereof) that were brought to bear in the Exxon *Valdez* spill, as well as in other large offshore spills.

Two factors are important to the question of why public and private oil spill response capabilities seem so limited today. First, very large accidents and catastrophic oil spills have not occurred very often in U.S. waters. The last major tanker spill near the United States was the *Alvenus* spill off the Gulf Coast in 1984. It was about one-third the size of the *Exxon Valdez* spill, and, even though a large portion of the 2.7 million gallon spill was deposited on Texas beaches, the type of oil and the local conditions were such that beach cleanup was reasonably effective. Second, many believed that the responsible industry and government agencies were prepared. The exhaustive contingency plans appeared to be evidence of the preparation and demonstration of adequate capabilities.

In the light of actual events, the response capabilities of both government and private entities proved inadequate for an *Exxon Valdez* type of accident. It is also clear that the few other large offshore spills that have occurred in U.S. coastal waters in the past 10 to 15 years have mostly escaped public attention, largely because natural events dispersed or mitigated the impacts. One spill caught fire, burning most of the oil; others happened where favorable winds and currents carried and dispersed most of the oil to the open sea.[1]

Photo credit: U.S. *Coast Guard*

The Exxon Valdez, flanked by two tugboats, in Prince William Sound.

Many people have asked how can we be so ill-prepared for massive oil spills in the modern world of high technology. Perhaps the United States has not given attention to developing appropriate technology in this arena; maybe we haven't made needed investments in research; or maybe management of the response was just inept.

This OTA study addresses the question of technological promises and limitations. The technology now available for oil spill cleanup in the United States and overseas has many limitations affecting capabilities in real world situations. This has resulted in only very small percentages of actual cleanup for almost all past major ocean spills. Some sources claim that the most oil that can be recovered

1 In the *Burmah Agate* accident off the Gulf Coast in 1979, the oil caught fire and resulted in most of the spill burning up. In the *Argo Merchant* spill off New England in 1976, the offshore winds carried almost all of the oil out to sea and it was dissipated in the open ocean.

Table 2-1 -Large Oil Spills: A List of 66 Spills Greater Than 2 Million Gallons, 1967 to Present

No.	Date	Spill	Location	Volume (millions of gallons)	Ref(s)
1	1979-1980	Ixtoc 1, Well Blowout	Mexico	139-428*	abgh
2	1983	Nowruz Oil Field, Well Blowout(s)	Persian Gulf	80-185	ab
3	1983	Castillo de Beliver/Broke, Fire	South Africa	50-80'	abe
4	1978	Amoco Cadiz/Grounding	France	67-76	abfhm
5	1979	*Aegean Captain/Atlantic Empress*	Off Tobago	49*	abl
6	1980-1981	D-103 Libya, Well Blowout	Libya	42	a
7	1979	Atlantic *Empress/Fire*	Barbados	41 .5*	abl
8	1967	*Torrey* Canyon/Grounding	England	35.7-38.6*	bcf
9	1980	*Irenes Serenade/Fire*	Greece	12.3-36.6*	am
10	1972	*Sea* Star/Collision, Fire	Gulf of Oman	35.3*	bf
11	1981	Kuwait Nat'l Petroleum Tank	Kuwait	31.2	a
12	1976	Urquiola/Grounding	Spain	27-30.7'	bf
13	1970	Othello/Collision	Sweden	18.4 -30.7	bcf
14	1977	*Hawaiian* Patriot/Fire	N Pacific	30.4*	bf
15	1979	*Independents*	Turkey	28.9	a
16	1978	*No.* 126 Well/Pipe	Iran	28	a
17	1975	*Jakob Maersk*	Portugal	25*	f
18	1985	BP Storage Tank	Nigeria	23.9	a
19	1985	Nova/Collision	Iran	21.4	a
20	1978	BP, Shell Fuel Dept.	Zimbabwe	20	a
21	1971	Wafra	South Africa	19.6*	cf
22	1989	Kharg 5, Explosion	Morocco	19	g
23	1974	Metula/Grounding	Chile	16	cf
24	1983	Assimi/Fire	off Oman	15.8*	a
25	1970	*Polycommander*	Spain	3-15.3	c
26	1978	Tohoku Storage Tanks, Earthquake	Japan	15	a
27	1978	*Andros Patria*	Spain	14.6	a
28	1983	*Pericles GC*	Qatar	14	a
29	1985	Ranger, TX, Well Blowout	Texas	6.3-13.7	bk
30	1968	*World* Glory/Hull Failure	South Africa	13.5	bcf
31	1970	*Ennerdale/struck* Granite	Seychelles	12.6	cf
32	1974	Mizushima Refinery, Tank Rupture	Japan	11.3	cdf
33	1973	*Napier*	SE Pacific	11*	f
34	1980	*Juan A. Lavalleja*	Algeria	11	a
35	1989	*Exxon* Valdez/Grounding	Alaska	10.8	i
38	1978	Turkish Petroleum Corporation	Turkey	10.7	a
37	1979	Burmah Agate/Collision, Fire	Texas	1 .3-10 .7*	abc
38	1971	*Texaco Oklahoma,* 120 mi. offshore	North Carolina	9.2-10.7	cf
39	1972	*Tinder*	Mediterranean	10.4	f
40	1976	*St. Peter*	SE Pacific	10.4	f
41	1977	*Irene's Challenge*	Pacific	10.4	f
42	1972	*Golden Drake*	NW Atlantic	9.5	f
43	1970	*Chryssi*	NW Atlantic	9.5	f
44	1969	Pacocean/Broke in two	NW Pacific	9.2	f
45	1977	*Caribbean Sea*	E Pacific	9.2	f
46	1976	*Grand* Zenith/Disappearance	NW Atlantic	8.9	f
47	1976	Cretan star	Indian Ocean	8.9	f
48	1969	Keo/Hull failure	Massachusetts	8.8	bf
49	1969	Storage Tank	New Jersey	8.4	b
50	1977	Ekofisk Bravo, Well Blowout	North Sea	4.6-8.2	bf

a. A List of the 20..., 1989.
b. Reuters, 1989.
c. Van Gelder-Ottway..., 1976.
d. A Basic Spill..., 1981.
e. Lord et al., 1987.
f. Butler, 1978.
g. Woods and Hannah, 1981.
h. Teal and Howarth, 1984.
i. Caleb Brett, 1989
j. Ganten, 1985.
k. Quina et al., 1987.
1. Horn and Neil, 1981.
m. Bao-Kang, 1987.
n. Tracey, 1988.
0. Ocean Industry, 1980.
p. NRC, 1975.
q. Journal of Commerce, 1/4/90.

Tinker spills from the Iran/Iraq war were not generally available

• Fire burned part of spill

SOURCE: Exxon Corp and Office of Technology Assessment

Table 2-1- Large Oil Spills: A List of 66 Spills Greater Than 2 Million Gallons, 1967 to Present (Continued)

No.	Date	Spill	Location	Volume (millions of gallons)	Ref(s)
51	1972	*Giuseppi Guilietti*	NE Atlantic	8	f
52	1977	Venpet and Venoil/Collision	South Africa	7.4-8	ef
53	1976	Argo Merchant/Grounding	Massachusetts	7.7	bfh
54	1967	Humble Oil Pipeline, Offshore Leak	Louisiana	6 7	n
55	1973	*Jawacta*	Baltic Sea	6.1	c
56	1967	*R.C. Stoner*	Wake Island	6	c
57	1970	*Marlena*	Sicily	4.3	c
58	1970	Pipeline	Saudi Arabia	4.2	c
59	1971	Oil Well	Persian Gulf	4,2	c
60	1980	Tanio/Broke amidships	France	4.2	j
61	1988	Ashland Storage Tank, Rupture	Pennsylvania	3.8	b
62	1969	Santa Barbara Channel, Well Blowout	California	1.4-3,4	dfp
63	1970	Arrow/Grounding	Nova Scotia	1.5-3.1	ch
64	1970	Storage Tank	Pennsylvania	3	c
65	1984	Alvenus/Grounding	Louisiana	2.8	b
66	1970	Offshore Platform, Well Blowout	Louisiana	2.7	c

a. A List of the 20..., 1989.
b. Reuters, 1989.
c. Van Gelder-Ottway..., 1976.
d. A Basic Spill..., 1981.
e. Lord et al., 1987.
f. Butter, 1978.
g. Woods and Hannah, 1981
h. Teal and Howarth, 1984.
i. Caleb Brett, 1989
j. Ganten, 1985.
k. Quina et al., 1987.
I. Horn and Neil, 1981.
m. Bao-Kang, 1987.
n. Tracey, 1988.
0. Ocean Industry, 1980.
p. NRC, 1975.
q. Journal of Commerce, 1/4/90.

Tanker spills from the Iran/Iraq war were not generally available

• Fire burned part of spill

SOURCE: Exxon Corp and Office of Technology Assessment

after a major spill is 10 to 15 percent.[2] OTA obtained data from several documented open ocean large tanker spills that show the actual oil recovered at sea hasbeen less than 10 percent of oil discharged –usually much less. Probably between 6 and 8 percent of the oil spilled by the Exxon *Valdez* was recovered at sea,[3] although, as of this writing, Exxon is still in the process of developing a recovery estimate. Under the best conditions, with the best technology, with technology that is immediately available, and with the ablest organization, cleanup capabilities could be substantially improved. However, technical experts have widely ranging views on the magnitude of potential improvements, mainly because the best conditions seldom occur in the real world.[4]

Many claim that techniques other than mechanical recovery could be used to mitigate the effects of a large offshore oil spill without actually picking up the oil. These techniques include use of dispersants and burning. In fact these other techniques have seldom been used successfully. In some cases public concerns about side effects have prevented their use (these include possible toxic effects of dispersed oil and air emissions from burning oil). In other cases, sea conditions or the condition of the spilled oil have resulted in poor performance of these techniques.

[2] U.S. General Accounting Office, Adequacy of Preparation and Response to *Exxon Valdez* Oil Spill, October 1989.

[3] Walter Parker, Alaska Oil Spill Commission, personal communication, Feb. 12, 1990.

[4] At OTA's Oil Spill workshop in August 1989, several experts agreed that the high end of recovery capabilities for large ocean spills might hypothetically reach more than 30 percent with the best technology.

The main question, therefore, is what improvements could be expected if new technologies or techniques were employed in the future. This OTA study has concluded that improvements could be made and that the most obvious improvements would not require any technological breakthroughs-just good engineering design and testing, good maintenance and training, timely access to the most appropriate systems, and rapid, informed decisions. The improvements that can be made, however, also have limitations, and the inherent practical difficulties of recovering oil from the ocean will always hinder spill response efforts, sometimes to a major extent.

The key findings from this OTA evaluation are summarized below:

- Mechanical containment and recovery is the primary U.S. oil spill response method. The technology currently available for mechanical oil spill cleanup has many limitations, and only very small percentages of oil have been cleaned up from most major spills. While new designs have appeared over the years, the basic technology has not changed in the past decade.
- Current mechanical containment and recovery technology (especially that available in the United States) is not usually effective in waves greater than 6 feet, winds greater than 20 knots, and currents greater than 1 knot (perpendicular to a boom). Wind and current conditions in U.S. port areas, not to mention offshore areas, often exceed these limits, leaving little margin for the effective use of existing mechanical equipment.
- Improvements in mechanical recovery technologies that can be expected from stepped-up research and development efforts are unlikely to result in dramatic increases in total oil recovered from a catastrophic spill. In general, the improvements that are likely to offer greater effectiveness for large offshore spills involve larger, more costly equipment, strategically located for quick response.
- One prospect for reducing the high cost of more effective containment and recovery equipment for large spills is to employ dual purpose vessels. Army Corps of Engineers' dredges, for example, could be designed or retrofitted with oil spill recovery equipment, and be on call to fight spills as needed. Commercial barges, Coast Guard vessels, and other vessels of opportunity may also be employed. Such an approach may also offer the advantage of keeping more equipment in strategic locations.
- Dispersants, like mechanical cleanup methods, have their place as an oil spill countermeasures tool. Greater use of dispersants has been hampered in part by concerns about toxicity and in part by concerns about effectiveness. Currently available dispersants are less toxic than the oil they dispersers but dispersed oil can be toxic until it breaks down or is diluted sufficiently, and it will impact a greater fraction of the water column (or the sea bottom if used in shallow water) than undispersed oil. Dispersant use may involve a trade-off between the environmental effects of a treated oil slick with the shoreline impacts of an untreated one.
- The effectiveness of dispersants is perhaps of more concern than their toxicity. A number of experts disagree about the effectiveness of dispersants, and there is as yet no reliable method to test effectiveness in field operations. Although

[5]National Research Council, *Using Oil Spill Dispersants on the Sea* (Washington, DC: National Academy Press, 1989), p. 3.

some currently available dispersants have proved effective in ideal situations, ideal conditions rarely exist in the real world. Research to improve dispersant effectiveness is continuing and appears to be producing some encouraging results.

- Abroad, some countries rely almost exclusively on mechanical cleanup methods (e.g., Norway and the Netherlands), while others (e.g., the United Kingdom) rely almost exclusively on dispersants. Some countries have much larger mechanical systems than those currently available in the United States (e.g., dual purpose dredges in the Netherlands) and thus have much greater capacities for high volume recovery. Different policies regarding the use of mechanical methods are due largely to different physical conditions in each country; different dispersant policies relate to varying perceptions about their effectiveness and toxicity.
- In situ burning of spilled oil appears to have merit in certain spill situations, especially if the oil can be contained and thickened with the use of fireproof booms. This technique is not currently an important oil spill countermeasure but is being investigated further in the United States. Some experiments have resulted in high burn percentages and thus high removal rates. Nevertheless, burning is probably also limited in its applications. Igniting and keeping a slick burning may be a problem in some circumstances; in others, burning may jeopardize the stricken vessel and any oil remaining on board– oil which might otherwise be off-loaded; and the resultant visible air pollution (which must, however, be balanced against the invisible air pollution caused by allowing evaporation of the toxic volatile components of the oil) may be unacceptable.
- Despite the shortcomings of all existing countermeasure approaches, each may have applications in certain situations. There is no one general solution to an oil spill. Many technologies may be very effective in certain applications but completely inappropriate in others. Regardless of the technique(s) employed, the effectiveness of the response will be greatly enhanced if there is a rapid response by a professional response team that understands which techniques are best under which conditions. The speed of a response is critical and is dependent on rapid decisionmaking, logistics, and training.

  Decisionmaking: If important decisions, such as how to deploy mechanical equipment and whether to use dispersants, are not made within the first few hours after a major spill, the spill may be beyond effective control. Rapid decisionmaking is difficult in the United States, in part because oil companies have the responsibility to clean up major spills but not the authority to use all means they deem appropriate. Rapid decisionmaking could be enhanced if the government were responsible for combating major vessel spills, as is the case inmost European countries; if authority within the government were more centralized; and if, through more thorough contingency planning, a greater number of decisions could be made without delay.

  – *Logistics:* Having the right equipment on scene when needed is essential to a rapid response. Equipment may either be strategically located or rapidly moved to the spill site, but in either case the recovery effort will only be as good as the weakest link in the system. Response system elements such as adequate ships or barges to accept recovered oil, temporary storage sites, and a means to dispose the recovered oil are often crucial to a successful operation and are often ignored.

– *Training:* A career track for oil spill response professionals does not now exist in the Federal Government. With the Coast Guard rotation system currently in effect, operational expertise is hard to come by, and even if developed, maybe lost before required. The establishment of a trained professional cadre to fight oil spills throughout the country (and perhaps abroad too) could make a significant difference in the government's ability to respond rapidly to spills. To be effective, professional training must include the conduct of periodic exercises and contingency plan testing.

- The response to a major spill would be more rapid and efficient if certain regulations could be waived or streamlined. Regulations that are appropriate under normal operating procedures but which may cause unnecessary delay in emergency situations include: 1) Clean Water Act restrictions that prohibit the decanting of oily water collected during cleanup operations, and 2) Jones Act restrictions that restrict the use of available foreign vessels without a waiver.
- The oil industry, through a new Petroleum Industry Response Organization (PIRO), proposes to establish 5 or more regional oil spill response centers and claims it could endow each with the capability to fight a 30,000-ton (about 9 million gallons) spill. In January 1990 the PIRO Steering Committee recommended adoption of this proposal with a 5-year budget of almost $400 million and membership by 20 oil companies. This is a worthwhile concept and could bring about a major increase in U.S. capabilities when implemented. However, industry and the appropriate Federal agencies must work together to devise an efficient, integrated approach to fighting major oil spills. The benefits of the regional center approach could be enhanced if the specific organization, function, and outfitting of each center were jointly determined. Also, if the government continues to rely on private resources for spill response, it must carefully monitor the availability and capability of those resources.
- Increased R&D on oil spill response technologies will likely yield incremental benefits. Important problems can be better understood, but technological breakthroughs that would result in major improvements in mechanical cleanup capabilities are unlikely. The most important problems have to do with 1) providing technical backup for decisions on use of techniques such as dispersants and other chemicals, 2) developing technical standards based on full-scale tests of capabilities of specific equipment, and 3) sound engineering design and construction of substantial and reliable systems in enough quantities to meet performance requirements for oil recovery under real world operating conditions.
- One aspect of future technical improvements – that of pollution prevention – may provide significant benefits to the overall oil spill problem. While many have advocated this as an area needing attention, it has not been included in the scope of this OTA study. A 1975 OTA study (ref. 2, chapter 1) addresses this issue and an on-going National Academy of Sciences/National Research Council study is investigating the current situation with regard to the double-bottom, double-hull issue.

- Given the difficulty of containing and cleaning up a catastrophic spill at sea, many have advocated more attention to techniques that would protect priority coastal areas (e.g., booms). OTA has *not* found evidence that shoreline protection has been effective except under ideal weather conditions. Efforts are probably needed, however, to improve capabilities of protective systems and to assure the availability of the best equipment.