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The names *Argo Merchant*, *Amoco Cadiz* and, most recently, *Exxon Valdez* evoke none of the nostalgic fascination often associated with the wreck of great ships. Instead, the mere mention of these hapless tankers induces an uneasiness that quickly builds to revulsion and then disgust when one considers the environmental implications of such mishaps. The recitation of the names of these unlucky vessels has a macabre ring evocative of a death knell.

The political impact of environmental disasters, particularly those that affect the sea, should not be ignored by military planners. The public is no longer willing to accept environmental desecration by industry, and should not be expected to tolerate it as a collateral effect of war if we hope to retain the popular support so crucial to military success.

Heightened environmental awareness has altered the political reality of what is and is not an acceptable military course of action in pursuit of operational goals. For example, the worldwide outcry over the environmental implications of the Chernobyl and Three Mile Island accidents renders the idea of attack against an enemy's nuclear utility plants unthinkable in conventional war. By the same logic, the use of a herbicide like Agent Orange on the tropical rain-forest sanctuary of a guerrilla force, though acceptable only a generation ago, would be politically inadvisable today. Public outrage at the sickening devastation to Prince William Sound as a result of the *Exxon Valdez* grounding suggests that attack on an enemy crude oil tanker would meet with resounding denunciation, regardless of the theater of operations in which the attack took place.

The environmental, and therefore political, costs of conducting attacks against an enemy's crude oil transport system are unacceptably high. Theater

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commanders must determine how best to achieve the operational goal of disrupting enemy fuel supplies without resorting to attack on the environmentally sensitive crude oil transport system. The desired result can be achieved with much less environmental risk by focusing interdiction efforts on the enemy's refinery capacity and distribution network for refined petroleum products.

The term "crude oil transport system" refers to that segment of the international oil industry concerned with the transport of crude oil from the wellhead to the refinery by ship or pipeline or, as is frequently the case, some combination of the two. Crude oil production and shipment to the refinery is referred to within the industry as the "upstream" stage, while the production and distribution of refined petroleum products is referred to as the "downstream" stage.[1]

This distinction between the upstream and downstream stages of the industry is important from a military perspective because attack against the tankers, port facilities, drilling platforms, and pipelines of the upstream stage poses much greater environmental risks than attack against the refineries and small-volume carriers of the downstream stage. The difference in degree of risk is directly related to the volume of petroleum subject to leakage into environmentally sensitive areas as a result of attack.

Large concentrations of crude oil are moved through the upstream stage daily. It is estimated that as much as three billion barrels of crude, much of it concentrated in the fragile hulls of gigantic tankers, is moving through the transport system at any given time.[2] While the average tanker transporting crude oil in World War II displaced 12,000 deadweight tons (dwt), its modern counterpart displaces from 200,000 to 300,000 dwt with behemoths in excess of 500,000 dwt not uncommon.[3] In comparison, a *Nimitz*-class carrier displaces approximately 90,000 displacement tons.[4]

The environmental effects of an attack which would result in the sinking of a modern tanker would be similar to those caused by the wreck of the *Amoco Cadiz* off the Brittany coast in 1978 in which 223,000 tons of crude oil were spilled. In addition to the fouling of hundreds of kilometers of pristine coastline, oyster fisheries were contaminated and growth defects noted in certain species of bottom fish as a result of petroleum pollution.[5] Other more sinister long-term effects of catastrophic spills must also be considered in weighing the efficacy of such an attack. Researchers have found that phytoplankton, the plant life that forms the lowest level in the marine food chain, is highly intolerant of even very low levels of petroleum pollution.[6] In addition, evidence gathered after the wreck of the *Argo Merchant* off New England in 1976 indicates that the eggs of commercially important species such as cod and pollack suffered a 50 percent mortality rate in waters affected by the spill.[7]

Attack against the offshore drilling platforms of the upstream stage of the enemy's petroleum industry would also pose grave environmental risks. The accidental blow-out of the Mexican offshore well Ixtoc 1, in the Gulf of Mexico in June 1979, provides a convenient example of what the outcome of such an attack might be. Despite the efforts of the Mexican government to bring the erupting well under control, it spewed oil continuously for almost nine months before it was successfully capped. The Ixtoc 1 disaster is the largest oil spill on record.[8] The resulting environmental damage to fisheries and tourist industries along the Mexican and Texas coasts has embroiled the two governments in a bitter dispute over compensation.[9]

Yet in October 1987, the United States chose to conduct just such an attack. Naval vessels of the Middle East Joint Task Force shelled the Iranian oil platform *Rashadat* to demonstrate, in the words of President Reagan, a "prudent yet restrained response" to Iranian provocations in the Persian Gulf.[10] The fact that the Iranians were using the platform as a surveillance and operations base did not make more acceptable the very serious environmental risks associated with destruction of an offshore well. One has to wonder if the theater commander and the National Command Authorities even considered the possible environmental crisis that might have resulted from this "prudent yet restrained response."

Perhaps the most convincing argument against further pollution of the sea as a consequence of the indiscriminate use of military force is the implication for world food supplies. If current birth rates continue, the present world population of 5.2 billion will almost double by 2025 and triple before the end of the next century.[11] The only hope of feeding such a multitude rests in expanding the annual harvest from the oceans. Scientists estimate that the haul from conventional fishing methods could yield up to four times the present catch, while anticipated developments in "aquaculture" could increase that yield considerably.[12] Wanton disregard for the environmental consequences of military action might well result in the loss of this vital protein source to future generations, precisely when it is needed most.

Attack against the crude oil pipelines of the upstream stage also poses significant environmental risks. The factors relating to potential environmental damage are line capacity and proximity of the target section to ecologically sensitive areas such as watersheds and arable land. The large volume capacity of many of the world's pipelines indicates the dimensions of the environmental crises that might result from such attacks. Approximately 50 percent of the oil exported from the Persian Gulf, or 4.7 million barrels per day (mbd), is transported by pipeline.[13] The Iraqi pipelines terminating in Turkey and Syria each carry approximately .5 mbd.[14] As a point of comparison, the Alyeska pipeline in Alaska has a capacity of 2 mbd.[15]

The greatest environmental risk in pipeline attack is the contamination of ground water supplies by the highly toxic water-soluble components of crude oil known as aromatic hydrocarbons.[16] Studies of ground water systems or "aquifers" throughout the United States indicate that aromatic hydrocarbon contamination has already occurred in dangerous concentrations, particularly in oil-producing regions and areas where petroleum-based fertilizers and pesticides have been used extensively.[17] The most disturbing aspect of the contamination threat posed by these highly toxic carcinogenic compounds is their alarming persistence. Once an aquifer has been contaminated by water-soluble organic chemicals, it can remain so for the indefinite future, possibly thousands of years.[18]

While attack on pipelines of the capacities described above might well result in lasting ecological damage, the military advantage to be gained would likely be temporary and of little strategic importance. Evidence from the Iran-Iraq War indicates that Iran was readily able to repair damage to its Kharg Island pipeline system despite frequent Iraqi air strikes.[19]

Interdiction of an enemy's fuel supply in the downstream stage of the petroleum industry allows the theater commander to employ more discriminate means of attack against targets that are not likely to generate unwanted environmental and political repercussions. The key to conducting environmentally less damaging attacks against this stage of the industry is to avoid large-volume targets such as the storage tanks and pipeline terminals associated with refinery installations.

Primary emphasis should be placed on attacking the refinery process plant in which crude oil is converted into numerous useful petroleum products.[20] Since the process plant can handle only a limited volume of petroleum at a given time, elimination of this facility would interrupt fuel production without serious environmental impact.

By adjusting the scope of an attack against an enemy's refinery process plant, the theater commander can choose either to completely disrupt fuel production or merely to prevent production of the more highly refined products such as gasoline and aviation fuels. The fundamental step in refining crude oil involves the separation of the naturally occurring hydrocarbons that comprise the resource into components or fractions. This separation is accomplished by heating the crude in a distillation column or tower. The lighter fractions, precursors of high-performance fuels, are bled off the top of the column while heavier fractions are extracted from the lower part of the column. The lighter fractions require further refinement to form gasolines and aviation fuels, while the heavier fractions can frequently be used without further processing as low-grade diesel, ship bunker fuel, boiler fuel for electric utility plants, and heating oils.[21]

The next step in the refinement of the lighter fractions involves heating them under pressure in the presence of catalysts that promote formation of new compounds. This process is called catalytic cracking and is accomplished in a facility called a catalytic reformer.[22] By destroying the catalytic reformer, the commander can disrupt the enemy's ability to produce gasoline, high-quality diesel and aviation fuels, without affecting enemy ability to produce the low-grade fuels which power industrial production. If interdiction of all fuel production is the commander's objective, attacks can be directed principally against the distillation towers, with secondary emphasis on the catalytic reformers.

This idea of precisely focusing an attack so as to achieve a desired limited result can be taken a step further. Through use of the broad range of intelligence capability available to the theater commander, the enemy's source for the discrete catalysts required for refined fuel production can be identified. A variety of means, not necessarily military, might then be employed to deny the enemy access to industrial chemicals vital to his ability to wage war.

A secondary means of interdicting an enemy's fuel supply in the downstream stage involves attacks designed to disrupt or destroy critical points in the lines of communication through which refined products must pass to reach consumers. Railroads, bridges, and port facilities that serve the refineries are the obvious targets. This category of attack would also include destruction of railroad tank cars and other small-volume carriers of petroleum products. A well-coordinated effort to eliminate small-volume carriers could have decisive results: 90 percent of the Soviet Union's refined petroleum products are transported via railroad tank cars.[23]

Attacks against refinery capacity and the lines of communication for refined product distribution are ideally suited for employment of "surgical" weapons such as precision-guided munitions. These targets are also vulnerable to strikes by special operations forces who can be trained to knock out key nodes in the enemy's downstream petroleum industry with little risk of collateral environmental damage.

In order to avoid the unwanted environmental and political costs of interdicting enemy fuel supplies in the upstream stage of the oil industry, the following rules of engagement are proposed:

- Destructive attacks against offshore wells, crude oil tankers, and pipelines be prohibited.
- Destructive attack against crude oil and refined petroleum product storage facilities (tank farms) be prohibited.
- Tankers may be stopped, searched and, if found to be transporting war materials other than crude oil, seized.

The proposed rules of engagement are not intended to deny operational commanders the advantages to be gained from disrupting enemy fuel supplies. Rather, they would serve to focus interdiction efforts on the key nodes of the environmentally less risky downstream stage of the industry.

Rules of engagement designed to limit the collateral environmental damage resulting from military action offer only a partial solution to the larger problem of waging limited war in an ecologically fragile but heavily armed

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world. The logical extension of this concept would be an international agreement to protect aspects of the environment vital to human survival by prohibiting attack against environmentally risky targets such as the upstream stage of the petroleum industry. Such an agreement would, in effect, be a form of arms control with emphasis not on reducing the number and type of weapons, but rather on limiting the categories of targets against which weapons could legitimately be employed. An arms control agreement of this nature would be effective only so long as states perceived their enduring interests to be served by the accord. However, protection of the ecological fabric that sustains life is arguably the most enduring interest of all.

Such an agreement would likely have broad political appeal both on a national and international level: Appeal on a national level, because it addresses environmental concerns of an increasingly more alert and informed populace; appeal on an international level, because it would extend the focus of arms control discussions from the present bipolar orientation to a multinational one in which all states could express an interest in an area of mutual concern. It is precisely this broad international support that would encourage states to abide by the restrictions of the agreement rather than endure international condemnation.

The exercise of restraint in war is not a concept born of the nuclear age. Warriors have, since ancient times, recognized the need for limits on the use of violence in furthering political aims. The olive branch as ancient symbol of peace, security, and the fecundity of nature takes root in this idea. Indeed, it was the longevity of the olive tree and its central role in Mediterranean culture that caused the ancients to regard its destruction in war as an act beyond moral justification; hence its enduring symbolic appeal.

As the weapons of war have grown more lethal, the environmental consequences of their injudicious use have become more costly. We must expand the concept of restraint to include the protection of those aspects of nature vital to human survival. Prohibition against attack on the upstream stage of the enemy's petroleum transport system is an example of restraint in the ancient tradition which recognizes that there will be generations to follow long after our war and its objectives have been forgotten.

Notes

1. "Oil Transport and Storage Industry," *OPEC Bulletin*, no. 14, 1983, p. 55.
2. *Ibid.*, p. 60.
3. *Ibid.*, p. 58; Ferdinande F. Banks, "Oil Tankers: Some Basic Economics," *OPEC Bulletin*, no. 18, 1987, p. 10.
4. Warships' size is almost always given in displacement tons. Nowadays the U.S. Navy uses full-load displacement, which includes the ship and everything in her. Deadweight tonnage, applied to merchant ships, only measures the ship's carrying capacity. The full-load displacement of a fully laden tanker would be more than her deadweight tonnage.

5. Lucien Lauhier, "An Ecological Impact Study," *AMBIO*, no. 9, 1980, p. 276.
6. Robert H. Howarth, "Fish versus Fuel: A Slippery Quandary," *Technology Review*, no. 83, 1981, p. 74.
7. Howarth, p. 73; Pierre Nounou, "The Oil Spill Age: Fate and Effect of Oil in the Marine Environment," *AMBIO*, no. 9, 1980, p. 301.
8. Robert D. Tomasek, "United States-Mexican Relations: Blowout of the Mexican Oilwell Ixtoc 1," *American University Field Staff Reports*, no. 20, 1981, p. 3.
9. *Ibid.*, p. 7.
10. U.S. President (Ronald Reagan), Statement, *Weekly Compilation of Presidential Documents*, no. 23, 1987, p. 1196 and Letter to Speaker of the House and President Pro Tempore of the Senate, no. 23, 1987, p. 1206.
11. "Report Says World Population Could Double Within 40 Years," *Virginian-Pilot*, 17 May 1989, p. A-3.
12. Dayton L. Alverson, "Fish for a Hungry World," *NOAA*, no. 5, 1988, p. 4; Doi Zenjiro, "From Fishing to Farming the Sea," *Japan Quarterly*, no. 33, 1986, p. 389; R. L. Edwards and J. B. Suomala, Jr., "World Fisheries in the Twenty-First Century, *Technology Review*, no. 83, 1981, p. 48.
13. Daniel Yergin, "Energy Security in the 1990's," *Foreign Affairs*, no. 67, 1988, p. 118.
14. Frederick W. Axelgard, "The Tanker War in the Gulf: Background and Repercussions," *Middle East Insight*, no. 3, 1984, p. 27.
15. "Alyeska Oil Pipeline Output," *Wall Street Journal*, 13 April 1989, p. A-2.
16. Howarth, p. 72; Laubier, p. 272.
17. David E. Burmaster and Robert H. Harris, "Synthetic Organic Chemicals Are Contaminating Groundwater in Many Parts of the Nation, Possibly Posing Unacceptable Risks to Human Health," *Technology Review*, no. 85, 1982, p. 52; Larry Freuhling, "Please Don't Drink the Water," *The Progressive*, no. 50, 1986, p. 31.
18. Burmaster and Harris, p. 54.
19. Axelgard, p. 28.
20. Alan D. Plaistowe, "Key Developments in the Petrochemical Industry to the Year 2000," *OPEC Bulletin*, no. 18, 1987, p. 11.
21. *Basic Oil Industry Information*, (Vienna: Organization of Petroleum Exporting Countries, 1983), pp. 30-31.
22. *Ibid.*, pp. 31-33.
23. "USSR," *OPEC Bulletin*, no. 16, 1985, p. 69.

In the open field of the sea the most direct route is the most natural, and, other things being equal, the best; but many circumstances may influence the decision. Paramount among these is the strength of the navy as compared with that of the enemy,—a strength dependent not only upon aggregate tonnage or weight of metal, but also upon the manner in which those aggregates have been distributed among the various classes of vessels and upon the characteristics of each class in point of armament, armor, speed, and coal endurance. All these qualities are elements in strategic efficiency, sometimes mutually contradictory; and the adjustments of them among themselves may seriously affect strategic calculations. This illustrates that the composition of a national fleet is really a strategic question.

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