Annu. Rev. Environ. Resour. 2003. 28:587–617
doi: 10.1146/annurev.energy.28.050302.105617

First published online as a Review in Advance on August 14, 2003

JUST OIL? THE DISTRIBUTION OF ENVIRONMENTAL AND SOCIAL IMPACTS OF OIL PRODUCTION AND CONSUMPTION

Dara O'Rourke[1] and Sarah Connolly[2]
[1]*Department of Environmental Science, Policy, and Management, 135 Giannini Hall, University of California, Berkeley, California 94720; email: orourke@nature.berkeley.edu*
[2]*Department of Urban Studies and Planning, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Room 7-337, Cambridge, Massachusetts 02139; email: sarahc@mit.edu*

Key Words petroleum, environmental justice, energy policy, health impacts

■ **Abstract** This review presents existing data and research on the global distribution of the impacts of oil production and consumption. The review describes and analyzes the environmental, social, and health impacts of oil extraction, transport, refining, and consumption, with a particular focus on the distribution of these burdens among socioeconomic and ethnic groups, communities, countries, and ecosystems. An environmental justice framework is used to analyze the processes influencing the distribution of harmful effects from oil production and use. A critical evaluation of current research and recommendations for future data collection and analysis on the distributional and procedural impacts of oil production and consumption conclude the review.

CONTENTS

I. INTRODUCTION

The National Energy Policy of the United States asserts that the country currently "faces the most serious energy shortage since the oil embargoes of the 1970s," which has been precipitated by "a fundamental imbalance between supply and demand" (1). The National Energy Policy Development Group (NEPDG), the panel convened by Vice-President Dick Cheney to develop the national energy policy, argues this crisis is driven by declining reserves in the United States and by "overly burdensome" and "often excessive and redundant" regulations that hinder new exploration and production of oil.

This panel asserts that the answer to today's oil problems lies in supporting more domestic oil exploration, increasing access to overseas oil, and developing more refining capacity in the United States. The NEPDG thus calls for (a) streamlined and more flexible regulation of oil exploration, production, and refining and (b) the opening of oil exploration in the National Petroleum Reserve-Alaska, the Outer Continental Shelf coastal regions, and the Arctic National Wildlife Refuge; it further recommends "an Executive Order to rationalize permitting for energy production . . . to expedite permits and other federal actions necessary for energy-related project approvals" (2).

President Bush has made this one of his top policy priorities, arguing that "It is in our nation's national interest that we develop more energy supplies at home" (3). Vice-President Cheney has added, "One of the things we need to do is to build more refineries" (4).

The administration is thus advancing energy policies that will significantly increase oil production and refining in the United States and that facilitate increased U.S. access to and investment in oil production and refining overseas. It is worth noting that the Bush administration is not the first to pursue increased access to oil as a matter of national interest. In January 1980, the Carter Doctrine identified the Persian Gulf as a "vital interest" of the country and declared that "an attempt by an outside force to gain control of the Persian Gulf region would be regarded as an assault on the vital interests of the United States." The Carter administration subsequently established a Rapid Deployment Force for use in the Middle East, deployed a permanent U.S. naval force in the Persian Gulf, and acquired new military bases in the region (5).

Although the case for the economic and political benefits of increased production and control over oil has been clearly articulated, the environmental, health, and social costs of increased oil flows are largely absent from government policy deliberations. And perhaps more importantly, the actual distribution of costs and benefits of increased oil production among countries, communities, and individuals is almost completely absent from public discourse.

Clearly, there are very real trade-offs resulting from increased oil production and consumption. But how well do policy makers and the public understand the costs and benefits of such a commitment to oil? What data are available to evaluate the impacts of oil production and consumption at different stages in the oil life cycle? What evidence and analysis are available to compare trade-offs in security, economic development benefits, energy dependence, environmental harm, health costs, and cultural consequences of increased oil production? The purpose of this review is to examine these trade-offs and to assess the distribution of economic, environmental, and health impacts of petroleum production and consumption.

Oil obviously provides significant benefits to society. Oil serves a wide diversity of purposes, which include transportation, heating, electricity, and industrial applications, and is an input into over 2000 end products (6). Oil is a high energy density abundant fuel, which is relatively easy to transport and store, and is extremely versatile in its end uses (7).

Oil is also the most valuable commodity in world trade. As Doyle (8) notes, "Roughly two billion dollars a day now change hands in worldwide petroleum transactions. It is the world's first trillion-dollar industry in terms of annual dollar sales." The oil industry is phenomenally profitable for some corporations and governments. Taxes from oil are a major source of income for some 90 governments. Petroleum is the largest single item in the balance of payments and exchanges between nations and a major factor in local level politics regarding development, jobs, health, and the environment. For many countries, oil is crucial to national economic viability, accounting for upwards of 80% of total national exports for Libya, Iran, Kuwait, Saudi Arabia, and Venezuela (9).

The global oil industry also provides significant jobs, profits, and taxes. As the International Labour Organisation (ILO) notes (6) the oil industry directly employs more than 2 million workers in production and refining. The ILO further estimates that each job in oil production or refining generates one to four indirect jobs in industries that either supply needed inputs or benefit from value added activities.

Interestingly, there are limited public data on the benefits of oil. Revenue and investment data from oil producing regions are sparse. This lack of transparency on oil's benefits has, in fact, motivated an international "Publish What You Pay" campaign (10) to require oil companies to disclose their payments to developing country governments for oil concessions. Dispersed information sources indicate that some countries, such as Ecuador and Angola, receive up to 50% of their revenue from oil taxes and profit sharing (11, 12).

Oil, also, obviously creates significant and varied negative impacts and costs to human health, cultures, and the environment. Thus, it is critical to evaluate the costs as well as the benefits of oil. Although the NEPDG report encourages more oil development, it provides little information on the negative consequences of this development. Instead, the report cites only technological advances that have minimized the impacts of oil exploration and refining.

Past analyses of the oil industry have fallen into several categories. First, there are a wide number of industry sources of data and analysis on the locations, production levels, technological challenges, and economics of oil production and refining (13, 14). There have also been a wide range of historical analyses of political and economic developments in the oil industry around the world (15–17). And more recently, there have emerged a growing number of exposes and reports on the environmental and social impacts of oil exporation, transport, and refining.

Unfortunately, there is no comprehensive source of data available to analyze the global distribution of impacts of oil production and consumption. A wide range of sources—government data, academic analyses, media coverage, nongovernmental organization (NGO) reports—must be consulted to evaluate the costs and benefits of oil.

II. ENVIRONMENTAL JUSTICE FRAMEWORK

This review presents existing data and analyses of the global distribution of the impacts of oil. Using an environmental justice framework (18, 19), we describe and evaluate the environmental, social, and health impacts of oil extraction, transport, refining, and consumption. This perspective seeks to provide a lens through which to examine the distributional and procedural impacts (and inequities) of oil extraction, transport, refining, and consumption among socioeconomic and ethnic groups, communities and countries, and ecosystems. Within this conceptualization, major concerns include the distribution of control over oil, the distribution of environmental and socioeconomic costs of oil, the hazards and risks from oil, and the procedures and politics surrounding the regulation of these risks.

The environmental justice framework stresses the need to evaluate power in driving the distribution of benefits and costs of industrial activities. In industries such as oil, it is not just ownership, as we will discuss below, but rather control over key stages of the oil chain that significantly influences who benefits and who pays the costs of oil development. Thus, we begin with an inquiry into current patterns of control over oil resources, infrastructure, and refining and follow with an assessment of the distribution of power and influence over government decisionmaking and regulation of the industry (Section III).

Next, we evaluate the distribution and regulation of environmental and health hazards from oil production and consumption. We are interested particularly in the distribution of risks and costs, both at the local and global level, of oil exploration, drilling, and extraction (Section IV), transport (Section V), refining (Section VI), and consumption (Section VII).

We also seek to analyze whether existing regulatory systems adequately protect impacted communities at each stage in the life cycle of oil. Extensive regulations govern oil exploration and refining. However, there is also wide variation in the implementation of these regulations, weak enforcement in many locales, and failures of regulation in certain arenas. We are thus interested in whether enforcement is effective at different stages in the oil supply chain and whether regulatory mechanisms are sufficient to motivate remediation and prevention of future impacts (Section VIII).

The review concludes with a critical evaluation of current research and data and with recommendations for further analysis of the distributional and procedural impacts of oil production and consumption.

III. CONTROL OVER OIL

Perhaps the most critical and historically contentious questions related to oil are simply who owns, controls, or has access to this resource? Control over reserves, production, distribution, and refining is critical to the distribution of benefits and costs of oil and to deeper global, economic, and political dynamics.

Approximately 90 countries produce oil, although a few major producers account for the bulk of world output. The Energy Information Agency estimates that the eleven Organization of Petroleum Exporting Countries (OPEC) members (Algeria, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, and Venezuela) account for roughly 77% of the world's proven oil reserves and 40% of world oil production (20). The Persian Gulf contains approximately 680 billion barrels of proven oil reserves, which represents approximately 66% of the total world oil reserves (21). The Persian Gulf maintains 31% of the world total oil production capacity (just over 22 million barrels per day) (22).

In 2001, Persian Gulf countries had oil exports of approximately 16.8 million barrels per day of oil. As would be expected, Saudi Arabia exported the most oil of any country in 2001, with an estimated 7.4 million barrels per day (22). Major non-OPEC oil producing countries include the United States, Mexico, Denmark, Norway, the United Kingdom, the Russian Federation, China, and Vietnam.

Proven reserves—the most basic measure of who has the oil, and how much—have actually changed over the past 20 years. Proven reserves increased 54% between 1980 and 1990, largely due to improvements in exploration and drilling, but were then stagnant between 1990 and 2000 with an increase of only 1.4% globally (23). As would be expected, many countries' reserves are declining significantly. In the United States for instance, proven reserves declined from 36.5 billion barrels in 1980 to 30.1 billion barrels in 2000 (24). Table 1 presents basic information on oil reserves, production, and exports from leading oil producing nations.

While the physical location of oil does not change, systems of control over oil have changed significantly over the past two decades. In particular, there has been a

TABLE 1 World oil reserves, production, and exports in 2001 (25, 26)

Country	Total oil reserves (billion barrels)	Total oil production (million barrels per day)	Net oil exports (million barrels per day)
United States	22.0	9.02	0.9
Saudi Arabia	261.7	8.73	7.38
Russia	48.6	7.29	4.76
Iran	89.7	3.82	2.74
Mexico	28.3	3.59	1.65
Norway	9.4	3.41	3.22
China	24.0	3.30	0.1
Venezuela	76.9	3.07	2.60
Canada	6.6	2.80	1.8
United Kingdom	4.9	2.59	1.7
Iraq	112.5	2.45	2.00
United Arab Emirates	97.8	2.42	2.09
Nigeria	22.5	2.26	2.00
Kuwait	96.5	2.15	1.80

major restructuring and concentration of ownership in the global oil industry. This change in power and control has had significant implications for the distribution of benefits accruing to oil producers and refiners and for the distribution of costs to oil producing regions and consumers.

Historically, state-owned companies controlled most oil in the world. The four largest state oil companies, Saudi Aramco, Petroleos de Venezuela, Iran's NIOC, and Mexico's Pemex, produce 25% of the world's oil and hold 42% of the world's reserves (27). Physical ownership over oil, however, may not be as important as mechanisms of control and distribution. Access to and control over oil is as important today as actually owning it, and increasingly, private oil companies are exerting critical control over the industry. In this regard, privatization has progressed rapidly during the 1990s. In virtually every region of the world, an industry that was previously considered critical to economic and physical security and that was owned by the government has been partly or wholly sold to local and foreign private investors.

A recent wave of mergers, worth over $200 billion, has further changed the face of the industry during the 1990s (28). A top echelon of "super majors" has been created that far surpasses other publicly traded oil companies by any measure of size. "The scale of the super majors puts them on a par with the largest state companies. The four super majors—ExxonMobil, Royal Dutch/Shell, BP-Amoco, and Total Fina Elf—have a preponderance in the downstream, with about 32 percent of global product sales and 19 percent of refining capacity. This counterbalances to a large extent the dominant upstream positions of the four large state oil companies, Saudi Aramco, Petroleos de Venezuela, Iran's NIOC, and Mexico's Pemex. With the super majors and the largest state oil companies, the industry is now dominated by a handful of 10 or 12 giant concerns that dwarf those immediately beneath them" (27).

The recent concentration of the industry is particularly stark among firms operating in the United States. By 2001, five corporations (ExxonMobil, BP-Amoco-Arco, Chevron-Texaco, Phillips-Tosco, and Marathon) controlled 61% of the U.S. retail gas market, 47% of the U.S. oil refinery market, and 41% of U.S. oil exploration and production. These firms currently control 15% of world oil production—more than Saudi Arabia, Yemen, and Kuwait combined (29).

This change in control over oil extraction and distribution has had significant impacts on the very countries that own oil. The economic strength of a nation directly affects its ability to negotiate with the super majors and in turn to benefit from selling or leasing oil. Poor nations that are dependent on oil sales for key revenues are often adversely affected by their ownership of the resource (30). As Ross (12) has shown, poor countries that are oil dependent often have slower rates of economic development, higher levels of corruption, higher military spending, worse performance on reducing child malnutrition and adult illiteracy, and are more vulnerable to economic shocks.

There are also clear inequities in the distribution and consumption of oil. Advanced industrialized countries use orders of magnitude more oil than many

TABLE 2 World oil net importers in 2001 (25)

Country	Net oil imports (million barrels per day)
United States	10.8
Japan	5.4
Germany	2.7
South Korea	2.1
France	2.0
Italy	1.7
China	1.6
Spain	1.5
India	1.3

developing countries. Table 2 shows that the United States is by far the largest importer and consumer of oil in the world.

The United States imports almost 11 million barrels of oil per day. Interestingly, the United States currently only imports approximately 24% of its oil from the Persian Gulf; Canada is its top source of imported oil (15%), followed by Saudi Arabia (14%), Venezuela (14%), Mexico (12%), and Nigeria (6%) (31).

The United States is also the largest refiner of oil in the world, with overall refining capacity of approximately 16.6 million barrels per day. The average capacity of U.S. refineries increased from 70,000 barrels per day in 1985 to 115,000 barrels per day in 2001 (32). However, during this period, the number of U.S. refineries actually decreased by half from 324 to 143, further concentrating control in a handful of corporations and impacts in fewer communities. Russia, Japan, and China are the only other countries with refinery capacities exceeding 3 million barrels per day. Russia's refinery capacity stands at an estimated 5.4 million barrels per day, Japan's at 4.8 million, and China's at 4.5 million (25).

IV. IMPACTS OF EXPLORATION, DRILLING, AND EXTRACTION

Oil exploration, drilling, and extraction are the first phase—or what the industry calls the "upstream" phase—in the long life cycle of oil. There are currently approximately 40,000 oil fields in the world, (33) and there have been over 4000 new oil exploration licenses granted in the past 10 years (34). Increasingly complicated and expensive processes for locating oil deposits in remote and inhospitable locations, bringing the oil to the surface, and then getting it to a market have major environmental, cultural, and health impacts (35–37).

On- and off-shore exploration, drilling, and extraction activities are inherently invasive and affect ecosystems, human health, and local cultures. Oil companies combine the use of remote sensing and satellite mapping techniques with seismic testing to identify potential oil reserves. When reserves are identified remotely, companies build roads, platforms, and pipelines, bring in crews and vehicles, and drill exploratory test wells. Once oil is discovered, exploration activities are expanded for commercial-scale extraction, which requires more wells and infrastructure. Techniques for oil extraction include a range of drilling techniques and the use of subsurface explosives (including in a few historical cases the use of nuclear charges) (38).

The physical alteration of environments from exploration, drilling, and extraction can be greater than from a large oil spill. Major impacts include deforestation, ecosystem destruction, chemical contamination of land and water, long-term harm to animal populations (particularly migratory birds and marine mammals), human health and safety risks for neighboring communities and oil industry workers, and displacement of indigenous communities.

Exploration requires moving heavy equipment (mobile rigs for temporary drilling can weigh over 2 million pounds) into remote environments. Clearing land for roads and platforms can lead to deforestation and erosion (38). Drilling during both exploration and extraction phases uses significant quantities of water, which are contaminated through drilling and then discharged along with cuttings into the environment. These discharges result in chemical contamination of land and water from petroleum waste, drilling fluids, and by-products of drilling such as water, drill cuttings, and mud. As Epstein & Selber assert, "The general environmental effects of encroachment into natural habitats and the chronic effects of drilling and generating mud and discharge water on benthic (bottom-dwelling) populations, migratory bird populations and marine mammals constitute serious environmental concerns for these ecosystems" (38).

The oil and gas industry in the United States alone creates more solid and liquid waste than all other categories of municipal, agricultural, mining, and industrial wastes combined. Oil and gas drilling and pumping produce most of the sector's waste. Approximately 20% of nonhazardous waste produced in the United States every year comes from oil and gas exploration and production. However, the majority of production waste from the industry is the hazardous and toxic effluent known as *produced water*. Produced water is extracted from the ground along with oil and is often reinjected into wells under high pressure to force more oil to the surface. Produced water not reinjected is discharged into surface waters (8). As Doyle explains, this "produced water is at least four times saltier than ocean water and often contains 'industrial strength' quantities of toxins such as benzene, xylene, toluene, and ethylbenzene. Heavy metals such as barium, arsenic, cadmium, chromium, and mercury have also been found in produced water. Produced water can also be radioactive—in some cases, as much as 100 times more radioactive than the discharge of a nuclear power plant" (8).

In 1995, it was estimated that 15 billion barrels of produced water were extracted annually in the United States. Over 90% of onshore produced water is reinjected into wells (39). Reinjection is permissible under the Resource Conservation and Recovery Act (RCRA), because Congress conditionally exempted drilling fluids, produced waters, and other wastes from crude oil production (39).

Water used in oil production can also be contaminated by chemicals used during extraction. For example, the oil industry uses millions of tons of barium, a toxic heavy metal, in drilling fluids each year. Common components of drilling fluids can solubilize the barium, creating hazardous waste, which is often discharged into the environment from leaks of reinjected materials (8).

Exploration and extraction also produce voluminous amounts of solid wastes known as *drilling wastes* and *associated wastes*. In 1995, the U.S. sector produced 146 million barrels of drilling waste and 22 million barrels of associated wastes (39). Although associated wastes constitute a relatively small proportion of total wastes, they are most likely to contain a range of chemicals and naturally occurring materials that are of concern to health and safety. Each year 58% of associated wastes in the United States are reinjected, 9% are sent to commercial facilities, and 8% are disposed of through evaporation pits (39). In oil fields, virtually every stage in production has a waste pit. As Doyle notes, during drilling, “various muds, oily fluids, lubricants, and other chemicals are used to cool the drill bit, stabilize the walls of the bore hole, or liquefy earthen cuttings. These fluids and additives accumulate in large quantities during the drilling process, and are often stored or finally disposed in waste pits” (8). Exposed waste pits pose a danger not only to aquifers but also to animals and birds that mistake the pits for water holes and become coated with toxic wastes (8).

In addition to operational leaks, oil spills also occur during extraction. In 2002, the National Academy of Sciences estimated that 38,000 tons of petroleum hydrocarbons were released into the world’s oceans each year during the 1990s as a result of oil and gas operations (40). On- and offshore oil production can also create significant air pollution. Emissions from drilling equipment, hydrocarbons escaping from wells, flaring of natural gas, and emissions from support vehicles can degrade local air quality (41).

Oil exploration, drilling, and extraction can also lead to a range of acute and chronic health impacts. These risks occur through exposure to naturally occurring radioactive materials brought to the surface during drilling, as well as through the bioaccumulation of oil, mercury, and other products in mammals and fish that humans consume (38). Noise, vibration, and exposure to toxic chemicals are also issues in upstream and downstream operations. Many of the substances used in daily extraction work cause adverse dermatologic and pulmonary reactions among workers. The most common dermatologic conditions are contact dermatitis and acne, but other conditions include keratotic facial and neck lesions, neoplastic change from exposure to oil and sunlight, and acquired perforating disease and calcinosis of the hands and fingers. Adverse pulmonary reactions to hard metal (a mixture of tungsten carbide and cobalt used for oil well drilling bits) include asthma, hypersensitivity pneumonitis, and interstitial pulmonary fibrosis (38).

The risk of explosions, injuries, and fatalities during exploration and extraction are also cause for concern. Virtually every segment of oil and gas production involves risk of fires and explosions, particularly offshore drilling operations that are vulnerable to blowouts. The handling of heavy pipes and other equipment also creates safety risks. Thus, oil workers around the world face significant occupational hazards. Oil exploration and drilling is the most dangerous sector of the oil industry. Recently, the oil and gas sector has experienced a series of major fires and explosions in both extraction installations and refineries. For example, in 1998 in Africa and the Middle East, there were 54 fatal incidents in onshore operations and 17 fatal incidents offshore (6).

Oil exploration often occurs in remote and harsh environments, such as deserts, jungles, the Arctic, and far offshore. Workers live in or near these harsh workplaces for long periods. These working conditions can create additional risk during transport, and stress from long shifts and social isolation.

There are no good international data or comprehensive analyses of the distribution of impacts from oil exploration, drilling, and extraction. However, a number of recent studies have shown that current oil exploration has a disproportionate impact on indigenous populations and sensitive, remote ecosystems (42). Kretzmann & Wright, for instance, report that indigenous groups in 6 continents and 39 countries "face an immediate to medium-term threat from new oil and gas exploration" (42). In the western Amazon alone, at least 50 indigenous groups, many of which are the world's last isolated indigenous peoples, live within oil and gas concessions that are under exploration or preproduction. These groups include the Tagaeri and Huaorani of Ecuador; the Mascho-Piro, Nahua, and Kugapakori of Peru; and the Nukak and U'Wa of Columbia. Beyond the Amazon, oil exploration, drilling, and extraction affect the Baka, Bakoli, and Ogoni of Central Africa; the Tavoyans, Mon, and Karen of Burma; the Eastern Khanty peoples of Western Siberia; and the Gwich'in of Alaska (42).

Oil production activities not only disrupt sensitive environments, but threaten the survival of indigenous populations that live in these ecosystems. Kretzmann & Wright argue that "territorial integrity and control are necessary for the cultural reproduction and ultimately the survival of Amazonian indigenous populations whose way of life and well being are closely tied to a thriving rainforest" (43). Throughout the Amazon basin, road building causes deforestation, which contributes to the loss of territory and displacement of native groups. The opening of access roads allows settlers with competing interests such as logging and mining to enter indigenous communities and colonize the areas (43). This colonization can also bring infectious diseases to previously unexposed native populations (38).

The contentious nature of these interactions can often lead to conflict over oil resources and infrastructure. At least four types of conflicts occur over oil: (a) conflict with indigenous groups over oil development; (b) civil unrest or war that uses disruption of oil operations as a tactic; (c) superpower geopolitics (e.g., control over Middle East oil reserves); and (d) terrorism targeting oil facilities. Table 3 summarizes examples of just one type of conflict, incursions into indigenous lands to control oil. Though by no means comprehensive, this table demonstrates the widespread impacts of oil development on indigenous peoples.

TABLE 3 Incursions into indigenous lands to control oil (44–46)

Location	Indigenous group	Companies and agencies involved
Alaska	Gwichin	BP Amoco ExxonMobil Chevron Phillips Petroleum
Australia	Aboriginal	Dept. of Mineral and Petroleum Resources
Bolivia	Chiquitano Ayoreo Guaraní Weenhayek	Andean Development Corporation British Gas Enron Gas TransBoliviano SA Inter-American Development Bank Pan-American Energy Petrobras Repsol YPF Shell Transredes United States Overseas Private Investment Corporation World Bank
Brazil	Apurina Paumari Deni Juma	Brazilian National Development Bank El Paso Energy GasPetro (Petrobras) Halliburton
Burma	Karen	Unocal Total Fina Elf
Colombia	Uwa	British Petroleum Occidental Shell AirScan Ecopetrol
Ecuador	Sarayacu Kichwa Shuar Achuar Huaorani	Agip Oil Alberta Energy Burlington Resources ChevronTexaco Kerr McGee Occidental Petroleum Repsol-YPF Westdeutsche Landesbank
Indonesia	Aceh	Exxon
Nigeria	Ogoni Ijaw	Shell Nigerian National Petroleum Company
Peru	Kirineri Nahua Nanti	Hunt Oil Inter-American Development Bank Shell United States Export-Import Bank

Migration of oil crews to new reserves also creates socioeconomic and human rights concerns, especially in the Middle East and other regions of the developing world, because poor and lower class populations move both by choice or are motivated (sometimes forcibly) to relocate to oil development centers. In Saudi Arabia, for example, 35% of the population is composed of immigrant workers. In addition, foreign workers account for 61% of the total workforce of Oman, 83% in Kuwait, and 91% in the United Arab Emirates (47).

This supply of cheap foreign labor, primarily from South Asia, is essential to the profitability of oil production in the Middle East. Countries, such as India, Pakistan, Nigeria, Egypt, Sudan, Bangladesh, Sri Lanka, Thailand, Indonesia, and the Philippines, provide both skilled and unskilled labor to the Middle East. In several Persian Gulf states, these temporary immigrant workers outnumber citizens by a factor of two to one or even three to one. Their presence in the region underscores the wealth disparity between those who bear the costs and those who benefit from oil production. Although the ruling classes in these kingdoms are among the richest people in the world, much of the citizenry does not benefit from the significant profits earned by the industry (48).

Even the most basic workplace rights and health and safety protections are abridged in some of the largest oil-producing countries. In Saudi Arabia, labor laws prohibit the right of workers to organize unions or bargain collectively and grant employers extensive control over foreign workers' movement. Human Rights Watch reports that many foreign workers suffer under oppressive working conditions and are denied legitimate claims to wages, benefits, and compensation (49).

V. IMPACTS OF OIL TRANSPORT

The current separation between the location of oil reserves and the location of oil consumption necessitates that crude oil be transported great distances to refineries and consumer markets. This has led to the development of increasingly complex transportation systems that allow oil to be delivered virtually anywhere in the world. Major oil routes now stretch from the Middle East to Japan, from South America to Europe, and from Africa to the United States. Transport of oil occurs via supertankers, barges, trucks, and pipelines. Oil tankers are currently the primary means of transportation, but oil is increasingly being transferred through pipelines. Today, oil makes up over half of the annual tonnage of all sea cargoes, and there are now more miles of oil pipelines in the world than railroads (50).

Transportation of oil results in regular oil spills throughout the world. Although large oil spills are well publicized, smaller but cumulatively significant spills from shipping, pipelines, and leaks often go undocumented. As Doyle explains, "oil transport—by pipelines, railcar, or truck—generates an unknown and untabulated amount of waste, including tank bottom sludges, contaminated water from storage tanks, oil/water separator sludge, solvent degreasers, used oil, contaminated product, product that does not meet specifications, lubricants, spent antifreeze, and clay filtration elements" (8).

Accidents occur along all segments of the transport system and at each point of transfer. Since the 1960s, large-scale oil spills have occurred almost every year. Transport by water is currently more likely to result in a spill than transport by pipeline. Ocean transport of crude oil and petroleum products accounted for 3000 gallons spilled per billion ton-miles in 1983 and nearly 8000 gallons per billion ton-miles in 1984. Pipeline spills contributed less than 100 gallons per billion ton-miles for both years (41).

In the past 20 years, there have been over 30 oil spills of 10 million gallons or more each. One to three spills of this size occur each year (50). In fact, a few very large spills are responsible for a high percentage of oil spilled annually. From 1990 to 1999 there were 346 spills over 7 tons, which totaled approximately 1.1 million tons, but 830,000 tons (75%) were spilled in just 10 incidents (just over 1% of incidents). Annual figures, therefore, can vary greatly depending on the number of large spills. For example, in 1999, 29,000 tons were spilled, but in 2001 only 8000 tons were spilled (51).

A key to the size of spills has been the trend in tanker construction toward massive ships. In the 1930s, large tankers carried about 20,000 tons of oil. By the early 1970s, tankers could carry 800,000 tons of oil. This increase in size (some tankers are over three football fields long) also increases the likelihood of accidents because supertankers are harder to maneuver (50). Table 4 highlights the largest oil spills on record.

To provide some perspective, the *Exxon-Valdez* spill, which released 12 million gallons of oil (53), was the largest U.S. spill recorded to date, but only the 28th largest oil spill in world history (38). The *Prestige* oil tanker that split in half off

TABLE 4 Ten largest oil spills in history ranked by volume (52)

Rank	Name	Year	Volume in gallons
1	Persian Gulf: tankers, pipelines and terminals, offshore Saudi Arabia	1991	240,000,000
2	Ixtoc I oil well, Ciudad del Carmen, Mexico	1979–1980	140,000,000
3	Nowruz Field, Persian Gulf	1983	80,000,000
3	Fergana oil well, Uzbekistan	1992	80,000,000
5	*Castillo de Bellver* tanker, offshore Cape Town, South Africa	1983	78,500,000
6	*Amoco Cadiz* tanker, offshore Brittany	1978	68,670,000
7	*Aegean Captain* tanker, offshore Tobago	1979	48,800,000
8	Production well D-103, Tripoli, Libya	1980	42,000,000
9	*Irenes Serenade* tanker, Pilos, Greece	1980	36,600,000
10	Kuwait storage tanks	1981	31,170,000

TABLE 5 Hot spots for tanker oil spills since 1960 (55)

Location of hot spot	Number of spills
Gulf of Mexico	267
Northeastern United States	140
Mediterranean Sea	127
Persian Gulf	108
North Sea	75
Japan	60
Baltic Sea	52
United Kingdom and English Channel	49
Malaysia and Singapore	39
West Coast of France/North and West Coasts of Spain	33
Korea	32

the coast of Spain in 2002, causing major ecological and economic damage, was carrying approximately 22 million gallons of oil.

Oil spills occur literally all around the world. The Oil Spill Intelligence Report has documented spills of at least 10,000 gallons in the waters of 112 nations since 1960. However, they also note that spills occur more frequently in certain areas (54). Table 5 shows a number of "hot spots" for oil spills from tankers.

In recent years there has been a steady increase in number of small spills while large-scale spills have stayed relatively constant. The cumulative impact of small spills of less than 100,000 gallons adds up to about 10 million gallons per year worldwide (50). Table 6 shows that the greatest quantity of oil from marine transport is actually released in the form of bilge and fuel oil. In fact, emissions of

TABLE 6 Sources of oil spills from marine transport, 1990 (56)

Emission source	Tons per year
Bilge and fuel oil	250,000
Tanker operations	160,000
Tanker accidents	110,000
Nontanker accidents	10,000
Marine terminal operations	30,000
Dry-docking and scrapping of ships	10,000
Total	570,000

bilge and fuel oil are equivalent to approximately five *Exxon-Valdez* spills per year. For many years, it has been common practice to dump oil-contaminated ballast water and tank washings directly into the sea. So while most of the large-scale spills result from grounded tankers or tanker collisions, the cumulative contamination from numerous relatively small accidents, leaks, and intentional discharges can actually surpass that of large spills from shipping (38).

Pipelines, which are highly prone to corrosion, are also a source of spills, leaks, and fires. Many pipelines are used long after their engineering life span (an estimated 15 years) (38). Using the U.S. Office of Pipeline Safety database, Nesmith & Haurwitz have estimated that 67 million gallons of crude oil, gasoline, and other petroleum products leaked from U.S. pipelines in the last decade. However, "there is consensus—among the industry, its regulators and its critics—that the database underrepresents the quantity of oil products that escapes from pipelines." The actual amount of leakage is potentially twice as high as the annual reported average (57). Even the U.S. government, in the National Energy Policy, acknowledges that inland oil spills are a major source of oil emissions and that these spills appear to be on the rise. As they report, "the federal government receives many more inland oil spill notifications (9,000 notifications a year in the early 1990s versus 10,000 to 12,000 a year in the late 1990s)" (2).

The main impacts of vessel oil spills obviously fall on marine ecosystems and coastal communities. A number of factors influence the scale of these impacts, including the size of the spill, the kind of oil, the season of the spill, and the vulnerability of local plants and animals (40). The spill size often determines the area affected, whether it reaches the shore, and how much of the shore it covers. The extent of contamination also depend on the nature of the coastal ecosystems and the types of birds and mammals affected (58). Some ecosystems, such as mangroves, salt marshes, coral reefs, and polar bear habitats, are particularly sensitive to oil spills and can take years to recover (59).

Oil spills also threaten human health through illness and injury during the spill, during cleanup, and through consumption of contaminated fish or shellfish. Drinking water supplies can also be contaminated through spills (50). But as Burger notes, "There are remarkably few studies of the health responses of local people exposed in the months following a spill" (50). In one study in Scotland following an oil spill, community members reported increased health problems, including increased psychiatric symptoms (50).

Oil spills can also have long-lasting economic consequences by damaging fisheries, excluding fisherfolk from fishing grounds, fouling fishing gear, and reducing fish stocks in succeeding years (50). Commercial fisheries can also be negatively impacted by the simple perception of tainted fish. Public concern about eating fish exposed to oil spills can damage the market for fish from an affected region. Even a few oiled fish can taint an entire region's catch. In the case of the *Exxon Valdez* oil spill in Alaska, closing the fisheries in Prince William Sound resulted in a season's loss of income for commercial fishermen and an estimated $135 million in lost revenues (50).

Subsistence communities are often even more severely harmed by oil spills. Unfortunately, there is no global database on impacts of oil releases on indigenous communities or sensitive ecosystems. Recent cases, however, highlight troubling impacts. The *Exxon Valdez* oil slick covered shorelines used by the Chugach people of Alaska for subsistence hunting, fishing, and gathering. Fifteen Aleut communities in Prince William Sound and the Gulf of Alaska were affected by the oil spill. Subsistence harvests came to a virtual halt after the oil spill. Communities decreased their harvests between 14% and 77% depending on whether they had access to oil-free upland species. One community on Chenaga Bay on the Prince William Sound reduced its harvest from 342 to 148 pounds per person per year. Another community in English Bay on the Kenai Peninsula reduced consumption from 289 to 141 pounds per person per year. The variety of species harvested also declined from 23 to 12 (50).

Oil pipelines have also caused disproportionate impacts on low-income and minority communities in the United States and been connected to human rights violations around the world. In the United States for example, the Pacific Pipeline, a project constructed by a consortium of Chevron, Unocal, and Texaco in the late 1990s, faced a lawsuit from the City of Los Angeles that alleged their routing of the pipeline constituted an environmental injustice. Pacific Pipeline is a 132-mile long heavy crude pipeline that transports 130,000 barrels per day of oil from Bakersfield, California, through the heart of Los Angeles, into the refinery district on the Pacific Coast (60). In transit through the City of Los Angeles, it bisects 75 neighborhoods. Analysis conducted by Impact Assessment Inc. for the City of Los Angeles demonstrated that 74 of the 75 communities had minority populations higher than the national average; 72 of the 75 had minority populations higher than the California average; 42 of the 75 had minority populations over 90% of the total tract population; all of the tracts had a higher percentage of non-English speakers than the national average; and 62 of 75 had per capita income lower than the national, state, county, and city levels (61).

Construction of oil pipelines in developing countries has also been associated with human rights abuses. The current debate regarding the construction of the Chad-Cameroon Pipeline highlights the potential for corruption and violations of human rights in such projects. The project, sponsored by an international consortium lead by ExxonMobil and ChevronTexaco involves the development of the Doba oil fields in southern Chad and the construction of a 1070-kilometer pipeline to an offshore oil-loading facility on Cameroon's Atlantic coast. Advocacy groups such as Rainforest Action Network (RAN) have raised concerns about increasing violence and human rights abuses, corruption, and devastation of the Bakola (or Pygmie) peoples who live along the pipeline. RAN notes that "both the US State Department and Amnesty International have documented serious human rights abuses by Chad and Cameroon governments, including extrajudicial killings, torture, abuse, rape, limiting freedom of the press and arresting opposition politicians and other civilians. Many believe that there has already been an increase in violence and human rights abuses in Chad as a result of the pipeline project" (62).

VI. IMPACTS OF OIL REFINING

Oil in its crude form has limited uses. It must be separated, converted, and refined into useful products such as gasoline, heating oil, jet fuel, and petrochemical feedstock. The basic oil refining process involves thermal “cracking” which applies both pressure and intense heat to crude oil in order to physically break large molecules into smaller ones to produce gasoline and distillate fuels. Any crude-oil constituents that are not converted into useful products during this process, or captured by pollution-control technologies, are released to the environment (63). Refineries produce huge volumes of air, water, solid, and hazardous waste, including toxic substances such as benzene, heavy metals, hydrogen sulfide, acid gases, mercury, and dioxin (64).

There is no single source of data on global refinery emissions or impacts. However, U.S. refinery emissions are reported by the Environmental Protection Agency (EPA) through the Sector Facility Indexing Project (SFIP) and the Toxic Release Inventory (TRI). Several independent studies have also examined refinery emissions in the United States (63, 65, 66). In the 1990s, the U.S. EPA targeted oil refineries as their top enforcement priority (64). According to the EPA, in 1999, 54% of refineries were in “significant non-compliance” (meaning they have committed persistent, serious violations) of the Clean Air Act; 22% were in significant noncompliance with the Clean Water Act; and 32% violated the Resource Recovery and Conservation Act (67).

The Emergency Planning and Community Right-to-Know Act of 1986 requires that manufacturing facilities above a certain size provide information about toxic chemical releases and offsite waste transfers to the national TRI. The oil refining sector, but not exploration or extraction, is required to report to the TRI. Each refining facility in the United States must report annual emissions of roughly 600 listed chemicals. Unfortunately, as Epstein et al. note, “Of the hundreds of toxic chemicals in crude oil and refinery products, only a few are typically reported to TRI. Many of those not included have similar structural, physical, and toxicological properties to those that are reported . . . . According to the Amoco Yorktown study, this refinery’s TRI report forms cover only 9% of the total hydrocarbons released” (63).

Local environmental impacts from oil refineries result from toxic air and water emissions, accidental releases of chemicals, hazardous waste disposal, thermal pollution, and noise pollution. Analysis of the TRI data reveals that the petroleum refining industry releases 75% of its toxic emissions to the air, 24% to the water (including 20% to underground injection and 4% to surface waters), and 1% to the land (39). The primary hazardous air pollutants released by the industry are benzene, toluene, ethyl benzene, mixed xylenes, and n-heptane (39). The accumulation of refinery air emissions such as hydrocarbons, sulfur dioxide, and particulates in the atmosphere also contributes to acid rain (38). U.S. refineries are the second largest industrial source of sulfur dioxide, the third largest industrial source of nitrogen oxides, and the largest U.S. stationary source of volatile organic compounds (VOC) emissions, producing more than twice as many VOCs as the next sector, organic chemical plants. Refineries are also the fourth largest source of toxic air pollutants (65). Paul Templet, former head of the Louisiana Department of Environmental Quality and professor at Louisiana State University's Institute for Environmental Studies, has measured jobs and tax subsidies per pound of pollutants emitted and shown that petroleum refining produces 1048 pounds of pollution per job, as compared to 460 pounds of pollution per job for paper manufacturing, 222 pounds for plastics manufacturing, 61 pounds for tobacco production, and 28 pounds for food production (68).

The majority of refinery emissions actually occur through leaks rather than through regulated smokestacks or effluent pipes. In 1999, Congressman Henry A. Waxman commissioned an investigation into fugitive emissions from oil refineries by the minority staff of the House of Representatives Government Reform Committee. The study found that oil refineries significantly underreport leaks from valves to regulators and that these fugitive emissions add millions of pounds of pollutants to the atmosphere each year, including 80 million pounds of VOCs and 15 million pounds of toxic pollutants (65). Production pressures in the oil industry are such that it is more economical to allow fugitive emissions and to lose some oil than to close down leaky facilities for repair (8).

An EPA study of the Amoco oil refinery in Yorktown, Virginia, demonstrated that the cumulative effects of refinery leaks can lead to major impacts. Although only 0.3% by weight of crude oil by-products from the Amoco refinery was released into the environment, this led to over 11,000 gallons of oil components released (66). Because the oil refining industry in the United States processes more than 16 million barrels of crude oil each day, approximately 50,000 barrels of byproduct likely are released per day.

Refineries also use thousands of gallons of water per day for production and cooling processes. Treatment of liquid effluent does not entirely eliminate contaminants such as aromatic hydrocarbons (benzenes and napthenes) that enter waterways utilized by humans, fish, and wildlife (38). For example, one recent study of water pollution from oil refineries found significant levels of aromatic hydrocarbons that contributed to important differences in the diversity and abundance of fish between stations located up- and downstream from refineries (38). Thermal pollution from the release of refinery effluent, which is warmer than surrounding waters also disrupts marine ecosystems.

The operation of refineries results in fires, explosions, and chemical spills. In California, for example, refineries are responsible for over 90% of all accidental releases in the state. Hazardous-waste disposal from refinery facilities also threatens nearby communities. According to the EPA, oil refining is one of the top hazardous waste producing industries: "Disposal methods for toxic refinery wastes have tended to take advantage of wide open spaces instead of environmentally sound waste management techniques" (8). In fact, approximately two thirds of solid wastes from U.S. refineries are disposed of through burial in onsite reserve pits (39).

Wastes from oil refineries can create health risks to facility workers and surrounding communities. Workers are at risk of accidents involving fires, explosions, and chemical leaks and spills. Health hazards include exposure to heat, polluted air, noise, and hazardous materials, including asphalt, asbestos, aromatic hydrocarbons, arsenic, hexavalent chromium, nickel, carbon monoxide, coke dust, hydrogen sulfide, lead alkyls, natural gases, petroleum, phenol, and silica. Epstein & Selber (38) report a number of health impacts from exposure to these materials; these include the following:

1. severe burns or skin and eye irritation from high levels of benzene and hydrogen sulfide fumes, which may lead to dermatitis, bronchitis, and chemically induced pneumonia;
2. headaches and mental disturbances from carbon-monoxide exposures;
3. chronic lung disease from long-term exposures to coke dust, silica, and hydrogen sulfide;
4. psychosis and peripheral neuropathies from exposures to lead alkyls used as gasoline additives; and
5. increased cancer risks from exposures to carcinogenic materials such as benzene, xylene, arsenic, and hexavalent chromium.

Management of refineries and their impacts are also increasingly being outsourced to service companies. Conoco and ExxonMobil, for example, have contracted Philip Services to operate and maintain oil refineries, which minimizes the actual owners' liability and keeps contract employees' wages low. Contract workers are usually nonunion and often poorly trained; this results in more accidents and more risk to workers and surrounding communities.

Philip Services also operates landfills and other treatment, storage, and disposal (TSD) facilities for the oil industry and has disposed of waste materials at more than 200 third-party disposal facilities. Many of these sites have been declared superfund sites, although Philip's liability for cleanup of these sites is unknown. Even tracking Philip's current pollution record is difficult, given the loopholes in disclosure for TSD operations and as Philip has dozens of subsidiaries. In fact, in June 1999, Philip declared Chapter 11 reorganization.

Health impacts extend outside the walls of refineries, where studies have demonstrated the relationship between proximity of communities to refineries and cancer. For example, a 1994 analysis of 264 childhood leukemia clusters in the United Kingdom showed relative, nonrandom proximities to oil refineries (38). A similar study of all 22,458 children aged 0–15 years dying from leukemia or cancer in England, Wales, and Scotland between 1953 and 1980 found increased incidence of leukemia and other cancers near industrial facilities, particularly oil refineries, oil storage facilities, and railside oil distribution terminals (38).

A 1995 report by the Environmental Defense Fund, which used 1992 TRI data on the refining industry, developed a ranking of refineries throughout the United States. The study compared the pollution produced per barrel refined at each facility. Through this comparative analysis, it showed wide variation in emissions (and thus impacts) from facilities on local environments and human health. The report identified West Virginia, Kansas, Texas, Mississippi, and Wisconsin as the five worst states in terms of emissions per pound of product. Nevada, Georgia, New York, Alaska, and New Jersey were ranked as the five most efficient states (63).

The EPA SFIP brings together similar types of comparative environmental performance data on refineries. The SFIP reports production levels, compliance and inspection data, chemical releases and spills, and, interestingly, demographics of the surrounding population. By combining TRI data with inspection reports and demographic data, the SFIP is a unique resource for evaluating the distribution of impacts from oil refineries. These data show for instance that 56% of people living within three miles of refineries in the United States are minorities—almost double the national average.

Anecdotal evidence from areas surrounding particularly polluting refineries seems to confirm that low-income and communities of color are disproportionately affected by these facilities. For instance, predominantly African-American communities in Louisiana report long-term exposures to toxics and general disregard for health impacts from refineries located in the so-called Cancer Alley region along the Mississippi River. The residents of Saint Charles Parish in Louisiana provide graphic examples of these problems. At just one refinery, the Shell Norco facility, there have been repeated explosions that have claimed workers' and community members' lives, including a boy mowing a lawn and an older woman sleeping inside her house (personal interview with M. Richards member of Concerned Citizens of Norco, February 28, 2001). An explosion of a catalytic cracker at the refinery in 1988 resulted in the death of seven workers and the destruction of millions of dollars in property (69). In addition to these major events, numerous episodes of leaks, fires, tank car derailments, flares, and other problems have plagued the community. An entire website, funded by the Sierra Club Legal Defense Fund, has been established to track incidents of flaring in Norco (70).

Oil refining also has major impacts on poor communities in developing countries. In his recent book *Riding the Dragon* (71), Doyle documents environmental injustices observed at Shell's South African Petroleum Refinery (SAPREF) in Durban. Doyle's inventory of pollution concerns and major accidents at this one facility is staggering: underreporting of as much as 10 million pounds of sulfur dioxide per year; massive unreported oil leaks; explosions and fires releasing tons of hydrogen fluoride. More specific reports in 2001 include two fires, a chemical solvent spill, and a fuel spill all in January; a March leak of 25 tons of tetra-ethyl lead; a July underground pipeline leak of 1,000,000 liters of gas into the ground; a June failure of a refinery flare resulting in the release of unburned gases, including substantial amounts of hydrogen sulfide; a mid-August failure of the asphalt plant at the refinery; a September, marine fuel oil pipeline leak and about ten days later, another flare failure; and an October spill of 2000 liters of oil into Durban Harbor during a ship refueling operation.

Community organizing and monitoring in response to these events has led to documentation of emissions, contamination levels, and disease incidence in neighborhoods adjoining the SAPREF refinery. Residents have documented "very high benzene levels in the air—levels 30 times those permitted in the US . . . . In Durban, leukemia rates are 24 times the South African national average. Respiratory problems there are four times the national average" (71). Residents report ongoing acute health effects such as coughing, burning eyes, headache, dizziness, and nausea. They also complain about cases of severe asthma in the community, as well as cases of rare immune diseases, such as teenage lupus erythematosus and childhood kidney cancer.

Unfortunately, here again, no national or international agencies currently collect or publish data on community health impacts from oil activities. Data on mortalities from oil accidents are collected by different agencies depending on whether a worker or community member is killed and whether the accident is caused by a pipeline explosion, a refinery accident, or a tanker. The best data currently available, and even these are limited, cover workplace injuries and deaths in oil production and refining (72, 73). However, virtually no data are available on chronic health impacts among communities living close to refineries.

VII. IMPACTS OF OIL CONSUMPTION

The combustion of petroleum products contributes to numerous environmental impacts including air pollution, water pollution from gasoline and gasoline additives, and global warming. All three of these problems often disproportionately affect low-income, minority populations and developing nations.

Gasoline is composed of hydrocarbons, which as we have noted, include a number of carcinogenic compounds. In addition, substances, such as alkyl lead, oxygenates, and additional aromatic hydrocarbons (which include benzene, xylene, and toluene) are added to gasoline to improve its performance during combustion. The acute and chronic health effects from exposure to gasoline and its additives have been documented and include cancer, central nervous system toxicity, and poisoning from additives. These impacts tend to be concentrated particularly among lower-income populations that live closer to service stations, refineries, and transfer or storage facilities (38).

The combustion of oil results in six primary air pollutants: VOCs, oxides of nitrogen (which combine with VOCs to produce low-level ozone), carbon monoxide, particulate matter, oxides of sulfur, and lead. Although gasoline in the United States is now required to be unleaded, lead emissions from combustion of gasoline in the developing world are still common.

The International Center for Technology Assessment has quantified the externalized costs of using internal combustion engines with gasoline. According to their calculations, the unquantified environmental, health, and social costs of gasoline usage in the United States total between $231.7 and $942.9 billion per year. The cost of damage from automobile fumes is estimated to be between $39 and $600 billion per year. The estimate of the annual uncompensated health costs associated with auto emissions is $29.3 to $542.4 billion, which may be low given that auto pollution has been conclusively linked to increased health problems and mortality (74).

The environmental and health impacts of air pollution from gasoline combustion tend to occur disproportionately among low-income communities, communities of color, and poorer populations in developing nations. For example, although leaded gasoline is banned in the United States, its use is still widespread throughout the developing world where residents living in congested, high-traffic areas are exposed to lead emissions. In the United States, diesel emissions pose a similar risk to inner-city populations that face the highest level of exposure to diesel exhaust emissions from buses and trucks. Furthermore, "within cities, the highest density of buses and bus stations are found in the poorest neighborhoods, and poverty, race, and asthma rates are positively correlated" (38).

A study by Gotlieb et al. further demonstrates that asthma morbidity and mortality disproportionately impact minority populations, pointing out that in the early to mid-1980s the asthma mortality rate among black residents of the United States, aged 5 to 34 years, was three to five times as great as the rate among whites. This study, which was conducted in 1992, concluded that the asthma hospitalization rate in Boston was positively correlated with poverty rates and percentages of nonwhite residents and inversely correlated with income and educational levels. The asthma rate varied significantly within the city, from a low of 0.7/1000 persons in the Kenmore Square area to a high of 9.8/1000 in Roxbury (75).

It is now widely believed that human activities, primarily the burning of fossil fuels, are modifying natural atmospheric processes and contributing to global warming. Approximately three quarters of the anthropogenic emissions of carbon dioxide to the atmosphere have come from the combustion of fossil fuel (76). The Intergovernmental Panel on Climate Change has forecast major changes in ecological systems (and agricultural systems) and particularly stark impacts in some of the poorest countries in the world.

The United Nations Environment Program (UNEP) has also warned that the populations most vulnerable to climate changes are the landless, poor, and isolated. UNEP explains that "poor terms of trade, weak infrastructure, lack of access to technology and information, and armed conflict will make it more difficult for these people to cope with the agricultural consequences of climate change. Many of the world's poorest areas, dependent on isolated agricultural systems in semi-arid and arid regions, face the greatest risk. Many of these at-risk populations live in sub-Saharan Africa; South, East and Southeast Asia; tropical areas of Latin America; and some Pacific island nations" (77). It is also anticipated that low-lying islands may become totally uninhabitable, and entire populations will become environmental refugees (78). As some advocacy groups have argued, "On a global scale, climate change is likely to be the biggest environmental justice issue ever. The reason is simple: the poor are most vulnerable to the effects of climate change" (78).

The impacts of changes in global climatic patterns have already been witnessed throughout the developing world. Examples of devastating episodes include

Hurricane Mitch in Central America in 1998, which killed over 10,000 and created hundreds of thousands of environmental refugees; flooding in Bangladesh in 1998 that affected millions of people in one of the poorest nations on Earth; severe storms and flooding in Venezuela in 1999 that killed an estimated 20,000 and left 150,000 homeless; and extensive floods in Mozambique in 2000 and 2001 (38, 78).

VIII. REGULATING THE OIL INDUSTRY

The oil industry is regulated at each stage of its life cycle through a patchwork of environmental, health, and safety laws. The current U.S. administration and the oil industry itself have argued that the industry is actually "over-regulated" (1, 79). Environmental advocacy groups argue, conversely, that while the industry is subject to many formal regulations, the implementation of these regulations is often inadequate, particularly in poor communities and developing countries (8).

As each nation has its own regulations, it is not possible here to summarize global oil regulation. Instead, we focus on the regulatory framework of the United States and look in particular at the effectiveness of these regulations and their implementation.

The U.S. oil industry is regulated under a dispersed, fragmented, and sometimes overlapping set of statutes (39), which include the Federal Land Policy and Management Act; the Federal Oil and Gas Leasing Reform Act; the Outer Continental Shelf Lands Act; the National Environmental Policy Act; the Oil Pollution Act; the Clean Air Act's National Emission Standards for Hazardous Air Pollutants, National Ambient Air Quality Standards, New Source Review (NSR), and New Source Performance Standards; the Clean Water Act's National Pollutant Discharge Elimination System and Spill Prevention Control and Countermeasure Requirements; the Emergency Planning and Community Right-to-Know Act; and the Underground Injection Control program of the Safe Drinking Water Act.

Several states have also implemented local environmental standards for oil extraction and refining, which, in general, are stricter than federal standards. California, for instance, has implemented regulations for reformulated gasoline that are stricter than the Clean Air Act; an Air Quality Maintenance Plan which seeks to reduce emissions from stationary sources such as refineries; and comprehensive leak identification, maintenance, and inspection programs (80).

Both the production processes and the products of oil refining are regulated for their impacts. The formulation and composition of fuels is thus regulated to prevent environmental and health impacts (81). U.S. fuel regulation programs include the Oxygenated Fuels Program, the Highway Diesel Fuel Program, the Reformulated Fuels Program, and the Leaded Gasoline Removal Program.

Workplace hazards from oil production and refining are regulated by the Occupational Safety and Health Administration (OSHA). OSHA regulates occupational exposures to chemicals such as benzene, a common emission in petroleum refineries. OSHA has also developed safety management rules requiring refineries to conduct detailed reviews of their processes to determine workplace risk and injury potentials to workers (81).

Not withstanding this long list of statutes and agencies, the oil industry also benefits from a number of exemptions, or what their critics call loopholes, from federal environmental laws. A coalition of community groups in the United States recently complained that "despite a broad patchwork of regulations on refining operations, numerous loopholes allow refinery operators to skirt the law and operate their plants in a manner dangerous to public health" (82).

For instance, there is a "petroleum exclusion" exemption under the Comprehensive Environmental Response, Compensation, and Liability Act (81). Petroleum and the toxic components of crude oil, such as benzene, are exempted from classification as hazardous substances unless the concentration of these substances is increased by contamination or by addition after refining (39). The oil extraction industry is exempted from reporting toxic chemical releases to the TRI (39). Under the 1980 Amendments to the RCRA, Congress conditionally exempted drilling fluids, produced waters, and other wastes associated with exploration, development, or production (39). Oil exploration and production activities in offshore waters of Texas, Louisiana, Mississippi, and Alabama are exempt from Clean Air Act standards (39). Oil stripper wells are exempt from the Clean Water Act's standards. Crude oil gathering pipelines under six inches in diameter are exempt from the Hazardous Liquid Pipeline Safety Act. Oil barges are exempt from double hull requirements of the Oil Pollution Act (39).

The Bush Administration also recently loosened a major regulatory burden on oil refineries by rescinding "new source review" requirements when refineries upgrade technology or expand their capacity (83). By eliminating this regulatory requirement, oil refineries can now significantly expand capacity without applying for new permits or undergoing additional evaluations of Clean Air Act compliance. Environmental groups have criticized this change, arguing that the initiative "will allow virtually all pollution increases from old, high-polluting sources to go unregulated and public participation to be excluded" (84).

Another exemption in U.S. regulation relates to grandfathering of old refineries. Grandfathered plants, those built before environmental laws came into force, can operate without meeting current federal emissions standards (64). Accidental releases, upsets, and flaring, which the Waxman report documented, occur quite frequently at oil refineries; these allow significant emissions to go unregulated during nonpermitted events (64, 65). For example, the EPA has reported incidents of sulfur-dioxide releases through flaring in a single day that exceed annual permitted releases (65).

As we have noted, the EPA itself reports significant levels of noncompliance of the industry with air regulations, water standards, and solid waste regulations (85). But EPA enforcement resources have recently been cut back, thereby reducing the EPA's ability to police this noncompliance. The EPA's top enforcement officer recently resigned in frustration over the agency's reduction in inspections and fines. In an unusual public critique, he lamented, "We don't have an EPA anymore. We just have the White House and the energy lobby" (86).

Oil pipeline regulation is also limited in a number of regards. The U.S. government relies on an underfunded, understaffed agency, the Office of Pipeline Safety, to monitor over 2 million miles of oil and gas pipelines (enough to reach around the Earth 88 times). The agency has only 55 inspectors, and it rarely imposes fines for leaks, explosions, or even worker deaths. As Jim Hall, the former chairman of the National Transportation Safety Board, stated, “there is almost an absence of regulation” for oil pipelines (57).

The Office of Pipeline Safety reported annual leaks of approximately 6.7 million gallons of oil and gas per year during the 1990s, the equivalent of over one *Exxon Valdez* spill every two years. There were also 23 reported fatalities from pipeline accidents during the 1990s, which included several children (87). Because federal inspectors cannot monitor all 2.2 million miles of pipeline, the government asks industry to self-report pipeline problems. Unfortunately, industry metering systems are not accurate enough to detect most leaks or spills. This has led to the operation of leaking pipelines, unreported spills, and an increase in spills and incidents over the last 10 years (57). According to an audit conducted for the California State Assembly, actual pipeline spills outnumbered industry reported spills by ten to one (57).

As mentioned, levels of compliance and performance of oil refineries vary widely across the United States (63). Community groups have documented, largely through anecdotal reports, accompanying variations in regulatory enforcement. Some assert that Texas and Louisiana, the largest oil refining states, have the weakest enforcement agencies (64). California agencies appear to be stricter and more effective. A simple analysis of data from the EPA’s SFIP shows that high minority communities (those communities with over 30% minority populations within 3 miles of a refinery) were subject to fewer inspections and enforcement actions than refineries in predominantly white communities. Figures 1 and 2 present simple trend lines of variations in inspections and enforcement actions with respect

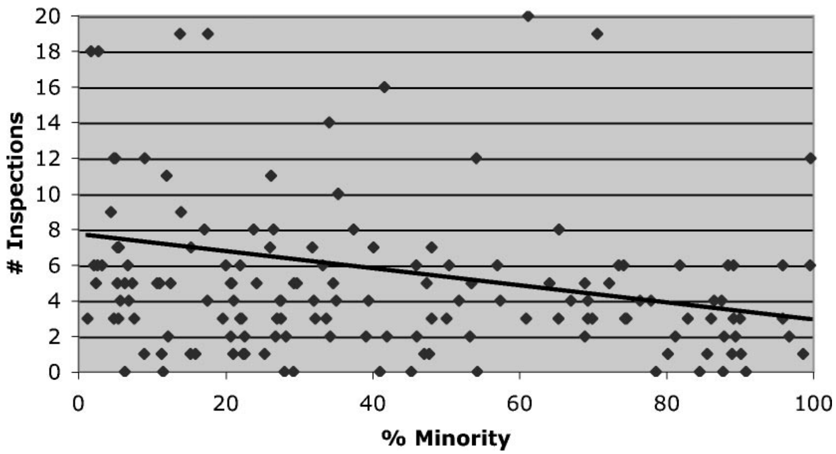

Figure 1 Incidence of inspections shown using least squares fit.

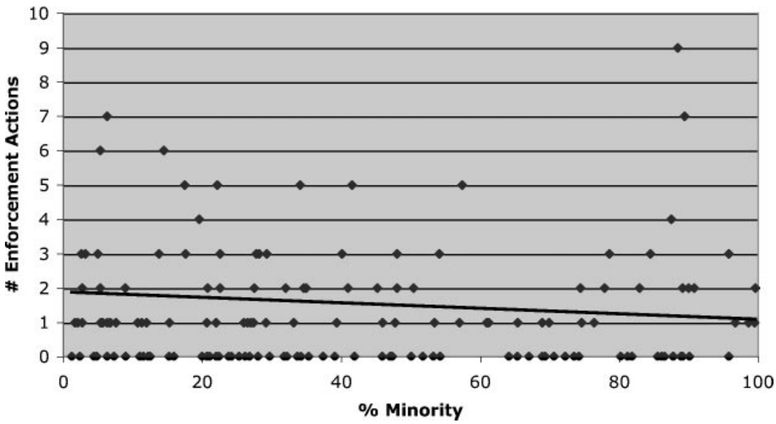

Figure 2 Incidence of enforcement.

to minority populations living in proximity to refineries in the United States. These data, while preliminary, seem to indicate a correlation between race and regulatory enforcement and, at a minimum, makes clear the need for further analysis of variations in the implementation of environmental regulations.

Environmental and health regulations in developing countries, although almost impossible to evaluate systematically, appear to be even weaker and more variable than U.S. regulations. A number of key oil-producing countries have either weak environmental laws, weak enforcement of these laws, or no environmental policies at all. The U.S. Energy Information Administration reports that "Nigeria does not have a pollution control policy" (88), and the laws that do exist are not enforced. Ecuador lacked environmental regulations until 1990, and dependence on oil revenue has since hindered environmental enforcement (11). Saudi Arabia did not have an environmental protection agency until 2001 (89).

IX. CONCLUSIONS, FURTHER RESEARCH, AND POLICY IMPLICATIONS

The impacts of oil production, transport, refining, and consumption are significant and widespread. From environmental impacts on fragile ecosystems, to cultural impacts on indigenous groups, health impacts on workers and communities, global climatic impacts, and military conflicts, oil is perhaps the single most controversial and influential commodity in the world. Our analysis of existing data has shown that oil's adverse impacts, which spread out virtually everywhere oil flows, appear to disproportionately affect groups such as indigenous communities, migrant workers, and poor communities living near refineries, pipelines, and gas stations. However, further research is needed to specify the distribution of environmental and social impacts from oil.

Although numerous studies have analyzed individual, discrete impacts of oil, little data or analysis is available assessing the overall distribution or cumulative impacts of oil. Current research and government data fail to evaluate the global distribution of benefits and costs from oil. It is virtually impossible to access even basic data on the spatial or demographic distribution of impacts from oil. One exception is the EPA's SFIP, which provides data on the demographics of populations living in proximity to oil refineries in the United States. But even these data are limited to simple measures of environmental performance of refineries.

Past studies have also failed to evaluate critical issues influencing the distribution of these impacts. Changing systems of control over the industry are particularly important in determining both who makes decisions over oil production, transport, and refining and who benefits from these decisions. The super-major oil corporations control an increasing percentage of oil extraction and refining and increasingly set the terms of oil's distribution and impacts. There is also very little information available to evaluate the implementation and effectiveness of government regulation of oil.

Thus, significant research is required to better measure and evaluate impacts of oil. There is a need for more and better data on environmental releases from oil extraction, transport, and refining. And there is a need for more and better analysis of the distribution of these impacts. Most governments currently rely on industry self-reporting of emissions, leaks, and accidents. Even in the United States, inspectors for key segments of the industry are scarce; ambient air sampling around facilities is limited; and monitoring of point sources, leaks, and accidents is minimal. Additionally, virtually no epidemiological or toxicological data are available on exposed communities, such as those living near refineries.

Greater public disclosure of data on the environmental, social, and financial impacts of oil exploration, production, and refining is also needed. Greater transparency regarding the performance of the oil industry would, at a minimum, help alert stakeholders to the true costs of oil consumption. A number of groups have called recently for reporting of oil revenues and payments to developing country governments and of the social and environmental impacts of these investments. Nongovernmental organizations and community groups around the world have also been calling for increased government inspections and enforcement authority over the oil industry. Even in the United States, exemptions and loopholes specific to the oil industry create a range of problems in environmental regulation. Finally, governments will have to engage and struggle with regulating oil companies if they are to seriously advance mechanisms to regulate global carbon emissions and mitigate climate impacts.

Oil is clearly at the center of current industrial development and economic activities. However, oil is also at the heart of some of the most troubling environmental, health, and social problems we face. How we manage both the benefits and costs of oil production and consumption will help determine the wealth, health, and safety of the planet. Understanding the distribution of impacts of oil and the effectiveness of current systems of regulation over these impacts is critical to advancing more democratic control over oil and to maximizing the benefits of oil while minimizing its adverse impacts. More open and robust debates in the United States and around the world regarding oil extraction, transport, refining, and consumption are critical to making our oil economy more just, equitable, and sustainable.

ACKNOWLEDGMENTS

The authors thank the Massachusetts Institute of Technology for financial support, George Draffan for research assistance, and Dan Kammen for helpful comments.

LITERATURE CITED

1. Natl. Energy Policy Dev. Group. 2001. Overview. See Ref. 90, pp. viii–xv
2. Natl. Energy Policy Dev. Group. 2001. Protecting America's environment. See Ref. 90, pp. 3-1 to 3-14
3. Bush GW. 2001. *President Bush Calls for Action on Economy, Energy Remarks by the President to Business, Trade and Agriculture Leaders, October 26*. http://www.whitehouse.gov/news/releases/2001/10/20011026-9.html
4. Cheney R. 2001. *Town Hall Energy Meet., July 16*. http://www.whitehouse.gov/vicepresident/news-speeches/speeches/vp20010716-2.html
5. Klare M. 2001. *Resource Wars: The New Global Landscape of Global Conflict*, pp. 33, 60–61. New York: Metropolitan Books
6. Int. Labour Organ. 2002. *Oil and Gas Production; Oil Refining.* http://www.ilo.org/public/english/dialogue/sector/sectors/oilgas.htm
7. Youngquist W. 2000. *Alternative Energy Sources*. http://www.hubbertpeak.com/youngquist/altenergy.htm
8. Doyle J. 1994. *Crude Awakenings: The Oil Mess in America: Wasting Energy Jobs and the Environment*. Washington, DC: Friends Earth
9. Energy Intell. Group. 2003. *Polity Score and Reserves Table*. http://www.energyintel.com/grounds/tables.htm
10. Publish What You Pay Coalition. 2003. *Publish What You Pay Campaign*. http://www.publishwhatyoupay.org/
11. Trade Environ. Database. 2002. *Ecuador Oil Exports. The Mandala Project.* http://www.american.edu/TED/ECUADOR.htm
12. Ross M. 2001. *Extraction Sectors and the Poor*. Boston: Oxfam Am.
13. Anonymous. 2002. Worldwide Report. *Oil Gas J.* Dec. 23. 100(52):62–145
14. Pet. Econ. Ltd. 2002. Energy Map of the World. http://www.petroleum-economist.com
15. Yergin D. 1991. *The Prize: The Epic Quest for Oil, Money, and Power*. New York: Simon & Schuster
16. Sampson A. 1975. The Seven Sisters: *The Great Oil Companies and the World They Shaped*. New York: Viking
17. Clark JG. 1990. *The Political Economy of World Energy: A Twentieth Century Perspective*. Chapel Hill: Univ. North Carolina Press
18. Bullard R. 1994. Environmental justice for all. In *Unequal Protection: Environmental Justice and Communities of Color*, ed. RD Bullard, pp. 3–22. San Francisco: Sierra Club Books
19. Pulido L. 1996. A critical review of the methodology of environmental racism research. *Antipode* 28(2):142–59
20. Energy Inf. Adm. 2003. *Country Analysis*

Briefs: OPEC Fact Sheet. http://www.eia.doe.gov/emeu/cabs/opec.html

21. Standard & Poor's. 2002. Industry Surveys: Oil & Gas: Production & Marketing. April 4, p. 2. New York, NY
22. Energy Inf. Adm. 2002. *Country Analysis Briefs: Persian Gulf Oil and Gas Exports Fact Sheet*. http://www.eia.doe.gov/emeu/cabs/pgulf.html
23. Standard & Poor's. 2002. See Ref. 21, p. 3
24. BP-Amoco. 2002. *Statistical Review of World Energy*. http://www.bp.com/centres/energy2002/2001inreview.asp
25. Energy Inf. Adm. 2002. *Country Analysis Briefs: Non-OPEC Fact Sheet*. http://www.eia.doe.gov/emeu/cabs/nonopec.html
26. Energy Inf. Adm. 2002. *World Petroleum Supply and Disposition, 2000*. http://www.eia.doe.gov/emeu/iea/table31.html
27. Energy Intell. Group. 2003. *Ranking the World's Top Oil Companies, 2001: Fewer, Bigger, and Fiercely Competitive* (Abstr.). http://www.energyintel.com/ResDocDetail.asp?document_id=50195
28. Standard & Poor's. 2002. See Ref. 21, p. 9
29. Slocum T. 2001. *No Competition: Oil Industry Mergers Provide Higher Profits, Leave Consumers With Fewer Choices*. Public Citiz. http://www.citizen.org/documents/nocompetition.PDF
30. Karl TL. 1997. *The Paradox of Plenty: Oil Booms and Petro-States*. Berkeley: Univ. Calif. Press
31. Natl. Energy Policy Dev. Group. 2001. Strengthening Global Alliances. See Ref. 90, pp. 8-1 to 8-21
32. Standard & Poor's. 2002. See Ref. 21, p. 11
33. Mead W. 1993. Crude oil supply and demand. In *The Environment of Oil*, ed. RJ Gilbert, pp. 43–84. Boston: Kluwer Acad.
34. Petroconsultants UK Ltd. 1998. *World Petroleum Trends Rep*. Petroconsultants, London
35. Edoigiawerie C, Spickett J. 1995. The environmental impact of petroleum on the environment. *Afr. J. Health Sci.* 2(2):269–76
36. O'Connor O. 2000. *The Hidden Costs of Offshore Oil*. Living Oceans Soc., April/May. http://www.web.net/nben/envnews/media/00/offoil.htm
37. Pelley J. 2001. Will drilling for oil disrupt the Arctic National Wildlife Refuge? *Environ. Sci. Technol.* 35(11):240A–47A
38. Epstein PR, Selber J. 2002. *Oil: A Life Cycle Analysis of Its Health and Environmental Impacts*. Boston: Center Health Glob. Environ., Harv. Med. Sch.
39. US Environ. Prot. Agency Off. Compliance Enforc. 2000. *Profile of the Oil and Gas Extraction Industry*. Washington DC: GPO
40. Natl. Res. Counc. 2002. *Oil in the Sea III: Inputs, Fates, and Effects*. Washington, DC: Natl. Acad.
41. Caswell MF. 1993. Balancing energy and the environment. In *The Environment of Oil*, ed. RJ. Gilbert, pp. 179–214. Boston: Kluwer Acad.
42. Kretzmann S, Wright S. 1998. *Drilling to the Ends of the Earth: The Ecological, Social and Climate Imperative for Ending Oil Exploration*. Berkeley, CA: Rainfor. Action Netw. Proj. Undergr.
43. Kretzmann S, Wright S. 1997. *Human Rights and Environmental Operations Information on the Royal Dutch/Shell Group of Companies, 1996–1997*. Berkeley, CA: Rainfor. Action Netw. Proj. Undergr.
44. Amazon Watch. 2002. *Mega Projects*. http://www.amazonwatch.org
45. Hum. Rights Watch. 2002. *Corporations and Human Rights*. http://www.hrw.org/advocacy/corporations/
46. Project Undergr. 2002. *Oil Campaign*. http://www.moles.org/ProjectUnderground/oil/index.shtml
47. Model Arab Leag. 2002. *Codifying Immigrant Laborer Rights in the Arab World*. http://www.geocities.com/mtaerea1984/Pages/immigrant_labor.htm
48. South Asian Voice. 2001. *Understanding the Complexities and Contradictions of the Middle East Oil Wealth, Colonial and Neo-Colonial Intervention, and Cheap South Asian Labor*. http://india_resource.tripod.com/mideastoil.html

49. Hum. Rights Watch. 1999. *Saudi Arabia Human Rights Developments*. http://www.hrw.org/wr2k/Mena-08.htm
50. Burger J. 1997. *Oil Spills*. New Brunswick, NJ: Rutgers Univ. Press
51. Int. Tanker Own. Pollut. Fed. Ltd. 2002. *Past Spills Statistics*. http://www.itopf.com/stats.html
52. Welch J. 1994. International spill statistics: 1993. In *Oil Spill Intelligence Report*. Arlington, MA: Cutter Inf. Corp.
53. Earth Crash Earth Spirit. 2002. *Pollution: Oil Spill Central*. http://eces.org/ec/pollution/oilspills.shtml
54. Etkin DS. 1997. Oil Spills From Vessels (1960–1995): An International Historical Perspective. Cambridge, MA: Cutter Inf. Corp.
55. Natl. Ocean. Atmos. Adm./ Natl. Ocean Serv. 2002. *Oil Spills in History*. http://response.restoration.noaa.gov/faqs/history.html
56. Int. Counc. Local Environ. Initiat. 1993. *Oil Discharged into the Marine Environment from Maritime Transport*. http://www.iclei.org/efacts/oilspi1.gif
57. Nesmith J, Haurwitz RKM. 2001. Spills and explosions reveal lax regulation of powerful industry. *American-Statesman*, Austin, TX, July 22, p. A1
58. Boesch DF, Butler JN, Cacchione DA, Geraci JR, Neff JN, et al. 1987. An assessment of the long-term environmental effects of US offshore oil and gas development activities: future research needs. In *Long Term Environmental Effects of Offshore Oil and Gas Development*, ed. DF Boesch, NN Rabalais. London: Elsevier Appl. Sci.
59. IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP. Jt. Group Experts Sci. Aspects Mar. Pollut. 1993. *Impact of Oil and Related Chemicals and Wastes on the Marine Environment, GESAMP Rep. Stud. 50*. London: Int. Marit. Organ.
60. Rooney Eng. Inc. 2000. *Pacific Pipeline System*. http://www.rooney-eng.com/ppsi.htm
61. Impact Assess. Inc. 1995. *Documentation in Support of Socioeconomic Review Comments to Draft Environmental Impact Statement/Subsequent Environmental Impact Report: Pacific Pipeline Project*. La Jolla, California
62. Rainfor. Action Netw. 2002. *The Chad/Cameroon Rainforest Oil Pipeline Case Study*. http://www.ran.org/ran_campaigns/citigroup/cs_chadcam.html
63. Epstein LN, Greetham S, Karuba A. 1995. *Ranking Refineries: What Do We Know About Oil Refinery Pollution from Right-to-Know Data?* Washington, DC: Environ. Def. Fund
64. Texas Sustain. Energy Econ. Dev. Coalit. 2001. *Crude Polluters: A Survey and Analysis of the US Refinery Sector and a Blueprint for Refinery Reform, Austin: Texas SEED Coalit.*
65. Minor. Staff, Spec. Investig. Div., Comm. Gov. Reform, US House. 1999. *Oil Refineries Fail to Report Millions of Pounds of Harmful Emissions*. Prep. for Represent. Henry A. Waxman. Nov. 10 http://www.house.gov/reform/min/pdfs/pdf_inves/pdf_enviro_oil_refine_rep.pdf
66. Kizior GJ. 1991. *Amoco/EPA Pollution Prevention Project: Solid Waste Sampling*. Naperville, IL: Amoco Oil Co. Environ. Eng. Res.
67. US Environ. Prot. Agency Off. Compliance Enforc. 1999. *Compliance and Enforcement Reports*. http://www.epa.gov/Compliance/resources/reports/planning/results/accomplishments/
68. Templet PH. 1993. The emissions-to-jobs ratio: a tool for evaluating pollution control programs. *Environ. Sci. Technol.* 27(5):810–12
69. Bell R. 1997. Shell official: '88 deal led to suit; residents unhappy with settlement, he says. *Times Picayune*, August 30, p. B1
70. Concerned Citiz. Norco Sierra Club. 2001. *FlareCam*. http://www.sierraclub.org/planet/200209.shell_victory
71. Doyle J. 2002. *Riding the Dragon: Royal*

Dutch Shell and the Fossil Fire. Boston: Environ. Health Fund.
72. Bur. Labor Stat. 2002. *Fatal Occupational Injuries by Industry*, 1996–2001. http://www.bls.gov/iif/oshwc/cfoi/cftb0155.pdf
73. Occup. Saf. Health Adm. 2003. *OSHA Priorities: Oil and Gas Well Drilling & Servicing*. http://www.osha.gov/oshinfo/priorities/oil.html
74. Int. Cent. Technol. Assess. 2002. *The Real Price Of Gasoline.* http://www.icta.org/projects/trans/rlprexsm.htm
75. Gottlieb DJ, Beiser AS, O'Connor GT. 1995. Poverty, race, and medication use are correlates of asthma hospitalization rates. *Chest* 108(1):28–35
76. Intergov. Panel Clim. Chang. 2001. *Climate Change 2001: The Scientific Basis*: *Summary for Policymakers*. http://www.ipcc.ch/pub/spm22-01.pdf
77. UN Environ. Program. 2001. *UNEP Climate Change Information Kit* http://www.unep.ch/conventions/info/ccinfokit/Infokitpercent20-percent202001.htm
78. Bruno K, Karliner J, Brotsky C. 1999. *Greenhouse Gangsters vs. Climate Justice*. San Francisco, CA: Transnatl. Res. Action Cent. http://www.corpwatch.org/upload/document/greenhousegangsters.pdf
79. Anonymous. *Refining damage mounts*. *Oil Gas J.* March 11. 100(10):19
80. Calif. Air Resour. Board. 2002. *California Air Pollution Control Laws*. http://www.arb.ca.gov/bluebook/bb02/toc.htm
81. US Environ. Prot. Agency Off. Compliance Enforc. 1995. *Profile of the Petroleum Refining Industry*. Washington, DC: GPO
82. Texas Sustain. Energy Econ. Dev. Coalit. 2001. See Ref. 103, p. 10
83. Stolberg S. 2002. Senators cross party lines on clean air. *New York Times*. January 22, p. A23
84. Environ. Def. 2002. *Fallout from EPA Rules Rollback*. Statement by Vickie Patton, sr. atty. Environ. Def. June 17. http://www.environmentaldefense.org/article.cfm?contentid=2132
85. US Environ. Prot. Agency Off. Compliance Assur. 1999. *Fiscal Year 1998 Accomplishments Report.* http://www.epa.gov/Compliance/resources/reports/planning/results/accomplishments/fy99accomplishment.pdf
86. Schaeffer E. 2002. *CBS News*. June 13
87. Off. Pipeline Saf. 2002. *Pipeline Statistics*. http://ops.dot.gov/stats.htm
88. Energy Inf. Adm. 2002. *Nigeria: Environmental Issues*. http://www.eia.doe.gov/emeu/cabs/nigenv.html
89. Energy Inf. Adm. 2002. *Saudi Arabia: Environmental Issues*. http://www.eia.doe.gov/emeu/cabs/saudenv.html
90. Natl. Energy Policy Dev. Group. 2001. *National Energy Policy*. Washington, DC: GPO