THE NATIONAL ACADEMIES

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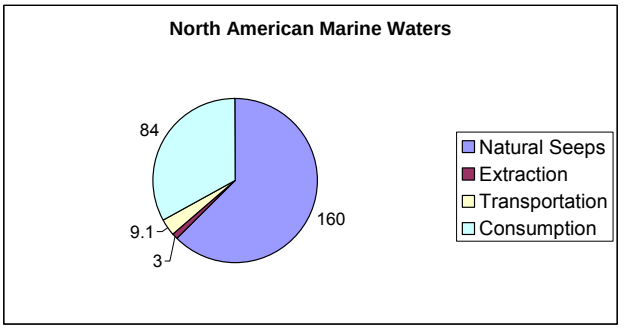
Oil in the Sea III

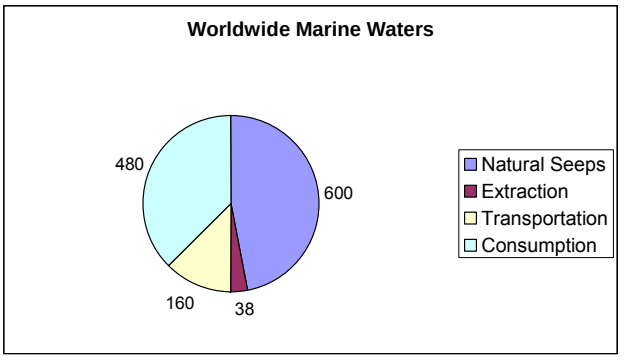
The United States and other nations that regularly make decisions regarding energy use spend a significant amount of time examining policies affecting the extraction, transportation, and consumption of petroleum. These policies require balancing economic considerations with the environmental consequences of widespread petroleum use. As has been recognized for some time, petroleum can present a significant risk to marine life. Even a small amount released at the wrong time or place can have a severe impact.

New estimates indicate that the overall amount of petroleum released to the marine environment may be lower than earlier thought. This reflects, in part, advances over the last decade in marine transportation and oil and gas production techniques. Spillage from vessels in North American waters from 1990 to 1999 was less than one-third of the spillage during the prior decade, and, despite increased production, reductions in releases during oil and gas exploration and production have been dramatic as well.

However, releases from extraction and transportation of petroleum represent less than 10 percent of inputs from human activity. Chronic releases during consumption of petroleum, which include urban runoff, polluted rivers, and discharges from commercial and recreational marine vessels, contribute up to 85 percent of the anthropogenic load to North American waters. These releases can pose significant risks to the sensitive coastal environments where they most often occur.

Oil in the Sea III is the third report from the National Academies on this subject, the last of which was published in 1985. Since 1985, several governmental and private agencies have created databases with more complete information on petroleum releases and their impact on the environment. This new report proposes a clearer methodology for estimating petroleum inputs to the sea and makes recommendations for further monitoring and assessment that will help policymakers prioritize next steps for prevention and response.





Average annual contribution (1990-1999) from major sources of petroleum in kilotonnes.

Sources of Oil in the Sea

Petroleum inputs into North American and worldwide marine waters were computed for four major sources – natural seeps and releases that occur during the extraction, transportation, and consumption of petroleum. The last three include all significant sources of anthropogenic petroleum pollution. This summary highlights the major findings about each major source, but the full report also provides extensive discussion of the regional variation of these sources in North American waters.

Natural Seeps of Petroleum

Natural seeps occur when crude oil seeps from geologic strata beneath the seafloor into the water. Seeps are often used to identify potential economic reserves of petroleum. They contribute the highest amount of petroleum to the marine environment, accounting for 45 percent of the total annual load to the world's oceans and 60 percent of the estimated total load to North American waters.

The presence of these seeps, though entirely natural, significantly alters the nature of the local marine ecosystems around them. Seeps serve as natural experiments for understanding adaptive responses of organisms over generations of chemical exposure. Seeps also illustrate how dramatic community- and population-level changes can be. The report recommends that programs be implemented to understand the fate of petroleum from natural seeps and ecological responses to them.

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Extraction of Petroleum

World oil production continues to rise, from 8.5 million tonnes (1 tonne equals about 294 gallons) in 1985 to 11.7 million tonnes in 2000. In that same time, the number of offshore oil and gas platforms rose from a few thousand to approximately 8,300 fixed or floating offshore platforms. Historically, oil and gas exploration and production of petroleum have represented a significant source of spills. The second largest marine spill in the world was a blowout that released 476,000 tonnes of crude oil into the Gulf of Mexico in 1979.

During the past decade, however, improved production technology and safety training of personnel have dramatically reduced both blowouts and daily operational spills. Today, accidental spills from platforms represent about one percent of petroleum inputs in North American waters and about three percent worldwide. The committee recommends that federal agencies continue to enhance efforts to promote extraction techniques that minimize accidental or intentional release of petroleum.

Transportation of Petroleum

The amount of oil transported over the sea continues to rise. Since 1985, the Middle East's exports of oil to the United States have almost tripled, and exports to the rest of the

	North America			Worldwide		
	Best Estimate	Min.	Max.	Best Esimate.	Min.	Max.
Natural Seeps	**160**	**80**	**240**	**600**	**200**	**2000**
Extraction of Petroleum	**3.0**	**2.3**	**4.3**	**38**	**20**	**62**
Platforms	0.16	0.15	0.18	0.86	0.29	1.4
Atmospheric Deposition	0.12	0.07	0.45	1.3	0.38	2.6
Produced waters	2.7	2.1	3.7	36	19	58
Transportation of Petroleum	**9.1**	**7.4**	**11**	**150**	**120**	**260**
Pipeline Spills	1.9	1.7	2.1	12	6.1	37
Tank Vessel Spills	5.3	4.0	6.4	100	93	130
Operational Discharges (Cargo Washings)	na	na	na	36	18	72
Coastal Facility Spills	1.9	1.7	2.2	4.9	2.4	15
Atmospheric Deposition	0.01	trace	0.02	0.4	0.2	1
Consumption of Petroleum	**84**	**16**	**2000**	**480**	**130**	**6000**
Land-Based (River and Runoff)	54	2.6	1900	140	6.8	5000
Recreational Marine Vessel	5.6	2.2	9	nd	nd	nd
Spills (Non-Tank Vessels)	1.2	1.1	1.4	7.1	6.5	8.8
Operational Discharges (Vessels ≥100 GT)	0.10	0.03	0.30	270	90	810
Operational Discharges (Vessels<100 GT)	0.12	0.03	0.30	nd	nd	nd
Atmospheric Deposition	21	9.1	81	52	23	200
Jettisoned Aircraft Fuel	1.5	1.0	4.4	7.5	5.0	22
Total (in thousands of tonnes)	**260**	**110**	**2300**	**1300**	**470**	**8300**

Average annual input (1990 – 1999) of petroleum to marine waters by source (in kilotonnes).

world have doubled. While the devastating impact of spills has been well publicized with images of oil-covered shores and wildlife, releases from the transport of petroleum now amount to less than 4 percent of the total in North American waters and less than 13 percent worldwide. The four major sources of petroleum discharges in the transportation sector include pipeline spills, tank vessel spills, operational discharges from cargo washings, and coastal facilities spills.

Transportation-related spills are down for several reasons. The enactment of the Oil Pollution Act of 1990 placed increased liability on responsible parties, and other regulations required the phase out of older vessels and the implementation of new technology and safety procedures. By 1999, approximately two-thirds of the tankers operating worldwide had either double-hulls or segregated tank arrangements – a vast improvement over older single hull ships. Operational discharges from cargo washing are now illegal in North America, a law that is rigorously enforced.

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However, there still remains a risk of spills in regions with less stringent safety procedures or maritime inspection practices. The report recommends that federal agencies expand efforts to work with ship owners domestically and internationally to more fully enforce effective international regulatory standards that have contributed to the decline in oil spills.

In the United States, nearly 23,000 miles of pipeline are used to transport petroleum. In some regions, much of this infrastructure is more than 30 years old, and unless steps are taken to address the problem, the likelihood of a spill from this source is expected to increase. The report recommends that federal agencies continue to work with state environmental agencies and industry to evaluate the threat posed by aging pipelines and to take steps to minimize the potential for a significant spill.

Consumption of Petroleum

From 1985 to 2000, global oil consumption increased from 9.3 to 11.7 million tonnes per day, an increase of more than 25 percent. Releases that occur during the consumption of petroleum, whether by individual car and boat owners, marine vessels, or airplanes, contribute the vast majority of petroleum introduced through human activity. Land-based activities contribute to polluted rivers and streams, which eventually empty to the sea. Consumption-related inputs contribute one-third of the total load of petroleum to the sea and represent 85 percent of the anthropogenic load to North American marine waters and 70 percent worldwide.

In North American marine waters, land runoff combined with marine boating and use of jet skis account for 22 percent of total petroleum inputs and 64 percent of inputs from human activity.

Land-based inputs are highest near urbanized areas and refinery production. More than half of the land-based inputs in North America are estimated to flow to the near shore waters between Maine and Virginia, a region with many urbanized areas and also many sensitive coastal estuaries. In North American marine waters, land runoff combined with marine boating and use of jet skis account for 22 percent of total petroleum inputs and 64 percent of inputs from human activity.

The threat of pollution from urban areas is expected to rise. Current trends indicate that by the year 2010, 60 percent of the U.S. population will live along the coast. Worldwide, two-thirds of the urban centers with populations of 2.5 million or more are near coastal areas.

In 1990, heightened awareness of the large number and design inefficiencies of two-stroke engines commonly used in recreational vehicles led the U.S. EPA to begin regulating the “non-road engine” population under the authority of the Clean Air Act. The marine industry responded by developing cleaner engines in the late 1990s, but the report recommends that federal agencies continue efforts to encourage the phase-out of the older inefficient two-stroke engines and establish a coordinated enforcement policy.

Inputs from land-based sources such as river and urban runoff are poorly understood and difficult to measure, so estimates have a high degree of uncertainty. The report recommends that federal agencies work to develop and implement a system for monitoring input of petroleum to the marine environment from land-based sources via rivers and storm- and waste-water facilities.

Significant Cross-Cutting Issues

Studies completed in the last 20 years confirm that no spill is entirely benign. Further, there is no correlation between the size of a release and its impact. Instead, as in the real estate maxim, it's all about "location, location, location." The effects of a petroleum release are a complex function of the rate of release, the nature of the petroleum, and the local physical and biological character of the exposed ecosystem. Some petroleum components are more toxic than others. Polycyclic aromatic hydrocarbons (PAH) are known to be among the more toxic components of petroleum, and their initial concentration is an important factor in the impact of a given release.

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Growing evidence suggests that toxic compounds such as PAH in crude oil or refined products at very low concentrations can have adverse effects on biota. This suggests that PAH from chronic sources may be of greater concern than was thought 10 or 15 years ago and that effects of petroleum spills may last longer than expected.

The report recommends that federal agencies take several actions to better understand the behavior and effects of petroleum hydrocarbon releases. These actions include:

- Studying the fate and hydrodynamic transport of petroleum in the sea.
- Developing and implementing a rapid response system to collect in situ information about spill behavior and impacts.
- Significantly enhancing research efforts to more fully understand the risk posed to humans and the marine environment by chronic release of petroleum, especially the cumulative effects of petroleum-related toxic compounds such as PAH.
- Continuing research on effects of releases on wild populations, including implementing a program to assess ecosystems in areas known to be at risk from spills or other releases of petroleum.

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This study was jointly overseen by the National Academies' Ocean Studies Board and Marine Board.