Transport Environmental Risks

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For HEN 402 Environmental Risks

Introduction, Aviation and Water Transport

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Transport Environmental Risks

Introduction

The theme Environmental Risks in Transport will deal with a listing and explanation of various risks and the finding of some solutions. I'll give a brief outline of our presentation, a few words on the history of transport, and then a focus on aviation and shipping. Igor will speak about land transport, covering car culture and alternative technical solutions. Marek will speak about some tools that can serve to regulate or solve these problems, especially focusing on induction and reduction theories. Kristyna will speak about lowering these environmental risks from a regulatory, political and financial perspective, providing some possible remedies for the CR.

History of Transport

Transportation technology has been with humanity since about 3500 B.C. when the wheeled cart and river boat were invented.

Egyptian tomb painting 1450 BC

However, changes have been increasingly felt since the late 19th century when aviation, automobile and shipping culture made great leaps of progress. The first combustion engine automobile was invented by Benz in 1885 (even though French inventor Cugnot made the first self-propelled vehicle back in 1765).

1895 Benz Velo - 10 years after first patented Benz automobile of 1885.

Shipping expanded substantially in the 1880s when steel hulls and steam engines were introduced.

Inventions by the Wright brothers lead to the first airplane in 1903.

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The great advances in these areas became increasingly connected with the steel, petroleum and chemical industries, so the substantial risks associated with the quality and quantity of transport have also increased. But even if transport involved "clean" fuel, the sheer volume, social and health costs (accidents, noise, vibration, stress) of our transport culture are making the present trends unsupportable into the future. (In fact, Henry Ford's first cars used "clean" biofuel made of hemp.[1] The reasons for its disuse can partly be explained by the petroleum, forestry, and chemical lobbies that would gain momentum in the early 20th century.)

Main Environmental Risks of Transport

Most importantly, since transport is not a clean sector the risks are many:
Those mentioned above

1) **Social & health** risks (traffic jams, stress, accidents & deaths of people & animals)
2) **Vibration & noise** pollution

and the many more serious problems

1) **Pollution** or emission of toxins (into air, land and water)
2) **Energy** consumption
3) **Infrastructure & land** demands (disrupting ecosystems and habitats)
4) **Climate** change effects
5) **Ecosystem** diversity loss

Transport Styles of U.S. Versus Europe

Today the U.S. is a leader in the volume of transport but also the main contributor to transport related risks. The issue of public transit, which is cleaner than personal travel, provides an interesting example to show the differences between America and Europe. Surprisingly, at the start of the 20th century, American cities were leaders in public transit. By contrast, today much of metropolitan America is suburban for social and economic reasons, making public transit problematic. US travelers often return from Europe amazed by the efficiency of urban transit and wonder why U.S. cities can't compare. "Transit is used for about 10% of passenger trips in urban Western Europe, compared with 2% in the US." [2] Some reasons include Europe's higher vehicle and fuel taxes, urban land use regulation, public attitudes and transit service convenience. Some of these social and economic factors will be discussed, as well as some recommendations:

A Ten-point Transport Plan for Government (UK)

1. Tax reforms: Keep the costs of motoring constant rather than falling.

2. Air travel: Remove tax exemptions and stop airport expansion plans.

3. Incentives for changing travel patterns: Fund programmes to influence travel patterns.

4. Roads and road-user charging: Raise money to pay for alternatives to car travel by charging toll fees.

5. Land-use planning: Promote higher density development on brownfield sites that use public transport links.

6. Speed enforcement: Reduce motorway speed limits.

7. Freight: Promote regional sourcing for food and construction materials while increasing investment in rail and water freight transport.

8. Public transport: Develop the quality and quantity of public transport.

9. Walking and cycling: Improve conditions and promote as attractive and healthy alternatives to car travel.

10. Cleaner vehicles and fuels: Make legally binding improvements for fuel economy and CO_2 reductions.[3]

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[1] http://konopa.cz; viewed Nov. 22, 2006.
[2] http://trb.org/news/blurb_detail.asp?id=2666; viewed Nov. 18, 2006.
[3] http://www.transport2000.org.uk/campaigns/maintainCampaigns.asp?CampaignID=20, viewed Nov. 19, 2006.

Five Levels of Activity in Transport

1) infrastructure (airports, highways, parking and links)

2) vehicle manufacture

3) vehicle travel (fast and frequent)

4) vehicle maintenance

5) vehicle disposal (hazardous)

These are all very expensive and have numerous externalities. Energy, resources, and environmental effects should be considered at every level.

Air Pollution

Air pollution is the most serious environmental externality of transportation.
It is the cause of about **5% mortality** in Europe, with transport being responsibly for 55% -70% of the impact.[4]

Land transport represents about 10% of the world's CO_2 emissions[5]; air transport 10%; and water transport 2%.

World Petroleum-based Energy Consumption

The proportion of **world oil energy consumption** used by the transport sector has gone up from 42% to 58% since 1973, while other sectors (including industry) have come down.
Energy consumption of water, rail and transit have remained constant in the US since the 1970s, but road and air have doubled.
Generally, transport uses up about 20% of the energy needs of developed countries. [6]

[4] http://ec.europa.eu/research/conferences/2002/pdf/presspacks/1-1-emissions_en.pdf, viewed Nov 22, 2006
[5] http://www.guardian.co.uk/usa/story/0,,1808314,00.html; viewed Dec 2, 2006; The Guardian, June 29, 2006.
[6] http://people.hofstra.edu/geotrans/eng/ch8en/conc8en/ch8c3en.html, viewed Nov 22, 2006.

Aviation Environmental Risks

Airplane travel is responsible for about 10% of the world's anthropogenic CO_2 emission and involves many other environmental risks. (The term CO_2 when used in general aviation emissions statistics represents **carbon dioxide**, as well as **nitrogen oxide**, **carbon** and **sulphur** particles.) Aviation does not reflect real environmental and social costs because it has had **historical privileges** from a time when governments were supporting the start of aviation, and had their national "flag carriers". Aviation fuel is still exempt from tax and aircraft manufacturing and airports continue to get government support. These benefits give air travel an uncompetitive advantage resulting in a higher volume of air travel and therefore increased risks[7].

Growth in Air Travel Demand

The **rise in demand for air travel** is one of the most serious environmental threats as 300 million tonnes of CO_2 are emitted currently. There are around 20 million commercial flights reported annually (2005) and CO_2 per flight can range from about 70 kg [Brno-Prague] to 6 tonnes [Prague – Sydney].[8]
Trans-continental flights that reach an altitude of over 9000 m have more dangerous emissions as burning fuel in the **stratosphere** reacts with **ozone** to form particles whose effect is known to be harmful but is not completely understood yet.

Subsidies and unfair tax advantages for air travel are causing the increase in growth. Air passenger numbers would decrease if there was a tax on aviation fuel and airline tickets at the same level as land-based transport, and if the costs of the impacts of aviation on public health, air pollution, noise, and climate change were internalized into the actual prices, that is an **environmental tax** to reflect the "environmental realities". If governments implemented such a tax, it would be about £40 per flight. "This would ultimately be paid by the person flying or the person bringing in lettuces from Africa, " bringing about radical shifts in long-distance trade.[9]

Recommendations for aviation:

1) END **tax-free status** of aviation fuel;

2) ENCOURAGE people to take journeys of less than 500 km by **train**, eliminating **45%** of flights in Europe.

Airplane travel is 3 times **less energy efficient** than cars and 17 times less than trains. The average airport takes up about 500 hectares of land that is completely paved, affecting ecosystems, not to mention the increased vibration, sound, air, soil and even water pollution levels.[10] (Occasionally military and commercial jets release excess fuel into the ocean.)

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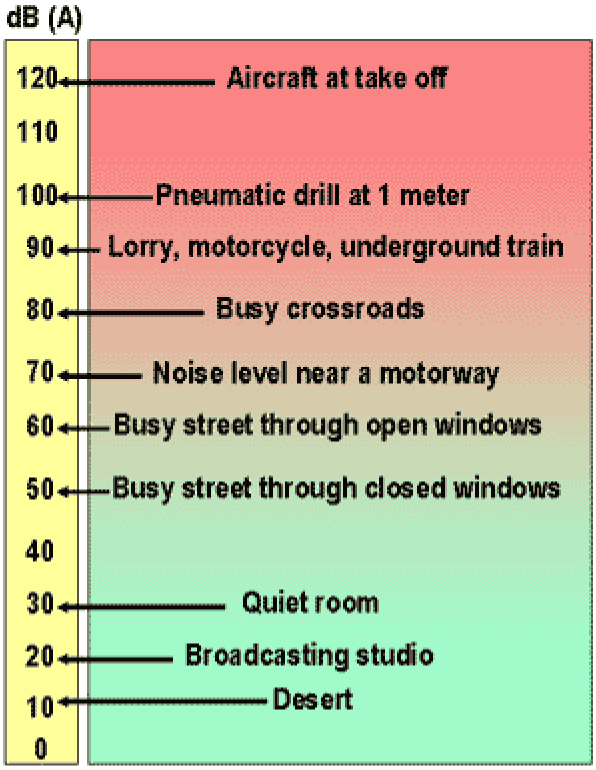
[7] http://www.transportenvironment.org/docs/Publications/2006/2006-10_can-e_te_position_paper_aviation_impacts.pdf
[8] https://www.atmosfair.de/index.php?id=30&L=3
[9] Nov. 2005 Euro Federation for Transport and Env (T&E).
[10] Dirner

Noise Levels from Different Sources[11]



Commercial Flight & Accident Statistics

	# of planes	**# of departures**	**accidents / million departures**
1960			**60**
1970	**4000**	**6 million**	**5**
2005	**20,000**	**20 million**	**3**

There has been a gradual increase of planes and departures (with a dip in 2001 & 2002), but fewer accidents.

The total number of world-wide commercial plane accidents between 1959-2005 was just under 1500.[12]

Toxic Pollutants

It may be known that the pollution from air accidents involves the dispersal of vast amounts of airplane fuel, kerosene and other chemicals, but less known are some other hazardous substances found on airplanes, namely depleted uranium (DU).

Depleted uranium (DU) is used in weapons, aircraft, ships, buildings and other areas of modern industry (even elevators) where there is a need for a very dense (heavy) material. It is about 40% less radioactive than naturally-occurring uranium (safe under 20 cm of soil!), is very cheap and available. (In the US, weapons manufacturers obtain DU from the government for free!)

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[11] Adapted from R. Tolley and B. Turton (1995) *Transport Systems, Policy and Planning: A Geographical Approach*, Burnt Mill, Harlow Essex: Longman Scientific & Technical, p. 279.

[12] http://www.boeing.com/news/techissues/pdf/statsum.pdf, Statistical Summary of Commercial Jet Airplane Accidents Worldwide Operations 1959-2005, May 2006.

The Boeing 747 uses DU as ballast (extra weight for balance), carrying over **1500 kg of this radioactive material** in its tail and wings (in special containers). Lead, cast iron, tungsten, nor steel could be used but are more expensive.

DU is a dangerous radioactive and chemically toxic form of industrial waste when it is out of the ground and concentrated in one location, or once it is burned, or ground into fine dust and scattered in the air and water.

To give an idea of the quantities of hazardous substances that are dispersed in an accident, here is the example of a Boeing 747 that crashed near Amsterdam in 1992. It was carrying 75 tons of kerosene, 10 tons of chemicals, flammable liquids and gases, and 1500 kg of DU ballast.

When uranium burns it creates a chemical reaction and a cloud of uranium oxide that is released into the atmosphere. An aircraft doesn't have to crash for its DU to create health risks; a technician was found using a hammer and chisel to remove DU from its container.

(DU weapons were also used by NATO in Kuwait, Yugoslavia, Iraq, leaving behind long term contaminated land, illness, and birth defects.) [13]

Other **toxic pollutants** used in aviation are benzene, formaldehyde and de-icing spray. The de-icing spray covering an airplane before takeoff in winter helps ensure a safe flight, but it also leaves behind toxins called **endocrine disrupters** (i.e. "hormone disrupters" that can cause cancer, birth defects and immunity problems because they copy hormones but send bad signals). The Environmental Protection Agency (EPA) estimates that 35 million gallons of aircraft de-icing fluid are applied annually in the U.S. alone (ending up in the soil and ground water).[14]

Wildlife

Loss of Wildlife is documented here in a statement on technology invented to reduce animal deaths. An "audio telescope" has been developed to help airports with bird-aircraft collisions by locating and identifying birds by their calls. Collisions with birds in flight, called "bird strikes," have caused over $2 billion worth of damage to US aircraft since 1990. Worldwide, wildlife strikes have destroyed more than 163 aircraft and killed more than 194 people since 1988! [15] (The numbers of birds killed is not mentioned.)

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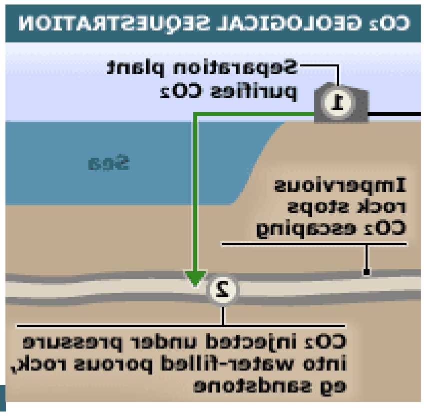
[13] http://www.aeronautics.ru/archive/du-watch/us_gov_about_du.htm,Venik, March 29, 2001.

[14] http://pubs.acs.org/subscribe/journals/esthag/40/i10/html/051506news1.html, May 15/06 - Environmental Science & Technology Online.

[15] http://www.ens-newswire.com/ens/nov2006/2006-11-09-09.asp#anchor6, Environmental News Service, November 9, 2006.

Carbon Sequestration

On a more optimistic note, there is new technology being developed to reduce CO_2 emissions: a technique called **carbon sequestration** to capture greenhouse gas emissions like CO_2, so they can be stored underground, rather than be allowed to enter the atmosphere.[16]



3 WAYS TO CAPTURE CO_2

Carbon is chemically removed before hydrocarbons are burnt, leaving a hydrogen-based fuel.

Carbon dioxide is removed from waste gases after combustion.

Oxygen is fed into a fossil-fuel burning power plant instead of air, resulting in pure carbon dioxide which does not need separation.

3 WAYS TO STORE CO_2

Carbon dioxide is pumped into fossil fuel reservoirs like oilfields or coal beds.

The captured material is stored in deep saline aquifers.

Carbon dioxide is used for a commercial purpose like enhancing plant growth in greenhouses.

Conclusions:

1) **Air pollution** - 10% of the world's CO_2 is from aviation
2) **Rise in demand** for air travel requires end of subsidies
3) **Lowest energy efficiency** of all transport
4) The highest **noise levels** are produced by flights
5) **Commercial accidents** have numbered about 1500
6) **Hazardous materials** include depleted uranium
7) **Carbon sequestration** - a solution to lower CO_2?

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[16] http://news.bbc.co.uk/2/hi/uk_news/3814607.stm

Shipping & Water Transport Environmental Risks

About **2% of world CO_2 is from ships**. Ships are more efficient financially, in fuel use, and in their **NOx and CO_2** emissions than both rail and road transport. In fact, about 90% of all world good are transported by ship.[17]

Comparing Freight Modes – Per Ton-Mile (TRB, 2002)

	Cost	Fuel Use	Hydrocarbons	CO	NOx
Units	*Cents*	*Gallons*	*Lbs.*	*Lbs.*	*Lbs.*
Barge (ships)	0.97	0.002	0.09	0.20	0.53
Rail (train)	2.53	0.005	0.46	0.64	1.83
Truck	5.35	0.017	0.63	1.90	10.17

[18]

Water pollution: 200 litres of oil end up in the water per boat per month (just operationally, that is not counting accidents).
The large amount of **sulphur** that is still being used in marine transport causes **acidification of water**. (Sulphur in land transport has been reduced, so marine use is relatively higher now).

Shipping, including boat facilities, ports, dry docks, transfer stations, waterways are all a part of an expensive **infrastructure**. Waterways along rivers also take up lots of space – 10 hectares per km of river.[19] Manufacture of ships involves the use of **hazardous substances** (such as depleted uranium). Also, an average ship contain 5-6 tons of asbestos, making shipbreaking hazardous work.[20]

Straightening of waterways and regulation of flow usually results in the speeding up of water flow and accumulation of wave action. This can be especially detrimental during **flooding** when the force of the water is uncontrollable and there is little absorption effect of river bank trees, because there are usually none left.

EU Solutions and Projects[21]:

"Clean Ship" – cradle to grave integrated approach with no harmful air or water emissions, including regulation of manufacture and use of hazardous substances in building and repairing (life cycle) of vessels.

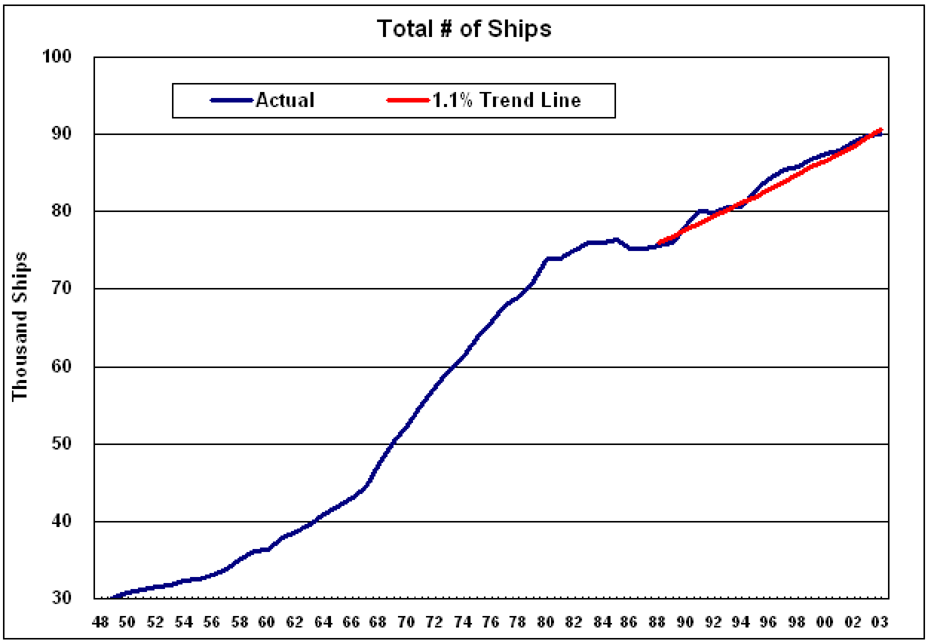
Clean "SkySails" for merchant vessels can reduce fuel costs by 50%.

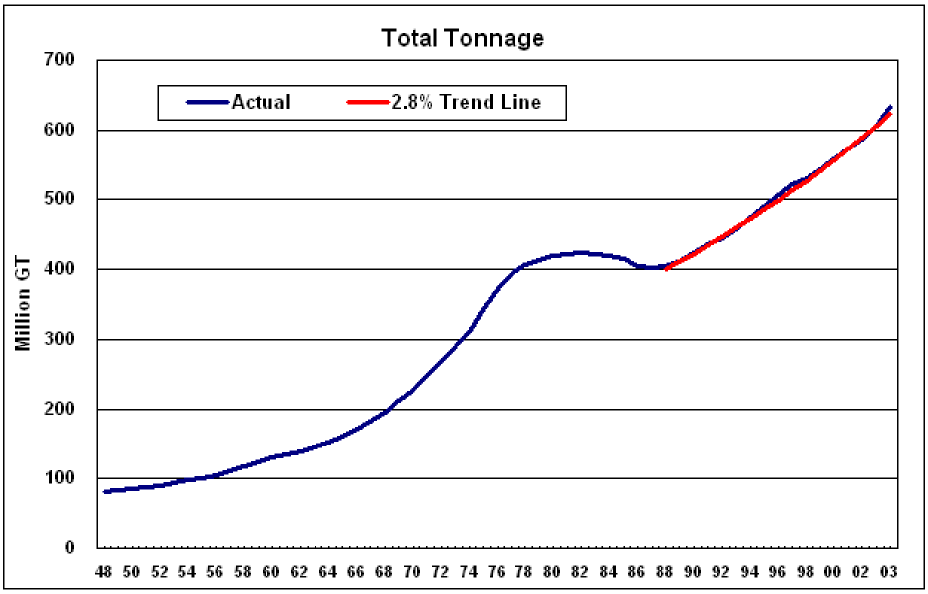
"Motorways of the Sea" are being introduced in EU to reduce road congestion, and include appropriate tariffs and taxes to participate, along with tax incentives for "clean ships".

[17] http://www.slashgear.com/german-skysail-saves-daily-fuel-cost-by-1000-052766.php, viewed on Dec. 4, 2006.
[18] http://www.vtpi.org/tdm/tdm16.htm; viewed Dec 2,2006.
[19] (Dirner)
[20] http://www.ilo.org/public/english/bureau/inf/features/06/clemenceau.htm, viewed on Nov. 22, 2006.
[21] http://www.transportenvironment.org/docs/Publications/2004Pubs/proceedings%20_towards%20clean%20ships_%20final.pdf, viewed on Nov. 22, 2006.

Growth of the World Fleet Since WWII

The trend lines on the past 15 years of these two charts show that the number of ships in the world fleet grows at less than half the rate of tonnage growth, partly because the average **ship gets bigger** and **industry gets more efficient**.
[22]





[22] http://www.coltoncompany.com/shipping/statistics.htm, *Lloyd's Register of Shipping "World Fleet Statistics"*, April 30, 2005.

Largest Tanker Spills

(Spills of 11 million gallons or more till 1999)

Rank	Location	Year	Ship	Spill (million gallons)
1	64 km off Table Bay, South Africa	1983	Castillo de Beliver	78.5
2	off Portsall, Brittany, France	1978	Amoco Cadiz	68.7
3	1175 km NE of St. John's, Newfoundland	1988	Odyssey	43.1
4	32 km NE of Trinidad & Tobago	1979	Atlantic Empress	42.7
5	in the port of Genoa, Italy	1981	Haven	42.0
6	450 km E of Barbados	1979	Atlantic Empress	41.5
7	off Land's End, England	1967	Torrey Canyon	38.2
8	in the Gulf of Oman	1972	Sea Star	37.9
9	in Navarino Bay, Greece	1980	Irenes Serenade	36.6
10	in the North Sea, off Belgium	1971	Texaco Denmark	31.5
11	593 km W of Kauai, Hawaii	1977	Hawaiian Patriot	31.2
12	in the Bosporus, near Istanbul, Turkey	1979	Independentza	28.9
13	off Ponta Delgada, Azores	1969	Julius Schindler	28.4
14	in La Coruna harbor, Spain	1976	Urquiola	28.1
15	off Garth Ness in the Shetlands, Scotland	1993	Braer	25.0
16	in Porto de Leisoes, Portugal	1975	Jakob Maersk	24.3
17	in La Coruna harbor, Spain	1992	Aegean Sea	21.9
18	140 km S of Kharg Island, Iran	1985	Nova	21.4
19	near entrance to Milford Haven, Wales	1996	Sea Empress	21.3
20	in the Atlantic, off South Africa	1971	Wafra	20.2
21	185 km off Morocco	1989	Khark 5	20.0
22	in Tralhavet Bay, Sweden	1970	Othello	18.0
23	111 km NW of Puerto Rico	1975	Epic Colocotronis	18.0
24	off Brazil	1960	Sinclair Petrolore	17.6
25	93 km from Muscat, Oman	1983	Assimi	15.8
26	off Honshu Island, Japan	1974	Yuyo Maru No. 10	15.8
27	1287 km off Angola	1991	ABT Summer	15.0
28	180 km E of Durban, South Africa	1992	Katina P.	15.0
29	off Hokkaido Island, Japan	1965	Heimvard	14.7
30	off Cape Villano, Spain	1978	Andros Patria	14.6
31	105 km E of Durban, South Africa	1968	World Glory	14.2
32	333 km W of Iwo Jima, Japan	1975	British Ambassador	14.2
33	30 km NE of Doha, Qatar	1983	Pericles GC	14.0
34	in the Straits of Magellan, off Chile	1974	Metula	13.9
35	in the Indian Ocean, off Seychelles	1970	Ennerdale	13.8
36	in the Strait of Malacca, near Dumai, Indonesia	1978	Tadotsu	13.2
37	off the Columbia River, near Warrenton, Oregon	1968	Mandoil	12.6
38	in the SE Pacific, off Chile	1973	Napier	11.3
39	11 km off Dubai, U.A.E.	1979	Patianna	11.2
40	off the E coast of Greece	1972	Trader	11.0
41	in Prince William Sound, Alaska	1989	Exxon Valdez	11.0

[23]

[23] Adapted from http://www.coltoncompany.com/shipping/statistics/spillstanker.htm; International Oil Spill Statistics 1999, August 3, 2001.

Other Oil "Spills"[24]

Worldwide each year, about 210 million gallons of petroleum (54%) enter the sea from the extraction, transportation, and **consumption of crude oil and products** refined from it; an additional 180 million gallons (46%) come from natural seepage, (more than twice as much as the biggest tanker spill above).

Nearly 85% of oil in North American ocean waters released from human activities are from land-based runoff, polluted rivers, airplanes, small boats and jet skis. Less than 8% comes from tanker or pipeline spills; 3% is from oil exploration and extraction. Consumers of oil -- not the ships that transport it -- are responsible for most of the oil in the ocean (oil runoff from cars and trucks, recreational boats and jet skis make up 75% of oil released through consumption).

A spill's impact also depends on the type of toxins present in the oil. The riskiest are organic compounds known as polycyclic aromatic hydrocarbons (PAHs), which have adverse effects on marine life even at low concentrations. This means chronic releases from runoff and recreational boating may cause more damage than previously thought.

So it may be easy to blame big tanker spills on ocean pollution (which is why they get all the publicity), but in fact it is **chronic consumer habits that cause the most damage**.

Conclusions:

1) Shipping is **more energy efficient** and less polluting than other transport modes (except some trains).
2) **Water and air pollution** from ships are still problems, creating about 2% of world CO_2.
3) Large amounts of **sulphur cause acidification of water**.
4) **Volume and efficiency** is increasing.
5) The **infrastructure** (ports, canals), manufacture, operation, maintenance and disposal activities of shipping are expensive, involve **hazardous substances**, and can adversely affect **natural water flow** (dangerous during flooding).
6) The EU **"Clean Ship"** concept could solve many environmental risks if implemented.
7) Annual **consumption of petroleum products** and natural seepage each release more oil than double the largest oil tanker spill ever!

English Humour: Why is it that when you transport something by car, its called a *shipment*, but when you transport something by ship, its called *cargo*?

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[24] http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=10388; National Academies News, May 23, 2002; viewed Dec. 2, 2006.

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VIDEO (1 minute) http://news.bbc.co.uk/2/hi/uk_news/3864099.stm, Stockholm Recommendations on World Aviation, BBC News, Sunday, 4 July, 2004, viewed Nov. 18, 2006.