

OCEANOGRAPHY

11. Marine Pollution

notes from the textbook, integrated with original contributions



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What is Pollution?

- Any harmful substance or energy put into the oceans by humans is considered to be pollution
- Environmental Bioassays are carefully controlled experiments to assess how a particular pollutant affects marine organisms
 - concentration of pollutant that causes 50% mortality among test organisms
 - Bioassays often are not useful because they do not study long time effects, interactions with other substances, and are too expensive, time-consuming, and often organism-specific

The Issue of Waste Disposal in the Ocean

- Waste disposal facilities on land have limited capacities that are already being exceeded
- Open ocean has mixing mechanisms to mix and dilute pollutants
- Long-term effects not known
- Spreading pollutants over huge areas, albeit diluted
- Debate about dumping wastes in ocean
 - Some scientists say we should not do it
 - Some scientists say it would be fine, as long as pollutants are properly disposed and monitored

What Are the Main Types of Marine Pollution?

- Marine pollution comes from substances such as petroleum, sewage, and various chemical compounds
- All of these can have severe deleterious effects on marine organisms, particularly along the coastline
- Coastal waters tend to be more polluted than open ocean because
 - Most pollution is dumped along coastal waters
 - Coastal waters are shallower and not as well circulated as the open ocean

Main Types of Marine Pollution

- Petroleum
- Sewage sludge
- DDT and PCBs
- Mercury
- Non-point-source pollution and trash

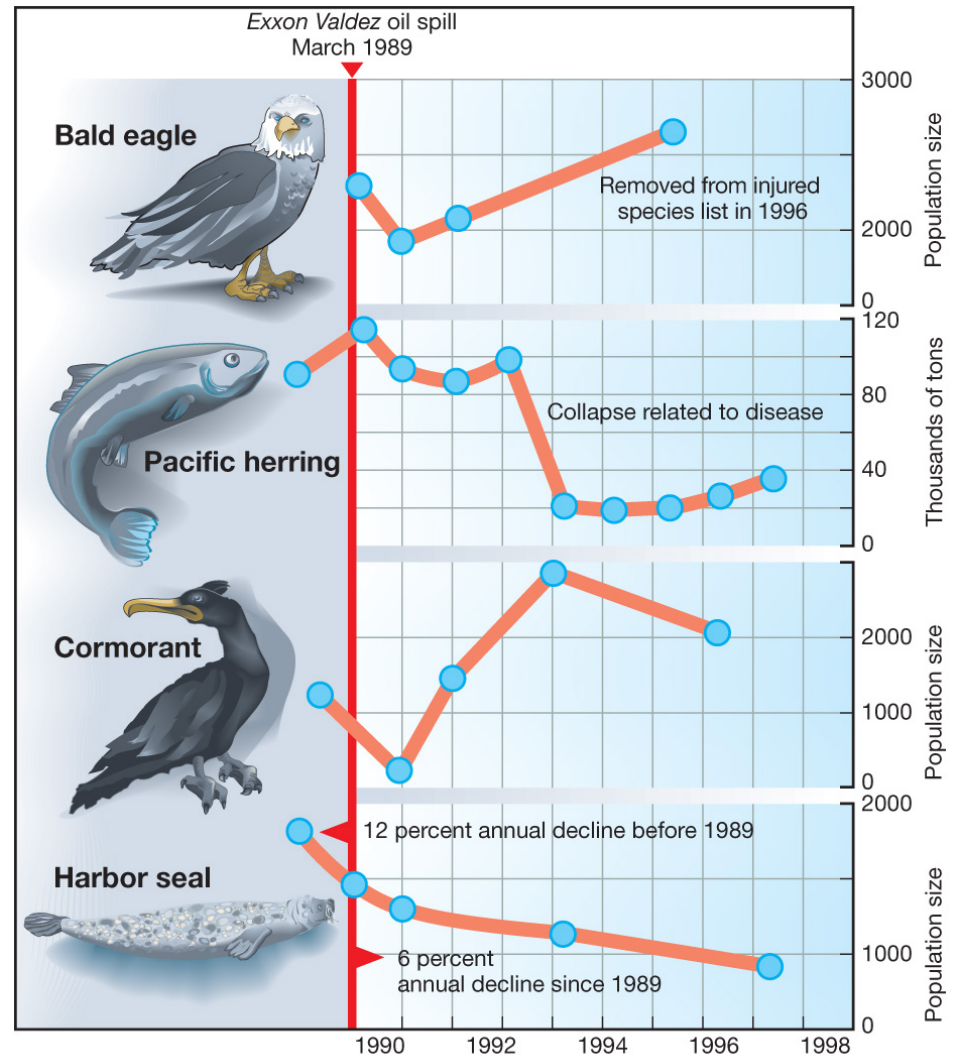
Petroleum

- **Oil spills**
 - from transport accidents
 - from oil extraction
 - 2010 *Deep Water Horizon* in the Gulf of Mexico
 - from tanker collision
 - 1989 *Exxon Valdez* spill in Prince William Sound, AK
 - from loading / unloading accidents
 - intentional spills
 - 1991 Persian Gulf (Iraq) War
 - Most oil spills are small scale, and not as big as the previous cases

Alaska's *Exxon Valdez*



- *Exxon Valdez* spill
 - Many organisms were killed outright
 - Long-term consequences unknown
 - Quicker than expected patterns of species recovery



World's Largest Oil Spills

TABLE 11A

THE WORLD'S LARGEST OIL SPILLS

Rank	Date	Location	Source of spill	Size of spill	
				million liters	million gallons
1	1/1991	Kuwait, Saudi Arabia	Oil terminals, tankers	908	240
2	6/1979	Gulf of Mexico	Ixtoc #1 oil well	530	140
3	3/1992	Uzbekistan	Oil well	333	88
4	2/1983	Iran	Oil well	303	80
5	8/1983	Near the coast of South Africa	<i>Castillo de Bellver</i> tanker	299	79
6	3/1978	Near the coast of France	<i>Amoco Cadiz</i> tanker	261	69
...
53	3/1989	Prince William Sound, Alaska	<i>Exxon Valdez</i> tanker	44.0	11.6

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Ixtoc 1, Campeche, Mexico

- Blowout of undersea oil wells
 - Ixtoc #1 Mexico spill
 - World's largest spill from well



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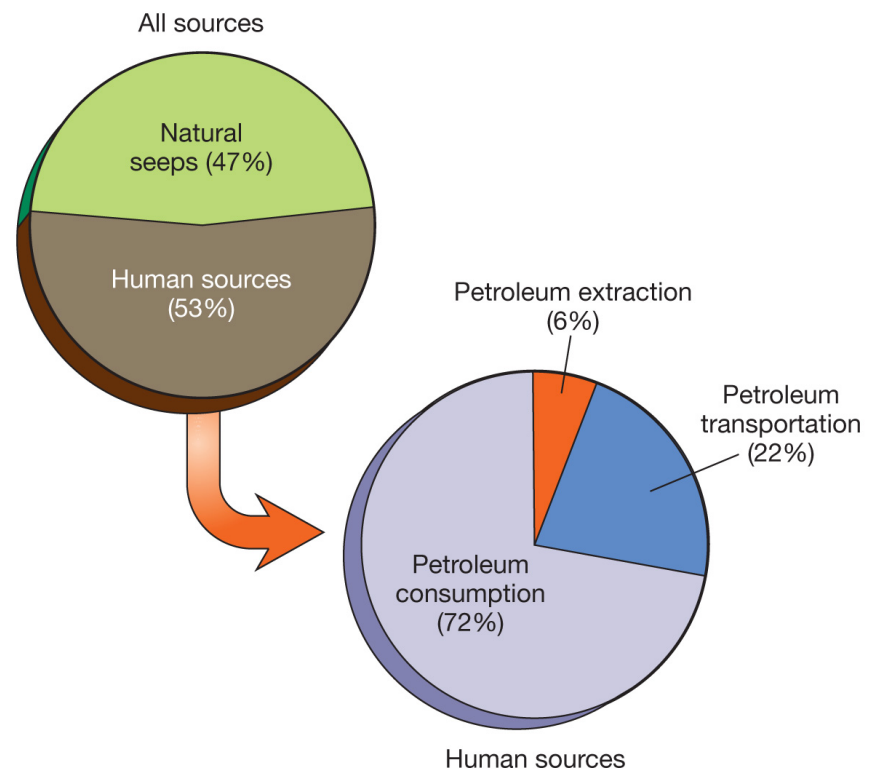
U.S. Coastal Waters Affected by the Gulf Oil Spill



How damaging is oil pollution in the ocean?

- Oil is a mixture of various hydrocarbons
- Hydrocarbons are natural substances, and as such they can be biodegraded by microorganisms
- Oil dissipates and breaks down, even becoming food for marine species
- Natural oil spills are small and widespread, and have occurred for millions of years
 - Seem to be beneficial to the ecosystem!

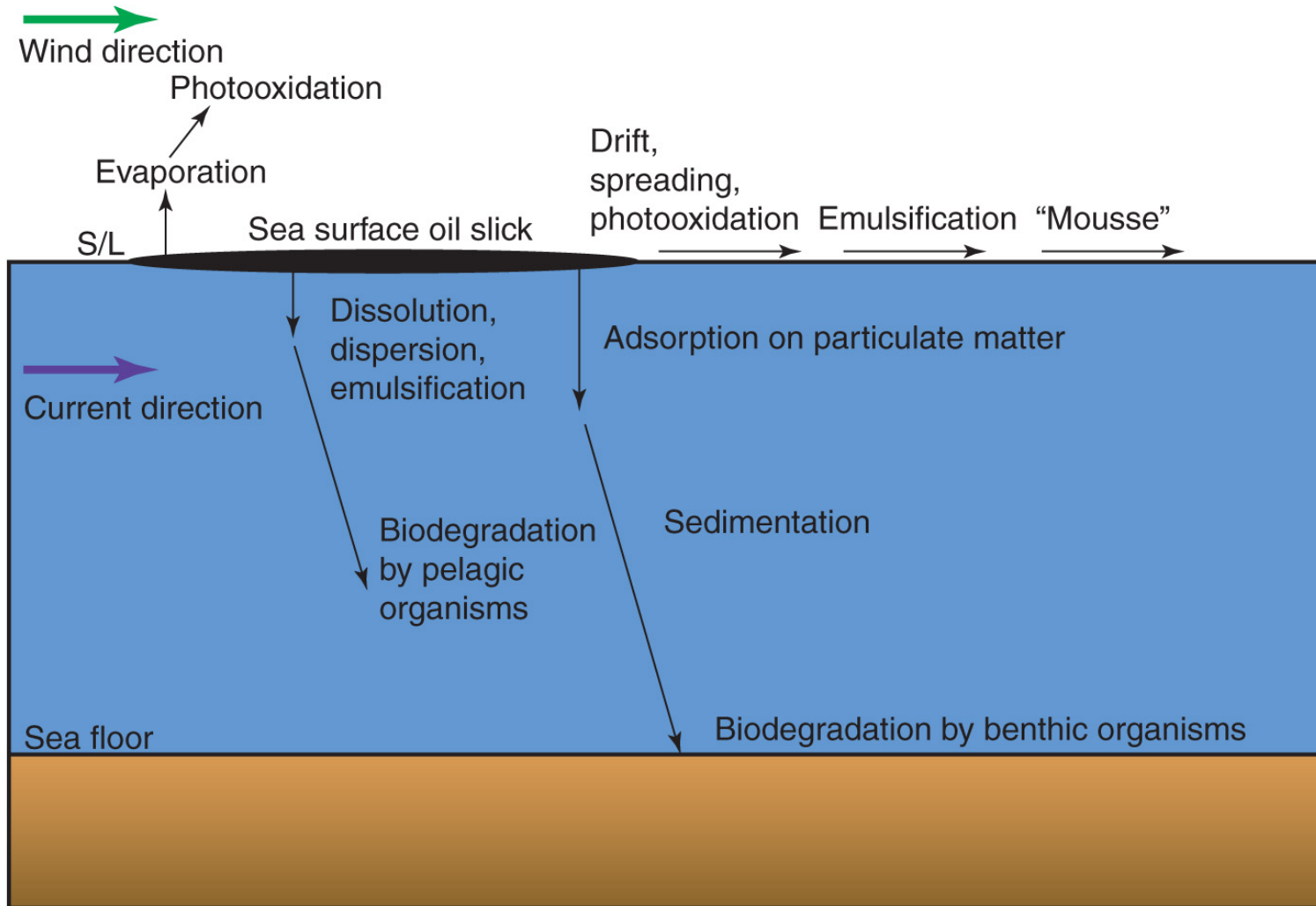
- Still, there are toxic compounds in petroleum that make it very dangerous
- Most of the oil that enters the ocean is the result of small, frequent, widespread release of oil related to human consumption
 - Car leaks
 - Gas stations
 - Refineries, plants



Cleaning Oil Spills

- Oil breaks down by natural processes
 - Volatile light components evaporate
 - Tar balls sink
- Remaining oil can be skimmed or absorbed
- **Bioremediation**
 - using bacteria and fungi to biodegrade oil
 - Releasing bacteria in the ocean
 - Providing conditions that stimulate bacteria growth

Cleaning Oil Spills



Preventing Oil Spills

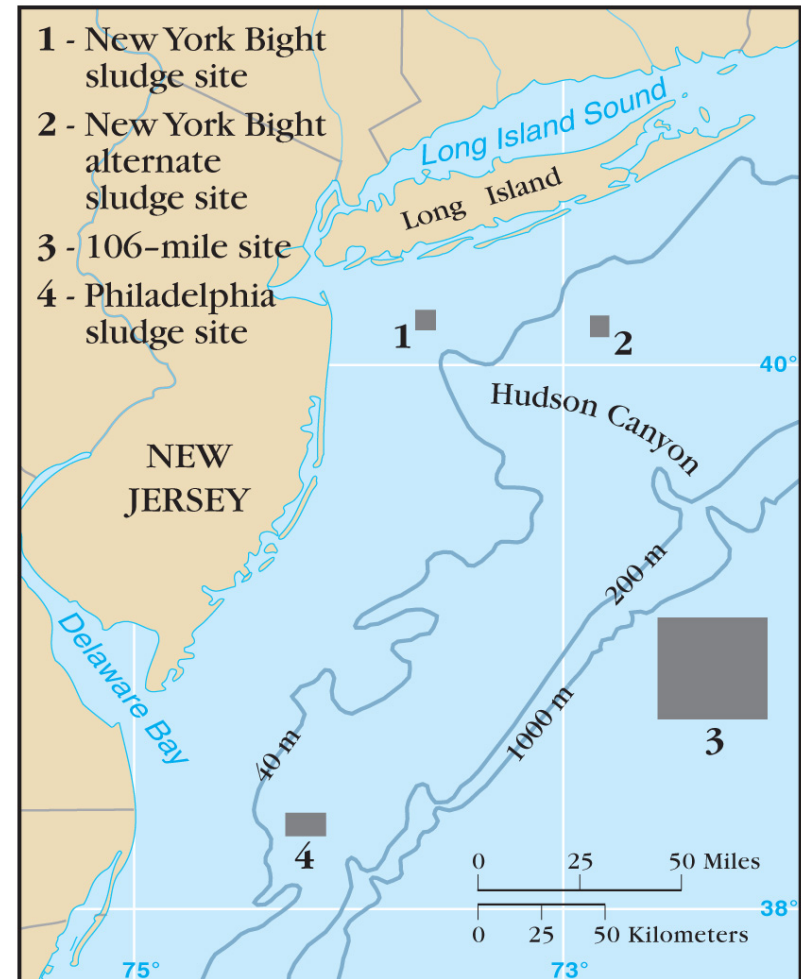
- Best way to prevent pollution is prevention
- Oil Pollution Act of 1990
- Single-hulled tankers barred from U.S. and European ports, not allowed within 320 km
- Double-hulled tankers mandatory since 2015
- Redesigning ships

Sewage Sludge

- Semisolid material after treatment
 - Primary treatment
 - Solids allowed to settle and lose water
 - Secondary treatment
 - Exposition to bacteria-killing chlorine
- No dumping of sludge in ocean after 1981
 - Clean Water Act, 1972
- Many exceptions/waivers

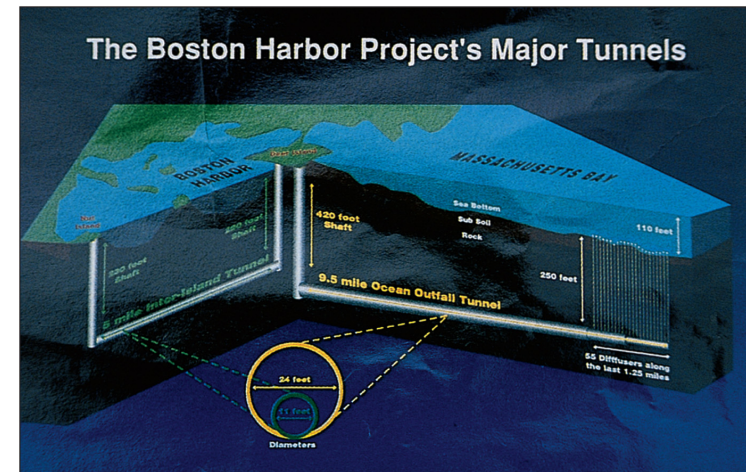
New York's Sewage Sludge Disposal

- First, shallow-water sites
- Then (1986), deeper-water site
- Adverse effects on fish
- 1993 – all sewage disposed on land

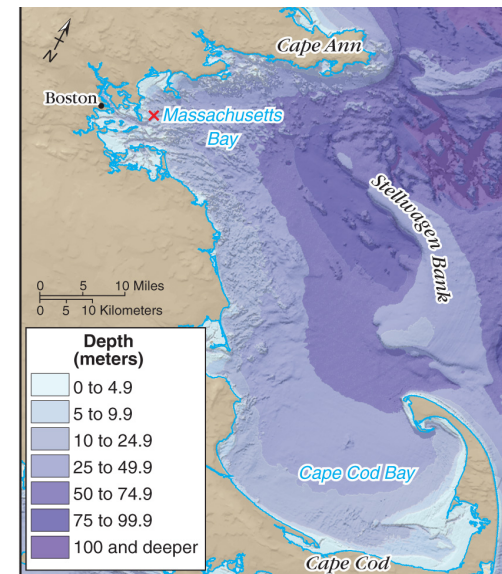


Boston Harbor Sewage Project

- Cleanup of harbor where sewage dumped in shallow water
- Treated sewage released into deep water via tunnels (1998)



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(b)

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DDT and PCBs

- DDT (a pesticide) and the industrial chemical PCBs (polychlorinated biphenyls) are now found widespread in oceans
 - DDT was used as insecticide
 - PCBs were used as liquid coolants and insulation materials
 - Both banned in 1977 worldwide, in 1972 in the U.S.
- They are persistent, biologically active organic pollutants introduced into oceans entirely as a result of human activities
 - Toxic
 - Long life, dissolved in seawater
 - Accumulated in food chain
 - Spread by ocean currents, found in measurable amounts even in Antarctica

DDT

- Decline in bird populations
 - Long Island osprey
 - California brown pelican
- Rebound of some marine bird populations



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Mercury and Minamata Disease

- Mercury (Hg) is a liquid metal that has many uses
- Bacteria can convert it to Methyl Mercury, which is toxic to most living organisms



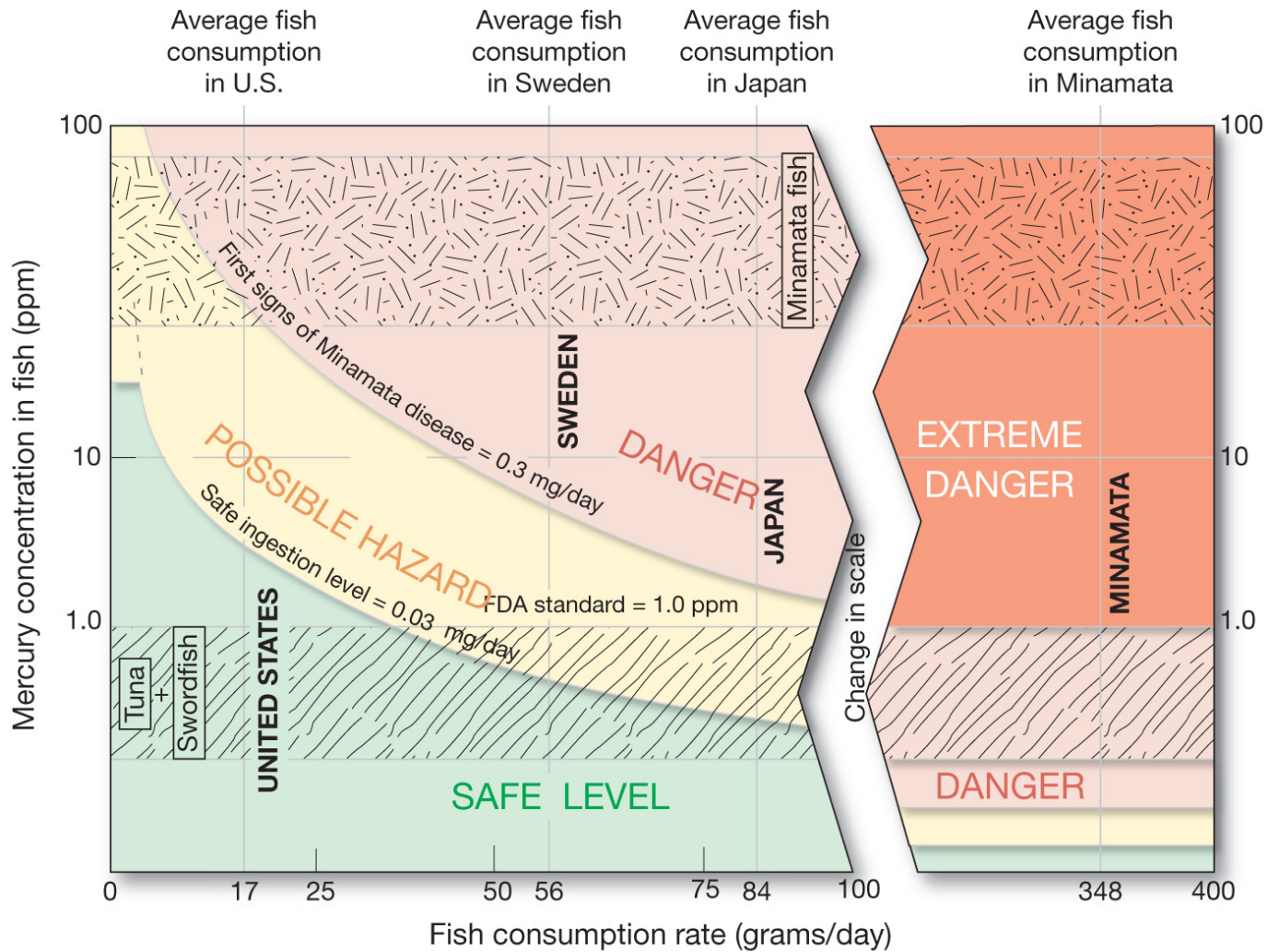
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- A chemical plant in Minamata Bay, Japan, released mercury in ocean waters from 1938 to 1968
- Mercury was absorbed by fish and shellfish
- First reported ecological changes in 1950
- Government denied connection but by 1953 humans were poisoned
 - Neurological disorder

Bioaccumulation and Biomagnification

- **Bioaccumulation** – organisms concentrate pollutant from seawater
- **Biomagnification** – organisms gain more pollutant by eating other contaminated organisms
- Safe levels of mercury determined by
 - Rate of fish consumption by people
 - Mercury concentration in fish consumed
 - Minimum ingestion rate of mercury to cause damages

Mercury Accumulations



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Non-Point-Source Pollution and Trash

- Any type of pollution entering the ocean from multiple sources
 - For example, from storm drains
 - Trash
 - Pesticides and fertilizers
 - Road oil



Ocean Dumping Law

Under the MARPOL agreement and U.S. federal law, it is illegal for any vessel to discharge plastics or garbage containing plastics into any waters. Additional restrictions on dumping non-plastic waste are outlined below. All discharge of garbage is prohibited in the Great Lakes or their connecting or tributary waters. Each knowing violation of these requirements may result in a fine of up to \$500,000 and 6 years imprisonment.

Within 3 nautical miles of shore and anywhere in lakes, rivers, bays, and sounds.

ILLEGAL TO DUMP Plastic
All other trash

3 to 12 nautical miles offshore

ILLEGAL TO DUMP Plastic
Dunnage, lining & packing materials that float
All other trash if not ground to less than 1"

12 to 25 nautical miles offshore

ILLEGAL TO DUMP Plastic
Dunnage, lining & packing materials that float

Outside 25 nautical miles offshore

ILLEGAL TO DUMP Plastic

State and local laws may place further restrictions on the disposal of garbage.

WORKING TOGETHER, WE CAN ALL MAKE A DIFFERENCE!

CENTER FOR MARINE CONSERVATION 1725 DeSales Street, NW Washington, DC 20036 (202)429-5609

Plastics

- Vast majority of marine debris
- 80% of marine debris comes from land sources
 - Most of it plastic
- Plastic floats and is not readily biodegradable
 - Can remain in the ocean for a long time
 - Entangle fish, marine mammals, and birds
 - Plastic bags choke turtles who mistake them for jellyfish
- Even worse, some plastics attract toxic compounds, e.g., DDT, PCBs, oil

Effects of Plastic Marine Trash



(a)



(b)



(c)

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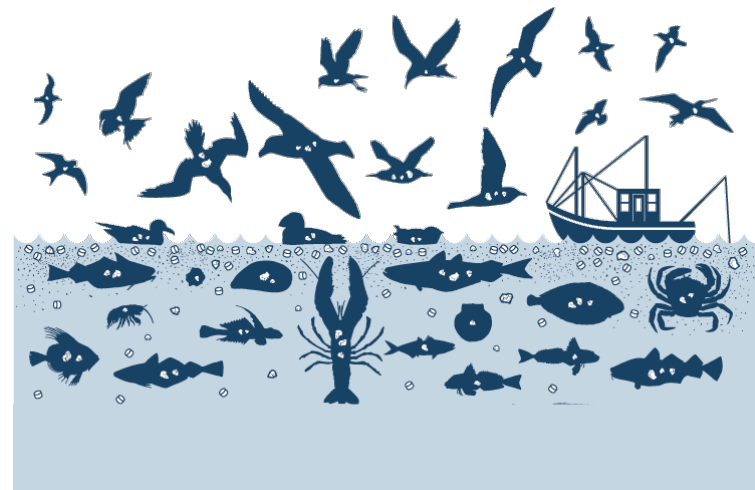


Brief history of plastics

- Known from 1862
- Industrially produced since end of WW2
- The very same properties that make plastics so advantageous for human societies make them unusually persistent and damaging when released into the marine environment:
 - lightweight
 - strong
 - durable
 - inexpensive

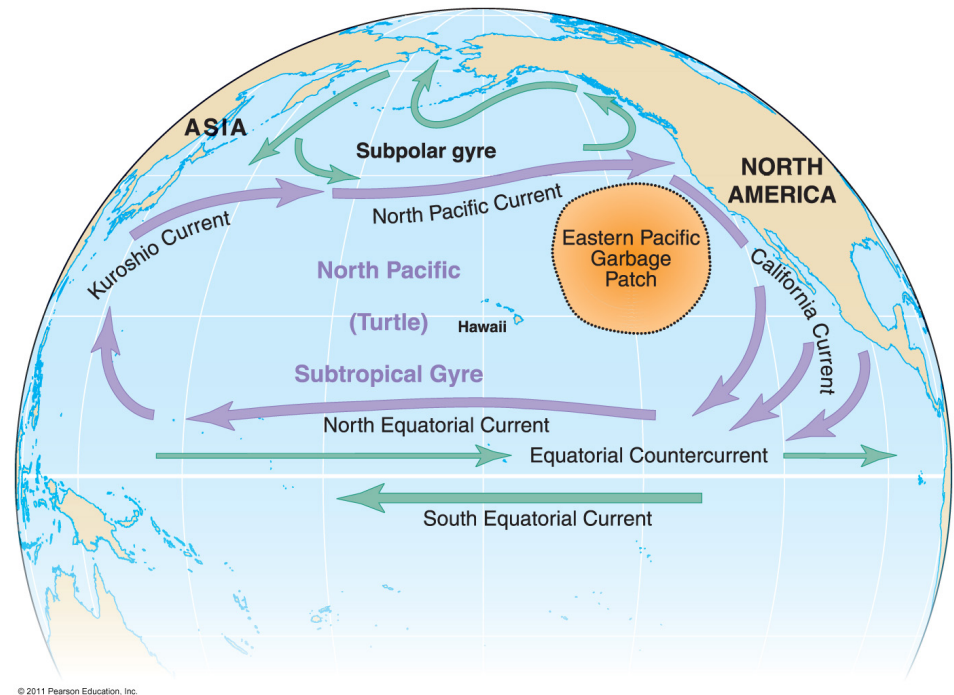
Plastic Nurdles

- Plastic nurdles are very small pre-production plastic pellets
- Plenty of them found in the ocean
- Like other plastics, nurdles are mistaken for prey by many marine animals and seabirds and enter the food chain



Plastics in the Ocean

- Floating plastics can be subject to photodegradation
 - Breaking up into smaller pieces
- Marine plastic particles increasing significantly
- Regions of floating trash
 - Eastern Pacific Garbage Patch



Can we reduce the amount of Plastic in the ocean?

- Limit use of plastic, recycle what we have
 - Several countries have banned use of plastic bags
- In 1988 **MARPOL** (marine pollution) convention:
 - Proposed treaty banning disposal of plastics
 - Regulating other trash dumping at sea
 - 122 nations ratified by 2005
- Many countries still do not have facilities available for garbage disposal

Biological Pollution: Non-Native Species

- Originate elsewhere, introduced by humans intentionally or accidentally
- They lack predators, so they outcompete and dominate native populations
- Can introduce new parasites
- Invasive species cause extensive damage annually



Destructive Seaweed Threatens California's Coastline



Caulerpa taxifolia

- If you see this seaweed while diving, **DO NOT** disturb it — report it!
- If you find it on your fishing gear or watercraft, bag it, and report it.
- Never dump the contents of your aquarium into any storm drain, creek, lagoon, bay, or ocean.
- For more information, visit: <http://swr.nmfs.noaa.gov>

Your help is needed!



- A few examples of invasive species
- *Caulerpa taxifolia*, is an invasive decorative alga introduced in saltwater aquariums
- The zebra mussel was accidentally introduced outside of its native environment, and has become an invasive species in many countries worldwide
- The comb jelly *Mnemiopsis leidyi* has also done extensive damage after having been transported in ballast water

End of Chapter 11, part 1

Marine Pollution