

# Anthropogenic Changes: Water and Oceans

## Water

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- water is becoming more and more scarce as a result of population increase and climate change
- global water use increased sixfold between 1900 and 1995; it has more than tripled since 1950; the rate of increase is twice as large as the rate of population growth (UNEP3 estimate)
- at the same time, freshwater supplies and some freshwater lakes have shrunk dramatically, e.g. Aral Sea, Lake Chad and the marshlands of Mesopotamia
- global water use now stands at 4340 km<sup>3</sup> per year, 8 times the annual flow of the Mississippi River
- annual irretrievable water losses have increased about 7-fold between 1900 and 1995 and now stands at 2900 km<sup>3</sup>; about 86% of this loss occurs in agriculture while the rest is lost in industry, municipal supply and reservoirs<sup>6</sup>
- several shortages affecting at least 400 Mio people today could affect 4 billion people (more than half the world's population) within 50 years; main culprits: waste and inadequate management
- 2.4 billion people (40% of world population) lack adequate sanitation facilities
- one person in three already lives in 'water stressed' countries where consumption exceeds 10% of total supply; if current trends continue, 2 out of 3 will live in such conditions by 2025
- one person in six has no regular access to safe drinking water
- water is used for domestic and industrial purposes but most (75%) is used in agriculture
- in 2000, agriculture and domestic each wasted 800 km<sup>3</sup> of water and industry 400 km<sup>3</sup>; by 2025, a UNEP3 estimate put these numbers to 1000, 1100 and 500
- drinking water supplies for poor people would be doubled with just a 10% improvement in the efficiency of irrigation
- countries with the highest rates of water usage (liters per person per day): Kazakhstan, Uzbekistan, Kyrgyzstan, Tajikistan, Azerbaijan, Armenia, Iraq and Guyana

- countries in which more than 50% have no access to improved water sources, such as a protected well, spring or tap: Haiti, Oman, Cambodia, Fiji, Papua New Guinea, Madagascar, Eritrea, Ethiopia, Kenya, Uganda, Rwanda, Democratic Republic of Congo, Angola, Equatorial Guinea, Chad, Sierra Leone, Guinea, Guinea-Bissau, Mauritania
- by 2025 two-thirds of the world's population will be short of water
- commercial companies are buying exclusive rights to rivers and aquifers, often in areas where the local people are chronically short of water
- power struggles over water are increasingly likely to be the cause of conflict
- the destruction or contamination of water supplies is itself a weapon of war
  - Examples: in the 1991 Gulf War, Iraq destroyed Kuwait's desalination capacity
  - in the 1991 Gulf War, the U.S.-led coalition bombed Baghdad's water system
  - from Angola to Timor, enemies have been killed and their bodies thrown in wells to poison local water supplies

#### SOME GOOD NEWS

- the number of people with some form of improved water supply rose from 4.1 billion (79% of world population) to 4.9 billion (82%)
- DID YOU KNOW? by 2025 two-thirds of the world's population will be short of water!

## The Oceans and Coastal Changes

- oceans cover 70.8% of Earth's surface
- oceans hold 95% of Earth's water
- 60% of population lives near coasts
- 200 Mio people depend on fishing
- coastal habitats changed by pollution, dredging, filling, draining
- deforestation increases runoff into oceans (and polluting agricultural chemicals with it)
- deforestation increases soil erosion and more sediments reach coastal areas
- mining runoff; e.g. mercury is used to extract gold from dirt
- waste disposal, untreated or improperly treated sewage, nuclear waste

- UNEP estimates that 18,000 pieces of plastic litter are floating on every km<sup>2</sup> of the ocean
- lax regulations allow world's growing fleet of more than 200 large cruise ships to dump untreated sewage into oceans (each day, a standard ship generates 95,000l of sewage from toilets, 540,000l sewage from sinks, galleys and showers, 6 tons of garbage and solid waste, 56l of toxic chemicals, 26,500l oily bilge water)
- along shipping lane between Iceland and Scotland, 3 times more plastic found in 1990s than in 1960s
- more than 100,000 mammals and sea turtles die each year from entanglement in, or ingestion of, plastics
- even pollution of atmosphere is taking toll on ocean life (see Mercury web page)
- coastal dead zones
  - : provoked by nitrogen, phosphorus, and other nutrients from fertilizer, large livestock farms, and septic systems
  - dramatic increase in recent decades
  - there are now 146 dead zones worldwide
  - most severe dead zones: (6 20,000 km<sup>2</sup>) Bay of Bengals, Gulf of Mexico, Arabic Sea, Baltic Sea, East China Sea
- beach cleanups<sup>7</sup>: 6.2 Mio volunteers have removed nearly 50,000 tons of debris from world's beaches and waterways
- a small number of objects account for a large share of this debris:
  - 60% is from recreational activity (fishing lines, nets, beach toys, food wrappers)
  - 29% is from cigarette butts and filters

## The Health of Coral Reefs

- the health state of coral reefs is often used to estimate the oceans' health in general
- coral reefs are important source of revenue for tourist industry
- corals attacked has many sources <sup>6</sup>:
  - physical damage: explosive fishing, anchor damage, construction, boat grounding, reef walking, removal of protective vegetation from islands

- freshwater runoff: from cities and cleared land
- introduction of invasive predators
- climate change: warming, sea level rise, hurricane activity
- exploitation: fishing, collecting corals, coral mining
- sedimentation: mining, dredging, filling, construction, soil erosion
- pollution: industry, oil spills, sewage, agricultural chemicals, fish farming, waste dumping, anti-fouling paint, etc

## Global Warming and the Oceans - Ocean Acidification

- see Lecture 23 for coupling between atmosphere and oceans
- current estimates are that the atmosphere stores about 46% of human produced CO<sub>2</sub>, the oceans take up 29%, the northern hemisphere forest regrowth 7% and other parts in the biosphere 18%
- according to NOAA (National Ocean and Atmosphere Administration) studies, the oceans' chemistry has changed 100 faster since the industrial revolution began than in the previous 650,000yrs
- the amount of CO<sub>2</sub> dissolved in ocean water has increased from 398.1ppb in 1850 to 529.9 ppb in 2005 (30% increase in acidity); predictions put this number to 926.7 ppb by 2100
- the pH has changed from 8.16 in 1850 to 8.05 in 2005 and could be as low as 7.85 by 2100
- sea life that is likely impacted by a more acidic ocean: soft-shelled clams, corals, calcareous plankton and pteropods
- pteropods are small snails that build calcium carbonate shells; they are a critical part of the food chain in polar and near-polar seas; they are the preferred food for herring, pollock, cod, salmon and baleen whales

## Fishing Industry

- fish considered healthy food, with high levels in fatty acids and trace minerals; fish is good for neurological functions, reduced cancer risk, heart disease
- for more than 1 billion people (mostly in Asia), fish supplies 30% of proteins (6% on average globally)

- seafood has become scarcer as demand has grown; e.g. Chinese consumers now eat 5 times as much seafood per capita as in 1961; total fish consumption in China has increase 10-fold and in the U.S. 2.5-fold<sup>7</sup>
- people tend to remember fish populations only during own lifetime and are not aware what it was like only a generation ago, so many are not aware of creeping seafood decline
- experts may set false reference points for evaluating economic losses from overfishing and for recommending restauration; very large historical fish catches may be dismissed as myths/inaccurate anecdotes (this process is called "shifting baseline"); e.g. Atlantic cod was once plentiful but current generation may grow up thinking that cod never was in the Atlantic
- today, most of world's seafood, from tuna to salmon to bay scallops, is threatened with extinction
- for less-threatened species, like shrimp or farmed salmon, main issues are how they are raised or caught, which can have adverse impacts on the environment
- today's fishing technique's include sonar to locate fish, ever-longer long-lines, ever-growing trawl and driftnets, larger and stronger winches, larger refrigerators
- today's fishing fleets now cover wide swaths, leaving little room for fish to hide and escape
- at same time, fuel consumption has increased dramatically; e.g. in 2000, burned 43 Mio tons of fuel to catch 80 Mio tons of fish; i.e. fishermen used 12.5 times as much energy to catch fish as fish provide to those who eat them; this is still more energy efficient than raising beef and raising salmon!
- there is no sign that commercial fishing companies will voluntarily change their practices, especially as the soaring demand for fish continues to push up its value

## Declining Fisheries - Some Numbers

- of some 30,000 known fish species, only approx. 1000 are eaten by humans; only a small share of these make up most of the catch; e.g. Alaska pollock, Peruvian anchovy, Atlantic bluefin tuna, and Chilean jack mackerel make up 13% of global wild catch and carp, catfish, tilapia and salmon dominate aquaculture (fish farms)
- 7 nations take in 2/3 of the global catch: China (47.3 Mio tons), Peru (6.1), India (5.9), Indonesia (5.7), U.S. (5.5), Japan (5.5); Japan now world's largest importer

- in 2003, world's fish farmers and fishing fleets harvested 132.5 Mio tons of seafood, 7 times what it was in 1950
- 74% comes from marine areas, 26% come from inland freshwater bodies
- of the marine harvest, 88% come from shallow shelf areas (less than 120km from coast, no deeper than 200m)
- another 25% is discarded at sea as unwanted by-catch, e.g. birds, unwanted fish, marine mammals, turtles, juveniles of the targeted species, even fish sought after in other fisheries
- approx. 67% of world's major stocks have been fished at or beyond their capacity
- another 10% have been harvested so heavily that fish populations will take many years to recover
- since 1997, wild harvests have fallen 13% from the peak of approx. 87 Mio tons
- fish farming harvest increased 50% from 35.8 Mio tons to 54.8 Mio tons; now accounts for 40% of global fish harvest
- by 2004, industrial fleets had emptied oceans of at least 90% of all large predators (tuna, marlin, swordfish, sharks, cod, halibut, skates, flounder), within the last 50 years
- size and quality of fish declining
- some inland lakes may be affected even more; harvest from lakes and rivers has quadrupled since 1950s (now 8.7 Mio tons/year, excl. fish farms); e.g. catch of legendary Mekong catfish (3m long, 300kg) has fallen from 60 in 1995 to 4 in 2005

## Declining Fish Stock - Example Sharks

- 350 species of variable size (a few inches to 15m), all of which are threatened
- dramatic decline in Northwest Atlantic in just 15 years; e.g. Hammerhead has declined by 89% since 1986, White Shark has declined 79%, Tiger Shark by 65%, Thresher Shark by 80%, Blue Sharks by 60%
- some sharks in Gulf of Mexico declined by 90%
- nearly 50 shark species close to disappearing worldwide
- a bowl of shark fin soup can cost \$200 - shark fin industry booming
- approx. 100 Mio sharks are caught each year, yielding 8000 tons of fins

- particularly inhumane as only shark fins are harvested, while sharks are thrown back into ocean to die
- several nations have banned such practice
- trade in several species is prohibited under international law but laws may not always be effective
- being on top of the food chain, shark meat and fins can contain concentrations of mercury higher than what is considered safe to eat
- finning has been banned from the Atlantic and Mediterranean but is still going on in the Indian and Pacific

## **The Giant Sea Bass - Close to Extinction**

- critically endangered
- up to 2.5m long, and 255 kg
- very slow reproduction; fish stock doubles only once in 14 years
- lives in kelp forest off California and Japan
- once common, it supported commercial fishing industry in the 1800s in Southern California, with hundreds of thousands of kg annually
- by late 1970s it was found that local populations were in serious trouble
- since 1982 protected from commercial and sport fishing

## **Some Bad Fishing Practices**

- poisoning with sodium cyanide (e.g. S.E. Asia)
- dynamite (e.g. Mediterranean)
- gillnets/drift nets (trap/drown large mammals and birds)
- trawling; trawling clears virtually all continental shelved (within 120km of coast, up to 200m deep water) twice a year (equals 150 times area of global forest); likened to clear-cutting techniques in forests as everything along the floor is swept up/destroyed

## Fishing Industry - Some Good News

- marine reserves have shown to be effective to rebuild depleted fish populations; have to be large enough; may not work in open ocean; have to include coastal area on land to effectively avoid/decrease pollution
- aquaculture/fish farms relieve strain on wild fisheries (though salmon farms are considered problematic), e.g. cat fish, trout
- citizens are trained/help with seeding area with young fish/shellfish, e.g. Peconic Bay/ NY Long Island is seeded with scallops, clams and oysters
- London-based Marine Stewardship Council certifies certain seafood as "sustainable" and has granted its label to 18 fisheries worldwide, incl. North Sea herring, Australian mackerel, and Baja red rock lobster
- more than 370 products in nearly 30 nations now carry the "Fish Forever" logo
- certain food companies base their business on "the story behind the fish" (how it's raised, caught and processed)
- large chains like Unilever, Wal-Mart and Red Lobster have committed to source their seafood only from intact fish populations
- EcoFish identifies and markets seafood originating from environmentally sustainable fisheries (now in 1000 stores and 150 restaurants)
- CleanFish markets seafood caught by smaller-scale fishers that are less likely to harm the marine environment
- some high-profile celebrities and companies rally against shark-finning and Hong Kong university and Disneyland took shark fin soup off their menus
- groups like the Monterey Bay Aquarium in California and the Blue Ocean Institute in New York are issuing guide to inform people which seafood is the most "ocean friendly" (see below); guides encourage shoppers which species to avoid
- these fish cards are not yet widely used but could be effective to put pressure on fishing industry; e.g. campaigning for dolphin-safe tuna fishing in late 1980s was quite successful
- since becoming a U.S. state in 1959, Alaska's constitution requires to protect and conserve salmon habitat; local fishing industry worked with government to rebuild and not overfish stock; regulations strictly limit number of fishing permits; state biologists monitor spawning; since 1959, harvest increased from 20 Mio tons the 206 Mio tons, the third largest catch on record

- Cape Cod Hookers: local fishermen distinguish themselves by promoting "old-fashioned" hook line fishing that damage fish less than commercial techniques; by-catch more likely to survive; fish more expensive but story sells well
- Loch Duart, Scotland (farmed) Salmon: developed better farming techniques to avoid pollution; more room for fish avoids the application of antibiotics; uses only native fish species; now train fish farmers in Maine and Nova Scotia
- on the downside: this does not include farmed salmon and Asian-farmed shrimp, which constitute the bulk of chains' seafood sales
- on the downside: endangered species (swordfish, Atlantic cod, Chilean sea bass) make comeback on restaurants' menus
- suggested methods to improve situation<sup>7</sup>:
  - eliminate fisheries and energy subsidies (global fishing fleets are an estimated 250% larger than are needed to catch what oceans can sustainably produce)
  - reallocate payments to encourage the use of less destructive gear, direct marketing to consumers, and ecological fish farming
  - establish a global network of marine reserves
  - eliminate bottom trawling (dragging such nets has been likened to clear-cutting forests)
  - reduce wasted and illegal catches
  - encourage ecological fish farming

## Good and Bad Fish to Buy

### References

1. "The Penguin State of the World Atlas" by Dan Smith, 2003. Penguin Books, ISBN: 0-14-200318-2
2. Flyer from the Algalita Marine Research Foundation
3. United Nations Environmental Programme (UNEP) web site
4. "State of the World 2003" by Chris Bright et al., 2003, The Worldwatch Institute, Norton & Company, ISBN: 0-393-32386-2
5. "State of the World 2004" by Erik Assadourian et al., 2004, The Worldwatch Institute, Norton & Company, ISBN: 0-393-32539-3

Table 1: A Table Issued by the Audubon Society

Enjoy	be careful	avoid
anchovies	cod (Pacific)	cod (Atlantic)
dungeness crab	lobster (American)	caviar (imported//wild-caught)
crawfish	shrimp (U.S. farmed or trawl-caught)	shrimp (imported)
catfish (farmed)	rainbow trout (farmed)	flounder and soles (Atlantic)
halibut (Pacific)	Mahi-Mahi	halibut (Atlantic)
mussels and clams (farmed)	scallops (bay and sea)	Chilean sea bass (toothfish)
oysters (Pacific farmed)	oysters (wild-caught)	monkfish
sablefish (Alaska, Brit. Columbia)	squid (calamari)	grouper
salmon (wild Alaskan)	swordfish (Atlantic)	salmon (farmed, incl. Atlantic)
sardines	tuna (canned)	orange roughy
tuna: ahi, yellowfin bigeye, albacore (pole/troll-caught)	tuna: ahi, yellowfin, bigeye albacore (longline caught)	tuna bluefin
striped bass (farmed)		red snapper
tilapia(U.S. farmed)		sharks

6. "The Human Impact on the Natural Environment" by Andrew Goudie, 2000, The MIT Press, ISBN: 0-262-57138-2
7. publication 172 "Catch of the Day" from the World Watch Institute
8. Baum et al, 2003. "Collapse and Conservation of Shark Populations in the Northwest Atlantic", Science, Vol 299, 389-392.

## Recommended Reading

Not required to pass the tests, but for the interested souls:

- "Earth's Climate, Past and Future" by William F. Ruddiman, 2000. W.H. Freeman and Company, ISBN: 0-7167-3741-8
- "State of the World" by The Worldwatch Institute, W.W. Norton and Company. Topics change from year to year but the 2004 book (ISBN: 0-393-32539-3) was on consumerism and globalization, waste/recycling of resources, catch-up of developing countries, water productivity and increasing shortage. Earlier books were on energy resources, greenhouse effect, Kyoto Protocol and the spread of and fight against diseases.
- "Earthshock" by Andrew Robinson, 1993, Thames and Hudson, ISBN: 0-500-27738-9

- "Global Warming" by John Houghton, 1999, Cambridge Univ. Press, ISBN: 0-521-62932-2