1 ***The Coastal Ocean***

Trujillo & Thurman, Chapter 11

Oceanography 101

2 ***The Big Question:***

Who "owns" the World Ocean?

3 **Chapter summary in haiku form**

Who owns the oceans?
Not Somalian pirates –
They belong to all!

4 ***Overview***

- Coastal waters support about 95% of total biomass in ocean
- Most commercial fish caught within 320 km (200 mi.) from shore
- Important also for shipping, oil and gas production, and recreation
- Many pollutants found here

5 ***Ocean ownership***

- AD 1609 (Dutch)
  - sea is free to all (*mare liberum*)
    - assumption: fish resources are inexhaustible
- AD 1702 (English)
  - territorial sea under coastal nation's sovereignty (3 nautical miles from shore)
    - distance of cannon shot

6 ***United Nations and ocean laws***

- 1958-1982 United Nations Law of the Sea Conferences
  - National sovereignty extends 12 nautical miles
  - Exclusive Economic Zone (EEZ)
    - 200 nautical miles (370 km) from land (mineral and fishing resources)
  - Right of free passage for ships
  - Open ocean mining regulated by International Seabed Authority
  - United Nations arbitrates disputes

7 ***EEZ of the U.S***

8 ***Characteristics of coastal waters***

- Adjacent to land (to edge of continental shelf)
- Influenced by river runoff, wind, tides
- Salinity variable
  - Freshwater runoff
  - Winds
  - Mixing by tides
  - Evaporation

9 ***Characteristics of coastal waters***

- Temperature variable
  - Low-latitudes: restricted circulation, very warm
  - High-latitudes: sea ice
  - Seasonal changes
  - Prevailing winds

10 ***Salinity characteristics***

11 ***Temperature characteristics***

12 ***Coastal geostrophic currents***

- Wind and runoff
- Piled up surface water affected by Coriolis effect
- Flow parallel to coast

- Example: Davidson Current

13 ***Coastal geostrophic currents***

14 ***Types of coastal waters***

- Estuary
  - Partially enclosed coastal area with ocean water and freshwater (runoff) mixing
- Coastal wetland
  - Ecosystem with water table close to surface
- Lagoon
  - Shallow coastal water separated from ocean
- Marginal sea
  - Relatively large semi-isolated body of water

15 ***Origin of estuaries***

- Rising sea level “drowns” what was once land
- Coastal plain estuary
  - Former river valley now flooded with seawater
- Fjord
  - Former glaciated valley now flooded with seawater
- Bar-built estuary
  - Lagoon separated from ocean by sand bar or barrier island
- Tectonic estuary
  - Faulted or folded down-dropped area now flooded with ocean

16 ***Origins of estuaries***

17 ***San Diego Bay***

18 ***San Diego Bay***

19 ***Mission Bay, an artificial estuary***

20 ***Horseshoe Bay, B.C., Canada***

21 ***Classification of estuaries***

Based on mixing of freshwater and saltwater

- Vertically mixed
  - Shallow, low volume
- Slightly stratified
  - Deeper
  - Upper layer less salty; lower layer more salty
  - Estuarine circulation
- Highly stratified
  - Deep, relatively strong halocline
- Salt wedge
  - Deep, high volume
  - Strong halocline

22 ***Classification of estuaries***

23 ***Estuaries and human activities***

- Important breeding grounds for many marine animals
- Protective nurseries
- Pressures from increasing human populations
  - Columbia River estuary (salt wedge)
  - Damages due to dams, logging

24 ***Columbia River estuary***

25 ***Chesapeake Bay Estuary***

- Slightly stratified
- Seasonal changes in salinity, temperature, dissolved oxygen
- Anoxic conditions below pycnocline in summer
- Major kills of commercially important marine animals

26 ***Types of coastal wetlands***

27 ***Characteristics of coastal wetlands***

- Biologically important
  - Nurseries, feeding grounds for commercially important marine animals
- Efficiently cleanse polluted water
- Absorb water from coastal flooding
- Protect shores from wave erosion

28 ***Loss of coastal wetlands***

- Half of U.S. coastal wetlands lost to development (housing, industry, agriculture)
- U.S. Office of Wetland Protection, 1986
  - Minimize loss of wetlands
  - Protect or restore wetlands
- Predicted rise in sea level over next 100 years will destroy or shift wetlands inland

29 ***Lagoons***

- Freshwater zone
- Transition zone of brackish water
- Saltwater zone
- Hypersaline in arid regions

30 ***Marginal seas***

- Mostly from tectonic events
  - Ocean crust between continents, e.g., Mediterranean Sea
  - Behind volcanic island arcs, e.g., Caribbean Sea
- Shallower than ocean
- Connected to ocean
  -

31 ***Mediterranean Sea***

- Remnant of Tethys Sea
- Deeper than usual marginal sea
- Underlain by oceanic crust
- Thick salt deposits

32 ***Mediterranean Sea***

33 ***Mediterranean circulation***

- Atlantic Ocean surface flow
- High rates of evaporation
- Mediterranean Intermediate Water very salty
- Returns to Atlantic Ocean as subsurface flow
- Circulation opposite to estuarine circulation

34 ***Mediterranean circulation***

35 ***Marine pollution***

- Any harmful substance or energy put into the oceans by humans
- Harmful to living organisms
  - Standard laboratory bioassay – concentration of pollutant that causes 50% mortality among test organisms
- Hindrance to marine activities (e.g., fishing)
- Reduction in quality of sea water

36 ***Waste disposal in ocean***

- Diluting pollutants with huge volume of ocean water
- Long term effects not known
- Debate about dumping wastes in ocean
  - None at all
  - Some, as long as properly disposed and monitored

37 ***Main types of marine pollution***

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

38 ***Petroleum***

39 ***Petroleum***

- Biodegradable hydrocarbons
- Recovery faster than expected
  - *Exxon Valdez* oil spill, 1989
- But many organisms killed outright
- Long-term consequences uncertain

40 ***Oil spills in U.S. (lower 48)***

41 ***Oil spills in U.S.***

- *Argo Merchant*, Nantucket, 1976
  - No oil on shore
  - Mainly plankton damaged

42 ***Cleaning oil spills***

- Natural processes
  - Volatilization
  - Photo oxidation
  - Emulsification
  - Biodegration by pelagic organisms
  - Biodegration by benthic organisms
- Artificial processes
  - Skimming or absorbing surface oil slick
  - Bioremediation by “hydrocarbon-eating” bacteria

43 ***Cleaning oil spills***

44 ***Preventing oil spills***

- Double hulled oil tankers by 2015
  - 1990 Oil Pollution Act
- Burn oil before it spreads
  - 1999 M/V *New Carissa*

45 ***Sewage sludge***

- Semisolid material after treatment
- No dumping of sludge in ocean after 1981
  - Clean Water Act, 1972
- Many exceptions/waivers

46 ***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

47 ***Boston Harbor sewage project***

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

48 ***Point Loma sewage treatment plant outfall***

49 ***DDT and PCBs***

- Pesticide DDT
- Industrial chemicals PCBs (polychlorinated biphenyls)
- Widespread in oceans
- Persistent organic pollutants

- Toxic
- Long life dissolved in seawater
- Accumulated in food chain

50 ***DDT***

51 ***Mercury and Minamata disease***

- Methyl mercury toxic to most living organisms
- Chemical plants, Minamata Bay, Japan, released mercury in 1938
- By 1950 first reported ecological changes
- By 1953 humans poisoned
  - Neurological disorder

52 ***Bioaccumulation and biomagnification***

- Bioaccumulation – organisms concentrate pollutant from seawater
- Biomagnification – organisms gain more pollutant by eating other 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

53 ***Bioaccumulation and biomagnification for mercury***

54 ***Non-point-source pollution and trash***

- Not from underwater pipelines
  - For example, from storm drains
- Trash
- Pesticides and fertilizers
- Road oil
-

55 ***Trash from dumping***

- Some trash can be legally dumped far from shore
  - Biodegradable (e.g., food) or
  - Sinkable (e.g., glass, metal)
- Some trash cannot be dumped
  - Plastic
    - Lightweight (floats)
    - Not easily biodegradable
    - Plastic can incorporate pollutants, such as DDT and PCBs

56 ***End of CHAPTER 11***

The Coastal Ocean