Biological Oceanography: Benthos

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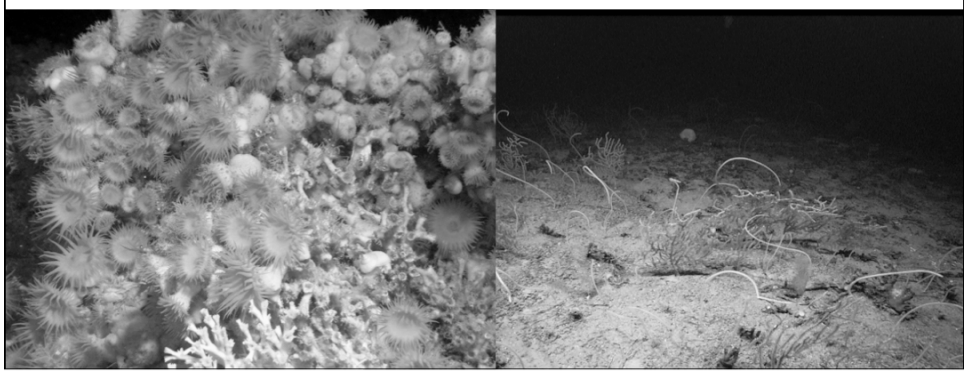


Biological Oceanography: Benthos

- Benthic Generalizations, Introduction
- Sediments and Biogeochemistry
- Deposit Feeding
- Suspension Feeding
- Reproduction and Recruitment
- Distribution Patterns
- Photosynthetic Habitats
- Deep Sea Reducing Habitats
- High Latitude Systems
- Seamounts
- Corals and Coral Reefs
- Deep Water Corals
- Benthic Pollution and Disturbance

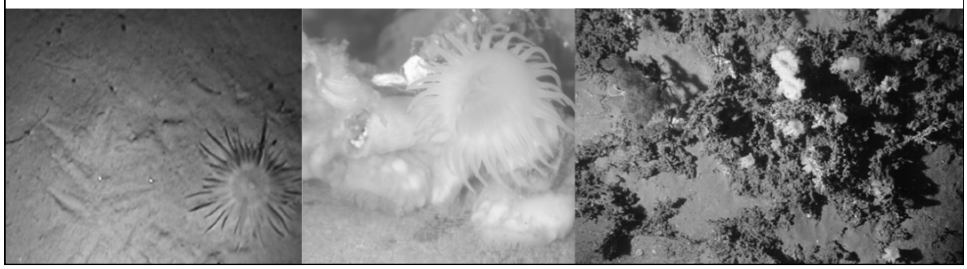
1. Benthic Generalizations & Introduction

- Terminology
- Why care about the benthos?
- Benthic Major Players
- Benthic Habitats
- Sampling the Benthos
- Bentho-Pelagic Coupling

Dr Rhian G. Waller
9th April 2010
Reading: Gage & Tyler, 1991, Ocean Sampling

Benthic Generalizations

- **Benthic**
  - Living on or in the seafloor
- **Benthic Ecology**
  - Study of structure and dynamics of organisms living on or in the ocean floor
  - Interactions of these organisms (at individual, population and community levels) among themselves and with their environment

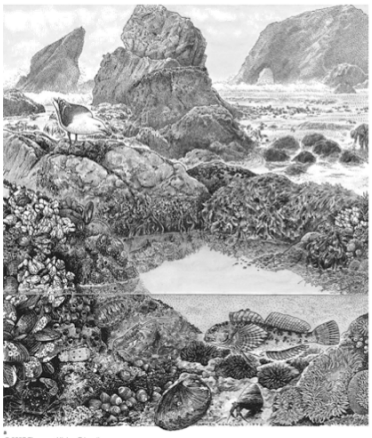


Benthic Generalizations

- **Terminology**
  - **Benthopelagic (demersal)**
    - Occurring in the water column at the seafloor, i.e., within the benthic boundary layer
  - **Epibenthic (epifauna)**
    - Living at the sediment-water interface
    - Mostly attached
  - **Infaunal**
    - Living with the seafloor
  - **Interstitial**
    - Occurring in pore spaces among sediment grains

Benthic Generalizations

- **Challenges different from pelagic environment**
  - Environment can change in short distances
  - Benthic communities are more varied than pelagic



"I don't know why I don't care about the bottom of the ocean, but I don't."

by Saxon (New Yorker Magazine, 1983)

Why care about the benthos?

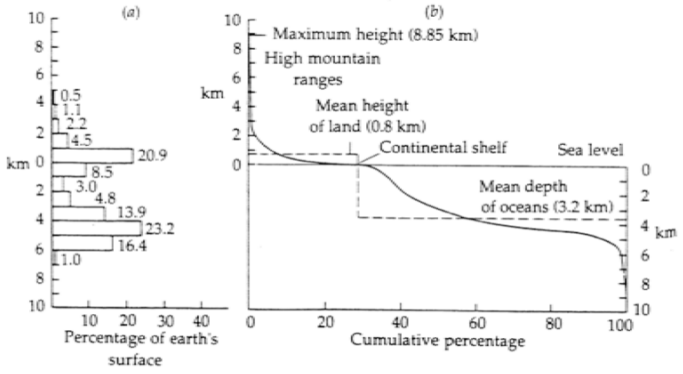
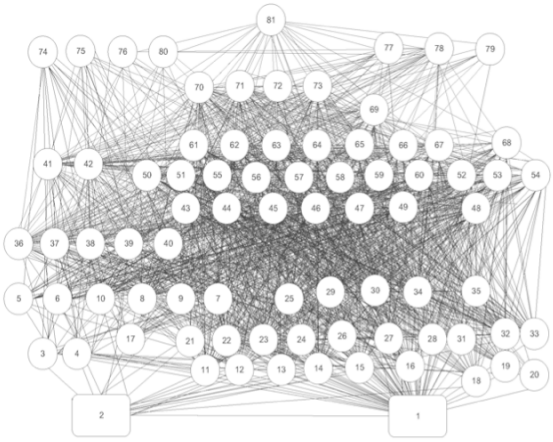


Fig. 2.4. Distribution of Earth's surface lying at different levels: (*a*) frequency distribution, (*b*) cumulative-frequency curve based on (*a*) termed the Hypsographic Curve. This should not be confused with the superficially similar profile of the continental margin shown in Fig. 2.2.

- 70% of the worlds surface is underwater!
- The largest expanse of Earth's surface lies at 4000m depth

Gage and Tyler, 1991

Why care about the benthos?



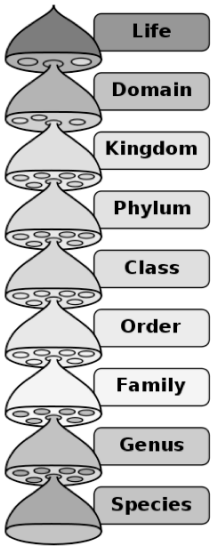
- **Foodweb for the NW Atlantic Shelf**
  - (simplified)
  - 64% are benthic or demersal
- Does not include smallest animals!
  - Only macroscopic higher taxa!

- ↑ Diversity of habitats = ↑ Diversity of benthic fauna
- Benthic foodwebs very complex!

Kaiser et al., 2005

Most phyla are found in (or on) seafloor

- **3 Domains**
  - Differences in genome
  - Bacteria, Archaea & Eukaryota
- **5 (6) Kingdoms**
  - Closely related organisms
  - Monera (Eubacteria/Archaebacteria), Protista, Animalia, Plantae, Fungi
- **36 Phyla**
  - Organisms based on general body plan
  - Only 1 Phylum not found in the Oceans
    - Onychophora (velvet worms)



	Benthic Marine	Pelagic Marine	Freshwater	Terrestrial
Metazoan Phyla	26	11	14	11
# Endemic Phyla	10	1	0	1

- But – just 15% of known species are marine
  - Marine environments generally more homogeneous
    - Less speciation than terrestrial
  - Ocean less explored
- Major players in the Benthos
  - Most species or most abundant
    - Benthic Microorganisms
    - Seaweeds
    - Invertebrates

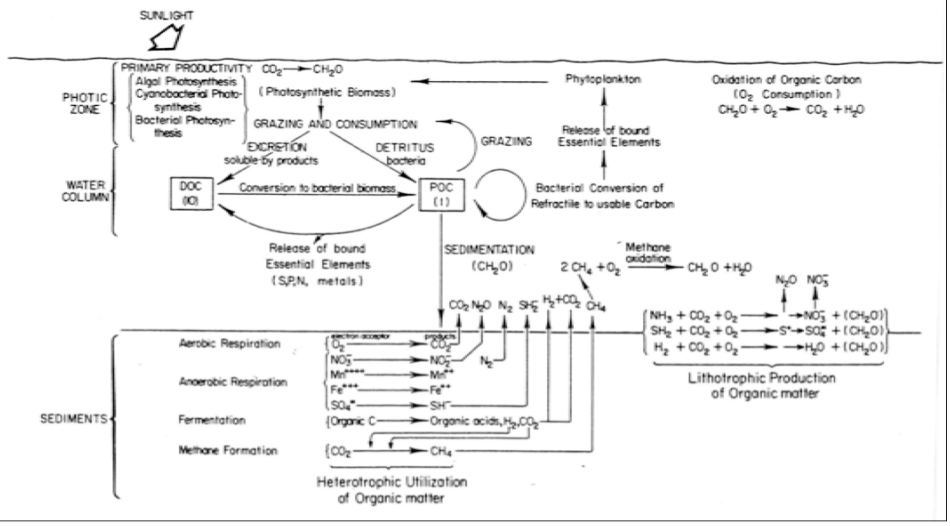
Leveque & Mounolou, 2003

Benthic Major Players

- **Benthic Microorganisms**
  - **Diatoms**
    - Photosynthetic
  - **Bacteria**
    - Dominate marine sediments
    - Important for decomposition of organic matter into marine sediments
  - **Cyanobacteria**
    - Blue-Green Bacteria
    - Photosynthetic & nitrogen fixation
    - Anoxic sediments
  - **Fungi**
    - Decomposition of particulate organic matter

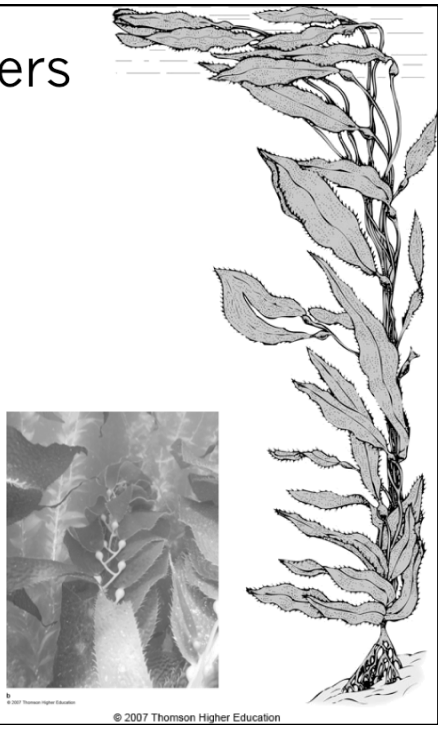
- Microorganisms play important roles in the ocean
- In the benthos
  - Respiration
  - Fermentation
  - Methane Formation

Nitrogen Formation
etc.

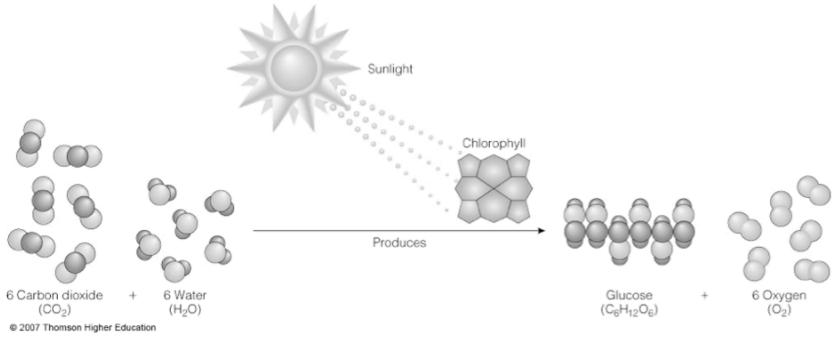


Benthic Major Players

- **Seaweeds**
  - Require Photosynthesis & Nutrients (nitrogen & phosphorous)
    - Gather nutrients from overlying water
  - **Thallus**
    - **Blade**
    - **Stipe**
    - **Holdfast**
      - Hold thallus to substrate
      - No nutrient uptake, so not roots
    - **Pneumatocysts**
      - Gas bladders to keep thallus suspended in seawater



Seaweeds



Seaweed Group	Pigments	Storage Products	Light used
Green Algae	Chlorophyll a,b	Starch	Red, blue
Brown Algae	Chlorophyll a, c, fucoxanthin	Laminarin, Mannitol	Red, blue
Red Algae	Chlorophyll a, d, phycoerythrin, phycocyanin	Floridan starch	Green

Benthic Major Players

- **Benthic Invertebrates, 9 major phyla (>1000 species)**
  - Annelids
    - Segmented worms - polychaetes
  - Arthropods
    - Crustaceans
  - Bryozoans
  - Cnidarians
  - Echinoderms
  - Molluscs
  - Nematodes
    - Round worms
  - Platyhelminthes
    - Flat worms
  - Poriferans
    - Sponges

Habitats

- Many types of benthic habitat
- **Habitat dictates**
  - What type of animals live there
  - How many animals live there
  - What characteristics/tolerances the animals have that live there
- **Habitat formation**
  - **Geological**
    - Rocky, sandy etc.
  - **Environmental**
    - High waves, temperature extremes, etc.
  - **Biological**
    - Created by organisms
    - E.g., Coral Reefs, Kelp Forests, Mangroves, etc.

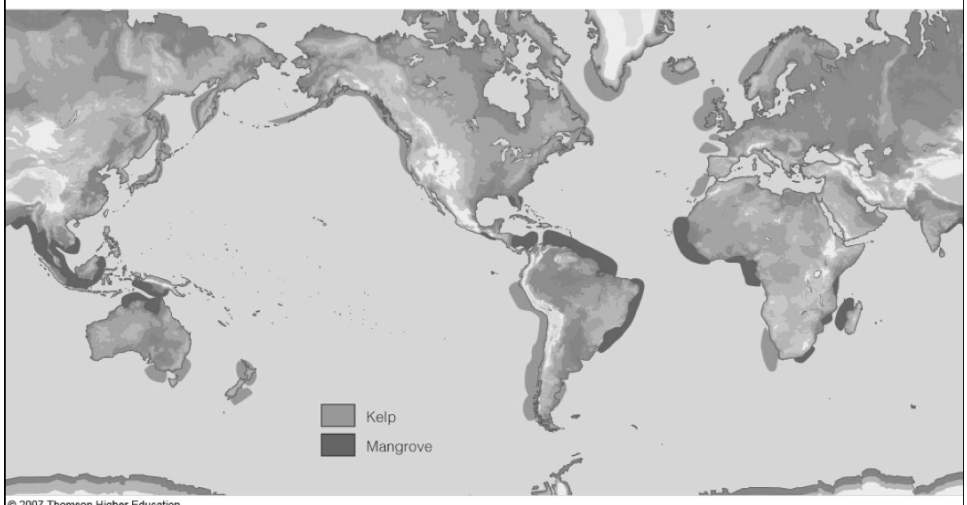
Benthic Habitats

- **Tidelands and Estuaries**
  - **Intertidal**
    - Between highest and lowest extent of tides
    - Have to be both marine & terrestrially adapted
  - **Estuaries**
    - Geologically ephemeral, biologically rich
    - High nutrients (fresh water input)
  - **Spartina Salt Marshes**
    - Dominated by cord grasses (terrestrial)
    - Quiet water areas, trap sediment
  - **Mangroves**
    - Dominated by mangrove trees (terrestrial)
    - Specialized root system to utilize anoxic sediments

Benthic Habitats

- **Photosynthetic Habitats**
  - **Sea Grass Beds**
    - Higher flowering plants (vascular, so not seaweeds)
    - Shallow soft sediments (extend by rhizomes)
    - Scallops, clams, urchins, turtles
  - **Kelp Forests**
    - Dominated by Brown Algae
    - Cool, shallow water
    - Urchins, mussels, lobster, sea otters
  - **Coral Reefs (shallow)**
    - Internal photosynthetic algae – zooxanthellae
    - Sunlit, warm waters
    - Crabs, urchins, shrimp, fish
- *Need primary production not only for carbon fixation, but also contribute to structure of habitat*

Kelp & Mangrove Habitats

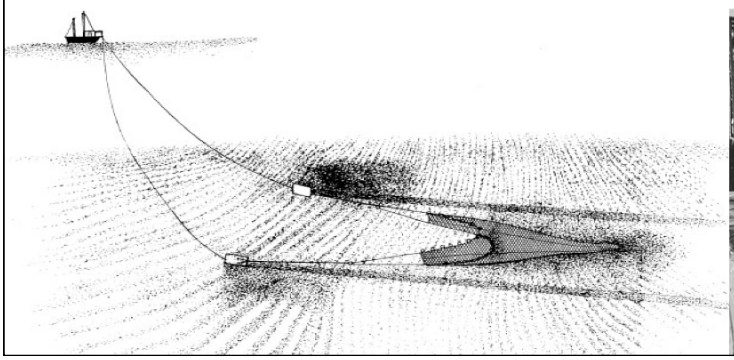


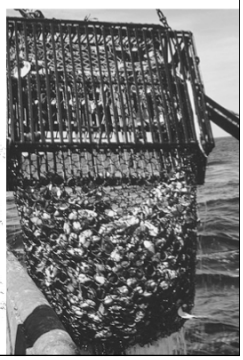
Benthic Habitats

- **Deep Sea Habitats**
  - 84% of ocean lies deeper than 2000m
  - Soft sediments dominate
    - **Reducing Habitats**
      - Hydrothermal vents, seeps & whale falls
      - Habitats controlled by chemosynthesis
    - **Seamounts**
      - Rise at least 1000m from the seafloor
      - High currents, high nutrients
- *Majority still require photosynthesis – food fall from surface*

Sampling the benthos

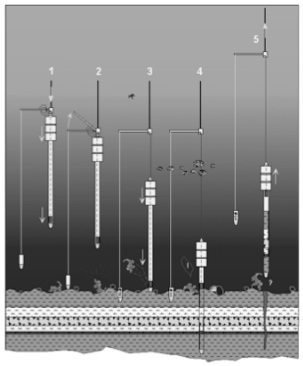
- **Trawl**
  - Can be larger, metal doors or mouth, net bag and cod end
- **Dredge**
  - Smaller, metal mouth, usually chain bag





Sampling the benthos

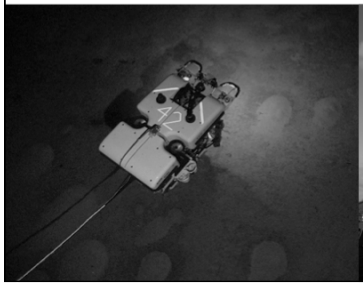
- **Grab Sampling**
  - Small surface samples
- **Box Core**
  - Larger surface (~50cm) samples
- **Multicore/Megacore**
  - Replication of surface samples
- **Kaston/Piston Core**
  - Longer cores to get depth





Sampling the benthos

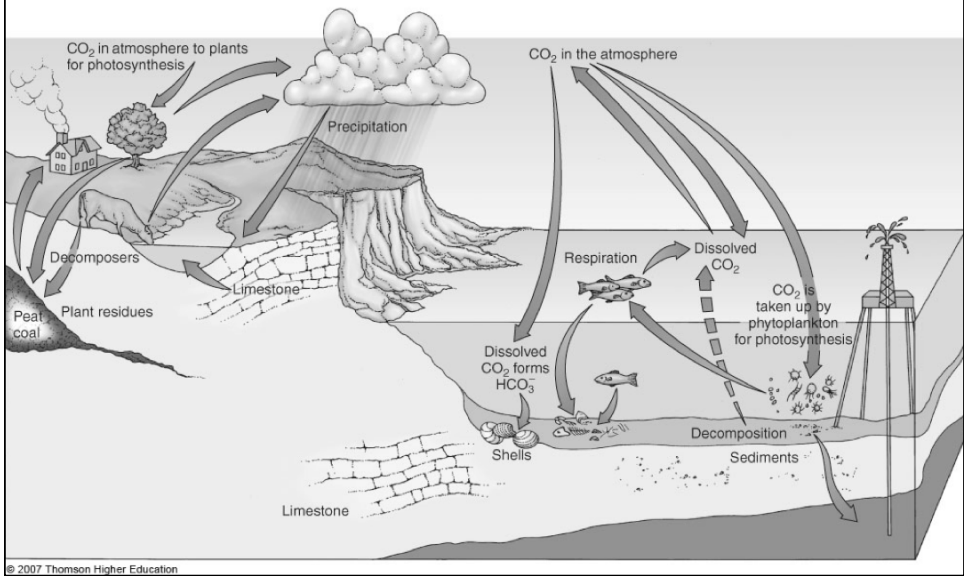
- **HOV**
  - Human Occupied Vehicle
- **ROV**
  - Remotely Occupied Vehicle
- **AUV**
  - Autonomous Underwater Vehicles
  - Pictures primarily, not samples

Sampling for what.....

- **Taxonomy & ecology**
  - What species are there?
  - How do those species live & interact with the environment
- **Species Richness**
  - How many species are in an ecosystem
  - Also known as Species Density
- **Species Evenness**
  - Relative abundance or proportion of individuals
- **Biodiversity**
  - The number of species AND the proportion (evenness) of species
- **Environment**
  - Food Flux – from pelagic to benthos
  - Habitat

Terrestrial & Aquatic; Pelagic & Benthic – all interconnected



Bentho-Pelagic Coupling

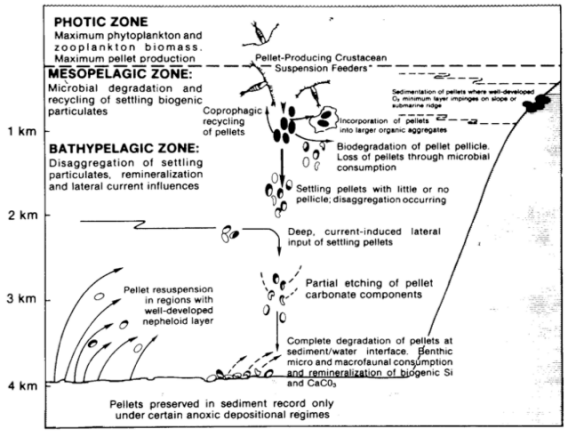


Fig. 8. Model of oceanic fecal pellet mass flux.

- Organic matter produced in pelagic falls to benthos
  - Consumed by sediment dwellers
  - C, N, P cycled
- Animals in the benthos require pelagic animals for nutrition
  - Vice-versa

Bentho-Pelagic Coupling

- Flux reaches even deepest parts of the ocean
  - Just takes a long time.....

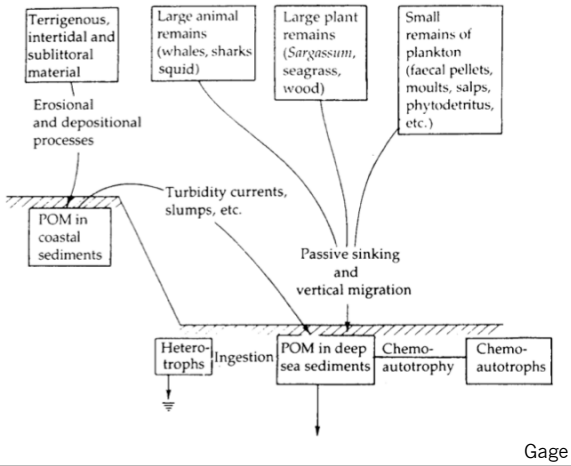


Fig. 11.1. Conceptual model of the potential sources, transport and sinks for organic matter to the deep sea. (Slightly modified from Rowe & Staresinic, 1979.)

Gage & Tyler, 1991

Conclusions

- Majority of Earth's surface is marine benthos
- Dominant Benthic Organisms
  - Microorganisms, photosynthetic organisms, invertebrates
- Benthic Habitats
- Interconnections in the ocean
  - Bentho-Pelagic Coupling