Benthic Ecology and Demersal Resources

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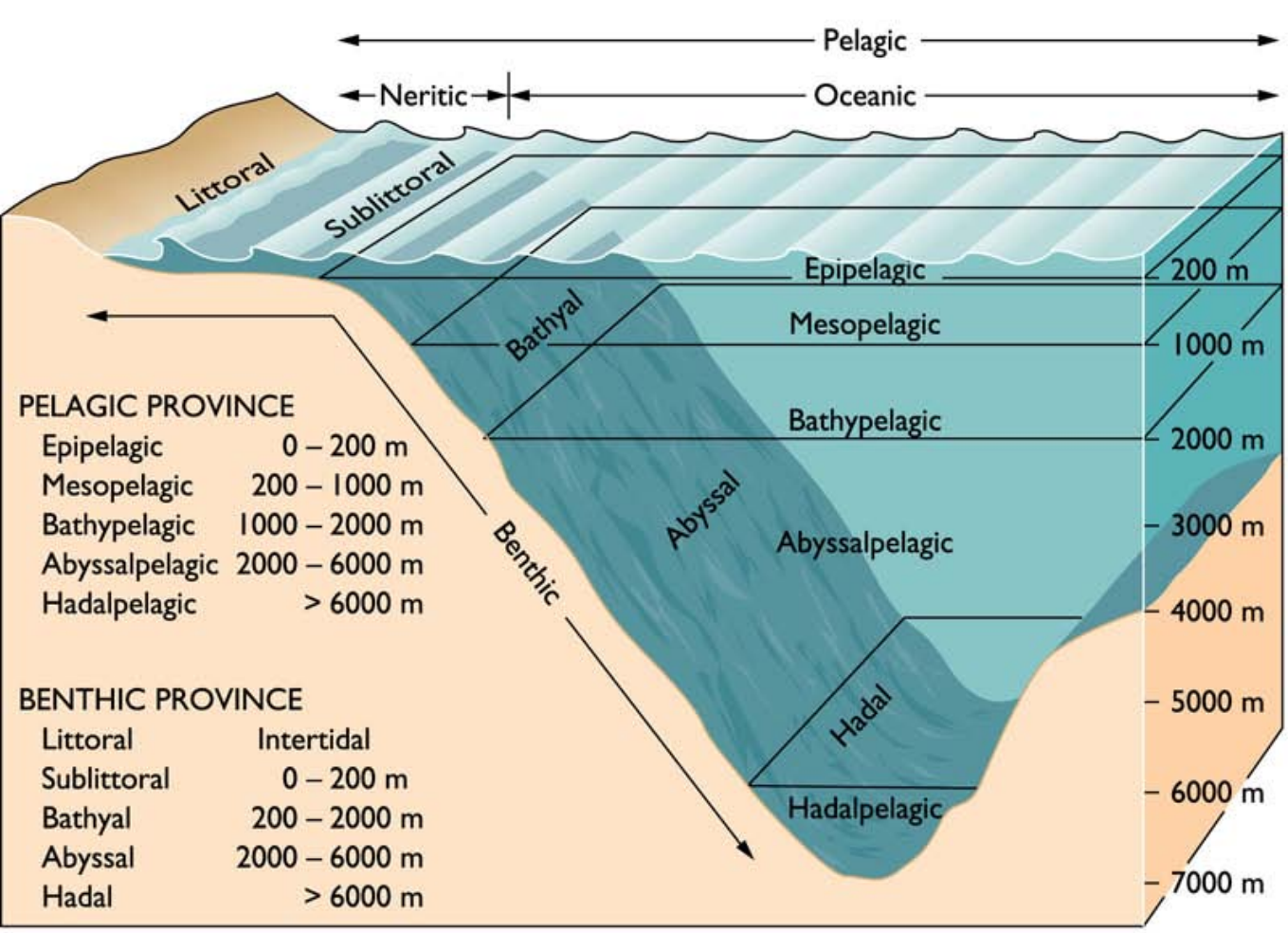
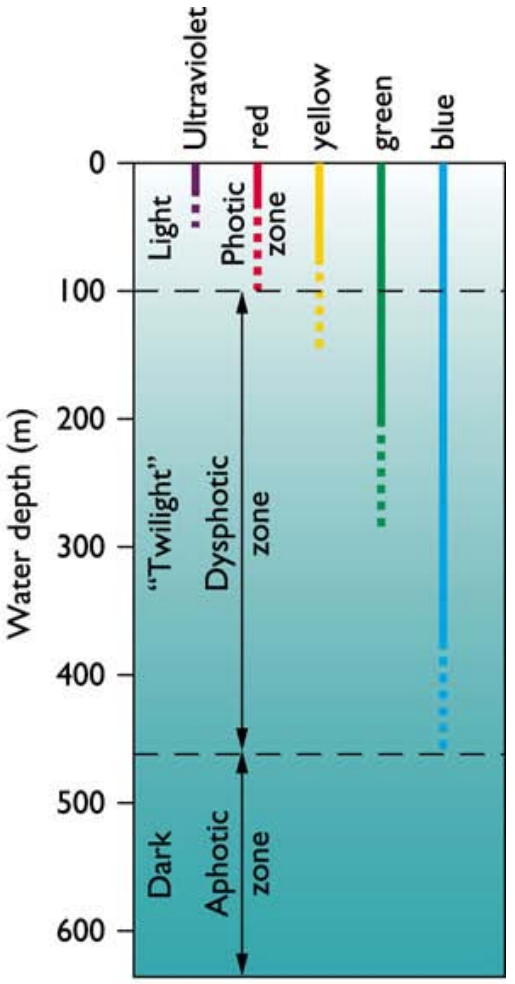
NIO understanding the seas

Divisions of the Marine Environment



(a) BIOZONES



(b) LIGHT ZONES

Benthos

Community of organisms - live on, in, or near the seabed, also known as the benthic zone

Live in or near marine sedimentary environments, from tidal pools along the foreshore, out to the continental shelf, and down to the abyssal depths

Most organisms in the benthic zone are scavengers or detritivores

Ecology

- Factors regulating the distribution and abundance of organisms in the ocean

- Influence of physical and chemical parameters on organisms in the various ecosystems

- Ecosystem - includes the living (biotic) and non-living (abiotic) portions of the environment.
  - e.g., coral reefs, estuary, rocky intertidal habitats, Mangroves, etc.

Benthic Ecology

Environmental factors influencing benthos include

-temperature
-salinity
-pressure
-nutrients
-dissolved gases
-currents
-light
-suspended sediments
-substrate (bottom material)
-river inflow
-tides and waves.

Benthic Lifestyle

- Benthos
- Epibenthic
- Burrowers
- Borers
- Infaunal, Semi-infaunal
- Benthic swimmers
- Interstitial

Classification – Based on size

Macrobenthos - The larger, more visible benthic organisms – greater than or equal to 0.5mm (shortest dimension)

e.g. Polychaete worms, bivalves, echinoderms, sea anemones, corals, sponges, sea squirts, turbellarians, larger crustaceans (crabs, lobsters, etc)

Meiobenthos - Tiny benthic organisms that are less than 0.5mm but greater than 0.1 mm in size.

e.g. nematodes, foraminiferans, water bears, gastrotriches and smaller crustaceans such as copepods and ostracodes, amphipods.

Microbenthos - Microscopic benthic organisms that are less than 0.1 mm in size.

e.g. Some examples are bacteria, diatoms, ciliates, amoeba, flagellates.

Classification – Based on feeding mode

- Suspension feeders
- Deposit feeders
- Herbivores (macroalgae or microalgae)
- Carnivores
- Scavengers

Classification – Based on feeding guild

Herbivores – Eat non-microscopic plants (seaweeds, sea grass) e.g. Urchins, Benhtic Fishes

Carnivores – Eat other animals e.g. starfish, crabs, fishes, worms etc.

Scavengers – Feed on carcasses and remains of other animals and plants
Many deposit feeders are scavengers - Fish, sea stars, snails, cephalopods, crustaceans are important predators and scavengers.

Food sources for benthos

Algae and organic runoff from land or from the pelagic zone

In coastal waters and other places where light reaches the bottom, benthic photosynthesizing diatoms can proliferate.

Filter/Suspension Feeders – Sponges and bivalves dominate hard, sandy bottoms

Active Suspension Feeders – Draw particles towards the mouth parts by creating a current
Passive Suspension Feeders – Protrude a feeding organ & collect particles as they are deposited

Deposit feeders – Ingest sediment and use organic matter and microbial organisms in the sediment as food.
Optimize their intake of food by adjustments of particle size to be ingested and adjustment of gut passage time.

Classification - By type

Zoobenthos

Zoobenthos comprises the animals belonging to the benthos

Phytobenthos

Phytobenthos comprises the plants belonging to the benthos, mainly benthic diatoms and macroalgae (seaweed)

By location

Epibenthos

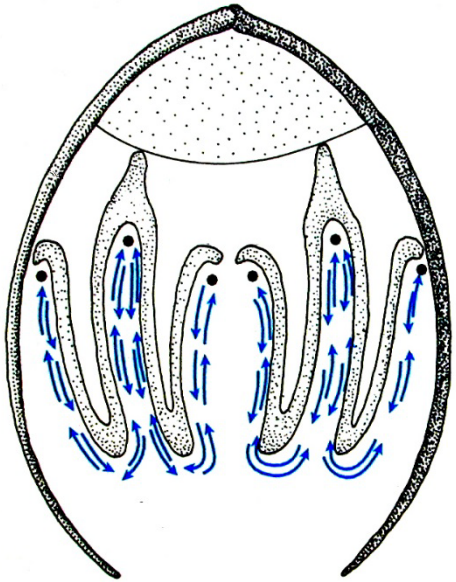
Epibenthos lives on top of the sediments.

Hyperbenthos

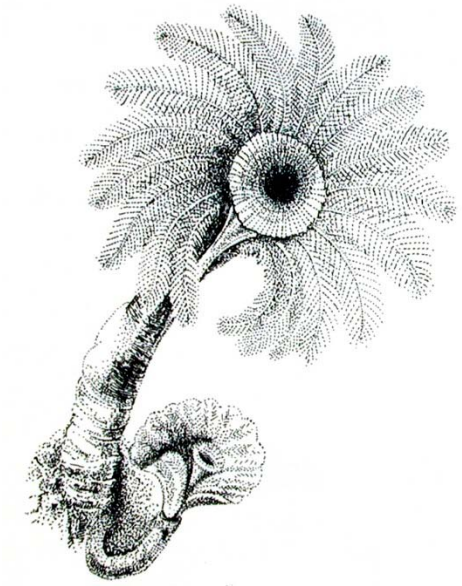
Hyperbenthos lives just above the sediment.

Suspension Feeders

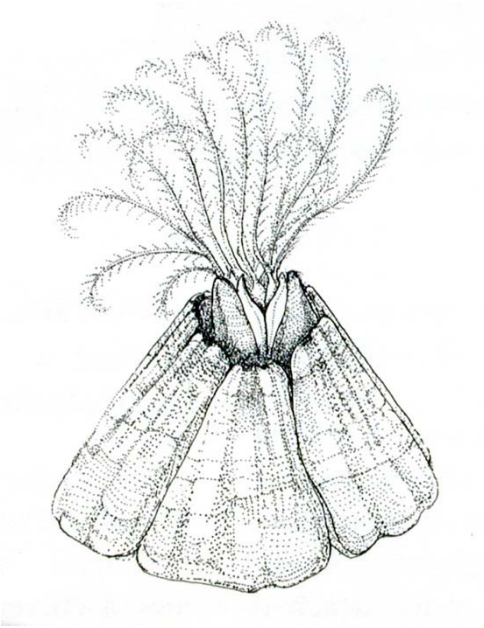
- Feed on small particles
- Passive versus active suspension feeders



Bivalve, x-section

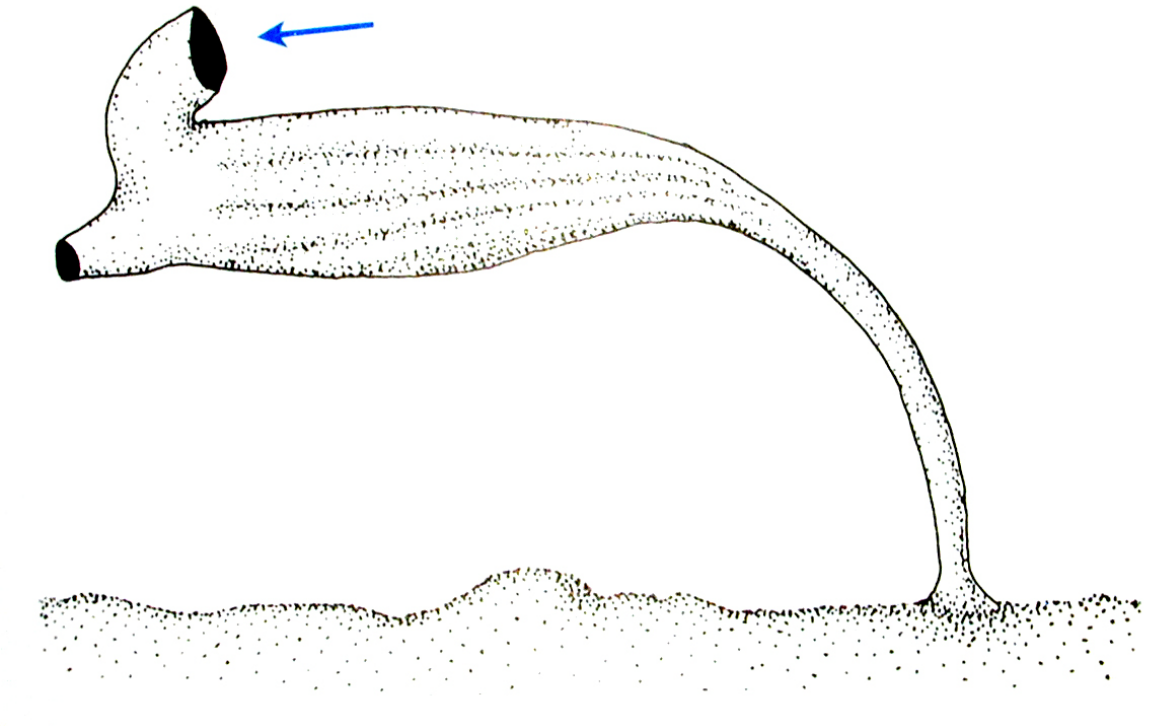


Polychaete *Serpula*



Barnacle

Suspension Feeders

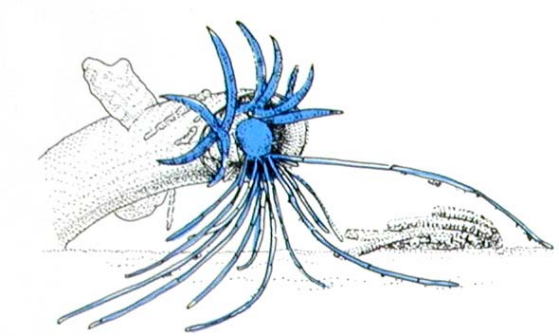


Sea squirt *Styela montereyensis*
Passive suspension feeding mechanism

Deposit Feeders

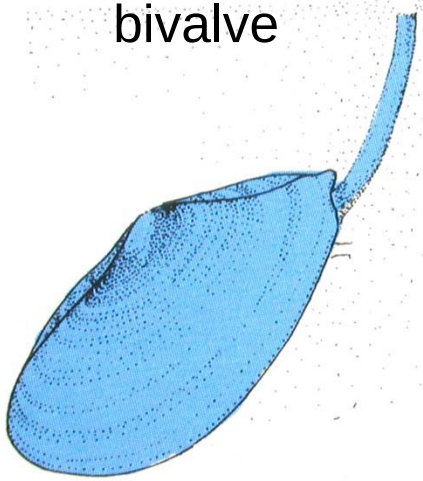
- Feed upon sediment, within the sediment or at sediment surface
- Head-down deposit feeders feed within the sediment at depth, usually on fine particles, defecate at surface
- Surface browsers - Feed on surface microorganisms such as diatoms
- Feeding activity accelerates microbial attack - grazing stimulates microbial metabolism, resulting in tearing apart of organic particles

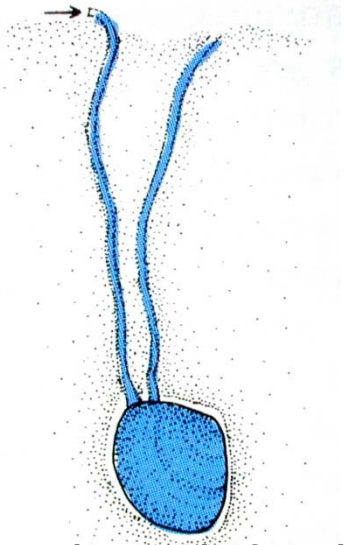
Deposit Feeders



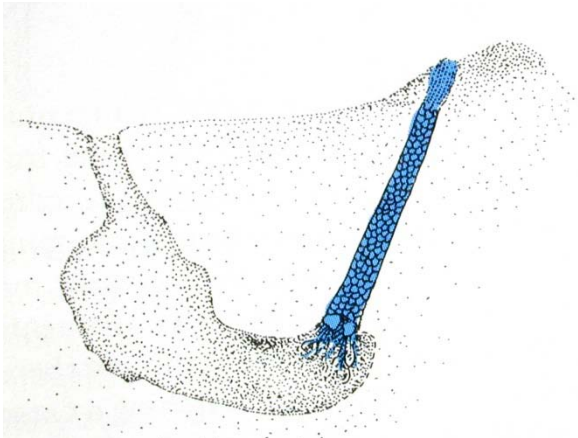
Surface tentacle feeding polychaete

Within Sediment Tentacle feeding bivalve

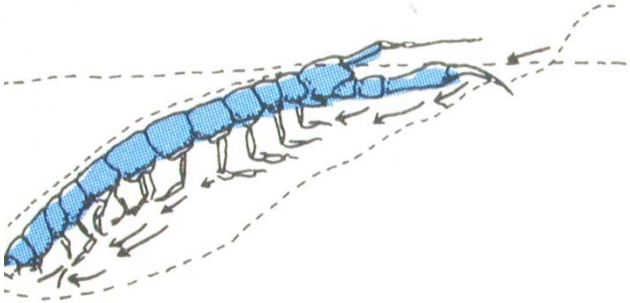




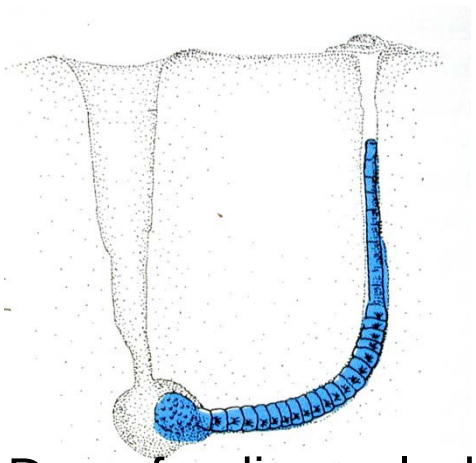
Surface deposit-feeding siphonate bivalve



Within sediment or deep feeding Polychaete

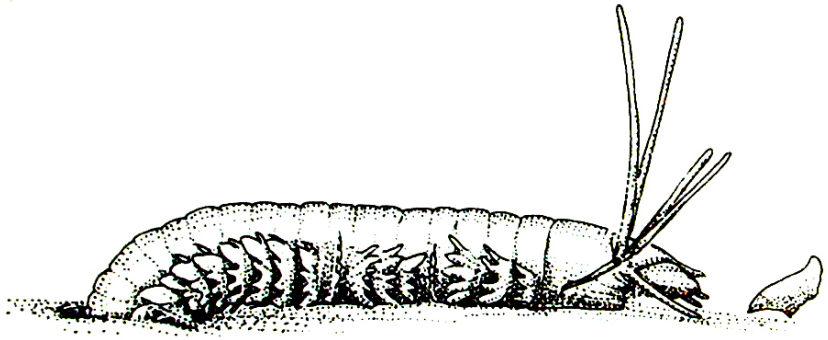


Surface feeding Amphipod

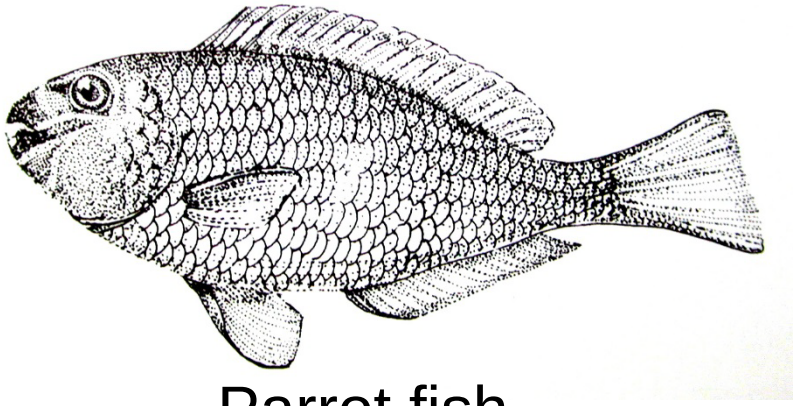


Deep feeding polychaete

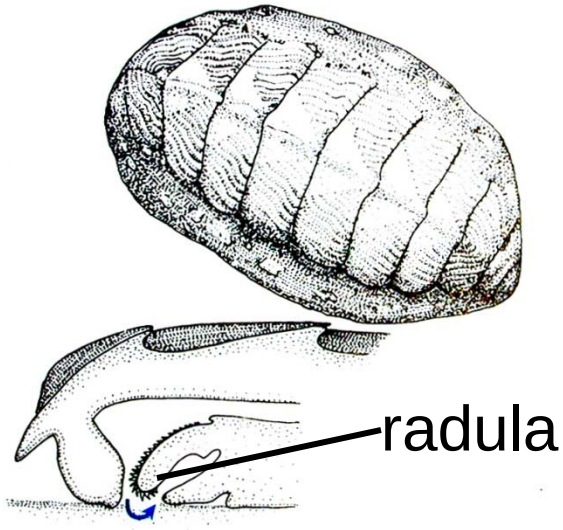
Herbivores



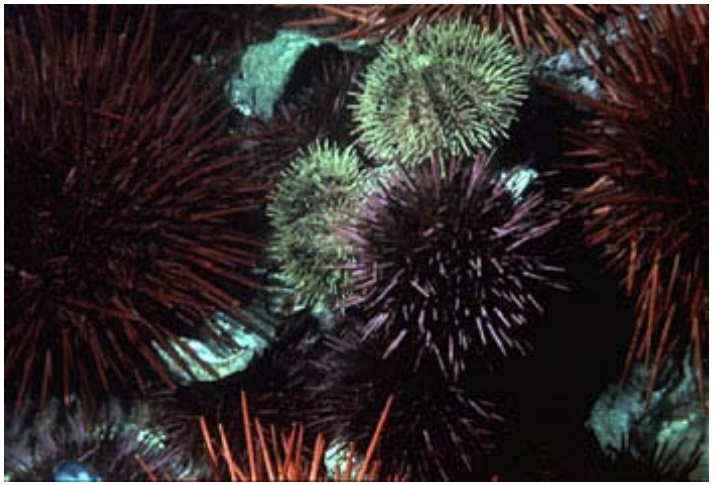
Polychaete *Nereis vexillosa*



Parrot fish

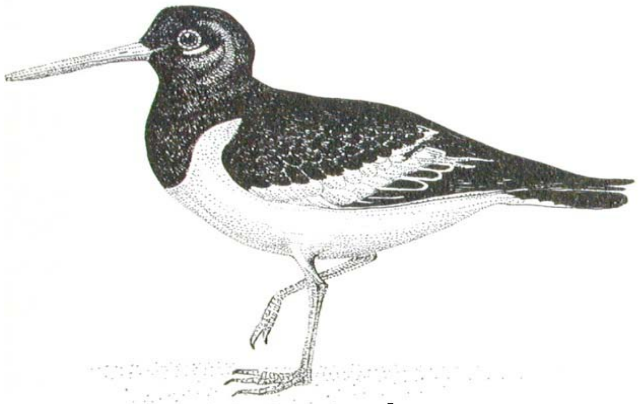


Chiton

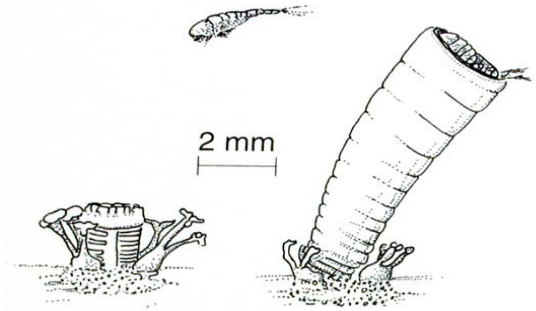


Urchins

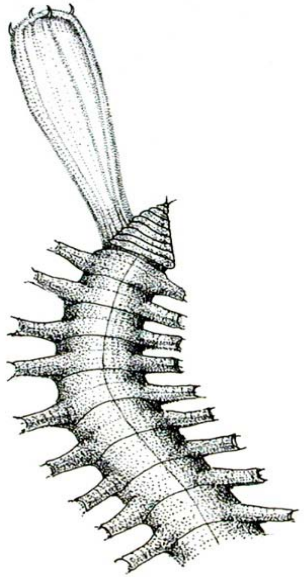
Carnivores



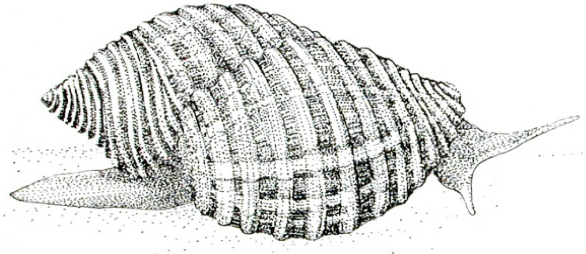
oystercatcher



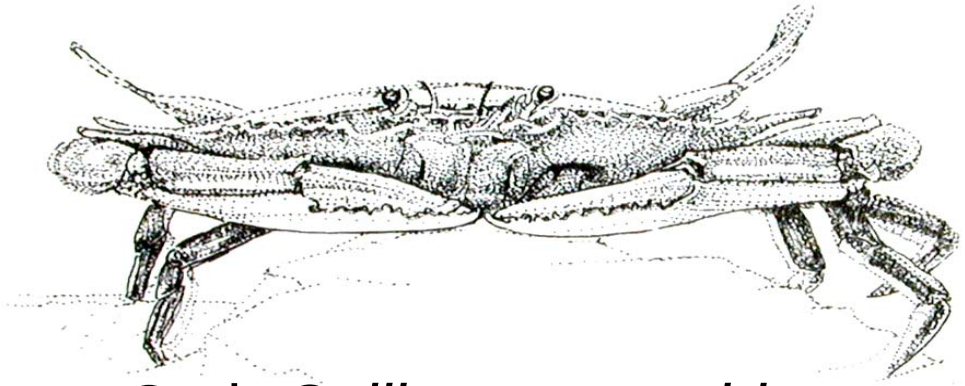
Bivalve *Cuspidaria*



Polychaete *Glycera*

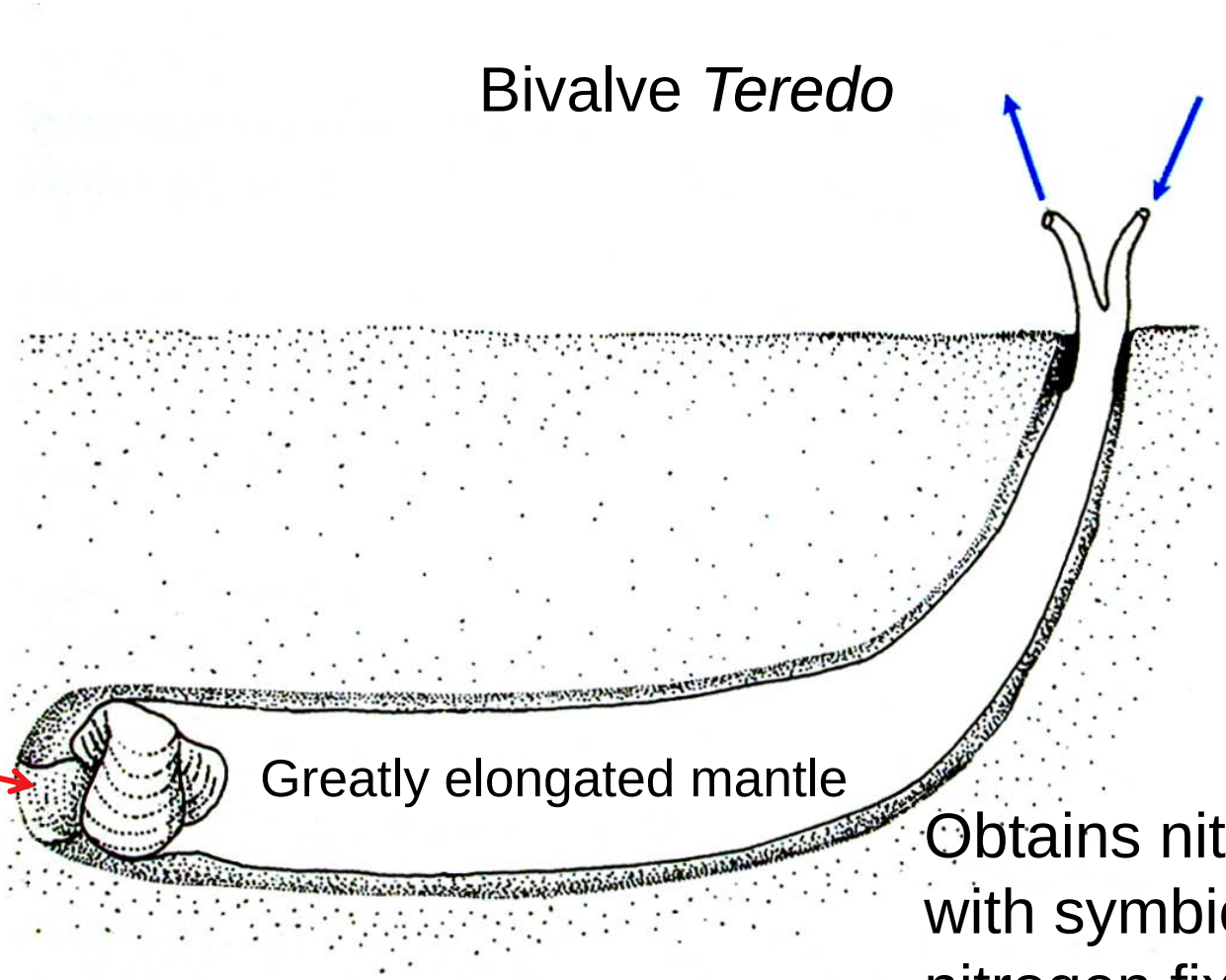


Gastropod *Nucella*



Crab *Callinectes sapidus*

Cellulose feeder



Burrowing in sediment

- Burrowers use hydromechanical and mechanical digging mechanisms to move through the sediment

- Hydromechanical burrowing - combines muscle contraction working against rigid, fluid filled chamber (skeleton)

- Form penetration anchor first to allow further extension of body into sediment

- Form terminal anchor to allow pulling of rest of body into the sediment

Burrowing in sediment

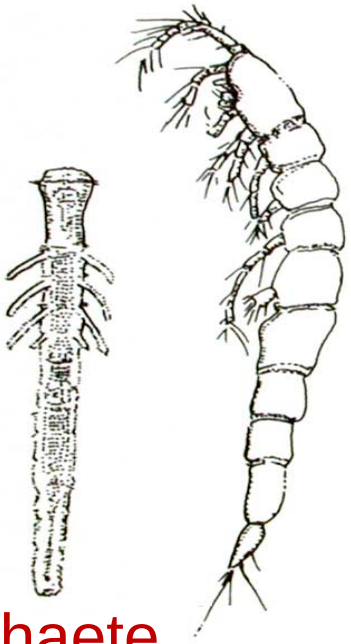
Biogenic structures - burrowing and processing of sediment affects sedimentary structures

1. Burrowing in mud increases water content of sediment
2. Increases grain size (pellets)
3. Alters vertical and 3-D mechanical structure

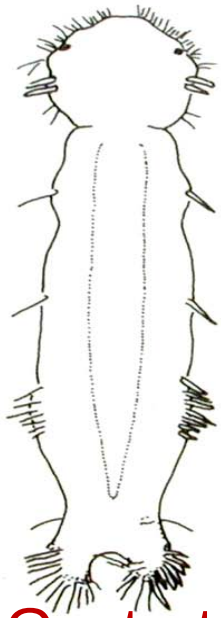
Interstitial animals

- Live in the pore waters of sediment- in sand grains
- Belong to many taxonomic groups
- Elongate, wormlike form, in order to move through tight spaces

Harpacticoid

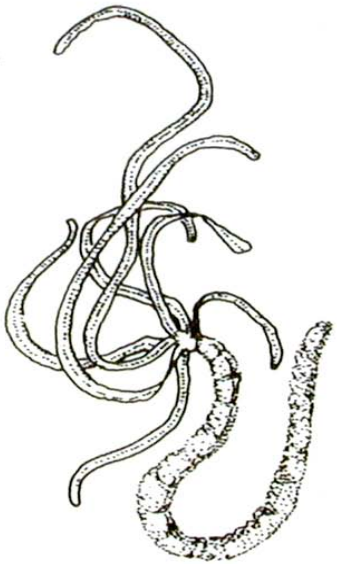


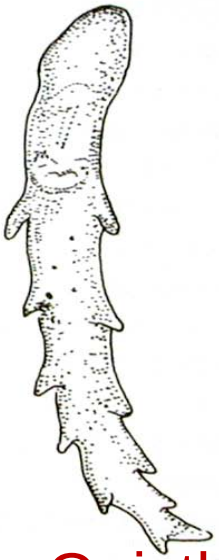
Polychaete



Gastrotrich

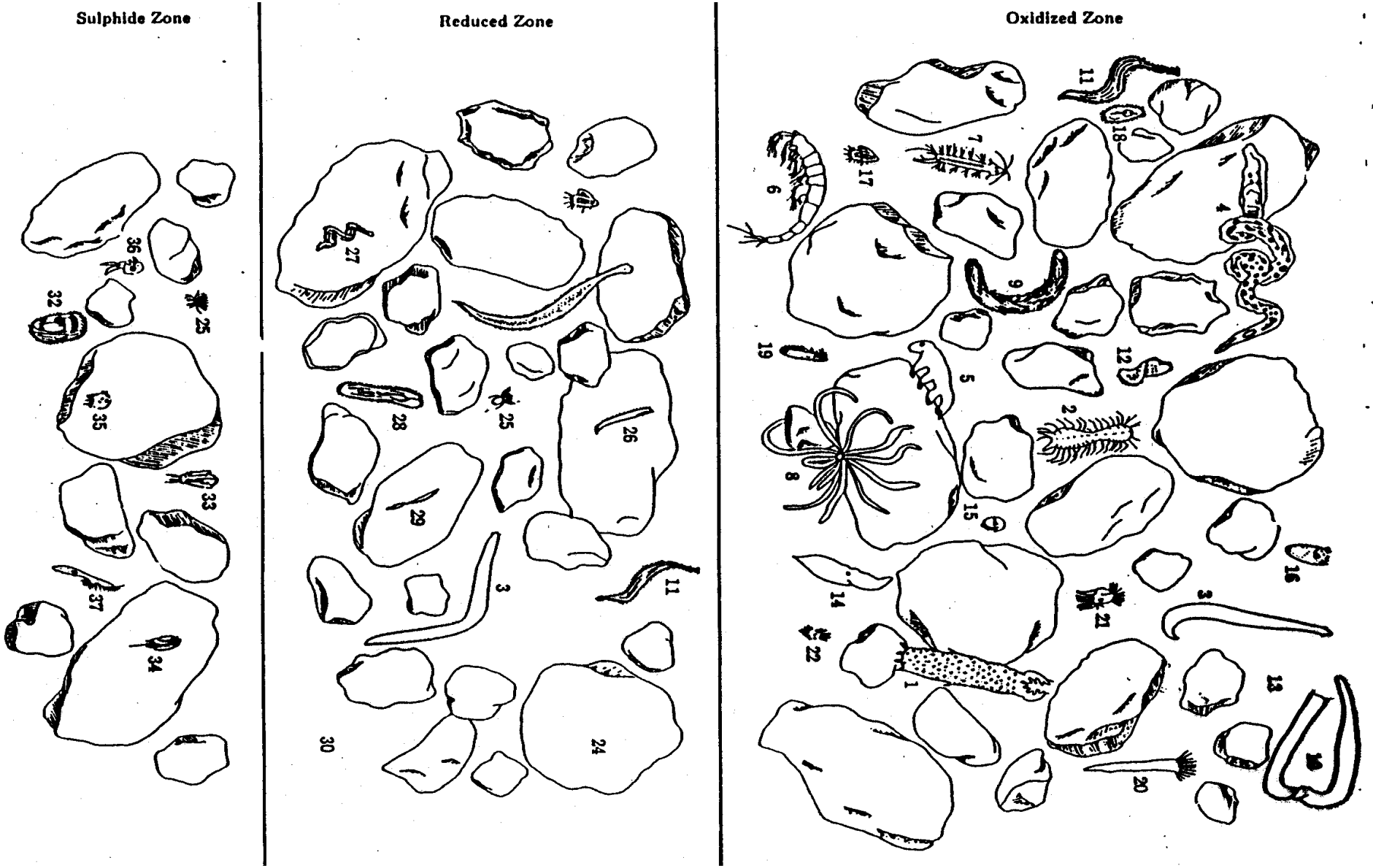
Hydroid





Opisthobranch gastropod

Interstitial organisms



Soft-Sediment Microzone

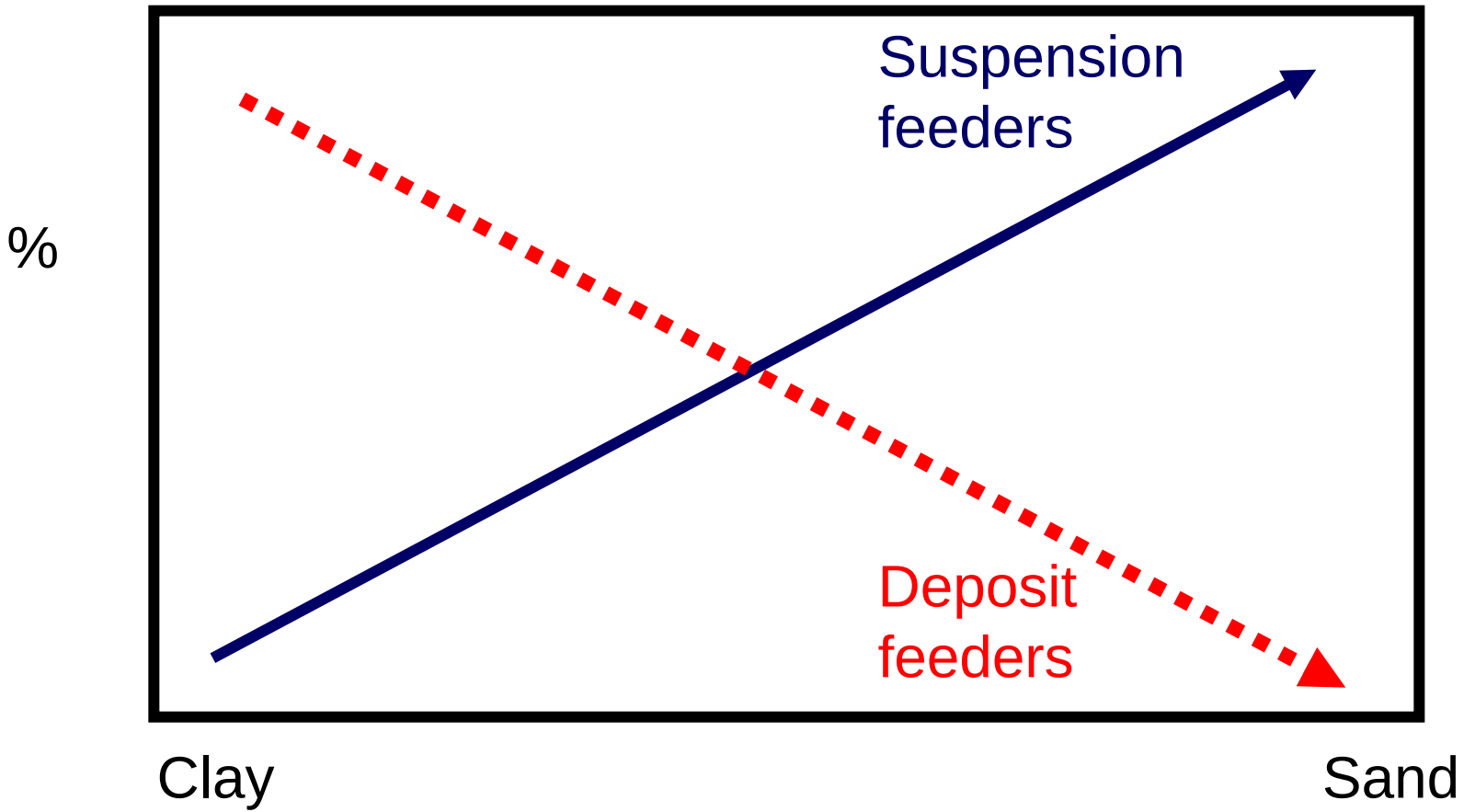
- Microbial types also vary with depth below the sediment water interface
- Towards the surface, aerobic bacteria dominate (energetically most efficient to use oxidation)
- Deeper, bacteria present that can live in the absence of oxygen and can produce energy through various chemical means

Grain Size vs Feeding Type

- Sandy bottoms
  - – High water flow
  - – Shallow waters

  Suspension feeders
- Muddy (clay-silt) bottoms
  - – Low currents
  - – Deep Ocean

  Deposit feeders



Sediment Stabilizing vs Destabilizing organisms

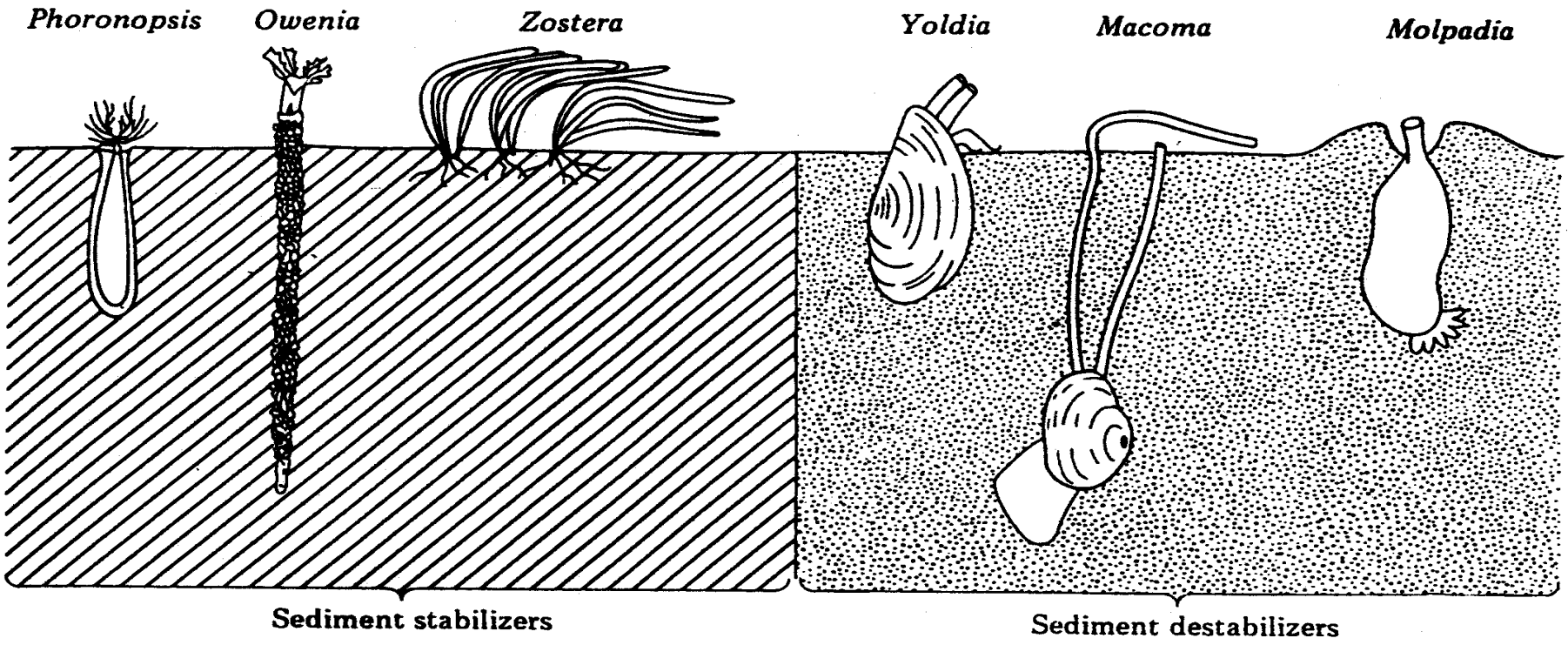


Figure 5.4 Representatives of the two functional groups of sedimentary organisms: sediment stabilizers and sediment destabilizers or bioturbators.

Ecological Roles

1. Help stabilize the sediment
2. Prevents resuspension of sediments in water (water is clearer)
3. Binds substratum, reduces turbidity, and reduces erosion
4. Sediment accumulation slows velocity of incoming water
5. Food for many organisms
6. Refuge for many organisms

Deep Sea Benthos

- Characteristics of many deep sea benthos are:
  - low activity levels
  - slow growth & development; long lives
  - the deeper the water, the decrease in number and diversity of benthic organisms
  - Late reproductive maturity

- Some common adaptations are:
  - Bottom feeders
  - high water content in their bodies to deal with the pressure
  - bioluminescence to attract food and mates & large eyes
  - Long sharp teeth or fangs (act like spears)
  - Large flexible stomachs

Deep Sea Benthos

Physiology

- Low metabolic rate and activity level

Ecological

- Long lived species
- Slow colonization rates
- Low population densities, but high species diversity

Deep-Sea Benthic Environments

Characterized by:

Low availability of food

- No light, no photosynthesis
- Falling remains of dead organisms, decaying organic matter

Low (0-2°C), relatively constant temperature

High pressure (400-500 times atmospheric)

Deep-Sea Benthic Environments

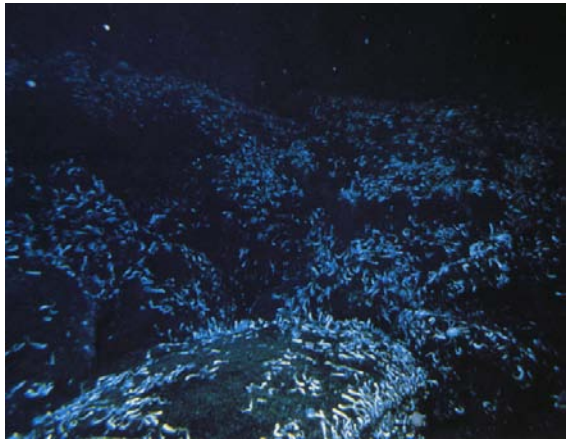
What supports of life around hydrothermal vents?
What is the energy source for this ecosystem?

Chemosynthesis

- Basis of life around deep sea hydrothermal vents is **chemosynthesis** rather than photosynthesis
- Chemical energy rather than solar energy supports the ecosystem
- Bacteria rather than plants are the primary producers
- Organisms must have adaptations to prevent sulfide from poisoning oxygen binding site

Hydrothermal Vent Macrofauna: Worms

Vestimentiferan worms
(*Riftia pachyptila*)



Serpulid polychaete worms

Hydrothermal Vent Macrofauna: Bivalves

Giant clams

(*Calyptogena magnifica*)

Mussels
(*Bathymodiolus thermophilus)*

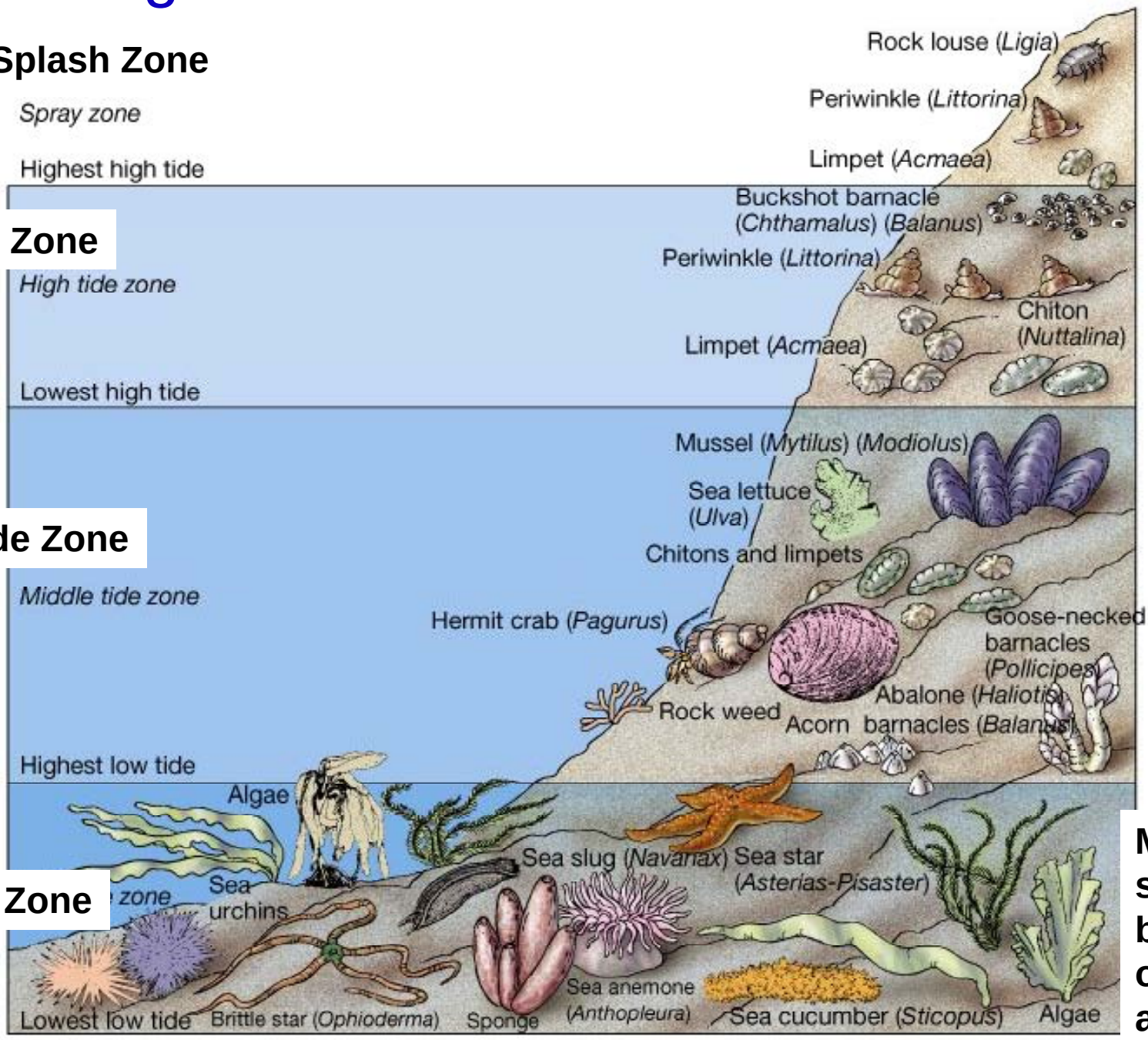
Intertidal region

Spray or Splash Zone

High Tide Zone

Middle Tide Zone

Low Tide Zone



Mostly shelled orgs

organisms

Many soft bodied orgs and algae

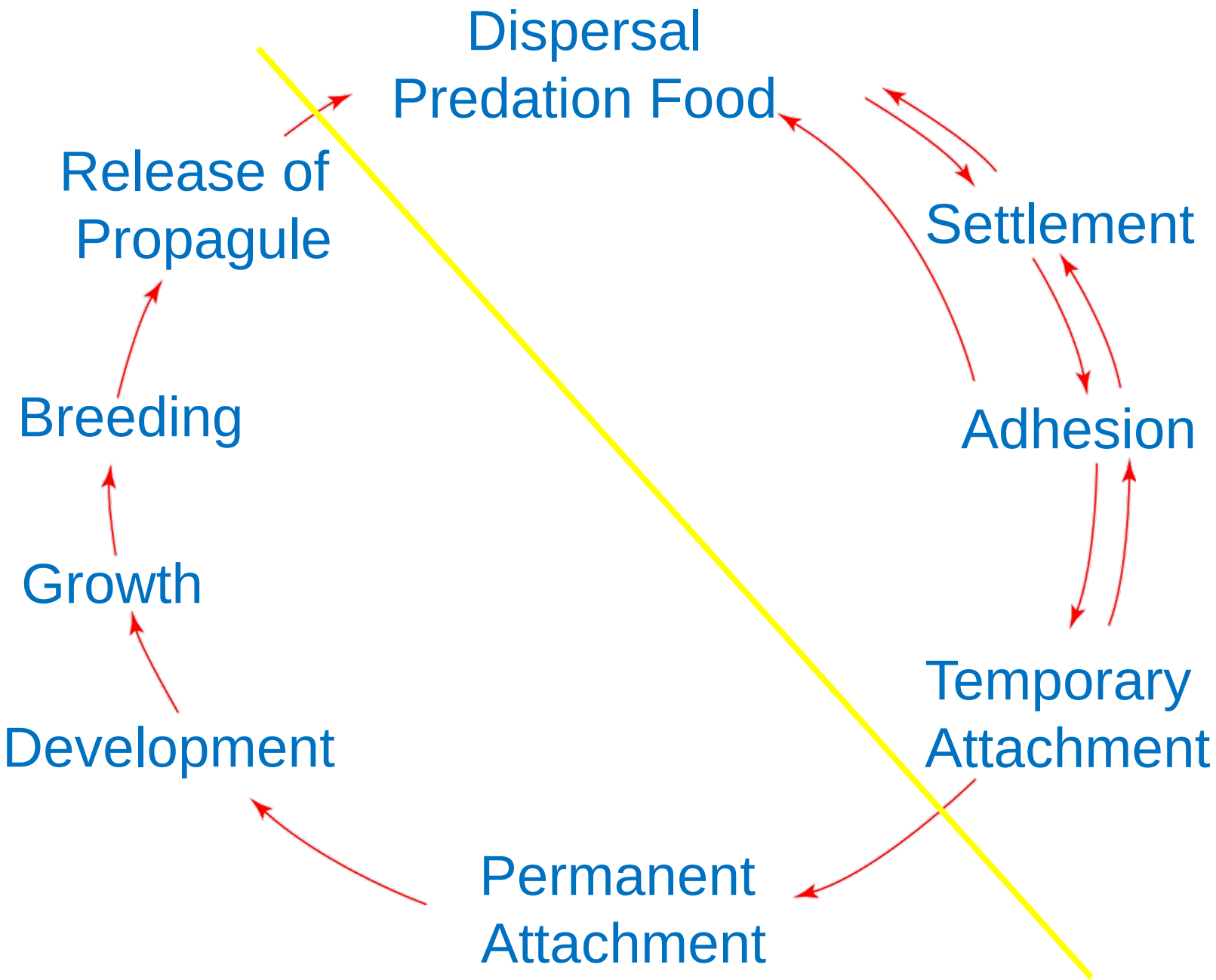
Benthos in the Intertidal region

Community determinant factors

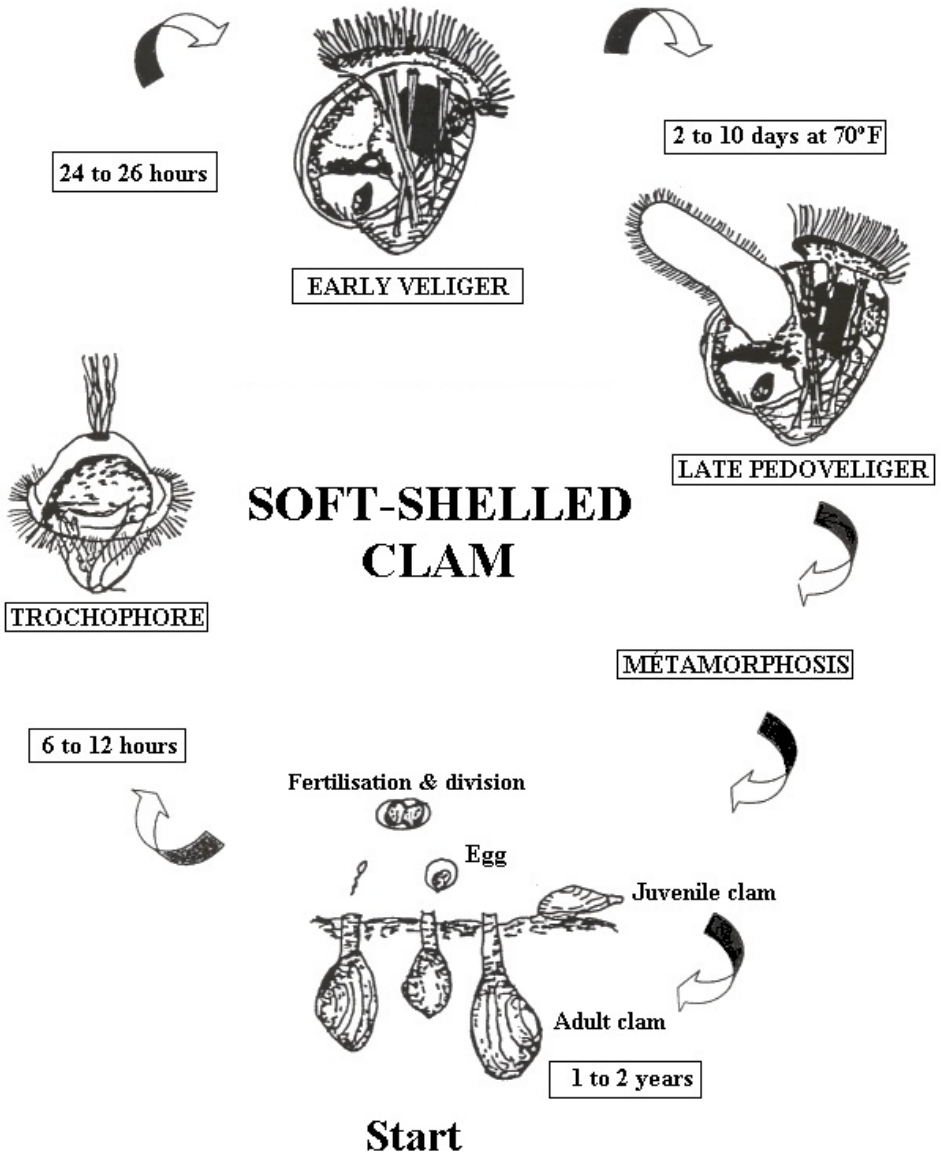
- Larval Supply / Settlement
- Physical Forcing
- Competition
- Predation

- High Diversity
- Low movement
- High adaptive mechanisms – Behavioral, Morphological, Physiological

Sessile/Sedentary Invertebrates



Clam: Benthos or plankton?

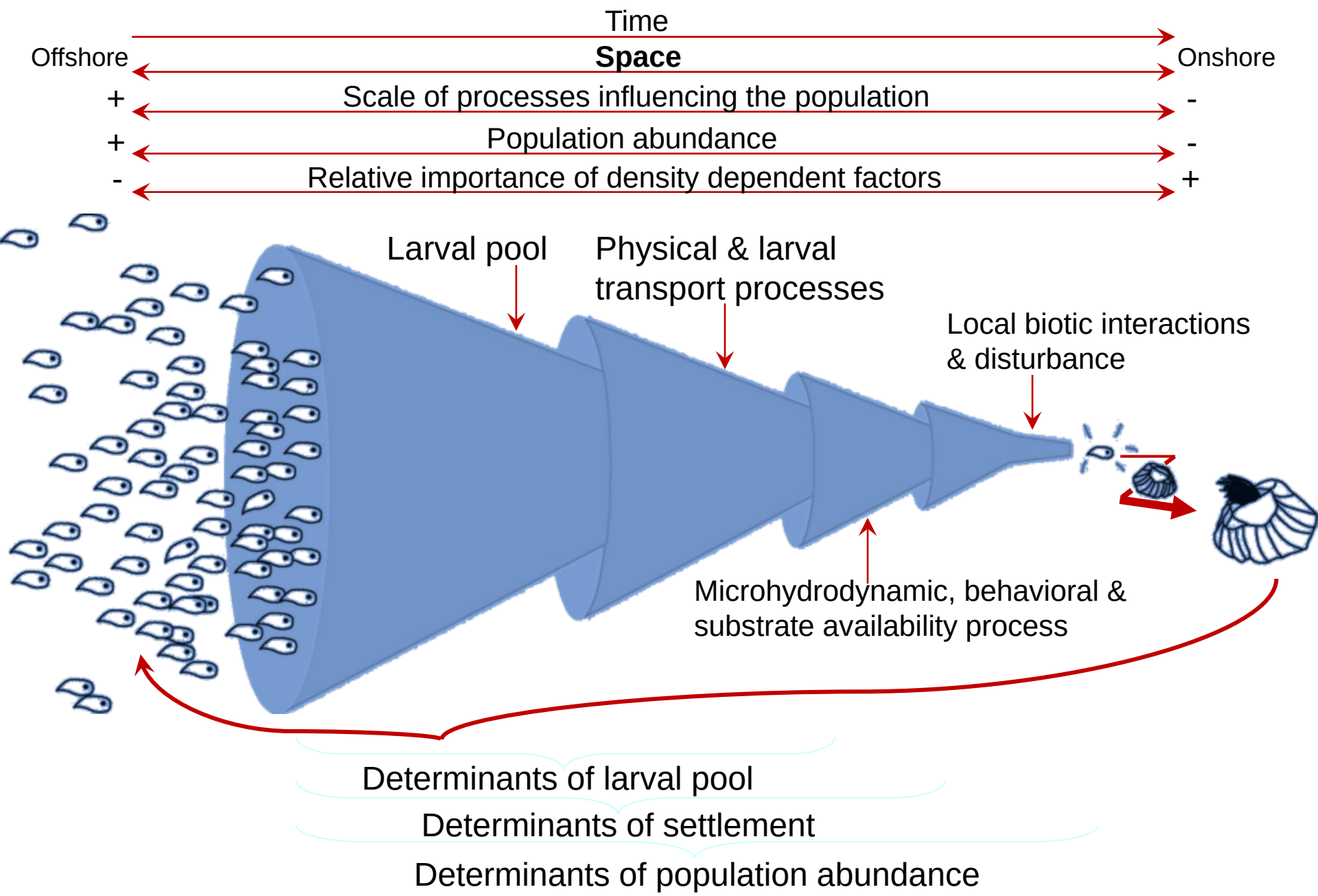


Population connectivity of marine organisms

Connectivity: Ensuring linkages between sites through currents, migratory species, larval dispersal

- Organisms distributed as many small breeding groups (populations)
- Pattern set by geography, hydrodynamics, and biology
- Populations interact through exchange of individuals (connectivity)
- May be isolated, a metapopulation, or a large, but subdivided population

Understanding population connectivity to develop spatial management methods for capture fisheries!!



So: Jesús Pineda, *Oceanography of the Eastern Pacific*, 1 (2000) 84-105

Benthic Population

Connectivity with different trophic levels -Important to take into consideration the benthic population inhabiting within and above the sediment

Demersal fishery - Sustained by benthic organisms

Benthic organisms - Release larvae into pelagic realm and how larvae are dispersed and borough back to the recruitment site to replenish the population is important from fishery perspective

How these are distributed over different type of sea bed and particular season favors any particular group of organisms and in turn these support specific fishery is an important issue

Resources

Measurement of secondary production - Essential to the management of aquatic resources

Fish - Depend to a high degree upon zooplankton and benthos for food

- Understanding the production processes of invertebrates will facilitate management of fish stocks or prediction of rates of fish production/ living resources

Food production, availability, and quality

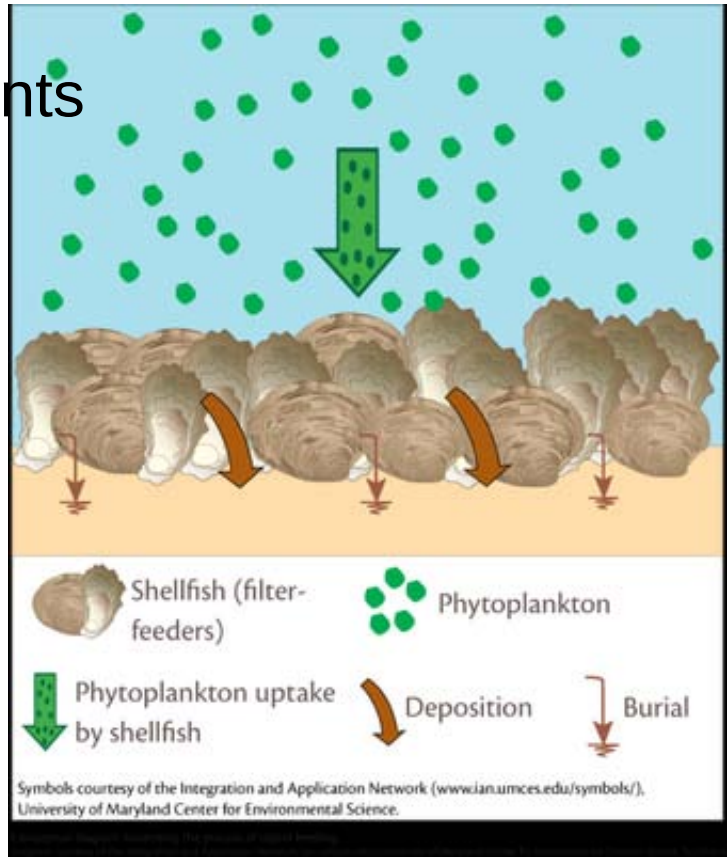
- Community of heterotrophs can fix no more energy than the amount made available to them by primary producers.
- The rate of primary production must set the upper limit for secondary production.
- Rates of production of benthos and zooplanklon are positively related to food availability
- Rates of zooplankton and benthos production are positively related to rates of primary production

Benthic-pelagic coupling

Nutrient exchange or benthic-planktonic coupling occurs between bottom sediments and overlying water column

Main coupling factors

- Organic matter input in surficial sediments
- Resuspension process
- Nutrient recycling
- Contaminant sequestration



Organic matter input in surficial sediments

Main forcing factors

- Depth

Shallow sediments – High coupling; Deep Sediments - Low coupling

- Decay rate of organic matter
- Settling velocity
- Disequilibrium between production and consumption in surface waters

Resuspension processes

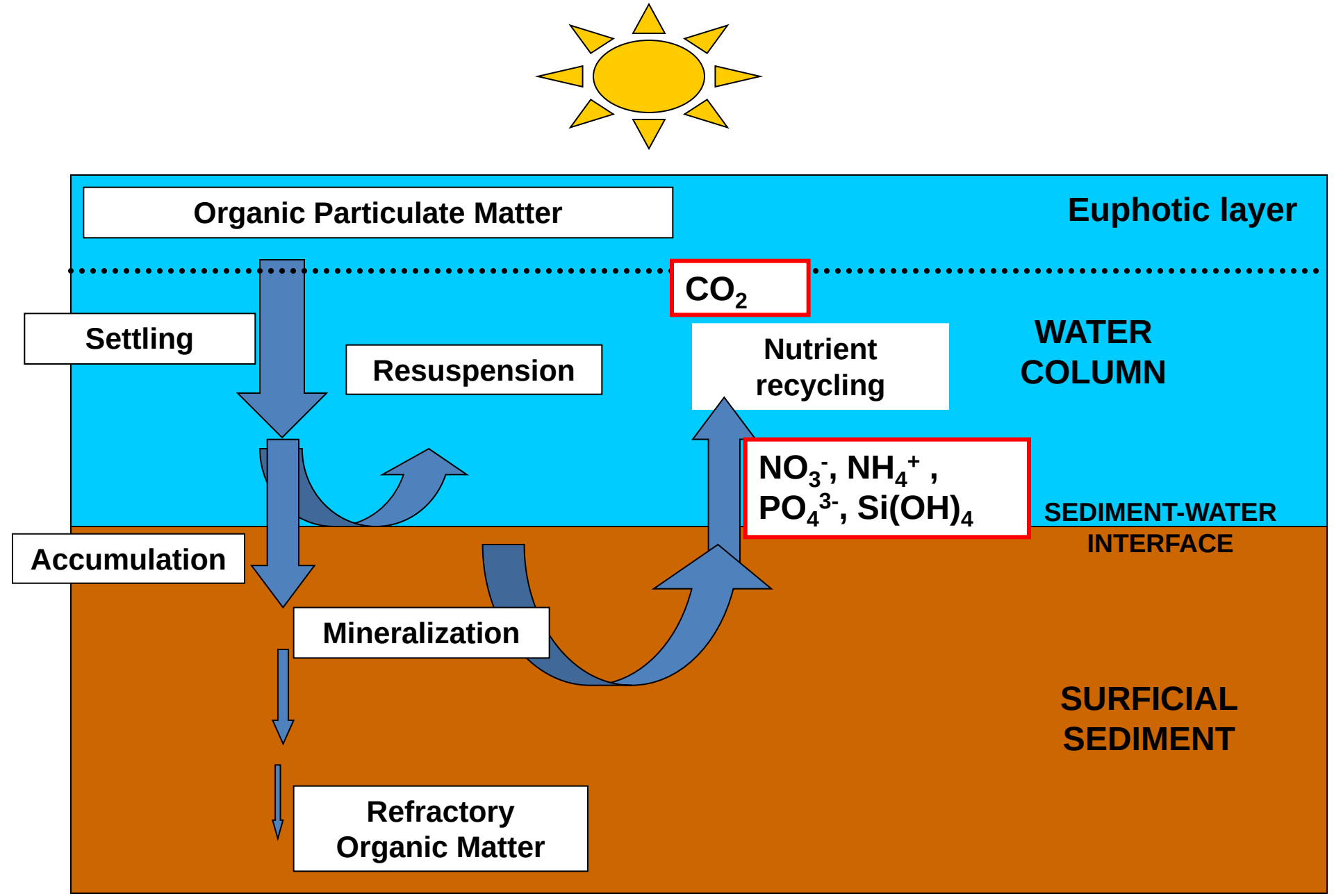
- Mainly:
  - Sediment particles (Inorganic, Organic aggregates, dead organisms)
  - Microphytobenthos

    Either fixed on particles or free but resuspended
  - Macrophytes

    The distal part of macrophytes is regularly cut by waves and movements on rocks
  - Macrobenthic organisms

    Either larval stages, or adults (Polychaetes).

Benthic-pelagic coupling



Demersal Resources

Fish are a taxonomically and morphologically diverse group.

Broad feeding types: Filter feeders, Planktivores, Piscivores and Benthic feeders.

Filter feeders - strain the water column indiscriminately for small prey, typically phyto- and zooplankton.

Planktivores - Prey upon individual zooplankton, (Copepods, mysids and gammarids)

Piscivores – Prey upon small fishes

Benthic, or bottom-dwelling - Include sturgeon, catfish, flounder etc. Because of their habitat orientation, they feed primarily on epibenthic organisms such as amphipods, bay shrimp, and bivalves.

Demersal Resources

- Benthic animals play an important role in energy transfer as they are utilized as prey by fish and larger crustaceans

- Benthic animals support important commercial and recreational fisheries

- Clams, Oysters, Scallops and other molluscs; Lobsters, Crabs, and Sea urchins are economically valuable benthic species

- Tube-building worms and amphipods can be important food for - juveniles of economically and ecologically important fish species

- Benthic surface-dwelling (epifaunal) communities support - sea anemones, zoanthids (colonial anemones), sponges, hard and soft corals, sea stars, lobsters, squat lobsters (galatheids), shrimp and crabs

Disturbance to benthic ecosystems

Disturbance - “any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability or the physical environment”

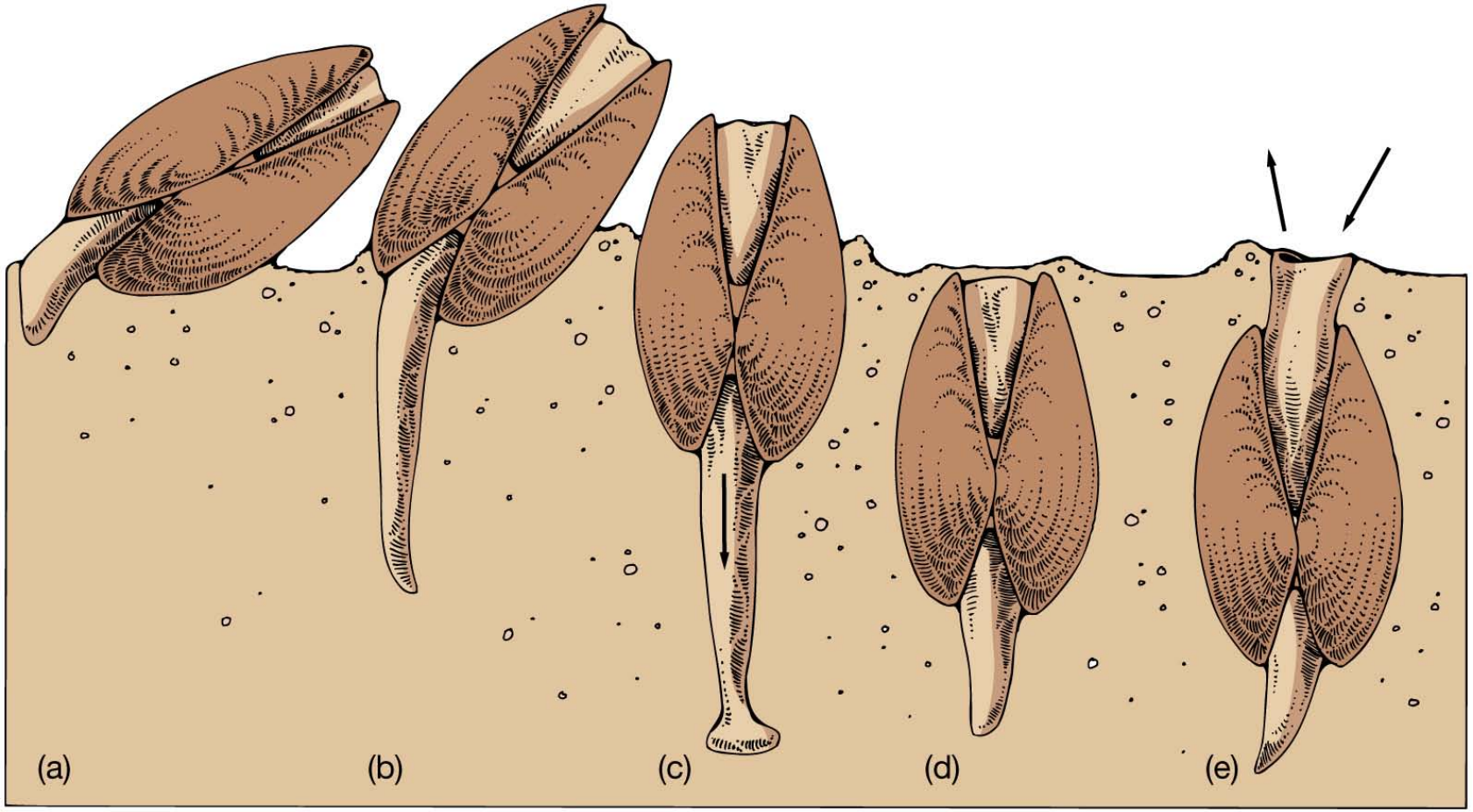
Disturbances - Organic enrichment and/or hypoxia change benthic community composition.
Anthropogenic disturbances also include bottom trawling

Response strategies do not rescue an animal from a disturbance, mortality will occur, resulting in altered community composition

Impacts of trawling on the seabed and benthic communities

- Destruction or damage to structurally complex habitats
- Reduction of habitat heterogeneity and homogenisation of subtly textured habitats
- Reduction in bioturbation
- Death and damage to infauna and epifauna
- Reduction in benthic species diversity
- Re-suspension of sediments
- Attraction of scavengers
- Declines in larger, slow growing species
- Increases in smaller, faster growing taxa

(Jennings and Kaiser 1998, Auster and Langton 1999, Collie *et al.* 2000a,b, Jennings *et al.* 2001, Kaiser *et al.* 2002, Widdicombe *et al.* 2004, Kaiser *et al.* 2006, Hiddink *et al.* 2008).



Thank You