3. Deposit Feeding

- What is feeding & deposit feeding?
- Getting and Keeping the food
  - Types of deposit feeding
- Digesting the food
  - Nutritional Needs
- Particle Selection
- Particle Movement

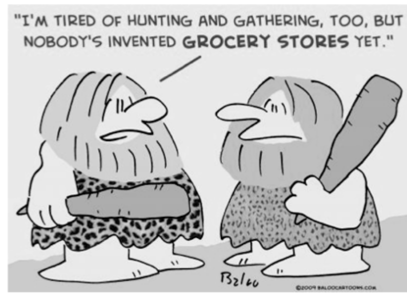
Dr Rhian G. Walller
12th April 2010
Reading: Levinton, Chapter 13, "Life in the Mud and Sand"

Feeding

- Why study feeding?
  - Nutritional needs of organisms
    - Control life histories
  - Movement and recycling of particles
- Two main types of feeding in the benthos
  - **Suspension Feeding**
    - Feeds on particles by removing them from suspension
  - **Deposit Feeding**
    - An animal that ingests deposited, particulate food
    - Inert material of low nutritional value
    - *Has the greatest biological effect on sediment microstructure*

Feeding

- To feed – complex!
  - Get the food
  - Retain the food
  - Digest the food
- Require specific structures and strategies



Deposit Feeding

- Ingest sediment
  - Gain nutrition from microalgae, POM & bacteria
  - Sediment complex mixture
    - Inorganics, microorganisms, decomposing organic matter, pore water etc.
- Tend to be found in areas with finer sediments
  - 10-30 μm peak range
- **INGESTION** – Take in Food
- **DIGESTION** – Absorb Food

Types of Deposit Feeders

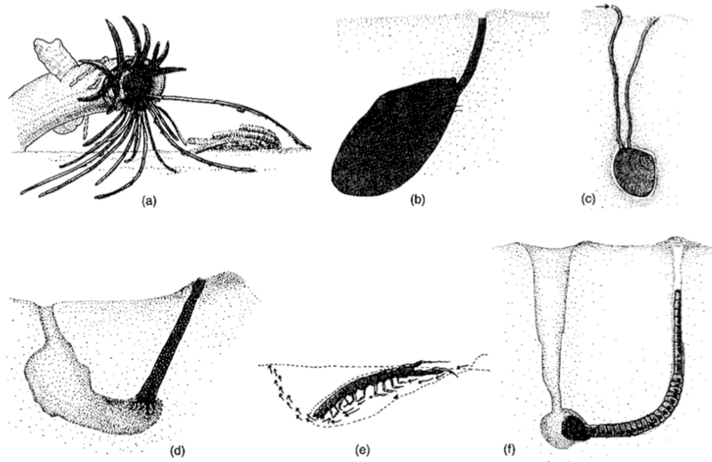
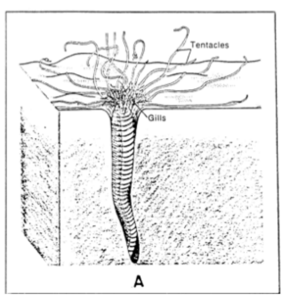


Fig. 13.7 Some deposit-feeding animals: (a) the surface tentacle-feeder *Hobsonia;* (b) the within-sediment tentacle-feeding bivalve *Yoldia limatula;* (c) the surface deposit-feeding siphonate bivalve *Macoma;* (d) the within-sediment feeding *polychaete Pectinaria;* (e) the surface-feeding *Corophium;* (f) the deep-feeding *Arenicola.* (Drawing of *Hobsonia* copied from an original by P.A. Jumars.)

Tentaculate Surface Deposit Feeders



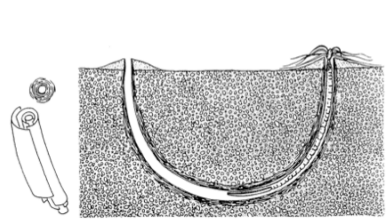
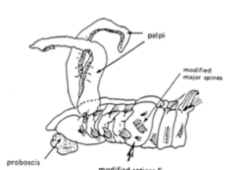
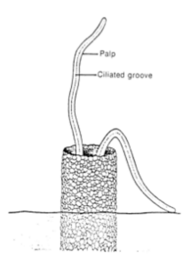


Figure 4.20 The U-burrow of *Amphitrite ornata*, showing (left) the laminated mud wall in cross section and as an exploded constructional diagram. Data adapted from Rhoads (1967) and Aller & Yingst (1978).





- Use tentacles to feed
  - Gather particles
  - Need flow to disturb sediment and mix
- Sit in burrows
  - Single or U shaped

Tentaculate Surface Deposit Feeders

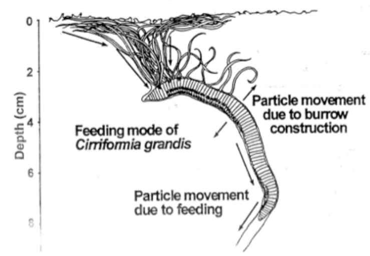
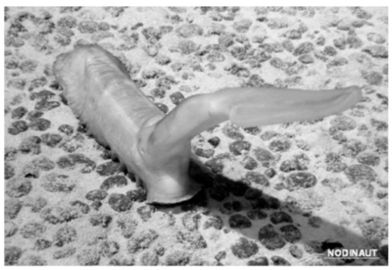
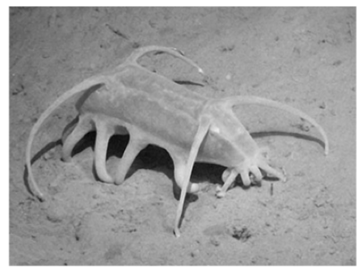


Figure 2. Feeding and burrowing mechanisms of *C. grandis*. Particles are collected near the sediment-water interface and are deposited along the entire length of the burrow. Burrows are created by displacing sediment approximately one half body width.

- Feed on surface layers of sediment
- Can be infauna or epifauna
- E.g. Polychaetes, Sea cucumbers





Tentaculate Subsurface Deposit Feeders

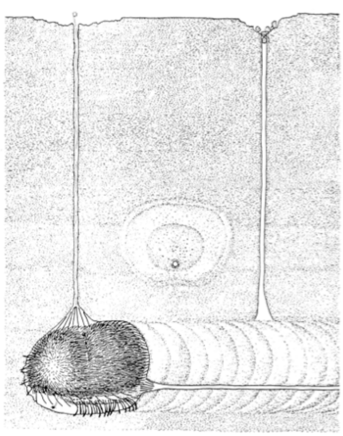


Figure 5.11 *Echinocardium cordatum* in its burrow. Behind it an abandoned shaft remains open in the muddy substrate. Above, a cross section of the backfill and subcentral drain.

- Feed below the surface using tentacles
- Shaft to surface still remains
  - Path down
  - Allow siphoning of ejected material

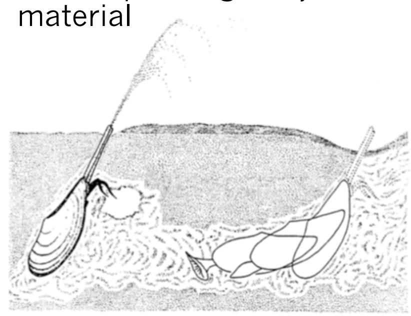


Figure 5.1 *Yoldia limatula*, deposit feeding and shifting from left to right to a new feeding site. Modified after Rhoads (1963, 1974) and Aller & Cochran (1976).

- E.g. Urchins, Bivalves

Funnel Feeder

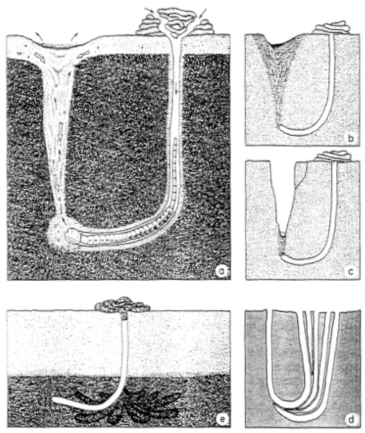
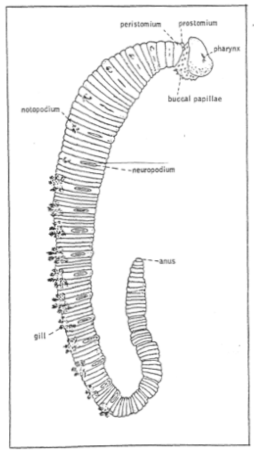


Figure 4.10 The work of *Arenicola marina*. (a) The standard system whereby sediment is conveyed down the head shaft (left), selectively ingested at its base, and deposited as castings above the tail shaft. Coarser grains accumulate below the head. Oxygenated sediment pale. White arrows show sediment movement, black arrows water currents. The thorny buccal parts are shown everted as a terminal anchor. (b) Burrow variants occurring in loose and (c) firm sediment. (d) Unusual variant where *A. marina* succeeds in exploiting clayey substrate. (e) Compound structure produced where the worm, deposit feeding in an organic rich substrate, moves the burrow radially around a stationary tail shaft. Modified after Schäfer (1962), Rijken (1979) and other sources mentioned in the text.



- Create sediment cone
- Moves food (sediments) towards head
- E.g. Polychaetes

"Shoveling" Subsurface/Surface Deposit Feeder

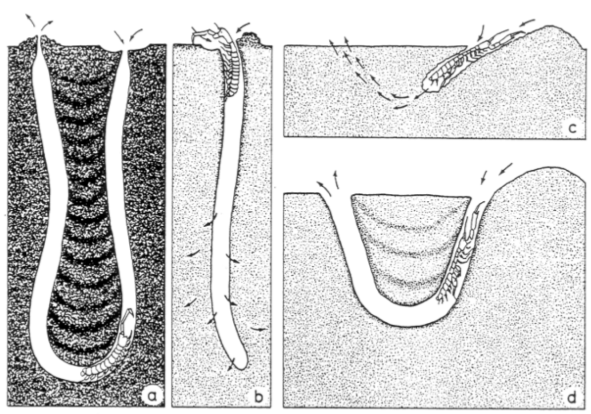
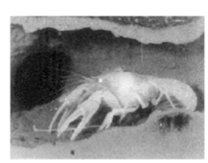


Figure 4.9 (a) U-burrow of *Corophium volutator* in mud and (b) in sand. Arrows indicate water currents. Modified after Seilacher (1953a). (c) A stage in burrow construction by *C. arenarium*. Passage of respiration water through the sand weakens the substrate and eases construction of a second shaft. This U-burrow is then gradually deepened (d). Data from Ingle (1966).

- Feed both on surface and subsurface
- Tend to select particles
- E.g. Shrimp



Getting the food…

- Tentaculate Surface Feeders
  - Use tentacles to feed on surface
- Tentaculate Subsurface Feeders
  - Use tentacles to feed within the sediment
- Funnel Feeders
  - Use tunnels and feeding to create U-shaped burrows, funneling sediment into mouth
- Subsurface/Surface Deposit Feeders
  - Use mandibles to shovel food from both surface and subsurface
- **All species tend to have unique burrows**
  - Feeding strategy, mouth parts, size, etc…

Unique Burrows

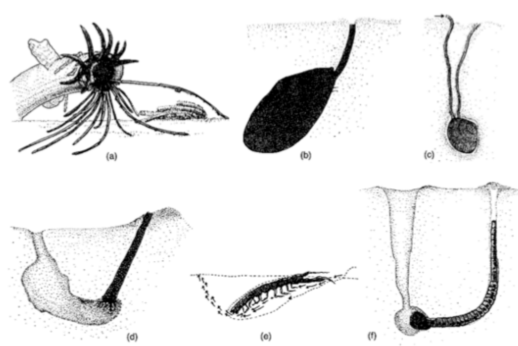
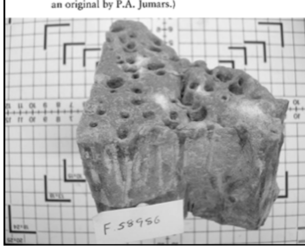
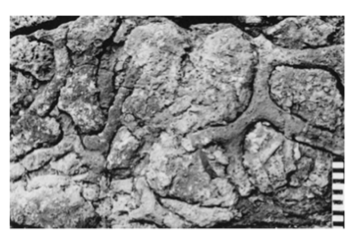


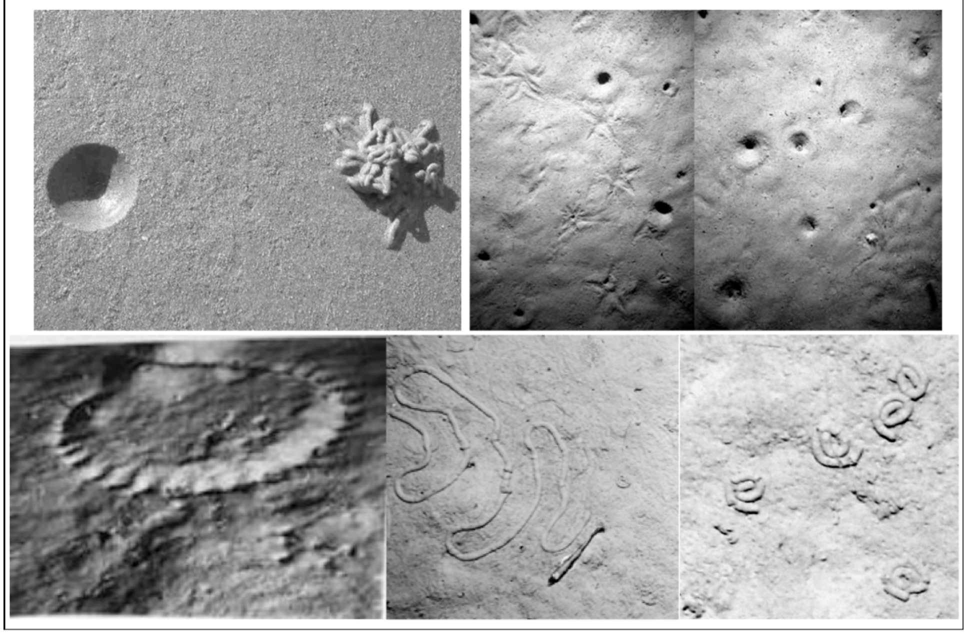
Fig. 13.7 Some deposit-feeding animals: (a) the surface tentacle-feeder *Hobsonia;* (b) the within-sediment tentacle-feeding bivalve *Yoldia limatula;* (c) the surface deposit-feeding siphonate bivalve *Macoma;* (d) the within-sediment feeding *polychaete Pectinaria;* (e) the surface-feeding *Corophium;* (f) the deep-feeding *Arenicola.* (Drawing of *Hobsonia* copied from an original by P.A. Jumars.)

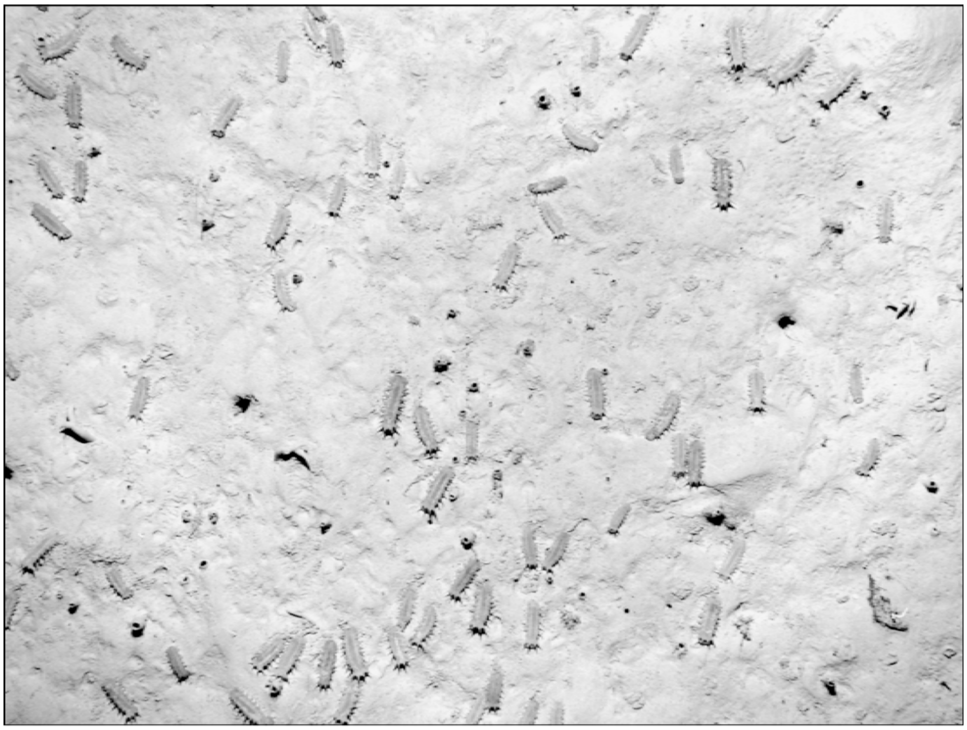


- Even in the fossil record



Feeding & Poop Trails too!





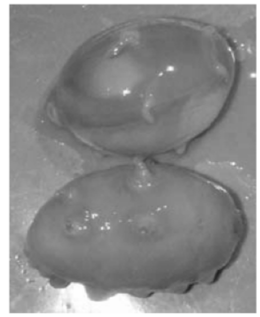
Digest the food....

- Organisms need to maximize net rate of energy gain
  - Deposit feeders tend to be continuous feeders
- Ingestion Rates
  - Smaller food particles – ingested faster
  - Higher quality food particles – ingested faster
    - Taghon & Jumars, 1984
- But – time available for digestion decreases as amount of food taken in increases
  - Intermediate rate of ingestion best
    - Lopez & Levington, 1987

Digest the food...

Nutritional needs of deposit feeders:

- •Organic carbon
- •Organic nitrogen
- •Essential fatty acids (long chain PUFAs)
- •Essential amino acids (~10)
- •Sterols
- •Vitamins



Potential food sources:

•Vascular plant detritus	$C_{org,}$ N?, sterols?
•Algae (live and dead)	C_{org}, N?, sterols, PUFAs
•Sediment bacteria	C_{org}, N, E.A.A.s?
•Protozoa and meio-fauna	all nutrients
•Amorphous OM	C_{org}, ?

Digest the food....

- Two feeding strategies
  - Swallow sediment non-selectively
    - Absorb the good stuff, poop the rest
  - More selective feeding on specific particles
    - Sort sediment first, then eat the good stuff

- Some animals actively select for different food sources
- Some animals passively select
  - Selected absorption

TABLE 2
Absorption of microbes and sedimentary organic matter by deposit feeders

Species	% absorption		
	Bacteria	Microalgae	Organics[a]
GASTROPODS			
Potamopyrgus jenkensi (Heywood & Edwards, 1962)	–	–	4
Hydrobia ventrosa (Kofoed, 1975)	75	60–71	34[b]
Hydrobia totteni (Lopez & Cheng, 1983)	36–49	30–48	29
Amphibola crenata (Juniper, 1981)	56	–	–
BIVALVES			
Nucula annulata (Cheng, 1983 & unpub.)	66–78	–	0–76
Nucula proxima (Cheng, 1983 & unpub.)	87–92	–	0–16
ANNELIDS			
Tubifex tubifex (Brinkhurst & Austin, 1979)	–	–	3.0
Limnodrilus hoffmeisteri (Brinkhurst & Austin, 1979)	–	–	5.2
Nereis succinnea (Cammen, 1980a)	57–62	–	10.5[c]
Cirriformia tentaculata (George, 1964)	–	–	7.9
Capitella capitata 1 (Forbes, 1984)	33	–	38
ARTHROPODS			
Hyallela azteca (Hargrave, 1970)	60–83	45–75	6–15
Corophium volutator (Nielsen and Kofoed, 1982)	–	80–92	–
Chironomus plumosus (Johannsson, 1980)	–	–	0–14
ECHINODERMATA			
Parastichopus parvimensis (Yingst, 1976)	43	47	11–43

[a] Bulk sedimentary organic matter, including detrital and microbial fractions.
[b] Barley hay
[c] *Spartina* detritus

Lopez and Levinton, 1987

Understanding Feeding

- Nutritional source can change from juveniles to adults
- Species in the same area don't necessarily feed on same particles

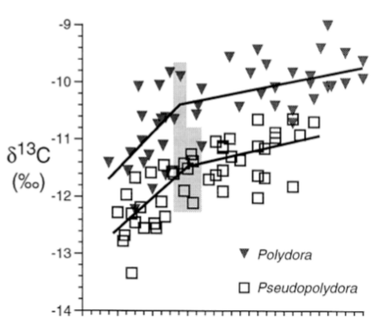


Figure 8. Comparison of the body-size-dependent variations in delta-^{13}C between the two polychaetes collected from False Bay. Shaded regions indicate body lengths within the 95% confidence interval around the estimated breakpoint in the piecewise linear model for each species.

- Case Study
  - Hentschel, 1998
  - Polychaetes
- Adults in same areas fed on different food sources
  - Juveniles fed on benthic diatoms
  - Adults fed on macroalgae detritus
- This in turn can affect recruitment
  - Benthic diatoms are ephemeral

Deposit Feeding

- **Has the greatest biological effect on sediment microstructure**
  - Deposit feeders are dominant organisms in muddy sediments
    - The majority of the benthos is sediment
  - Individual sediment particles are transported long way
    - Relative to the size of the particle
  - Near continuous movement of particles
    - Little rest between feeding

Particle Movement

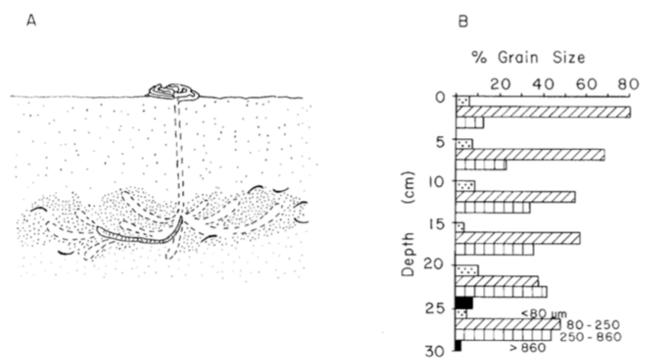


Figure 10. Segregation of particle sizes often occurs during feeding. (A) Subsurface feeding by the lugworm *Arenicola* and surface defecation of ingested material can result in pockets of coarse material at depth. After Rijken (1979). (B) Average vertical grain size distribution resulting from feeding by *Arenicola* in tidal flats of Dutch Wadden Sea. After Baumfalk (1979).

- Eat food of one size grain
  - "Deposit" it somewhere else....

Aller, 1982

Particle Movement

- Particles can be mixed in a number of ways
- Depends on the deposit feeding/burrowing strategy
  - Unidirectional
  - Loops

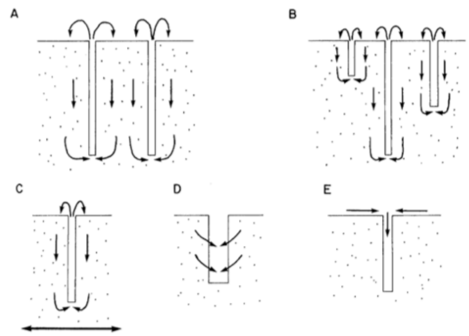


Figure 2. (A) Hypothetical transport paths of particles around individual subsurface deposit feeders of uniform size. (B) Multiple transport loop scales around organisms of varied size. (C) Particle transport loops are subject to lateral motion depending on mobility of deposit feeders. (D) Infilling of biogenic cavities results in particle transport independent of feeding activity. (E) Vertical dimension of feeding loops goes to zero in case of surface deposit feeders and in some cases may result in injection below the interface of surface-derived fecal material.

Aller, 1982

Hydrodynamics

- Hydrodynamic regime important for feeding
  - Low current = Finer sediment grains
  - High current = Larger sediment grains
  - V. High current = No sediment grains
- Currents can also create ripples, sediment waves, bars
  - Create microhabitats for benthic organisms
- Deposit feeders need finer particles to remain to feed
  - *Higher currents tend to see more species of suspension feeders*

Conclusions

- Deposit feeding = ingestion of sediments, either in bulk or selectively
  - Different by species
  - Different through life stages
    - Can control recruitment
- Four main modes of deposit feeding
- Deposit feeding mixes the benthic layers
  - Bioturbation
- Hydrodynamics control where deposit feeders found