Benthic feeding guilds, functional groups & bioturbation

Class 2: 9/4/08 Th

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Slide 1 Benthic feeding guilds, functional groups & bioturbation

NOTES:

Reading assignments for Class 2-4

Feeding guilds, bioturbation & benthic diatoms

- Feeding & Feeding guilds
  - Gallagher's Chapter 1
  - Cammen 1980
  - Fauchald & Jumars
- Bioturbation
  - Gallagher Chapter 2
  - Boudreau, B. P. 1998. Mean mixed depth of sediments: the wherefore and the why. Limnol. Oceanogr. 43: 524-526.
  - Shull, D. H. 2001. Transition-matrix model of bioturbation and radionuclide digenesis. Limnol. Oceanogr. 46: 905-916.
- Microphytobenthos
  - Gallagher Chapter 3: Microphytobenthic production
  - Gould & Gallagher (1990)
  - Glud, R. N, M. Kühl, F. Wenzhöfer, and S. Rysgaard. 2002. Benthic diatoms of a high Arctic fjord (Young Sound, NE Greenland): importance for ecosystem primary production. Mar. Ecol. Prog. Ser. 238: 15-29.

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Slide 2 Reading assignments for Class 2-4

NOTES:

Big ideas for today's class

- The diverse meanings of 'biodiversity', niche, functional groups & guild
- Major benthic feeding guilds defined by where they obtain food and their motility
  - Macrophages, especially carnivores
  - Microphage
    - Deposit feeding (surface & subsurface)
    - Suspension feeding
- Functional groups of benthos
  - Major groups described by Woodin, Jackson & especially Don Rhoads
  - Rhoads et al. Described succession & response to pollution in terms of functional groups, not species

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Slide 3 Big ideas for today's class

NOTES:

Biodiversity

A variety of definitions

- NRC (1995): *'the collection of genomes, species, and ecosystems occurring in a geographically defined region.'*
- Hubbell (2001, p. 3): species richness and relative abundance in space and time.
- Biodiversity can be defined in terms of hierarchy and level of biological oroganization: Structure, Function & Composition

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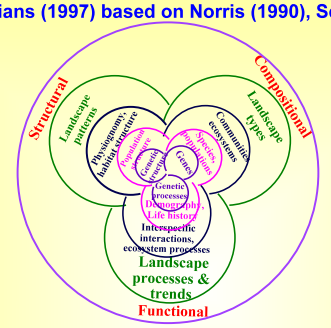
Slide 4 Biodiversity

NOTES:

Biodiversity: All 4 levels

Orians (1997) based on Norris (1990), See Chapter 5



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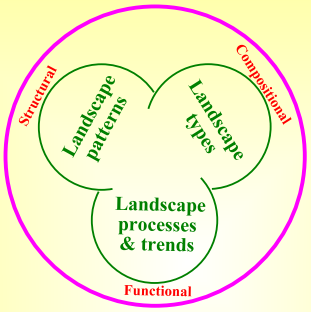
Slide 5 Biodiversity: All 4 levels

NOTES:

Biodiversity: Landscape

Amenable to remote sensing



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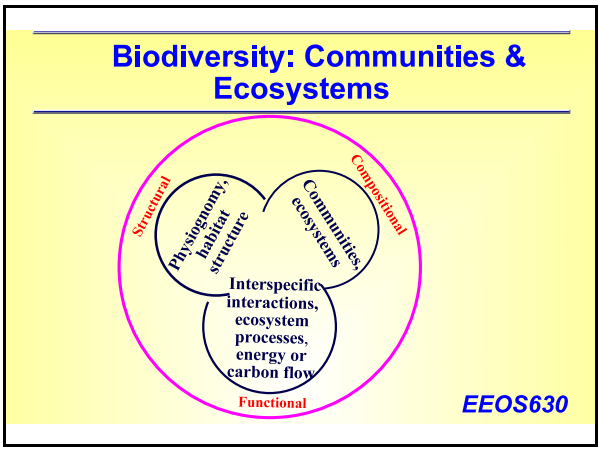
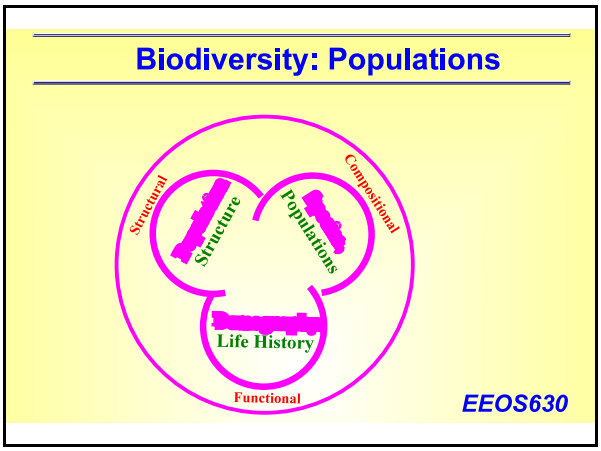
Slide 6 Biodiversity: Landscape

NOTES:



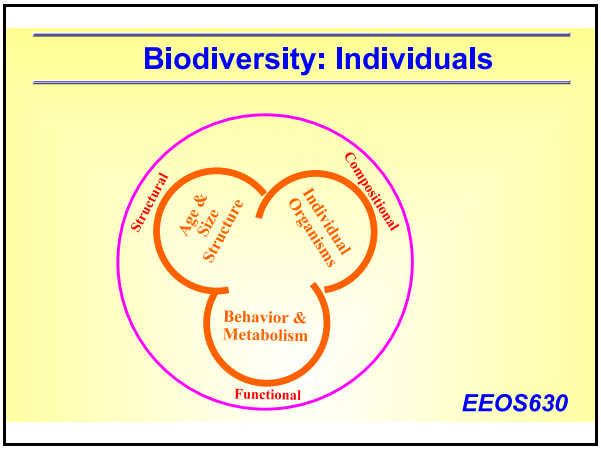
Slide 7 Biodiversity: Communities & Ecosystems

NOTES:



Slide 8 Biodiversity: Populations

NOTES:



Slide 9 Biodiversity: Individuals

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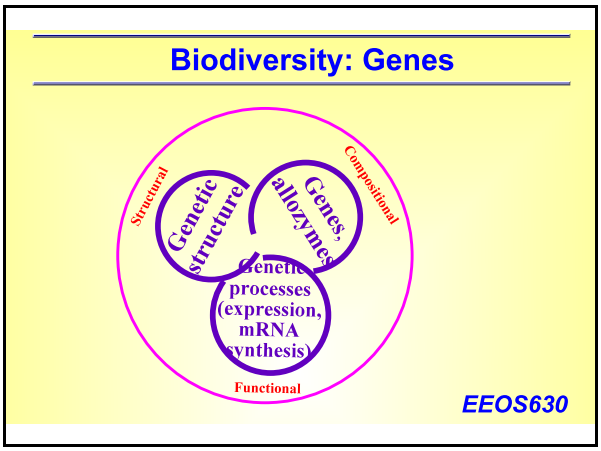

Slide 10 Biodiversity: Genes

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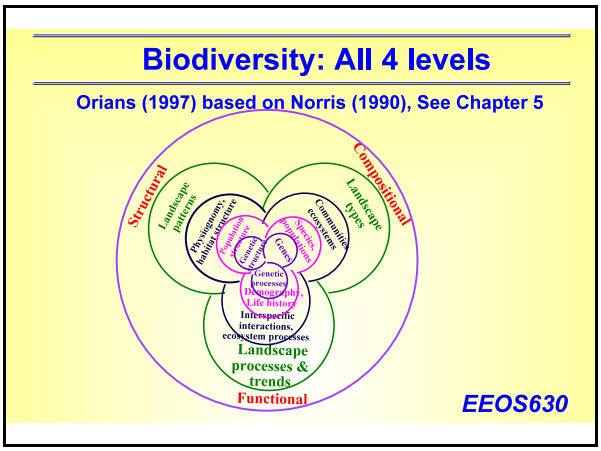
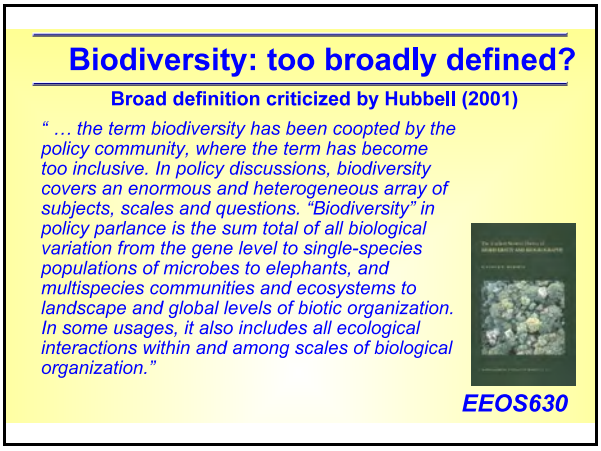


Slide 11 Biodiversity: All 4 levels

NOTES:



Slide 12 Biodiversity: too broadly defined?

NOTES:

Species: the fundamental units of biodiversity

Harvard's EO Wilson (1992, p 35-38)

- The species concept is crucial to the study of biodiversity. It is the foundation of systematic biology.
- Not to have a natural unit such as the species would be to abandon a large part of biology into a free fall, all the way from the ecosystem down to the organism.
- Without natural species, ecosystems could only be analyzed in the broadest terms, using crude and shifting descriptions of the organisms that compose them.
- Biologists would find it difficult to compare results from one study to the next.

Slide 13 Species: the fundamental units of biodiversity

NOTES:

Mayr's biological species concept

Mayr 1982, p. 273 The growth of biological thought

"A species is a reproductive community of populations (reproductively isolated from others) that occupies a specific niche in nature."

Mayr argues that the 'niche occupation' clause is necessary to apply the biological species concept to asexual clones, *"It is thus customary to combine into species those asexual individuals and clones that fill the same ecological niche or that play the same role in the ecosystem."*

Slide 14 Mayr's biological species concept

NOTES:

What is an organism's niche?

GE Hutchinson's Fundamental Niche (1978, p. 160)

- "Each niche can be regarded as a set of points, each one of which defines a possible set of environmental values permitting the species to live."
  - The **fundamental niche** is the ***hypervolume*** defined only by abiotic environmental variables and food
  - The **realized niche** includes the effects of negative interactions with other organisms
    - Canonical correspondence analysis & WA-PLS are relatively new methods for analyzing this species-environment relationship
    - Used for inferring paleoclimate
- Elton (1927) described the niche as the function performed by the species in the community
- Both senses are used in ecology

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Slide 15 What is an organism's niche?

NOTES:

Ways of classifying the benthos

Species, functional groups, and guilds

- Old but still accepted dichotomies
  - Meiofauna vs. Macrofauna
    - permanent meiofauna
    - Temporary meiofauna
  - Infauna vs epifauna
- Feeding types
  - Predators, scavengers, deposit feeders, suspension feeders, interface feeders
  - Deposit feeders
    - Surface deposit feeders
    - Subsurface deposit feeders
      - Rhoads' conveyor belt species
      - Reverse conveyor belt species
- Woodin's functional groups: tube builders, burrowers or suspension feeders
- Jumars & Fauchald's Polychaete Feeding Guilds

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Slide 16 Ways of classifying the benthos

NOTES:

Sampling the benthos

0.25-m^2 Box corer shown

- **What question is being asked?**
  - **Questions dictate sampling designs**
    - Monitoring designs
    - Biodiversity assessment
    - Assessing an impact after it **may** have occurred: Green's BACI: Before-after comparison
  - **Should be statistically valid**
- **Sampling devices**
  - **Petersen, Van Veen or Ted Young grab**
  - **Box core**
  - **HAPS multicorer**
  - **Profile Camera (e.g., REMOTS™)**

Slide 17 Sampling the benthos

NOTES:

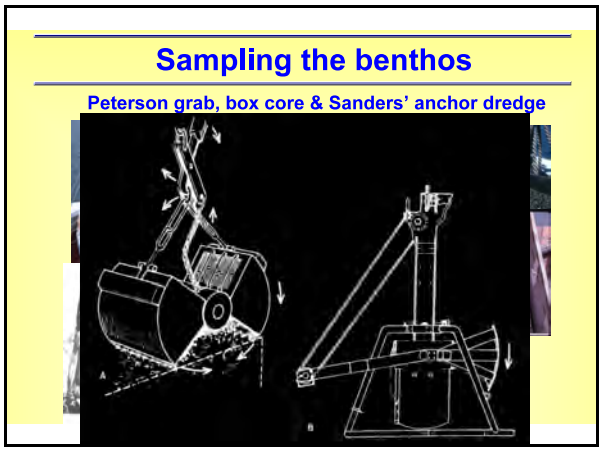
Sampling the benthos

HAPS Multicorer shown

- **Mesh sizes**
  - **0.3, 0.5, or 1.0-mm mesh**
  - **Meiofauna: use 63-µm mesh**
- **Sample size: 0.25-, 0.1-, 0.043-m^2 or smaller (drinking straws)**
  - **Large enough to sample the largest organism of interest**
  - **Trade-off between sample area & statistical power**

Slide 18 Sampling the benthos

NOTES:



Slide 19 Sampling the benthos

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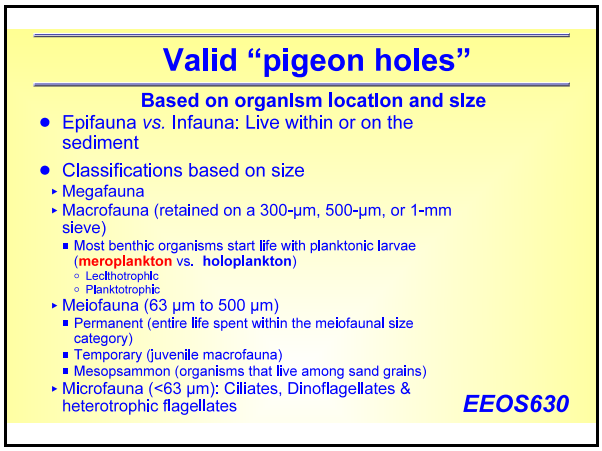
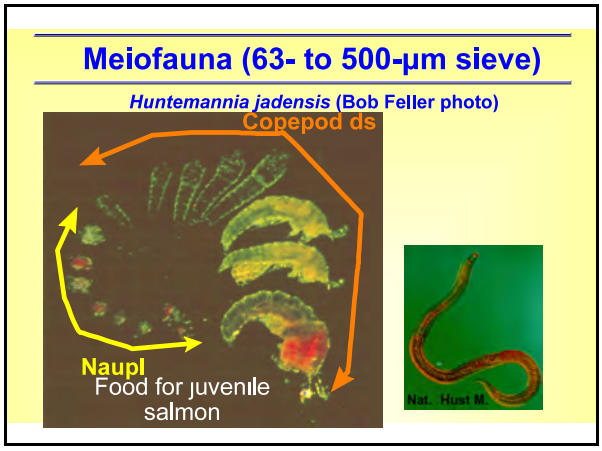


Slide 20 Valid "pigeon holes"

NOTES:

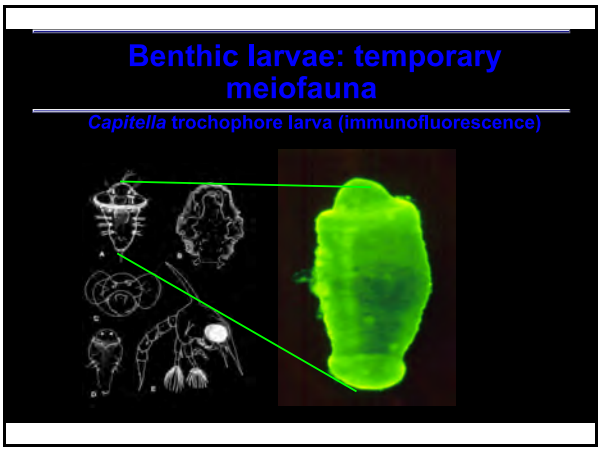


Slide 21 Meiofauna (63- to 500-µm sieve)

NOTES:

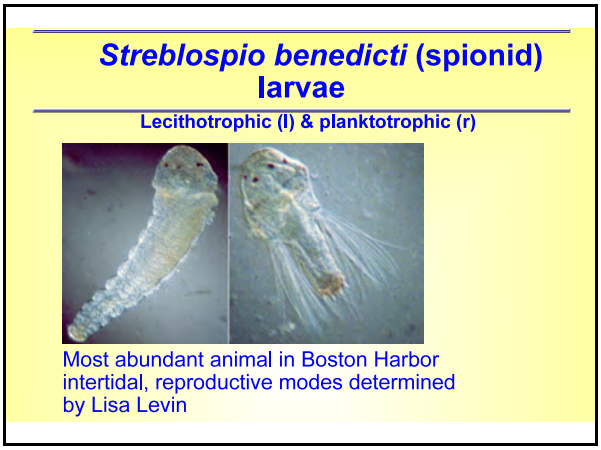
Slide 22 Brian Marcotte's argonauts

NOTES:



Slide 23 Benthic larvae: temporary meiofauna

NOTES:



Slide 24 Streblospio benedicti (spionid) larvae

NOTES:

Functional groups

Peter Calow's (1981) Invertebrate Biology: A Functional Approach

"This book is about how invertebrate animals function -not just about how they work but also about why they work in the way they do. The term function means `the work a system is designed to do', but in a biological context design is not quite the correct word, for organisms are not intelligently conceived nor are thy intelligently selected. ....

By functional biology, then, I mean the search for explanations of the success of particular traits in given ecological circumstances; or why, in other words, those traits which have turned up by chance have then been naturally selected. There is also a very important predictive side to the programme. What traits would be expected to evolve in particular ecological conditions?" (Calow, page 11)

Functional groups are a supplement not a substitute for species identification

Slide 25 Functional groups

NOTES:

Guilds: arenas for competition

Seed gathering ants & rodents are members of the same guild, Brown *et al.* (1986)

"[A guild is] a group of species that exploit the same class of environmental resources in a similar way. This term groups together species, without regard to taxonomic positions, that overlap significantly in their niche requirements." Root (1967)

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Slide 26 Guilds: arenas for competition

NOTES:

Benthic functional groups

Based on interactions with the sediment; Functional groups are not feeding guilds

- Woodin's (1976) functional groups
  - 1) Tube builders
  - 2) Suspension feeders
  - 3) Burrowers
- Woodin & Jackson's (1979) functional groups
  - 1) Mobile burrowing organisms, a.k.a. Thayer's (1979) bulldozers
  - 2) Destabilizing sedentary organisms (*e.g.*, *Molpadia oolitica*).
  - 3) Sedentary organisms which project above and below the sediment surface (*e.g.*, sea grasses).
  - 4) Tube builders
  - 5) Sedentary organisms which don't destabilize or stabilize sediments

Slide 27 Benthic functional groups

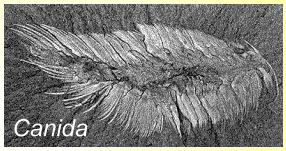
NOTES:

The oldest known polychaetes

Burgess shale, 505 MYA, Cambrian explosion

Simon Conway Morris remarks: "In comparison with the situation in many modern marine environments, the Burgess shale polychaetes had a relatively minor role." S. J. Gould in 'Play it Again'

Subsurface deposit feeders evolved about 150 million years ago; Thayer's (1979) bulldozer hypothesis for extinction of sessile species

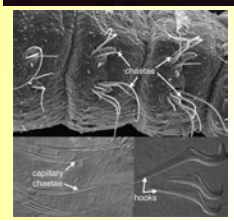


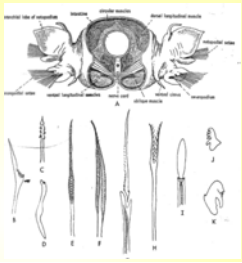
Slide 28 The oldest known polychaetes

NOTES:

The polychaete worm body type

Hooks usually indicate tube-dwelling orientation





Slide 29 The polychaete worm body type

NOTES:

Jumars & Fauchald's Feeding guilds

Guilds defined on the whether particles were ingested in bulk or individually and on motility

- Macrophages
  - herbivores
  - carnivores
  - omnivores
- Microphages
  - Suspension feeders
  - Surface deposit feeders
  - Subsurface deposit feeders
  - ***Interface feeders*** **(Many spionids & ampeliscids, not in Jumars & Fauchald)**
- Motility
  - sessile
  - discretely motile, can move between feeding periods
  - motile

Note that Jumars & Fauchald's guilds aren't defined rigorously in terms of resource use. They rely on feeding morphology. It's the food not the mechanism for acquiring food that should define guilds (e.g., ants vs. Rodents)

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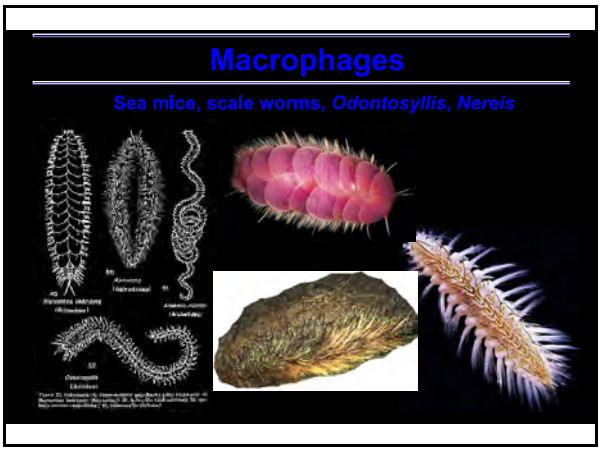
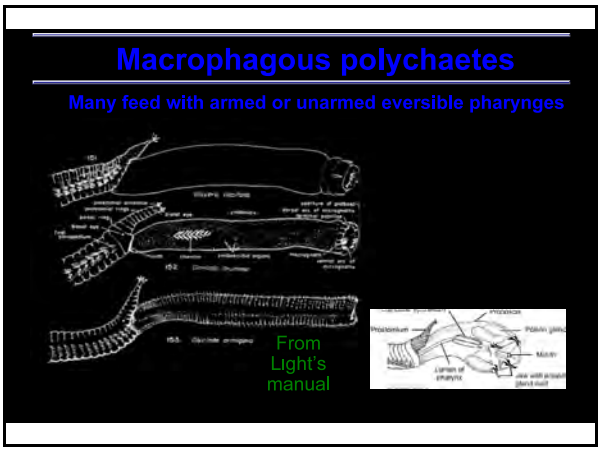
Slide 30 Jumars & Fauchald's Feeding guilds

NOTES:



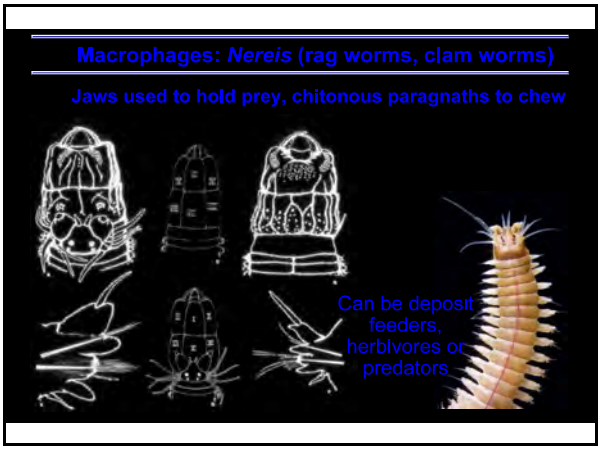
Slide 31 Macrophages

NOTES:



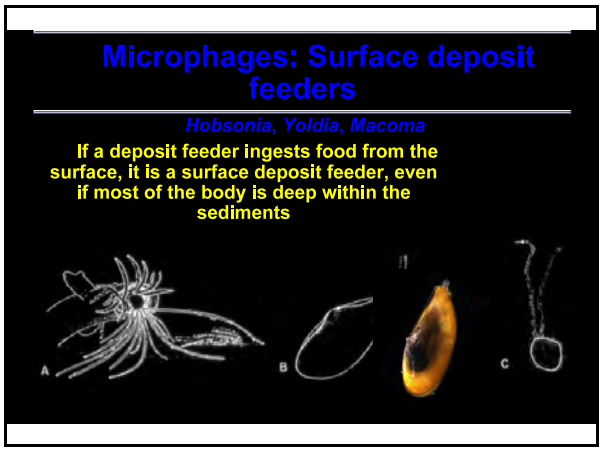
Slide 32 Macrophagous polychaetes

NOTES:



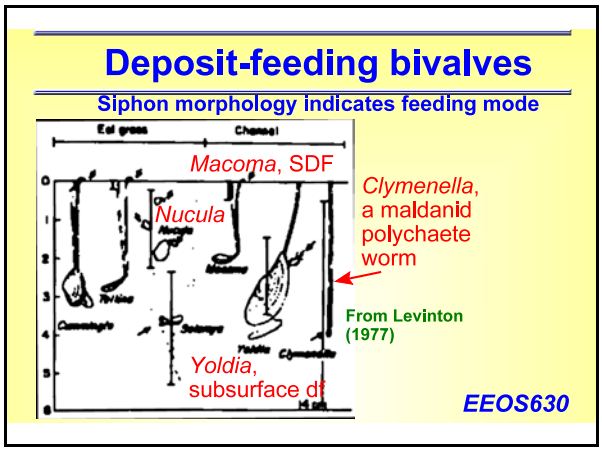
Slide 33 Macrophages: Nereis (rag worms, clam worms)

NOTES:



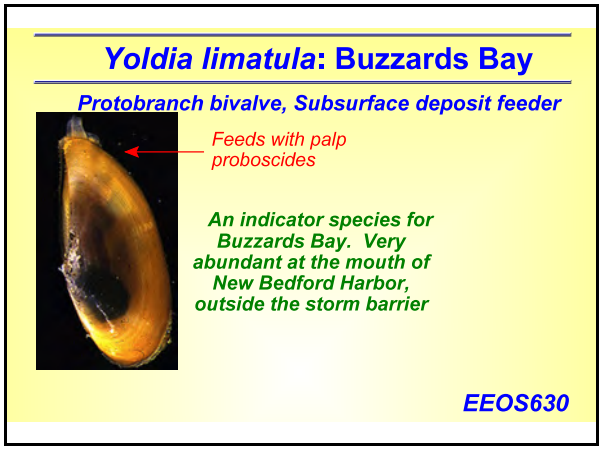
Slide 34 Microphages: Surface deposit feeders

NOTES:



Slide 35 Deposit-feeding bivalves

NOTES:

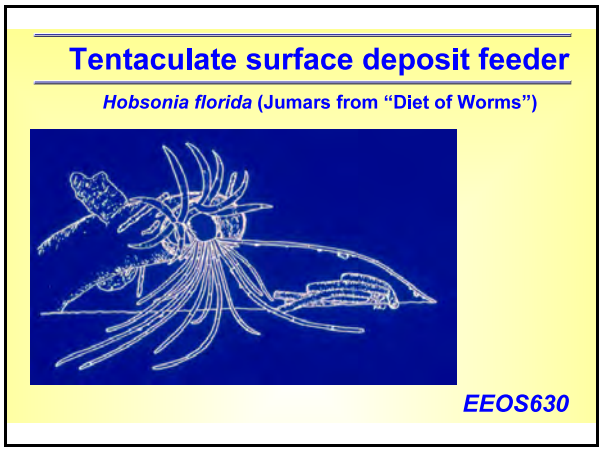


Slide 36 Yoldia limatula: Buzzards Bay

NOTES:

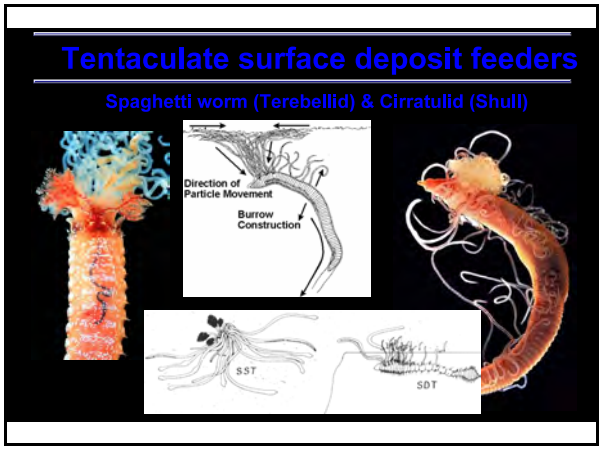
Slide 37 Macoma balthica, a key indicator species worldwide

NOTES:



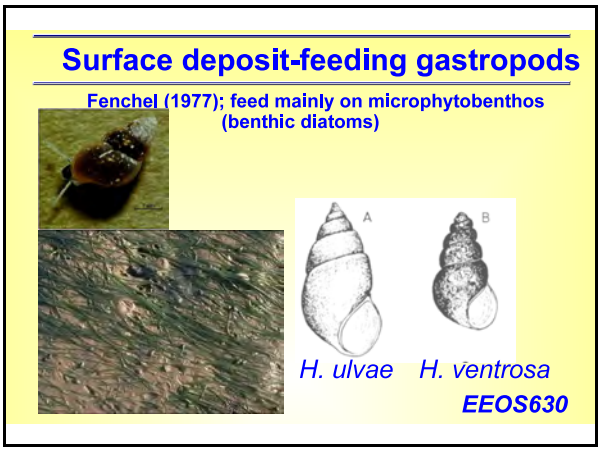
Slide 38 Tentaculate surface deposit feeder

NOTES:



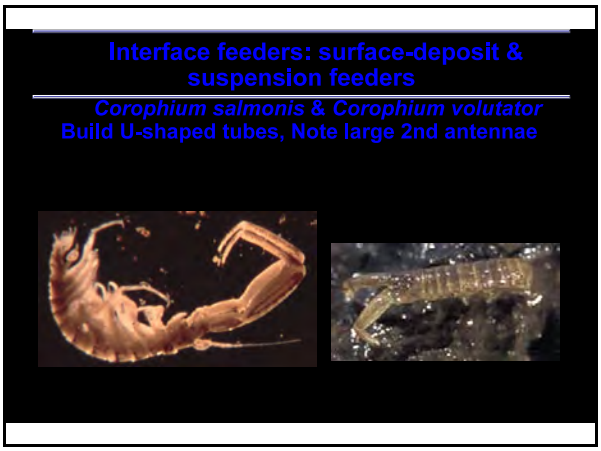
Slide 39 Tentaculate surface deposit feeders

NOTES:



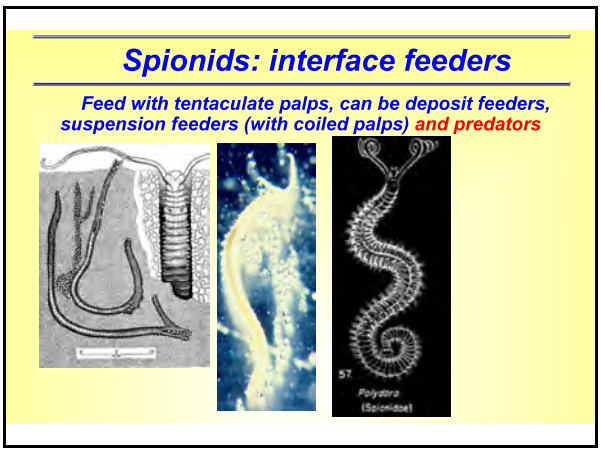
Slide 40 Surface deposit-feeding gastropods

NOTES:



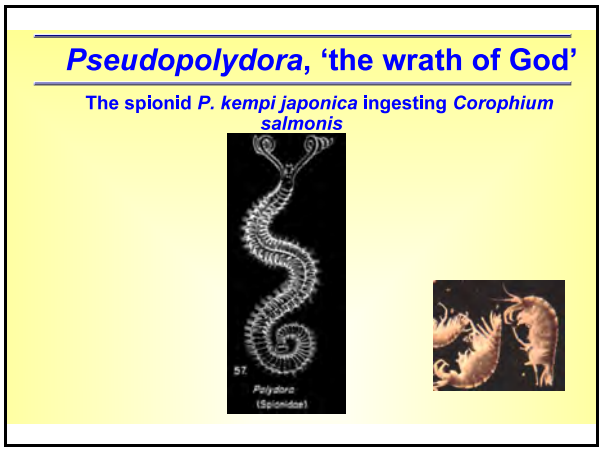
Slide 41 Interface feeders: surface-deposit & suspension feeders

NOTES:



Slide 42 Spionids: interface feeders

NOTES:

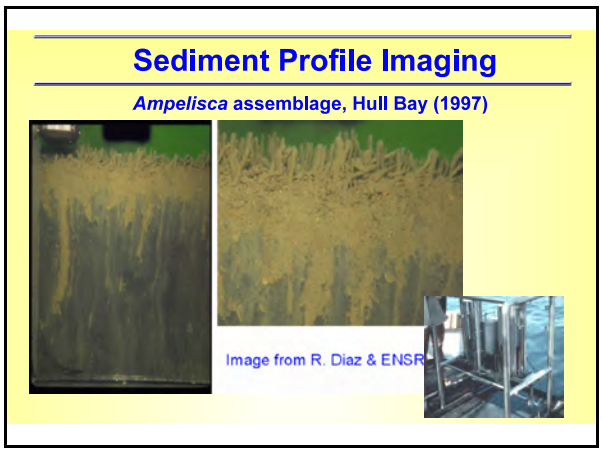


Slide 43 Pseudopolydora, 'the wrath of God'

NOTES:

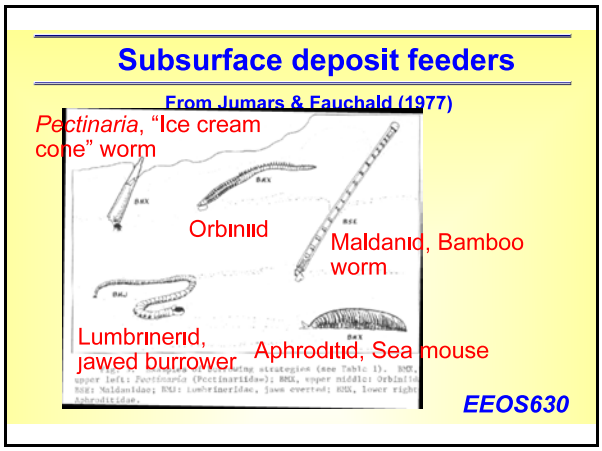
Slide 44 Interface feeders: Ampelisca abdita

NOTES:



Slide 45 Sediment Profile Imaging

NOTES:

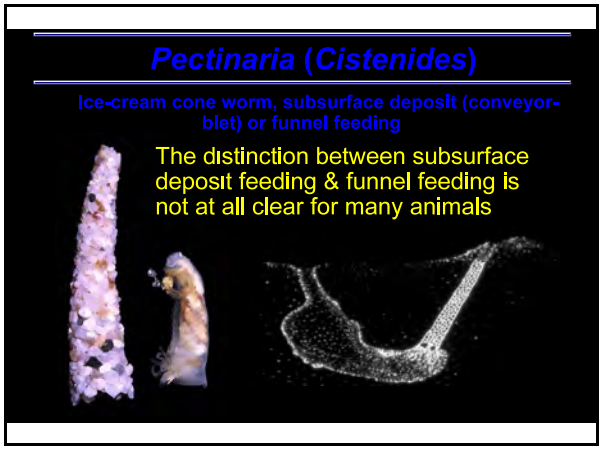


Slide 46 Subsurface deposit feeders

NOTES:

Slide 47 Maldanids: Bamboo worms

NOTES:

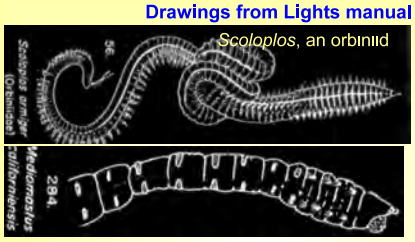


Slide 48 Pectinaria (Cistenides)

NOTES:

Burrowers or subsurface deposit feeders

Drawings from Lights manual



Note burrowing shape (worm-like)

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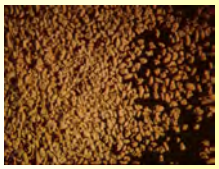
Slide 49 Burrowers or subsurface deposit feeders

NOTES:

Capitella sp. I

Shallow subsurface deposit feeder & premier pollution indicator, see Gallagher & Keay 1998

Wang, Xu-Chen, Yi-Xian Zhang, and R. F. Chen. 2001. Distribution and partitioning of polycyclic aromatic hydrocarbons (PAHs) in different size fctions in sediments from Boston Harbor, United States. Marine Pollution Bulletin *42*: 1139-1149.



Slide 50 Capitella sp. I

NOTES:

Capitella sp. Ia, flounder food

Can reach 9 cm, dominant in Boston's Inner Harbor

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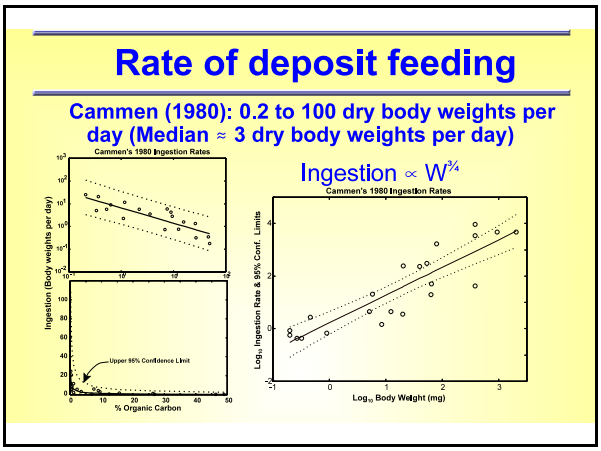
Slide 51 Capitella sp. Ia, flounder food

NOTES:

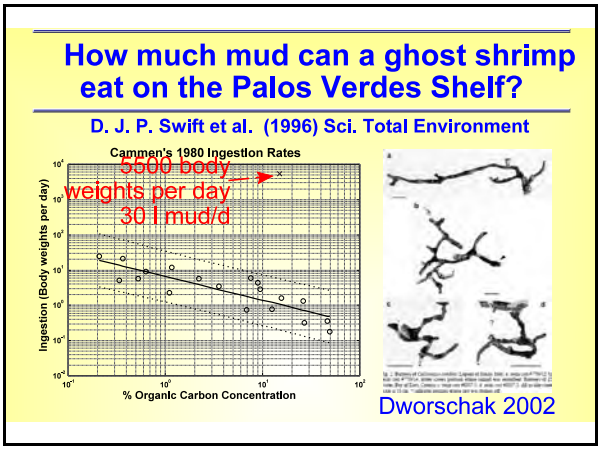
Slide 52 Lug worm feeding (funnel feeding)

NOTES:



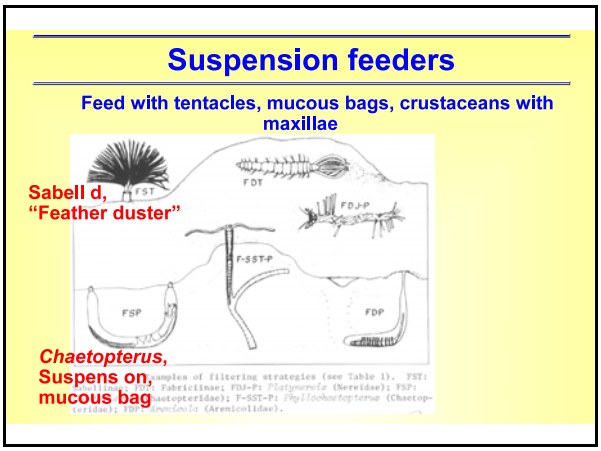
Slide 53 Rate of deposit feeding

NOTES:



Slide 54 How much mud can a ghost shrimp eat on the Palos Verdes Shelf?

NOTES:



Slide 55 Suspension feeders

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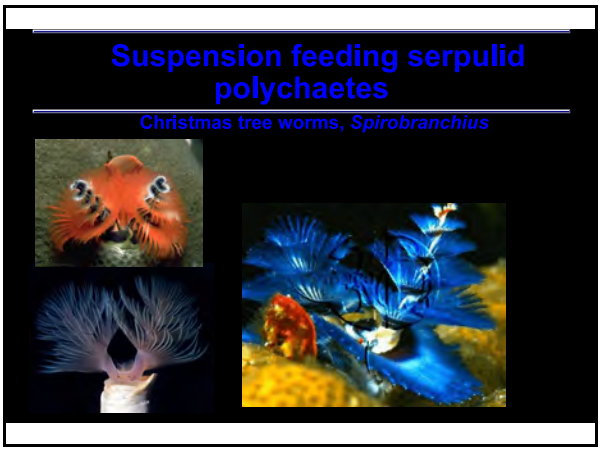
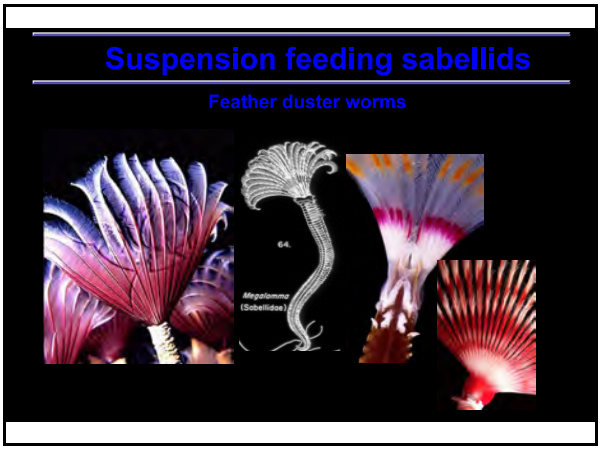


Slide 56 Suspension feeding serpulid polychaetes

NOTES:

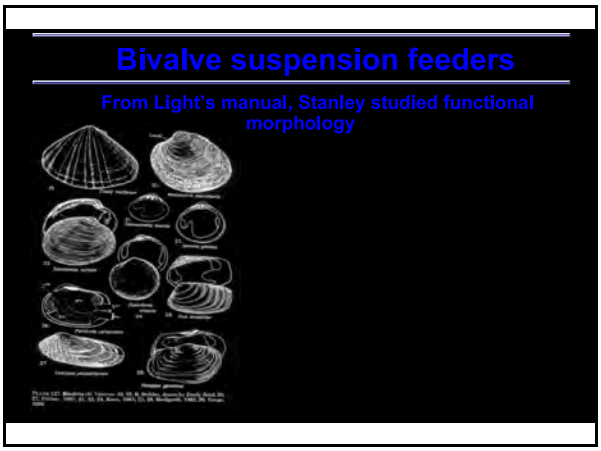


Slide 57 Suspension feeding sabellids

NOTES:

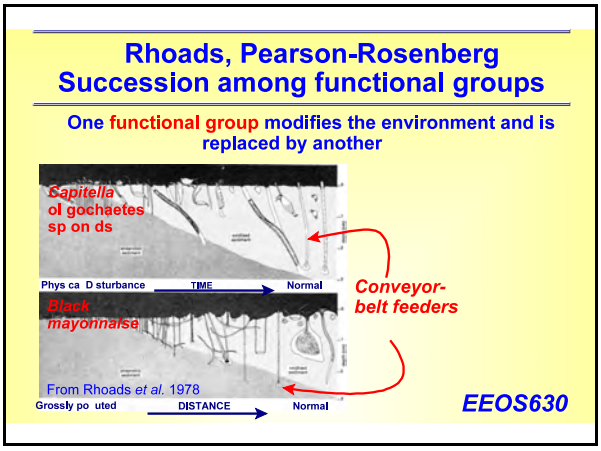
Slide 58 Sabellaria reefs

NOTES:



Slide 59 Bivalve suspension feeders

NOTES:



Slide 60 Rhoads, Pearson-Rosenberg Succession among functional groups

NOTES:

Conveyor-belt feeders

Coined by Rhoads (1974). Maldanids & *Molpadia* are the model.

Don Rhoads' (1974) descriptive phrase for a subsurface deposit feeder that feeds at depth and defecates at the sediment surface.

The less common **reverse conveyor-belt feeders** feed at the surface and defecate at depth. Both feeding modes are called non-local mixing because the movement of particles doesn't fit the commonly used diffusion analogy

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Slide 61 Conveyor-belt feeders

NOTES:

Non-local mixing

Boudreau (1986b)

*"Infaunal macroorganisms are capable of exchanging sedimentary material over distances equal to or greater than the scale over which the concentration of tracer changes substantially. This type of non-diffusive bioturbation is called **nonlocal mixing**."*

Funnel feeders

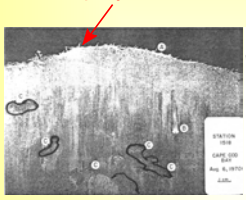
Slide 62 Non-local mixing

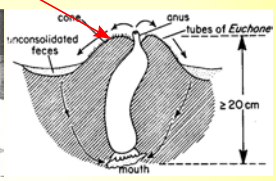
NOTES:

Conveyor-belt feeding echinoderm

***Molpadia*, sea cucumber, an echinoderm; Cape Cod Bay through the Gulf of Maine, Rhoads & Young (1971)**

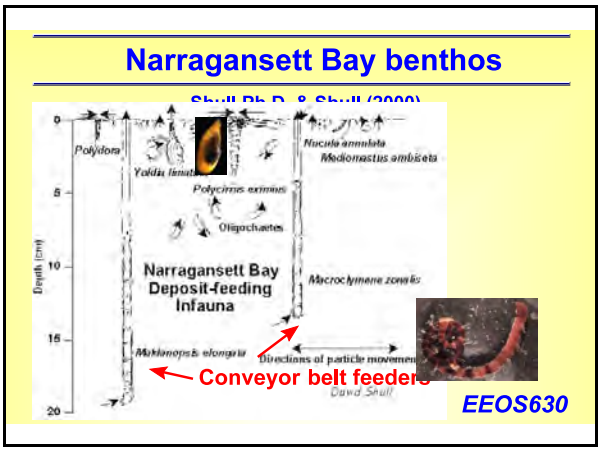
Euchone incolor, a feather-duster polychaete worm





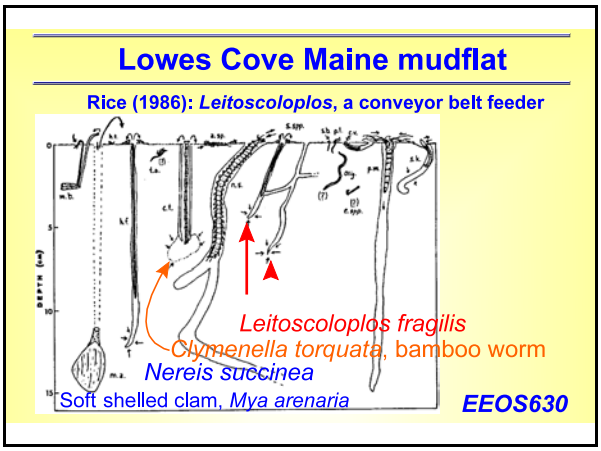
Slide 63 Conveyor-belt feeding echinoderm

NOTES:



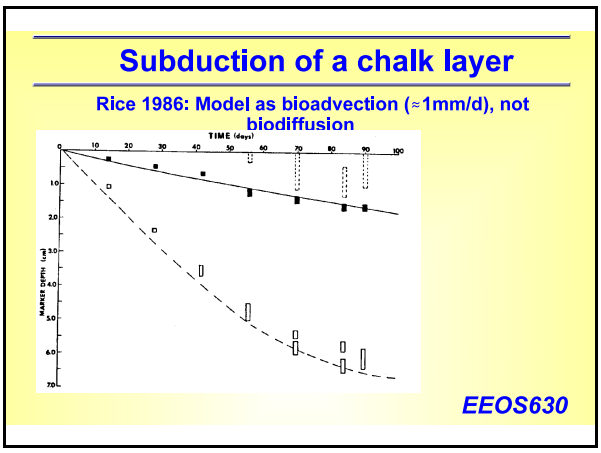
Slide 64 Narragansett Bay benthos

NOTES:



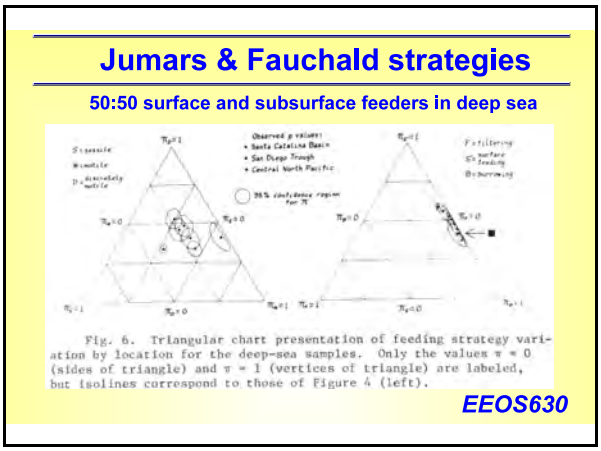
Slide 65 Lowes Cove Maine mudflat

NOTES:



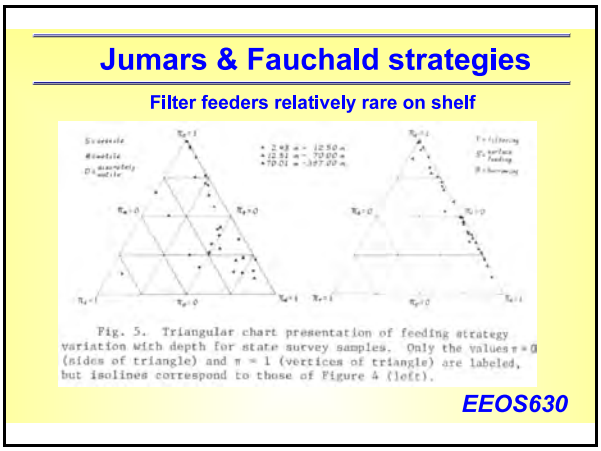
Slide 66 Subduction of a chalk layer

NOTES:



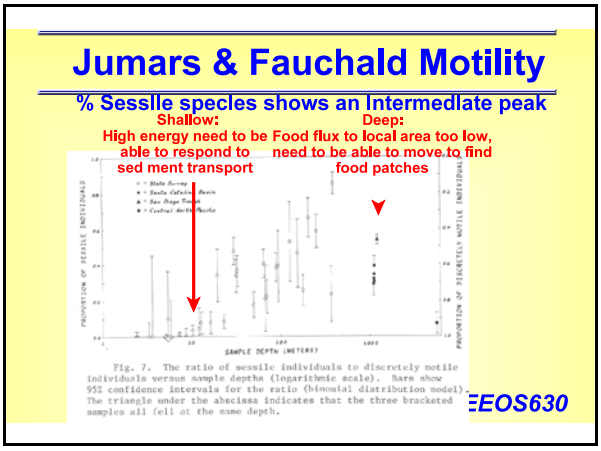
Slide 67 Jumars & Fauchald strategies

NOTES:



Slide 68 Jumars & Fauchald strategies

NOTES:



Slide 69 Jumars & Fauchald Motility

NOTES: