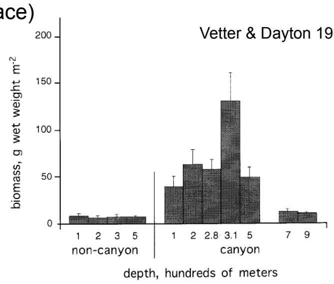
Patterns in Space and Body Size

Patterns in Space

Patterns in Space

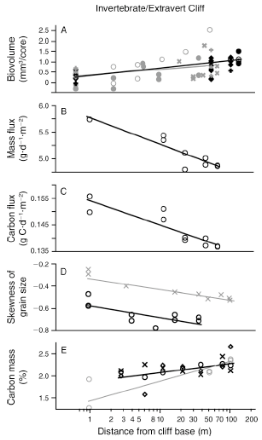
- What leads to spatial variation in biomass?
  - Primary production at the surface
  - Depth & distance from land (correlated to primary production at the surface)
  - Slope upwelling
  - Submarine canyons & trenches



Vetter & Dayton 1998

Fig. 4. Mean macrofaunal biomass (wet, ethanol preserved) in Scripps Canyon from 100 to 280 m, La Jolla Canyon from 300 to 900 m, and outside of the canyons from 100 to 500 m. Bars = 1 standard error.

Patterns in Space



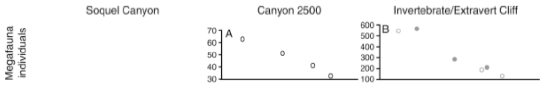
Though more productive near canyon walls, fewer animals in sediment cores, correlated to more megafauna nearer the walls in photo transects = predators attenuated funneling effect of canyon in primary production!

FIG. 5. Biological and environmental attributes at Invertebrate/Extravert Cliff in relation to distance from the cliff base, plotted on a log scale. Invertebrate Cliff is denoted by gray symbols, and Extravert Cliff by black with varying symbol type denoting different seasons and ROV dives. Regression statistics are given in Table 2. (A) Average biovolume across all species per core, (B) mass flux in sediment traps deployed 15 m off the bottom, (C) carbon flux in sediment traps deployed 15 m off the bottom, (D) skewness of sediment grain size distribution from cores, and (E) percentage of the total mass of carbon in the sediment from cores.

McClain & Barry 2010

Patterns in Space

- Submarine canyons
  - While a funnel for organic matter, also a haven for predators:
    - If organic matter is funneling from the canyon walls, then we should expect high biomass at the base of the wall and decay further away from wall
    - Predator biomass was highest near cliff walls



Distance from cliff base (1-100m)

McClain & Barry 2010

Patterns in Space

- Did they sample well?

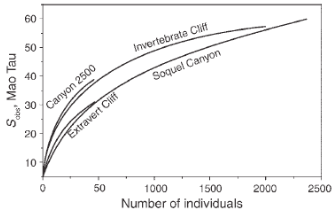
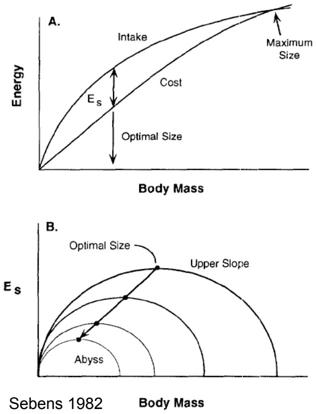


FIG. 3. Species accumulation curves (measured as Mao's Tau) for all four sampling sites.

McClain & Barry 2010

Size Structure

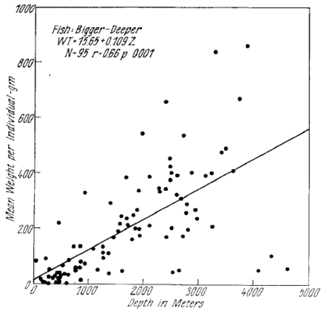


Sebens 1982

What is optimal size?

- Energy intake as function of body size
- Energy surplus (E_s) = intake – cost
- Max E_S = optimal body size → max amt energy for reproduction
- Optimal body size: intake = cost

Size Structure



Polloni et al. 1979

- Fish: mass increases with depth
- Slope decreases with depth

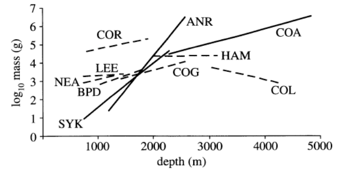
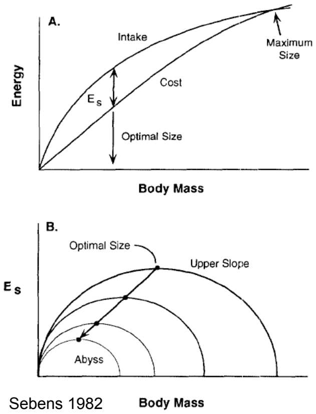


Figure 3. Body mass-depth relationships for the 10 most abundant species of demersal fish caught in the Porcupine Seabight and Abyssal Plain (heavy line = scavengers; broken line = non-scavengers); see table 1 for species codes.

Collins et al. 2005

Size Structure



Sebens 1982

- How does decreasing standing-stock in deep sea affect body size?
- How does temperature affect body size?
- What can we predict about optimal body size with depth? Small or big?

Size Structure

But...

Depends on other characteristics...

and...

Collins et al 2005

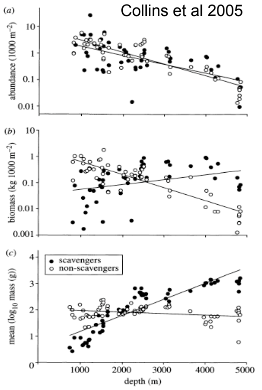


Figure 1. Relationships between (*a*) abundance, (*b*) biomass and (*c*) mean size ($\log_{10}$ body mass) and depth for scavenging and non-scavenging demersal deep-sea fish in the Porcupine Seabight and Abyssal Plain.

Size Structure

- Gastropods: Size increases with depth
- Slope decreases with depth
  - -What does this mean?

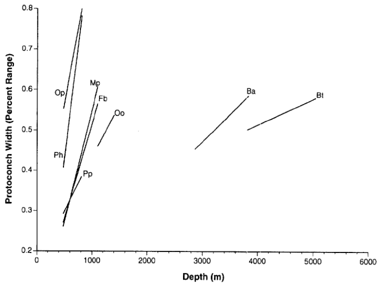
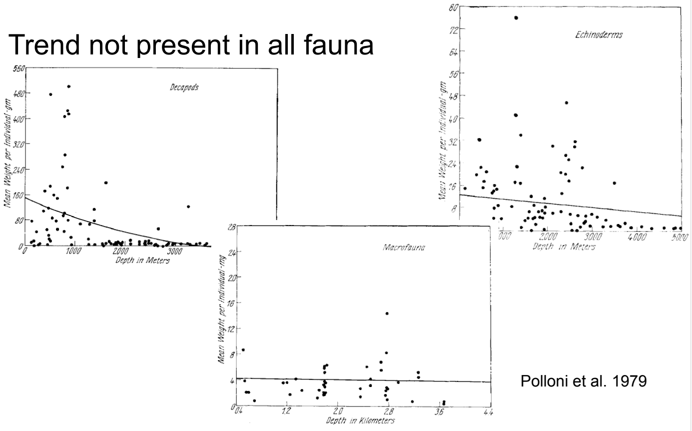


Fig. 5. Larval size (width of the larval shell), converted to percent range, plotted as regression lines against depth. Data are from Fig. 4. Regression equations and their statistics are given in Table 1. Symbols refer to species in Fig. 4.

Rex & Etter 1998

Size Structure

Trend not present in all fauna



Polloni et al. 1979

Size Structure

- So what the rules and patterns?

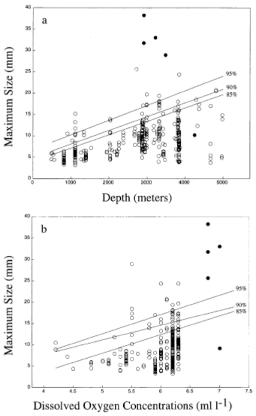
Dwarfism

&

GIGANTISM

Size Structure

- Gigantism correlates to O2 concentration (Turrid gastropods: McClain & Rex 2001)



Size Structure

- Ecological theory argues that small individuals use resources more rapidly while large individuals may monopolize resources
  - Large body size might extend foraging ranges or provide a refuge from predation
  - Small body size ensures more individuals in populations for intraspecific encounters for sexual reproduction
  - Lipps & Hickman 1982: 'caloric dwarfs' large skeletal structure-building organisms have little tissue, low growth and metabolic rates

Size Structure

- McClain et al. 2006: The Island Rule

  “Island environments produce distinctive selection pressures, including reduced predation, relaxed competition and diminished food supplies that can often yield complex evolutionary trajectories in body size. Typically small-bodied vertebrates exhibit gigantism on islands, while dwarfism is common in larger-bodied species”

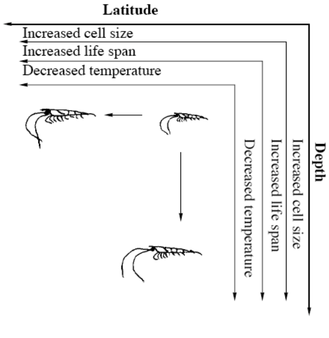
- What does this sound like??

(rhymes with Milo's magentic dawn paint)

Size Structure

- Bergman's Rule (Crustaceans: Timofeev 2001)

  At lower temperatures of development, cells get bigger



Scheme 1. Schematic representation of the unity of processes in marine crustaceans as a function of latitude and depth of inhabitation.

Size Structure

- Slope not = 0
- Small shallow snails get bigger
- Large shallow snails get smaller as predicted by The Island Rule

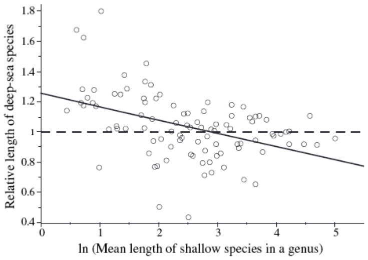


Figure 1 Relative length (S_i = mean length of deep-sea species divided by that of congeneric shallow-water species) as a function of mean length of the shallow-water species. Regression equations are given in Table 1. Results are shown for method 1, in which species were classified as deep-sea or shallow-water species based on minimum depth. The slope of the regression was significantly less than zero, therefore the pattern was consistent with the island rule, a graded trend in the deep sea from gigantism in the smaller species to dwarfism in the larger species. All units in mm.

Size Structure

- Dwarfism AND gigantism are prevalent trends with depth
- Physiology and phylogenetic constraints are proposed as mechanisms