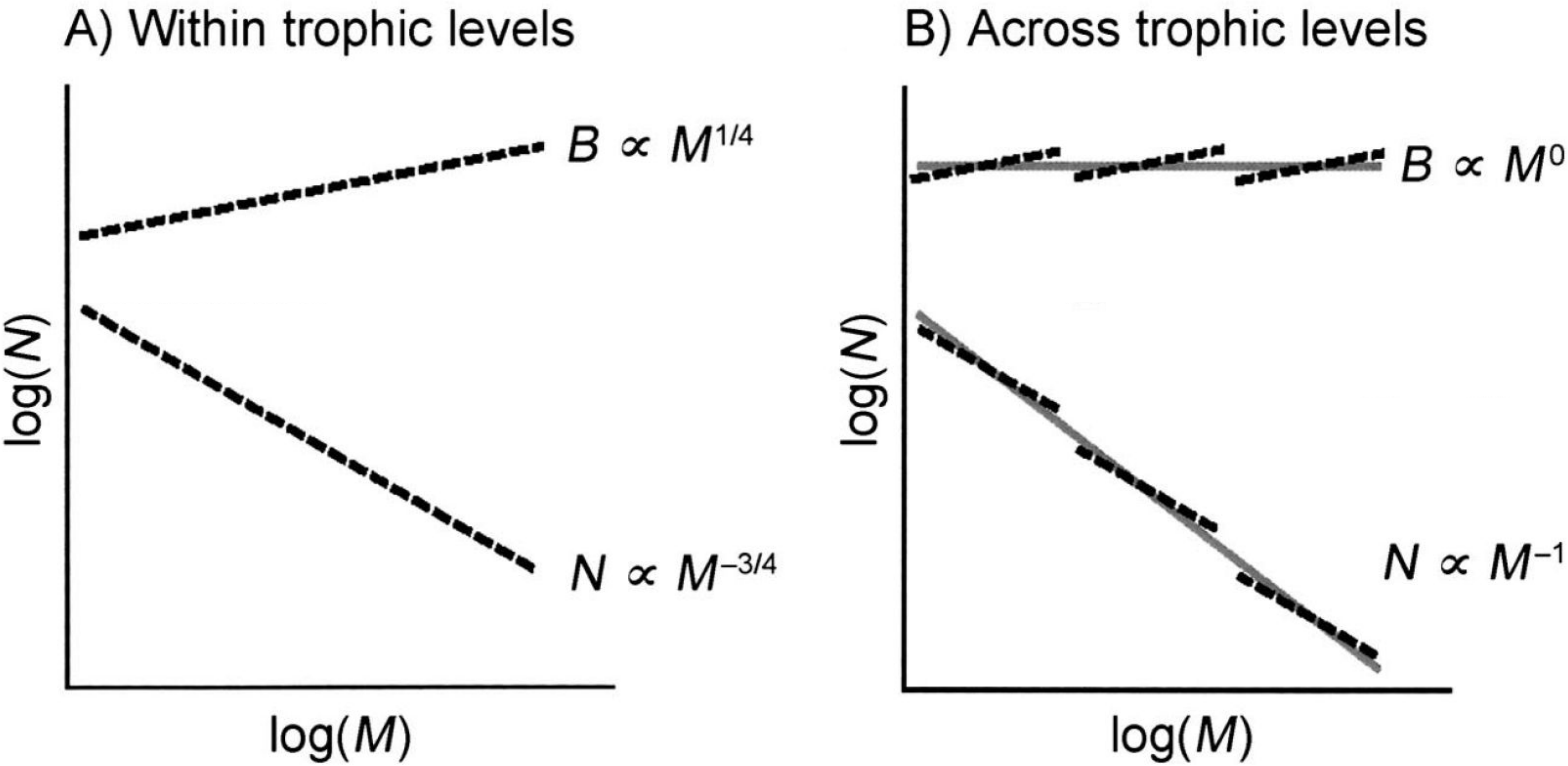
FINAL SCIENCE MEETING, 5 - 6 JUNE 2017

University of Winchester (King Alfred Campus)
Sparkford Road, SO22 4NR

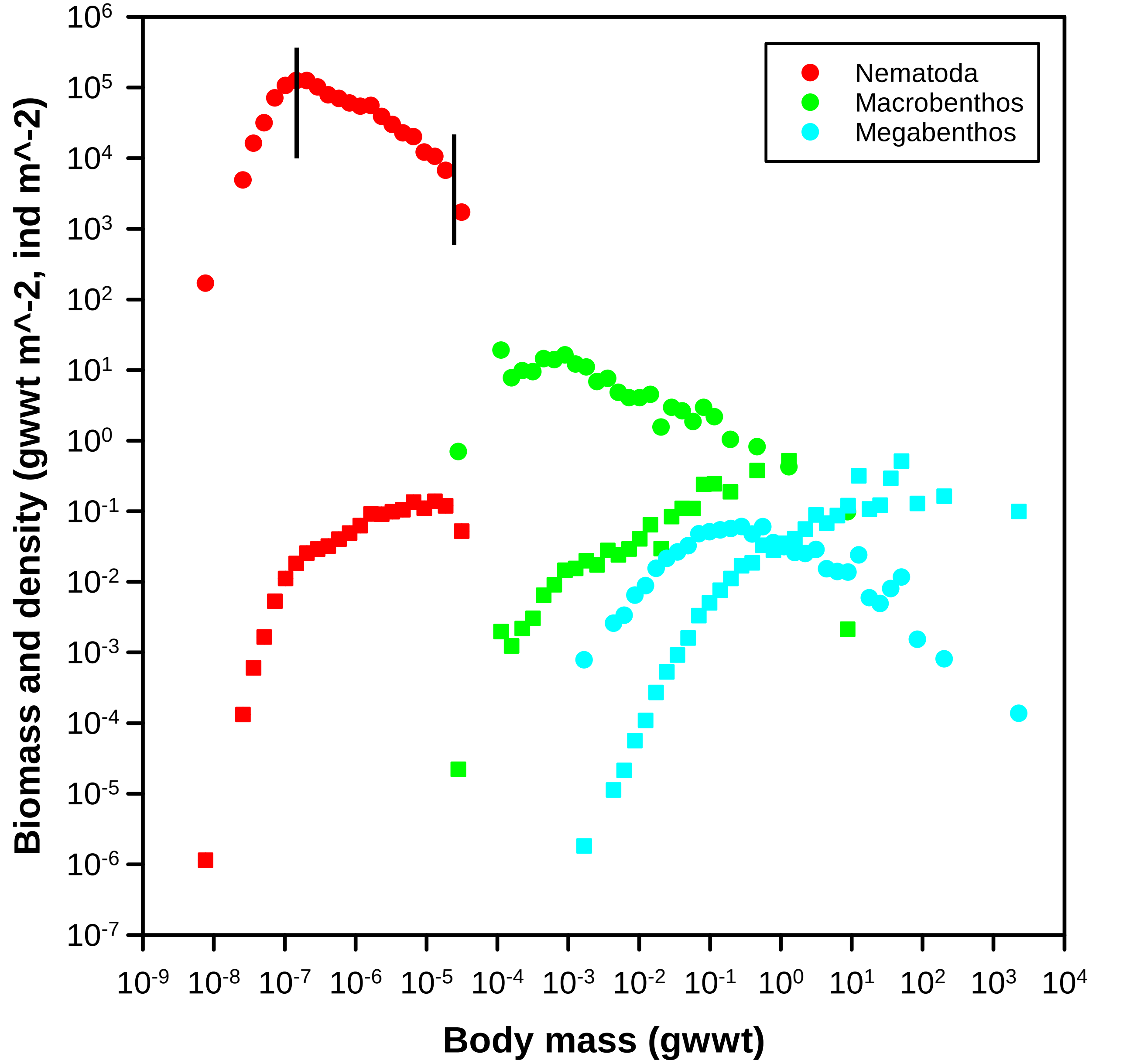
Benthic processes, fluxes and interactions

WP2 grouped presentations (Module 2):

- Megafauna and scaling-up *in situ* seafloor standing stock observations *Brian Bett et al*



METABOLIC THEORY OF ECOLOGY – Brown *et al*. (2004)



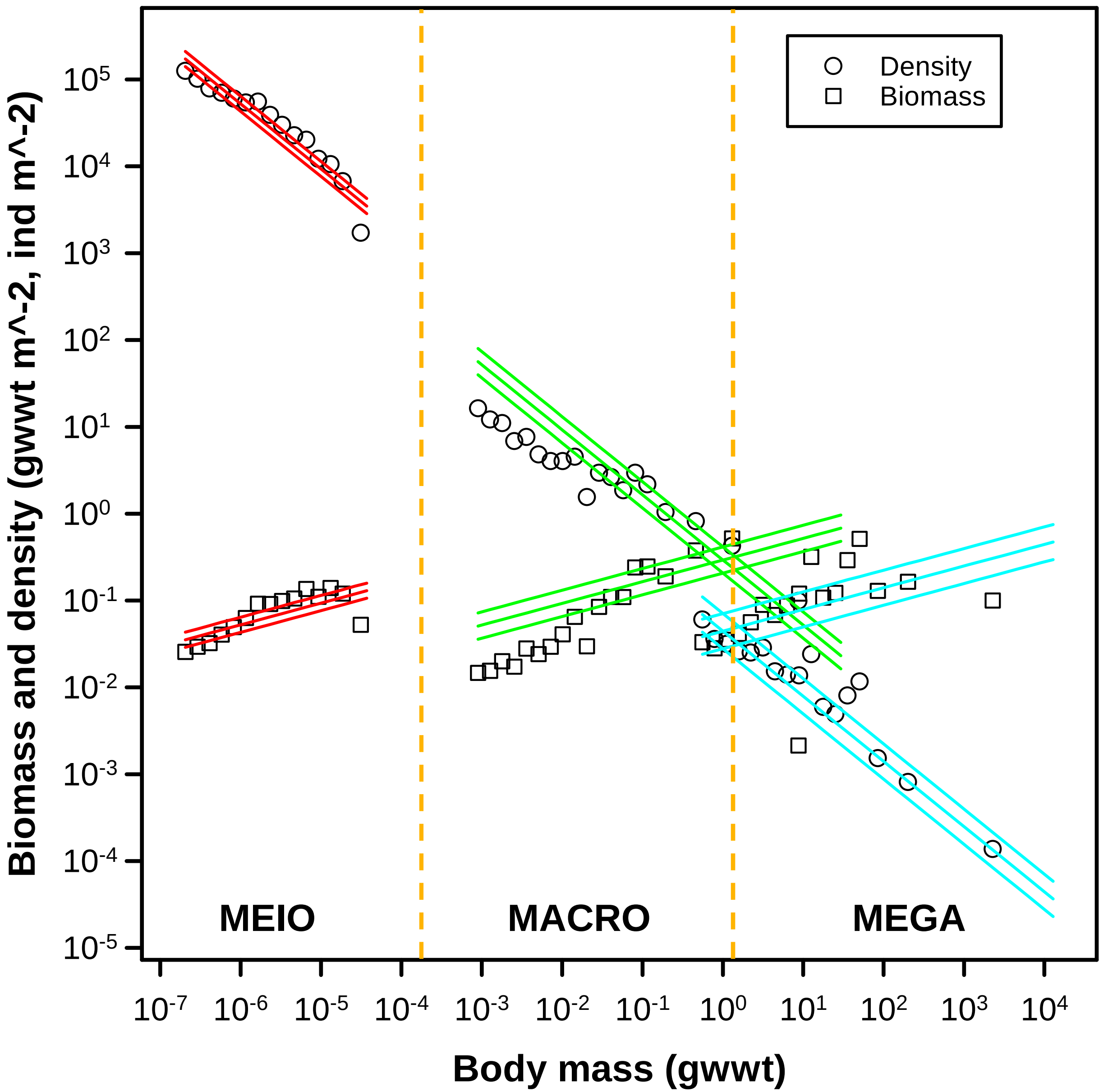
SSB Sites A+G+H+I

Nematoda
21 x 1.85 cm^2
4,069 ind.

Macrobenthos
82 x 800 cm^2
7,515 ind. (1,207 singletons)

Megabenthos
15 x 2,600,000 cm^2
2,911 ind.

- “sieve veil”
- “sample veil”



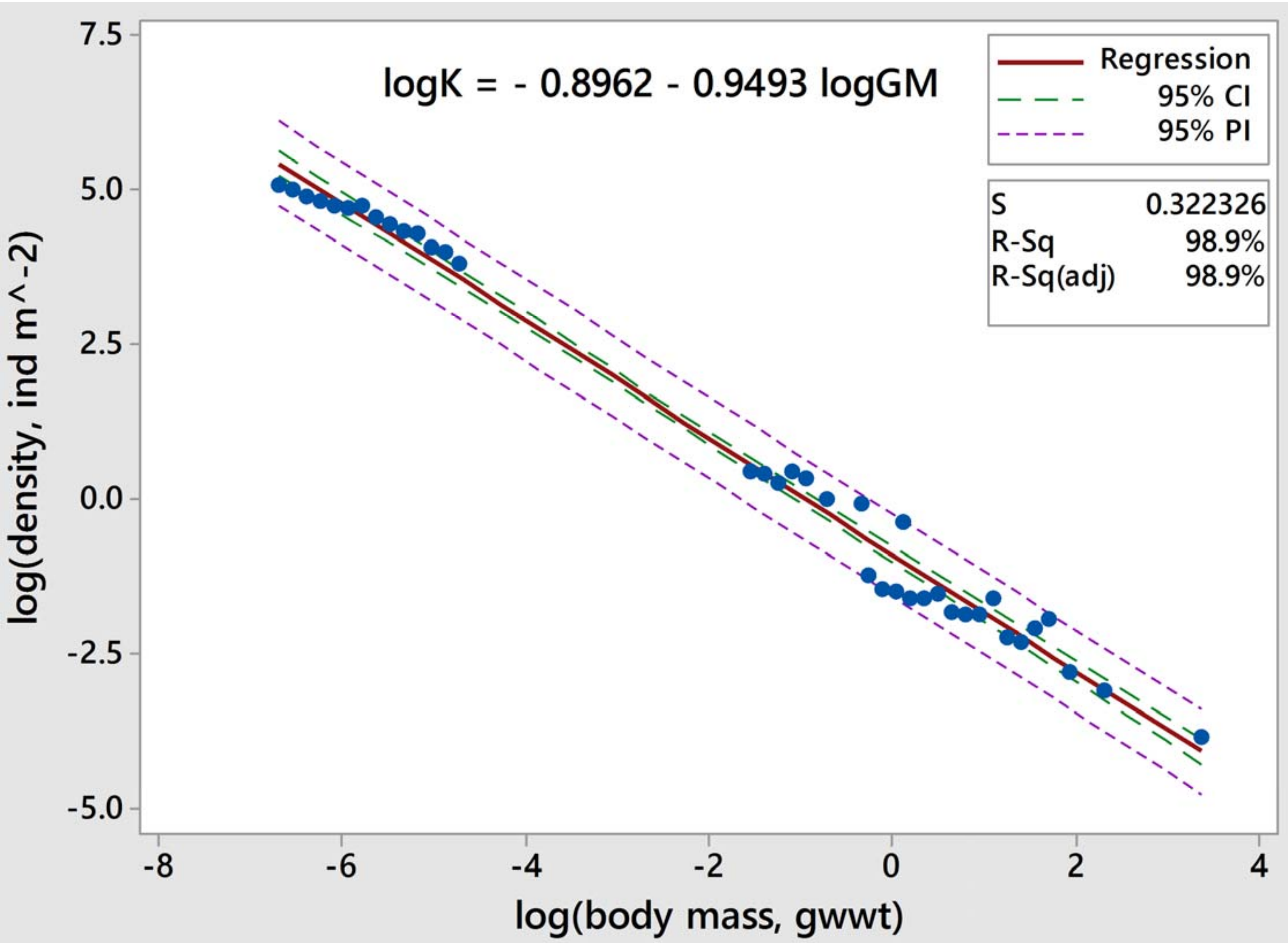
"reliable data"

- Sieve veil removed
- Macrobenthos singletons
- N.B. missing:
  large meiobenthos
  small macrobenthos
- N.B. overlapping macro- and megabenthos

Group	Mean (95% CI)
Nematoda	1.2 (1.0, 1.4) gwwt m^{-2}
Macrobenthos	7.7 (5.4, 10.9) gwwt m^{-2}
Megabenthos	5.3 (3.3, 8.4) gwwt m^{-2}

$$W_i \propto M_i^{+0.25}$$

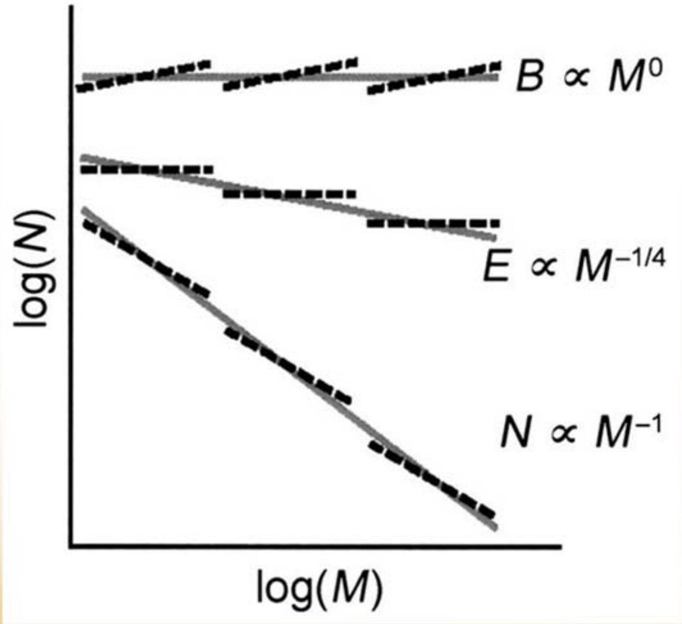
$$K_i \propto M_i^{-0.75}$$



$$K_i = 0.127 M_i^{-0.95}$$

$$W_i = 0.127 M_i^{+0.05}$$

$$B_i = 0.127 M_i^{-0.20}$$



General MTE model for SSB sites A+G+H+I

	Mass range	Standing stock		Metabolic flux		
Component	wwt	gwwt m^{-2}	mgC m^{-2}	mW m^{-2}	mgO_2 d^{-1} m^{-2}	mgC d^{-1} m^{-2}
Microbes and nanobenthos	9.4fg - 1.2ng	1.15	89	43.5	269	101
Protozoan and metazoan meiobenthos	1.2ng - 0.2mg	2.02	156	30.2	186	70
Macrobenthos	0.2mg - 1.3g	2.54	196	2.6	16	6
Megabenthos and demersal fish	1.3g - 15kg	4.10	316	0.4	3	1
Shelf sea benthic ecosystem	9.4fg - 15kg	9.80	757	76.7	474	178

FIELD DATA

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ERSEM DATA

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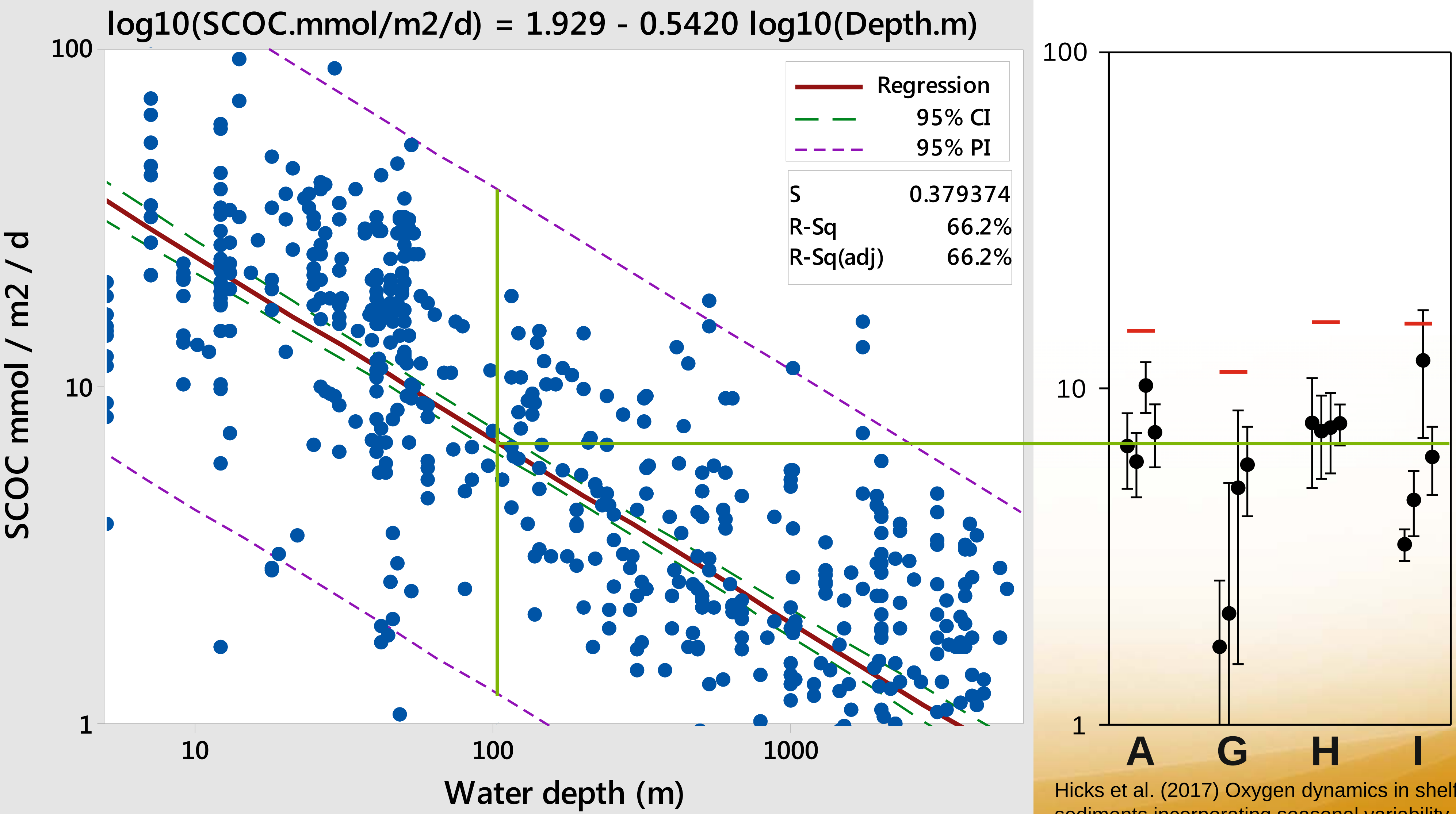
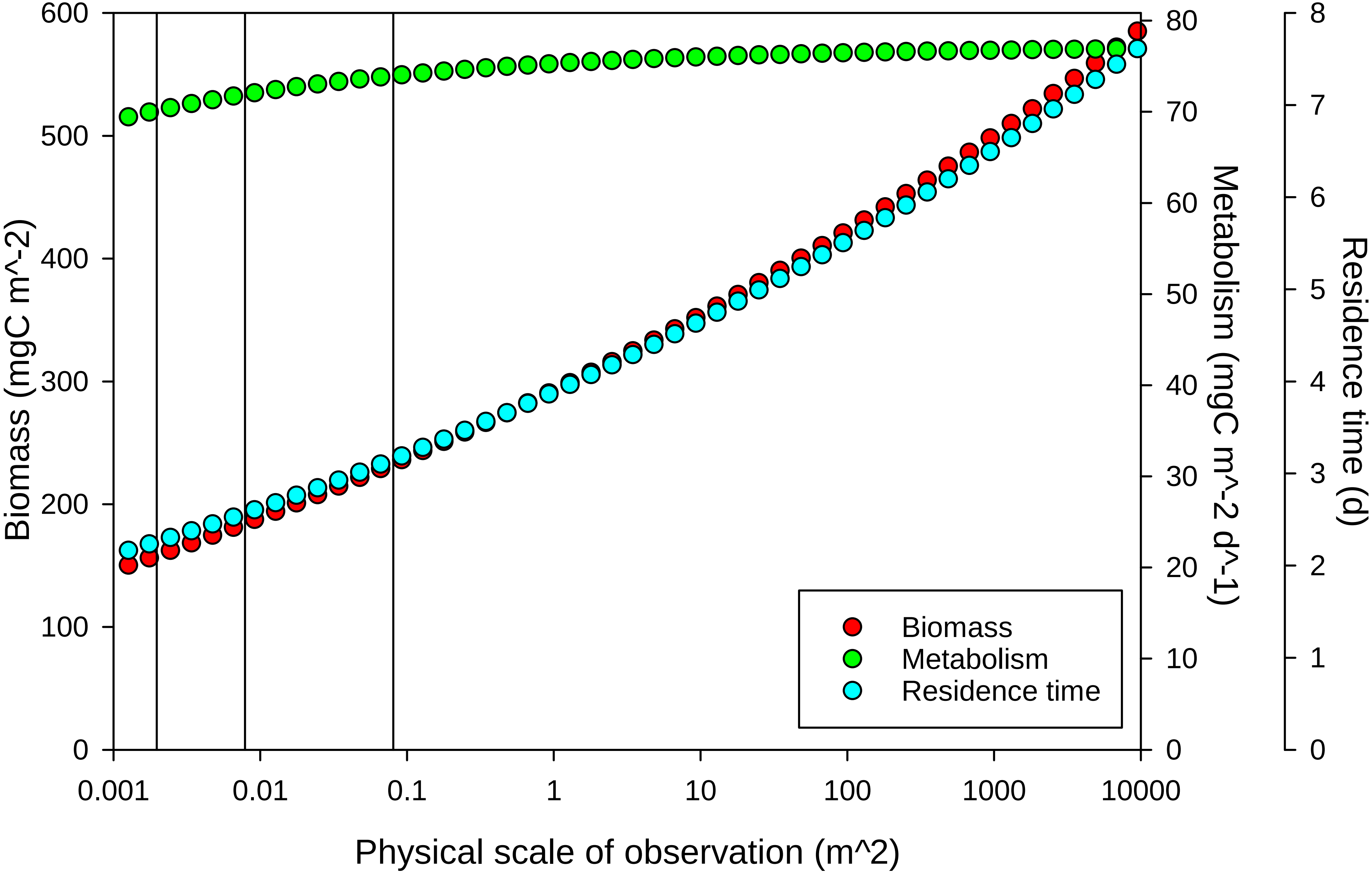
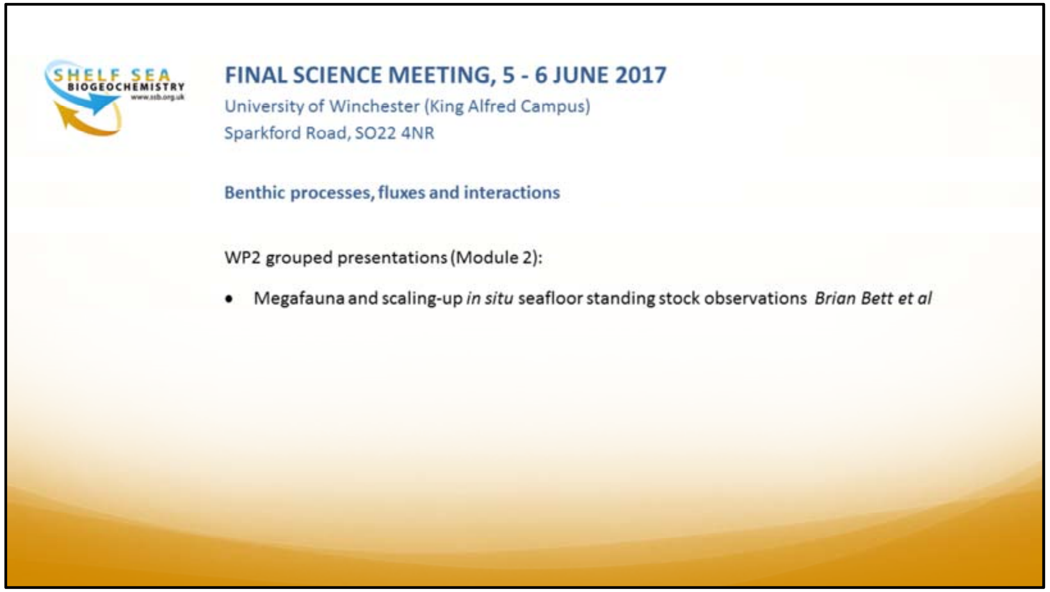
Aerobic bacteria	120
Meiofauna	140
Suspension feeder	1800
Deposit feeder	3900



Hicks et al. (2017) Oxygen dynamics in shelf seas sediments incorporating seasonal variability. Biogeochemistry DOI 10.1007/s10533-017-0326-9



Biomass (mgC m^-2)
Metabolism (mgC m^-2 d^-1)
Residence time (d)
Physical scale of observation (m^2)
Biomass
Metabolism
Residence time
0.001
0.01
0.1
1
10
100
1000
10000

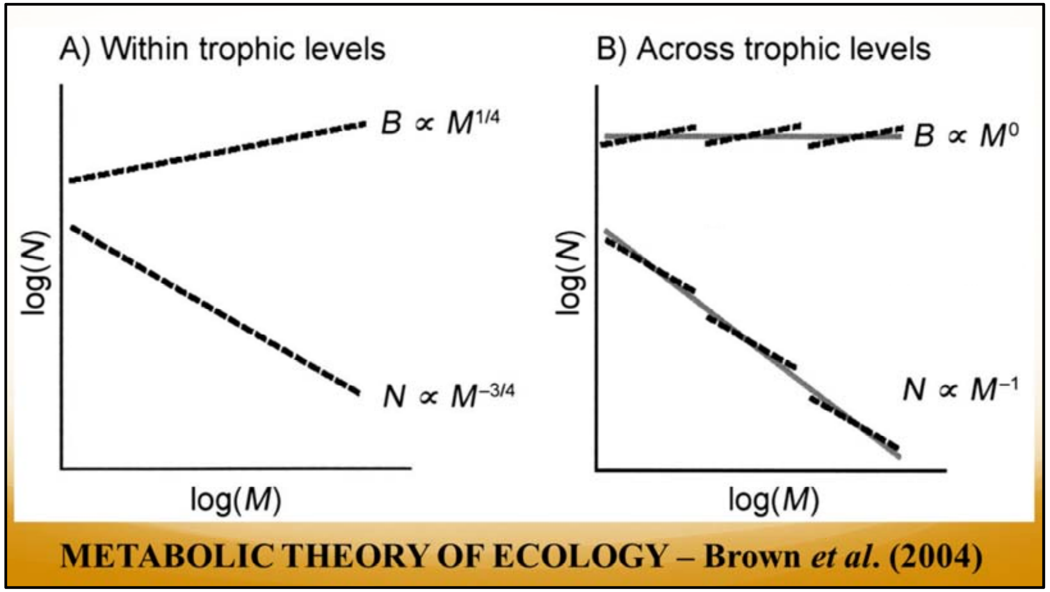


This presentation concerns work in progress drawing data from multiple sources within the SSB benthic community.

Please do not cite this work, or use any of the data values provided without consulting:

Dr Brian J Bett
Ocean Biogeochemistry & Ecosystems
National Oceanography Centre
Southampton SO14 3ZH, UK.

Tel. +44 (0)23 80596355
Email: bjb@noc.ac.uk
https://www.researchgate.net/profile/B_Bett



The Metabolic Theory of Ecology provides one means to simply summarise / model the structure and function of ecosystems and their components.

At a basic level it predicts that within trophic levels:

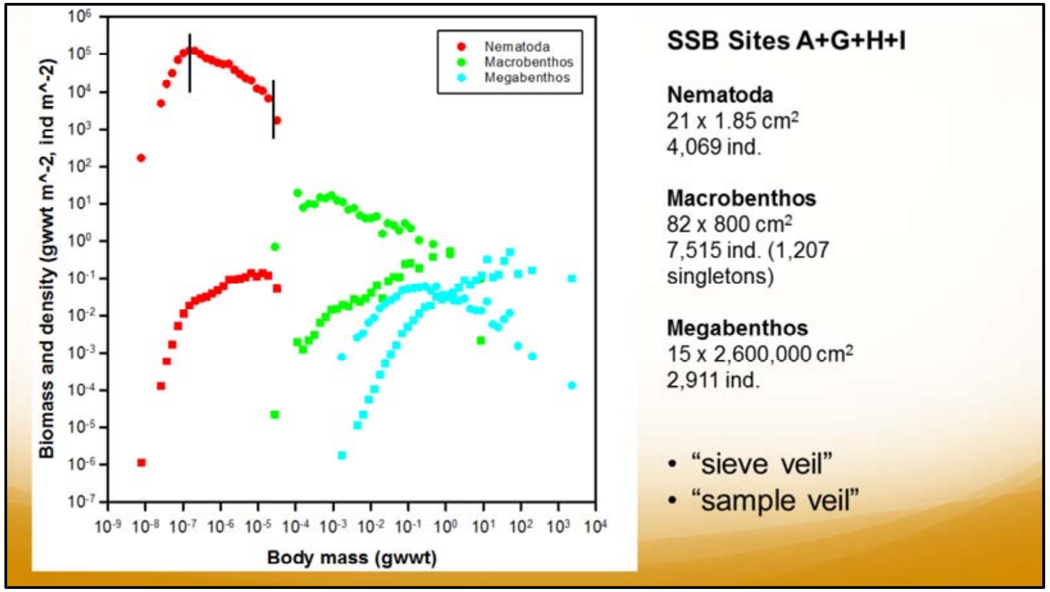
Biomass increases with 1/4-power scaling across geometric body mass classes,

Density decreases with -3/4-power scale

Across multiple trophic levels, as a result of trophic inefficiency:

Biomass approximates a constant

Density approximates -1-power scaling



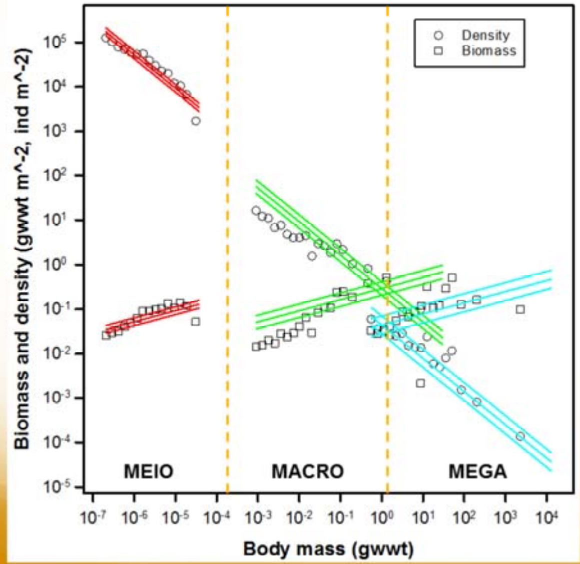
Composite body mass spectra for SSB sites A,G,H and I

The strategic programme enabled an intensive sampling effort and body mass assessment for a large number of individuals.

Note that macrobenthos were not assessed by individual, but an approximation of the body mass spectra is possible by reference to singletons (single specimens of a particular species encountered in a single sample).

Taking the nematodes density spectrum as an example – note two key points:

1. The "sieve veil" body mass below which specimens are inefficiently captured (i.e. sampling artefact not reality)
2. The "sample veil", largest body mass classes is under-represented (typically) as a result of incomplete census



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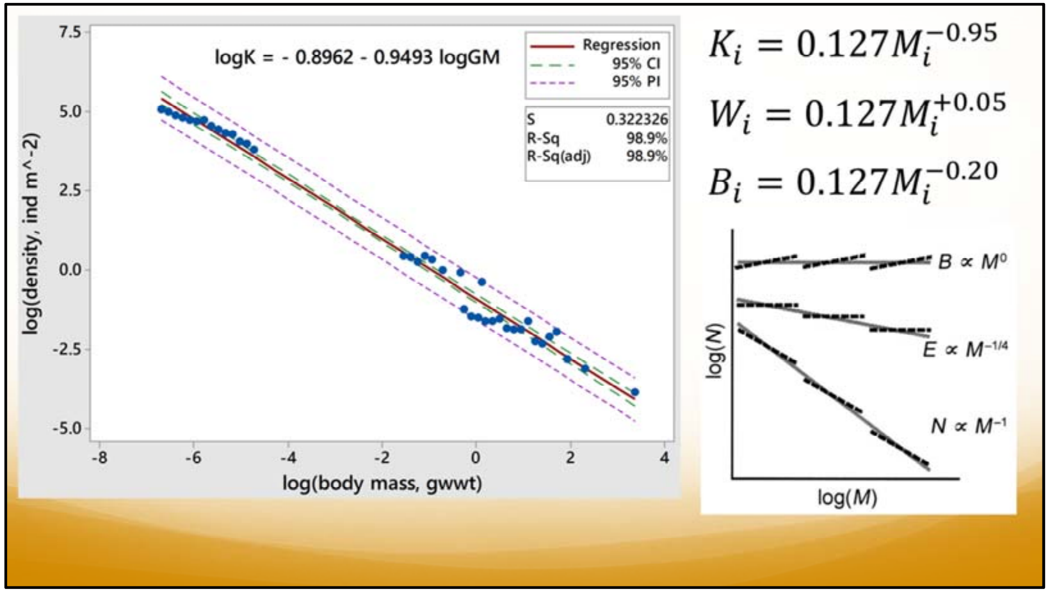
The same with below "sieve veil" data removed, note:

1. Left side of macrobenthos spectra are under-estimated by the absence of common taxa from the singleton spectra
2. Missing section, corresponding to large meiobenthos / small macrobenthos
3. Extensive overlap between macrobenthos and megabenthos
4. Overall, a good match to generality of MTE

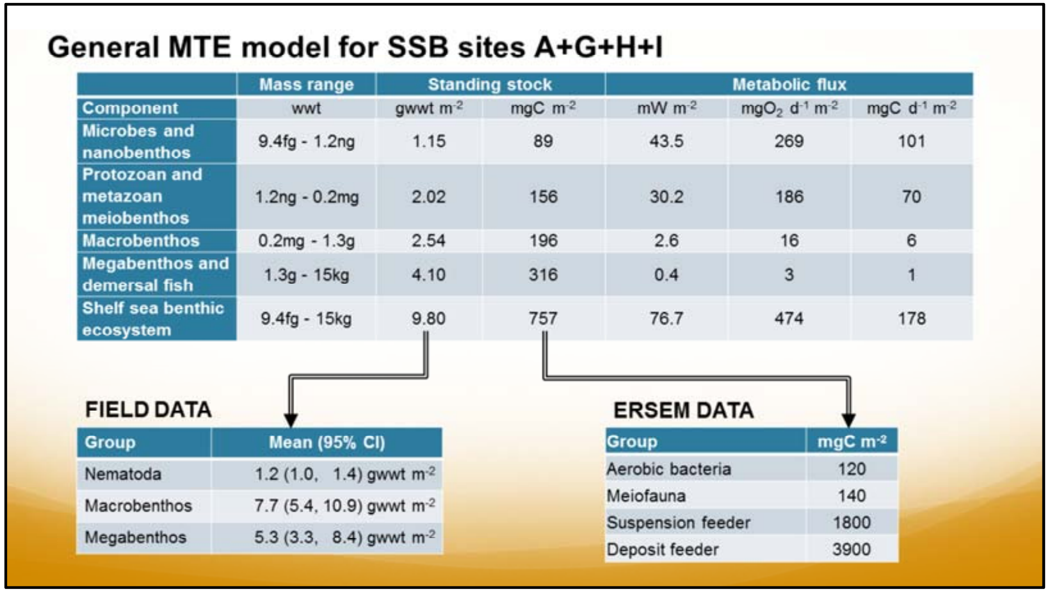
The lines fitted represent simple (single trophic level) MTE based on geometric mean (and 95% confidence interval) of the field measured biomass



Focussing on the most reliable data:

- Removing below “sieve veil”
- Removing above “sample veil”
- Removing left-side singleton macrobenthos
- Considering density only, as it much less ‘noisy’ than biomass

A close match to MTE prediction of -1-power scaling (and by inference, constant biomass, and -1/4-power population metabolism



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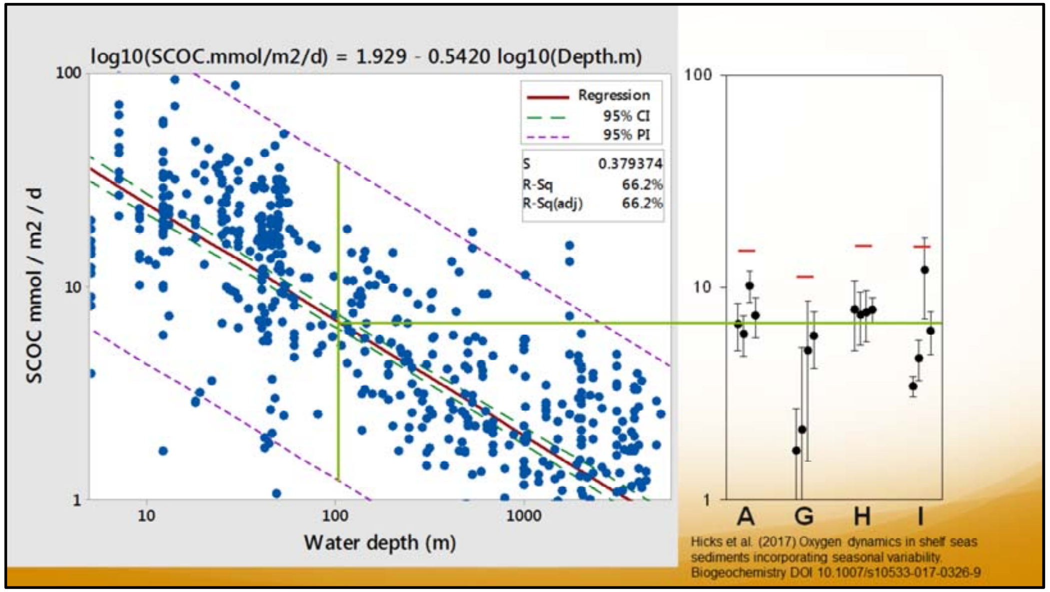
What can be done with this (these) equation(s):

Biomass estimation that avoids gaps and overlaps (as are evident in the field dataset)

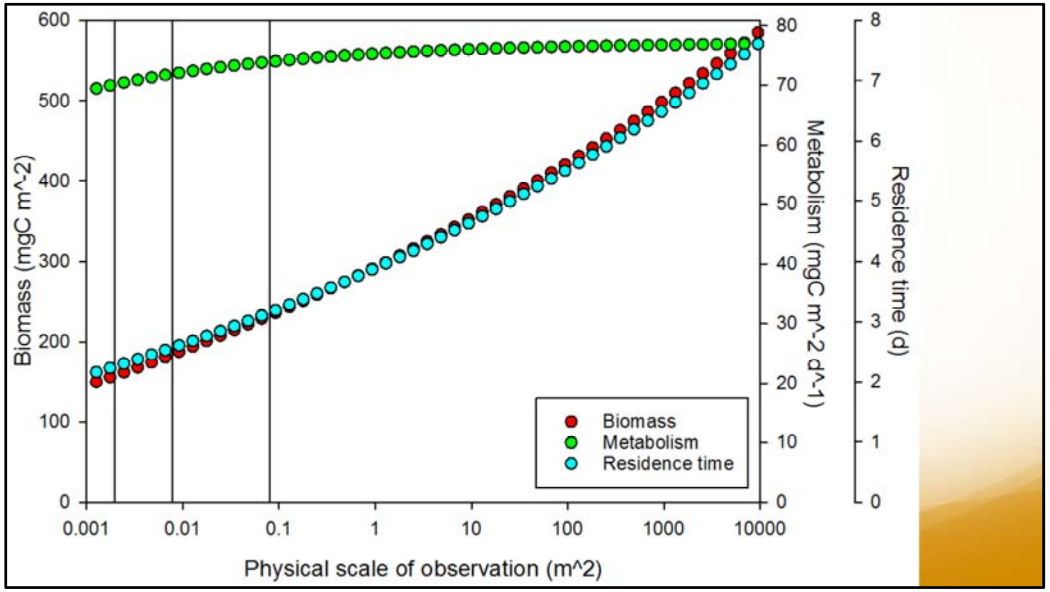
Estimation of ecosystem resource use



Validating the predicted metabolic demand.

Scatter plot of sediment community oxygen consumption data (Andersson et al., 2004) by water depth predicts typical SSB SCOC of 7 mmol m^-2 d^-1, consistent with the fieild data published by Hicks et al. (2017). The 'red bars' indicate value estimated with the MTE model (i.e. based on size spectra only).

Andersson et al. (2004) Respiration patterns in the deep ocean. GEOPHYSICAL RESEARCH LETTERS, VOL. 31, L03304, doi:10.1029/2003GL018756



Potential application of MTE approach in ‘scaling-up’ field observations.

Sediment community oxygen consumption is quite accurately in relatively small physical samples [vertical black lines represent sampled are in 5 cm, 10 cm, and 32 cm ID cores], though is systematically a little lower than total system metabolism as a result of the absence of larger organisms at these small physical scales.

However, total benthic system biomass IS NOT ACCURATELY MEASURED at small physical scales, and may require hectare scale assessment (as was provided by Autosub surveys during SSB).

Failure to fully assess benthic standing stock biomass (to c. hectare scale) may introduce significant error to estimates of carbon residence time in the benthic system.