Size spectra of the plankton community- Lake Constance data documentation

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Lake name: Lake Constance

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Sampling site

Lake Constance (LC) is a temperate, large (476 km^2), deep (mean depth = 101 m, max. depth 252 m), and warm-monomictic lake north of the European Alps of glacial origin. It has weak pelagic-benthic coupling, and little allochthonous input into the pelagic zone (Bäuerle and Gaedke 1998). The focal measuring site is in the north-western fjord-like arm of the lake (mean depth ca. 100 m, max. depth 146 m).

Organisms

We provide the size spectrum in units of carbon or phosphorus distributed across 33 size classes comprising organisms from bacteria to zooplankton. In both datasets, the organismic groups are labelled from 0-9:

0 = all functional groups (1-8) together, i.e. the total plankton biomass
1 = Bacteria
2 = Autotrophic picoplankton (APP)
3 = eukaryotic phytoplankton
4 = Heterotrophic nanoflagellates (HNF)
5 = Rotifers
6 = Ciliates
7 = Herbivorous crustaceans
8 = Carnivorous crustaceans
9 = all autotrophs together (groups 2+3)

Datasets overview

Biomass size spectra (i.e. frequency distributions of biomass arrayed by individual weights) provide an important contribution to the search for generalization in pelagic ecosystems. Biomass size spectra were constructed by allocating all organisms into size classes according to their individual body mass (size) and computing the total biomass per size class (Gaedke 1992a, Gaedke 1992b, Gaedke 1993).

We provide two datasets which comprise the weekly (growing season Apr-Nov) to approximately bi-weekly (winter months) measurements of biomass in units of carbon (dataset 1) and phosphorus (dataset 2) distributed across 33 size classes for the years 1987-1996. Size classes are the log2 of the body mass in units of carbon or phosphorus, e.g., size class -8 for carbon means that the body mass of the organisms falling into this size class ranges between $2^{-8.5}$ and $2^{-7.5}$ pg C / individual. This organism would be a bacterial cell. The corresponding size class in phosphorus is smaller, e.g. the size class corresponding to -8 in units of carbon is -13 for phosphorus, because there is less phosphorus than carbon in the cell (in this example, 2^{-13} pg P/ind.). The difference of 2^5 reflects the stoichiometric C:P ratio in the organism which is about 32:1 (weight : weight) for bacteria in LC (cf. Hartwich (2012) and Hochstädter (2000) for more information on C:P ratios in LC).

The data shows an approximately even size distribution of biomass in units of carbon from bacteria (2^{-8} pg C / ind.) to crustaceans (2^{27} pg C/ind or ca. 10^{-4} g C / ind.), resembling distributions found in marine pelagic systems (meaning a seasonal average, see Sheldon (1972)). This implies that a certain biomass of small organisms sustains approximately the same biomass of larger ones. The fit of the normalized biomass size spectrum to a straight line with a slope of -1.0 is very close ($r^2 = 0.98$), indicating a decrease of abundance per size class *N* proportional to the increase of body mass *m* (*N* is proportional to m^{-1}). A more positive (shallower) slope > −1 implies that the biomass of larger organisms exceeds the biomass of smaller ones and vice versa. Hence, the slope informs about the efficiency of the energy transfer from small to large organisms. Slopes of normalized biomass size spectra in LC are steep in early spring (slope = - 1.16) indicating a dominance of small organisms and a low transfer efficiency to larger organisms. From spring to early summer, the size distribution of organisms shifts toward larger organisms (slope increases up to -0.94) (Gaedke 1992 a, b, 1993). For details on cyclic seasonal patterns in plankton dynamics in LC, see Boit and Gaedke (2014).
To illustrate the datasets, we show the size spectrum in units of carbon (Fig. 1) and phosphorus (Fig. 2) for specific days during the first recorded year 1987.

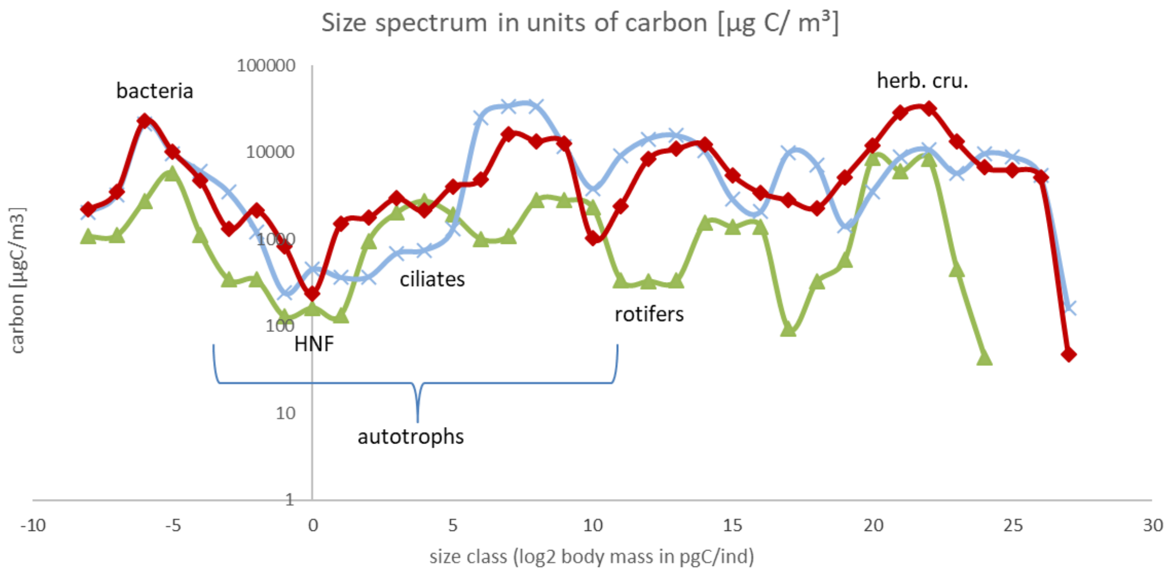

Fig. 1: Sheldon-type size spectrum in units of carbon [$\mu gC/m^3$] across 33 size classes in LC for a day in early spring (23/03/1987, green triangles), the clear water phase (15/06/1987, red squares), and the summer (11/08/1987, blue crosses) of 1987. Data points represent size classes, lines are interpolated. HNF = heterotrophic nanoflagellates; autotrophs = APP and eucaryotic phytoplankton; herb. cru. = predominantly herbivorous crustaceans; carn. cru. = carnivorous crustaceans. The approximate positions of the major functional groups in LC are indicated. Note that the size spectrum is approximately even, indicating that there is as much biomass distributed on the higher trophic levels as on the lower ones. A shift toward a dominance of larger organisms (herbivorous crustaceans such as daphnids in this case) is observed during the clear water phase.

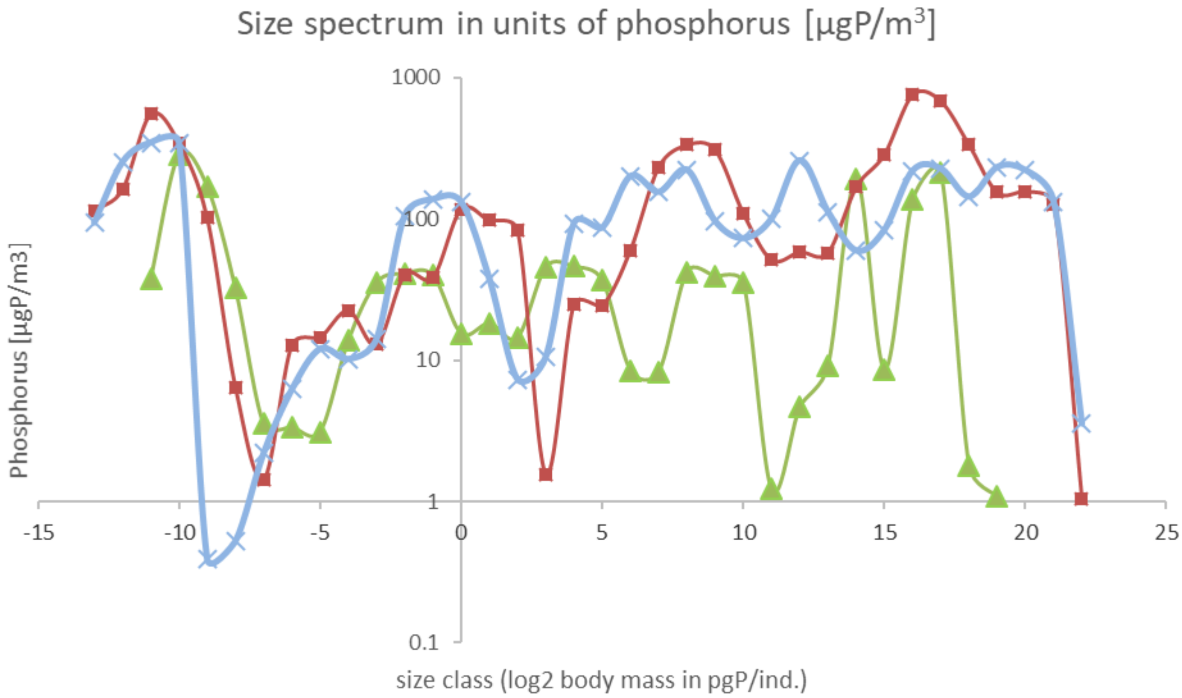

Fig. 2: The size spectrum in LC in units of phosphorus [µgP/m^3] for the same days (green = spring, red = clear water phase, blue = summer) and the same organismic groups as in Fig. 1. The size classes appear smaller than in Fig. 1 because there is less phosphorus than carbon in the organisms, depending on their group-specific C:P ratios (cf. Hartwich (2012) and Hochstädter (2000)).

Sampling methods

The basic measurements to establish the biomass size spectra are measurements of the seasonal abundance of all pelagic organisms at different water depths, measurements of individual body size of the organisms, and factors for converting original measurements of body size to units of carbon. For details, see Gaedke (1992a) and the descriptions of the data sets of individual plankton groups in LakeBase (i.e. this data repository).

Weekly measurements were carried out by a large team of scientists who paid equal attention to all major groups of organisms of the pelagic community (i.e. bacteria, autotrophic picoplankton, larger phytoplankton, heterotrophic flagellates, ciliates, rotifers, crustaceans, fish).

Depth-integration and unit conversion

Biomass in units of carbon or phosphorus is given here in [µg/m^3]. This implies the data is depth-averaged over the water column of the uppermost 0-20m (roughly the euphotic zone) and projected onto a volumetric unit of 1m^3. Other authors prefer an areal unit per square meter. The conversion factor from the areal unit µg/m^2 to µg/m^3 is 1/20 because each cubic meter within the 20m-deep water column is thought to contain 1/20 of the depth-integrated biomass per square meter.

Dataset description

Dataset 1:

Filename: "Dataset1_LakeConstance_SizeSpectrum_Carbon.xlsx"

This dataset (n = 49876) contains the approximately weekly (Apr-Nov) to bi-weekly (Dec-Mar) biomass in units of carbon [µgC/m^3] of 8 functional groups and two further aggregated groups (see the point "Organismic groups" above) from 1987-1996. Biomass per size class is averaged over 0-20m depth.

Column headers

A. Date
B. Group
C. Size class (log2 [pg C / ind])
D. Biomass [µg C/ m^3]

Dataset 2:

Filename: "Dataset2_LakeConstance_SizeSpectrum_Phosphorus.xlsx"

This dataset (n = 49998) contains the approximately weekly (Apr-Nov) to bi-weekly (Dec-Mar) phosphorus content [µgP/m^3] of 8 functional groups and two further aggregated groups (see the point "Organismic groups" above) from 1987-1996. The data are given for the same sampling dates and the slightly higher number of lines in this data set originates from an occasionally larger size range covered in units of P than C. Phosphorus per size class is averaged over 0-20m depth.

Column headers

E. Date
F. Group
G. Size class (log2 [pg P / ind])
H. Phosphorus [µg P/ m^3]

References

General references on Lake Constance

Bäuerle E, Gaedke U (1998) *Lake Constance: characterization of an ecosystem in transition*. Arch. Hydrobiol. Spec. Issues Advanc. Limnol. 53. Stuttgart, Germany: Schweizerbartsche Verlagsbuchhandlung.

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Specific references for this dataset

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