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Why bother about depth?

Relevance of metabolism below the upper mixed layer in lakes

We present results from a newly developed method (Fig. 1) to determine depth specific rates of GPP, NEP and R using frequent automated profiles of DO and temperature. Metabolic rate calculations were made for three lakes of different trophic status (Table 1) using a diel DO methodology that integrates rates across the entire depth profile and enables in situ evaluation of the photoacclimative response of the aquatic autotrophs to changes in light conditions.

We find that:

1. Seasonality in GPP, R and NEP (**Fig 3**) is driven by changes in the physical and optical structure (**Fig 2**)
2. Not taking account of vertical differences in metabolism underestimates GPP and R and lead to the erroneously conclusion of areal NEP > 0 during stratification (**Fig 4**)
3. Vertical variability in NEP is strongly related to light in epi- and metalimnion (**Fig 5**)
4. The deviation of areal metabolic estimates using the traditional single sonde approach was up to 60% for GPP and 90% for R when $Z_{eu} > Z_{mix}$ (**Fig 6**)
5. Coupling between GPP and R was highest in surface waters, but overall surprisingly low, indicating high background R in all layers (**Table 2**)
6. There is a significant photo acclimation to decreasing light conditions with depth (**Fig 7**)

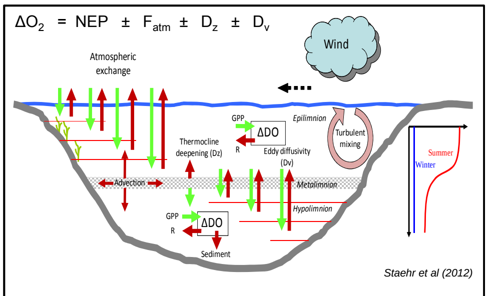

Fig 1. Metabolic method. Metabolic rate calculations were made using a method that integrates rates across the entire depth profile and includes DO exchange between depth-layers driven by mixed layer deepening and eddy diffusivity

Studied lakes

	Hampen	Vedsted	Castle
Area (Ha)	76	8	22
Max depth (m)	13	11	9
Chl a (μg L^{-1})	5.3 ± 4.3	41 ± 21	65 ± 67
K_d (m^{-1})	0.7 ± 0.1	0.8 ± 0.2	1.7 ± 0.7
TP (μg L^{-1})	22.7 ± 5.8	19.5 ± 25.6	102 ± 34
DOC (mg L^{-1})	2.97 ± 0.08	4.79 ± 0.56	3.46 ± 0.29
Z_{mix} (m)	4.7 ± 1.7	3.8 ± 0.4	5.1 ± 1.0
Z_{eu} (m)	6.25 ± 0.89	3.99 ± 0.73	2.24 ± 0.60

Table 1. Morphometrical and limnological descriptors of the 3 studied lakes (mean ± SD during the studied period).

Physical structure

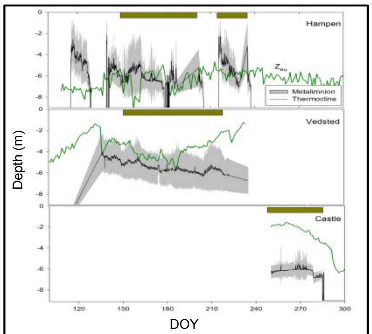

Fig 2. Seasonal variation in the physical structure of the water column and the depth of the photic zone (Zeu, 1% of surface irradiance). Horizontal bars identify the studied periods in each lake.

Metabolic rates with depth

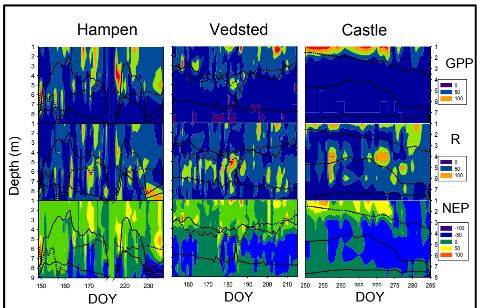

Fig 3. Depth specific daily rates (mmol O_2 m^{-3} d^{-1}) of gross primary production (GPP). respiration (R), and net ecosystem production (NEP) in Hampen, Vedsted and Castle Lake. The upper and lower limits of the metalimnetic zone are shown as solid black lines and depth of the photic zone is shown as a dotted black line. Time is shown as day of year (DOY)

Areal rates

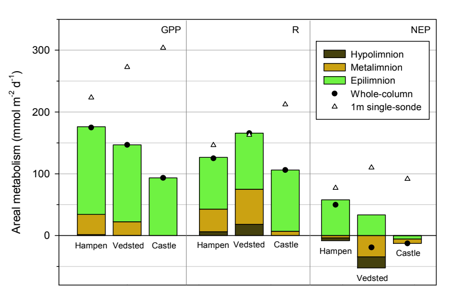

Fig 4. Mean areal rates of the depth layers (colored bars) and integrated whole-column rates (circles) for the three studied lakes. The single-sonde (1m depth) estimates are also shown (triangles).

Light dependency

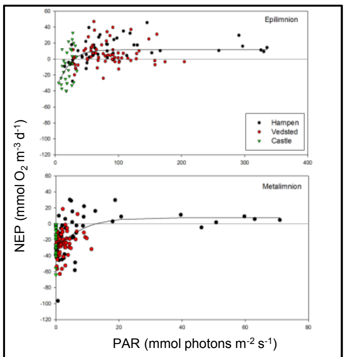

Fig 5. Relationship between daily specific NEP (mmol m^{-3} d^{-1}) and mean daily available PAR in each depth layer.

Epilimnic contribution

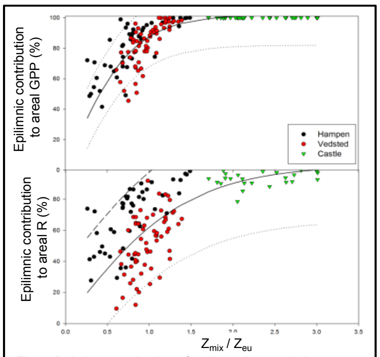

Fig 6. Relative contribution of epilimnetic metabolism to whole-column areal GPP and R. The lines correspond to a fitted hyperbolic function with 95% confidence intervals (dotted).

Lake	Depth zone	R^2	slope	β
Hampen	epi	0.42	0.58±0.10	n.s.
	meta	-	n.s.	35.8±5.62
	hypo	-	n.s.	31.5±3.34
	whole column	0.46	0.65±0.10	6.9±3.9
Vedsted	epi	0.14	0.38±0.12	15.8±4.4
	meta	0.09	0.50±0.19	30.1±2.6
	hypo	0.05	-3.49±1.6	25.9±1.6
	whole column	0.17	0.44±0.12	20.3±3.0
Castle	epi	-	n.s.	41.4±5.8
	meta	-	n.s.	26.5±3.4
	hypo	-	n.s.	7.1±2.0
	whole column	-	n.s.	25.5±3.7

Table 2. Slope, intercept and R^2 of the equation R= β + aGPP) of the GPP vs R relationships in the volumetric rates of epi-, meta- and hypolimnion. β is the background respiration, expressed in mmol m^{-3} d^{-1}.

Photo acclimation

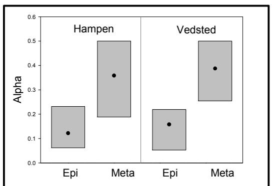

Fig 7. Light utilization efficiency (alpha, mean ± s.e.) is higher in the lower light conditions of the metalimnion.

Acknowledgements

The NETLAKE - NETworking LAKe observatories in Europe made this analysis possible. Network-level activities of NETLAKE are funded in by the European Research Council COST action ES1201. BO was supported by a grant from the Spanish Ministry of Education (JC2011-0111). Peter A. Staehr was supported by the Danish Council for Independent Research I Natural Sciences grant no 10-085238, and by the Danish Centre for Lake Restoration (CLEAR). Jesper Christensen was supported by the Danish strategic research council; Monitoring remote environments with Autonomous sensor Network-based data Acquisition" (MANA).

References

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