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Sediment records compared with 33 years of monitoring data through a eutrophication phase and subsequent recovery in Lake Mjøsa

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ABSTRACT

1. Records of algal pigments and diatoms were extracted from sediment cores taken from 236 m depth in Lake Mjøsa, a large (362 km²) and deep (mean depth 152 m) lake in eastern South Norway.
2. Radiometric dating revealed that the upper 8 cm of the core reached back to an estimated date of 1874, reflecting a very low sedimentation rate at the coring site. The longest core was 49 cm long.
3. The organic content (loss on ignition, LOI) of the sediments was low, with a pre-1850 level of about 8% of dry weight. LOI increased to around 16% between 10 and 7 sediment depth, and fluctuated around this level above 7 cm.
4. Pigment records covered the full core length of 49 cm. The chlorophyll A record indicated a slight, gradual increase in productivity that started prior to 1850, a rapid increase in 20th century until the 1970’s, and a rapid decline until about 1990, levelling off in fluctuations well above the background levels until the top of the core (2005). Among blue-green pigments, zeaxanthin occurred only in the 20th century and peaked simultaneously with chlorophyll A, while canthaxanthin was present at low levels through most of the core, peaked in the 20th century about a decade before the chlorophyll A peak, and disappeared thereafter.
5. The diatom record covered the top 10 cm of the core, reaching back to before 1850. Species composition indicated three zones: pre-1950, dominated by indicators of oligotrophy; about 1950-1980, with increased dominance by meso- and eutrophic indicator species; and post-1980 with oligotrophic taxa increasing again, although pre 1950 levels were not reached.
6. Historical data indicate that eutrophication in Lake Mjøsa accelerated markedly after about 1950, although signs (algal blooms) had been recorded earlier. Regular monitoring of lake water quality commenced from 1972. Conditions deteriorated rapidly in the early 1970’s, with a peak algal biomass in 1974. *Planktothrix* blooms prompted sewage treatment, a ban on phosphorus-containing detergents, and strict control of fertiliser application in agriculture of the region. The remedies were effective. Algal biomass declined through the 1980’s and have been low since then. Phosphorus levels have declined continuously since 1976, and the set target level of 6 µg total P·L⁻¹ has not been exceeded after 1997 (seasonal means).
7. The mean epilimnion temperature over the summer stratification period in the lake has increased by about 1.5 °C over the monitoring period. Published temperature reconstructions for this region indicate a slight temperature increase from around 1830, another slight increase around 1900, a drop around 1960, and a more rapid increase from the end of the 20th century. Possible temperature effects on algal biomass or composition could not be distinguished, probably being masked by the prominent effects of nutrient enrichments.
8. The algal indicators of the sediment record recapitulate the historically known lake development quite accurately for the 33 years covered by monitoring data. Phosphorus levels inferred from diatom species composition seem to capture the rapid eutrophication and
recovery phases well. However, the inferred phosphorus concentrations were about double the levels recorded by the monitoring program.

9. The sediment record indicates that the lake still has not recovered fully in terms of species composition and diversity of diatoms, in spite of phosphorus levels approaching assumed natural low levels. This conclusion is confirmed by monitoring data.
Figure A. Stratigraphy of organic matter (loss on ignition, LOI) and algal pigments in Core A from Lake Mjøsa. Pigments are expressed per gram organic matter. Radiometric dates are indicated on the left hand scale.
Figure B. Lake Mjøsa core A - diatom stratigraphy. The radiometric dates are shown on the left hand side and the CONISS clusters are shown on the right hand side. Only taxa occurring at > 1% are shown.