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Lakes and reservoirs
3.3. Lakes and Reservoirs

Chapter 7 in Book Chapman

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Online Module Water Quality Assessment
CONTENTS

1. General characteristics of lakes
2. Importance of lakes
3. Monitoring
Origins

- Oxbow lakes, Nicaragua
- Caldera lake, Nemrut Dag, Turkey
- Glacier lakes, Lake Michigan
Origins 2
Rift lakes, Lake Tanganyika (with wildfires May 2004)

Salt lakes, Aral Sea (May 2009)

http://earthobservatory.nasa.gov/IOTD
Importance of sunlight
Temperature profiles

**Epilimnion**

**Metalimnion/Thermocline**

**Hypolimnion**

![Temperature profiles - Martin Lake](Temp/D.O. Profiles - Martin Lake)
Thermal stratification

Dimictic lake
Stratifies/mixes twice per year
T < 4 °C (winter); > 4 °C (summer)

- changes in surface water (epilimnion) temperature throughout the year (in temperate climates)
- temperature remains about constant in profundal zone (hypolimnion)
- during spring and fall turnover, thermocline gets disrupted and temperatures of epi- and hypolimnion are =
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Represa Rincon del Bonete in the Rio Negro reservoir, Uruguay

Catchment area 40,000 km²
Total volume (80 m height) 8,800 hm³
Production 160 MW
Constructed in the years 37-48!
Renovated in the 1990s
Orchards

Michigan has over 1,100 fruit farms which grow apples and the state has about 8.5 million apple trees on approx. 20,000 hectares.

On Lake Constance, Germany, about 1,600 fruit growers cultivate about 7,400 hectares. Yearly about 220,000 tons pomaceous fruits are produced for the fruit trade.

Do you have an example from your region, where the lake effect is the cause for extensive apple (or other fruit) production?
Fishing: Blessing or (Darwin’s) Nightmare
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3. Monitoring
Guiding principle: one station per homogeneous area for well-mixed lakes: one station may be sufficient!

Generally more stations in case of:
- Large and/or irregular lakes
- Large variations in water depth and sediment composition

Also dependent on monitoring objectives, e.g.:
- Input/output budget
- (one-time) research on impacts of pollution sources

Also here preliminary surveys are very important:

**Bathymetry** (depth contours); research on (in)homogenity → number of stations. Also overall sediment mapping.
Bathymetry

surface area could “shrink” in which case the outermost contour line and each of the depth contour lines would change right along with the water levels.

A well-made bathymetric map will usually include:

A The name, county and geographic location of the waterbody;
B An outline of the lake shoreline, drawn to a known scale;
C Depth contour lines drawn at known intervals;
D Symbol indicating geographic orientation (i.e., north);
E Name of the mapmakers and date.

While the map shown here is not designed for navigation purposes, it can be used to calculate important morphometric features of a lake such as:

- surface area, maximum length, mean length, maximum width, mean width, maximum depth, mean depth, shoreline length, shoreline development, and volume.
Example:
Satellite image chlorophyll-a in "IJsselmeer" (Central Lake) in the Netherlands (red > yellow > green > blue)

High spatial variation → more locations
Algae produce $\text{O}_2$ during day; and consume at night → Dissolved oxygen (DO) often $>100\%$ during the day, and near zero at night

**ÅSo in case of eutrophication:**
- Large DO variations over day/night
- Also: high pH values (up to pH $>10$) during day-time

→ always monitor a station at about the same time of day (and, of course, note down time of sampling/field analysis !)
Thermal stratification in deep lakes in summer

**Stratification:** anaerobic conditions hypolimnion $\rightarrow$ sediment release of nutrients, *etc.* $\rightarrow$ enhanced phosphate, ammonia, $\text{H}_2\text{S}$, $\text{CO}_2$, *etc.* levels.

Monitoring: epilimnion + hypolimnion + 1 m above and/or below the thermocline.
Example: oxygen deficiency at the bottom of Lake Grevelingen, Netherlands

Stratification: oxygen deficiency not visible by standard measurement at water surface
Often multipurpose: water extraction, power generation, drinking water extraction,..

Generally more stations needed than for lakes; sampling stations in all three zones:

- Riverine zone: most polluted, high TSS
- Lacustrine (lake) zone: least polluted
- Transition zone
OPTIMIZATION OF MONITORING

DeGray lake, USA:

15 → 5 stations