

Towards a Better Environment in Lake Furesø

Lake Furesø is part of a large natural resort situated close to urban areas. All year round, the area is used for numerous recreational activities. However, the environment of the lake suffers from former times' wastewater pollution. The consequence hereof is clearly visible, when the water in the summer suddenly turns thick and green due to a strong growth of algae.

Seen from a geological point of view, Lake Furesø is part of the very extensive system of subglacial stream trenches which were formed by glacial streams when the calotte of Glacial Age melted approx. 10-12,000 years ago. The landscape left by the ice was full of large and small lakes. Lake Furesø is one of the lakes on the course of River Moelleaa from Lake Bastrup Soe to the Sound. Lake Furesø contains around 127 million m³ of water, which has a detention time in the lake of 10-15 years.

In the spring of 2003, the biggest lake restoration project ever was commenced in Denmark. The objective is to change the ecological balance so that the lake, hopefully in the course of a number of years, will become quite as clear and rich in species as it was at the beginning of the 20th century.

The restoration of Lake Furesø is financed by Frederiksborg County and the Municipality of Farum. Since Lake Furesø has been appointed a natural resort of international value, the project is supported financially by the EU's LIFE-Nature Programme.



Web site:
www. Furesoe.dk



Restoration of Lake Furesø



A Lake in the Middle of an Urban Area

At the beginning of the 20th century, Lake Furesø was located far away in the countryside. It was one of the best lakes of Northern Europe, with a rich flora and fauna. Later on, the small villages situated around the lake grew into large urban areas, from where wastewater full of for instance nutrients was led directly into the lake. We only very late realised the consequences for the environment of the lake a recurrent growth of algae, which make the water green and muddy and leaves the bottom of the lake desolate due to lack of oxygen.

Contrary to what is the case for many other Danish lakes, we quite precisely know the condition in Lake Furesø before it was polluted. Examinations from the beginning of the 20th century tell about an unusually clear lake where fish could be seen swimming in deep water, and with a cover of bottom flora till a depth of 8 m.

In order to restore good life conditions for the flora and fauna of the lake, and in order to ensure a large recreational area

for the inhabitants of Copenhagen, a large restoration project has now been commenced.

The idea of the project is to fish up a large number of the non-predatory fish of the lake, i.e. roach and bream and to pump out pure oxygen in the deepest places of the lake all over the summer.

A recurrent sight Lake Furesø with green and thick water after a warm summer with little wind, which provides good growth conditions for the algae of the lake.



Foto: Peter B. Jørgensen

Life in Lake Furesø

With a depth of 38 m, Lake Furesø is Denmark's deepest lake. The steep slopes and the undulating bottom of the main basin and the low watered areas in Store Kalv help create a variation, which offers the opportunity of rich flora and fauna.

! Once summer arrives with its light and warm weather, the growth season begins for the floating algae of the lake. If they have really good conditions, they are capable of shading the bottom vegetation to such an extent that it disappears. Algae use nutrients such as nitrogen and phosphorus for their growth. In Lake Furesø, it is the quantity of phosphorus that determines the growth of algae.

! An oxygen tank has been placed on land, from where oxygen is led to the bottom of the lake through tubes.

! There are some relics of the past in the lake, i.e. some small species of crustaceans, which have survived in the cold and deep water of the lake even since Glacial Time.

! Roaches are non-predatory fish. In muddy lakes, they may be present in very large numbers. As long as they are young, they live from zooplankton, whereas they eat anything once they are adult.

! On the bottom of Lake Furesø, many tonnes of phosphorous from discharge of waste-water in former times are found. Phosphorous is chemically bound to iron compounds but only as long as oxygen is present in the water!

! Long periods of oxygen depletion mean the death of mussels, mosquito larvae, and other animals which can not escape.

! Lake Furesø is an important recreational place for inhabitants and tourists in the entire Copenhagen area. You can go for a swim, you can fish, and you can sail.

! Zooplankton such as daphniae, cyclops, and rotifer help keeping the volume of algae low. However, some species of blue-green algae may be too much to cope with.

! The fishing in Lake Furesø takes place by means of pound net and seine. When the fishing by means of pound net is at its highest level, up to 36 nets can be seen along the shores.

! When adult, the bream is part of the explanation why the water is muddy, because it roots in the lake bottom for food. The spawn takes a good part of the quantity of zooplankton.

! A sound lake has a large population of perch and pike. They are both predatory and hunt by means of their eyes – therefore they feel best in lakes with clear water.

! Bottom flora is of great importance to the ecology of the lake. It helps keeping the lake bottom stable, and it is a hiding place for many of the animals of the lake.

! In connection with the oxygen depletion during summer, phosphorous is released into the bottom water. During winter, a mixing of the waters of the lake takes place, which makes phosphorous accessible for the algae during the year to come.

! When bacteria at the bottom of the lake decompose dead fish and algae, they use oxygen. A large algae production may therefore entail oxygen depletion in the bottom water.



! In the summer, a metalimnion is created at a depth of 12-15 m in Lake Furesø. This is a separation between warm surface water, which is rich in oxygen, and cold bottom water, which does not contain much oxygen.

Drawing: Carsten Groth-Pedersen

! In order to avoid oxygen depletion during summer, part of the restoration project is an annual outlet of 400-600 tonnes of pure oxygen at the three deepest places of the lake.

Focus on Lake Furesø for a Hundred Years

The Cradle of Freshwater Ecology
 At the beginning of the 20th century, Lake Furesø was one of the cleanest lakes in Northern Europe, and one of the richest in species. On the shore, at Frederiksdal, the zoologist Carl Wesenberg-Lund has set up a little field station. His work in Lake Furesø becomes the start of freshwater ecological research in Denmark, and thanks to his thorough examinations of biology and chemistry in Lake Furesø, we now – 100 years later – have a very clear picture of the environment in the lake, before pollution really set in.

At the beginning of the 20th century, bottom flora (light grey) covers the whole of Store Kalv and the shores of Lake Furesø until a depth of 8 m. The field station was a rebuilt deck house from a schooner.



Foto og tegning: Wesenberg-Lund, Ferskvandsbiologisk Laboratorium



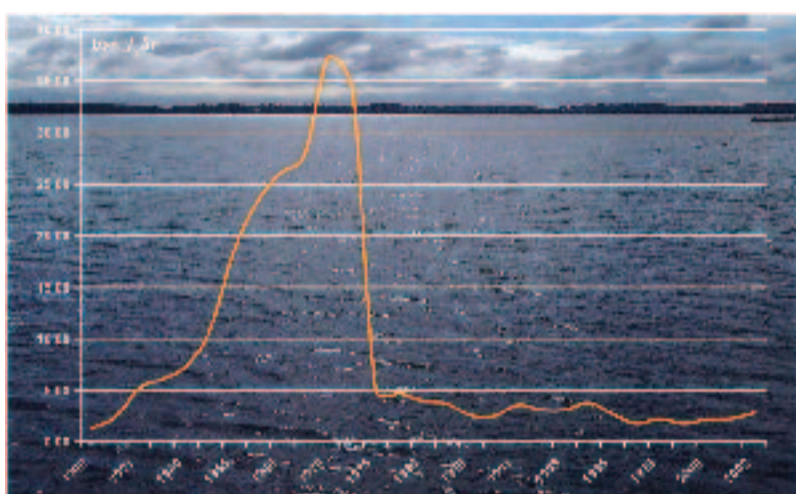
Foto: Inge T. Grey

Unique Fauna and Flora

The pollution originating from the growing towns has started. Around year 1900, 1.3 tonnes of phosphorous is led to the lake from the surroundings every year. The water is so clear that you can see the fish swimming at a depth of 10 m. The clear water also provides good light conditions for the bottom flora. The many different life conditions along the shores of the Main Basin and in Store Kalv leave space for up to 33 different species of submarine flora.

High-cost Clothes Washing

The towns surrounding Lake Furesø have grown bigger. At the beginning, the wastewater from the growing population is led directly into the sea through the sewers. Later on a number of wastewater treatment plants are built, which remove large materials, but which only have limited effect on nutrients such as nitrogen and phosphorous. Alone the introduction of phosphates in detergents in the early 1950'ies entails a huge increase in the phosphorous load from wastewater. As long as oxygen is present in the bottom water, phosphorous is bound chemically to iron compounds in the sea bottom, but the phosphorous becomes accessible to the algae during the recurrent summer periods with oxygen depletion.



The curve shows the development of the discharge of phosphorous into Lake Furesø. It was especially during the period 1950 to 1970 that 70 tonnes of phosphorous were accumulated at the bottom of the lake.

Foto og grafik: Morten Jepsen

Sin of the Past

Simultaneously with the increased efficiency of the wastewater treatment plants, several of the towns around the lake have relocated their discharge of wastewater to be discharged directly into the Sound. Lake Furesø still receives wastewater from Farum, where the wastewater is led through Stavnsholt Wastewater Treatment Plant, which has been extended for both phosphorous and nitrogen removal. Due to the annual discharge of 2-4 tonnes of phosphorous, the surroundings' load on Lake Furesø is similar to the conditions at the beginning of the century. Food for the recurrent large growths of algae is now to a large extent provided by the phosphorous accumulated at the bottom of the lake.



Foto: Peter Fabricius

Nature Restoration

On national and international level, ongoing activities are supposed to compensate for the lack of respect for the flora and fauna in the past. The restoration project in Lake Furesø is started in the spring of 2003. The primary objective of the project is to restore a lake with clear water and an extensive cover of bottom flora and no or only very short periods with oxygen depletion. The method is limitation of the algae production by intervening in two places in the complicated ecological connections of the lake.

Foto: Ida Dahl-Nielsen



A plant has been set up at Stavnsholt. Here the oxygen is kept fluent under pressure, until it is discharged into the sea bottom through approx. 5,000 m of tubes.

Phosphorous is bound to Oxygen

In order to avoid the oxygen depletion in the bottom water in the summer, which results in liberation of phosphorus from the bottom of the lake, oxygen is led out under the metalimnion from the three deepest places in the lake. The oxygen comes from a store on land. Since atmospheric air only contains 21% of oxygen, pure oxygen is used. It is expected that the oxidation will take place every summer for a period of 10 years. The required volume of oxygen changes in the course of the project period, but a volume of 400 to 600 tonnes per year is foreseen.

The three oxygen diffusers – here a model – spread the oxygen in the bottom water by means of tubes with thousands of small holes. Before the bubbles reach the metalimnion, the oxygen has been dissolved in the oxygen-depleted bottom water.

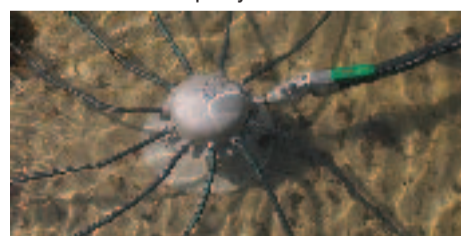


Foto: Ida Dahl-Nielsen

Adjustment of the Fish Stock

Part of the problem in Lake Furesø is an inappropriate balance between the different parts of the food chain, among others the balance between predatory and non-predatory fish. The restoration project changes this balance by a targeted fishing up of non-predatory fish – especially roach and bream. In this way a large stock of predatory fish is created, for instance perch, which lives on deep water and pike, which primarily hunts along the shore. Many predatory fish in Lake Furesø help

Foto: Peter Fabricius



Foto: Ida Dahl-Nielsen

keeping a good balance in the food chain. The fishing of non-predatory fish is planned for 2003, 2004, and 2005. More different fishing equipment and much more intensity is used in the spring. At this time of year, the fish are easier to catch because they seek on to low water in order to spawn.

The many non-predatory fish are landed at Fiskebæk. The majority are processed for animal food, only a minor part of the big roaches are sold on the fish market in Copenhagen.

The pound nets are emptied for non-predatory fish – in some periods once a day. Predatory fish like pike, perch and zander are set out again.



Foto: Ida Dahl-Nielsen

Knold and Tot – two specially constructed boats for fishing by seine net of up to 1 km.