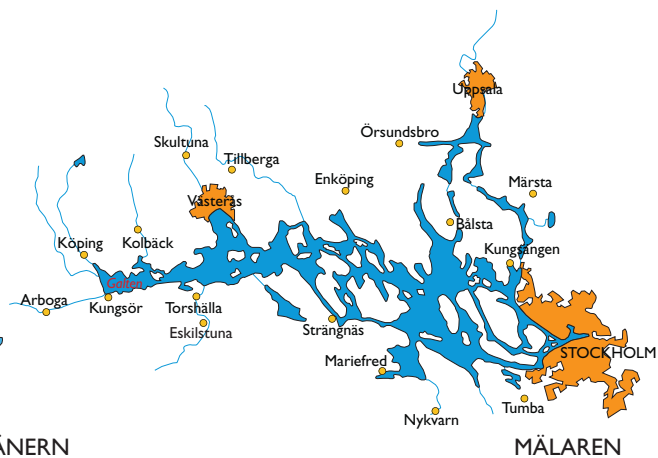
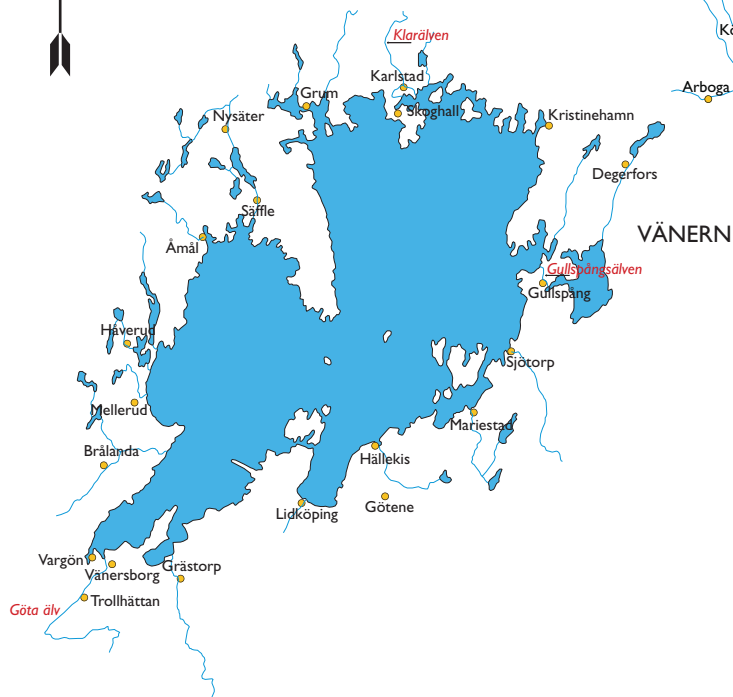




Life on lakes Vänern, Vättern and Mälaren

A TALE OF NATURE AND ENVIRONMENT



LIFE ON LAKES VÄNERN, VÄTTERN AND MÄLAREN

A TALE OF NATURE AND ENVIRONMENT

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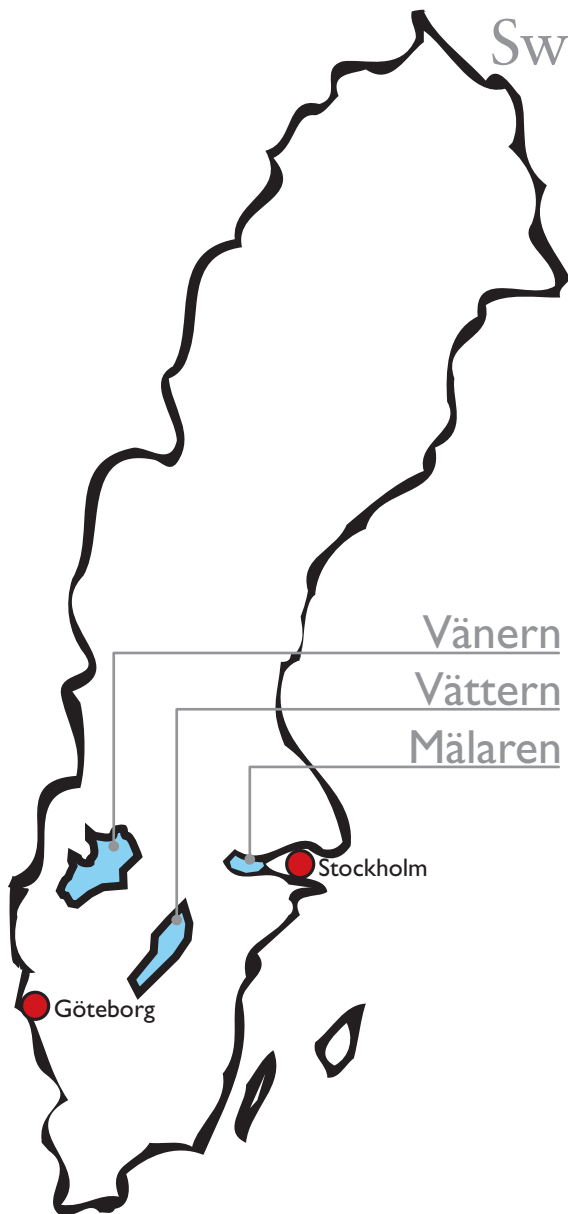
Sweden's three largest lakes

VÄNERN, VÄTTERN AND Mälaren are three different lake types with a number of common denominators. People have lived by the lakes since time immemorial. Traces of ancient dwellings, pastures, harbours and cargo routes can be found all over the lakeside areas. Palaces and manors share the countryside with dwellings from the iron and the bronze age. The lakes' shores and archipelagos therefore, have great cultural as well as natural value and should be looked upon as part of Sweden's national landscape.

The lakes are enormous water reservoirs that together constitute more than 60 percent of the country's total lake volume. Together, they daily supply approximately 2.5 million people with drinking water, almost one third of the Swedish population. The lakes' surfaces correspond to 20 per cent of the country's total lake surface.

Both commercial and sport fishing are extensive and the lakes are popular holiday resorts. Commercial shipping goes on in the lakes Vänern and Mälaren. The lakes are also used by industries and urban areas as recipients of wastewater.

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Fish and fishing



Perch *Perca fluviatilis*



Grayling *Thymallus thymallus*



Ruffe *Gymnosephalus cernuus*



Smelt *Osmerus eperlanus*



Vendace *Coregonus albula*

THE LAKES HOST many fish species; there are 36 permanent species in Vänern, 30 in Vättern and 29 in Mälaren. Together the lakes have 44 species of the country's total of 53 species of freshwater fish. The most common fish in the three lakes is smelt. This is followed by vendace in Vänern and Vättern, and ruffe in Mälaren. Arctic char (*Salvelinus alpinus*) and whitefish (*Coregonus spp.*) thrive in Vättern's cold water. More heat-demanding species such as pikeperch and perch favour Mälaren. In Vänern both cold and warm-water species mix.

There are strains of naturally spawning lake-migrating trout (*Salmo trutta*) in Vänern and Vättern. Grayling that migrate up the lake's tributaries to spawn are also characteristic of Vättern. In Vänern, there are also two strains of naturally spawning salmon (*Salmo salar*), the Gullspång and Klarälv stocks. A special characteristic of these is that they spend their entire lives in freshwater and do not migrate to the sea. The rivers Gullspångsälven and Klarälven are the only sites within EU where this type of land-locked salmon still spawns.



River lamprey *Lampetra fluviatilis*



Pikeperch *Stizostedion lucioperca*



Salmon trout *Salmo trutta*



Four-horn sculpin *Trigloporus quadricornis*

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The very size of the lakes allows them to host species normally associated with the sea. Besides salmon in Vänern, all three lakes also host river lamprey, a red-listed endangered species. It grows and matures in the tributaries, and migrates to the lake as an adult (10-40 cm), living on vendace and smelt.

Another species the lakes have in common, and that is otherwise

found in the Baltic Sea, is the four-horn sculpin. The four-horn sculpin is a so-called glacial relict, an arctic shore fish. The largest specimens reach 25-28 cm.

During the past century, sport fishing has increased in the lakes while commercial fishermen have decreased. About 80 professional fishermen work on Vänern, 40 on Mälaren and 20 on Vättern. Together they make up a bit more

than half of the country's licensed lake-fishermen. The economically most important fish have been pikeperch and perch for a long time in Mälaren, while whitefish and arctic char are of more importance in Vättern. On Vänern, vendace is important; it is fished for its roe. Commercial fishermen have catches an average of approximately 890 tons of fish in Vänern, 270 tons in Mälaren and 90 tons in Vättern.

Bird-life



Young sea eagle

OSPREY (*Pandion haliaetus*) is a typical species of the lakes; it is easy to recognise as sails on white wings against the sky and suddenly dives to catch a fish.

Birds of prey decreased enormously during the 20TH century due to both hunting and environmental toxins.

Toxins, such as mercury, PCB and DDT have been banned and the birds have been placed under protection. The increase in birds of prey can be taken as a sign of a cleaner environment and the marsh harrier (*Circus aeruginosus*) is nowadays common in the reed beds. The sea eagle (*Haliaeetus albicilla*) has returned to breed in both Mälaren and Vänern.

The continental cormorant (*Phalacrocorax carbo sinensis*) has increased in numbers in all three lakes, posing somewhat of a problem for the commercial fishers since the birds sometimes damage the catch. On the other hand a number of endangered bird species seek protection, from e.g. nest-plundering minks, in the cormorant colony.

Vänern has northern Europe's largest freshwater archipelago with 22 000 islands, islets and skerries. The lake has plenty of nesting birds and is also an important resting site for migrating birds in the spring and autumn. Vänern is distinguished by the many skerries with colonies of breeding waterfowl of which several species are normally considered seabirds. The most common birds in the lake are the common gull (*Larus canus*), the tern and herring gull (*Larus argentatus*). Several endangered species breed in Vänern, such as the black-throated diver (*Gavia arctica*), turnstone (*Arenaria interpres*), Caspian tern (*Sterna caspia*) and bittern (*Botaurus stellaris*).



Sweden has 40 % of Europe's breeding osprey couples. The birds build large nests highly placed in old pines for the best view imaginable. Source: sofnet.org

BIRDS CHARACTERISTIC OF Lake Vättern are the red-breasted merganser (*Mergus serrator*), common sandpiper (*Actitis hypoleucos*), black-throated diver, cormorant and osprey. The birds nest in the archipelago in the northern part of the lake and along the shores. The spread of nesting sites is far wider here than in the colonies on Vänern. In autumn and spring many migrating birds can be seen following Vättern in a northerly-southerly direction.

The great crested grebe (*Podiceps cristatus*), the grey heron (*Ardea cinerea*), the greylag goose (*Anser anser*), the mute swan (*Cygnus olor*), the bittern and the common tern (*Sterna hirundo*) can be found in many of Mälaren's bays and coves. A few colonies of black-headed gull (*Larus ridibundus*) also exist. Examples of endangered species are garganey (*Anas querquedula*), black tern (*Chlidonias niger*) and gadwall (*Anas strepera*).



Turnstone

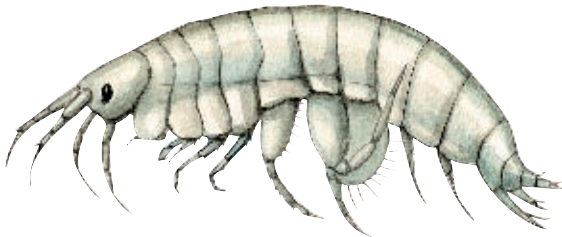


Black tern

Teeming bottoms



Thorn amphipod
Pallasea quadrispinosa



Baltic amphipod
Monoporeia affinis

THE LAKES BOTTOMS teem with life. The small crustacean, the Baltic amphipod (*Monoporeia affinis*) is the most common. It is possible to find more than an unbelievable 10 000 amphipods per square metre in some areas of Mälaren's bottom. Aquatic worms (*Oligochaeta*) are also common. The Baltic amphipod grows to 7 - 11 mm and is important feed for fish such as whitefish, ruffe and smelt. The North American species signal crayfish (*Pacifastacus leniusculus*) is also found on the bottom. The species was planted after the native noble crayfish (*Astacus astacus*) was killed off by the crayfish plague. The population of signal crayfish in Lake Vättern have increased rapidly in the last few years and is fished commercially.

Glacial relicts

The Baltic amphipod and many other animals such as the four-horn sculpin fish, and the thorn amphipod (*Pallasea quadrispinosa*) are species that inhabit the lakes when they were a sea following the last ice age. The species stayed on as the land rose and the saltwater gradually became fresh. These species are called glacial relicts.

Lovely lakes

Anders Geidemark



Lake Mälaren consists of many bays and basins each with its own character. It is a flatland lake surrounded by fertile soils. The lake is therefore rich in nutrients with warmer and more turbid water than that in lakes Vänern and Vättern.

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Lake Vättern is Sweden's second largest lake with extremely clear and nutrient-poor water. The catchment area is small in relation to the lake's volume so it takes theoretically 60 years for a complete turnover of the water. The lake is deep and cold, resting in a fault with distinct and sharp sides. Together this makes for a special light and magnificent views.



Mikael Johansson

Melker Dahlstrand



Sweden's largest lake, Vänern, resembles a great inland sea with bare cliffs but also with quiet reed-bed bays and a wide archipelago. The water is nutrient-poor and quite clear but not as extremely so as Vättern.

Environmental history

VÄNERN, VÄTTERN AND Mälaren's environmental histories are similar to one another. Hydropower stations were built on the lakes' tributaries very early. Power station dams and water regulations led to the extinction of many strains of fish. The water level in Vättern was regulated in 1928 and in Vänern in 1935. The lakes have been exposed to sewage and wastewater from industries and urban areas since the beginning of the 20TH century. In the proximity of industries and towns, there was often a foul-smelling mess in the water.

The paper and pulp mills' discharge of fibres and mercury into Lake Vänern was extensive. At its

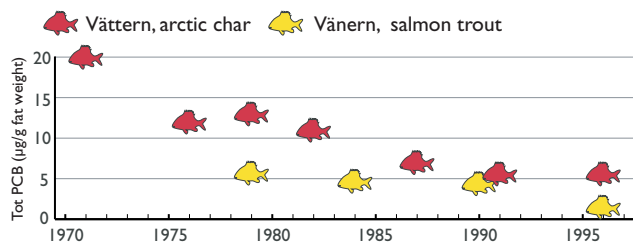
worst, in the 60s and 70s, pike fished from part of the lake was not fit for human consumption due to the high concentrations of mercury.

The toxins PCB and DDT also reached unhealthy levels in fatty fish from Lake Vättern as a result of the paper mills' discharge of chlorinated organic compounds. Additional metals from mining and deposition also polluted the lake.

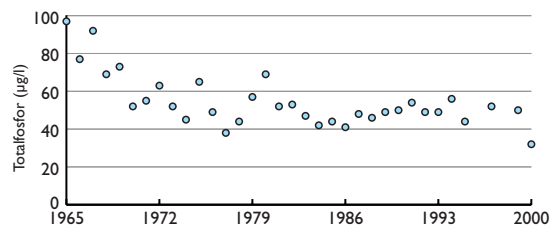
Lake Mälaren was earlier affected by the mining and steel plants in the surrounding Bergslagen area. Mälaren was also the most heavily loaded with nutrients. The lake also suffered from algal blooms throughout most of

the summers, leading to areas of the bottom being completely depleted of oxygen. The blooms often consisted of toxic algae. The lake was mainly affected by the municipal sewage, but nutrients leaching from surrounding farmland also affected the water to an increasing extent.

In order to block saltwater from the Baltic Sea entering Lake Mälaren the water level was regulated in the 40s. The regulation improved oxygen levels in the lake's bottom water. The quality of Eastern Mälaren's water was improved yet further in the 70s and 80s when municipal wastewater was led away from Eastern Mälaren and into the Baltic Sea.



PCB-concentrations have decreased in arctic char from Lake Vättern and salmon trout from Lake Vänern.



Concentrations of phosphorus have decreased in several of Lake Mälaren's bays. The diagram presents annual averages of total phosphorus in Bay Galten.

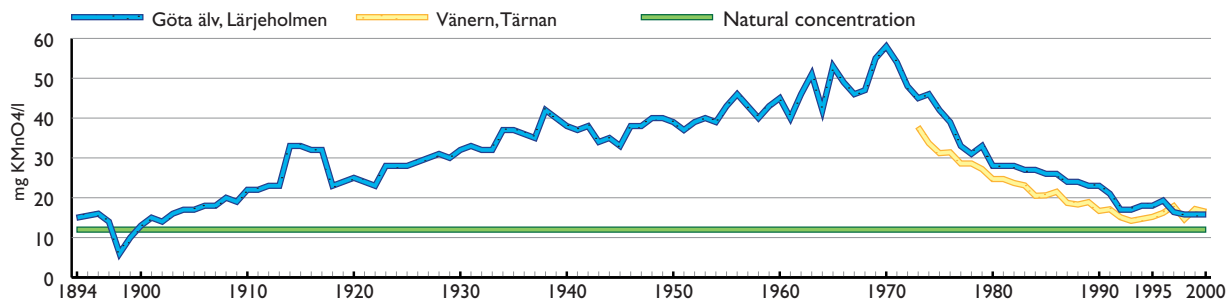
The lakes are recovering

IN 1969, an environment protection law was passed that came to have great influence on the lakes' recovery. Authorities, as well as industry, were forced into a new environmental consciousness. Mercury was also banned, government subsidies were granted for environmental protection measures, and new technologies were developed. During the 70s sewage treatment was vastly improved. In industry, wastewater purification was developed, as were production methods.

The sum of all of these measures led to the lakes' condition eventually improving. The large and visible discharges of fibres and wastewater lessened. The algae blooms in Lake Mälaren decreased and levels of oxygen in the bottom waters rose. Concentrations of nutrients, however, were still too high in certain areas of the lake. The reed beds along the shores and in coves have grown denser and troublesome algal blooms still occur, some of which consist of toxic species.

Levels of phosphorus decreased in all three lakes and water transparency increased. Concentrations of organic material in Lake Vänern decreased drastically (see diagram) and discharges containing mercury have stopped. Despite decreasing levels of toxins in fish, e.g. mercury, DDT and PCB, concentrations of toxins are still heightened in lakes Vättern and Vänern and fatty fish are subject to limiting recommendations for human consumption. The lakes Vänern and in particular Vättern are extremely nutrient-poor and therewith also more sensitive to environmental toxins than the nutrient-rich Lake Mälaren.

Lake Vänern and Vättern's water can, far from land, be drunk as it is without any purification. Lake Mälaren has quite a way to go before reaching this state.



The diagram shows the effects of the extensive improvement in wastewater purification undertaken by the paper mill as well as the municipalities in the 70s. The diagram presents organic

material measured as potassium permanganate in Lake Vänern and in the outlet of River Göta älv.

Environmental issues

THE EXTREME POINT sources of pollutants have, thanks to extensive measures, decreased enormously. Many diffuse sources of pollutants remain, such as leaching from agricultural soils, sewage from rural homes, atmospheric deposition and the general use of chemicals in society. Some of today's most urgent environmental issues are mentioned below. Issues that need to be taken care of in order to fulfil the three national environmental objectives are: *No eutrophication, Healthy lakes and water-courses and Toxin-free environment.*

Less nitrogen to the sea

Nitrogen concentrations in lakes need to be lowered in order to decrease eutrophication of the seas. Lake Vänern's water flows into the Skagerrak while Mälaren and Vättern's flow into the Baltic. In seas, nitrogen causes algal bloom and subsequent oxygen depletion. Concentrations of phosphorus also need to be lowered in Lake Mälaren since algal blooms and oxygen deficiency still occur in some areas. Excessive levels of phosphorus also occur in certain of the lakes' tributaries.

A number of steps need to be taken in agricultural practices in order to lower levels of nitrogen and phosphorus in the lakes. These steps could be green buffer zones between arable land and water-courses, spring ploughing, and catch crops that all lower the risk of leaching from arable soils. Recreating wetlands next to arable land is another example, as wetlands have their own biological purification system using bacteria.



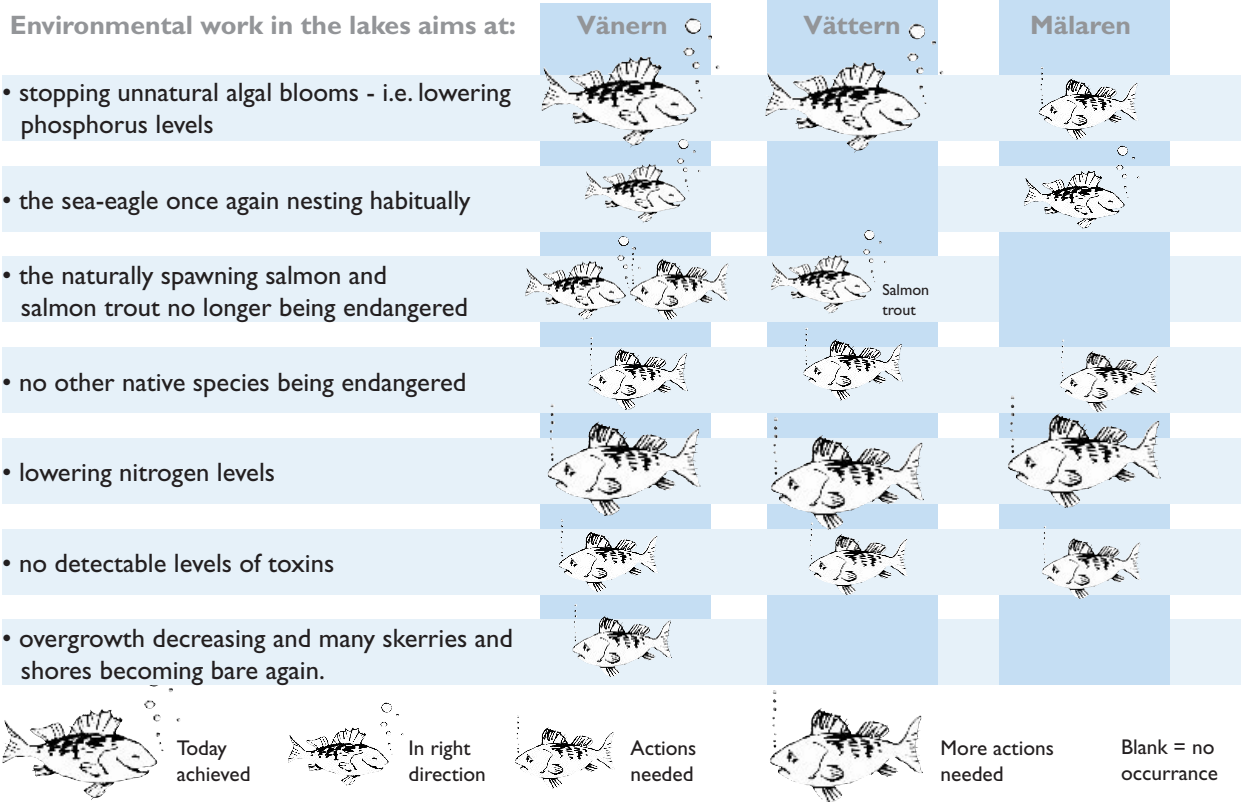
Deposition of nitrogen as well as nitrogen discharge from urban areas must also decrease. Many rural households need to improve the quality of their discharge, and leaching from woodlands needs attending to.

In Lake Vänern reeds have spread and become denser in many bays and archipelagos. The coverage of bushes and trees on islands and shores has also greatly increased since the 1970s. The cause of this overgrowth is not clear and may depend on e.g. water regulation, climate changes, excess nitrogen and decreased grazing.

Toxin concentrations must decrease

The supply of recognized toxins is no longer an urgent problem for our lakes. However, many of these substances are very stable and remain in the water over great lengths of time. In addition, we do not yet know the environmental effects of many of the chemicals and medicines that are in use today. Even very low concentrations of hormone-affecting

substances can cause major damage to organisms. The use of chemicals in society needs to change radically, the aim being that no toxins that do not occur naturally in the environment should occur.



Environmental monitoring

THE CONTINUOUS INVESTIGATIONS of Lake Mälaren began in 1965, of Vättern in 1971 and of Vänern in 1973. Today, three societies for water conservation are responsible for environmental monitoring of the three lakes. The investigations

are financed by the Swedish Environmental Protection Agency, Swedish National Board of Fisheries and members of the societies for water conservation. The monitoring programme includes the following:

- Water chemistry
- Plant plankton
- Animal plankton
- Bottom animals
- Water chemistry at the outlet
- Water chemistry of the tributaries
- Hydroacoustic fish count
- Toxins in fish (Vänern and Vättern)
- Inventories of nesting birds (continuous only in Vänern)
- Control of endangered fish strains (only Vänern and Vättern)
- Macrophytes ("higher forms of vegetation by the shores")
- Sediment chemistry
- Precipitation chemistry (Vättern)
- Temporary campaigns and investigations
- Annual reports, information markets etc.
- Extensive evaluation every sixth year

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Some lake facts

Lake surface, km ²	5 650	1 910	1 120
Max. depth, m	106	128	63
Average depth, m	27	40	13
Volume, km ³	153	78	14
Turnover rate, years	8-9	58-60	2-3
Catchment area, excluding lake surface, km ²	46 800*	4 400**	22 600***
Number of islands (>25m ²)	12 285	858	1 416
Shore length, including islands, km	4 500	800	2 400
Drinking water (number of persons)	800 000	250 000	1 500 000
Water regulation, normal, m	0,7-0,8	0,3-0,4	0,7
Water transparency, m	4-6	10-15	1-3
Phosphorus, normal, µg/l	6-8	4-6	20-60
Nitrogen, normal, mg/l	0,8	0,7-0,8	0,6-2
Chlorophyll, normal, mg/m ³	2-3	0,8-1,2	3-20

* 10 % of Sweden
 ** 1 % of Sweden
 *** 5 % of Sweden

Societies for water conservation

THERE ARE APPROXIMATELY 55 societies for water conservation in Sweden for all the larger watercourses, lakes or coastal areas. The first associations were founded in the 1950s. Their original mission was to co-ordinate and supervise recipient control in the lake, watercourse or coastal area, i.e. to check the water quality. This task is still one of central importance, but today, many associations also work on taking measures for improving water quality, spreading information about the lakes and water planning.

Membership in the societies for water conservation is voluntary and the associations are non-profit organisations. Members are often an organisation that care about the water, use it and/or influence it is one way or another. Examples are municipalities, industries, hydropower companies, agricultural and forestry organisations, county administrative boards, other authorities and interest groups for fishing or nature conservation.





This brochure has been produced by Lake Vänern's Society for Water Conservation, Lake Vättern's Society for Water Conservation, Lake Mälaren's Society for Water Conservation, the Swedish Environmental Protection Agency and the Swedish National Board of Fisheries. The brochure is financed by the Swedish Environmental Protection Agency.

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